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ESTUDOS DO GEMF
N.º 15 2005

**PUBLICAÇÃO CO-FINANCIADA PELA
FUNDAÇÃO PARA A CIÊNCIA E TECNOLOGIA**

Impresso na Secção de Textos da FEUC
COIMBRA 2005

Horizontal Differentiation and the survival of Train and Coach modes in medium range passenger transport, a welfare analysis comprising economies of scope and scale

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Abstract

The Portuguese transport system as a whole suffers from the dominance of personal transportation, this being generally less efficient. Coaches and trains struggle to stay in the business.

This model explains the markets' performance beyond price differentials, bundling the transport modes' appeal in one index for each. The differentiated transport cost approach accounts for product differentiation, economies of scope accruing to the consumer, and allows for economies of scale, in the form of fixed costs, to be weighted in, as well as tax policies towards motoring. It goes further by building a general welfare function that permits all factors and competition regimes to be properly compared. These are a monopoly by cars, duopolies with cars and each of the public transports, and oligopolies with public transports either competing or colluding.

Simulations are carried out, and discussed in light of swings in market share and changes in welfare, with a reasonable claim to plausibility.

Both public transports make the public better off by staying in the market, although the coaches' contribution is more decisive. Trains results are weighted down by heavy fixed costs, and the far reaching coach network of destinations offers the second best service (behind that of cars). Collusion in the public transports is a price worth paying, when compared with the car monopoly emerging from bankrupt operators.

Keywords: Horizontal Differentiation; Intermodal choice; Oligopoly; Economies of Scope; Economies of Scale; Regulation
JEL Codes: L13; L59; L92

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1. Introduction

The Portuguese market for intercity travel is studied in terms of the demand choice for three competing modes: train, coach and automobile.

A horizontal differentiation model based on transport costs, in the Hotelling tradition, is built around a circular city, as proposed by Salop. There, the three modes compete on price and the time-proven and variously interpreted transport cost single parameter. Here this parameter stands for the linearly increasing discomfort – loss of utility, and thus welfare – of bridging the gap from the individuals' ideal transport needs to the actual three modes' existing supplies. The transport cost framework, assuming homogenously distributed individuals across a spectre where some firms offer discretely located products/services, provides a simple and insightful way of depicting the choices and uneven losses consumers face regarding their transport modes.

A major departure from most studies using these models is the use of different transport cost parameters for the various transport modes, thereby capturing their differences in comfort, time, flexibility and market coverage (in terms of the network of timetables and destinations' reach).

Beyond the setting up of the model, several regimes and price setting rules are considered, ranging from the automobile's monopoly, its duopoly with each of the collective transports and the three modes' coexistence. A crucial difference in the nature of the competitors is that the personal transport (cars) is a "passive" mode, in the sense that car owners (which most people are) provide their own supply and so price and cost are the same and are taken as given. In the non-monopoly cases prices are set by profit maximization rule, resulting in a 'Bertrand' differentiation induced mark-up on marginal cost, except in a regime where the collective modes maximize joint profit, assuming some sort of merge.

With these regimes to observe, a plausible set of parameters for marginal costs, government taxation of motoring, and transport costs (the different modes' strengths) is put forward, and discussed in terms of the market outcome (the modes' shares and profits) and welfare. Then simulation is carried out using several parameters responding to existing trends, or possible events or policy measures.

The context of these undertakings is that of financially pressed collective transports, risking bankruptcy and inherent departure from the market. The forces impairing sustainability include the economies of scale present in the capital intensive railway transport, and the massive convenience offered by the car in an individualistic society. The bulk of the loss in welfare to the economy as a whole from departing modes lies in the accrued transport costs from covering larger distances in terms of individual needs and actual supply, but also from the productive efficiency of collective modes which cost less “per seat”, given that most cars run with a sole passenger. The reduction in transport costs from maintaining several modes can be viewed as an economy of scope, not in the classical production sense, but in the utility effect – consumers don’t actually benefit from consuming more varieties (they choose a single mode) but from having their preferred variety closer to them.

Section 2 explains the context of the market and its framework, within classical Industrial Organization, and examines the options available to its modelling, both those spurned and that which was pursued. Section 3 presents the model, its mechanics and the extensions that enable several regimes to be portrayed. In section 4 simulations are carried out to a number of parameters, whose values are put forward so as to be “realistic”. The ensuing results are given ample discussion in terms of welfare and market behaviour, subject to current or possible trends and policy actions. Section 5 concludes.

2. Market specificities and modelling options

2.1. A rough sketch of the market

In a small country of average non commuting journeys under 200 miles (over 300km) without properly developed river or sea transport, land based transport rules. From a necessity perspective, the (considerable) distance from substitute or complementary local transportation services result in a market for domestic medium and long range passenger transport, as defined by classical industrial economics. Moreover, from the supply side, the number of truly autonomous (and heterogeneous) players is very small: given that the bulk of the population owns a car, the average citizen, at a given cost (comprising fuel, tolls and parking, taxes, maintenance and acquisition expenditures) can provide himself with transport services; or he can take the largely monopolistic rail operator or, lastly, he can resort to the highly concentrated coach market, comfortably led by a private consortium, called ‘Rede Nacional de Expressos’ (standing for national network of ‘express’ − fast − coaches). In all, three players − a passive one, in the form of personal transportation, and two quasi monopolies in the collective modes − confer the market an oligopolistic nature. It is this properly defined oligopoly market, and its peculiar features, foremost resulting from belonging to the transport sector, that will be studied in terms of industrial organization, both in modelling approach and discussion.

2.2. Overview of modelling alternatives

Transport cost based models, dating back to Hotelling (1929), rely on “delivery price” formalized, in the most widely used versions, as the sum of price and linear transport cost, that is, a fixed parameter of transport cost multiplied by the travelled distance.

