Lecture 9 - Transportation

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1 Key economic characteristics of transport industries

1. Transport is capital intensive.

    (a) One of the most important inputs for any tranport mode or sector is the fixed cost associated with the underlying infrastructure. For automobile transport, a fixed cost must be incurred to build roads. For trains, rails must be constructed. For boats, a river or a canal must be maintained. For air travel, airports and traffic control need to be invested in. As a result of these heavy fixed costs, these industries are increasing returns to scale industries. Because of this, the provision of transport infrastructure is a natural monopoly. In the absence of government intervention, the monopoly provider of the infrastructure is likely to provide too little at too high a price in order to maximise profits. Two common methods that attempt to address this problem are: a) public provision of infrastructure, b) government regulation of privately provided transport infrastructure.

    (b) A second important input in transport is the vehicle/carriage/train/rolling stock/boat/etc. This input is also an important fixed cost in providing transport. This capital input is sometime provided by firms, sometimes by governments, and sometimes by consumers.

    (c) An important technological constraint that governs the relative efficiency of organizational arrangements concerning infrastructure and vehicles, is the cost of contracting or coordinating the services provided by the two forms of capital. For trains, the costs of coordinating the services of the rail infrastructure and independent rolling stock is often relatively high. For automobiles, the costs of coordinating the services of the road infrastructure and the vehicles is relatively low. That is one reason why rail providers and train providers tend to be integrated while road providers and car providers tend not to be integrated.

2. A model.

(a) Let demand for transportation be

$$y = d(p).$$

(b) Let production cost under private provision be

$$\begin{aligned} C(y) &= kn + cy \\ y &= \sum_{i=1}^{n} y_i \end{aligned}$$

where k is the fixed cost, n is the number of firms, c is the marginal cost, and y_i is the supply of firm i.

(c) Costs are minimised when there is one firm.

(d) Monopoly solution is

$$\max_{\{p\}} \{d(p)\,p - k - c\,d(p)\}$$

with first order conditions

$$\begin{aligned} d(p) + (p-c)\frac{\partial d}{\partial p} &= 0 \qquad (1) \\ \frac{d(p)}{p \cdot \frac{\partial d}{\partial p}} &= \frac{p-c}{p} \\ \frac{1}{\varepsilon} &= \frac{p-c}{p} \end{aligned}$$

where

$$\varepsilon = \frac{p}{d(p)}\frac{\partial d}{\partial p}$$

is the elasticity of demand and $\frac{p-c}{p}$ is the percentage markup of price over marginal cost. This formulation shows that the optimal markup of the monopolist depends on the elasticity of demand.

(e) Or alternatively,

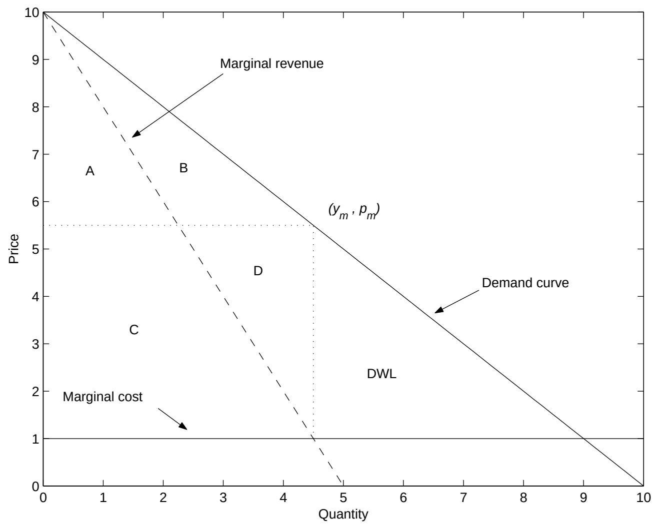
$$\max_{\{y\}} \left\{y d^{-1}(y) - k - cy\right\}$$

with first order conditions

$$\begin{aligned} d^{-1}(y) + y\frac{\partial d^{-1}(y)}{\partial y} - c &= 0 \\ d^{-1}(y) + y\frac{\partial d^{-1}(y)}{\partial y} &= c \end{aligned}$$

where $d^{-1}(y)$ is the inverse demand curve. This formulation is equivalent to (1). It shows that the optimal quantity of the monopolist is the one that equates marginal revenue to marginal cost.

