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By

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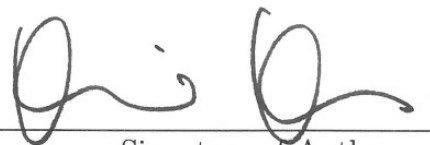
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*Le véritable voyage de découverte ne consiste pas à
chercher de nouveaux paysages mais à avoir de nouveaux
yeux.*

Marcel Proust

*Do not quench your inspiration and your imagination; do
not become the slave of your model.*

Vincent van Gogh

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Abstract

The thesis presents three essays on privatisation and market reform in infrastructure industries. An analysis of the British railway sector over a period of 40 years investigates whether the privatisation and divestiture of the former state monopolist led to performance improvements. Statistical and econometric analysis highlights the importance of scale economies. Further, there are strong suggestions that while liberalisation initially led to an increase in cost efficiency, performance deteriorated over time. The second essay looks at a very broad sample of over 2000 publicly and privately owned utilities in OECD countries. A range of performance measures are used to establish that market reform and private ownership have a statistically and economically significant impact on firm profitability and efficiency. Sub-sample analysis suggests that the effects are not uniform across industries. Building on some stylised facts, the third essay proposes a theoretical model of contract length in a monopoly franchise bidding system. In particular, the model introduces a mechanism, which can induce bidders to reveal the total surplus-maximising contract length to the uninformed regulator. In addition, it is established that in some cases truth revelation comes at a cost, and that bidders can extract a strictly positive information rent.

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Over the course of the last three years, I received many useful comments and suggestions from faculty members, at seminars, at conferences, and at workshops. I tried to acknowledge these with regard to the individual papers, an attempt necessarily incomplete due to the sheer number of contributors, who have brought this work forward. I owe my gratitude to fellow students and staff at the University of Bristol and the University of Vienna who fostered my interest in economic research and provided a very fruitful working environment.

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Karina Knaus

Introduction

The general theoretical and empirical body of the literature on privatisation appears to have come to the conclusion that *ceteris paribus* privatisation leads to a more efficient provision of goods and services. Yet, empirical studies often fail to distinguish sufficiently between a change of ownership and other (often simultaneous) reforms, such as liberalisation, the introduction of competition, deregulation, and divestiture. Against this backdrop, and drawing on the results of an enormous body of literature, this thesis attempts to shed light on the privatisation experience in industries, in which, due to the presence of subadditive cost functions, externalities and universal service obligations, the case for privatisation is less clear: infrastructure industries or ‘public’ utilities.

Despite a common theme, the thesis consists of three distinct papers: (1) ‘An Empirical Analysis of Liberalisation and Efficiency in the British Rail Industry’, (2) ‘Reforming Utilities: The Empirics of Performance, Ownership and Liberalisation’, and (3) ‘On Competition for the Market and the Cost of Truth Revelation with Asymmetric Information’¹. Although the research questions of each paper are related because of similar underlying issues — perhaps best summarised as ‘Does privatisation “work” in the presence of market failure?’ — each has a slightly different focus and

¹Based on joint work with Jörg Borrmann.

follows a distinct methodological approach.

The first paper assesses the impact of private ownership and the introduction of competition on cost efficiency in the British rail industry over a period of 40 years. The second paper addresses the question of how far regulatory regimes and competition can account for post-privatisation improvements (found by the majority of previous studies) across infrastructure industries. The third paper deals with more specific issues which arise when attempting to introduce competition in an industry with natural monopoly properties via the means of franchise bidding. The main focus is on the optimal duration of such franchise contracts in the presence of asymmetric information.

The two empirical studies on British railways and utilities respectively, both focus on the performance of a privatised regime as opposed to a nationalised regime, while attempting to account for the effects of competition and regulatory changes. The panel data study on publicly and privately owned utilities relies on a random and fixed effects model to account for industry and country specific factors. When looking at the privatisation and restructuring of British Rail, descriptive statistics are applied alongside a more formal econometric time series model. The theoretical paper on franchise bidding develops an auction mechanism in a finite horizon model to reveal the welfare-maximising contract length, even when the regulator is uninformed.

The thesis highlights the difficulties which can arise when infrastructure industries are privatised. Findings suggest that competition and regulation play a crucial part in determining whether a privatisation programme can be termed successful (with regard to performance and other measures). Moreover, as discussed in Chapter 4, some crucial factors, such as franchise length, have not been sufficiently dealt with in

theory or practice.

In particular, research presented in this thesis shows that efficiency improvements after the British Rail privatisation were short-lived, and that scale economies and transaction costs may well have contributed to this performance decline. Secondly, looking at a large scale sample across industries, this thesis finds that market reform decreased the profitability of firms while efficiency with respect to investments increased. This is in line with economic theory which suggests that increases in competition and market reform will make firms less profitable and more efficient. With respect to ownership the results are less clear. After highlighting vastly different regulatory approaches with respect to monopoly franchise contract length, Chapter 4 shows that it may be possible to design a mechanism which forces bidders to reveal the total surplus-maximising contract length directly.

The outline of this thesis is as follows. Chapter 1 examines the literature on privatisation in particular relating to infrastructure privatisation. Chapter 2 analyses the British rail industry between 1964 until the end of the first franchise period, while Chapter 3 presents the panel data study on private and public utilities. The final chapter of this thesis, based on joint work with Jörg Borrmann, introduces an auction mechanism, which can reveal the true optimal franchise duration in a setting with informed bidders and an uninformed regulator.

Chapter 1

Does Ownership Matter? Evidence from Infrastructure Industries

The first chapter will briefly outline theories on privatisation, followed by some new evidence from empirical studies. In line with the title of this thesis, the focus is on economic infrastructure: energy, postal services, telecommunications, transport and water. A large body of literature attempts to find links between privatisation and performance. It is by no means clear from the outset if, or how, privatisation should influence economic performance. In addition, there are many different channels through which privatisation may work. The emphasis will be on the models and methods that have been adopted, as-well as possible problems researchers encounter in attempting to test them. The chapter intends to set the scene for the theoretical and empirical findings presented in the latter part of this thesis.

I Introduction

In economics privatisation has been studied across a wide variety of fields, from information economics over corporate governance to political economy, from finance to

industrial organisation. The common ground can be summarised in a fairly straightforward fashion: How does privatisation work, why is it done, and what is the outcome? These most general of questions are those that appear plausible in any policy evaluation context. Yet, privatisation has attracted so much attention from scholars (and politicians and the media alike, one might add) because the answers to these questions can potentially feed another: How much should the state be involved in the economy? In this sense one may view privatisation as just one tiny particle in the liberalisation vs. protectionism universe, but even so, considering the spread of privatisation around the world, it is undoubtedly one of the most universally adopted pro-market reforms (which may well be because in general privatisation leads to immediate benefits for any government: the proceeds from sale).

The global spread of privatisation programmes in the last three decades has been impressive, to say the least. Between 2000 and 2006 low and middle income countries saw 1426 transactions, with a combined value of US\$ million 104,871.42 in 2006 alone.¹ Over a third of these transactions can be attributed to the infrastructure sector. In Europe, on the other hand, *Privatization Barometer* reports over 2000 transactions since the privatisation of British Petroleum in 1977 with proceeds totaling US\$ million 53,174.22 in 2006. In recent years, the data reveal a steady growth of transactions in low and high income countries and, perhaps more surprisingly, a still impressive number of transactions in Europe driven by privatisations in the finance and utilities (mainly telecommunications) sector.²

The question of ownership and state involvement has been ever so prominent in the history of economic analysis. One of the most quoted being Adam Smith (1776),

¹Source: World Bank Privatization Database.

²Source: Privatization Barometer Database, <http://www.privatizationbarometer.net>.

pleading that ‘... [al]though the profusion of government must, undoubtedly have retarded the natural progress of England towards wealth and improvement, it has not been able to stop it.’ However, Book V of *The Wealth of Nations* reveals that Smith (1776) sees scope for public involvement, and implicitly ownership, not only in defence and justice but also infrastructure (roads, harbours, bridges) and education.³ Schumpeter (1934) touches the subject of ownership when he discusses the nature of entrepreneurship. While he remarks that private ownership is not central *per se*, he does at the same time emphasise the importance of the capitalist ideas of success and competition for the characterisation of the modern entrepreneur, other economic arrangements, he concludes, may not produce the incentives necessary to drive innovation and economic development:

... die Art, in der im kapitalistischen Leben “Sieg” und “Erfolg” gemessen wird ... ist durch ein anderes soziales Arrangement nicht leicht zu ersetzen, aber es ist kein Widersinn nach einem solchen zu suchen. Zwar müßte in einer den privaten Unternehmer ausschließenden sozialen Organisation nicht nur für sie Ersatz gefunden werden, sondern weiter auch für jene Funktion des Unternehmers, die er erfüllt, wenn er [sic] den größten Teil seines Gewinns zurücklegt statt ihn zu verbrauchen;⁴(Schumpeter 1934, p.139)

Whether the archetype of the entrepreneur as envisaged by Schumpeter (1934) is relevant for the type of infrastructure privatisations investigated in the literature

³His views on education are somewhat dated as he writes ‘There are no public institutions for the education of women, and there is accordingly nothing useless, absurd, or fantastical in the common course of their education. They are taught what their parents or guardians judge it necessary or useful for them to learn; and they are taught nothing else. Every part of their education tends evidently to some useful purpose; either to improve the natural attractions of their person, or to form their mind to reserve, to modesty, to chastity, and to œconomy: to render them both likely to become the mistresses of a family, and to behave properly when they have become such.’ (Smith 1776, p. 428)

⁴Author’s translation: ... the way, in which “victory” and “success” are measured in capitalist life ... is not easily supplemented by an alternative social arrangement, but it is not futile to search for it. Albeit, it would be necessary, for any social organisation excluding private entrepreneurs, not only to replace it [this way], but also the function, which the entrepreneur fulfils, when he saves a big part of his profit instead of spending it.

presented below (typically large-scale programmes or sizeable companies) may be questioned, yet, the central theme of competitive forces which fuel innovation is picked up by economists seventy years later as a pro-privatisation argument (Shleifer 1998):

Private ownership should generally be preferred to public ownership when incentives to innovate and to contain costs must be strong. In essence, this is the case for capitalism over socialism, explaining the “dynamic vitality” of free enterprise. The great economists of the 1930s and 1940s ... ignored the enormous importance of ownership as the source of capitalist incentives to innovate.⁵(pp.147-148)

Infrastructure industries, that is energy, postal services, telecommunications, transport, and water, have repeatedly been at the centre of attention, when discussions of state (during the 1940s), versus private (during the 1980s), versus state (during the late 2000s) ownership were rife. A fact, which reflects, on the one hand, their economic importance and, on the other hand, that those industries are subject to different types of market failure. Specifically, infrastructure industries tend to retain (even when divested) a natural monopoly⁶ element, namely the network. One should point out that the degree of market failure can by no means be assumed to be constant over time. In telecommunications, for example, technological progress has decreased the degree of natural monopoly typed market failure, whereas the importance of externalities (greenhouse gas emissions, pollution, noise) in transport and energy has dramatically increased, or at least the awareness thereof.

To put it differently, one could argue that infrastructure industries are the first to be nationalised in a period of state involvement and the last to be privatised when pro-market reforms are undertaken ⁷. Yet, private ownership in infrastructure industries

⁵Of course only time will tell if in 50 years this statement will read along the lines of “the great economists of the 1980s and 1990s ignored the importance of contract uncertainty, externalities ...”

⁶This thesis assumes throughout that natural monopolies are characterised by subadditive cost functions, see Baumol, Panzar & Willig (1988).

⁷See for example the privatisation experience in Britain (Vickers & Yarrow 1988), Austria (Belke

is by no means restricted to the large privatisation programmes of the 1980s and 1990s. The first sub-surface railway, the Metropolitan Railway, was privately owned from 1863 until 1933, when it was taken over by the London Passenger Transport Board (*London Passenger Transport Act 1933*). Similarly, when the first eighteen-mile commercial flight took place in the United States in 1914, the government did not appear to be interested at all. The regulation of airlines was not directly related to concerns over market failure but the result of an initiative by the Post Master General to establish a national air transportation system (Morrison & Winston 1995). The history of private involvement in infrastructure is not restricted to transport alone, the water and waste water sector in France has seen private participation for at least one hundred years (Chong, Huet, Saussier & Steiner 2006).

This chapter will show that attempts to formally study privatisation are largely based on political economy arguments. For infrastructure industries the focus is often slightly different, with a particular focus on informational asymmetries and regulation. The outline of the chapter is as follows: Section II will summarise the most important theories on the impact of ownership on firm performance, not necessarily restricted to infrastructure. In particular, the political economy literature will be contrasted with alternative approaches. The third section looks at the empirical findings with regard to firm performance and quality. Section IV offers some concluding remarks.

& Schneider 2004), or Ukraine (Estrin & Rosevear 1999).

II Theoretical Underpinnings

Early⁸ theoretical models approach privatisation (nationalisation) either from a market failure perspective or from a political economy perspective. Models of the latter do not usually take into account forms of market failure (such as externalities, natural monopoly properties, public good properties etc.), whereas social welfare models miss political aspects. First attempts to unite those two strands of the literature (Laffont & Tirole 1993, Banerjee 1997) introduce an intermediate agent (e.g. a bureaucrat or a regulator) who does not maximise social welfare but considers only his or her own utility function, thereby keeping the market failure rationale for public ownership while at the same time covering political economy facets.

(i) The Political Economy of Privatisation

The premise of political economy models is that state ownership implies an organisational structure whereby ownership is distinct from control. In principle, taxpayers as the ultimate owners of state-owned enterprises have no direct way to exercise influence on the managers controlling the firm (Mueller 2003). Depending on the discretion of the government, managers may pursue goals largely unrelated to the maximisation of taxpayers' wealth. Shleifer & Vishny (1994) set out to explain the superior performance of private and privatised firms by modelling the behaviour of managers in state-owned enterprises. Their model shows that politicians prefer control (through

⁸The term 'early' may be slightly misleading with regard to the privatisation literature. In this context I casually apply it to refer to early attempts to formally study privatisation in contemporary economics which mainly evolved after the first privatisation programmes were launched during the late 1970s and early 1980s. Hence, I will not mention more general discussions on the levels of state or government involvement in the economy.

direct ownership or regulation) over manager control because it puts them in a better position with regard to bargaining power. Thus, a firm with negative profits can still be of positive value to a politician if she can win employee votes. Interestingly, Shleifer & Vishny (1994) point out that their model gives a new explanation for the existence of large national monopolies such as railroads, tobacco, or postal services. These firms are under the control of politicians simply because they are *large* and, hence, represent a large number of votes. The model serves well to illustrate the need to account for politicians' motivations, but at the same time any concern for market failure or social welfare is irrelevant.

Between 1960 and 1980 the national monopolist British Rail employed on average around 250,000 staff which can be considered a sizeable portion of the electorate (especially once one adds staff numbers and their families⁹ for other nationalised industries of that time). This raises the question why any politician would adopt a privatisation programme. So, for politicians to be willing to privatise they have to expect a high share in voters with preferences for low taxes and a low share of voters who are in public employment. Such conditions would typically be fulfilled for a right-wing or conservative government.

Such an explanation, however, fails to mention that there are some (in principle) traceable and tractable reasons why the government gets involved: to mitigate the effects of market failure. From the wider perspective of misgovernance, Banerjee (1997) explicitly allows for a benevolent government attempting to minimise the social costs of market failure. The agency model rests on the assumption of a conflict of interest within the government (namely bureaucrats and the government). This could

⁹One may even wish to draw comparisons to tribal voting as described in Mueller (2009).

be plausible to the extent that at a given time some politicians might be concerned with welfare and others with maximising their own utility function. Such a distinction is common in the economics of regulation, namely between the government (or politician) and the regulator. The conclusions are not encouraging because agency problems within the government combined with market failure lead to red tape, corruption, and distorted incentives (Banerjee 1997).

In terms of outcomes, it appears less decisive whether it is bureaucrats who are not interested in maximising social welfare or whether it is politicians. It is very easy to imagine situations where one could observe both, a government trying to stay in power by appealing to large parts of the electorate, and in addition prevailing agency problems within the government, generating red tape, corruption, and inefficiency. The existence of corruption may also be exploited by intermediary agents not directly involved with the government apparatus (Hasker & Okten 2008).

From the political economy perspective, privatisation serves as an instrument to curb political discretion and depoliticise the given firm or industry. This in turn leads to an increase in efficiency, as vote-maximising politicians favour excess employment (Boycko, Shleifer & Vishny 1996). On the other hand, when property rights are ill-defined, the state may exploit firms regardless of ownership status. Even when property rights are strong, politicians may exercise influence to a certain degree, for example through regulation. In this case, it can be shown that privatisation weakens the ability and incentives of interest groups to influence political decision making (Bennedsen 2000). Che & Qian (1998) demonstrate that when the risk of expropriation is high, some form of (local) government ownership is preferable to private ownership. In this instance, local governments are better equipped to deal

with *state failure* caused by institutional weaknesses.

Recent theoretical literature has again put some qualification on results derived in the 1990's (Besley & Ghatak 2001, Börner 2004, Biais & Perotti 2002). In the light of increasingly negative assessments of some countries' privatisation programmes and experiences (e.g. Russia, or failed railway privatisation in Britain, Argentina and Brazil), quality and pricing issues have emerged. In particular, they highlight the potential for a combined presence of state and market failure.

If governments aim to maximise votes, then they use underpricing of privatisation shares to attract voters, often through public issue. Revenue-maximising governments, on the other hand, will simply maximise their private monetary payoff. In both cases, Börner (2004) shows that governments do engage in excessive privatisation to make profit or win votes. The model suggests that we should observe underpricing. Therefore, predictions delivered by political economy models generally differ due to the assumptions made concerning government behaviour. This in turn raises one central question: What is (are) the government objective(s)? As far as empirical evidence is concerned, there is evidence of underpricing and quality issues, as-well as excess employment and inefficiency in SOEs.

It has of course been long recognised in the public choice literature that governments are not benevolent but are likely to maximise political support given financial constraints (see Mueller (2003b)). If this is the case, it is unclear, why governments should prefer state or private ownership, as most objectives, such as a redistributive agenda, could be achieved through regulation. Governments may, therefore, weigh the cost of regulation against the cost of transfer through state ownership (Rosa 1993). In the next section we, thus, turn to regulation and contract theory as a supplemental

explanatory route.

(ii) Alternative Approaches

The spread of privatisation programmes has also contributed to the renewal of two strands of the literature: contract theory and the economics of regulation. For infrastructure industries, one of the defining contributions was Baumol et al. (1988) who first systematically define crucial concepts such as “natural monopoly”. With privatisation reaching infrastructure industries such as telecommunications and airlines, economists devised new systems of regulation (Littlechild 1984, Kahn 1988), the most prominent being the rise of incentive regulation. Among the seminal realisations of the new economics of regulation undoubtedly were that regulators (a) are subject to informational asymmetries, and (b) need to be given the tools to enforce regulatory contracts (Laffont & Tirole 1993). Theories on regulation are, therefore, closely influenced by the findings of information economics and contract theory.

Under certain conditions, it has been shown that privatised and nationalised firms need not differ if the government is benevolent and not tied up in agency conflicts (Sappington & Stiglitz 1987, Williamson 1985, Banerjee 1997). Privatised firms may be regulated into mitigating market failures, and a benevolent politician-owner may be able to imitate the actions of a private owner. Given perfectly enforceable contracts the government can be just as efficient as the private sector, whereas a privatised firm can be just as social as the government. With incomplete contracts, on the other hand, it is neither necessary to rely on political economy arguments and assume a revenue/voter-maximising government nor agency problems between different branches of state authorities –

...our main results should be seen as an existence theorem: It shows that privatization can be strictly superior to nationalization *even in the best of all worlds for the government*. Thus, even if it were possible to perfectly fix all the deficiencies of the political system, a case for privatization could still be made. (Schmidt 1996, p. 4)[emphasis in original]

This result is based on seminal work by Grossman & Hart (1986) and Hart & Moore (1988). Incomplete contract models for private/public ownership problems look at potential hold-up problems between the government and firms or employees. These models are particularly suited for evaluating private-public partnerships or industries where the government still is involved, for example through regulation. This hold-up problem is demonstrated in Hart, Shleifer & Vishny (1997), where the government-owner can hold-up the manager-employee without offering rewards as an incentive. On the other hand, in the private ownership case the manager-owner is not subject to hold-up. However, Hart et al. (1997), similarly, demonstrate that private ownership may lead to lower quality investments or quality-shading. Hart (2003) extends the analysis to public-private partnerships and highlights the importance of appropriate performance measures.

Traditionally, regulation of public utility services focused on the rate level and, albeit to a lesser extent, the level of quality (Kahn 1988). Typically for a public utility, a monopoly's limits were set with regard to a "fair" rate of return on capital. However, Averch & Johnson (1962) demonstrate that rate-of-return regulation leads to incentive problems. In particular, it has been shown that generally incentives are distorted towards excessive capital-intensity, or "gold-plating" (Kahn 1988, Train 1991). In response, other types of regulatory mechanisms have been developed, most prominently RPI-X regulation (Littlechild 1984). As a result, the focus of attention shifted to the informational asymmetries between the regulator, as the principal, and

the regulated firm, as the agent (Laffont & Tirole 1993).

Overall, theory suggests that although a strong case for privatisation can be built on the foundations of the political economy/public choice literature some qualifications seem to arise from particularities in infrastructure industries. Thus, problems such as quality shading may stand in the way of achieving “better” services. Nevertheless, advances in regulatory and contract theory point the way to regimes, which have the potential to alleviate some of these problems. The next section will highlight how these theoretical findings hold up when compared to empirical evidence.

III Empirical Evidence

Evidence on performance improvements after privatisation is summarised, amongst others, by Megginson & Netter (2001) and Djankov & Murrell (2002). Generally, the empirical evidence suggests that for a broad range of efficiency measures (Megginson, Nash & van Randenborgh 1994, Dewenter & Malatesta 1997, Megginson, Nash, Netter & Poulsen 2004, D’Souza, Megginson & Nash 2007) privatisation leads to performance improvements. These studies, however, typically do not account for other simultaneous market reforms such as regulatory reform, restructuring or the removal of entry barriers. This section, therefore, sets out to highlight the findings particularly relevant to the privatisation experience in infrastructure industries.

As a notable exception, D’Souza et al. (2007) compare pre-and post privatisation performance for 161 firms over a period of 40 years, while taking regulatory reform into account. In addition, they consider the possible sources of performance improvements. They find that privatisation improves profitability, whereas restructuring

and high employee share ownership increase the positive effect of privatisation. Post-privatisation state ownership and foreign ownership lead to lower employment levels. Overall, it appears that corporate governance drives post-privatisation improvements. Although the paper uses a variety of methods (such as the Wilcoxon signed rank test for change in means, or the Kurskal-Wallis test for differences between subsamples, and OLS for sources of improvement), changes in regulation or competition are measured as a utility firm dummy only. Moreover, the explanatory power of the model is quite weak ($\bar{R}^2 = 0.04$).

Looking at specific industries, researchers have attempted to analyse the direct and indirect effect of reforms on a large variety of variables, from punctuality records for public transport to sanitation and levels of child mortality. One of the first questions, however, which arises relates to cost efficiency and prices in the industry. In general, results show that for most industries privatisation and reform had a positive impact on efficiency, especially in terms of costs, and, to a much lesser extent, a positive impact on consumers, especially in terms of prices.

With regard to efficiency, the privatisation of electricity in England and Wales appears to have led to permanent cost reductions of 5 per cent a year. However, this fall in unit costs only led to increases in profits and was not passed on to consumers in the form of reduced prices. In the sample period from 1986 to 1996 labour productivity in the electricity sector outgrew the UK's productivity growth (Newbery & Pollitt 1997). Andres, Foster & Guasch (2006) take a broader approach by analysing over 100 electric utilities in South America. They argue that while changes in efficiency and employment are stark during the transition period, only modest improvements can be observed thereafter. Interestingly, with regard to prices, results are ambiguous.

There is also evidence that privatised utilities are more labour efficient. In Estache & Rossi (2004) private electricity distribution companies use up to 45% less labour to produce the same output as a public counterpart. Further, they suggest that price-cap regulation appears to offer efficiency advantages over rate-of-return regulation or hybrid schemes.

In some instances, costs savings seem to have been passed on to consumers. For example, in the British telecom industry prices have halved after privatisation (Florio 2003). Other changes included the decrease in employment levels, which was, however, accompanied by slight increases in wages. Most of the changes in financial, quality, and price indicators are predominantly connected to liberalisation and regulatory pressure rather than privatisation alone (Florio 2003). This result is also supported by Bortolotti, D'Souza, Fantini & Megginson (2002) who analyse 31 national telecoms and compare pre- and post-privatisation performance using and panel data analysis. Again, performance improvements appear to be related to regulatory changes rather than privatisation alone.

While findings on efficiency and profitability are largely positive, it appears to be natural extension to attempt to investigate their cause. As pointed out in the general privatisation literature, restructuring prior to privatisation is fairly common (Megginson & Netter 2001). While in the European airline industry some airlines show increases in labour profitability and productivity, it also appears to be the case that these might be related to the deep restructuring measures taken and paid for by the government, and ultimately the tax-payers, beforehand (Macchiati & Siciliano 2007).

