Network Industries, Economic Stability and Spatial Integration

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Abstract

The evidence on the implications of transport for regional economic and political integration is mixed. This is not surprising since transport is one element of a complex web of factors that determine the extent to which spatial areas become integrated. There are also good reasons to expect the optimal level of cohesion to vary between groups of regions and variations in the degree of integration. Much of the recent attention in Europe regarding the use of transport as an instrument of integration has centered upon the creation of an appropriate infrastructure as illustrated by the TENs Programmes of the European Union. Notwithstanding questions concerning the suitability of this approach to bring about greater cohesion through investment strategies, there are also issues concerning the way operations and use of transport networks can contribute to greater spatial economic integration. The focus of recent policies has been the liberalization of transport markets and the greater involvement of the private sector in providing actual transport services. There are theoretical grounds for suggesting this can enhance both the technical and dynamic efficiency of supply and these tend to be supported by the emerging empirical findings. The difficulties with relying on market and competitive forces to provide network services is the nature of supply and demand characteristics associated with networks may not produce a stable solution. At the extreme they can result in deficiencies in output and, under less theoretically rigid conditions, can lead to volatility in supply. The result is that even where transport may have the potential to enhance spatial cohesion this potential will not be completely realized. This paper, drawing in particular on the theories of Edgeworth, looks at the underlying nature of this potential problem, examines the empirical evidence with respect to some European transport networks and considers appropriate policy responses.

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INTRODUCTION

There has been a recent upsurge of interest in the economics of network industries. In part this can be explained by the dynamic technology and dramatic growth that has been experienced in the telecommunications industries, a process that is strongly supported by dynamic network externalities and the efficiency increases accompanying information and communications technology (ICT) networks. Less dramatic, but nonetheless important has been increased demand for transport services as incomes have risen, new logistics philosophies such as just-in-time production have gained acceptance, and barriers to international trade have been reduced. On the supply side, there has been increased interest in the role that investment in network infrastructure can play in both helping to stimulate spatial convergence of economic development and, at the macro-level, lead to increased aggregate production[1].

Institutionally the European Union (EU) has taken an increasing interest in the provision and use of networks as instruments in industrial, regional and trade policy. The Single Market initiative of the early 1990s has resulted in a phased removal of economic regulatory controls over most modes of transport, and the Trans-European Networks (TENs) initiative has began a processes aimed at stimulating more investment in new international infrastructure and greater overall co-ordination in policies.

This paper is less concerned with the enlargement and improvement of network infrastructures but instead explores their efficient use. In particular, the paper looks at issues of network stability and economic integration. Within this domain, a number of particular themes selective in there coverage are examined. In terms of exclusion, we do not attempt an assessment of the strict importance of network availability for economic development or economic integration. Although these are topical and important themes, they are ignored in our analysis. Nor is any new econometric work presented but instead reliance is placed on

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[1]   An interest recently stimulated by the empirical work of Aschauer (1990).

exploring the evidence of previous empirical work, the basic characteristics of modern networks and on insights gained from case study information.

What we concerned ourselves with is the extent to which the increasingly liberalized markets in network industries are likely to be stable in economic terms, and if instability is a possibility, then what should the policy response be[2]. By homing in on these issues, assumptions regarding the role of networks in regional integration are inherent. The very fact that potential economic instability in some network markets has been seen as a threat justifying a policy response by a number of national authorities implies that stability is an important goal for those concerned with spatial economic integration. There is little point in extending or improving physical networks if they are not subsequently used optimally.

ECONOMIC FEATURES OF NETWORKS

Networks exhibit a number of distinguishing features that affect their economic performance. The characteristic that has attracted the greatest attention in recent years is network synergy whereby positive externalities are generated as a network is expanded (Capello and Rietveld, 1997). A large bus network, for example, everything else being equal, offers far more options of route and destination choice than does a smaller one. Equally, a telephone network has more value if there is a large number of users who can make calls receive calls from each other. From a suppliers perspective, these conditions are often referred to as 'economies of market presence' in the management science literature. From an economic regulation perspective the nature of many networks means that a

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[2] In this context, instability in its extreme form would mean under or zero supply because a rational supplier would not enter a market knowing that it would result in sub-normal profits being earned at the new level of aggregate supply. This clearly poses problems in terms of evaluating the implications of such conditions. It should also be noted that the interest here is in inherent instability, not the type of transitory situation which can arise as markets adjust and actors make decisions based on less than complete information.

series of specific problems can be posed beyond those of the more general challenges associated with devising regulatory structures.