The circular city model, by Salop (1979), centred on Nash equilibria from free symmetrical entry, offers a way to describe the competition in a market with a free but finite number of firms, through price and a linear differentiation parameter. Thus are avoided the discontinuities of dealing with the Hotelling’s linear city extremes, and the asymmetries with which such a model would deal with more than two firms[1].

In the field of Industrial Economics, and given the complexity of a service such as transportation (through various means) which precludes the assumption of homogenous good (service, in this case), two major strings of analysis of differentiation stand out as alternatives to the Hottelling-Salop framework: vertical differentiation and classical horizontal differentiation tracing back to Chamberlin (1933). The two are examined and an explanation is given to the shortcomings they would present in characterizing this market.

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[1] See Martin (2002), chapter 4, section 4.2.5.and 4.2.6. pages 100-105.

In vertical differentiation models[2], there is usually a parameter/attribute that grants a product superiority over the others, after which a game is played over equilibrium prices, given the cost of such attribute. In this "transport with choice" market there isn't a universally superior transport, any more than there exists an attribute a mode can acquire, enabling it to become better than the rest. Although the car is more flexible and convenient to most people, there are several cases where that fails to apply: young, old and disabled people are either by age or health contidion or ability liable to be excluded from driving; very poor people might not be able to afford a car (although a working second hand vehicle can be had by as little as 1,000 Euros, or less than 1,200 USD); a number of consumers also may be (at times fortuitously) specially well served by public transports − living or working nearby stations, thus dispensing with the taxi's additional cost; having compatible timetables with those on offer, residence of relatives, places where they prefer to shop, etc. On the other hand, certain public transports are often at a disadvantage to a lot of people: coaches tend to be cramped, with little room for overweight people; those placing a high value on their time, require either the fastest route (the car) or a mode where they can work during the journey (the train). Most importantly, the (lack of) scope of the dedicated railway network, compromising point to point trips, and the subordination to discrete (non ideal) timetables, accrued by possible delays, concur to place the public modes generally at a convenience disadvantage over the personal transport.

Also, the notion that there is a discrete insurmountable difference in quality between (usually) two products − conveyed by vertical differentiation literature − is at odds with a market where an important unifying element stands out: the need to be transported in timely fashion. This provides any mode with an opportunity to challenge or beat a "superior"rival: simply provide a competitive package in terms of time, cost and a threshold of quality.

In Murta (2005), a work which here finds a follow-up, the transport cost line of modeling is complemented in another chapter by an empirical study that follows the horizontal differentiation tradition of Chamberlin (1933), later developed by Spence

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[2] Here, the presentation by Tirole (1988), based on the work by Shaked and Sutton (1982) and Shaked and Sutton (1983), who in turn fed on the contributions by Gabszewicz and Thisse (1979) and Gabszewicz, Shaked, Sutton et al. (1981), was followed.

(1976), and also Dixit and Stiglitz (1977). These models are based on the concept of the representative consumer, who chooses (optimum) quantities of several products, and displays, due to the decreasing marginal utility principle, a taste for variety.

Although this approach provides tractable classical demand functions, handy for econometric study, where different price sensitivities can be tested, the essential nature of the differentiation is relegated to an ‘a priori’ “black box”. This transport market flagrantly marked by horizontal choice, where price competition is far from the whole picture − the car is the most expensive medium and enjoys market dominance − a proper, explicit treatment of differentiation is required. Besides, here consumers don’t prefer variety, or choose quantity − rather, they choose in a binary way to consume or not each medium, and only one gets to be chosen[3].

Finally, the approach by Lancaster (1966), related to the Chamberlinian, describing a good as a multi-dimentional vector of characteristics is best suited to goods with a standardized grid of differentiation, like computers (which evolved to become a pack quantities of characteristics − processing speed, disk and memory space, monitor size, etc.), iogurts or even automobiles (classifiable along a range of attributes). Transport services, though, fit the needs of each consumer differently, in terms of location, comfort, safety, timetables, speed, etc.

So modal choice in the Portuguese market for medium/long range passenger transport is modeled within a transport cost Hotelling framework.

2.3. Precedent applications and rationale for this approach

In prior developments of this analysis, by Murta (2002) and Murta (2003), versions were created with asymmetrical location of firms, giving the leader a prior advantage over public transport. This was not the case here, for the sake both of simplicity and to make the task of explaining the market outcome more honest and demanding. Contrary to the initial formulation, this isn’t inspired in the actual shares of the various modes.

Also, in Murta (2005) and in the cited articles, the phenomenon of congestion is incorporated, as affecting the road based modes, and being caused by the cars (which,

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[3] This being medium to long range travel, a sole, main transport is chosen, even if at the extremes complementary modes (such as buses or taxis) may be necessary.

running half empty, take up much more road space per passenger than coaches). That path wasn't pursued here for several reasons:

a) once the analysis is being taken to the more complex realm of welfare (unlike the previous cases), simplicity in the working of the model was to be preserved (and such treatment of congestion significantly impairs it);

b) congestion is less of a problem in long range traffic than it is in commuting traffic;

c) the analysis can easily be carried over to other countries if it doesn't rely on the severity of the congestion problem;

d) both cars and coaches can be interpreted as suffering from congestion in this model (through a rise in their transport costs, that stand as their relative strength in capturing extra customers); it was only the link between the cars' traffic and the coaches' congestion that was omitted.

So transport cost for consumers of a differentiated service in a variety space is the loss of utility associated with bridging the gap, in such a space, from their ideal variety to the existing best. That loss, in this market, is plausibly different from one transport mode to another. Settling for a form of public transport, with associated uncertainty regarding the sum of waiting and journey time, when that option isn't near one's ideal, should be direr than to opt for your own vehicle. Between them coaches offer a much wider range of both timetables and destinations than trains, so they're bound to be "easier" to accept for a large share of the public.