Another way to approach the question of performance, and in particular efficiency,

is to rely on non-parametric methods such as Data Envelopment Analysis (Charnes, Cooper & Rhodes 1978). Recent studies focus on railways (Asmild, Holvad, Hougaard & Kronborg 2009), airports (Domney, Wilson & Chen 2005), or water (Picazo-Tadeo, Sez-Fernandez & Gonzalez-Gomez 2008). For European railways Asmild et al. (2009) find that reforms improve operating efficiency. Distinguishing between operating efficiency of material and staff, it is found that accounting separation and other reforms only influence one or the other.

One methodological problem common to most industry-specific studies is the use of the counterfactual. If, however, the sample is relatively large, econometric approaches can be used to mitigate this problem. Chong et al. (2006) look at the French water industry, which, with its numerous local authorities, represents a prime candidate for such advanced analysis. Using a sample of 5000 municipalities and a switching regression model, they look at different contracting schemes for water provision used by those authorities. Contracts range from pure management contracts to outright privatisation. They find that the choice of contract in each municipality is not random, and that prices are higher when concessions are awarded in a public-private partnership. On average, the difference in retail price is over 16 per cent compared to public provision.

One important question in this context is not just which type of reform is chosen (e.g. franchising versus competition in the market) but also the sequencing of reforms. Using a large panel with data from almost 200 countries, Wallsten (2002) looks at the impact of reform sequence on performance in the telecommunications sector. Relying mainly on dummy variables, the author shows that the establishment of a regulator prior to privatisation, and the existence of an independent regulator, have a positive

impact on performance indicators, such as the number of mainlines, or the number of mainlines per capita. A private ownership dummy variable, on the other hand, has a negative and statistically significant coefficient with the number of mainlines as the dependent variable, and a positive coefficient with the number of cellular subscribers as the dependent variable. This peculiar result may be related to the timing of the introduction of new technology and privatisation,¹⁰ and does not offer conclusive evidence on the actual causal relationship between performance and privatisation.

Rather than focusing on firms or the industry as a whole, researchers have also followed a microeconomic approach (Galvani, Gertler & Schargrotsky 2005, Chong et al. 2006, Alcazar, Nakasone & Torero 2007). Analysing privatisation in the electricity sector in Peru, Alcazar et al. (2007) compare households in communities where privatisation has taken place to those communities where it had not. Using a two-step matching procedure to construct an empirical control group with similar characteristics as the treatment group, they show that privatised providers offer a higher quality of service. In addition to reporting a lower number of monthly blackouts, households with a private provider reported lower prices. As a result, electricity consumption was also higher compared to the control group.

The number and duration of blackouts are a standard indicator for electricity service quality, similar, for example, to the number of mobile subscribers for telecoms or the number of trains arriving on schedule for railways. In telecommunications, privatisation appears to have a positive impact on efficiency and quality indicators, such as network expansion (Ros 1999, Ros 2000). However, the underlying assumption

¹⁰It could of course be argued in a Schumpeterian fashion, that technological progress was made possible through private entrepreneurship, but econometric analysis in Wallsten (2002) does not rule out that results are coincidental.

in the use of such indicators, from a total-surplus maximising point of view, has to be that the optimum has not yet been reached. It is unlikely, however, that for quality indicators, “perfection”, such as 100% punctuality or zero blackouts, maximises total welfare.

With such considerations, it seems maybe natural to look at the effect of reform beyond such quality indicators. Again, relying on household level data Galiani et al. (2005) try to link the privatisation of water and waste water services to child mortality. In a difference-in-differences microeconomic analysis, the paper establishes that water privatisation lowered child mortality in Argentina. Subsequent franchise terminations, such as in Buenos Aires, put these results under new scrutiny.

IV Conclusion

This chapter attempted to highlight some of the most important theoretical and empirical results relevant for privatisation of economic infrastructure. The main issue at stake is brought to the point in the title of Newbery & Pollitt’s (1997) paper ‘The Restructuring and Privatisation of Britain’s Cegb – Was it Worth It?’. Clearly, with instances of extensive restructuring and deregulation in mind, it is not only legitimate but obligatory to ask this question.

From a political economy point of view, it has been shown that privatisation or nationalisation can both be interpreted as means to a simple end, which is to win as many votes as possible. While incentive and incomplete contract problems within governments, for example between the bureaucrat and the manager are relevant, at the core the separation of ownership and control remains the biggest problem. Taxpayers evidently have (almost) no control over actions, accounts, investments, etc.

of state-owned enterprises. They are presented with the extreme difficulty of having to evaluate, as the ultimate owners, not just firm performance but, if they aim to maximise their utility, how a particular firm's performance fits into the entire realm of government expenditures.

In the case of infrastructure industries, subadditive costs, universal service obligations, externalities, and the reliance on limited and unevenly distributed resources,¹¹ make the design of suitable privatisation or liberalisation policies especially difficult. The economics of regulation has aimed to tackle at least some of these problems. The rise of incentive regulation and price caps has meant that the inefficient use of capital, or "gold-plating", is less common. On the other hand, there are still numerous open question, for instance with regard to investments, benchmarking, or franchise bidding. Chapter 4 will give an example of how theoretical models can help to solve practical issues, in this case the optimal franchise duration.

In empirical work, case studies often do find increases in financial performance after privatisation or deregulation in a number of infrastructure industries. Attention is also given to possible reasons for such improvements, since evidence indicates that different types of reforms have a different impact. Evidence on other issues such as quality or employment remains sketchy. Falling in line with other case studies, Chapter 2 aims to provide a thorough analysis of the British railway industry.

It is also clear that accounting for ownership changes and regulatory reform in infrastructure is extremely difficult in empirical work. Often data limitations and other methodological problems impede the inclusion of different industries. Although industry studies have the distinct advantage to assess the impact of reform on a more

¹¹Natural gas or water come to mind.

sophisticated level, Chapter 3 aims to take a more general approach, and analyses performance, ownership, and reform across different infrastructure industries over time. Taken together this thesis contributes to the research area of economic infrastructure with a case study of British railways, a cross-industry, large-scale panel data model, and a theoretical model on the optimal duration of franchise bidding contracts. It is also clear from the survey presented above, that many important research questions above, and beyond, performance still need to be addressed, such as the timing of reform, quality, investments, or employment effects.

Chapter 2

An Empirical Analysis of Liberalisation and Efficiency in the British Rail Industry

This chapter analyses the privatisation and restructuring experience in one of the last strongholds of state provision of infrastructure services in Great Britain: passenger railway services. Providing a detailed survey of railway literature, the analysis draws on an extensive database of the British rail industry from 1964, to the end of the first franchising period in 2005/06. Economic theory and descriptive statistics help to motivate an econometric approach, which sheds light on the most important determinants of cost efficiency over the 40 year period. A particular focus of the analysis is industry performance after the restructuring period of 1994-97. Results suggest that while initially successful in improving cost efficiency, the effect evaporated over time. Further, estimated coefficients emphasise the importance of competition and economies of density in the British sample.

I Introduction

The economic analysis of rail transport has a long-standing and thriving tradition (Wellington 1893, Lorenz 1916, Acworth 1922). One of the reasons why railway economics has such a sustained history is that railroads have some particular characteristics, which make them analytically challenging, and at the same time a prime candidate for policy debates: Railroads as an infrastructure industry exhibit natural monopoly properties, sunk costs, and limited scope for competition. Moreover, railways receive public funding, and act as a potential substitute for road and air transport, while generating comparatively fewer externalities, such as pollution (noise and air) and congestion. Thus, the paper addresses a number of broader issues, while of course, being sensitive to the limitations applying to any case study.

In European countries most railways have been state-run at least since World War II, and despite their perceived inefficiency, little was set to change until, on July 29th 1991, a EU Council Directive was released, which required the separation of railway infrastructure from operations and mandated the introduction of competition in construction, maintenance, and provision of services:

The aim of this Directive is to facilitate the adoption of the Community railways to the needs of the Single Market and to increase their efficiency;

- by ensuring the management independence of railway undertakings;
- by separating the management of railway operation and infrastructure from the provision of railway transport services, separation of accounts being compulsory and organizational or institutional separation being optional,
- by improving the financial structure of undertakings,
- by ensuring access to the networks of Member states for international groupings of railway undertakings and for railway undertakings engaged in the international combined transport of goods.

(Council Directive 91/440/EEC of 29 July 1991: Article 1)

Further, the Directive required that

Member States shall take the measures necessary to ensure that the accounts for business relating to the provision of transport services and those for business relating to the management of railway infrastructure are kept separate. Aid paid to one of these two areas of activity may not be transferred to the other. The accounts for the two areas of the activity shall be kept in a way which reflects this prohibition. Member States may also provide that this separation shall require the organization of distinct divisions within a single undertaking or that the infrastructure shall be managed by a separate entity.

(Council Directive 91/440/EEC of 29 July 1991: Article 6)

Although not directly propagating the introduction of private ownership, the directive laid down the basis of any such future development: The separation of infrastructure from operations (at least in accounts) – thereby separating the natural monopoly element from the potentially competitive element. In principle, this allows for, either the introduction of competition with the state incumbent (as for example in the case of AT&T or BT), or the divestiture and subsequent privatisation of the state monopoly (as for example in the case of electricity unbundling). One year after the release of the directive, in July 1992, the UK White Paper *New Opportunities for the Railways* was published by the Department of Transport. These new opportunities were meant to arise from the introduction of private management and liberalisation of the sector. The steps that were consequently undertaken by the government of John Major between 1994 and 1997 were the most radical to be introduced in Europe, up to today. Although there has been some movement back to a less market-oriented approach (e.g. the creation of a new infrastructure manager that runs as a non-for-profit company rather than publicly listed company, such as the original infrastructure manager), the complete separation of infrastructure and most types of operations (i.e. passenger and freight services, rolling stock provision, infrastructure services, etc.), is still in place.

One central question raised by major policy changes such as the restructuring and subsequent divestiture of the former state monopolist British Rail, is whether efficiency improvements as a result of liberalisation efforts can be observed. Although Chapter 1 argues that the political economy literature on privatisation emphasises that policy makers may pursue a range of different goals (Perotti 1995, Bennedsen 2000), efficiency is a key argument forwarded (by economists and politicians alike) in favour of a more liberalised, privately dominated, market structure. Whilst this question has been investigated, and possibly answered affirmatively, to a great extent in the general privatisation literature (Megginson et al. 1994, Megginson & Netter 2001), the impact of liberalisation measures on efficiency in industries subject to market failure is less certain.

In particular, in industries, which continue to exhibit strong natural monopoly properties, liberalisation, and specifically horizontal and vertical separation, may lead to a deterioration of observed efficiency (Estache, Gonzáles & Trujillo 2002). One of the main reasons is that rail infrastructure is subject to sunk costs, since when demand falls, parts of the network cannot easily be transferred to another geographical market. Therefore, the network typically remains a bottleneck and can, thus, only be separated from the potentially competitive rail services. This divestiture in turn may lead to inefficiencies because the vertically and horizontally separated rail industry may give rise to increases in transaction costs (Williamson 1976) and incomplete contracts problems (Grossman & Hart 1986, Hart & Moore 1988).

Therefore, more specific questions arise in the context of the privatisation and restructuring of railways. Do vertical economies matter in a separated rail industry? If so, how large is their impact on cost efficiency? Is competition for monopoly effective

in decreasing expenditure per unit of output? Does one of those effects dominate the other? Beyond those issues of efficiency and competition, key questions typically also surround the development of safety and employment issues in a liberalised rail industry.

There are two main reasons to look at the railway industry in Great Britain. Firstly, the process of privatisation and events ever since (i.e. high-profile accidents, effective renationalisation of the infrastructure manager) gave rise to heated discussions, within and far beyond academia, whether the privatisation of British Rail was too hasted or even unnecessary. Secondly, very few other railways have followed the UK example, and attempted a separation of tracks and rolling stock operations. The more common policy is to split the private monopoly into several freight and passenger units, which enjoy quasi local monopolies.

In this chapter, I develop a time series model that is based on a general-to-specific and a Bayesian econometric approach. An artificially integrated operator is created for the period of the liberalised regime to compare pre- and post privatisation performance, measured as costs per unit of output. The paper is structured as follows. Section II outlines the framework for the analysis, and discusses the key models with regard to rail liberalisation. Section III offers a brief overview of the sample and data collection methods, and outlines the methodology that will be applied in this paper. Section IV presents the empirical results, and Section V concludes.

II Framework for Analysis

Empirical and theoretical literature on the economics of railways can at least be traced back to the 19th century (Wellington 1893). Early post WWII empirical studies of

railroad costs mainly focused on excess capacity and the difference between long-run and short-run costs. The great interest in the estimation of the magnitude of economies of density was related to the United States regulatory system (for trucking and rails) of the time, which led to concerns over the misallocation between different modes of transport. Therefore, one goal of those studies was to show that for light density lines road haulage provides the cheaper alternative. In the last thirty years technological advances (that is speed improvements, further electrification) combined with greater awareness of environmental externalities have rendered some of those early arguments less decisive.

(i) Examining Railroad Costs

Modern econometric studies of railway costs start with Borts (1954) and Borts (1960). Borts (1960) estimates a cost function of the form

$$C = \beta_1 Q + \beta_2 L/Q + \varepsilon, \quad (\text{II.1})$$

where Q is car miles and L is total carloads. Specifying total costs as $C(y) = f(Q, \frac{L}{Q})$ assumes that the correct measure for rail freight output is miles and load per mile, taking into account both the length and size of haul. Later studies typically use freight tone miles (or kilometres) as an output measure. Using a sample of 61 US freight railway firms, he finds that marginal costs of freight carloads, β_1 , to be \$.25 in the Eastern Region, \$.16 in the Southern Region and \$.18 in the Western region. He also estimates the equation using within regressions of firm size, which does not lead to statistically different estimates of marginal costs with respect to size. The large difference in the marginal cost estimates between the Eastern Region and the

other two regions is attributed to higher traffic densities. Further, average costs are higher than marginal costs in the South and West but not in the Eastern region. An interesting exercise in this context uses his results to compute returns to scale, defined as

$$S = \frac{C(y)}{yC'(y)} = \frac{AC(y)}{MC(y)}. \quad (\text{II.2})$$

Substituting Borts's (1960) estimates in II.2 it can be shown that small firms have higher increasing returns to scale and that large Eastern firms have constant returns to scale. This is in line with the central point emphasised by Lorenz (1916), which is that density as a source of scale economies cannot go on '*in infinitum*' (ibid., p.211), as full capacity is reached. Therefore, one implication is that economies of density will most likely be a relevant factor for regional and less congested railways but peripheral for urban commuter lines where capacity is already fully utilised.

Building on the Borts (1960) study, the 1970s and 1980s produced a large number of cost studies, concluding that one should distinguish between economies of size and economies of density as a source of economies of scale. In the short run, when capacity is fixed, the utilisation existing capacity (cars, tracks ...) to full capacity is called economies of density. This source of scale economies will cease, once existing resources are congested. Economies of size, on the other hand, refer to increases of capacity (doubling a track, larger rolling stock) without the duplication of all inputs, which potentially could go on forever. The majority of cost studies, however, assume that capacity is fixed, and do not estimate economies of size.

Again, relying on the US freight sample, Griliches (1972) finds that returns to scale vary between 1.35 and 1.03, depending on the size deflation factor used. When

more weight is given to small railroads, increasing returns to scale are found. In the undeflated model he finds constant returns to scale. His results support earlier studies, in particular the hypothesis that economies of density are only one possible source of scale economies. Thus, in principle, it appears to be important to account for different types of economies of scale. On the other hand, empirical studies struggle to find a suitable measure for economies of size.

Yet, the central motivation of cost studies on the U.S. freight industry was not primarily to obtain estimates of economies of scale or economies of density but estimates of excess capacity, while building ‘a powerful case against railroad regulation in its present form’ (Levin 1981, 1). Friedlaender (1971), for example, looks at the costs of regulation by estimating long and short run elasticities for 88 railroads, and puts the costs of excess capacity of around \$3 billion¹. Keeler (1974) estimates rail cost functions, and finds 200,000 miles, or 320,000 kilometres, of excess track capacity in a cross-section of 51 American railroads, a figure, which can be compared to the total US rail network of 226,427 kilometres in 2007². Criticism for previous cost models comes from Harris (1977) for omitting variables and using misspecified output measures but he also calls for the closure of almost half of all US freight lines. He suggests estimating average costs as

$$\frac{TC}{Y} = AC = \beta_1 + \beta_2 \frac{1}{AL} + \beta_3 \frac{1}{DENS}, \quad (\text{II.3})$$

where output, Y , is defined as revenue tone miles, AL is the average length of haul and density is measured as output divided by network size. The inverse relationship

¹Roughly \$8 billion in 2009 USD, with an average inflation rate of 3.2%.

²Source: CIA World Factbook, <https://www.cia.gov/library/publications/the-world-factbook>

between average costs and density is derived through the basic cost model, which includes network size as an explanatory variable. With a cross-section model of the US freight industry, where companies differ with regard to network size, it is necessary to take this into account when estimating a cost function.

In a first attempt to approach the problem of heterogeneous qualities and attributes of rail outputs, Spady & Friedlaender (1978) use an hedonic cost function. Estimating average costs using an hedonic specification, yields an average cost curve, which rises as output grows, so that large firms have higher average costs than small rail freight firms. The approach points towards a possible explanation for the mergers of small and large railway firms of the time. The implication of Spady & Friedlaender (1978) is that quality criteria, such as punctuality, should be taken into account when estimating railroad costs.

With increasing concerns over the financial situation of many U.S. railways, deregulation was conjured up as a possible solution, and in 1980 the Staggers Rail Act was passed. These possible positive effects are simulated in Levin (1981). He looks at the potential effects of deregulation on profitability and railway rates. Some degree of competition, i.e. setting $\rho = n/k = 3$, where n is the number of firms, k is the change in industry output a firm believes to result from a one unit change in output, will lead to rates of return on replacement value of 4% to 8% and rate increases of around 10% to 80%. These large differences in tariffs are a result of the regulatory regime at the time, with different tariffs being set for different goods. The predicted rise in profits and prices depends crucially on the assumed elasticity of demand and the degree of competition used in the simulation.

The rise of the translog cost-function,

$$\ln C = \sum_{i=1}^N \alpha \ln X_i + 1/2 \sum_{i=1}^N \sum_{j=1}^N \alpha_{ij} \ln X_i \ln X_j + \varepsilon, \quad (\text{II.4})$$

allowed for specifications of multiple inputs, X_1, \dots, X_n , and, yet, after the deregulation of US railways, interest in the subject faded. Nevertheless, the literature documents that the estimation of rail cost functions is by no means a straightforward undertaking.

Major issues arise with respect to the source of economies of scale, which, on the one hand, is related to the optimal utilisation of existing resources and, on the other hand, to the expansion of services. Furthermore, flexibility in cost functions, such as allowing for nonlinearities and interactions, has furthered understanding railway costs. In view of the analysis presented in the latter part of this chapter, heterogeneity, especially quality of service, should not be omitted from any cost model.

After recent reforms taking place in rail sectors around the world, the focus of new studies shifted to the effects of deregulation and policy changes (Wilson 1994, Estache et al. 2002). Whereas Wilson (1994) concentrates on the effect of deregulation on prices, Estache et al. (2002) look at total factor productivity as a measure for efficiency. Wilson (1994) finds an increase in average rates post US deregulation of 10%, which is at the lower end of earlier predictions (Levin 1981). Experiences in Argentina and Brazil are also mixed. Although the evaluation of total factor productivity shows large efficiency gains, TFP growth is due to improvements in outputs not inputs. Moreover, there appears to be large scope for strategic behaviour when concessions are awarded (Estache et al. 2002). This chapter attempts to merge the tradition of estimating railroad costs with newer approaches, which focus on the impact of liberalisation.

(ii) *Competition for Monopoly: Franchise Bidding*

When an industry contains monopolistic (track and stations) as well as potentially competitive elements, there are two major options for a decision maker. The first is to restructure prior to privatisation, and force the integrated incumbent to divest or, alternatively, keep the vertically integrated monopolist, and regulate the incumbent in a way that fosters competition and entry. The former strategy was, for example, adopted in the British electricity market and the latter in the British telecommunications market (for an overview of the early privatisation programme in Britain see Vickers & Yarrow (1988)). Vickers (1995) models this setting in the presence of imperfect competition and imperfect information. He shows that, depending on demand conditions, separation or integration might be preferable.

One of the criticisms of the divestiture approach (i.e. breaking up the vertically integrated firm and prohibiting the owner of an essential facility to participate in the competitive business) is the presence of vertical economies. Often decision makers have, therefore, opted for the less radical option of letting the vertically integrated incumbent continue operations while simultaneously regulating access charges and fostering some competition. This is an approach characteristic of early privatisation attempts of UK utilities prior to BR (Vickers & Yarrow 1988). The separation of different stages of production, on the one hand, and distribution, on the other hand, implies that transfer and connection costs arise, which would not apply to an integrated monopolist.

Williamson (1971) offers an early attempt to systematically show the attractiveness of vertical integration and internalisation. Sources of vertical economies can

include costly contractual arrangements, coordination failures in the provision of services (which is particularly relevant for the rail industry), costly market transfers, information problems, and a higher degree of uncertainty and risk aversion. Kasperman & Mayo (1991) develop and examine a model of vertical economies in the electricity industry, and detect the presence of significant vertical cost complementarities. Empirical evidence from Jensen & Stelling (2005) finds significant vertical economies for the Swedish rail industry.

If the decision making authority opts for vertical and horizontal separation of services, there is still the question what exact shape competition might take. In the railway industries, direct competition on the track is rare, as technological limitations apply. To be specific, only one service can run on a particular track at a given time, which differs considerably from, say telecommunications, where calls can be made simultaneously. Of course different allocation mechanisms could be envisaged, for example the auctioning of railway slots.

Such a regime may not be practical and fairly costly, so that an alternative is to award regional monopoly concessions to rail operators, as in the British case. The merits of franchise bidding for the right to monopolise were highlighted in a seminal discussion by Demsetz (1968). Early formal models on the optimal design of franchise auctions include Laffont & Tirole (1987) and Riordan & Sappington (1987). However, empirical tests seldom address the effectiveness of franchise bidding in a public utility setting. This is regrettable as the success (failure) of vertical separation and divestiture of a network industry largely depends on the (un)successful attempts to introduce competition in the downstream (operations) sector.

Criticism with regard to franchise bidding arose from the transaction cost literature (Williamson 1971, Williamson 1976, Goldberg 1976). The main difficulty thus uncovered, relates to the transferral of long-lived assets at the end of the franchise period. In particular, an incumbent will have an incentive to overestimate the value of the infrastructure assets so as to ensure a significant pay-off from the entrant. Extending franchise periods to the life of the assets, which for railway locomotives exceed 50 years, will raise other concerns, such as uncertainty and renegotiation. In addition, franchise bidding, as a repeated auction, faces commonly discussed issues, such as attracting a sufficient number of bidders or the prevention of collusion.

New empirical and theoretical contributions, however, try to investigate potential (practical) problems with franchise bidding and offer solutions (Engel, Fischer & Galetovic 1997, Harstad & Crew 1999, Crew & Kleindorfer 2002, Borrmann 2008). Indeed, Chapter 4 represents a similar attempt by analysing optimal franchise duration. Nevertheless, it remains the case that competition for monopoly is not without drawbacks.

As a further complication, when analysing franchising in the British railway context, it should be noted that the franchise bidding process in Britain can only loosely be termed a franchise auction in the economic sense suggested by theory. Since the start of the new framework, there has been a degree of uncertainty surrounding the exact process for franchising. From 1996 onwards, franchises have first been awarded by the Office of Passenger Rail Franchising (OPRAF), from 2001 by the Strategic Rail Authority (SRA) and then jointly by the SRA and the Department for Transport (DfT).

The franchises are awarded on the basis of the base services specification, bidder's priced options, and bidder-generated options. Pre-qualified bidders receive an Invitation to Tender (ITT), which sets out the frequency of service, and other essential requirements. Bidders are invited to set out a delivery plan for reliability, cost reduction, and revenue increase. Decisions are based on a Value for Money appraisal, which includes factors like risk management. The first round of franchise auctions was characterised by optimistic bids by prospective operators, resulting in a number of renegotiations and one early termination of the South Eastern franchise. Nevertheless, even the British franchising process does introduce some competition (or contestability rather) and, therefore, needs to be evaluated.

(iii) The Privatisation of Railways in Great Britain

The privatisation process and its shortcomings have been investigated in some detail (Curwen 1997, Gourvish 2002, Nash 1993, Nash 2002, Pollitt & Smith 2002). The account presented in this chapter captures some of the background and lesser known events.

From 1948 until 1997 the British Transport Commission (BTC) and later the British Railways Board (eventually trading as British Rail) was responsible for running and maintaining the British railroad system, with a few notable exceptions such as London Underground and some regional light railways and tramways. The powers granted to the BTC with the Transport Act of 1947 ranged from carrying passengers by rail, road, and waterway, to store and consign goods, from buying and leasing land, to construction and maintenance. The main limitations regarding the production of road vehicles and taxis were that,

the commission shall not have power to carry passengers by road in a hackney carriage adapted to carry less than eight passengers and used in plying or standing for hire in a street.

(*Transport Act 1947*, Chapter 49, p. 3)

The focus of the Transport Act was

to provide, or secure, or promote the provision of, an efficient, adequate, economical and properly integrated system of public inland transport and port facilities within Great Britain for passengers and goods with due regard to safety of operation; ... Provided that the references in this subsection to transport do not include references to transport by air. (*Transport Act 1947*, Chapter 49, p. 8)

In a contemporary analysis of the piece of legislation, Walker (1948) focuses on road transport and haulage, and does not dwell on railway reforms. His conclusions reflect a sense of uncertainty on the impact of the Act on the British transport system but, more importantly, he reflects on the nature of public enterprises and questions the motives of managers:

... the Commission and their servants, directed to act only in the “national interest,” would automatically be freed thereby from those malpractices, which have so often disgraced private monopoly in the pursuit of profit. But even should we be satisfied on that point, we must still enquire whether the qualities, which make these fears groundless are also those which make for business success in an enterprise as vast as that which the Commission and Executives are being called upon to manage. (Walker 1948, 30)

So, even if the managers of the SOE, that is the Commission and their servants, are able to act independently and strive to maximise consumer surplus, this may not be compatible with the goal of running an enterprise efficiently.

