THE VALUE OF RAILWAYS FOR CONSUMERS

(PORTUGAL ON THE EVE OF THE FIRST WORLD WAR)*

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abstract

This paper discusses methodological approaches to the assessment of economic effects of railways. Traditionally, economic historians assess the benefits of railways through the social savings. This concept, as defined in the literature, imposes several strong hypotheses. We argue that these hypotheses are too strong, which implies that the social savings cannot be considered an accurate measure of the impact of railways. Therefore, an alternative approach for measuring this impact is proposed. Instead of using a counterfactual analysis, we decided to look at the welfare gains due to the Railway, namely the consumers' surplus variation. Using the methodology followed in Environmental economics to value a recreation resource, we value the Railway in a given year by the consumers' surplus in that year. In order to estimate the consumers' surplus in 1914 we first had to estimate demand functions, which also allows calculations on passengers and freight price-elasticities. The results show that price-elasticities were low and consumers' surplus were remarkable, making clear the effects of government economic policy on implementing transportation facilities and low pricing for users.

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1. Introduction: Literature and methodologies

Railways have given rise to several studies and insights in Economic History. Extensive academic literature in this area exists for many countries from the 1960s on. Almost every country has developed literature on the estimation of economic and social impacts of railway building and operation. This is true of Portugal as well. However, there are only three detailed and systematic studies on the subject, which were presented as Ph.D. theses. Vieira (1983) studied the financial aspects of railways building, corruption and inefficiency, Pinheiro (1986) focused on the extension and features of the network, and Alegria (1990) adopted a geographical perspective on the whole transportation system (including roads and seaports). There are some other papers on transportation treating the subject, but only Justino (1988-89) analysed the role of the available transportation networks on the formation of the domestic market in the second half of the nineteenth century.[3] Yet, he does not present any estimate on social savings, having followed a more traditional perspective. Therefore, we might say that railway studies in Portugal have failed to embrace new economic history methodological approaches.

This paper is a first attempt to correct this failure. Using an approach different from the traditional Economic History concept of Social savings, this paper also contributes to a new perspective on the problem. The impact of the railway network is evaluated by its welfare gains, which were calculated using estimated demand functions for railways. The period covered is 1877 to 1914, as it captures most of the network economic role in the nineteenth century. On one hand, before 1877 less than 1000 kilometres had been built, and on the other hand, the entire network was

almost complete by the end of the century (attaining 3 115km in the eve of the First World War). So, the exercise captures a great part of the benefits accrued from using a faster and more comfortable transport device on the eve of the First World War, considered as the beginning of the new century.

Using an approach that differs from the traditional Economic History concept of Social savings, this paper also contributes to a new perspective on the problem. It presents a welfare gains methodology based on estimated demand functions as a measure of the impact of railway networks.

The paper begins with a brief history of the railways in Portugal. Section 3 explains the methodology used and compares it with the traditional one. The following section focuses on the demand estimation issue. Data description is presented in Section 5 and results in Sections 6 and 7. Finally, in section 8 we conclude.

2. The railway network in Portugal in the late nineteenth century

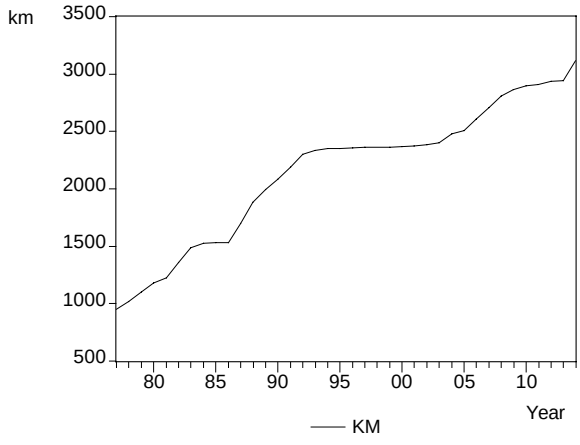
Building began in the 1850s but failed[4]. In 1860, the Lisbon-Santarém line was extended to the East (from Lisbon to the Spanish border) and North (from Lisbon to Gaia, on the left bank of the Douro, opposite Oporto). By 1864, 438 km had been built and opened to traffic. The link to Madrid was opened in 1866. Meanwhile, the first line in the southern part of the country had also been built to the Algarve (225 km).

During the 1870s and 1880s, The Beira Alta Railway Company was formed to build a line between Figueira da Foz and Vilar Formoso, a

[3] Justino, David – A formação do espaço económico nacional, Portugal 1810-1913, 2 volumes, Lisboa: Vega, 1988, 1989.

distance of 252 km. It was linked to the Spanish network and indirectly to the French and European network in 1882. At the same time, The Royal Portuguese Railway Company built the Beira Baixa railway between Abrantes (on the East line) and Guarda (on the Beira Alta line), which had an extension of 212 km, and also the West Railway between Lisbon and Figueira da Foz, which had an extension of 242 km. Additionally, a bridge over the Douro linked the North line with the city of Oporto in 1877, and a shortcut in the Lisbon-Madrid line was ready in 1880. The Minho District Railway Company built the line Oporto-Valença, a line of 152 km, which was linked with the Spanish network in 1886. It also built the Douro line between Oporto and Barca de Alva, which had a length of 206 km and was linked with the Spanish network in 1887. As for the 1890s and the early twentieth century until the First World War, it is possible to say that this period witnessed a slowdown in railway building, with only regional lines being added to these main trunk lines in the 1900s, as Figure 1 shows.