Nijkamp and Rietveld (2002) point to a myriad of factors affecting modal choice: related to the individual, or to characteristics beyond costs, to the value of time spent (and its various components[4]), to the context of the choice (where safety, or security − against theft −, weather conditions and punctuality can all be decisive), information and perceptions of the agent, quality or time thresholds the consumer demands, etc. In general, these factors will point in favor of personal transportation, with the exception of taking advantage of the journey time to work or rest, impossible to drivers and, all in all, still difficult to perform in coaches.

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[4] To departing station, from arriving station, waiting time, travel time, parking facilities, and all the related uncertainties.

3. The model and various regimes

The circular city model from Salop, adopted and adapted for this market[5], like the linear city forerunner from Hotelling, are centered on carving up the whole of a market, in terms of market shares, between firms, by finding the location of the indifferent consumer. He faces equal “delivery prices”, that is price plus transport cost from choosing between adjacent competing firms. In the linear city, there is only one such indifferent consumer, located somewhere around the center, and both firms have a captive “hinterland” or backyard of consumers between their location and the city’s bounds.

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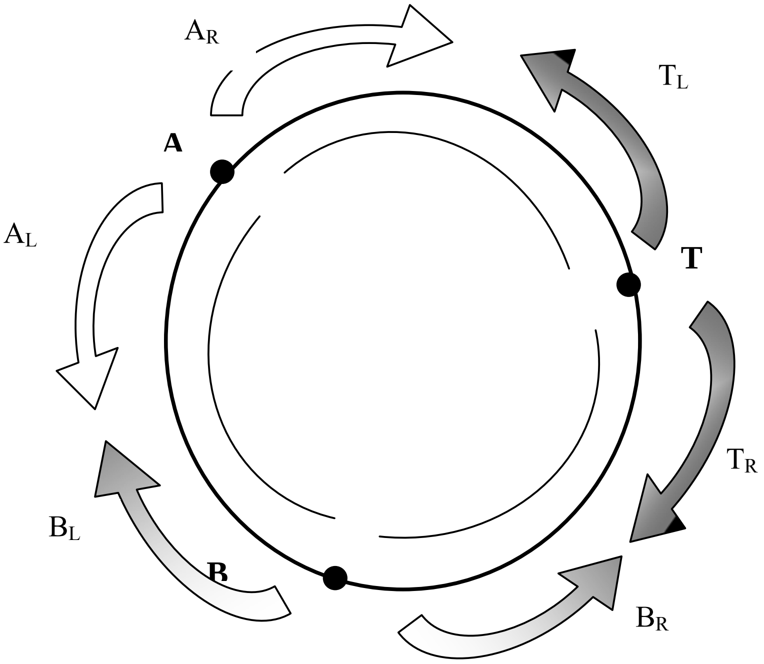
[5] Again, Tirole (1988), chapter 7, section 7.1., pages 279-287, was followed in computing equilibrium shares, and profit maximization and pricing rules.

Picture 1



Legend:

B = coach; T = train; A = automobile;

B_L = coach’s market share to its left, that is against the automobile;

B_R = coach’s market share to its right, that is against the train;

A_E = automobile’s market share to its left, that is against the coach;

A_D = automobile’s market share to its right, that is against the train;

T_E = train’s market share to its left, that is against the automobile;

T_D = train’s market share to its right, that is against the coach;

In this version of the Salop’s circular city, there are three indifferent consumers disputed by two modes each (see picture above), and firms compete with their two rivals, not having any captive stronghold. Utility for each individual is the difference between a given level of satisfaction and the delivery price, as shown in equation (1)

$$\text{Utility}|_{\text{consumes}} = U - (P_m + t_m.\text{distance}_m) \qquad (1)$$

Where *m* is the chosen transport mode. The modes are noted A for automobiles, T for trains, and B for coaches, relating to the common word Bus, associated with urban travel, to avoid confusion over the letter C possibly standing for cars.

Transport costs are parameters not subject to manipulation by the transport modes on a short term basis, but likely to be influenced by investments in highways, railroads that allow for more speed or a broadening of the network; an increase in departure frequency, or the absence of major disruptions due to workers' strikes or track or road repairs (equation 2).

$$\begin{aligned} t_T &= f(\overset{-}{Investment}_{RAILS}; departure\ \overset{-}{frequency}_{Train}; strikes \overset{+}{/} repairs) \\ t_B &= f(\overset{-}{Investment}_{ROADS}; departure\ \overset{-}{frequency}_{Bus}) \\ t_A &= f(\overset{-}{Investment}_{ROADS}) \end{aligned} \tag{2}$$

Marginal costs are proposed to be constant, with the train's capital intensive structure modeled with a fixed cost, absent from the lighter structured Coach, and the automobile's costs equaling its price, since provider and consumer are one and the same. Since motoring is heavily taxed in a number of ways, its price Pa was broken down to two components, the autonomous true cost to the economy and the tax element in its final enduser cost.

$$\begin{aligned} \text{Total Cost}_T &= c_T\, T + F_T \\ \text{Total Cost}_B &= c_B\, B \\ Pa &= Pa_{auton} + tax_A \end{aligned} \tag{3}$$

Utility for the three indifferent consumers becomes,

$$\begin{aligned} U - Pa - t_A \cdot A_D &= U - Pt - t_T \cdot T_E \\ U - Pa - t_A \cdot A_E &= U - Pb - t_B \cdot B_E \\ U - Pt - t_T \cdot T_D &= U - Pb - t_B \cdot B_D \end{aligned} \tag{4}$$

Since,

$$T_E = 1/3 - A_D$$
$$B_E = 1/3 - A_E \qquad (5)$$
$$B_D = 1/3 - T_D.$$

(4) can be manipulated to yield,

$$(t_A + t_T)\cdot A_D = t_T/3 + Pt - Pa$$
$$(t_A + t_B)\cdot A_E = t_B/3 + Pb - Pa \qquad (6)$$
$$(t_B + t_T)\cdot T_D = t_B/3 + Pb - Pt$$