In the following 45 years of state-owned railways the whole transport industry underwent considerable transformation. These changing circumstances found their first major manifestation in *The Reshaping of British Railways* (British Railways

Board 1963), a report outlining a programme of station closures, rolling stock reductions, and network shrinkage. Even though the recommendations set out in the report were largely followed, the financial success (that is a largely unsubsidised railway) envisioned at the beginning of the 1960s, did not materialise (Serpell 1983, 7). In his report for the Department of Transport on railway finances, Serpell (1983) stresses that further substantial route closures would be needed to result in passenger services breaking even. As a consequence, the report outlines different scenarios depending on the level of grants and subsidies a government would be willing to provide.

These concerns over the financial viability of rail services during the late 1970s and early 1980s coincided with the launch of a large scale privatisation programme in 1979 by the government of Margaret Thatcher. Whereas the first wave of privatisations concentrated on selling firms in competitive industries and included firms like British Petroleum, Britoil, Cable and Wireless, British Aerospace, Jaguar, and Rolls Royce, the mid-eighties saw a rising number of privatised utilities such as British Telecom, British Gas, British Airways, British Airport Authority, and the electricity and water supply industries (Vickers & Yarrow 1988). Even though Vickers & Yarrow's (1988) analysis of the UK privatisation describes the privatisation of British Rail as a remote prospect due to the limited scope for competition and significant sunk costs, first ideas to privatise the British railway system started to appear at the end of the 1980s. In 1989 a privatisation studies group was put in place by the British Railways Board to analyse the possible options for privatisation and the Board's response.³

By the time John Major took over from Margaret Thatcher in 1992, British Rail was one of the last big state-owned enterprises left. One year later the Railways

³The protocols and minutes of this study group have been transferred to the National Archives in Kent, and can be publicly accessed.

Act (*Railways Act 1993*) set out the proposal for the restructuring of the British rail industry, and the complete divestiture of British Rail into over 100 companies. The Act provides the basis for the new industry structure and the responsibility of the main actors (a summary is provided in Table I). The transfer of ownership of all of British Rail businesses was completed in 1997, just before the general election.

Table I: MAJOR INDUSTRY PARTICIPANTS IN 1997

Name	Abbreviation	Main Responsibilities
Train Operating Companies	TOC(s)	Running of passenger services as set out in the franchise contract.
Freight Operating Companies	FOC(s)	Running of freight services.
Rolling Stock Leasing Companies	ROCSO(s)	Leasing of rolling stock to freight and train operating companies.
Office of Passenger Rail Franchising	OPRAF	Prepare invitations to tender, award franchising contracts, secure services if no franchisee can be found or a franchise terminates early.
Railtrack		Operating all track and infrastructure, timetabling, operating signalling systems; Required to contract out maintenance and similar operations if value for money.
Health and Safety Executive	HSE	Regulation of safety.

TABLE I (CONTINUED)

Name	Abbreviation	Main Responsibilities
Office of Rail Regulation	ORR	Promote interoperability, foster competition, monitor prices, quality, access rights and safety.

Source: *Railways Act 1993* and the White Paper *New Opportunities for the Railways 1992*.

Since 1997 the rail industry has undergone many changes and some fundamental restructuring. In October 2002, after Railtrack was put into administration, the infrastructure manager was effectively renationalised as Network Rail, a non-for-profit company accountable to public and industry members as well as the Department for Transport. Between 2006 and 2008 the majority of original franchises had come to an end and, thus, had to be refranchised. However, the Department for Transport undertook a re-evaluation of franchise duration and size, and concluded that franchise areas should be larger and franchise periods should last longer – the franchises awarded 2006-2008 run between 7 to 10 years and, effectively, split Great Britain into 18 (as of June 2008) franchises only, instead of the original 25. Exceptions in the refranchising were the Chiltern franchise, which was franchised to Deutsche Bahn for 19 years and the Merseyrail 25 year franchise, which was awarded to Serco Group and NED Railways in July 2003⁴.

⁴Source: For a detailed description see for example the National Audit Office (Office 2008)

III Data and Methodology

(i) The Data

The data collected for this research mainly stem from the National Archives in Kew (where British Railways Boards documents were transferred to), from the Department for Transport and the industry regulators: Office of Passenger Rail Franchising (OPRAF), Office of the Rail Regulator (ORR), Strategic Rail Authority (SRA), Health and Safety Executive (HSE) and the Rail and Safety Standards Board (RSSB). Additional firm information was obtained from the firms themselves and the FAME database, which contains information on UK and Irish companies and businesses. The documentations and publications, which were used to construct the data base, fall into eight categories: (1) audited financial statements; (2) industry consultations; (3) policy reports; (4) firm prospectuses; (5) internal memoranda between officials; (6) quarterly and annual statistical publications; (7) evaluations of franchise performance; (8) press and statutory notices; and (9) industry reports.

Table II: SUMMARY STATISTICS OF VARIABLES

Variable	Min	Median	Mean	Max	St.dev
Network Size (km)	14300	14409	14941	20327	1231.06
Passenger Stations	2355	2483	2544	4145	338.93
Station Spacing	4.904	5.998	5.901	6.138	0.2418
Passenger Kilometres (m)	27358	30818	32084	41800	3658.07
Loaded Train Kilometres (m)	292.5	332	343.3	458.4	47.38
Expenditure ^a	178212	1274454	1964273	5879046	1967383
Infrastructure Expenditure	162229	970845	1091576	3393000	886213
Number of Staff ^b	44086	151323	166761	439551	9746.17
Staff Expenditure ^b	307900	1272773	1285811	2649848	754068
Directors' Remuneration	94.73	393.52	2738.84	16012.27	4832.79
Total Government Support ^c	120125	847000	1054659	3791000	900642
Punctuality ^c (per cent)	76.19	89.33	87.98	93.00	4.16
Trains Cancelled ^c (per cent)	0.74	1.33	1.46	3.20	0.0061
Train Age ^c (years)	15.35	21.14	20.88	23	1.67
Fatality Rate	0.1740	0.7015	0.7480	2.8168	0.4773
Fires on Trains	128	192	212	344	61.78
Train Accidents	863	1207	1176	1501	169.55
Diesel and Steam Rolling Stock (per cent)	30.08	50.05	49.41	76.74	12.71

TABLE II (CONTINUED)

Variable	Min	Median	Mean	Max	St.dev
Electrification (per cent)	9.35	22.35	23.45	32.92	6.71
Investment ^c	449000	939000	1639895	4722000	1285622
Rolling Stock Investment ^c	47000	329000	433632	1923000	432578
Petroleum Consumption (kg per km)	0.0137	0.0278	0.0286	0.0498	0.0144

Notes: All financial items are reported in real terms, £000s. Variables originally reported in miles were converted to kilometres using the factor 1.6093.

(a) Expenditure assigned to the provision of passenger Services only, excludes Infrastructure and Freight.

(b) Staff Numbers and expenditure for 1994 and earlier include all BRB staff, and are not strictly comparable to figures from 1994 onwards, as they only include staff employed in passenger service and infrastructure provision.

(c) Some observations missing

The database includes data for all original 25 passenger franchises, Railtrack, Network Rail, and the British Railways Board (BRB) over 43 years from 1964 until the time the first franchises expired in 2005. After a change in accounting standards in 1983, the years from 1984 correspond to the financial year 1983/1984, or 2004 to the financial year 2003/2004, etceteras. Although the limited number of cross section observations would generally be problematic for estimation, in this particular case the sample represents the entire population of train operating companies in Britain (including non-franchised services like Heathrow Express). The variables in the database and their description can be found in Table III. Firm, industry and franchise characteristics are arranged in groups: (1) production; (2) competition; (3) employment; (4) government support; (5) incentives; (6) quality; (7) safety; and (8) liberalisation.

Table III: DESCRIPTION OF THE VARIABLES

Variable Group	Variable Name	Description
Production	<i>DENS</i>	Output, that is passenger kilometres in 000s, divided by network size in kilometres.
	<i>AC</i>	Operating costs divided by passenger kilometres
	<i>LOAD</i>	Average number of passengers per train
	<i>INV</i>	Investment in track, renewals, new routes and electrification, signalling, buildings, plants and equipment (expenditure on fixed assets, excluding depreciation).

TABLE III (CONTINUED)

Variable Group	Variable Name	Description
Competition		
	<i>FRAN</i>	Number of franchises in year t .
	<i>COMP</i>	Number of companies in the industry in year t (i.e. franchise holders) divided by <i>FRAN</i> .
Employment		
	<i>STAFF</i>	Number of staff employed.
	<i>WAGES</i>	Annual wages and salaries.
Government		
	<i>GRANT</i>	Franchise grants.
Support		
	<i>SUB</i>	Subsidy payments (= grants) in 000s by central Government and PTEs, from 1974 under the PSO; does not include other grants.
Incentives		
	<i>PAYDIR</i>	Remuneration of Directors.
Quality		
	<i>AGE</i>	Average train age.
	<i>PERF</i>	Number of services delayed by more than 5 or 10 minutes.
	<i>CANCEL</i>	Number of services. cancelled
	<i>ELECTRIC</i>	State of electrification of the network.
	<i>ENERGY</i>	Petroleum dependence, measured as consumption in gramm per passenger kilometre.
Safety		

TABLE III (CONTINUED)

Variable Group	Variable Name	Description
	<i>FATAL</i>	Fatalities per train kilometre (excluding trespasses classified as suicides).
	<i>ACCIDENTS</i>	Number of train accidents per train kilometre (includes fires, excludes broken windscreens).
	<i>FIRE</i>	Number of accidents caused by outbreak of fires on trains.
Liberalisation		
	<i>LIB</i>	Dummy variable equal to 1 from 1994 onwards, 0 otherwise.
	<i>LIBDYN</i>	Dynamic liberalisation effects.

Notes: All variables, unless otherwise stated are reported in real terms.

Financial data for two train operators are reported for calendar years, and had to be transformed into financial years (by summation and dividing by 2). Wages and salaries reported for train operating companies in their early years of existence partially included costs for pensions and social security. However, this was not considered to be a major problem, since in the first few years these costs were negligible. Some values for *PERF* and *CANCEL* were missing, and had to be filled using statistical interpolation (this concerns solely BRB years). During the period of privatisation (1994-1997), the introduction of Railtrack and the separation of BR meant that the

transferral of assets, staff, or tasks most certainly led to measurement errors in reported figures. Similarly, the train operators did not come into existence at exactly the same time rendering the pooled financial data less reliable for this period. For the variable *ACCIDENT* train incidents caused by broken windscreens had to be excluded as those figures were only required to be reported after 1995. Eurostar (i.e. the trains operating in the tunnel between Great Britain and continental Europe) was excluded from the analysis because it was not part of the franchise scheme, and because of the special nature of its operations.

(ii) *Descriptive Statistics*

The time series variation of different output measures (in million kilometres) for passengers and freight transport can be traced in Figure I. The large rise in passenger numbers and average journey length from the mid 1990s until 2005 did not materialise in higher modal shares, which have remained stagnant at six per cent.⁵ Over the length of the entire sample, changes in mobility patterns are well reflected, so that, for example, in 1964 the share of rail in overall passenger transport was eleven per cent. In light of stagnant modal shares, the increase in passenger kilometres and train kilometres in the post-British Rail regime may well be attributed to an increase in total mobility. This increase in mobility was accompanied by an increase in total investment, including track, renewals, new routes and electrification, signalling, buildings, plants and equipment, as-well as rolling stock investment.⁶

⁵Source: Transport Statistics UK, 2006 edition.

⁶For investment comparable figures are only available from 1986 onwards.

Figure I: OUTPUT MEASURES AND INVESTMENT

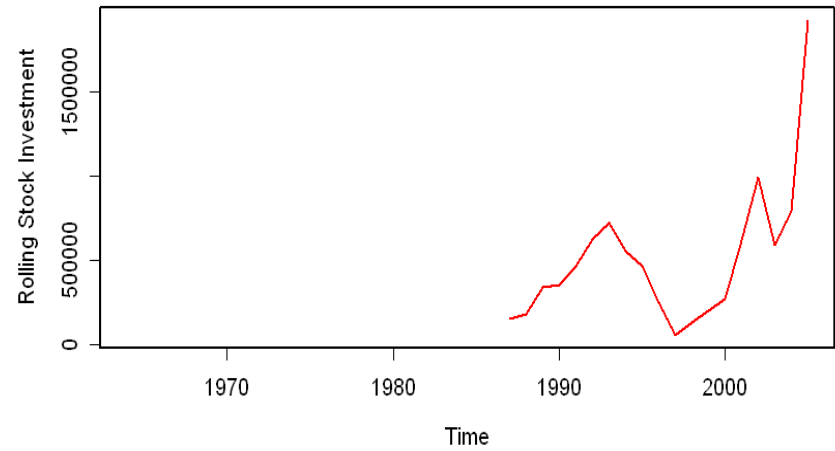
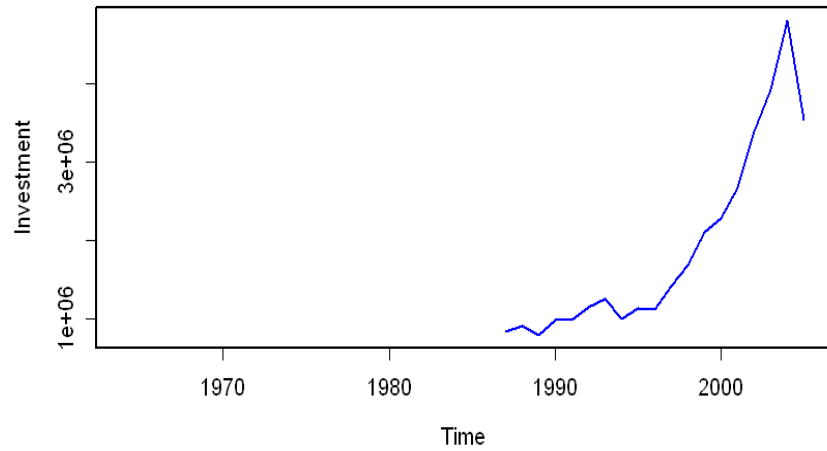
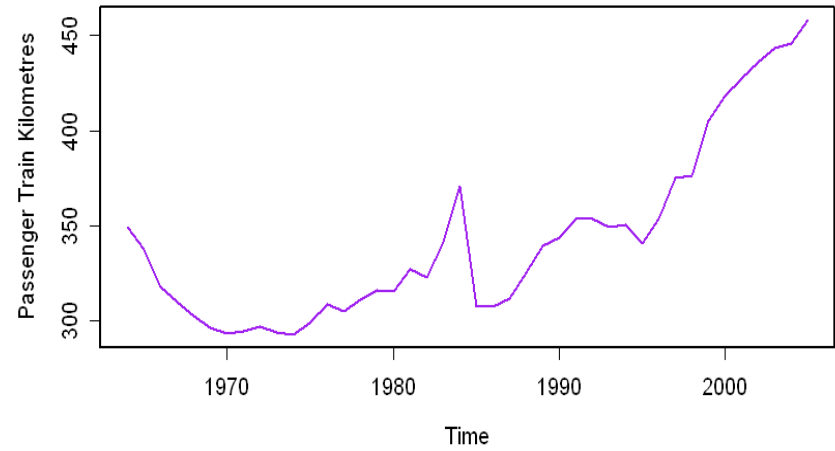
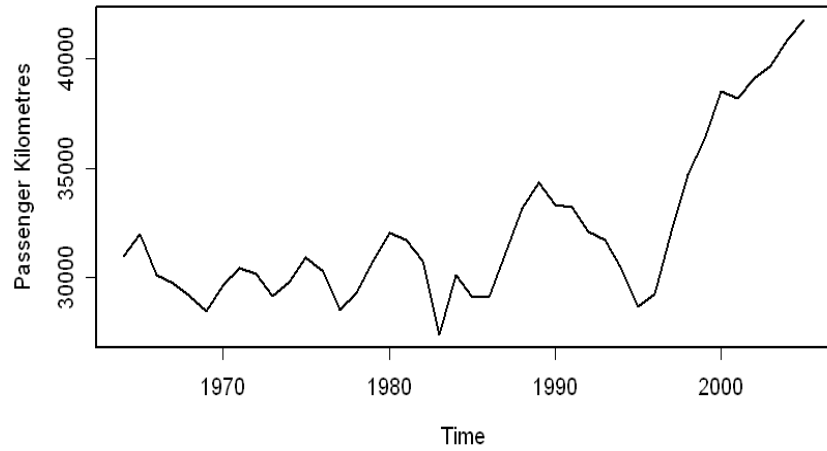


Figure II: ECONOMIES OF DENSITY

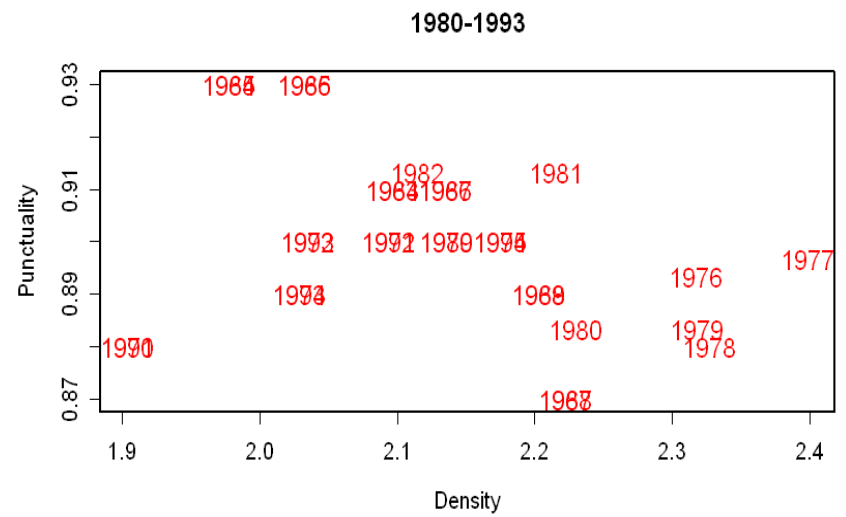
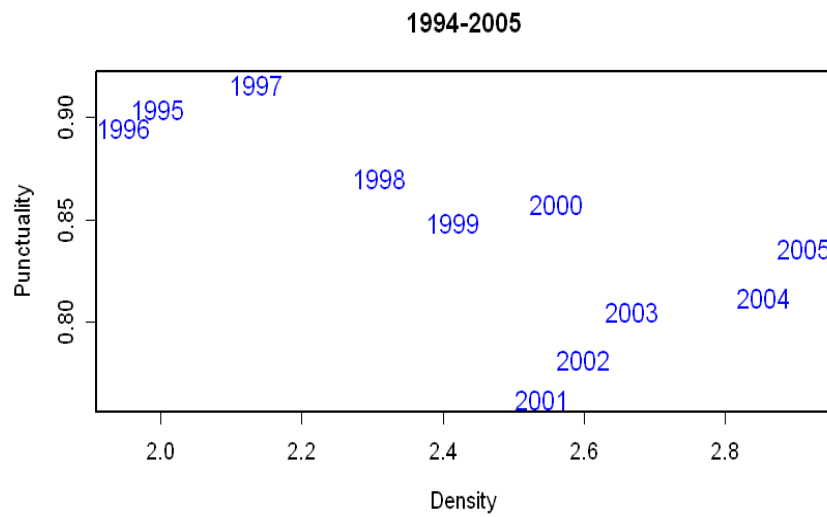
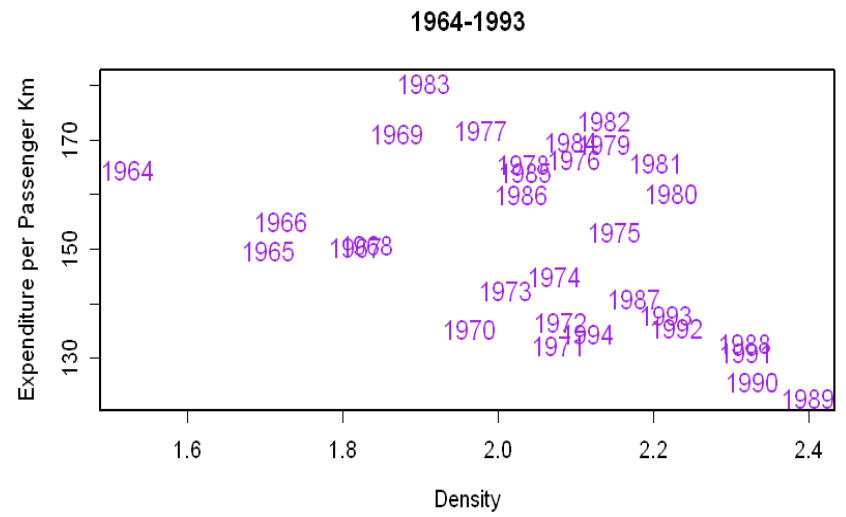
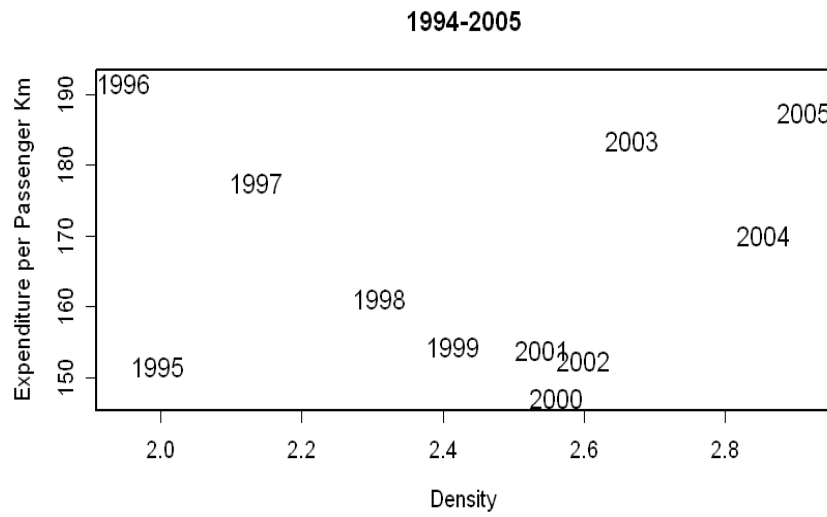


Figure II attempts to look at economies of density from different perspectives. In the first row, average costs are plotted against density that is output divided by network size. Typically, one would expect that average costs decrease as the network is utilised more fully, exploiting economies of scale. Such a relationship can loosely be observed, however, there will be a range of other factors influencing average costs.

Figure II also includes a scatter plot with punctuality and density. One could also argue that should a network get so dense that congestion becomes a major issue, punctuality will suffer. Again, a clear linear relationship is difficult to see, in particular, considering the small size of the sample. Interesting to note is the relatively bad punctuality record between 2001 and 2003. Some of this performance decrease can be connected to two fatal rail accidents and subsequent speed restrictions applied to the network.

Table IV summarises some key non-financial indicators during different phases of British rail history. As outlined in the previous section, the first major post-war changes to the network took place in the 1980s, so 1982-1992 could be labelled the contraction phase. The period of 1993 to 1997 can be seen as the restructuring phase, whereas the last period of the sample can be viewed as the liberalisation regime. It is clear that the network and number of stations have continuously decreased, except for the liberalisation period, which records an increase in arithmetic means. A similar effect can be observed for passenger kilometres. The one variable, which shows a continuous rise is electrification. Staff numbers similarly are an important figure of interest, however, because of a lack of detailed staff figures in British Rail records the early numbers are not comparable with the liberalisation figures. Nevertheless, staff numbers have continuously decreased between 1964 and 1993. Moreover, it is

Table IV: ARITHMETIC MEANS OF KEY NON-FINANCIAL INDICATORS

Variable	1964-1982	1982-1992	1993-1997	1998-2005
Staff Numbers	254290.29	137317.43	113533.67	70674.57
Passenger Km	29928.25	31916.04	30698.2	38310
Stations	2678.81	2433.29	2488.5	2504.4
Network Size	15338.72	14320.96	14350.13	14865.89
Station Spacing	0.1746	0.1699	0.1734	0.1685
Electrification	0.18	0.26	0.30	0.35

Network Size is reported in kilometres. Electrification is calculated as route kilometres electrified over route kilometres open to passenger traffic. Also note that staff numbers are not strictly comparable

quite impressive that at one time over a quarter of a million people were employed at British Rail.

A standard correlation matrix for selected variables is presented in Table V. The competition indicator shows a negative correlation with total costs and infrastructure costs. Punctuality and total costs are similarly negatively correlated, which might not be what one would expect, since an increase in operating costs should increase quality rather than decrease it. On the other hand, one could argue that an increase in punctuality implies less congestion, which in turn could lower operating expenditure. Regardless of these arguments, simple correlations or trends cannot take into account other factors influencing quality and costs. Therefore, the next chapter will attempt to follow a more thorough approach.