Physical communications networks are composed of a combination of fixed infrastructure (such as rail track) and mobile plant (such as trains). A key issue is the extent to which one can and should separate the regulation and ownership of the network infrastructure from the plant that makes use of it. A number of options are available but the issues involved are often complex. In some network industries such as road transport, much of the infrastructure is relatively flexible in terms of its use and is of such a general kind that there is little direct immediate interaction between decisions regarding its supply and use and the immediate decisions of those operating the mobile plant. This is less true of some other network industries where, for technical reasons, there is a closer link between infrastructure and operations. With rail transport, for example, overtaking is not easily done and co-ordination of infrastructure use across the various potential users is often seen as important[3].

Network infrastructure also seldom exhibits the classic characteristics of non-excludability and non-rivalness, and for its efficient use some mechanism of limiting access is required. A number of possible options are available that range from charging regimes to physical controls and rationing. One of the particular difficulties with many networks is developing a tractable access policy sensitive to the use made of the infrastructure. In many countries access to road transport infrastructure is limited by high annual license fees but these do not reflect actual use of the system nor provide incentives for efficient use. However, there may be high transaction costs associated with direct usage charging when jointness of supply imposes technical problems in defining appropriate prices and then imposing them on users.

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[3] This does not mean there is any agreement on how to treat track and operations in the railway industries (Brooks and Button, 1995).

In differing circumstances, networks can overlap and either compete with or complement each other. For example, local urban bus networks support inter-urban rail networks and telecommunications networks support the operation of air transport networks but motorway networks compete with inter city rail lines and postal systems compete with telecommunications networks. Given this interaction, insensitive regulatory structures can distort the synergy effects from complementary infrastructure or, alternatively, lead to misallocation of use when there is potential competition.

Regulation of any individual network must take into account the interactive effects that may impact the other competing or complementary networks. Linked to this are effects within networks, where any interventions influencing the performance of a particular link or node can have repercussions, often distant, on other elements of the network. For example, subsidies to a particular bus route may have implications for competing rail services but they may also impact, by altering travel behavior, another bus services. Slot allocation measures at one airport may have system-wide implications for all users.

Networks may provide suppliers with cost economies by allowing them to enjoy combined benefits of density and scope. An example of this is the hub-and-spoke operations practiced by many airlines. From the users' perspective, larger networks generally offer more choice (e.g. being linked into a large telecommunications system is generally much more useful than belonging to a smaller one). There are also economic benefits to suppliers resulting from market presence that facilitates more effective advertising and consumer awareness.

Indivisibilities exist in many industries, but this often poses problems for network industries offering a predetermined level of service. A scheduled train service, for example, offers a fixed number of seats but demand can vary both in a predictable way (daily peak/off peak demands) but also in a less certain way (variations in the weather).

Most manufactured and agricultural products are relatively durable in that if they are not consumed at the moment of production they can be kept for a certain period of time. In contrast, most network services, must be consumed at the point of production or are lost forever. An airline seat has to be taken at the time of departure or it will not be available again. Such features are not unique to network industries, seats in a theater have identical non-durable features, but such features result in pressures for suppliers to reduce prices to short run marginal costs with the prospect that full costs are not recovered. This issue is important to the existence of a core that is the focus of later in this paper.

ISSUES OF STABILITY

The 1980s and the 1990s have been characterized as a period of regulatory reform as the use of command-and-control instruments to steer industry has been liberalized. There has also been a general shift away from state ownership of manufacturing and services sector activities especially in the European economies. These changes have come about because of quasi-practical concerns expressed by economists such as Stigler and Posner who state interventions are often far from perfect and because of shifts on the intellectual side stimulated by economists like Schumpeter and van Hayek who believe that even perfectly executed policies limiting immediate monopoly power can delay and distort innovation.

While the economic analysis generally shows these changes to have enhanced the efficiency of production, the issue of long term stability in more competitive markets has received less attention.

Concerns over the economic stability of competitive markets has been examined over the last century yet it seems to attract only a periodic interest. Edgeworth (1881) addressed the subject of unrestricted competition for pure exchange with recontracting and Viner (1931) discussed stability issues of identical firms with U-shaped average cost curves and increasing marginal costs

producing a homogeneous product. Viner defined Pareto optimal conditions when competition exists between a large number of traders and coalitions[4].

The emergence of game theory in the late 1940s revived intellectual interest in market stability and, more recently, Scarf (1962) and Scarf and Debreu (1963) used this in developing the modern theory of the 'core' including giving a limit theorem for the core of an economy. Linked with this, but tackling the issue from a different angle, has been the development by Baumol and others of theories concerning the contestability of markets and their potential sustainability (Baumol *et al*, 1982).

More recently Telser (1978; 1987; 1990; 1991; 1994; 1996) has resurrected the topic so in a way relevant for the deregulated network industries that have emerged in the past two decades[5]. The economic analysis has been led largely by theoreticians, and much of it is of a technical nature[6]. The analysis of the early papers related to general exchange conditions issues, while the initial applied work was not specifically directed at the peculiarities of network industries (Bittlingmayer, 1982; 1985). The situation has changed somewhat recently with empirical literature emerging that emphasizes shipping (Pirrong, 1992; Sjostrom, 1989; 1993) and aviation (Button, 1996)[7].