And, using the notation,

$$\alpha = t_A + t_T\ ;$$

$$\theta = t_B + t_T\ ;$$

$$\delta = t_A + t_B,$$

Partial demands can be compactly written as,

$$A_D = (t_T/3 + Pt - Pa)/\alpha$$
$$A_E = (t_B/3 + Pb - Pa)/\delta \qquad (7)$$
$$T_D = (t_B/3 + Pb - Pt)/\theta$$

Adding (7) and using (5), the total demands appear,

$$A = (Pb + t_B/3)/\delta + (Pt + t_T/3)/\alpha - (1/\delta + 1/\alpha)\cdot Pa$$

$$T = (Pb + t_B/3)/\theta + (Pa + t_A/3)/\alpha - (1/\theta + 1/\alpha)\cdot Pt \qquad (8)$$

$$B = (Pa + t_A/3)/\delta + (Pt + t_T/3)/\theta - (1/\delta + 1/\theta)\cdot Pb$$

Equation 8 can be analyzed in three stages:

1) in the absence of both transport cost and price differentials, market shares will be a third for each;

2) with price differentials but one uniform transport cost, shares will be a third plus or minus the price differentials, weighted down by the strength of the transport cost, which insulates firms from competition (8.1);

$$\text{Share}_i = \frac{1}{3} + \frac{P_{j\neq i} - P_i + P_{k\neq i} - P_i}{2 \cdot t},\ i = A, B, T \tag{8.1}$$

3) with both different prices and transport costs, shares will reflect the modes' relative strengths in those variables.

In the case where any of the public modes departs from the market, the ensuing duopoly's shares become, using complementarity the same way as in (5),

$$M_i = 1/2 + \frac{2\,(Pj\neq i - Pi)}{t_i + t_{j\neq i}} \tag{8.2}$$

Having dealt with the way shares are distributed given transport costs and prices, next the various regimes for price competition are presented.

Pa is always a parameter, changeable over time by supply shocks (the price of crude oil), falling on the Pa_{auton} parameter, or government policy through numerous instruments (VAT, fuel tax, level of tolls, and reach of toll-free motorways, parking fees, circulation tax, etc.), all captured in tax_A.

Pb and Pt are formed in three ways, according to the competition regime. In duopoly brought by the demise of any of the other public transports, the price will be the optimal response to Pa. In a three way competition B and T will form price reaction functions to both competitors' prices and the Nash−Bertrand equilibrium will be that price vector which satisfies both equations. Finally if the struggling public modes decide to merge or cooperate in a cartel fashion, a joint profit function emerges, and equilibrium is to be found in the set of prices that satisfy its maximization.

In duopoly we have,

$$\pi m = (Pm - c_M)\ M \tag{9}$$

First order profit maximization condition,

$$\frac{\partial \pi m}{\partial Pm} = M - (Pm - c_M)\frac{1}{t_A + t_M} = 0 \tag{10.1}$$

Solving for Pm using (8.2), yields,

$$Pm^* = \frac{Pa + c_M + t_A/2}{2} \tag{11.1}$$

Whether M is B or T, since the train's fixed cost don't affect derivatives.

Next, with both public modes competing for price, first order conditions are,

$$\begin{aligned} \frac{\partial \pi b}{\partial Pb} &= B - (Pb\text{-}c_B)\left[\frac{1}{t_A + t_B} + \frac{1}{t_B + t_T}\right] = 0 \\ \frac{\partial \pi t}{\partial Pt} &= T - (Pt - c_T)\left[\frac{1}{t_A + t_T} + \frac{1}{t_B + t_T}\right] = 0 \end{aligned} \tag{10.2}$$

Reaction functions become, after solving (10.2) for their respective prices, using (8),

$$\begin{aligned} Pt &= \frac{\alpha\,(Pb + t_B/3) + \theta\,(Pa + t_A/3)}{2\,(\,\alpha + \theta\,)} + c_T/2 \\ Pb^* &= \frac{\delta\cdot(Pt + t_T/3) + \theta\cdot(Pa + t_A/3)}{2\cdot(\delta + \theta)} + c_B/2 \end{aligned} \tag{11.2}$$

Analyzing (11.2) it is noticeable firms will charge a mark-up over their costs, and follow the rivals' price increases. A strain in the competitors' consumer appeal (through a jump in their transport cost parameters) will partially be seized as an opportunity to raise the price. The response to an own variation in the transport cost is more indeterminate, in terms of price response, and so its derivative was calculated, for the coach, but with the results carrying entirely to the train,

$$\frac{\partial Pb}{\partial t_B} = \frac{(t_T - t_A)\cdot(Pt + t_T/3 - Pa - t_A/3)}{4\cdot(\delta + \theta)^2} \tag{12}$$

In this market $t_T - t_A$ will always be positive, since a train will never surpass the car in overall convenience. The sign of (12) will thus fall upon $Pt + t_T/3 >< Pa + t_A/3$. If the train's price/convenience mix is better than the car's, given that the car is a very strong competitor, that means the competitors are relatively close, and (12) becomes negative. More even competitors prompt a more cautious response to losses in marketing strength.