Table V: CORRELATION MATRIX OF SELECTED VARIABLES

Variables	Station Spacing	Punctuality	Electrification	Infrastructure Costs	Total Costs	Competition	Density
Station Spacing	1.00	0.18	-0.66	0.37	0.02	-0.41	-0.45
Punctuality	0.18	1.00	-0.56	-0.46	-0.66	0.13	-0.78
Electrification	-0.66	-0.56	1.00	0.04	0.42	0.27	0.62
Infrastructure Costs	0.37	-0.46	0.04	1.00	0.89	-0.39	0.47
Total Costs	0.02	-0.66	0.42	0.89	1.00	-0.22	0.70
Competition	-0.41	0.13	0.27	-0.39	-0.22	1.00	-0.17
Density	-0.45	-0.78	0.62	0.47	0.70	-0.17	1.00

(iii) Methodology

As outlined in Section II of this chapter, a number of variables have to be considered when estimating railways costs. When looking at the effects of deregulation, there are additional variables of interest, as cost per unit of output may also be interpreted as a measure of cost efficiency. In the framework set out in Section II, the most important factors to be accounted for are scale economies, heterogeneity in quality, network size, and density. Further, as the sample spans over 40 years, technological changes should also be considered.

Ideally, one may wish to estimate a translog-cost function using a panel, yet data are not available in a form suitable for estimating this type of cost function. Therefore, a more traditional approach seems a viable alternative. For the post-privatisation regime firm data are pooled to create an artificially integrated operator. Thus, cost efficiency, measured as average costs, can be modelled for the entire industry over the 40 year period.

Relying on both, previous empirical models and theories on the economy of railroads, the model is estimated as

$$\ln AC_t = \beta_1 DENS_t + \beta_2 COMP_t + \beta_3 LIB + \beta_4 LIBDYN + \beta Q_t + \varepsilon_t, \quad (\text{III.1})$$

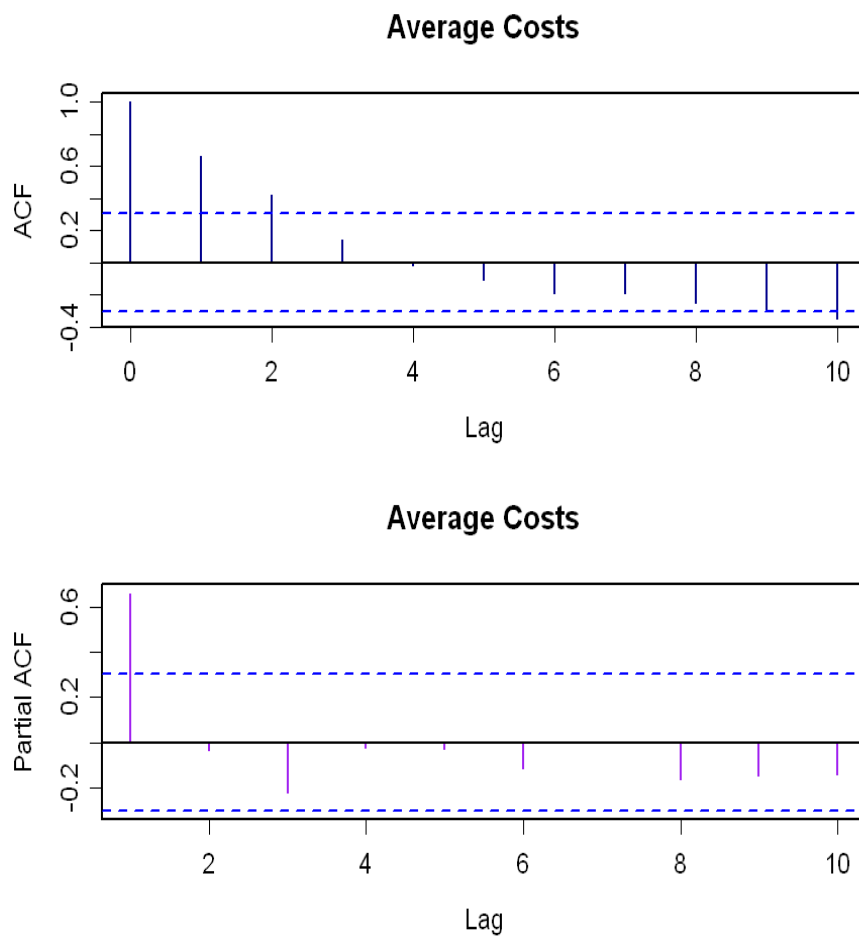
where the dependent variable, AC_t , is operating expenditure divided by output. On the right hand side the base specification comprises a constant, time, $COMP_t$, $DENS_t$, LIB , and $LIBDYN$. In addition safety, performance and technology variables are included in Q_t . Although the choice of time, t , as a dependent variable may seem ad-hoc at first, it is quite likely that over a 20 year period one does require at least a proxy for technological change or innovations of some kind.

Before estimating equation III.1, time series properties of the main variables and the explanatory variable are identified using graphical analysis and testing. Figure III shows the autocorrelation and partial autocorrelation functions for the explanatory variable AC_t . This may suggest, since the ACF declines over a number of lags, that the series might be non-stationary. An augmented Dickey-Fuller test confirms that AC_t does, indeed, have a unit root. Therefore, the analysis proceeds using the differenced series only. Figure IV looks at the distribution of the main variables in comparison to the quantiles of the normal distribution. While some of the sample quantiles do line up with the theoretical quantiles, this is clearly not the case for all variables.

Quality, safety, incentive, employment, government support, and performance variables are included in Q_t (see Table III for reference). The inclusion of variables in Q_t is based on formulating a general model and then testing down to obtain the best model. Such an approach is used to at least partially avoid what is referred to as 'data mining' in the literature (Lovell 1983), i.e. models are revised from bottom to top, given evidence already obtained from the data. Especially, the existence of a database with few observations and a relatively large number of variables implies that randomly running regressions may lead to controversial (and not replicable) results. As much as theory is one guide on which decisions about the inclusion of variables, and the structure of the model can be based, testing down from a general model can offer additional advantages. This has been demonstrated to great effect in recent literature (Hendry (2000), Hoover & Perez (1999)).

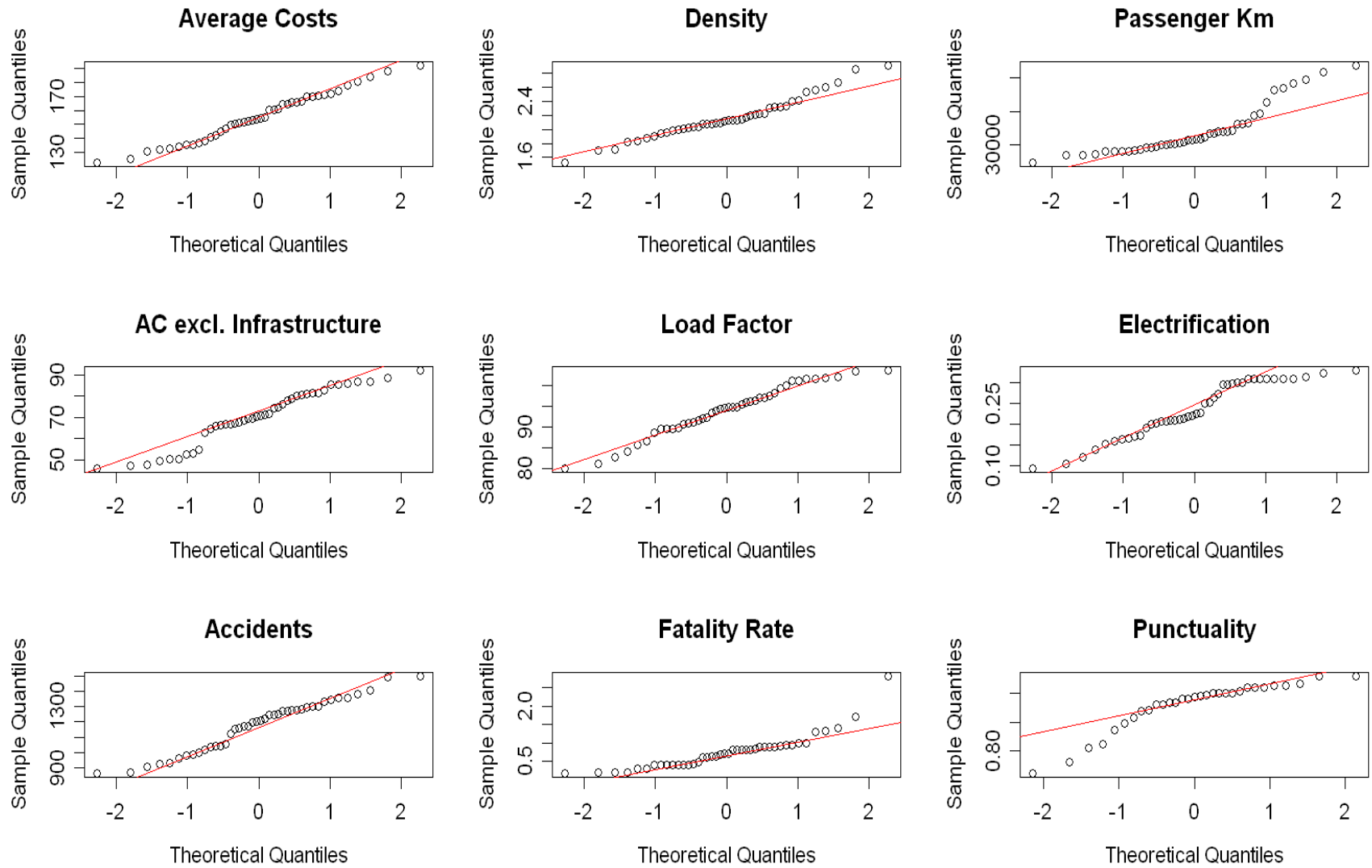
The limited number of observations means that in the general model there is a limit on the lag order that may be included. After estimating and testing a model,

Figure III: AUTOCORRELATION AND PARTIAL AUTOCORRELATION FUNCTIONS



progress analysis reports are evaluated and either the general model is rejected or it is not. The decision on whether to reject the more general model is based on values for log-likelihood, the AIC, BIC and HQ criteria and ultimately on critical values for F-tests for reduction of previously specified models.

Figure IV: QQ-PLOTS OF MAIN VARIABLES



The first step, when searching for the specification of the model, is to exclude variables with a very large p-value (typically 0.8 or higher). Then the next most general model that can feasibly be tested will allow for an autoregressive as well as distributed lags structure for the remaining variables. If applicable further reductions will be attempted by reducing the number of parameters. Ideally, the model, thus eventually selected, additionally meets the requirement of performing well in diagnostic tests and of being consistent with economic theory.

In addition the paper follows a Bayesian approach to model selection, a technique often referred to as Bayesian model averaging (BMA)⁷. One advantage of BMA is that model uncertainty can be accounted for in the analysis. On the other hand, certain care is needed because one central assumption of the BMA method is that one of the models is actually the correct one.

Given a variable of interest, in this particular case, AC_t , and the data, D , there are usually a number of feasible models, M_1, \dots, M_k , which could be used to analyse AC_t . Even if the uncertainty is restricted to the possible explanatory variables, the number of potential models quickly reaches millions.⁸

In BMA, based on the law of total probability, the posterior distribution of AC_t , is given by

$$\mathbb{P}(AC_t|D) = \sum_{k=1}^K \mathbb{P}(AC_t|M_k, D)\mathbb{P}(M_k|D), \quad (\text{III.2})$$

where $\mathbb{P}(AC_t|M_k, D)$ is the posterior distribution of AC_t given the model M_k , and $\mathbb{P}(M_k|D)$ is the posterior probability that M_k is the correct model, given that one of the models considered is correct. The posterior probability or the weight of a model, k , can be derived as

⁷For an excellent exposition of Bayesian econometrics see Geweke (2005).

⁸One famous article drawing attention to this problem is Sala-i-Martin (1997).

$$\mathbb{P}(M_k|D) = \frac{\mathbb{P}(D|M_k)\mathbb{P}(M_k)}{\sum_{l=1}^K \mathbb{P}(D|M_l)\mathbb{P}(M_l)}. \quad (\text{III.3})$$

The marginal likelihood of model M_k , $\mathbb{P}(D|M_k)$ is then given as

$$\mathbb{P}(D|M_k) = \int \mathbb{P}(D|\theta_k, M_k)\mathbb{P}(\theta_k|M_k)d\theta_k, \quad (\text{III.4})$$

where θ_k is the vector of parameters of model M_k . Equation III.2 can also be used to obtain the posterior mean of a regression parameter, β , comparable to a point-estimator,

$$\mathbb{P}(\beta|D) = \sum \tilde{\beta}^k \mathbb{P}(M_k|D), \quad (\text{III.5})$$

where $\tilde{\beta}^k$ is the posterior mean of β under model M_k . Similarly, an expression for the model-averaged standard error can be obtained. It can be shown that BMA offers advantages, most of all more reliable (and reproducible) results compared to other selection methods (Raftery, Madigan & Hoeting 1997, Hoeting, Madigan, Raftery & Volinsky 1999).

Until recently computation of a Bayesian model averaging procedure posed difficulties, in particular, as it involves the solution of the high-dimensional integral $\mathbb{P}(D|M_k)$. However, Raftery et al. (1997) provide a solution, which is especially useful for linear models. For estimation this paper relies on the statistics software R⁹ and its package BMA in Version 3.12 (Raftery, Painter & Volinsky 2005).

Another issue to consider in this particular econometric model are structural breaks. It could be argued that by assumption, the restructuring and privatisation of British Rail constitute a structural break in the data set. The advantage is that it

⁹www.r-project.org

is actually possible to test for this break using testing procedures such as the Chow test.

IV Results

(i) Discussion

The results from time series estimation and Bayesian estimation are presented in Table VI. Columns (1) and (2) report results applying the selected model to the full sample and the quality sub-sample respectively. Columns (3) and (4) report results for the Bayesian model averaging process, as found by the technique described in the previous section. Columns $Pr(3)$ and $Pr(4)$ show the posterior probability (in per cent) that the variable is in the model. Figure V graphically shows which variables have been selected for the 33 models over the entire sample, whereas Figure VI delivers the same output for the sub-sample where quality data were available.

The results suggest that while liberalisation initially led to higher cost efficiency in the British rail industry, developments since then have had a negative effect. Analysis of the first-differenced OLS estimation as presented in columns (1) and (2) suggest that the variables from the base specification, *DENS*, *LIB*, *COMP*, and *LIBDYN* are all statistically significant and of the expected sign. Safety and quality parameters such as *ACCIDENT* or *FATAL*, on the other hand, do not appear to have a measurable impact.

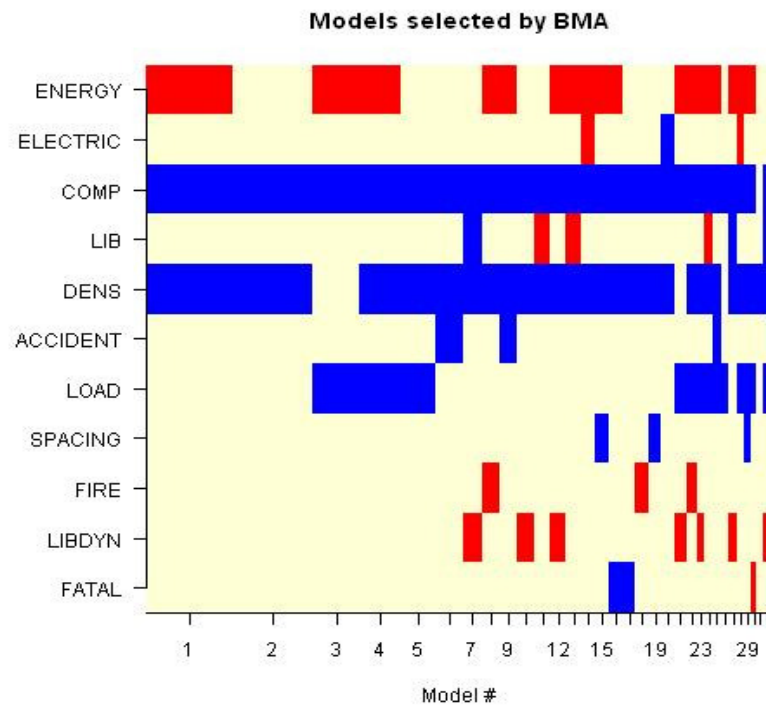
For economies of density, *DENS* columns (1) and (2) in Table VI indicate that an increase in density by 16,000 million passengers kilometers on a given network size would decrease average costs by around 0.5%. A similar magnitude of cost reduction

Table VI: ESTIMATION RESULTS FOR COST EFFICIENCY

Explanatory Variable	(1)	(2)	<i>Pr</i> (3)	(3)	<i>Pr</i> (4)	(4)
<i>DENS</i>	-0.0054* (-4.62)	-0.0044* (-4.14)	89.3	-0.0034* (0.002)	94.4	-0.0028* (0.001)
<i>LIB</i>	-110.00* (-2.35)	-124.40* (-3.35)	12.4	-5.3920 (24.9)	41.0	-33.093 (52.65)
<i>COMP</i>	-0.0049* (-2.38)	-0.0053* (-3.37)	99.0	-0.0063* (0.002)	100.0	-0.0060* (0.002)
<i>FATAL</i>	-0.0038 (-0.19)	0.0382 (1.35)	5.3	-0.0002 (0.004)	15.7	0.0050 (0.02)
<i>FIRE</i>	0.0002 (0.45)	0.0000 (0.05)	6.7	0.0000 (0.00)	3.9	0.0000 (0.00)
<i>LIBDYN</i>	0.0552* (2.35)	0.0624* (3.35)	14.3	0.0027 (0.01)	41.8	0.0166 (0.03)
<i>ELECTRIC</i>	1.1237 (0.89)		5.4	0.0133 (0.39)	6.3	0.0467 (0.48)
<i>PUNCTUAL</i>		0.6588 (1.79)			32.5	0.1715 (0.33)
<i>CANCEL</i>					5.3	-0.0043 (0.39)
<i>ENERGY</i>		0.1464* (2.44)	56.9	0.7828* (0.087)	100.0	0.1860* (0.065)
<i>ACCIDENT</i>			9.3	0.0000 (0.00)	4.0	0.0000 (0.00)
<i>LOAD</i>			32.4	-0.0018 (0.003)	17.2	-0.0005 (0.002)
<i>SPACING</i>			5.3	-0.0010 (0.02)	22.9	0.0450 (0.11)
\bar{R}^2	0.38643	0.6349				
Observations	42	32		42		32

Asterisk denotes statistical significance at common levels of significance. For columns (1) and (2) the values of the t-statistic are reported in parenthesis. For columns (3) and (4) rounded BMA standard errors are reported in parenthesis. \bar{R}^2 is the adjusted R^2 . The dependent variable in all models is the first differenced natural logarithm of cost per unit of output.

Figure V: BMA MODEL SELECTION OVER ENTIRE SAMPLE



can be achieved by increasing the number of effective competitors, as measured by *COMP*. *ENERGY* was only retained in the quality sub-sample as outlined in the discussion of methodology described in the previous section. It would suggest that in this sub-sample a one gramm/passenger kilometre reduction of petroleum dependence led to a 14% decrease in average costs. While this effect is large it should be noted that *ENERGY* very likely proxies for a variety of technological changes which have occurred over the 40-year period.

In the quality sub-sample, the percentage of trains arriving within 10 minutes of schedule, i.e. *PUNCTUAL*, is statistically significant at the 10 per cent level. This would suggest that increases in punctuality are indeed costly to the system. The regression also shows a much higher adjusted R^2 , however, this should be taken as a sign of the small number of observations rather than the increased fit of the model. It is, however, reassuring that the statistically significant explanatory variables in (1) do not change considerably in magnitude when restricting the sample size as in (2).

The posterior means and standard errors from BMA can be found in columns (3) and (4) of Table VI. First of all it is interesting to note that *DENS*, *COMP*, and *ENERGY* have very high posterior probabilities of being in the model. This can be inferred from columns Pr (3) and Pr (4), as-well as Figures V and VI. For the quality sub-sample BMA selects *COMP* for every possible model. The resulting posterior mean suggests that an 0.6% cost reduction can be achieved by increasing the number of effective competitors, *COMP* by one unit. Although the posterior mean of *DENS* is smaller than the point estimate provided in (1) and (2) economies of density is statistically significant and of the expected sign.

BMA also delivers results with concern to the liberalisation indicators, *LIB* and

LIBDYN. Even though the sign of the coefficients remains the same, the magnitude of the estimated coefficients decreases while the posterior standard error is high. Figures V and VI evidently show that *LIB* and *LIBDYN* were only included in a limited number of models. The weights in the BMA will, thus, result in low posterior means and high posterior standard errors.

In the quality sub-sample (from 1973 onwards) BMA posterior probabilities for quality indicators *PUNCTUAL* and *CANCEL* are 32.5% and 5.3% respectively. Although the coefficient on *PUNCTUAL* is positive, level the null hypothesis of the coefficient being zero cannot be rejected. All safety indicators such as fatality rate, *FATAL*, accident rate, *ACCIDENT*, or the number of fires on trains, *FIRE*, are similarly not statistically significant. It is also interesting to note that *ENERGY* and *COMP* were selected in all models.

The variables, *ACCIDENT*, *LOAD*, and *SPACING*, which were dropped from OLS estimation in the procedure outlined in the previous section, also show low selection probabilities and high standard errors in BMA. One notable difference between OLS and BMA results is that for the “best” models, BMA selected no more than 5 parameters, suggesting that there is a high payoff from overparameterisation. Secondly, the fact that *LIB* and *LIBDYN* were statistically significant in the OLS regression, but not in the BMA procedure, may be related to some natural tendency of the researcher to focus on variables of great interest. On the other hand, the coefficients on both parameters are of similar magnitude in the individual BMA models, but are eventually averaged out. Considering some short-comings of BMA modelling, one may not choose to discard the results of traditional OLS estimation.

To obtain an even better idea of the development of the British rail industry,

one may want to link these results from econometric estimation to some key figures not in the procedure. One could argue that although initially reforms successfully increased cost efficiency, the liberalised regime deteriorated from 1997 onwards. Most of the quality indicators do not seem to have an impact on average costs. Therefore, naturally, some questions remain with regard to the cause of deterioration of cost efficiency. It has often been suggested that over-regulation and speed restrictions after fatal accidents at Ladbroke Grove (1999), Hatfield (2000), and Potter's Bar (2002) led to high costs and a decrease in efficiency. Seeing as neither a change in punctuality, nor accident, or fatality rates have an effect on cost efficiency, this argument is difficult to support in light of the previous analysis.

On the one hand, one could argue that causality cannot be easily established in econometric analysis. Keeping this in mind, however, one may, nevertheless, look further. Data on train age were collected from 1985 onwards (and thus could not be included in the analysis without dramatically decreasing the number of observations), shows that while average train age remained roughly constant at around 20-22 years, it decreased rapidly to 15 years in the last few years of the sample. This dramatic change in quality could at least partially account for the deterioration of cost efficiency as it represents a shift in quality.

Secondly, vertical economies or transactions costs may have had an economically significant impact of efficiency because divestiture may, for example increase the cost of making a coordinated timetable. Again, this is difficult to establish in an econometric model, yet one could draw attention to one interesting variable in this context, *PAYDIR* or director's remuneration, as described in Table III. Again, while the salaries of directors and board members of the monopolist British Rail remained roughly

the same (in real terms) from 1964 onwards, restructuring into many different companies implied on average a 10-fold increase in executive pay. While this is at best viewed as circumstantial evidence, it highlights the fact that divestiture does introduce new costs to an industry. As such, it is crucial that other simultaneous reforms such as deregulation or the introduction of competition, which as the analysis shows can improve cost efficiency, are carried out.

Scope for discussion is delivered by the long-time downward trend in unit costs prior to privatisation, which could be also interpreted as ongoing restructuring measures. Empirical studies (see Megginson & Netter (2001) for an overview) have shown that efficiency gains for (formerly) publicly owned enterprises can be observed in the run up to privatisation as-well as afterwards. Indeed, it is not the case that the British Railways Board was surprised in 1994, realizing that they were, unexpectedly, about to be turned into 105 privately owned companies. On the other hand, the railroad industry was one of the last big industries in Great Britain to be privatised and liberalised, a move that was not yet openly discussed in 1984. Moreover, there was a positive signal when, contrary to expectations prevailing at the time, the electrification of the East Coast Mainline was carried out under the government of Margaret Thatcher. Debates about the restructuring of BR only started around 1989 and although a decision came about in late 1992, most questions about the exact industry structure were still unanswered. Therefore, it is likely that the downward trend also captures another effect like technological change rather than simply highlighting the effect of prior restructuring measures.

Table VII: SELECTED DIAGNOSTIC TEST

Test-statistic	(1)	(2)
Durbin-Watson	0.9167	0.5198
Shapiro-Wilk	0.1627	0.7258
Goldfeldt-Quandt	0.8167	0.4595
Harrison-McCabe	0.7770	0.3660
Box-Ljung	0.4159	0.1069

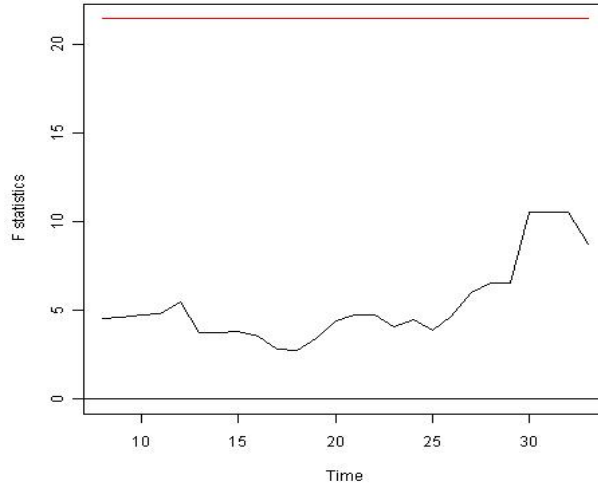
Reported values are p-values.