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[4]   Much of the literature of the inter-war period that looks at overhead costs and efficient operations also fits into lineage of core theory, e.g. Clark (1923), Jones (1924) and Knight (1921).

[5]   The evidence of the implicit concern with the possibility of market instability in liberal network industries over the years, although couched in somewhat different terms can be illustrated by a whole range of measures such as: the controls introduced into the UK bus and trucking industries in the 1930s; the banning of jitney operations in the US in the 1920s; the arguments in the EU in the 1960s and 1970s for the need of a lower fork on trucking rates; the acceptance by most countries on international cartel arrangements in shipping and aviation; and the adoption of the EU in the 1990s of the ability to limit market entry and control minimum air fares.

[6]   Telser (1994) offers a general introduction to the theory of the core that is at the heart of recent instability analysis but a much more accessible account is that of Smith (1995) in the particular context of the aviation market. Sjostrum (1989) is less technical and offers a practical approach to considering whether a market is likely to prove inherently unstable or not.

[7]   Button (1997) offers a more general examination of the relevance of core theory to network industries. It should be noted that the non-existence of a network service thought important for social reasons to do with policies of access or income distribution does not imply the lack of a core.

Telser (1996) highlights the types of situation where a core may be empty, 'With relatively large fixed costs, avoidable (set-up) costs, indivisibilities, or network effects, unrestricted competition cannot bring about a stable efficient outcome' and adds 'Many public utilities, transportation industries, and some manufacturing industries … seem to have cost conditions in which a stable, efficient equilibrium is possible only by means of a suitable restriction on competition'[8].

An Appendix to this paper explains in graphical form why some empty-core situations may emerge. The general conclusions reached from Sjostrom's synthesis of the theoretical work on these issues are:

- the greater the variation in suppliers' minimum average costs, the more likely there will be a competitive equilibrium;
- there is more likely to be an empty core when demand is less elastic;
- the larger a supplier's capacity relative to the market, the more probable the core will be empty;
- agreements to create a core are more likely during an economic recession;
- wide variability in demand or costs increase the probability of agreements;
- agreements are less likely when there are legal restrictions on entry.

To complicate this empirical analysis several of these conditions are also consistent with collusion for rent seeking purposes. Table 1 provides a summary of situations where this is the case. Hypothesis testing is possible where there are differences in direction of the relationship. For example, if demand conditions are relatively inelastic, then collusion is more likely for reasons of avoiding the problems of an empty core than for rent seeking motives.

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[8] A core may not be unique but there may be a number of potential outcomes that can constitute a core. Telser (1978) is particularly relevant for network industries and many of the main arguments surrounding core issues are set out in the context of a simple aviation market example.

EMPIRICAL EVIDENCE

While liberalization of network markets is an on-going process at the moment[9], there are an increasing number of experiences that may be drawn upon to assess the empty core hypothesis. These, however, must be taken as indicative of the possible existence of an empty core, and to-date no rigorous method of testing for empty cores has been devised.

Table 1. Differing conditions for rent seeking and stability collusion

	Chance of Collusion	
	Cartel	Empty core
Heterogeneous supply	Low	Low
Less elastic demand	Low	High
Small numbers case	High	High
Industry in slump	Unclear	High
Variable supply/demand	Low	High
Legal restrictions	High	Low

Sjostrom's own analysis, which essentially follows a 'structure, conduct and performance' approach, looks at conditions pertaining in shipping conference markets to explore the extent to which these cartels conform to situations consistent with either a monopoly rent seeking or empty core scenario. Given the data available, Sjostrom explores if there are legal restrictions on entry (making the core theory for collusion less likely) or severe temporal variations in demand and costs (making the core theory more likely). After looking at data relating to 24 shipping conference routes operating to and from the West Coast of the United States in 1982, he concludes that the cartel theory can be rejected and support can be found for the theory of the core[10].

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[9]   For example, Button and Keeler (1993) offer an account of recent developments in the transport sector.

[10]   Because the quantity shipped by a conference depends partly on the effectiveness of the cartel, Sjostrom used a two stage estimation of the general form:

CON = f[Q, SD, P, REST]
Q = f [CON, LDC, EXP, IMP]

where:

Pirrong's approach, of looking at shipping cartels complements Sjostrom's by putting emphasis on exploring costs[11]. In particular, he looks at the relations between cost, demand and market organization. Pirrong isolates conditions where the demand structure is finely divisible and the cost curves are non homogeneous when describing the circumstances where competition is not feasible. The evidence, he concludes, is consistent with Sjostrom's findings and suggests collusion and coalitions in the shipping market serve to ensure stability and avoid competitive chaos. Whether the exact nature of the collusion is efficient could not be judged.