To find the Bertrand equilibrium prices (11.2) are solved, in a two equation system,

$$\begin{pmatrix} 2\cdot(\delta + \theta) & -\delta \\ -\alpha & 2\cdot(\alpha + \theta) \end{pmatrix} \begin{pmatrix} Pb \\ Pt \end{pmatrix} = \begin{pmatrix} 2\cdot(\delta + \theta)\cdot c_B/2 + \delta\cdot t_T/3 + \theta\cdot(Pa + t_A/3) \\ 2\cdot(\alpha + \theta)\cdot c_T/2 + \alpha\cdot t_B/3 + \theta\cdot(Pa + t_A/3) \end{pmatrix} \tag{13.2}$$

Or, in matrix form,

$$M_{Bert}'\ \underline{P} = \underline{C}_{Bert}{}^{6} \tag{13.2}$$

Resulting in,

$$\underline{P}^* = \begin{pmatrix} Pb^* \\ Pt^* \end{pmatrix} = M^{-1}{}_{Bert} \cdot \underline{C}_{Bert} \tag{14.2}$$

Thirdly, in a merger or collusion, the joint profit function is,

$$\pi = (Pb - c_B)\ B + (Pt - c_T)\ T - F \tag{15}$$

First order maximization conditions are,

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[6] Where $\underline{P}$ is the vector in (14.2) and $\underline{C}_{Bert}$ is the vector in the right hand side of equation (13.2), composed only of parameters, without any variables.

$$\frac{\partial \pi b}{\partial Pb} = B - (Pb\text{-}c_B)\left(\frac{1}{t_A + t_B} + \frac{1}{t_B + t_T}\right) + \frac{Pt\text{-}c_T}{t_B + t_T} = 0$$

$$\frac{\pi t}{\partial Pt} = T - (Pt\text{-}c_T)\left(\frac{1}{t_A + t_T} + \frac{1}{t_B + t_T}\right) + \frac{Pb\text{-}c_B}{t_B + t_T} = 0 \tag{16}$$

Solving for Pb and Pt, we have,

$$Pb^{*} = \frac{(t_A + t_B)(2\,Pt - c_T + t_T/3) + (t_T + t_B)(Pa + t_A/3)}{2\,(\,2\,t_B + t_A + t_T\,)} + c_B/2$$

$$Pt^{*} = \frac{(t_A + t_T)(2\,Pb - c_B + t_B/3) + (t_B + t_T)(Pa + t_A/3)}{2\,(\,2\,t_T + t_A + t_B\,)} + c_T/2 \tag{17}$$

Solved in a similar matrix format,

$$\underline{P}^{*} = \begin{pmatrix} Pb^{*} \\ Pt^{*} \end{pmatrix} = M^{-1}_{Conl} \cdot \underline{C}_{Conl} \tag{18}$$

Where M_{Conl} and C_{Conl} are, respectively,

$$M_{Conl} = \begin{pmatrix} 2\cdot(\delta + \theta) & -2\,\delta \\ -2\,\alpha & 2\cdot(\alpha + \theta) \end{pmatrix} = \begin{pmatrix} M_{Bert11} & 2\,M_{Bert12} \\ 2\,M_{Bert21} & M_{Bert22} \end{pmatrix} \tag{19}$$

and

$$\underline{C}_{Conl} = \begin{pmatrix} 2\cdot(\delta + \theta)\cdot c_B/2 + \delta\cdot(t_T/3 - C_T) + \theta\cdot(Pa + t_A/3) \\ 2\cdot(\alpha + \theta)\cdot c_T/2 + \alpha\cdot(t_B/3 - C_B) + \theta\cdot(Pa + t_A/3) \end{pmatrix} = \underline{C}_{Bert} - \begin{pmatrix} \theta\,C_T \\ \alpha\,C_B \end{pmatrix} \tag{20}$$

So, up until equation (8) market outcomes could be found from given prices. Now there are several regimes for finding endogenous prices. The modelling task is concluded with setting up a general measure of welfare, valid for all these regimes, and also for a possible car monopoly.

$$W = 2 - [A\ (A\ t_A/4 + P_{auton}) + B\ (B\ t_B/4 + C_B) + T\ (T\ t_T/4 + C_T) + F_T] \qquad (21)$$

Equation 21 starts and ends with fixed terms: an autonomous value from which to deduct the losses, chosen to allow easy comparisons between positive numbers, and the fixed costs associated with the train. Following, we have a similar two-fold treatment for all the modes:

1) the transport costs are calculated using the uniform distribution of individuals hypothesis from standard Hotelling models, which allows for the average distance to the firm be retrived − given a share of A, for example, it stands for A% of one, divided unevenly to the left and right of A's location; the average (between left and right) maximum distance an individual can be from A will be A/2, and the minimum is zero; thus, total transport costs incurred by car users will be t_A, multiplied by A's share, A, times the average distance "traveled", A/4;

2) Costs to the economy of providing the transport services were computed without taxes (tax_A) or prices (Pt and Pb), since these were assumed to be net transfers between sector or fringes of the population. In the public transports only marginal costs remained, and for the car the term Pa_{auton} standing for its real cost net of tax came full use.

This welfare measure is valid in any competition situation[7]. For simplicity, the taxes were assumed not be distortionary. Social consequences of the pricing policies (including towards the car, indirectly conducted by the tax man) were ignored.

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[7] In monopoly A becomes 1, and the average distance is $\frac{1}{4} = (0 + \frac{1}{2}) / 2$.

4. Simulations

4.1. Analysis of a base scenery

This section uses the developed model to build a standard benchmark situation for the market, in terms of the parameters, commenting on the outcome in terms of demand (share) and welfare. Then it proceeds to perform several simulations on possible trends or policy actions, showing how the market, under this model, and in its various possible regimes, would react.

Table 1 – The parameters

t_A	1
t_B	4
t_T	5

tax_A	0,5
Pa_{auton}	1
= Pa	1,5

mgCost B	0,5
mgCost T	0,3
F_T	0,2

The benchmark case in tables 1 and 2 was built around certain known relations between market variables:

1) car use is the most expensive but, narrowly defined, not by much − most people act upon a narrow definition, ignoring a lot of maintenance and depreciation expenses, because they don't contemplate not having a car;

2) Marginal costs to the economy, per passenger, are considerably lower in public transports and, being the train a high capacity medium with a better environmental record, it is likelier to perform even better than coaches;

3) Motoring is significantly taxed through various channels;

4) Trains have important fixed costs, being capital intensive, here since the marginal costs multiplies by a share quite inferior to unity (T is less than 1/3), F_T assumes a greater importance than marginal, operating costs.