(ii) Model Diagnostics

Figure VII reports the results of the diagnostic tests on the econometric model and residuals. Goldfeldt-Quant and Harrison-McCabe are testing procedures to determine heteroscedasticity, Shapiro-Wilk tests independence, while the Durbin-Watson test statistic looks at autocorrelation, and Box-Ljung at the normality of residuals. The null hypotheses are no autocorrelation, homoscedasticity, independence, and normality respectively. As the reported p-values confirm, the residuals are normally distributed and well behaved. Moreover, the assumptions of constant variance and no autocorrelation are not violated. All diagnostic tests are performed on the full, (1), and the sub-sample, (2).

With a model as presented above, one concern is related to structural change. In a linear model with a single break point, t_{br} in a sample $t = 1, \dots, T$, this amounts to testing the null hypothesis of structural stability, versus the alternative,

Figure VII: F-TEST FOR STRUCTURAL STABILITY OVER TIME



$$\beta_i = \beta_A \quad (0 < t < t_{br}) \quad (\text{IV.1})$$

$$= \beta_B \quad (t > t_{br}). \quad (\text{IV.2})$$

The Chow test proceeds to fit regressions on the two sub-samples separated by the break point and rejects the null hypothesis of structural stability, if

$$F = \frac{RSS - ESS}{ESS(t - 2k)}, \quad (\text{IV.3})$$

is above the critical value (Chow 1960). RSS denotes the restricted sum of squares from the break-point sub-sample, whereas ESS denotes the sum of squares from the entire sample. Rather than relying on having to guess a particular break point, computing routines make it possible to calculate this F-statistic over the entire sample. Resulting F-values are plotted in Figure VII, with the red line representing the critical values at the 5% level of significance. As is evident from the graph, the hypothesis of structural stability cannot be rejected for any possible break point.

V Conclusion

Setting out from a general premise of railway economics this chapter analyses British railway data over a 40 year period. In particular, the chapter tries to investigate whether the divestiture and privatisation of the former state monopolist British Rail led to performance improvements. The British example is of special interest since it is the only European country to implement reforms in such an extensive form.

Statistical and econometric analysis highlights the importance of scale economies, in particular, economies of density. Furthermore, while liberalisation initially led to improvements in cost efficiency, results suggest that performance deteriorated over time. The analysis shows that reductions in average costs can also be achieved by increasing competition or decreasing oil dependency.

It should be noted that a generalisation of these results is difficult. The practical implementation of the post-privatisation structure has often been described as being far from optimal. Yet, the analysis of liberalisation effects in this paper is based on observations from an actual separation experience not an efficient one. Therefore, a dummy variable will act as a fairly crude proxy for and will pick up many different effects. On the other hand, the magnitude of *LIB* and *LIBDYN* suggests that restructuring and privatisation did matter in this particular case.

Apart from financial performance, quality is often a key variable of interest after liberalisation. For railways quality can, for example, be measured in terms of punctuality, station spacing, or train age. While the punctuality record of the different train operators is indeed mixed, train age has decreased significantly since privatisation. Of course, the remaining uncertainty is, whether 15-year-old trains offer advantages over older trains. In addition, simultaneous to privatisation efforts,

significant expansion has taken place as measured in network size, the number of stations, and passenger kilometres. Interestingly, there is a negative correlation between density and punctuality, suggesting that the increase in passengers hampered quality improvements.

Further, it should be noted that industry-wide risk-aversion after the high-profile accidents at Potter's Bar, Hatfield, and Ladbroke Grove have led to a quite dramatic increase in costs (especially for the infrastructure manager). Thus, it could be concluded, that even though vertical economies do matter, it is possible that careful industry design in combination with the stimulation of competition imply higher cost efficiency for a vertically separated railway industry rather than an integrated monopolist. Competition, as this paper shows, could be the essential tool in this context. Consequently, a careful reconsideration of the franchising process and the number of franchises should be a priority on the policy agenda. Especially the ongoing reduction of the number of franchises seems questionable in the light of this study.

A further general policy direction, suggested by the results, is the serious consideration of the option of local integrated monopolies that compete through franchise bidding may be a suitable alternative to a separate infrastructure manager. Noting the structure of the rail industry in Great Britain today, one cannot deny that considerable concentration is already in place. Most of the franchises are owned by three major players, who in turn mostly operate in related transport industries (bus operators, sea freight). It would be unrealistic to expect that a bus and rail operator owned (or "franchised") by the same parent company will compete with itself any more than British Rail fostered yardstick competition between its Intercity and Regional segments. One should keep in mind in this context that externalities arising

from road congestion, noise, and environmental pollution are of such magnitude that they should not simply be used to justify subsidies for railways, but more importantly a well-designed regulatory structure and thought-through franchising mechanism.

Chapter 3

Reforming Utilities: The Empirics of Performance, Ownership and Liberalisation

In this chapter I analyse the impact of market reform in a sample of over 2000 state-owned and privately owned utilities around the world between 1996 and 2006. Using OECD data, the paper differentiates between ownership effects and liberalisation effects. A range of performance measures are used to establish that market reform and private ownership do have a statistically and economically significant impact on firm performance and profitability. The chapter establishes the need of further research to look at particular reforms and merges empirical results with theoretical models.

I Introduction

Whereas privatisation and ownership studies (Megginson et al. 1994, Dewenter & Malatesta 1997, D'Souza & Megginson 1999, Dewenter & Malatesta 2001, Megginson et al. 2004, D'Souza et al. 2007) document efficiency improvements, the reasons for

achieving these improvements have not yet been firmly established in empirical work. In particular, there is some concern that these large scale studies do not sufficiently disentangle pure ownership effects from other factors, such as competition and market reform. For utilities and infrastructure, these other possible determinants of firm performance may be especially pronounced, considering many countries' drives towards deregulation and liberalisation.

The privatisation of utilities typically does not only involve the transfer of ownership shares but in many cases far-reaching market reforms. In the case of telecommunications, electric utilities, postal services, water, and transport, ownership changes are accompanied by deregulation, restructuring, divestiture and liberalisation. Typically traditional privatisation studies do not account for these different factors (for a survey see, for example, Megginson & Netter (2001)). When looking at efficiency it is, however, important to distinguish the impact of deregulation or changes in competitive forces from ownership effects. Otherwise, if we postulate that deregulation or competition have a positive influence on performance, the effect of ownership changes is likely to be overestimated.

While industry or country studies are much better able to, and in general do, account for market reform and liberalisation, such approaches have the drawback of being confined to one particular place or industry and as such offer less scope for generalisation. Therefore, the research in this chapter sets out to model firm performance on ownership and liberalisation across infrastructure sectors and across countries. To do so the OECDs regulation indicators are combined with financial firm level data. Apart from the most general question of whether regulatory reform "worked" the paper also tries to distinguish between different performance measures. It is, for

example, likely that market reform led to a decrease in profitability, while improving investment performance, and private ownership fostered increases in profitability.

Two central issues in the corporate governance literature are the identity of owners and the concentration of ownership (see, for example, Shleifer & Vishny (1997) or Mueller (2003) for excellent overviews). Chapter 1 points out that the governance mechanism, when the (major) shareholder of a firm is the government, is very different from other ownership structures. With state ownership, the providers of finance, i.e. the taxpayers, have no direct control over the managers of the firm, nor do they receive any direct repatriation of profits. In turn, it could of course be argued, that the need for taxpayer financing is related to the profitability and efficiency of the firm. Some infrastructure industries, such as railways in Europe, require subsidies (as a percentage of GDP, quite sizeable subsidies) to break even, let alone make profits. On the other hand, state shareholdings tend to be relatively large, therefore, reducing potential agency costs by being able to control managers (better).

While governments may pursue concentrated shareholdings to put pressure on managers, thereby reducing the agency problem between managers and the government-owner, the agency problems between politicians and taxpayers persist. In this sense, contrary to theories on ownership concentration, large government shareholdings may increase agency costs because of increased political pressure on the firm. Similarly, unlike other large institutional shareholders, like banks, governments do not necessarily follow the goal of maximising the returns on investment.

Yet ownership structure is not the only factor influencing performance, recent evidence on investment performance suggests that institutions and legal systems outweigh the effects of ownership structure (Gugler, Mueller & Yurtoglu 2004). With

regard to state ownership, the results presented by Gugler et al. (2004) are somewhat conflicting, with state owned (i.e. with state shareholdings of 10 per cent or more) enterprises performing well in all country groups except for the European-Germanic legal system countries. In French-origin and Asian-German origin countries state owned companies even outperform other ownership types.

Studies on corporate governance and performance attempt to allow for regulation and/or competition in some form. To account for competition D'Souza et al. (2007) use a dummy variable for regulated utilities (telecom, electric, gas, water) which is problematic, as, for example, mobile operations in telecommunications in many countries are no longer regulated, and, moreover, competition is present in at least some of these industries (via competitive bidding or otherwise). The OECD indicator variables account for direct or indirect competition, for example, instances where concessions are awarded, based on some form of bidding process.

In an industry-study Ros (1999) on telecommunications between 1986 and 1995, private ownership is associated with network expansion, whereas competition has a positive effect on efficiency (main lines per employee). Researching a sample of Spanish firms, Villalonga (2000) finds no significant efficiency effect, with privatisation leading both to increases and decreases in efficiency (in about as many cases). When adjusting the model to include political and organizational variables, these factors turn out to have a significant impact on post-privatisation performance.

There is evidence that ownership is largely responsible for post-privatisation performance improvement. D'Souza et al. (2007) find that there is a positive relationship

between profitability and state ownership, whereas regulation is statistically insignificant when regressed on changes in returns on sales. Privatisation studies often differentiate between utilities and non-infrastructure industries, despite the fact that these often make up a considerable proportion of the entire sample. In N. Boubarki & Guedhami (2005) infrastructure accounts for almost half the sample. A survey of the literature on infrastructure privatisation can be found in Chapter 1.

Section II of this chapter introduces the data set including descriptive statistics. The next part continues with an outline of the econometric considerations and methodology, followed by the presentation of the main results in part IV. Section V offers some conclusions.

II The Data

The data were mainly collected relying on three sources: the 1998 to 2006 versions of *AMADEUS*, Reuters Xtra 3000 and the OECD. Industries were selected on the basis of the North American Industry Classification System (NAICS) 2002. Codes included in the analysis are Utilities (22) including Electric Power, Transmission and Distribution (2211), Natural Gas Distribution (2212), Postal Services (4911), Air Transportation (481), Rail Transportation (482), and Telecommunications (517). Observations with missing financial or employment data were excluded, leaving a total of 2204 firms in the unbalanced panel data sample. The number of firms for each country and sector are given in Table I and Table II.

Table I: DISTRIBUTION OF FIRMS ACROSS COUNTRIES

Country	Number of Firms	Country	Number of Firms
Austria	20	Belgium	78
Czech Republic	62	Denmark	83
Finland	59	France	153
Germany	224	Greece	27
Ireland	22	Italy	203
Netherlands	152	Norway	163
Poland	82	Portugal	11
Spain	233	Sweden	80
Switzerland	63	United Kingdom	489

Table II: DISTRIBUTION OF FIRMS ACROSS INDUSTRIES

Industry	Number of Firms
Electricity (2211)	820
Natural Gas (2212)	162
Airlines (4810, 4811, 4812)	159
Rail (4820, 4821)	190
Post (4910, 4911)	53
Telecom (5151, 5179)	729

Note: NAICS Code in Parenthesis

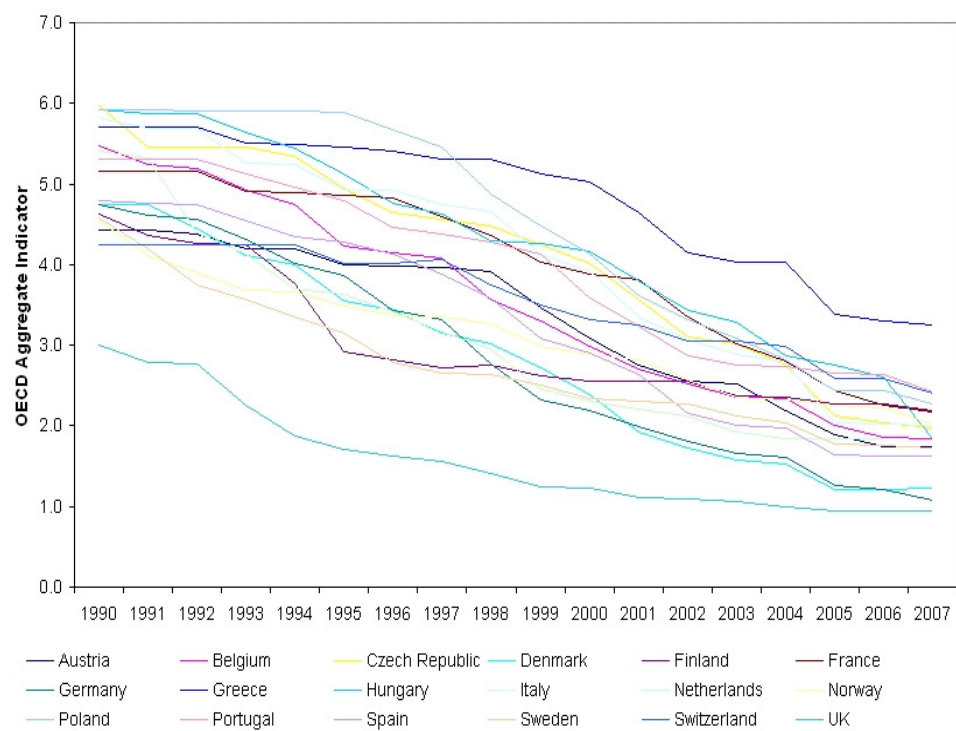
The majority of firms are located in the United Kingdom, Germany, Spain and Italy. The relative (to population) over-representation of UK based firms with a quarter of the sample, could be explained by the deregulation and liberalisation measures taken in the UK. Figure I of the aggregated regulatory OECD indicators between 1990 and 2007 shows that the UK is at the bottom end of the scale. In particular, at the beginning of the firm sample period the UK's aggregate indicator is equal to 1.8 out of 6 and thereby lower than some countries' indicators at the end of the sample period. This documents that regulatory reform in the UK was already well-progressed when most other countries only started their deregulation process. Therefore, the number of firms in the British infrastructure industries may be relatively large, considering that deregulation is often accompanied by vertical and horizontal divestiture of the former state monopolists. In particular, the deregulation of rail, airlines, natural gas and telecommunications created a large number of firms in sectors formerly served by British Rail, British Airways, British Gas and British Telecom.

Similarly, Table II confirms that the number of firms is distributed unevenly across sectors. The electricity and telecommunications sectors are represented heavily in the sample, suggesting that reform has been particularly prominent in those industries. On the other hand, these differences may also be related to technological aspects and historical developments. In electricity, distribution networks and generation were historically organised more locally, whereas airlines and postal services were organised on a national level.

Competition and regulatory indicators for OECD countries are estimated in Conway & Nicoletti (2006) and were revised in 2008¹. For each of the sectors and for each

¹<http://www.oecd.org/eco/pmr>.

Figure I: AGGREGATE OECD INDICATORS OF REGULATORY REFORM IN SAMPLED COUNTRIES, 1990-2007.



country these indicators are a weighted index of regulatory reform, taking into account entry regulation, the degree of vertical integration and market structure. For the purpose of this study, the updated 2008 version is the basis for the competition and ownership variables. The ownership variable is taken directly from the OECD indicators, whereas the liberalisation variable is an average of various competition and regulation indicators. The data span from 1996 to 2006 for Airlines, Rail Transport, Electricity, Natural Gas and Telecommunications and where, thus, matched with the NAICS codes from the firm data panel. A higher indicator always implies a lower degree of liberalisation.

The OECD data are graphically depicted in Figure ?? and Figure II. Deregulation and liberalisation efforts appear to have been considerable, and are particularly pronounced in the period under investigation. In principle, the indicators have been published for the years 1975 onwards but a downward trend for the majority of countries is only apparent from 1990 on. As pointed out above, the United Kingdom forms an exception, with reforms starting earlier than in other countries. However, it is also clear that the aggregated data conceal that the development has not been uniform across industries. Figure II traces the evolution of regulatory reform in selected countries. Railways, and in some cases postal services, have been subjected to deregulation and liberalisation measures to a lesser degree than, for example, electricity and telecommunications. The difference across countries is quite considerable, showing that reform has not been applied consistently.

Financial data, taken from the 2006 version of AMADEUS, include the Return on Assets (ROA), the number of Sales, Profits, the number of Employees, Operating profits, revenues and net incomes between 1996 and 2006. Summary statistics are

Table III: SUMMARY STATISTICS FOR OECD INDICATORS

Statistic	Liberalisation	Ownership
Minimum	0.000	0.00
1st Quantile	0.800	0.00
Median	1.600	2.60
Mean	1.958	2.54
3rd Quantile	2.600	4.50
Maximum	6.000	6.00
Correlation	0.4194	

Note: Maxima equal a high degree of state involvement.

given in Table IV. The sampled firms vary widely in size and profitability. Whereas eleven firms have employment figures above 100,000, over 1,800 firms have less than 1,000 employees. In 2006, eight firms made negative profits, whereas the mean in the same year was given by USD 68,840, making it on average more “profitable” than in preceding years.

Table IV: SUMMARY STATISTICS FOR FINANCIAL VARIABLES

Statistic	Employee	ROA	OpProfit	Sales	Profit	Revenue	NetIncome
Minimum	1	-100.00	-20764000	0	-2.679e+07	0	-31276640
1st Quantile	37	-0.110	-4	13201	-5.875e+01	14716	-25
Median	130	3.850	1747	38134	1.394e+03	42753	734
Mean	2125	3.125	38686	498595	2.817e+04	555146	7064
3rd Quantile	442	9.235	8932	138730	8.166e+03	168759	5103
Maximum	388859	96.790	36840082	185754205	3.375e+07	195054551	19405717

Note: These summary statistics refer to the entire sample. For estimation extreme observations were excluded.

In addition to our key variables of interest, that is financial performance, ownership and competition, a number of additional variables form part of the data set. A dummy variable indicates whether a company is publicly listed. Out of all sampled utilities 458 are quoted on a stockmarket, the majority have alternative corporate governance mechanisms. To account for business cycle effects, aggregated income data are added to the data set. For income data, the source was again the OECD, with Gross Domestic product in USD, constant prices, constant PPPs, reference year 2000 (in millions).

III Econometric Considerations

In the literature two principal methodologies have been adopted when analysing privatisation. Following Megginson et al. (1994) empirical studies have compared pre- and post-privatisation means or medians using statistical analysis. Another strand of the empirical literature has relied on econometric estimation, working under the premise that privatisation can be viewed as an intervention. This paper builds on the latter approach, while adopting it to the requirements set out in the previous sections.

In empirical work on privatisation aspects of firm performance include profitability, efficiency and output. Porta & de Silanes (1999), for example, measure profitability as the ratios operating income to sales, net income to sales, whereas operating efficiency is measured as cost per unit or the sales to employee ratio. Return on assets (ROA) has also been interpreted as an efficiency measure (Villalonga 2000). Additional common measures (Megginson & Netter 2001) of firm performance include sales per employee and the net income to sales ratio.

Finding adequate measures of the variables of interest, i.e. privatisation, regulation, and competition, is not straightforward. For privatisation, one would ideally build on actual ownership data (Gugler et al. 2004) and maybe even distinguish between different types of ownership, such as insider ownership. While this is feasible in small scale studies (Barberis, Boycko, Shleifer & Tsukanova 1996), the quality of ownership data for large samples is more difficult to assess and often privatisation dummies are utilised. In particular, state ownership in many cases does not involve direct (share)holdings but exists indirectly, through holding companies. Large scale data sets with this level of information are inherently difficult to obtain and maintain.

Similarly, with regard to regulation, one may wish to distinguish between different types of regulatory regimes or the intensity of competition. But even in industry studies, a lack of available data makes results on particular reforms less reliable (Asmild et al. 2009). Moreover, differences in regulation in a fairly homogeneous region, such as Europe, are difficult to assess with commonly used indicators distinguishing only between incentive regulation and rate of return regulation.

Therefore, estimation in this chapter with regard to ownership and liberalisation relies, as described in the previous section, on the regulation data set provided by Conway & Nicoletti (2006). Although the use of indices exhibits its own problems, they should offer additional information to ownership dummy variables. Similarly, while a liberalisation index is not as specific as data on regulatory institutions or concentration ratios, the use of panel data in this chapter should allow for an assessment of the impact of market reform over time and across countries and sectors.

Additional controls include a measure of firm size and a dummy for industry effects. Firm size, on the other hand, is proxied by employment levels. Similarly, a

dummy variable for quoted companies is included in all estimated models, as-well as GDP per capita, to implicitly allow for changes in the economic environment of a given country that may have an impact on firm performance.

One of the major advantages of an econometric approach is, that it aims to capture firm-specific time invariant effects. This is crucial as it is very likely that firm performance depends not only on measurable factors, but also unobservable effects such as management skills. Secondly, the time series properties of the sampled data are taken into account when analysing the observations.

The baseline approach adopted in this chapter is to estimate the following model:

$$Y_{it} = X_{it}\beta + D_{cj}\gamma_{cj} + Z_{cit}\delta_{ci} + \eta_i + \epsilon_{it}, \quad (\text{III.1})$$

where Y_{it} measures performance (costs, return, employment) of firm i at time t , X_{jct} is the set of variables of interest (ownership, competition, regulation) in sector j , in country c in each time period t , D_{jc} are sector and country dummies to account for sector-specific and country-specific effects and a set of additional controls, Z_{it} . Further the error is composed of firm-specific unobserved effects, η_i , and transient errors, ϵ_{it} , where the usual assumptions

$$E[\eta_i] = 0, \quad E[\epsilon_{it}] = 0, ; \quad E[\epsilon_{it}\eta_i] = 0, \quad E[\epsilon_{it}\epsilon_{is}] = 0 \quad (\text{III.2})$$

apply.

If the individual effects, η_i , are correlated with the explanatory variables, then applying the OLS estimator to III.1 is inconsistent. To obtain consistent estimates, equation III.1 is transformed to remove η_i , and then apply the OLS estimator. In econometrics this is usually referred to as fixed effects model. If, on the other hand, the time-invariant effects are uncorrelated with the other regressors, then the OLS

estimator will be consistent but inefficient so that GLS procedures are preferable (see discussion in standard textbooks such as Wooldridge (2002)). The important difference between both approaches is the correlation of η_i , so that fixed effects can be seen as the more general model, as it imposes fewer assumptions.

To determine which assumption is correct, or whether the fixed or random effects model should be preferred one can rely on the Hausman test (Hausman 1978). It compares the estimates coefficients, weighted by the variance-covariance matrix of the fixed effects (β_F) and random effects (β_R), that is

$$H = (\beta_F - \beta_R)(Var[\beta_F] - Var[\beta_R])^{-1}(\beta_F - \beta_R). \quad (\text{III.3})$$

Under the null hypothesis both models are consistent, whereas under the alternative hypothesis only the fixed effects estimator is consistent. If the null hypothesis cannot be rejected, then the random effects estimator is efficient, whereas the fixed effects estimator is not, and the former should be selected.

Alternatively, we can estimate a model which includes lagged terms such as

$$Y_{it} = Y_{it-1}\alpha + X_{it}\beta + D_{cj}\gamma_{cj} + Z_{cit}\delta_{ci} + \eta_i + \epsilon_{it}. \quad (\text{III.4})$$

However, in a dynamic panel data model such as III.4 the within-groups estimator will be biased downwards (Nickell 1981), so it may be an alternative to adopt the first-differenced GMM approach, first proposed by Arellano & Bond (1991), as well as the extended system GMM approach (Blundell & Bond 1998). Therefore, it might be useful to also look at GMM results as a reference. As in Chapter 2, estimation is carried out with the statistics software R², using the plm package by Millo & Y (2008), which allows for an unbalanced panel.

²<http://www.r-project.org>

IV The Main Results

First I present the results from the non-dynamic specification and then from the dynamic specification of the above model.

(i) Non-dynamic Estimation

Tables V and VI present results for return on assets (ROA) and sales per employee as the explained variable. Dummy variable estimates are not reported for the sake of brevity. In the random effects models the competition and ownership indicators are statistically significant, whereas in the fixed effects model the estimates are statistically insignificant in the ROA equation.

More interesting of course are the sign and magnitude of the effects. Return on assets, as an albeit imperfect measure of investment efficiency, is the dependent variable in Table V. It should be recalled that the competition and ownership indicators are such that a high value indicates a large degree of state ownership and less competition respectively, whereas low values indicate a liberalised, privatised sector.

The estimated coefficient for competition is negative in both, fixed effects and random effects models. This would indicate that firms in sectors with a higher degree of competition and regulatory reform exhibit a higher ROA ratio. It appears that deregulation measures improve the efficiency of investments made by managers of utilities, so that more net income is generated from total assets. From the random effects model, where the estimate is statistically significant, we can calculate that a one point change in the competition indicator increases ROA by four per cent. Thus,

if we assume that a sector in a particular country started out as a regulated, non-competitive industry, then liberalisation efforts would lead to considerable increases in average firm investment performance.