These developments in empirics also provide a basis for looking at the situation in aviation markets. While the analogy cannot be taken too far, parallels exist between the shipping conference system and the aviation market. Like scheduled aviation, shipping lines provide regular, scheduled services that involve, through electronic data interchange systems, crude yield management procedures (Brooks and Button, 1994). Tramp shipping is akin to the charter services operated in aviation and hub-and-spoke patterns of shipping service are emerging. Deferred rebates and other loyalty payments offered in some conference markets have similar implications to frequent flyer programs. The

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CON: Conference's share of liner shipments on its route
Q: Quantity shipped on liners
SD: Standard deviation of liner shipments on the route
P: Average value of goods shipped on the route by liner ships
RES: Dummy variable isolating Latin American, Indonesian and Philippine routes
LDC: Dummy variable isolating routes to and from less developed countries
EXP: Total exports of the country in which the liner cargo originated
IMP: Total imports of the region of the cargo's destination
The equations estimated using two-stage least squares yielded:

$$CON = 3.37 - Ln0.22Q + 1.53E\text{-}6SD + 0.03P - 0.54REST$$
$$LnQ = -0.24 + 2.98CON - 0.73LDC + 0.49EXP + 0.48\ IMP \qquad n = 24$$

The signs of the coefficients of the SD and REST variables are consistent with the existence of an empty core. They are significant at the 95 percent level.

[11]   The potential existence of an empty core has also been explored by examining cost function in the context of experimental economics as well as more conventional procedures discussed below (Van Boening and Wilcox, 1992)

move towards consortia in liner shipping has similarities to code-sharing in aviation markets and shipping berth allocation is common airport slots, with differential handling charges according to line in both cases.

While implicit recognition of the potential for an empty core situation is starting to arise in the reformed European aviation market, this area has only partly been explored. Comparative analysis is possible, and a number of studies have pointed to inherent similarities and differences between the European market and the obvious point of comparison, the deregulated US domestic market but they do not go beyond this (e.g. Button and Swann, 1992). Despite considerable out-flows of work on the efficiency of US domestic aviation very little has been attempted on market stability, Sandler (1988) being an exception.

Button (1996), makes use of the general analytical framework established by Sjostrom and Pirrong and examines the European international aviation market for signs of potential instability. The study took 1990 data covering 106 international routes within Europe.

The empirical results, based on Sjostrom market entry approach, provided indicative but not conclusive evidence that the increasing number of collusion arrangements emerging in European aviation markets may be coming about due to the existence of an empty core but they do not go beyond that[12]. The statistical

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[12]   The general formulation of the model employed was;

SE = f(AD, LR, NC, CR, TF, PL, NR, DV)

where:
SE: Percentage of traffic on a route carried by airlines from countries at either end of the route
AD: Distance between airports in kilometres
LR: Acts to reflect the nature of the legal environment is a dummy variable taking a unitary value if the route is the subject of a liberal bilateral.
NC: Number of carriers on the route
CR: A dummy variable taking a value of unity if the route serves north-south traffic to reflect possible competition from charter services
TF: Total flights
PL: Average load factor
NR: A dummy variable taking the value of unity if there was no service in 1985

associations, although generally in the direction that would support this hypothesis, are extremely weak. The direct application of Pirrong's cost function approach to aviation is difficult because of data limitations, but the general nature of the costs functions exhibited by the airlines would seem, from other empirical analysis, to offer the potential for an empty core condition to exist[13].

DV: The annual variability of demand between 1985 and 1990 expressed as the coefficient of variation in annual passengers carried on each route included in the analysis.

For estimation purposes the specification of the dependent variable is in terms of a log-odds transformation to allow for it being bounded in its natural form. Estimation was conducted using OLS. The estimated equation was:

$$Ln[SE/(1-SE)] = 8.855 - 0.001AD + 0.538LR - 2.002NC + 1.512CR +$$
$$0.001TF + 14.630PL + 5.101NR + 2.200DV \qquad n= 106 \quad R^2 = 0.50$$

The results offer some tentative support for the possible existence of empty core conditions.

[13]   More specifically, the types of condition are summarised by Pirrong (1992) as, '...if the cost functions of individual plants contain regions of both increasing and decreasing returns, demand is variable, and if plants serve several customers simultaneously, the core is almost always empty.'

POLICY OPTIONS

If some competitive network industries are potentially prone to instability why has this appeared to manifest itself so infrequently in practice? One purely theoretical answer, consistent with the theory of the core, is that suppliers will not exist in such markets and thus the hypothesis is not empirically refutable. In practice, however, the extreme conditions required for non-supply are unlikely to exist, and instability would more logically manifest itself in terms of rapid market entry and exit of suppliers and users accompanied by violent price fluctuations. There may be either natural market feedback reactions or implicit institutional factors that limit the problem.