Table 2 – The outcome in prices, shares and welfare

	Monop A	Duop with B	Duop with T	Bertrand	Collusion
Pa	1,5	1,5	1,5	1,5	1,5
Pb*	−	1,25	−	1,36	1,63
Pt*	−	−	1,15	1,24	1,52
Sh. A	100%	70%	72%	47%	57%
Sh. B	−	30%	−	27%	21%
Sh. T	−	−	28%	26%	21%
W	0,75	0,94	0,77	0,9	0,87

The results show the typical tendency for mark-up pricing, particularly strong in collusion, where Pa is surpassed. Higher transport costs would result in higher prices, a feature of the model that makes pricing behavior of these highly disadvantaged public competitors rather too aggressive. The consequence of this is felt in market share, where colluding transporters sacrifice a lot in size for profit.

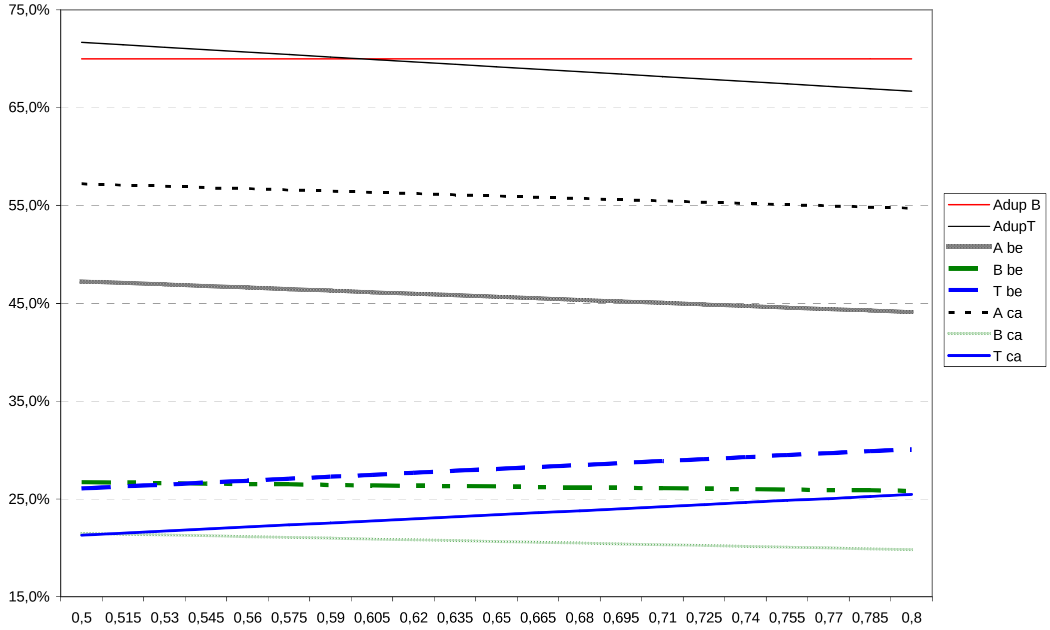
As for welfare, both monopoly and duopoly without trains (the first two columns) dispense with the fixed cost. Aside from that difference, Bertrand and Collusion oligopolies would be clear winners, but that is brought about by cancelling effects. The colluders' drive for price, although not a factor in welfare, aggravates transport costs by making the distribution of shares less even, with the leader having both the best transport cost and the worst marginal cost. Monopoly is the worst in average traveled distance but at the best transport cost (by far). Duopolies are intermediate in average distance in comparison with the extremes, and more or less cancel out higher price (B) with lower transport cost (again B), only the train's fixed cost accounting for the bulk of the difference. Bertrand competition offers almost the absolute best in welfare (but for the fixed cost), due to the most evenly distributed shares (minimizing transport cost), and dampening the dominance of the most inefficient transport − the car − in terms of marginal cost.

The main problem for welfare, and trains in particular, is that they struggle to make a profit in the all the regimes where they are present (even in the comfortable cartel, and the secluded duopoly). In the following simulations where the conditions for the train worsen (not all), their stay in the market would definitely be at risk.

4.2. Dearer oil

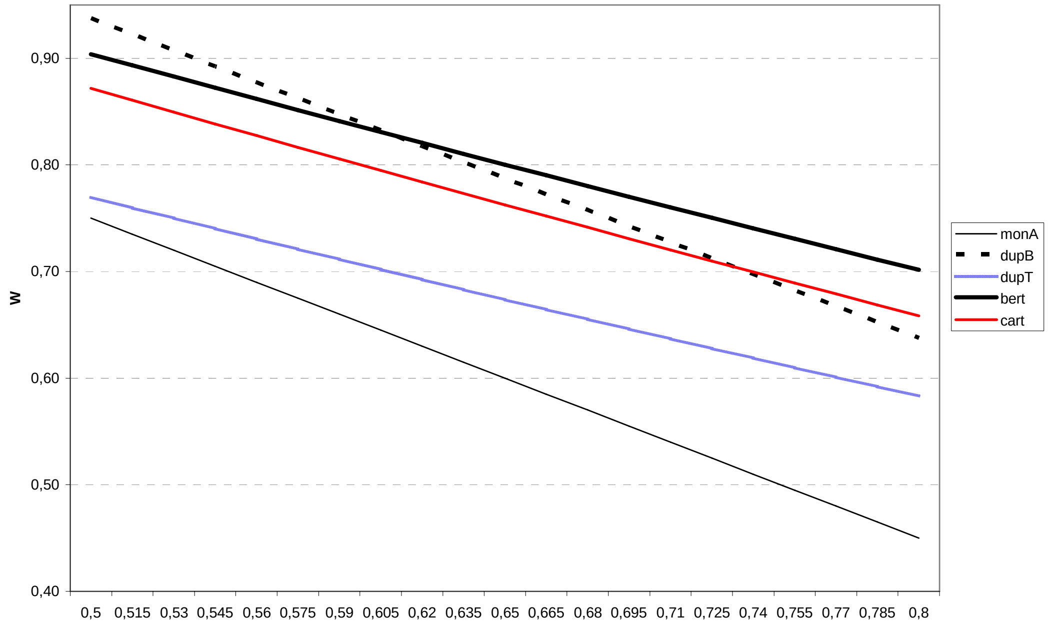
The effects upon this transport market, under the current modeling, from higher prices for oil (whether from geopolitical risks, natural catastrophes or sustained higher demand from emerging economies) would be represented by the joint rise in Pa_{auton} and c_B since these are the fuel based transports.