Private ownership, on the other hand, seems to lower return on assets for firms in the sample. With an estimated coefficient between 0.3 and 0.4 the magnitude of the effect is similar to that of the competition indicator. However, one has to be careful when interpreting the coefficient, in particular in connection with ROA as a dependent variable. One of the drawbacks when using ROA as a measure of firm performance is, that it is a very imperfect measure of efficiency in the sense that it does not show whether firms are able to generate income from a relatively low asset base. In particular, in relation to state owned enterprises it is generally assumed that their budget constraint is soft. So, even if, for example, those companies manage to generate high net income from a very high asset base, it does not mean that the same income could not have been generated from a lower asset base. With soft budget constraints as a result of a high degree of state ownership, it may be the case that large investments were made generating income resulting in a high ROA but not that capital was necessarily applied in the most efficient way.

Results for sales per employee as the dependent variable are presented in Table VI. In both fixed effects and random effects modelling, the estimated coefficients for competition and ownership effects are statistically insignificant. Again, individual effects and dummy coefficients, which were included in the models, are omitted from the report to focus on the main variables of interest.

While results of this model might be termed statistically inconclusive, it is striking is that competition is positive in sign and that in both models the effect of ownership

Table V: RANDOM AND FIXED EFFECTS MODEL FOR RETURN ON ASSETS

	Coefficients	Estimate	t-value	Pr(> t)
<i>Random effects</i>				
	Intercept	-5.934956	-1.252235	0.2105
	<i>ln</i> Employee	-0.260473	-2.061441	0.0393
	Quoted	1.137145	0.728883	0.4661
	Liberalisation	-0.414471	-3.286379	0.0010
	Ownership	0.419327	3.070632	0.0021
	<i>ln</i> GDP	0.674545	1.999951	0.0455
<i>Fixed effects</i>				
	<i>ln</i> Employee	-1.177755	-4.747359	0.0000
	Liberalisation	-0.178640	-1.696476	0.0898
	Ownership	0.304809	1.215195	0.2243
	<i>ln</i> GDP	10.52993	3.023416	0.0025

Notes: Unbalanced panel with $T = 1 - 10$ and $N = 1996$.

The number of observations totals 11029.

P-value for Hausman Test is 0.0000.

is smaller in magnitude, although the estimate of ownership in the fixed effects model is very different when compared to the random effects model. This would imply that sales per employee actually decreases with progressing liberalisation. Considering that this measure is widely used in the privatisation literature the results do appear surprising. The political economy literature, for example, often argues that state ownership may lead to excess employment to attract voters. If this is the case, then we should expect that sales per employee would increase if privatisation measures were taken.

On a second look, these results would turn out to be less contradictory. When competitive measures are introduced into an industry and more firms enter, then clearly given market demand sales per firm must decrease. If this fall in sales is not compensated by equally drastic changes in employment, then the Sales per Employee ratio will as a consequence decrease. Many of the former monopolists in the sample have seen their sales and market shares drop as a consequence of deregulation and liberalisation measures.

Indeed, when analysing this issue with regard to perfect competition, we may even expect that as sectors get more competitive the monopoly mark-up they are able to charge will fall, and as such firm performance, and in particular profitability, will deteriorate. A prime example for this effect could be the airline industry where industry-wide profits have fallen after the introduction of competition (Morrison & Winston 1995). As such, decreases in profitability in infrastructure industries may even be interpreted as a successful reform.

Table VI: RANDOM AND FIXED EFFECTS MODEL FOR SALES PER EMPLOYEE

	Coefficients	Estimate	t-value	Pr(> t)
<i>Random effects</i>				
	Intercept	6.007186	10.06082	0.0000
	<i>ln</i> GDP	0.017020	0.402306	0.6875
	Quoted	0.024447	0.119311	0.9050
	Ownership	-0.024712	-1.202382	0.2293
	Liberalisation	-0.217437	-10.54458	0.0000
<i>Fixed effects</i>				
	Intercept	1.339442	0.158017	0.8744
	<i>ln</i> GDP	0.327405	0.520699	0.6026
	Ownership	-0.027440	-1.324375	0.1854
	Liberalisation	0.029845	1.569270	0.1166

Notes: Unbalanced panel with $T = 1 - 10$ and $N = 1365$.

The number of observations totals 7623.

P-value for Hausman Test is 0.0000.

(ii) *Dynamic Estimation*

Fixed and random effects estimation results are reported in Table VII. They highlight the autoregressive structure of the dependent variable. Generally, the Hausman test suggests that only the fixed effects estimator is consistent, nevertheless both models are reported for comparison's sake.

The ownership and liberalisation indicators in the fixed effects model are both statistically significant at the 10 per cent level. The Hausmann test-statistic would suggest that the fixed effects estimator is consistent for the dynamic ROA model. The sign of the coefficients is the same as in the non-dynamic model.

The results suggest that reforms, such as vertical divestiture or the removal of entry barriers, which decrease the liberalisation indicator by one point, led to an increase in ROA of around 0.2. This can be compared to the sample mean of 3.125.

Table VIII delivers the results for Sales per Employee as specified by equation III.4 earlier. Estimates show that lagged values of the independent variable are highly statistically and economically significant, with a coefficient of around 0.5. The coefficient of *Quoted* is only significant at the 10 per cent level and positive. Again the Hausman test suggests that only the fixed effects estimator is consistent.

As compared to earlier non-dynamic modelling, $\ln GDP$ is no longer statistically significant. Most interesting, both the liberalisation indicator and the ownership indicator are now both highly statistically significant. When compared to the results of estimating *ROA*, one can observe that the sign of the coefficients is reversed.

The liberalisation indicator has a positive coefficient of around 0.07. This would suggest that, after taking into account time and individual effects, as-well as time series properties, more liberalisation, as measured by this indicator, would decrease

sales per employee by seven per cent. Recall, that the reform indicator carries a maximum value of 6, which corresponds to industries with complete vertical integration or significant market entry barriers.

The results for sales per employee, as a measure of output efficiency, are also reported in Table VIII. In this case the second lag of the explanatory variable is statistically significant at the 5 per cent level while the first lag is not. Again as opposed to the non-dynamic FE and RE estimates, GDP is not statistically significant.

The coefficient on ownership is also statistically significant and negative, with a value of -0.04 . This would suggest that a fall in the ownership indicator, i.e. less state involvement, would increase sales per employee by 3.6 per cent. One possible interpretation could be that privately owned firms are, indeed, more efficient, generating higher sales with comparatively fewer employees.

Overall the dynamic models deliver interesting results with respect to ROA and sales per employee. Whereas private ownership appears to have a negative impact on investment performance, it has a negative impact on sales per employee. For the liberalisation indicator results are reversed. For this sample of utilities liberalisation and competition improve ROA but decrease sales per employee.³

(iii) Diagnostic Checking and Robustness

Panel data models should be subjected to some scrutiny with regard to poolability, correlation between individual or time effects and the regressors. Moreover, time series properties, first and foremost serial correlation, need to be considered. In all

³The same estimations were carried out for other financial indicators such as profit per employee, and return on sales. Also GMM estimators were applied. This did not lead to a qualitative change in results.

Table VII: DYNAMIC MODEL FOR RETURN ON ASSETS

	Coefficients	Estimate	t-value	Pr(> t)
<i>Random effects</i>				
	Intercept	1.128961	0.476567	0.6337
	ROA _{t-1}	0.527804	18.30865	0.0000
	ln Employee	-0.816472	-1.716597	0.0861
	ln Employee _{t-1}	0.623347	1.278939	0.2010
	ln GDP	-0.620937	-0.063259	0.9496
	ln GDP _{t-1}	0.753137	0.076919	0.9387
	Ownership	0.131792	2.479771	0.0132
	Liberalisation	-0.096188	-1.161158	0.2456
	Quoted	-0.532734	-0.549137	0.5829
<i>Fixed effects</i>				
	ROA _{t-1}	0.194446	2.907919	0.0036
	ln Employee	-1.399998	-4.091756	0.0000
	ln Employee _{t-1}	0.667102	1.625305	0.1041
	ln GDP	9.334712	0.643790	0.5197
	ln GDP _{t-1}	-1.058247	-0.089875	0.9284
	Ownership	0.552664	2.219512	0.0265
	Liberalisation	-0.241732	-2.160389	0.0308

Notes: Unbalanced panel with $T = 1 - 10$ and $N = 1694$.

The number of observations totals 8975.

P-value for Hausman Test is 0.0027.

Table VIII: DYNAMIC MODEL FOR SALES PER EMPLOYEE

Explained Variable	Coefficient	Estimate	t-value	Pr(> t)
<i>Random Effects</i>				
	Intercept	1.262351	6.008554	0.0000
	\ln Sales per Employee $_{t-1}$	0.936649	23.51430	0.0000
	\ln Sales per Employee $_{t-2}$	-0.093915	-2.764139	0.0057
	\ln GDP	0.200346	0.210491	0.8333
	\ln GDP $_{t-1}$	-0.209192	-0.220575	0.8254
	Liberalisation	-0.028123	-3.731017	0.0002
	Ownership	-0.013535	-2.246564	0.0247
	Quoted	0.165732	2.562436	0.0104
<i>Fixed Effects</i>				
	Intercept	10.39426	1.633524	0.1024
	\ln Sales per Employee $_{t-1}$	0.467647	9.586423	0.0000
	\ln Sales per Employee $_{t-2}$	0.100990	2.903164	0.0037
	\ln GDP	0.566536	0.675863	0.4992
	\ln GDP $_{t-1}$	-1.142097	-1.317690	0.1877
	Liberalisation	0.072443	4.104632	0.0000
	Ownership	-0.036355	-2.000570	0.0455

Notes: Unbalanced panel with $T = 1 - 10$ and $N = 1084$.

The number of observations totals 5074.

P-value for Hausman Test is 0.0000.

models White standard errors and covariance matrix were used.

Testing for serial correlation can be done using the Breusch-Godfrey/Wooldridge test for serial correlation in panel data (see Wooldridge (2002) and Millo & Y (2008)). For all models the null hypothesis of no serial correlation cannot be rejected. To compare random and fixed effects model the Hausman Test (Hausman 1978) can be used to compare to sets of estimates. The test-statistic follows a χ^2 distribution with

$$H_{Test} = (\hat{\beta}_{FE} - \hat{\beta}_{RE})'(\hat{V}(\hat{\beta}_{FE}) - \hat{V}(\hat{\beta}_{RE}))^{-1}(\hat{\beta}_{FE} - \hat{\beta}_{RE}), \quad (IV.1)$$

where V is the estimated variance-covariance matrix of the fixed and random effects estimator respectively, and $\hat{\beta}$ represents the estimated coefficients. The null hypothesis is that both models are consistent and that the random effects estimator should be preferred. Results are reported in each Table, where applicable. While for models with ROA as the dependent variable only the fixed effects estimator is consistent, with sales per employee random effects estimator can be applied.

(iv) Subsample Analysis: The case of Electricity and Telecoms

One interesting issue, which arises from analysing the particular case of utilities, is whether reform, especially the removal of entry barriers and more competition would actually decrease profitability. Two sectors, which have seen the most dramatic changes, include electricity and telecommunications. Many countries started out with very high liberalisation and ownership indicators at the beginning of the sample period, while substantial reform meant, that towards the end of the sample period indicators reached very low levels.

Table IX: SALES PER EMPLOYEE IN THE ELECTRICITY AND TELECOMMUNICATIONS SECTOR

Sector	Coefficients	Estimate	t-value	Pr(> t)
<i>Electricity</i>				
	Constant	-13.9472	-3.9560	0.0001
	Sales per Employee _{t-1}	0.5679	5.5650	0.0000
	ln GDP	-0.1013	-0.0931	0.9258
	ln GDP _{t-1}	1.3308	1.2096	0.2266
	Liberalisation	0.0215	1.9120	0.0560
	Ownership	0.0668	2.0011	0.0455
<i>Telecommunications</i>				
	Constant	-53.07	-6.0648	0.0000
	Sales per Employee _{t-1}	0.5964	8.2894	0.0000
	ln GDP	8.3729	3.4219	0.0006
	ln GDP _{t-1}	-4.2442	-1.6426	0.1007
	Liberalisation	0.0158	4.9204	0.0000
	Ownership	0.0151	0.5683	0.5699

Notes: Unbalanced panel with 2614 (Electricity) and 1880 (Telecoms) observations.

Therefore, it seems worthwhile to look at electricity and telecommunications separately, and analyse a measure of profitability, such as sales per employee. For simplicity only results for the dynamic model in equation III.4 are reported. Table IX reports the results of this sub-sample analysis. For electricity, it appears to be the case that the first lag of sales per employee is highly statistically significant, as well as economically relevant. This, however, is not true for $\ln GDP$ and $\ln GDP_{t-1}$. This is not the case for the telecommunications sub-sample, where both $\ln GDP$ and $\ln GDP_{t-1}$ are statistically significant. This is in line with expectations, since one could argue that demand for telecom services is much more elastic and, therefore, reacts more strongly to business cycles.

The most notable difference to the analysis presented in the previous sections is that for electricity and telecommunications both indicators are positive. Indeed, it appears that in both cases more liberalisation and more private ownership actually led to a decrease in sales per employee⁴. This suggests that as more firms entered and were able to compete, and reforms such as third party access (TPA) were undertaken, sales and profits in the industry fell.

These results, however, do come with a large drawback, in the sense that removing the sector dimension implies that the indicator now only varies across countries and time. Seeing as industry dummies were statistically insignificant in the previous models, this would suggest that better results can be obtained in joint estimation.

⁴This is also the case when using other measures such as profit per employee.

V Conclusion

This chapter has attempted to demonstrate that recent reforms have had a significant impact on utilities' financial performance. Indicators used in this chapter include the commonly observed measures return on assets, sales per employee, and profit per employee. Relying on a number of econometric methods, the results suggest that ownership and liberalisation do have an impact on firm performance, although this impact is not uniform.

Building on the OECD data on liberalisation and ownership reform, the paper uses firm level financial data of over 2000 firms in 18 European countries for electricity, natural gas, airlines, railways, postal services, and telecommunications. The sample spans over a period characterised by extensive infrastructure reform from 1996 to 2006.

These reforms included the introduction of TPA agreements in most network industries, open sky arrangements infringing the rights of national airline carriers, vertical separation, privatisation of a large number of telecommunication utilities, and so on. One of the most exciting research questions in this area, therefore, would naturally be whether overall these reforms had a positive impact. One area where past research has highlighted the improvements brought on by deregulation and privatisation, is firm performance and to a much lesser extent quality or prices. However, large scale studies so far have found it difficult to account for liberalisation other than by using a dummy variable.

Therefore, this chapter attempted to extend this literature by taking a very broad approach to answering the question of market reform and firm performance. The findings suggest that while private involvement had a positive impact on sales per

employee, liberalisation measures actually had a negative influence on sales per employee. For return on assets, as a measure of investment performance, the results were reversed.

Looking at sales per employee for different sub-samples, in particular for the telecommunications and electricity industries, liberalisation and private ownership are associated with lower sales efficiency. As discussed previously, this may well be a sign of reforms successfully introducing competition into those industries, thereby lowering profits or sales.

This chapter has only been able to shed light on a small part of the arguments and issues surrounding infrastructure reform. It is vital that further research looks at the particular types of reforms and what they are meant to achieve. The picture of the unprofitable, inefficient state monopolist appears, from results presented in this chapter, less sharp than previously drawn.

Chapter 4

On Competition for the Market and the Cost of Truth Revelation with Asymmetric Information¹

This chapter is related to ground-breaking work by Chadwick (1859) on concessions as a supplement or even substitute to regulation. Introducing market incentives and corporate governance in the form of outright privatisation and competition is not an option in all infrastructure industries. While sectors like electricity and telecommunications have benefited from advances in technology, other industries such as water, local postal services, and railways have not been met by similar developments. Yet, the rise of incentive regulation and the advances in auction theory have opened the door for new ways of dealing with natural monopoly induced market failure. Franchise bidding carries the promise to achieve more competitive outcomes (that is second-best pricing, not marginal-cost pricing) even when informational asymmetries and the existence of essential facilities limit the scope of regulation. Despite these advantages, franchise bidding also raises a number of questions, in this chapter we approach one

of them: How can we determine the optimal franchise length?

I Introduction

The terminology *competition for the field* as an alternative to *competition in the field* was first coined by Chadwick (1859) as a solution to natural monopoly problems. In particular, he criticised the duplication of facilities and infrastructure in water services and railways and argued that bidding for the right to monopolise would bring significant cost savings while simultaneously leaving scope for competition at the bidding stage. In modern economics, Demsetz (1968) reintroduced the concept of franchise bidding as a substitute for regulation. Public authorities could thereby define and award monopoly concessions for a given good or service to the best (in terms of price or subsidies) bidder on fixed terms and over a pre-determined period of time. If this auction takes place over subsequent franchise periods, it is referred to as repeated franchise bidding.

It has been shown (Telser 1969) that, under certain conditions, such as an infinite number of bidders, franchise bidding can theoretically approach second-best outcomes (i.e. in the one product case, average-cost pricing) in industries with significant scale economies. Yet, while the economics of regulation has been growing and advancing steadily, and infrastructure policies have moved from direct state ownership to privatisation or PPPs, interest in franchise bidding has re-emerged only recently (Doni 2004, Meister 2005). The early critique from institutional economics (Goldberg 1976, Williamson 1976) appeared to have answered Demsetz' question

¹This chapter is based on joint work with **Jörg Borrmann**, University of Vienna, see co-author's statement in Appendix A.

‘Why Regulate Utilities?’ with a resounding “because franchise bidding is no viable alternative”. Transaction costs, especially with regard to asset-specific investments and hold-up,² halted interest in franchise bidding before it got off the ground.

For most utilities, the degree of (human and physical) asset specificity is significant, such that investments are often specialised and unique, and the returns from alternative employments of the investments are low. This introduces hold-up problems when specific assets have to be transferred at the end of the franchise period. Any incumbent anticipating these problems may therefore decide to keep investments low and run down the existing infrastructure. Moreover, the values of some types of infrastructure are extremely difficult to assess, e.g. water pipelines buried deep in the ground. To ease some of those issues, long-term contracts have been proposed (Williamson 1976), as a possible solution.

Long-term contracts may create problems of their own, as highlighted by the incomplete contracts literature (Grossman & Hart 1986, Hart & Moore 1988). With terms and in particular prices fixed over the entire franchise period, long-term contracts may be less suitable to account for account changing demand and cost conditions. Even though some contingencies can be written into the contract, contracts will remain incomplete. There is at least episodic evidence that the inherent uncertainty in long-term franchise contracts leads to renegotiation and early contract termination.

Recently, some of the main concerns with regard to franchise bidding, incomplete contracts and asset specificity have been readdressed in theoretical models. In Harstad & Crew (1999), the regulator can specify a downward sloping t-curve, so that bidders with lower bids are assumed to value transaction-specific assets higher and have to pay

²For a detailed survey of empirical evidence in the context of the institutional economics critique see Crocker & Masten (1996).

more, should they win the franchise. The t-curve specifies an exact relation between the price-bid and the value of the transaction-specific assets, which bidders have to abide to when submitting a simultaneous bid for prices and assets. They show that at least theoretically such an auction mechanism can mitigate the hold-up problem.

The question of contract length is not solely related to theoretical treatments of franchise bidding, it is also of great practical importance. In the very least, any regulatory or governmental agency interested in implementing a concession scheme must first decide on the length of the franchise term. One may conjure that there are many important factors which may influence the optimal (with regard to some welfare concept such as total surplus) length of a given franchise contract. If, for example, bidding costs are large, longer-term contracts will *ceteris paribus* lead to a higher surplus. Similarly, the degree of uncertainty and the longevity of assets, may be important factors when determining the optimal franchise duration.

To model optimal franchise duration, one would rely on some kind of welfare measure, such as total surplus (i.e. profits plus consumer surplus). Any auctioneer or regulator aiming to determine the contract length maximising total-surplus would need information on cost and demand conditions. However, one key argument in favour of franchise bidding is that it requires less information on part of the auctioneer than traditional regulation, and that information rents do not accrue (Harstad & Crew 1999). Therefore, if one is unwilling to relax informational assumptions, we need to find a way for informed firms to reveal the optimal contract length to the auctioneer.

Consequently, we propose an auction mechanism which, under certain conditions, can induce firms to reveal the optimal franchise duration. We make the extreme

assumption that the auctioneer does not have any information with regard to cost and demand conditions and, hence, cannot determine the total surplus maximising contract length directly. The auctioneer is, however, able to enforce a set of auction rules in which bidders not only submit a price bid but also a contract length bid.

To this end, we argue, that the issue of truth revelation can be broken down into two parts. On the one hand, any mechanism created with the aim of determining optimal franchise duration should establish incentives for bidders to coordinate. On the other hand, mere coordination does not suffice, as potentially interested bidders may gather around the ‘wrong’ equilibrium such as their profit-maximising contract duration. In accordance with these requirements our dynamic revelation mechanism provides two distinct instruments for the regulator, one coordination instrument and one instrument for punishment.

This chapter first gathers some stylised facts on franchise bidding. The next part describes the auction rules and general set-up of the model. Section V presents the case of homogeneous bidders under common knowledge, while in Section VI common knowledge exists only among bidders. Finally, results for heterogeneous bidders are presented in Section VI. The last section offers our conclusions.

II Some Stylised Facts on Franchise Bidding

Concessions for the right to monopolise have been awarded in a variety of industries and countries. Early examples include the cable and television licenses in the US (CATV), an industry with moderate sunk costs. However, recently concessions have been awarded in water and sewage industries, electricity, gas, transport infrastructure

(roads, railways, airports, ports), and telecommunications (most prominently 3G licenses in Europe—although strictly speaking oligopoly franchises). In the context of our model, the two primary aspects of interest are the length of franchise contracts and cases of early termination and renegotiation.

(i) Length of Franchise Contracts

Across industries and countries the type of contracts awarded, from short-term management contracts to a full transfer of ownership and risk, and the fashion in which contracts are awarded differ greatly, from sophisticated auction mechanisms to less formal “beauty contests” (Affuso 2002). In the French water sector, contracts are often renewed without competitive tendering. Prior to the ‘Public Services Delegation Law’ of 1995, which laid out new rules governing the provision of public services, some contracts were running for periods of 75 years or longer. One extreme example would be the municipality of Nice, which has had the same water supplier since the end of the 19th century (Elnaboulsi 2001, Chong et al. 2006).

Generally, the length of franchising contracts varies across industries and countries. Longer-term contracts, however, are more common than the short-term contracts envisioned by Demsetz (1968) and Posner (1972). This may be another indication that in infrastructure industries hold-up problems and investment incentives are considered to be the major issues. Depending on the type of industry and regulator preferences, concessions are awarded for periods of up to 100 years, although the typical period for infrastructure, such as water and railways, appears to be much shorter, with most governments and regulators opting for 15 to 30 year periods.

Water concessions in South America were awarded for periods of 20 to 40 years,

with franchises in Brazil and Ecuador running for 30 years, while Chile and Mexico awarded slightly shorter franchises of 20 to 25 years (Hall & Lobina 2002). In Bolivia water concession contracts (e.g. Cochabamba), were awarded for 40 years. Similarly, water privatisations in Africa (Bayliss 2001) involve renewable contracts of 15, 20 or 30 years, with some shorter management contracts also being awarded. These water concessions were typically tied with electricity concessions (for example in Chad, Gabon, Guinea-Bissau and Mali).

The case of the British railway sector has already been elaborated in some detail in Chapter 2. Nevertheless, it seems important to emphasise that the first round of franchises was fairly short, considering the longevity of the assets. The rail franchises were awarded for seven or ten years depending on investments, however, in the second round, a policy change was enacted and much longer franchises of 20 years and more were awarded. The electricity distribution system of the London Underground, on the other hand, was awarded for a much longer period, namely 30 years (Littlechild 2002).

In Argentina, electricity distribution as well as water concessions were awarded for 99 years. Bidding is scheduled to take place every ten years, with an initial period of 15 years. In railways, Brazil opted for longer term 30 year concessions, whereas Argentina differentiated between 30 (plus a possible ten year extension)-year freight concessions and ten (plus a possible ten year extension)-year passenger concessions (Estache et al. 2002).

So, typically, the length of franchise contracts in infrastructure tends to be around ten to 30 years. It is somewhat disconcerting that the particular length of the concessions appears slightly arbitrary, and that one may well argue that these medium-length contracts are merely chosen out of convenience or habit. In addition, it is, of

course, difficult to establish whether this bracket is too wide and should optimally be much narrower. This chapter highlights that decisions on contract length are inherently difficult to make.

(ii) Renegotiation and Early Termination

With regard to renegotiation and early franchise termination, the picture is similarly diffused. Cases from railways, water, and electricity franchise experiences suggest that pre-mature contract termination is neither the exception nor the rule. Although water concessions in Argentina have led to health improvements (Galiani et al. 2005), they were, at the same time, marred by renegotiation and early termination. Often, renegotiation centred on prices and tariffs.

Overall, one would have to conclude that early contract termination and renegotiation can be frequently found for infrastructure franchises, seemingly enforcing concerns that firms engage in ex-post opportunistic behaviour due to incomplete contracts and that governments face commitment issues. In Bolivia, Argentina, and Brazil, water concessions were terminated prematurely after failed renegotiation attempts. A very prominent case was the Buenos Aires water concession, which was terminated in 2006 despite 17 years of franchise contract remaining. Prior to renationalisation numerous renegotiations (and attempts) took place (Casarin, Delfino & Delfino 2007).

The Buenos Aires case highlights some common problems in renegotiation and early termination. There was some failure to expand capacity as outlined in the franchise contract. Moreover, tariffs increased by 80 per cent in real terms (Casarin et al. 2007). Other water franchises in South America were also terminated early.