Figure 1: Monopoly pricing



(f) The solution is shown in Figure 1.

- (y_m, p_m) is the monopoly quantity and price determined by the intersection of the marginal revenue curve and the marginal cost curve
- DWL is the deadweight loss relative to efficient pricing
- The area A+B is the consumer surplus at the monopoly solution
- The area C+D is the profit of the monopolist before paying the fixed cost

(g) It is possible for a monopolist to price and achieve an efficient solution. Suppose that the monopolist could charge a fixed fee such as an annual fee for road use and then charge a per unit fee of p_e. Then the monopolist could set

$$p_e = c \tag{2}$$

and $f_e = A + B + C + D + DWL$. This would be efficient. However, consumers would retain no surplus. All the surplus would go into monopoly profits.

(h) Regulated outcome: Government requires price satisfies (2) and restricts $f = \frac{k}{d(p_e)}$ so that monopolist earns zero profits.

i. Problem: monopolist has incentive to claim k and c are too big.

ii. Costly for government to monitor. Actual outcome is

$$\begin{aligned} f_r &= \frac{k + k_r}{d(p_r)} \\ p_r &= c + c_r \end{aligned}$$

where (k_r, c_r) are amounts due to imperfect monitoring and due to monitoring costs. To the extent $c_r > 0$, there will be some deadweight loss. Additionally, any component of these costs that primarily is spent on monitoring and regulating is effectively lost resources. Any component of (k_r, c_r) that is not spent on monitoring or on regulating, is effectively a transfer from consumers to the monopolist.

(i) Public ownership outcome. Government runs the system and sets efficient price.

i. Government not as efficient at minimising production cost. (Why? Because incentives of government are determined by political power and bureaucratic power. Also, government may have incentive to use public ownership to transfer resources from one group to another at the cost of efficiency. The former is a cost of public ownership. The latter is a rational choice of the government to trade off equity and efficiency.) As a result, it is likely that $k_g > k$ and/or $c_g > c$ so outcome is

$$\begin{aligned} f_f &= \frac{k_g}{d(p_g)} \\ p_g &= c_g > p_e \end{aligned}$$

ii. This results in:

A. Inefficiency if high costs are due to poor managemnt, bad incentives

B. Transfer to public sector employees. This may or may not be a good thing.

(j) Public/private subcontract

$$p_s = \frac{k_g + c_s}{d(p_s)} + c$$

where c_s is the contracting cost and the government charges an access fee per passenger of

$$f = \frac{k_g + c_s}{d(p_s)}$$

3. Externalities.

(a) Many forms of externalities are associated with the provision of transport services. These include congestion externalities, air, water, and noice pollution, aesthetic factors associated with land use, and architecture, and safety externalities.

(b) Many laws, government regulations and tax policies are aimed at improving the efficiency of market outcomes in the presence of these externalities. These include laws dealing with liability for automobile accidents, regulations on highway speeds and vehicle safety, taxation of petroleum, cngestion taxes, and many other government policies.

4. The costs and benefits of various transport services often depend in important ways on the time of travel and the location of travel.
   (a) Peak versus off peak travel are valued differently by consumers.
   (b) Travel to the centre of the city is valued differently than travel to the countryside and this relative valuation depends on time of day or time of the week.
   (c) Both the costs of operating a transport services and the social costs associated with them, also vary with both time and location. The marginal cost of an additional traveler on the subway is very high during peak hours and very low during off peak hours.