Graphic 1 − Market shares from joint rise in Pa_{auton} and c_B



Graphic 1 shows the shares of the car in the duopolies (since the competitor is simply left with the rest) and, of course, omits the monopoly case. The constant shares in road based duopoly were not mandatory, since the coach could absorb part of the cost increase − instead, it passes it to the consumer, emulating the automobile. Trains profit everywhere they compete, but coaches in oligopoly, particularly in (more aggressive) Bertrand competition, hold their own in market share, inevitably sacrificing margin.

Graphic 2 − Welfare from joint rise in Pa_{auton} and c_B

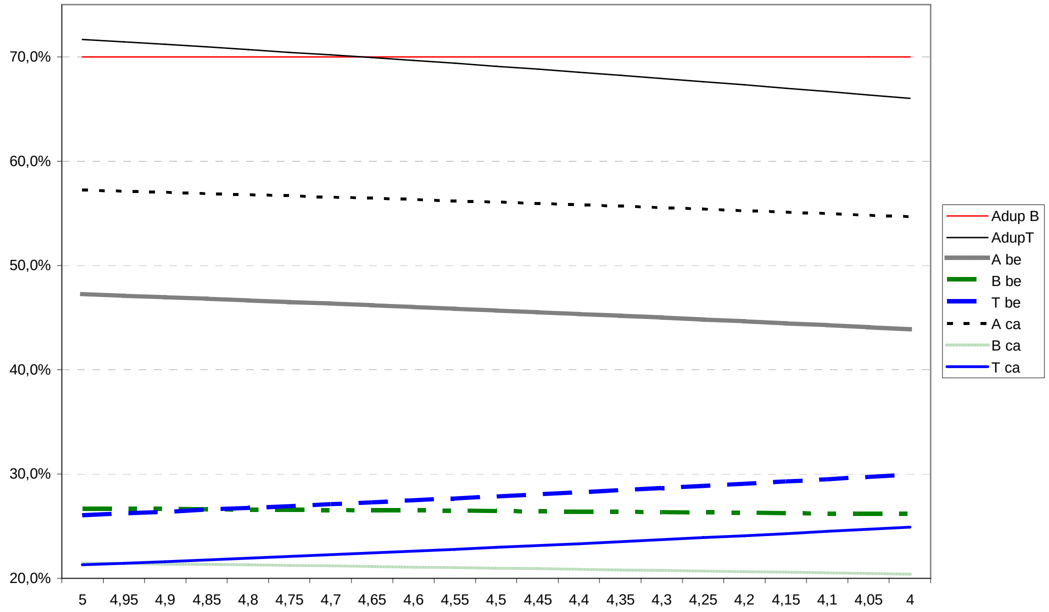


Graphic 2 shows the five regimes in terms of welfare, with road based dominated ones in freefall, compared to those where trains appear. Still, although the coach duopoly takes a beating, and is surpassed by both oligopolies, were coach operators to become bankrupt and leave, welfare would still loose either with or without trains.

4.3. A better service from trains

If a windfall investment would be made in the railways, building new lines, putting faster trains to service, increasing the average speed allowed in the current lines, running trains more frequently or punctually, or even stopping in a couple of more stations, any of the above would likely attract more passengers. That can be modeled through a decline in the trains transport cost.