Since there is a *prime facie* for suspecting at least some network industries may, if left to pure market forces, be confronted by empty core and instability problems, what should be the appropriate policy response? There are four broad ways policies can be developed to counter-act market instabilities in network industries or, stating in technical terms, to 'resolve' an empty core;

• the situation may be deemed unimportant and no action taken;

• policies may be instigated with the aim of manipulating the role of markets;

• policies may be instigated involving institutional measures that involve direct provision of networks; and

• policies may allow actors in the market to tackle the problem internally through the adoption of coalition or other measures.

Leaving the situation to market forces may prove the most effective approach. Because of lack of precise knowledge of the mechanisms at work or distrust of the suitability of the remedial policies at hand, intervention failures are likely to outweigh the market failure of instability if the latter is not severe[14]. In

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[14]   As with any activity, government intervention may result in intervention failures which produce outcomes worse than those associated with market failures. For instance, to protect a supplier against the full rigors of the market by instigating bankruptcy laws along the lines of Chapter 11 in the USA can worsen the empty core problem. Airlines, for example, have fixed costs associated with their aircraft but have avoidable costs associated with their use on scheduled services. If a relatively small number of airlines compete intensively to fill all seats

general it is difficult being precise about the existence of an empty core and even more difficult is the design of policies to ameliorate the problems associated with the market failure.

One approach is to directly intervene and limit the degree actors can price down to marginal cost or saturate the market. As Telser (1994) says, '…a general method of resolving an empty core requires imposition of suitable upper bounds on the quantities that may be sold by certain sellers. Such bounds always exist.'

The European Union implicitly exhibited concern about the potential for empty core problems in both trucking and aviation. Trucking, policies in the 1970s aimed at deriving a system of 'forked tariffs' with upper and lower limits, with the latter to prevent excessive competition. Equally, EU Council Regulation 2408/92 allows freezing of capacity when the aviation market is fundamentally unbalanced and Regulation 2409/92 for intervention to prevent downward spirals on air fares. At a local level, it is normal for taxicab markets to operate under a regime of regulated fares and, in some cases, with market entry controls[15].

The difficulty with direct actions, however, is to determine the appropriate price floor or capacity ceiling. A problem which is particularly pronounced in a network setting. The issue becomes one of weighing the potential costs of market failures, and the implications of the empty core, against the resources costs of intervention failures where parameters are misspecified. The problems are a mirror reflection of the challenges of specifying anti-trust and monopoly regulations when dealing with suppliers' efforts to gain an excess of market power.

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over a specified route, it is possible their fixed costs will not be recovered. If one or more carriers then seeks Chapter 11 bankruptcy protection this will reduce the fixed costs of their services but put financial pressures on their competitors. The others airlines will, in turn, be forced into bankruptcy to adjust their cost structure. After several successive rounds, fixed costs will fall to zero but also will the incentive to invest in these networks. The supply then falls to zero even though net social benefits would result from its provision.

[15]   The Medallion system in New York City is the most famous of the quantity control regimes.

Since the main problem of an empty core is insufficient or, at the extreme, no supply, government may intervene to directly provide capacity. This approach has been one argument used in the past to justify the sate ownership of networks. In general, removing of market incentives leads to reduced efficiency and higher unit costs of provision especially where policies mean that cross subsidies are deployed. In practice it has been difficult isolating circumstances that are a genuine empty core problem from instances where the demand curve for the network services lies entirely within the cost curve and, *ipso facto*, no capacity could be justified on positive economic criteria. Examples involve situations where there may have been grounds for public provision to meet an empty core problem but subsequent shifts in either costs or demand no longer justify such actions. Closures of rail links often pose this type of problem.

Intervention to stimulate supply may also take the form of subsidies or institutional structures that foster cross subsidization. The creation of postal and other networks have generally involved this type of intervention.

The final alternative is allows those in the market to tackle potentially empty cores themselves – that is develop managerial approaches and market strategies that circumvent the instability implications inherent in many network industries. In passenger aviation, for example, one can explain frequent flier programs in terms of retaining customer loyalty while keeping fares above short run marginal costs in a volatile market[16]. Further, airline mergers, particularly those after the introduction of the 1978 deregulation of US domestic markets, strategic alliances[17] and franchising can be seen as controlling aspects of supply and yield management techniques to price discriminate and generate maximum revenue.

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[16]   Telser (1996) argues the general case thus, 'Participants in a market lacking a core do contrive arrangements that will suitably restrict competition.… Long-term contracts between suppliers and their customers such as the take-or-pay contracts in natural gas are arrangements that restrict competition insofar as they eliminate some spot markets.'

[17]   These can take a variety of forms and often include related frequent flier programmes, code-sharing and co-ordinated schedules but can also embrace equity swaps.