They include the Tucuman franchise in Argentina and the Bolivian concession in Cochabamba, which were terminated early after price rises and failed renegotiation attempts.

Informal price negotiation also took place in Guinea (Bayliss 2001), whereas the Trinidad water concession with Severn Trent was terminated early in 1999 and responsibilities for water and waste water services were put back in the hand of the public authorities (Hall & Lobina 2002). These failures highlight that negotiations within a regulatory structure are less problematic than informal, unplanned renegotiations that go beyond contractual contingencies.

In Senegal, the first water privatisation attempt was short-lived with renationalisation after 18 months only. It ended in 2000 with the government repurchasing the shares of Hydro-Quebec International and Elyo. The original license period was ten years but after tariff disputes fostered by rising oil prices all shares were bought back by the government. In a second attempt in 2001, the privatisation mode was changed to a 25 year lease as opposed to the previous outright privatisation. Failure to reach an agreement with the winning bidder meant that the second attempt was consequently aborted. (Gökgür & Jones 2006)

Railway concessions have been awarded (amongst others) in Argentina, Brazil, Mexico, Germany, Sweden and the UK. Following financial difficulties the British Connex South Eastern franchise was terminated eight years prematurely by the Strategic Rail Authority (SRA) who then took over as a supplier of last resort. In Brazil and Argentina renegotiations started a few years into the franchise. The renegotiation process in Argentina included minor issues such as contract ambiguities but also the threat of bankruptcy and the response to excess demand (Estache et al. 2002).

The evidence presented here is highly circumstantial. In one of the few econometric contributions, an analysis of cable TV licenses showed that renegotiation did not occur frequently — in only 60 out of 3000 cases (Zupan 1989). However, it again should be noted that cable TV licenses differ from infrastructure industries not only in terms of cost structure but also demand. Water, sewage, electricity, and postal services for example do not have close substitutes and demand is inelastic, at least in the short term.

Generally, renegotiations are usually centred around tariffs and financing. Failure to resolve these disputes has, in some cases, lead to early contract termination and renationalisation. One part of the problem appears to be related to the auctioneer's commitment problems. Any regulator or government overseeing a concession scheme faces the dilemma of having to decide if and when to take the ultimate step of terminating a franchise. Of course, in the case of infrastructure concessions the seller often has residual interests in the franchise, and commitment to targets and tariffs set out in the contract may not be plausible.

In other instances, one may conclude that the winner's curse problem could be of similar importance. Often, the value of infrastructure concessions, sometimes after decades of state ownership, will not be known to bidders. Thus, the winning bidders may turn out to be those who over-estimated the possible returns and under-estimated the risks of running a long-term infrastructure franchise. This argument has also been forwarded by franchisees as a justification for renegotiation attempts.

What can be learned from these selected cases (for a summary refer to Table I) is, on the one hand, that franchise bidding schemes have been implemented widely in the past ten years, maybe more so than commonly assumed (see e.g. Harstad & Crew

(1999) who argue that franchise bidding has not been widely adopted). Further, we can observe that renegotiation and early termination occur, although it is likely that the selection is biased, as problematic cases are the first to be examined by scholars and the media alike. Moreover, franchise duration varies considerably, partially in accordance with risk sharing mechanisms, i.e. short-term management contracts vs. long-term full privatisation. By and large, however, medium-term contracts seem to be the favoured policy. While this chapter addresses one of the issues highlighted in this section, i.e. optimal contract duration, the need for further research remains pressing.

Table I: SELECTED CASES OF CONCESSIONS AWARDED

Location and Sector	Contract Length	Early Termination
France, water	1 to 75 years	
Argentina, water	typically 30 years in Buenos Aires 99 years (with rebidding)	Yes, failed renegotiation
Brazil, water	typically 30 years	Yes, failed renegotiation
Ecuador, water	typically 30 years	
Chile, water	20 to 25 years	
Mexico, water	20 to 25 years	
Bolivia , water	40 years	Yes, failed renegotiation
Senegal, water	first 10 years then 25 years	Yes, failed renegotiation
Chad, Gabon, Mali, water and electricity	15, 20 or 30 years	Yes, failed renegotiation
Britain, electricity (Underground)	30 years	

TABLE I (CONTINUED)

Location and Sector	Contract Length	Early Termination
Argentina, electricity	99 years in Buenos Aires (with rebidding)	
Britain, railways	7-10 and in the second period 20-30 years	1 early termination in first franchise period
Brazil, railways	30 years	
Argentina, railways	30 years for freight, 10 years for passenger ser- vices	Renegotiations, threats of bankruptcy

Source: Please refer to the text for citations of relevant papers.

III Set-up of the Model

In this section, we describe the set-up of the model and a set of well-defined auction rules, which will determine the outcome of the auction process. These rules are centred on two instruments used by the regulator, a penalty, p , and a coordination instrument, h . Moreover, we discuss our assumptions with regard to the behaviour of the auctioneer and the bidding firms.

(i) General Motivation and Description of the Mechanism

In principle, repeated franchise bidding does not require a finite time horizon. However, in practice, an auctioneer might want to change a definition of the franchise, or adapt the franchise duration due to changing cost and demand conditions, or even terminate a franchise agreement. Therefore, we realistically assume that there is a fixed finite time interval, $[0, T]$, which is divided n times to yield franchises of equal contract length, $l = T/n$, where n is a positive integer.³ Let the expected value, E , of total surplus, $TS(\cdot)$, be a function of time, t , and denote the social discount rate chosen by the auctioneer by r . Then, we can define the expected value, E , of n^* , the optimal number of bidding periods,⁴ which maximises expected discounted total surplus in the time interval, $[0, T]$ as:

$$E[n^*] = \arg \max \left(\sum_{i=1}^n \left(\int_{(i-1)\frac{T}{n}}^{i\frac{T}{n}} E[TS(t)]e^{-rt} dt \right) \right). \quad (\text{III.1})$$

There are two possible cases to differentiate. If bidders have common knowledge with respect to other players' cost functions then $E[n^*]$ will be identical for risk-neutral bidders. If bidders are not perfectly informed about each others cost functions, they will form individual estimates of $E[n^*]$, which we denote $E_j[n^*]$.

Due to a lack of information, the auctioneer is never able to determine $E[n^*]$ directly. At first glance, it seems reasonable to require firms to report their estimates of $E[n^*]$, or, $E_j[n^*]$, to the auctioneer. However, the difficulty is that firms can be assumed to maximise expected discounted profits: Let the expected value, E , of the profits, $\Pi_j(\cdot)$, of a firm, j , be a function of time, t , and denote the discount rate chosen by a firm, j , by ρ_j . Then, we can define the expected value, E , of ν_j^* , of a firm, j , the

³In principle, n , could be measured in days, weeks, months, or years.

⁴For simplicity, we assume that there is a unique global maximum of $TS(\cdot)$ at n^* .

optimal number of bidding periods,⁵ which maximises expected discounted profits in the time interval, $[0, T]$ by:

$$E[\nu_j^*] = \arg \max \left(\sum_{i=1}^v \left(\int_{(i-1)\frac{T}{v}}^{i\frac{T}{v}} E[\Pi_j(t)] e^{-\rho_j t} dt \right) \right). \quad (\text{III.2})$$

Therefore, $E[\nu_j^*]$ is the value which a risk-neutral firm, j , can be assumed to report. It has no incentive to report its true estimate of $E[n^*]$. As a second-best solution, the auctioneer may implement a mechanism to solve the problem. It determines n , which approximates $E[n^*]$.

To do so, the auctioneer asks all bidders to submit their estimate of $E[n^*]$ prior to the actual start of the franchise bidding auctions. It will also inform the bidders of the magnitude of crucial parameters they will need for their calculation, such as r , the social discount rate, and a , the administrative costs of the auctioneer, which, we assume, is billed to the bidding firms. Depending on the auctioneer's prior beliefs she will set a coordination parameter, h , and require that submitted estimates do not differ by more than what is expected by the auctioneer. If they do differ by more than h , no franchise auctions will take place and a supplier of last resort is chosen instead. If, however, the absolute differences between submitted estimates are within h , then, over the course of the franchise auctions, the auctioneer is able to update her beliefs on the optimal number of franchise periods, and she can use this new information to implement a penalty system. In particular, the auctioneer will punish bidders, if the submitted estimates turn out to be very far from the auctioneer's updated subjective estimate of $E[n^*]$, which we denote $E_A[n^*]$.

⁵For simplicity, we assume that there is a unique global maximum of $\Pi_j(\cdot)$ at ν_j^* .

Table II: TIMING OF THE MECHANISM

Timeline	Auctioneer	Bidders
$t = 0$	Informs public about mono- poly franchise and rules	
$t = 1$	Requires firms to register	
$t = 2$	Sets coordination parameter, h	
$t = 3$	Announces coordination pa- rameter, h , the social dis- count rate, r , the number of bidders, the administrative costs a , and the magnitude of penalty, p	
$t = 4$		Submit estimate of $E[n^*]$
$t = 5$	Announces if bidding process will take place	
$t = 6$	If bidding takes place she an- nounces contract length	
$t = 7$	Franchise auctions start	Take part in first franchise auction

Please refer to the auction rules outlined below.

(ii) Bidders

Each of the registered firms maximises expected discounted profits. Each bidder assumes that he has at least one non-colluding competitor at each stage of the bidding process.⁶ When submitting its estimate, m_j , of $E[n^*]$, the discounted profits expected by a registered firm are greater than zero. Bidders are perfectly informed about their own cost⁷ functions and the market demand function at each point in time in the time interval, $[0, T]$ (*private values assumption*). For simplicity, the market demand function is assumed to be common to all bidders.⁸ Bidders cannot observe the cost functions of the other bidders. The cost functions of the bidding firms exhibit economies of scale.⁹ None of the bidding firms is financially constrained.¹⁰

Bidders form subjective beliefs on the estimate that will trigger a penalty. These beliefs can be characterised by distribution and density functions, where $\text{Pr}_j(m_j) = \delta(m_j)$ denotes the subjective probability that the penalty will have to be paid after submitting an estimate, m_j .

From the outset, it is apparent that, if there is no common knowledge among bidders, the usefulness of truth revelation will be related to two factors. Firstly, if

⁶If bidders are homogeneous, then they will simply assume that the probability to win an auction is equal to the number of registered bidders divided by the number of franchise auctions. If bidders are heterogeneous, we assume that bidders cannot perfectly determine the cost function of the most efficient firm, willing to take part in the bidding process. Therefore, as long as their ex-ante valuations of the franchise over the entire time interval are positive they will take part in the submission of estimates, m_j , and the subsequent franchise auctions.

⁷In this context, costs are meant to include bidding costs.

⁸Franchise bidding with differences in demand has been analysed by Borrmann & Schaffhauser-Linzatti (2008).

⁹The concept of (cost) economies of scale is described in Baumol et al. (1988).

¹⁰As pointed out by Rothkopf (2001), the assumption that none of the bidding firms is financially constrained ensures that bidders are indifferent between winning and losing at the respective least profitable bids they are willing to make. This assumption is, for instance, fulfilled in case that capital markets are perfect. Some models have been developed which describe bidders facing financial constraints, e.g. Che & Gale (1998).

$E[n^*]$ and $E[\nu_j^*]$ are approximately similar, then there is not much to be gained from revealing $E[n^*]$. Secondly, if expectations of bidders, j , $E_j[n^*]$ differ in a biased and significant way from $E[n^*]$, then the collective estimate of the optimum might not be nearer to $E[n^*]$ than the auctioneers' expectation, $E_A[n^*]$. Therefore, the mechanism is useful only, if the firms have collectively a better understanding of the industry than the auctioneer.

(iii) *Auctioneer*

Prior to the bidding process the risk-neutral auctioneer has neither knowledge of the cost function of the bidder(s) with the most efficient technology, nor of the market demand function. She is able to credibly commit herself to the mechanism, especially the parameters set by herself such as, the social discount rate, r , the penalty, p , the coordination variable, h , her expected number, b , of bidders, her expected administrative costs, a , per auction, and the assumption that all participants are equal. Over time, as bidding takes place in $[0, T]$, she is able to gather information which may indicate the approximate welfare-maximising number of bidding periods, n^* . As such the auctioneer is able to update her belief to $E_A[n^*]$.

The coordination parameter, h , is related to the auctioneer's subjective belief of the degree of common knowledge in the industry. With a common market demand, these differences will be a result of different cost functions. In the absence of common knowledge from the point of view of the auctioneer, h , is a result of the inability of individual bidders to observe the cost-minimising (and thus total surplus-maximising) $E[n^*]$.¹¹ Implicitly, h is thus connected to the auctioneer's beliefs on bidders' cost

¹¹Without common knowledge, the cost-minimising bidder is not aware that she could in fact

functions and their individual estimates, $E_j[n^*]$. Like, n , it is a positive integer which can, for instance, be measured in days, weeks, months or years.

We can distinguish two cases. If the auctioneer believes that all firms taking part in the bidding process know $E[n^*]$, then she will set h equal to zero, because if for example firm A submits a bid of four franchise periods and firm B a bid of seven franchise periods then (at least) one of them is “lying”. In all other instances h will be greater than zero because each firm will have individual estimates $E_j[n^*]$. Thus, the auctioneer could for example set h equal to two franchise periods. In the above example the franchise auctions would still not take place, since the difference between submitted estimates is greater than the allowed absolute difference, $|4 - 7| = 3 > 2$. In this case a supplier of last resort will be instated.

For a risk-neutral auctioneer the magnitude of h will be related to her knowledge of the industry. With a fixed demand function the differences in $E_j[n^*]$ will arise through differences in cost estimates. These could, for example, be a result of the utilisation of technology, efficiency levels, different employments of labour and capital, and so on. An auctioneer will take exactly those factors into consideration when setting h . Of course, an auctioneer who has little knowledge of the industry will have more difficulty determining h than a well-established regulator who switches from some existing, well-functioning, regulatory regime to franchise bidding.

In infrastructure industries such as water for example, where technology is fairly homogeneous and standardised, an auctioneer would set a smaller h than in an industry such as telecommunications, which is driven by innovations, research and development. Similarly, if there is an industry which has been regulated, in particular with

determine, $E[n^*]$, without knowing the cost functions of all other bidders.

regimes that foster convergence such as incentive regulation and benchmarking, the auctioneer will know that differences in $E_j[n^*]$ cannot be too large. Other information the auctioneer could review would be the ownership structure in the industry. The differences in $E_j[n^*]$ might be larger, if there is a mixture of privately and publicly owned utilities rather than just privately owned ones. As such the auctioneer will use her knowledge of the industry to assess the possible differences in $E_j[n^*]$ and, possibly, the underlying differences in costs.

(iv) Rules and Timing of the Mechanism

Our mechanism, which uses the knowledge of the firms willing to participate in the bidding process, is defined by ten rules referring to different points in time.

Rule 1: At $t = 0$, the auctioneer informs the public about an exactly defined monopoly franchise for the provision of a particular good to be repeatedly awarded via competitive bidding in sealed-bid auctions without a reserve price within the fixed time interval $[0, T]$. She also informs bidders about the general framework (Rules 2 – 10).

Rule 2: At $t = 1$, the auctioneer requires all firms, j , $j = 1, \dots, M$, willing to participate in the bidding process to register.

Rule 3: If it is common knowledge among all registered firms as well as the auctioneer that all registered firms are identical, then the auctioneer sets the coordination variable, h , which reflects the knowledge of bidders, to 0 at $t = 2$. In all other cases, the auctioneer sets the coordination variable, h , to a strictly positive value at $t = 2$. The more heterogeneous the auctioneer expects the registered firms estimates, $E_j[n^*]$, to be, the larger is the value which h assumes.

Rule 4: At $t = 3$, the auctioneer informs all registered firms about the magnitude of h and about the social discount rate, r . She also informs all registered firms about the number, b^{12} , of bidders expected by her, which is assumed to be constant over auctions. In addition, she informs all registered firms of her own administrative costs, a , per auction which she expects, which is assumed to be constant over auctions, and will be billed to bidders. Furthermore, the auctioneer informs all registered firms that they will have to calculate their best estimate, m_j , of $E[n^*]$, i.e. the expected optimal number of bidding periods, until $t = 4$. The auctioneer obliges the registered firms to base their estimates on the social discount rate, r , on the auctioneer's expected number, b , of bidders, on the auctioneer's expected administrative costs, a , per auction, and on the assumption that all participants are equal.

Rule 5: If the auctioneer later detects that, for one or more firms, $|m_j - E_A[n^*]| \gg 0$, where $E_A[n^*]$ is the updated belief of the auctioneer, then she imposes a penalty on all registered firms who set $|m_j - E_A[n^*]| \gg 0$. The auctioneer determines the magnitude of this penalty, $p < 0$, at $t = 3$. She also informs all registered firms on p and on the circumstances under which the penalty will have to be paid by (some of) the registered firms. In the special case where $h = 0$, p will be imposed as soon as estimates differ. In addition, the auctioneer informs all registered firms that $0 \leq h \ll |m_j - E_A[n^*]|$.¹³

¹²This is a simplifying assumption to ensure, that all interested bidders can calculate the expected payoff from taking part in the actual franchise bidding auctions. The number of bidders will, all things equal, have an effect on the probability to win and thus effect bidder's valuations. For simplicity the auctioneer could, for example, declare that number of interested bidders, j , will be equal to b .

¹³This statement implies that it is easier for the auctioneer to determine the degree of cost differences among bidders, than to gather knowledge about $E[n^*]$. This assumption is fairly plausible, since in order to determine $E[n^*]$ the auctioneer needs information on cost and demand functions. Forming a belief on h only requires the auctioneer to think about how different the estimates, $E_j[n^*]$, could be.

Rule 6: At $t = 4$, the auctioneer asks all registered firms to submit their estimates, m_j , of $E[n^*]$, to the auctioneer.

Rule 7: At $t = 5$, the auctioneer announces to start the bidding process at $t = 7$, if $|m_j - m_k| \leq h \forall j \neq k$. If there are at least two registered firms, $j \neq k$, with $|m_j - m_k| > h$, the auctioneer does not start the bidding process. In this case, the good is delivered by some supplier of last resort over the entire fixed finite time interval, $[0, T]$. This supplier of last resort is appointed by the government. If the good is delivered by the supplier of last resort, the game ends.

Rule 8: If the auctioneer's coordination variable, h , equals 0, and if $|m_j - m_k| = h = 0 \forall j \neq k$, then $n = m_j, j = 1, 2, \dots, M$. In case that the auctioneer's coordination variable, h , is strictly positive, i.e. $h > 0$, then $n = \text{nint}\left(\frac{1}{M} \sum_{j=1}^M m_j\right)$, where $\text{nint}(\cdot)$ represents the nearest integer function.

Rule 9: In case that the bidding process was not stopped, an exactly defined monopoly franchise for the provision of a particular good is repeatedly awarded via competitive bidding in sealed-bid auctions without a reserve price within the fixed finite time interval, $[0, T]$. At $t = 6$, the auctioneer informs all registered firms that bidding will take place n times at the beginning of time intervals of equal contract length, l . Each time when an auction takes place, the monopoly franchise is awarded to the firm bidding the lowest price. In the event of a tie, only one of the bidders is chosen by a predetermined allocative mechanism, e.g. a lottery. The winning bidder has to supply the total quantity demanded of the good in the following contractual period at the price he bid. The first auction takes place at $t = 7$, which is identical with the lower bound of the fixed finite time interval, $[0, T]$, i.e. 0.

Rule 10: In case that the bidding process was started at $t = 7$, the auctioneer

gathers information on the true $E[n^*]$ in $[0, T]$ to enforce Rule 5. She has to announce which (if any) firms, j , have to pay the penalty, p .

IV Homogeneous Bidders under Common Knowledge among all Players

If the auctioneer knows that the interested firms are homogeneous with regard to their cost and demand functions, then Rule 3 applies, and therefore the auctioneer's coordination variable, h , equals 0. In addition, in this special case, the auctioneer will enforce the penalty, p , as soon as submitted estimates are not equal. Then the analysis of the mechanism is relatively straightforward.

Proposition IV.1. *If it is common knowledge among all firms, j , $j = 1, \dots, M$, willing to participate in the bidding process as well as the auctioneer that all firms, j , are identical, then there exists a unique equilibrium where all firms, j , reveal their best estimates, m_j , of $E[n^*]$ truthfully.*

Proof. In the case of identical bidders with common knowledge, the auctioneer will set the coordination parameter $h = 0$ and announce that a large penalty, p , will have to be paid if $|m_j - m_k| > 0$. The entire strategy set of the identical players is given by the submitted number of franchise periods, $m_j \in \mathbb{N}^+$ for all $j = 1, \dots, M$, where the expected payoff function of player j when submitting m_j , is a function of m_j and the other $-j$ players' strategies:

$$u_j(m_j, m_{-j}) = [V_j(a, b, l(m_j, m_{-j}), r, \rho_j) + \delta(m_j)p \tag{IV.1}$$

$$+(1 - \delta(m_j)) \cdot 0] \zeta(m_j, m_{-j}) + [0 + p](1 - \zeta(m_j, m_{-j})), \tag{IV.2}$$

where $V_j(\cdot)$ is the expected value of the franchise over the entire franchise period $[0, T]$, as a function of franchise length, $l = \frac{T}{n(\cdot)}$, the number of bidders b , the administrative costs, a and the discount rate r . The probability that all submitted bids are equal is denoted by $\zeta(m_j, m_{-j})$, and the subjective probability that the penalty p will have to be paid in this case is given by $\delta(m_j)$. According to Rule 2, if $h = 0$ and the submitted estimates, m_j , of the total surplus maximising number of franchise periods, $E[n^*]$, are not identical for all participating bidders, then the penalty, p , will have to be paid by all bidders. The probability that the difference between submitted estimates, m_j , is greater than 0 is given by $(1 - \zeta(m_j, m_{-j}))$.

If bidders submit the total surplus-maximising number of franchise periods, $E[n^*]$, then the value of the franchise for each of the individual bidders can be denoted $V(a, b, \frac{T}{E[n^*]}, r, \rho)$, which will be identical in the special case of homogeneous bidders. If all bidders submit an estimate $m_j = E[n^*]$, the payoff function simplifies to

$$u(E[n^*]) = \left[V(a, b, \frac{T}{E[n^*]}, r, \rho) + \delta(E[n^*])p + (1 - \delta(E[n^*])) \cdot 0 \right] \quad (\text{IV.3})$$

$$= V(a, b, \frac{T}{E[n^*]}, r, \rho) > 0, \quad (\text{IV.4})$$

where, from Rule 5, we know that, in this special case, $\delta(E[n^*]) = 0$, and no penalty will have to be paid. As the number of bidders is finite, i.e. under imperfect competition, the expected value of the franchise, $V(a, b, \frac{T}{E[n^*]}, r, \rho)$, is strictly positive for all bidders.

Further, in the special case of identical firms, the expected optimal number of bidding periods, $E[v^*]$, which maximises expected discounted profits in the time interval, $[0, T]$, will be identical for all bidders. By definition, this will be the number of franchise periods which will maximise the value of the franchise for each individual

bidder $V(a, b, l(v^*), r, \rho)$. The payoff function can then be denoted as

$$u(E[v^*]) = \left[V\left(a, b, \frac{T}{E[v^*]}, r, \rho\right) + \delta(E[v^*])p - (1 - \delta(E[v^*])) \cdot 0 \right] \quad (\text{IV.5})$$

From Rule 5, bidders know that the auctioneer is able to learn over the course of the franchise, and detect eventually whether the submitted estimate m_j differs significantly from $E[n^*]$. For the profit-maximising, $E[v^*]$, we state $|E[v^*] - E[n^*]| \gg 0$, and thus the subjective probability, $\delta(\cdot)$, that the penalty p will have to be paid is strictly positive. The fact that this penalty is sufficiently large guarantees that

$$V\left(a, b, \frac{T}{E[v^*]}, r, \rho\right) + \delta(E[v^*])p < 0, \quad (\text{IV.6})$$

and it follows that for all bidders, $j = 1, \dots, M$, the strategy to submit $E[v^*]$ is strictly dominated by the strategy $m_j = E[n^*]$, since

$$V\left(a, b, \frac{T}{E[v^*]}, r, \rho\right) + \delta(E[v^*])p < 0 < V\left(a, b, \frac{T}{E[n^*]}, r, \rho\right). \quad (\text{IV.7})$$

The second inequality arises, as shown above, from the fact that with a finite number of bidders, the bidder's valuations will be strictly positive. To complete the proof, we need to show that any other strategy $m_j \neq E[n^*] \neq E[v^*]$ will never be played by any of the bidders. In this case, the expected payoff is given by

$$u_j(m_j, m_{-j}) = [V(\cdot) + \delta(m_j)p + (1 - \delta(\cdot)) \cdot 0] \zeta(\cdot) + (0 + p)(1 - \zeta(\cdot)), \quad (\text{IV.8})$$

$$= [V(\cdot) + \delta(m_j)p] \zeta(\cdot) + p(1 - \zeta(\cdot)) \quad (\text{IV.9})$$

where $V(a, b, l(m_j), r, \rho)$ is a function of n , the number of franchise periods, as determined by the submitted estimates, m_j . With $m_j \in \mathbb{N}^+ \setminus \{E[n^*], E[v^*]\}$, the probability that the submitted estimates will differ, $(1 - \zeta(m_j, m_{-j}))$, will be strictly

positive. Since $p < 0$ is sufficiently large, we have

$$[V(a, b, l(m_j, m_{-j}), r, \rho) + \delta(m_j)p]\zeta(\cdot) < p(1 - \zeta(\cdot)) \Rightarrow u_j(m_j, m_{-j}) < 0, \quad (\text{IV.10})$$

for any submitted $m_j \in \mathbb{N}^+ \setminus \{E[n^*], E[v^*]\}$. Thus, with homogeneous bidders and common knowledge, any strategy $m_j \in \mathbb{N}^+ \setminus \{E[n^*]\}$ is strictly dominated by submitting an estimate of $m_j = E[n^*]$, for all bidders, $j = 1, \dots, M$. ■

Corollary IV.2. *If it is common knowledge among all firms, $j, j = 1, \dots, M$, willing to participate in the bidding process as well as the auctioneer that all firms, j , are identical, the estimates, m_j , of $E[n^*]$ are identical for all firms, j .*

Proof. Follows from Proposition IV.1. ■

Proposition IV.1 and Corollary IV.2 ensure that, in the case of identical firms and common knowledge, truth-revelation is the only equilibrium strategy. Therefore, all submitted estimates will be identical. To illustrate, we can construct a simple diagram using the valuations of the actual franchise contracts. Strategies with valuations lower than $V(E[n^*], \cdot)$ are not feasible and therefore can be ignored. For instance, strategies around $V(E[v^*], \cdot)$ will not be chosen because of the penalty p associated with setting $|m_j - E_A[n^*]| \gg 0$. With h equal to 0, firms are forced to coordinate, as any deviation $|m_j - m_{-j}| > 0$ results in a negative payoff, $u(m_j, m_{-j})$. Therefore, the only point where coordination is possible and expected payoffs are strictly positive is $E[n^*]$. The result of this special case is driven by the auctioneer's knowledge that firms are indeed identical, hence enabling the auctioneer to enforce the penalty instantaneously, that is as soon as submitted estimates differ.