Graphic 3 − Market shares from reduction of T’s transport cost

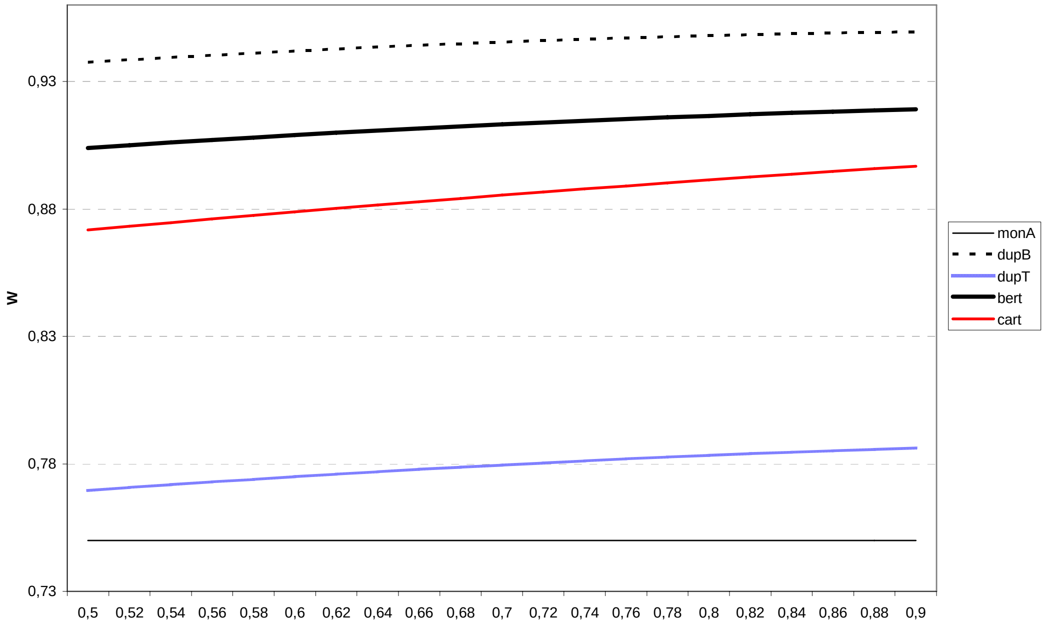


Such a reduction would bring predictable results in terms of welfare, with gains for the regimes where trains compete and no change in either monopoly or road duopoly. Graphic 3 describes the less obvious features, with the coach resisting a decline in share, at a cost of profit margin.

4.4. The tax man strikes drivers

The effects of further discouragement of motoring by tax policies, helping public finances, coping with dependency on foreign oil, propping up more efficient and environmentally friendly public transports, plagued by low profits (both) and high fixed costs (trains), is simulated below. Market shares behave unambiguously against the car. Welfare isn’t directly affected (since the raised revenue is considered a neutral transfer).

Graphic 4 − Welfare under increased taxation of Automobile

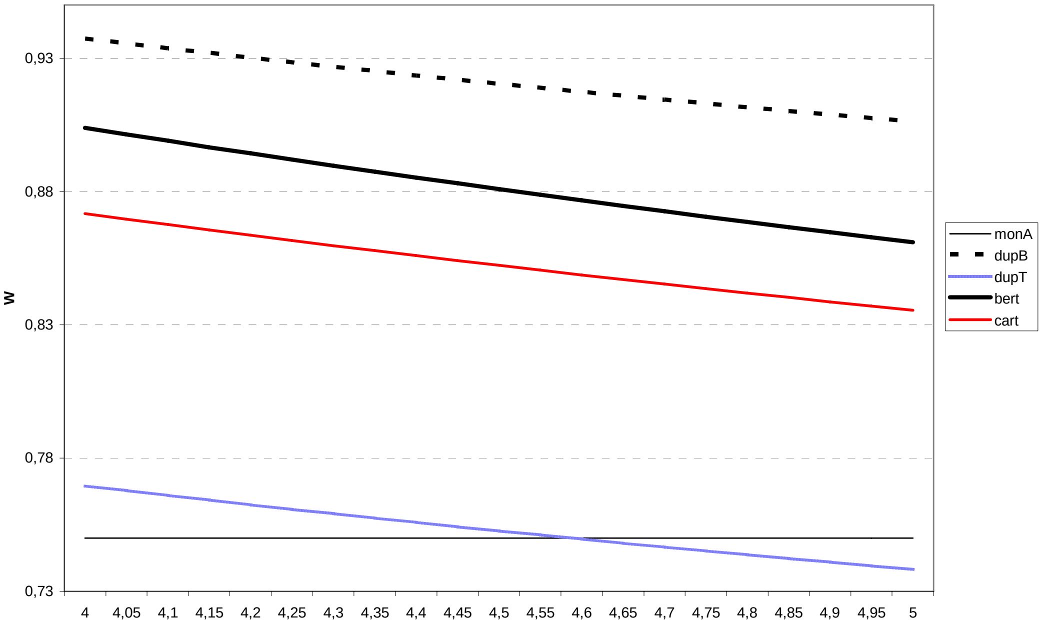


Graphic 4 documents the evolution. The general gain in welfare is accomplished in spite of the car's lead in transport costs and the general move by public transports towards higher prices (more pronounced in collusion). The net positive effect has to do with a better distribution of demand (lowering "traveled" distance), and the collective transports' lower marginal costs. Nevertheless, the bus duopoly would still beat the performances of having the train, which highlights its fragile position.

4.5. A retraction of public transport supply in light of struggling profitability

Under the dominance of personal transportation, not only can the very presence of either public transport be taken for granted, but also the extent of their supply of services can be slashed, in a desperate move for "damage control". Serving less destinations, with fewer stops, or shallower timetables would all result in a rise in transport costs, since they reflect the convenience of the service to the costumer.

Graphic 5 − Welfare under joint rise of T and B's transport costs



Graphic 5 demonstrates that no amount of increased competition and lower margins would halt a steep decline in welfare, in spite of the car's low (and thus efficient) transport cost, and stagnant price.

5. Conclusion

The Portuguese transport system as a whole (like many around the world) suffers from the dominance of personal transportation, this being less efficient, in fuel, in the use of space, in safety, and damaging gas emissions. Coaches and trains struggle to stay in the business, whereas nobody imagines having to do without the car. Expensive oil further hurts coaches, not affecting the car in such a determinant way. Revamping railways sounds expensive and unprofitable. Further taxing drivers is politically nigh impossible. Yet something must change, otherwise public transport will wither away, hurting the environment, congestion, efficiency and, ultimately, welfare.

This model explains the markets' performance beyond price differentials, bundling the transport modes' appeal in one index for each. The differentiated transport cost approach accounts for product differentiation, economies of scope accruing to the consumer − by having several nearer suppliers to choose from −, and allows for economies of scale, in the form of fixed costs, to be weighted in, as well as tax policies towards motoring. It goes further by building a general welfare function that permits all factors and competition regimes to be properly compared. Simulations are carried out, and discussed in light of swings in market share and changes in welfare, with a reasonable claim to plausibility. Both public transports make the public better off by staying in the market, although the coaches' contribution is more decisive. Trains results are weighted down by heavy fixed costs, and the far reaching coach network of destinations offers the second best service (behind that of cars). Collusion in the public transports is a price worth paying, when compared with the car monopoly emerging from bankrupt operators.

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