Similar types of argument, successfully used to maintain the system of shipping conferences and offering parallels for aviation, can be found in the form of conferences (Bennathan and Walters, 1972), deferred rebates (McGee, 1960) and, more recently, the development of consortia. Historically, the background is more extensive with shipping conferences existing since 1879 as technology first began to allow scheduled, network services to be offered. The continued existence of a conference structure, despite many official inquiries, offers testament to the role they play in limiting potential instability in shipping markets[18].

In several ways, this type of approach has been implicitly accepted in some policy areas. It was pursued in the domestic US aviation market when mergers policy, in the hands of the Department of Transportation, was comparatively lax in the twenty years following deregulation and devices such as the frequent flier program were developed. Equally, EU aviation policy has allowed mergers, provided that certain concessions are made (e.g. the relinquishing of designated routes) to limit resultant market power and has provided block exemptions from elements of competition policy. Further, frequent flyer programs have not been attacked under EU competition policy, and these provide a mechanism for retaining customer loyalty across periods of fluctuating demand. At the international level, shipping cartels have been permitted, the International Air Transport Association (IATA) has enjoyed the power to influence fare levels and, more recently, anti-trust immunity has been afforded by some governments to the strategic airline alliances that have emerged.

The policy challenge is to ensure if such devices are used, their potential costs in terms of the possible monopoly power do not exceed the benefits of

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[18] An alternative argument is that even without shipping cartels, the scheduled liner market could still have a core. Through the creation of freight forwarders, which consolidate traffic, an effective structure on monopsonist have emerged who can negotiate long term contracts with the shipping lines and thus can solve the empty core problem.

avoiding potential empty core situations. This is particularly difficult in network industries where conventional anti-trust policies pose problems of implementation because appropriate markets over which legal judgments can be made are difficult to define. This is exemplified by recent debates over international strategic airline alliances where policy makers must decide if it is a service, a route, a set of routes or a wider network that forms the basis of the market under review. The complexity of cost allocation over networks also poses serious potential problems of regulatory capture.

CONCLUSIONS

The economic evidence is that recent market liberalization has, in general, enhanced the technical and dynamic efficiency of network industries in the transport and telecommunications sectors. Markets, however, are not static entities, and there are inevitable shifts over time on both the demand and supply sides. In normal circumstances, this may not pose any serious problem, Given the basic characteristics of network industries, however, there is the possibility that instability may result and, in the extreme condition, no supply being provided despite the net economic benefits that exist. In other words, many network industries may be characterized by an empty core if competition is fostered.

While numerous cases exhibiting the extremities of an empty core are unlikely to emerge in practice, the features of many network markets mean that volatility may be high with services provided on an intermittent and unreliable basis. This raises issues about appropriate government policy responses to such conditions.

Policy may take a number of courses, but is unlikely that there is any ideal approach to handling the problem of empty cores. Much depends on the ability of policy makers and their analysts to identify instances where empty core problems are likely to exist and the possible order of their magnitude. But beyond, different policy approaches will have associated a variety of transaction cost considerations

and may be involved with complex distributional questions. There seems no straightforward *a priori* approach to policy formulation in empty core situations. Rather, additional empirical analysis is required to provide a more stringent set of criteria from which *ad hoc* sectoral policies can be developed. If the considerable investments which now go towards developing infrastructure networks are to achieve their primary goal of enhanced spatial economic integration, it is important that effective policies for tackling empty core problems be devised.

APPENDIX

Core theory focuses on cost and demand structures as determinants of market structure. In simple terms, for Adam Smith's 'Invisible Hand' theorem to eliminate dead-weight loss and prices to guide individuals to outcomes that maximize economic welfare (a) the aggregate industry production function must be superadditive so that the sum of the outputs of two separate organizations does not exceed the total output resulting from their merger and (b) the aggregate industry production function must have non decreasing returns to scale.

Telser and others have added to these two conditions in order to embrace the problems of empty cores. Notably, 'One feature …[of] empty cores is that the firms' total costs resulting from the factor prices generated by unfettered competition among them for the factors of production exceed the total revenue so that none can survive, although there is a net benefit to the public from having these commodities.' (Telser, 1966)

The literature on situations when an empty core can arise tends to be highly abstract and is often avoided because of the difficulty to access. This appendix provides verbal and graphic descriptions of the types of actual market situation when an empty core can emerge. It is not comprehensive but rather offers a degree of theoretical support for some discussion in the body of the paper. It draws on the theoretical writings of Telser but also Sjostrum's (1989) work, that clarifies many points regarding inefficient entry, and Pirrong (1992), that provides analyses cost indivisibilities.

1. The Viner Case

The core is often empty when demand is finely divisible but production costs are not. The often cited Viner (1931) case of a non-core outcome in a network industry is illustrated by taking two identical suppliers (such as airlines on a route) with standard U-shaped average cost curves. Therefore, fixed costs are assumed. Marginal cost on the route is a discontinuous function of total airline

output and equal to the minimum average cost of the aircraft at two points in Figure A1, namely Q1 and Q2. The demand is continuous and represented by D.