This first case is a good illustration of the way our mechanism works twofold. First, it forces bidders to cooperate, and, second, because of p , interested bidders are

unable to coordinate on strategies, with the highest valuations, $V(E[v^*], \cdot)$, so that, in the case of common knowledge, they are forced to reveal the true optimal franchise duration. This unique equilibrium is illustrated in Figure I.

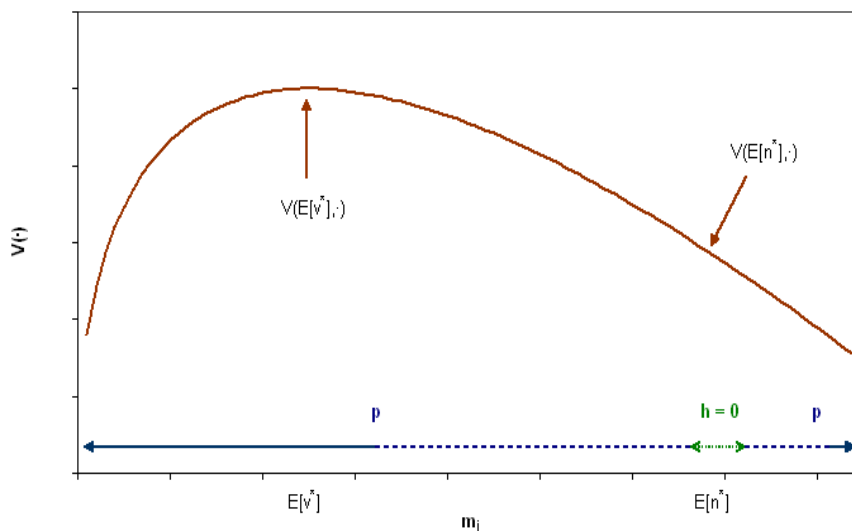


Figure I: EQUILIBRIUM WITH HOMOGENEITY AND COMMON KNOWLEDGE

V Homogenous Bidders under Common Knowledge only among Bidders

In the case of an uninformed auctioneer, Rule 2 applies and therefore the auctioneer's coordination variable, h , takes a strictly positive value depending on the prior belief of the auctioneer. The analysis of the mechanism is more complicated, and it is no longer the best strategy for each of the firms to reveal their best estimates, m_j , of $E[n^*]$ truthfully.

Proposition V.1. *If it is common knowledge among all firms but the auctioneer that*

all firms are identical, then there exists an equilibrium where the firms, j , submit an estimate equal to $E[n^*] \pm h$.

Proof. The expected payoff for player j as a function of submitted estimates, m_j and m_{-j} , of the optimal number of franchise periods is given by

$$u_j(m_j, m_{-j}) = [V_j(a, b, l(m_j, m_{-j}), r, \rho_j) + \delta(m_j)p + (1 - \delta(m_j)) \cdot 0] \zeta(m_j, m_{-j}) + (1 - \zeta(m_j, m_{-j})) \cdot 0, \quad (\text{V.1})$$

where $\zeta(m_j, m_{-j})$ is the probability that franchise auctions will take place n times in the interval $[0, T]$, with $l = \frac{T}{n(\cdot)}$, whereas $(1 - \zeta(m_j, m_{-j}))$ is the probability that submitted estimates, m_j , differ by more than the coordination parameter, h , announced in stage 2 and that consequently no bidding takes place.

Bidder j will only submit an estimate of, m_j , which thus solves the following maximisation problem:

$$\max_{m_j} \{ [V_j(\cdot) + \delta(m_j)p + (1 - \delta(m_j)) \cdot 0] \zeta(m_j, m_{-j}) + (1 - \zeta(m_j, m_{-j})) \cdot 0 \}. \quad (\text{V.2})$$

As a participation constraint, we require the expected payoff for, m_j , to be strictly positive:

$$[V_j(\cdot) + \delta(m_j)p + (1 - \delta(m_j)) \cdot 0] \zeta(m_j, m_{-j}) + (1 - \zeta(m_j, m_{-j})) \cdot 0 > 0. \quad (\text{V.3})$$

For any $\zeta(\cdot) > 0$, the condition simplifies to

$$V_j(a, b, l(m_j, m_{-j}), r, \rho_j) > \delta(m_j)p, \quad (\text{V.4})$$

where $\delta(m_j)$ is the subjective belief that the penalty, p , has to be paid when submitting an estimate, m_j , while $V_j(\cdot)$ is the value of the franchise which depends

on $n(\cdot)$, the average estimate of all submitted optimal number of franchise periods defined in Rule 8. In the case of homogeneous bidders and common knowledge, the expected value of the franchise will be the same for all bidders so that

$$V_j(\cdot) = V_{-j}(\cdot) = V(\cdot). \quad (\text{V.5})$$

From Rule 5 and Proposition IV.1 we can recall that, for identical players, the strategy of submitting the expected profit-maximising number of periods $E[v^*]$ is strictly dominated by the strategy of submitting the expected total surplus-maximising number of franchise periods, $E[n^*]$:

$$V\left(a, b, \frac{T}{E[v^*]}, r, \rho\right) + \delta(E[v^*])p < 0 < V\left(a, b, \frac{T}{E[n^*]}, r, \rho\right). \quad (\text{V.6})$$

Thus, the strategy space for any player, j , reduces to $m_j \in \mathbb{N}^+ \setminus \{E[v^*]\}$. From Rule 5, we also know that deviations from $E[n^*]$ with a magnitude of h , or smaller, will not trigger the penalty, as $0 < h \ll |m_j - E_A[n^*]|$ and therefore the subjective probability, $\delta(\cdot)$, that a penalty will have to be paid when submitting an estimate $m_j \pm h$, will be 0 and payoffs simplify to:

$$u(E[n^*] \pm h, m_{-j}) = [V(a, b, l(E[n^*] \pm h), r, \rho)] \zeta(E[n^*] \pm h). \quad (\text{V.7})$$

By assumption, for any given $\zeta(m_j, m_{-j})$, and, in the case of identical players, it must hold for any $\epsilon < h$ that

$$u_j(E[n^*] \pm h, m_{-j}) = [V(a, b, l(E[n^*] \pm h), r, \rho)] \zeta(E[n^*] \pm h, m_{-j}) > \quad (\text{V.8})$$

$$u_j(E[n^*] \pm \epsilon, m_{-j}) = [V(a, b, l(E[n^*] \pm \epsilon), r, \rho)] \zeta(E[n^*] \pm \epsilon, m_{-j}) > \quad (\text{V.9})$$

$$u_j(E[n^*], m_{-j}) = [V(a, b, l(E[n^*]), r, \rho)] \zeta(E[n^*], m_{-j}). \quad (\text{V.10})$$

For any other strategy, with deviations on the total surplus-maximising bid, $[E[n^*] \pm \varepsilon] \neq E[v^*]$, greater than those allowed by h , $\varepsilon > h$ we have:

$$u_j(E[n^*] \pm \varepsilon, m_{-j}) = \quad (\text{V.11})$$

$$[V(a, b, l(\cdot), r, \rho) + \delta(\cdot)p + (1 - \delta) \cdot 0] \zeta(\cdot) + (1 - \zeta(\cdot)) \cdot 0 \quad (\text{V.12})$$

$$u_j(E[n^*] \pm \varepsilon, m_{-j}) = [V(a, b, l(\cdot), r, \rho) + \delta(\cdot)p] \zeta(\cdot). \quad (\text{V.13})$$

Suppose now there exists a player j , with $\delta(E[n^*] \pm \varepsilon) > 0$ for any $\varepsilon > h$, then

$$u_j(E[n^*] \pm \varepsilon, m_{-j}) =$$

$$[V(\cdot) + \delta(\cdot)p + (1 - \delta(\cdot)) \cdot 0] \zeta(\cdot) + (1 - \zeta(\cdot)) \cdot 0 \quad (\text{V.14})$$

$$u_j(E[n^*] \pm \varepsilon, m_{-j}) < 0 < u_j(E[n^*] \pm h, m_{-j}), \quad (\text{V.15})$$

This particular player has the subjective belief that there is a strictly positive probability, and that a penalty will have to be paid for any $\varepsilon > h$. With a sufficiently large penalty, all payoffs resulting from strategies, $E[n^*] \pm \varepsilon$, will thereby be negative for this player. Thus, this player, j , will submit a bid where deviations on the expected total surplus-maximising number of franchise periods, $E[n^*]$, are exactly equal to h .

If there exists another player, $-j$, with $\delta(E[n^*] \pm \varepsilon) = 0$ for some $\varepsilon > h$, then the payoff from $u_{-j}(E[n^*] \pm \varepsilon, m_{-j})$ would be strictly positive iff the probability that all other bids will not deviate more than h is positive, that is we require $\zeta(\cdot) > 0$. In a competitive bidding process, with a sufficiently large number of bidders, there will exist a player with $\delta(E[n^*] \pm \varepsilon) > 0$ for any $\varepsilon > h$, and therefore $\zeta_{-j}(m_{-j} \pm \varepsilon, m_j) = 0$.

Thus, all players, j , will submit the bid, where they maximise their expected payoff with

$$u_j(E[n^*] \pm h) =$$

$$\begin{aligned}
&= [V(\cdot) + \delta(E[n^*] \pm h)p + (1 - \delta(\cdot)) \cdot 0] \zeta(E[n^*] \pm h) + (1 - \zeta(\cdot)) \cdot 0 \quad (\text{V.16}) \\
&= [V(\cdot) + 0 \cdot p + 1 \cdot 0] \cdot 1 + (1 - 0) \cdot 0,
\end{aligned}$$

where the coordination parameter, h , is fully exploited, with submitted bids $m_j = m_{-j} = E[n^*] \pm h$. ■

Corollary V.2. *If it is common knowledge among all firms, $j, j = 1, \dots, M$, willing to participate in the bidding process but not the auctioneer that all firms, j , are identical, the estimates, m_j , of $E[n^*]$ will be identical for all firms, j .*

Proof. Follows from Proposition V.1. ■

Again, the equilibrium can be illustrated using a simple graphical representation.¹⁴ Analogous to Figure I strategies yielding payoffs lower than those associated with $E[n^*]$ and strategies close or equal to $E[v^*]$ are not feasible. However, since the auctioneer guarantees in Rule 8 that h will be smaller than the point where the penalty p is enforced, players now have a new point, where coordination is possible, namely $E[n^*] \pm h$. This equilibrium will be the dominant strategy iff some players believe that deviations larger than h may trigger the penalty, that is $\delta > 0$. This will only happen if players assume that the auctioneer is good at gathering information during the course of the franchise, and setting at a penalty.

In this case, the interested bidders may exploit the entire coordination variable announced by the auctioneer, even though they are in fact identical. Intuitively, this result is not surprising, since in the case with known homogeneity among bidders but not the auctioneer, bidders have a real information advantage. Further, the size of

¹⁴Note that in principle the profit-maximising number of periods could be more or less than the total surplus-maximising number. In the depicted graph, the total surplus-maximising contract length is longer than the profit-maximising one.

the information rent is determined by h , the prior belief of the regulator, so that if the auctioneer “gets it very wrong”, the price in terms of welfare loss will be high. Proposition V.1 also highlights the importance of commitment. It is clear from the perspective of the regulator if $h > 0$ and if $m_1 = \dots = m_M$, that bidders are indeed identical. To obtain the true $E[n^*]$, the regulator could simply subtract or add h from the submitted estimates.¹⁵ Of course, the regulator must ensure that such she can commit to the auction rules and not deviate, as this would be sub-optimal from an ex-ante point of view. If bidders would anticipate such commitment problems, then the truth revelation mechanism cannot work.

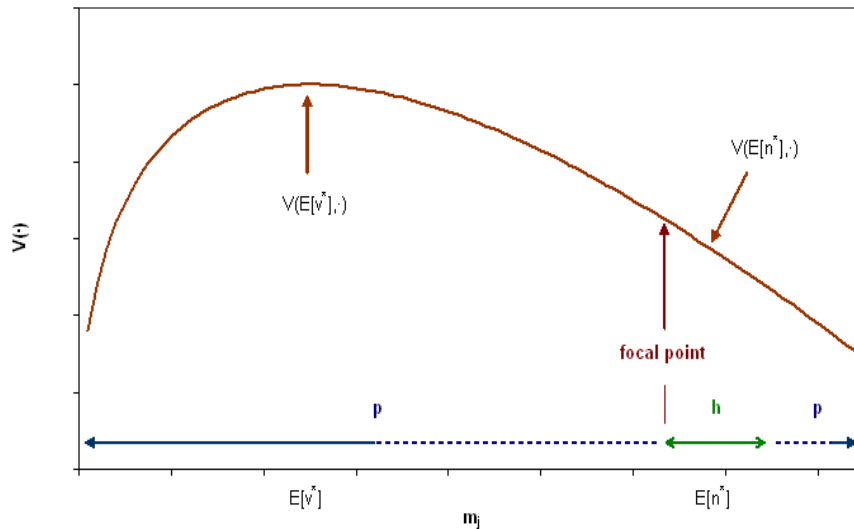


Figure II: EQUILIBRIUM WITH HOMOGENEITY BUT NO COMMON KNOWLEDGE

¹⁵This might not be easily possible, since the auctioneer would need to know whether longer or shorter franchise periods are better from the point of view of a total surplus-maximising agent.

VI Heterogeneous Bidders from the Point of View of all Players

The third possibility is the case when interested bidders are heterogeneous from the point of view of all players. Depending on her prior beliefs, the auctioneer will announce some $h > 0$ as outlined in Rule 2. Interested bidders believe that they are heterogeneous, and $V(\cdot) \neq V(\cdot)_j \neq V(\cdot)_{-j}$.

Proposition VI.1. *If some or all firms are heterogeneous from the point of view of the interested bidders, then deviations from the optimal $E[n^*]$ are limited by h .*

Proof. We have established that submitting a bid $m_j = E_j[n^*]$ will, for any given $\zeta(\cdot) > 0$, yield a strictly positive payoff

$$u(E_j[n^*], m_{-j}) > 0. \quad (\text{VI.1})$$

Similarly, submitting a bid $m_j = E_j[n^*] \pm h$ or $m_j = E_j[n^*] \pm \epsilon$, with $\epsilon < h$ for any given $\zeta(\cdot) > 0$, leads to the following payoffs:

$$u_j(E_j[n^*] \pm h, m_{-j}) = [V_j(a, b, l(E_j[n^*] \pm h), r, \rho_j)] \zeta(\cdot) > \quad (\text{VI.2})$$

$$u_j(E_j[n^*] \pm \epsilon, m_{-j}) = [V_j(a, b, l(E_j[n^*] \pm \epsilon), r, \rho_j)] \zeta(\cdot) > \quad (\text{VI.3})$$

$$u_j(E_j[n^*], m_{-j}) > 0. \quad (\text{VI.4})$$

We know from equation V.16 that any strategies $m_j = E_j[n^*] \pm \epsilon$, with $\epsilon > h$, will not be an equilibrium strategy. So now we are left again with a strategy set of $\{E_j[n^*] \pm h, E_j[n^*] + \epsilon, E_j[n^*]\}$ for any player j .

We now need to distinguish two possible cases, (1) that bidders assume that the auctioneer's announced h correctly reflects the degree of common knowledge in the

industry, and (2) that it does not. In the first case, we note that now $V_j(\cdot) \neq V_{-j}(\cdot)$ and therefore there may exist a player, j , for whom the payoff, for any given $\zeta > 0$, are given by

$$u_j(E_j[n^*] + h, m_{-j}) > u(E_j[n^*], m_{-j}). \quad (\text{VI.5})$$

At the same time, there may exist a player $-j$, for whom

$$u(E_{-j}[n^*] - h, m_{-j}) > u(E_{-j}[n^*], m_{-j}). \quad (\text{VI.6})$$

If both players in this case would submit this bid, then

$$m_j - m_{-j} = |(E_j[n^*] + h) - (E_{-j}[n^*] - h)| \quad (\text{VI.7})$$

$$= 2h > h. \quad (\text{VI.8})$$

Thus, such a bid will result in a payoff of 0, and no auction will take place.

Therefore, $E_j(n^*) \pm h$ will not be an equilibrium strategy. There is, however, another strategy which will ensure that the auction will take place, and guarantee strictly positive payoffs, namely

$$u_j \left(E_j[n^*] \pm \frac{h}{2}, (E_{-j}[n^*] \pm \frac{h}{2}) \right) =$$

$$= [V_j(\cdot) + \delta(E_j[n^*] \pm \frac{h}{2})p + (1 - \delta(\cdot)) \cdot 0] \zeta(\cdot) + (1 - \zeta(\cdot)) \cdot 0 \quad (\text{VI.9})$$

$$= [V_j(a, b, l(E_j[n^*] \pm \frac{h}{2}), r, \rho_j)] \zeta(E_j[n^*] \pm \frac{h}{2}, (E_j[n^*] \pm \frac{h}{2})), \quad (\text{VI.10})$$

with $\delta(\cdot)$, the probability that the penalty will have to be paid being equal to zero for all players. Any other strategy $E_j[n^*] \pm \epsilon$, with $\epsilon < \frac{h}{2}$, will result in a strictly smaller payoff than submitting $E_j[n^*] \pm \frac{h}{2}$. As we know from equation VI.7, any strategy, $E_j[n^*] \pm \epsilon$, with $\epsilon > \frac{h}{2}$, will not be played. This will leave only $E_j[n^*] \pm \frac{h}{2}$ as a possible equilibrium strategy.

In case (2), bidders believe that the auctioneer was not able to guess h correctly, and that the true heterogeneity in $E_j[n^*]$ is greater than the value assumed by the auctioneer. In this case, the strategy of submitting, $E_j[n^*] \pm \frac{h}{2}$, may yield zero payoffs iff $\zeta(E_j[n^*] \pm \frac{h}{2}, E_{-j}[n^*] \pm \frac{h}{2}) = 0$. Therefore, depending on player j 's beliefs on the degree of heterogeneity reflected in $\zeta(E_j[n^*] \pm \frac{h}{2}, E_{-j}[n^*] \pm \frac{h}{2})$, and on the valuations $V_j(\cdot)$, player j may find it optimal to submit some strategy $E_{-j}[n^*] \pm \epsilon$, with $\epsilon < \frac{h}{2}$. Thus, the players' optimal strategies are limited by h . ■

In the case of heterogeneous firms, the mechanism limits the deviations from the expected total-surplus maximising number of franchise periods, $E[n^*]$, by forcing bidders to take into account other bidders' possible valuations. Similarly to the previous case, with common knowledge only among bidders, the sufficiently large penalty ensures, that deviations larger than h are not an equilibrium strategy.

The deviations from the optimal $E[n^*]$ will also be smaller than in the previous case, as bidders now no longer have an informational advantage. Thus, this case is in between the previous two cases. Indeed, this result is quite intuitive, when bidders have more information on their heterogeneity than the auctioneer, then they would be able to extract more informational rent.

VII Conclusion

In this paper, we have demonstrated how an uninformed auctioneer, who tries to determine the welfare-maximising franchise duration, can devise a simple mechanism with the aim of forcing bidders to reveal their estimates of the optimal contract length. As shown in Section IV, in the case of homogeneous interested firms and common knowledge, we obtain the result that $E[n^*]$ is revealed truthfully. In all other cases,

bidders are able to extract a strictly positive information rent and are able to add a mark-up to $E[n^*]$. This implies that franchise bidding comes at a cost unless bidders are identical and it is known that they are.

At first sight, this may seem discouraging, since one of the main areas of franchise bidding is when the regulator has little or no information on cost and demand conditions. On the other hand, the regulator can minimise the informational rent she has to give up, by making h small. By setting $h > 0$, apart from case 1, the auctioneer gives players a coordination point, and thereby ensures that deviations from $E[n^*]$ are limited.

With regard to the regulator, the information requirements discussed in this paper are very low. This, however, is not the case for bidders. We assume that interested firms have perfect information about their own cost function and the market demand function at each point in time in the time interval $[0, T]$, which, admittedly, is a rather restrictive setting. Nevertheless, it seems sensible in a franchise bidding setting to assume that potential bidders are well-informed compared to the regulator.

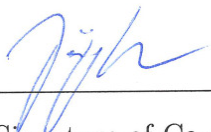
Our paper shows that revelation is difficult. The mechanism introduced can mitigate problems, albeit not perfectly. It will work best when potential bidders are known to be similar, which is most likely the case in infrastructure industries with an established technology and few differences in demand, such as water, postal services, as well as electricity transmission and distribution.

Appendix A

Co-author's Statement

I, Jörg Borrmann, University of Vienna, hereby declare that Chapter 4 of the thesis entitled “The Privatisation of Public Utilities” is based on joint work. I further declare that around 40 per cent of the work in Chapter 4 were undertaken by myself, the remaining percentage by Karina Knaus.

Vienna, July 2010



Signature of Co-author

Appendix B

Curriculum Vitae

Education	PhD Student in Economics, University of Vienna, Thesis Title: <i>The Privatisation of Public Utilities</i> Research Student in Economics, European University Institute MSc in Economics, University of Bristol, Dissertation with Distinction BSc in Economics and Sociology, University of Bristol, First Class Honours
Employment	Econometrician, E-Control, Austrian Regulatory Au- thority for Electricity and Natural Gas Full-Time Assistant, University of Vienna
Teaching	MSc-level courses: (a) Sector-specific problems in Public Utility Management, (b) Financial Services: Risk, (c) Advanced Topics in Public Utility Management; BSc- level course: (a) International Public Utility Manage- ment

- Awards**
- MSc and PhD scholarship from the British Economic and Social Research Council, (2003)
 - Full-time postgraduate scholarship from the Austrian Ministry for Education, Science and Culture (2004)
 - Research grant, University of Vienna (2007)
- Projects**
- Competition on the Rails: Evidence from the UK Experience*, 2006 - 2007 , funded by the Austrian National Bank.

Appendix C

Abstract

The thesis presents three essays on privatisation and market reform in infrastructure industries. An analysis of the British railway sector over a period of 40 years investigates whether the privatisation and divestiture of the former state monopolist led to performance improvements. Statistical and econometric analysis highlights the importance of scale economies. Further, there are strong suggestions that while liberalisation initially led to an increase in cost efficiency, performance deteriorated over time. The second essay looks at a very broad sample of over 2000 publicly and privately owned utilities in OECD countries. A range of performance measures are used to establish that market reform and private ownership have a statistically and economically significant impact on firm profitability and efficiency. Sub-sample analysis further suggests that the effects are not uniform across industries. Building on some stylised facts, the third essay builds a theoretical model of contract length in a monopoly franchise bidding system. In particular the model introduces a mechanism which can induce bidders to reveal the total surplus-maximising contract length to the uninformed regulator.

Appendix D

Zusammenfassung

Die Dissertation beleuchtet verschiedene Aspekte der Privatisierung und Liberalisierung in den Infrastruktursektoren Wasser, Transportwesen, Energie, und Postdienstleistungen. In einer Analyse des Britischen Eisenbahnsektors über einen Zeitraum von über 40 Jahren, wird der Frage nachgegangen ob die durchgeführten Reformen und Restrukturierungsmaßnahmen zu Änderungen in der Kosteneffizienz oder Qualität geführt haben. In einem zweiten Essay wird auf Basis einer Stichprobe mit über 2000 öffentlichen und privaten Infrastrukturunternehmen untersucht ob, und in welchem Ausmaß, Unterschiede im Hinblick auf finanzielle Kennzahlen erkennbar sind. Im letzten Kapitel wird in einem theoretischen Model ein Auktionsmechanismus vorgestellt, welcher die optimale Laufzeit bei Monopol-Konzessionen (“franchise bidding”) offenbart. Dabei wird unterstellt, dass die Bieter über mehr Informationen als der Regulator verfügen und der Mechanismus daher die Bieter dazu veranlasst, zumindest einen Teil dieser Informationen dem Regulator bekannt zu geben (“truth revelation”).

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