5. Government interventions in the transport industry are large.
   (a) Large components of transport infrastructure are publicly provided.
   (b) Large fractions of transport services are publicly provided in some countries.
   (c) Taxes and subsidies affect use of transport services, use of complementary goods and services, and pollution.
   (d) Governments regulate safety, land use, prices, entry into the industry.

6. Two main benefits from transport.
   (a) Consumer benefit from utility gained from transport.
   (b) Industry benefit from transport of inputs (materials, labor) outputs (goods) and/or customers.

7. Social welfare.
   (a) To maximise social welfare.
      i. For example, assume 3 types of transport investments and 6 types of transport services.
         A. Investments: k_1 is investment in road 1, k_2 is investment in road 2, and k_3 is investment in rail.
         B. Transport services: t_1 is travel by road 1 during peak hours, t_2 is travel by road 1 during off-peak hours, t_3 and t_4 are travel by road 2 during peak and off-peak hours, and t_5 and t_6 are travel by train during peak and off peak hours. Let $T = (t_1, t_2, t_3, t_4, t_5, t_6)$ be the vector of all transport services provided.

ii. Calculate industry benefit as function of transport investments (possibly heterogeneous). Suppose there are I industries. The total benefits to industry i are $B_i(T_i)$ where T_i is the vector of transport services used by industry i.

iii. Calculate consumer utility from transport investments (possibly heterogeneous). Suppose there are J consumers. The total benefits to consumer j are $B_j(T_j)$ where T_j is the vector of transport services consumed by consumer j.

iv. Calculate social costs of each for each level and composition of transport demand : (infrastructure costs + use and operating costs + externatities). Assume the total costs are

$$C(T, k_1, k_2, k_3) = C_1(k_1, k_2, k_3) + C_2(T, k_1, k_2, k_3)$$

A. $\frac{\partial C_1}{\partial k_i} > 0$

B. $\frac{\partial C_2}{\partial k_i} < 0$

C. $\frac{\partial^2 C_2}{\partial t_j \partial k_i} \leq 0$

(b) To maximise social welfare one must decide how much the society values each industry and each agent. Let λ_i be the value of industry i and let γ_j be the value of consumer j. Industries and consumers with high values of λ_i and γ_j are "important" or "valuable" or have high weight.

(c) The social welfare maximisation problem is

$$\max\left\{\sum_{i=1}^{I} \lambda_i B_i(T_i) + \sum_{j=1}^{J} \gamma_j B_j(T_j) - C(T, k_1, k_2, k_3)\right\}$$

subject to

$$\sum_{i=1}^{I} T_i + \sum_{j=1}^{J} T_j = T$$

(d) This problem can be quite complicated. There are $6 * (I + J) + 3$ choice variables and the functions C and B_i and B_j may be quite complicated.

(e) Efficient investment in infrastructure

i. Marginal cost of investments should all equal zero:

$$\frac{\partial C}{\partial k_1} = \frac{\partial C}{\partial k_2} = \frac{\partial C}{\partial k_3} = 0.$$

(f) Efficient use of transport services

i. Marginal benefits of each use of transport should equal marginal cost of transport

$$\frac{\lambda_i \partial B_i}{\partial T_i} = \frac{\gamma_j \partial B_j}{\partial T_j} = \frac{\partial C}{\partial T}.$$

8. The above problem is the social welfare maximisation problem. Solution is the efficient outcome. However, equilibrium outcome in transport market may be different.

9. Equilibrium in transport market

   (a) Government providers maximise utility subject to budgetary and regulatory constraints

   (b) Private providers maximise profits subject to regulations, consumer demand, and competition

   (c) Consumers choose mode to maximise utility

      i. Consumer user cost equals time + out-of-pocket expenses

      ii. In general the consumer user cost will not equal the social cost

   (d) In general, because of the market imperfections (and when private mechanisms to overcome these imperfections are insufficient) described above, private market equilibrium will not maximise social welfare. Government interventions may improve welfare relative to market equilibrium without government intervention. Government intervention could also reduce welfare if government chooses wrong interventions.