In this scenario if one airline operates a flight, excess profits will be earned. Expansion to two aircraft, as the second carrier is attracted to the market, will result in both making a loss as competitive pressures lead to prices being driven down to marginal cost. Only if by chance the demand curve intersects the average cost curve at a point coincidental with the marginal cost curve will a stable outcome emerge.

The problem is created because any increase in the number of firms from n to n+1 affects both the total variable cost and the total fixed cost of the industry. Optimality requires comparing a higher fixed cost of having one more firm and the reduction in variable cost of each firm producing less in a situation where demand is satisfied at a price equal to marginal cost. Efficient industry equilibrium will not generally be where the firm's unit cost is minimized. Increasing the number of firms does not affect the outcome until the number becomes very large at which point the Pareto-optimal number of undertakings is reached.
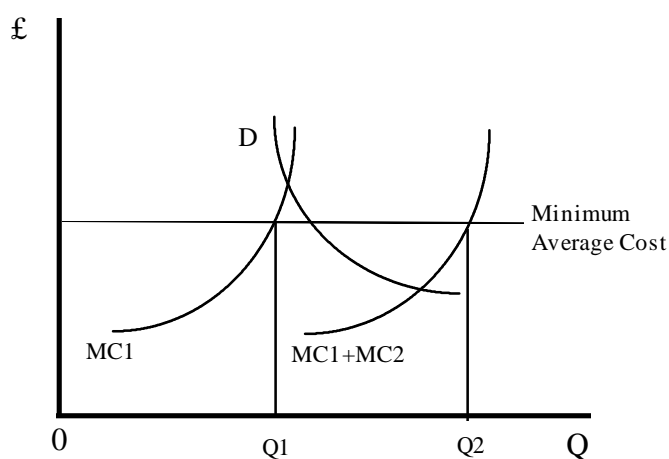

Figure A1

2. Non-identical firms

It is possible for an empty core to emerge if the Viner assumption of firms being identical is relaxed. For example, the firms may have different minimum average costs as seen in Figure A2. Here the industry supply curve is depicted as being discontinuous and upward sloping. In this case, the core is empty when the continuous market demand curve goes between the segments of the industry supply curve. The more homogeneous the suppliers are and the less their minimum average costs differ, the more likely is the market demand curve to pass through a gap (with perfect homogeneity one has the Viner case) and hence, the higher the probability there will be an empty core outcome. The greater the variation in cost curves, the higher the probability of a competitive equilibrium.
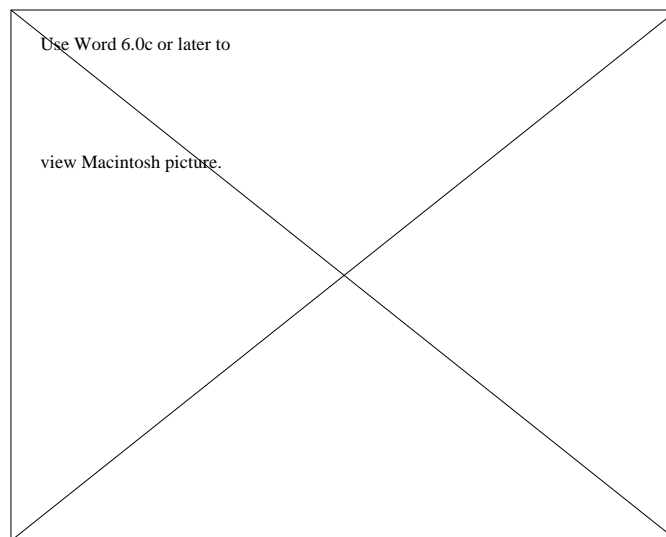
Use Word 6.0c or later to

view Macintosh picture.

Figure A2

3. Low elasticity of demand

Figure A3 illustrates a situation where suppliers are not homogeneous but each has a vertical supply curve. A typical section of the industry supply curve is depicted as VWXY. D1 and D2 represent possible, vertically parallel market demand curves. For the market to have a core the market demand must lie between Y and X. From simple observation, at any price, the less elastic the demand curve, the more likely it is to fall into a gap in the supply curve, e.g.

between X and W. At the extreme when demand is perfectly inelastic, the probability of an empty core is unity. With a perfectly elastic demand curve a core must exist.

4. *The market in a slump*

The state of the market can influence supply when fixed costs are involved. If individual suppliers have U-shaped cost curves that imply an element of fixity in costs, then they may remain in the market for a period, even if average total costs are not completely covered as would costs between C_1 and C_2 in the left-hand image in Figure A4.

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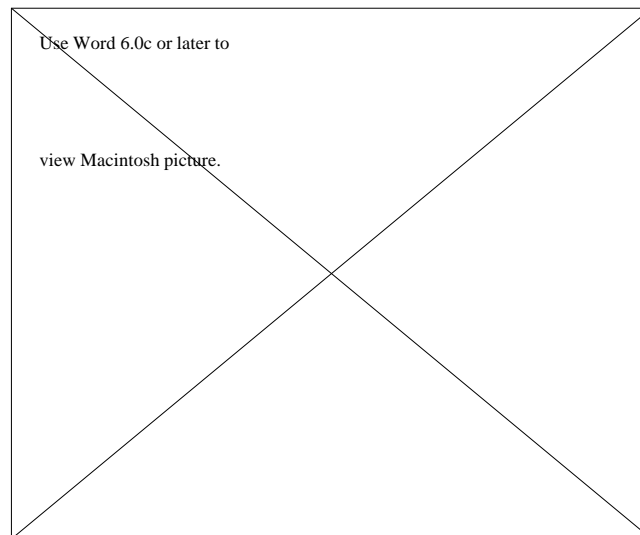
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Figure A3

The right-hand figure shows the market with n supplying undertakings. If demand rises slightly above D_1 there will be no entry since a newcomer of minimum scale q_1 would drive the price down below C_1. Equally, a small drop in demand would not cause an exit because of the fixed cost factor. In terms of core theory, the core is not empty for a small rise or fall in demand. If demand falls below D_2, then an empty core situation does emerge since the market cannot support all the n suppliers in the market.

From a pragmatic perspective, therefore, the core is more likely to be empty when an industry is in a slump. A shift up in the avoidable cost curves confronting firms has a similar implication.
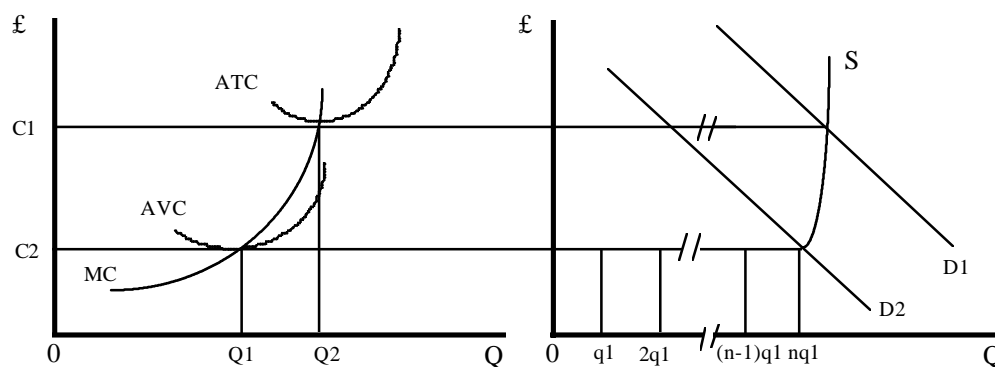

Figure A4

5. Fluctuating and uncertain demand

Linked to the above, variability in demand can lead to an empty core. In situations where there is a U-shaped long run cost curve (as in Figure A5) but with substantial fluctuations in demand (between D_1 and D_2 at the extremes) then establishing a fixed price at the competitive equilibrium, q, will result in losses at all times besides when demand coincidentally cuts the LRAC at the minimum point. Perfect market adjustments to allow prices to vary as demand fluctuates would remove this problem. But with the provision of scheduled services, where service output and prices are set in advance, there is very limited scope for this. With this information, suppliers will not enter the market unless they can be assured of a price across the range of demand fluctuations that ensures normal profits may be earned.
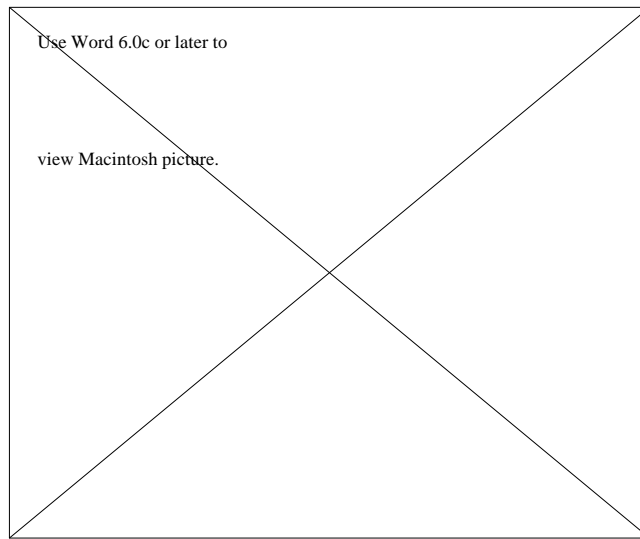
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Figure A5

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