Figure 1: Extension of the Railway network



Source: Mappas estatisticos do trafego dos caminhos de ferro portugueses, Ministerio das Obras Publicas, Commercio e Industria, 1904.

[4] Vieira, (1985).

3. Railways and welfare: Discussions and approaches

Most of the available studies on Portuguese railways are devoted to the network building, companies or main actors, while few studies address freight or pricing. Even so, opinions on the economic effects of the railways are markedly divergent. This divergence is not recent and goes right back to the building phase. If we look to nineteenth-century politicians who encouraged their construction, we may find enthusiastic opinions and hopes for the future:

"I support that railway creates and develops"

(…)

"Today railways are science: the best brains of Europe care about it and it is in application in the first rank countries of the world"[5]

Most arguments stress how railways are the best way to foster economic development. They stress the market facilities that they open for regional and local production and evoke the inefficiency of roads for freight:

"Roads are a great benefit, but roads cannot solve the economic problem; only railways can solve the economic problem."[6]

Very soon, however, nineteenth-century authors took another view. They criticised the "wonderful" virtues of railways in fostering economic development, as Portugal did not close the gap with industrialised European countries. Principal arguments were the low domestic production, high building costs and the lack of multiplier effects on

[5]António Maria Fontes Pereira de Melo, the Minister of Public Works and Prime Minister who most implemented railways - Speech in the Parliament, on 6-12-1865: "Eu sustento que o caminho de ferro cria e desenvolve"
"Os caminhos de ferro são hoje ciência:Tem-se ocupado d'ella os primeniros espiritos da Europa, e está em applicação nos primeiros paizes do mundo"

agricultural production.[7] Angel Marvaud prefers to stress the small size of the Portuguese network and its inability to produce multiplier economic effects: "Il n'y a guère en Europe que la Russie et la Péninsule des Balkans, qui offrent une aussi faible proportion".[8]

Disagreement about the economic effects of railways continued to be expressed by several historians of the twentieth century. Disappointment in the weak industrial development was a reason for disappointment in the effects of the transportation policy (*Fontismo*)[9] that had been pursued:

"In no way did *Fontismo* succeed in increasing national production or stimulating an industrial spurt."[10]

For many other authors, however, Portuguese modernisation is attributed to railways. Some stress the agricultural development attained in the second half of the nineteenth-century and the decreasing transportation costs.[11] Others prefer to highlight the industrial spurt in the last decades of the century until the eve of the First World War and the role of railways.[12]

As in other countries, the 1980s' appraisal of the economic performance and efficiency of railways is pessimistic. Recent work absorbed the traditional negative interpretation, also adding the recent doubts from Fogel's counterfactual arguments on railway competition against alternative transportation systems.[13] The argument considers the duplication of the available transportation capacity.[14] Portuguese

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[6] António Maria Fontes Pereira de Melo, Speech in the Parliament, on 2-4-1856: "As estradas são um grande bem, mas as estradas não resolvem a questão economica; a questão economica só a resolve o caminho de ferro".
[7] Oliveira Martins, História de Portugal – Lisboa: Guimarães Editores, 1972.
[8] Marvaud, Angel – Le Portugal et ses colonies – Paris, 1912, p. 178.
[9] From the enthusiastic policy pursued by António Maria Fontes Pereira de Melo.
[10] Godinho, Vitorino Magalhães, Prix et Monnaies au Portugal, Paris, Armand Colin, 1955:" En aucune façon le fontisme ne se soucie guère d'accroitre la production nationale, de pousser l'éssor industriel".
[11] Pereira (1983); Marques (1991), p. 107.
[12] Cabral (1976); Cabral (1979); Castro (1946, 1978); Serrão (1978).
[13] Fogel, R. W. – Railroads and American economic growth, essays in Economic History, Baltimore, 1964.
[14] Justino, 1989.

waterways are not a network, as rivers cross the country from east to west and were never linked through canals. Moreover, most of the rail network was built up through the river valleys. So, as the argument goes, there was a repetition of the existing transportation network. "Most of the lines only duplicated water systems of transportation."[15]

It is recognised that large southern regions that could not benefit from quick and cheap transportation were improved with railways, but many authors are quick to point out the role of seacoast navigation. Moreover, arguments using comparisons with the pre-railway period always mention injuries to industries located in the countryside or in continental cities, because of introducing competitive foreign goods. The usual example referred to is that of wool textile production. However, in this case, there are two contradictions. On the one hand the core of the argument asserts that when the rail network was built it was not only preferred to any other kind of transportation, but was also much more efficient than alternative traditional transportation. On the other hand, the survival of those industries would not be helpful for economic growth, as they were not efficient. Notwithstanding, the limited size of the network has recently been advanced as a cause of weak economic effects of the railways, meaning that their role is assessed positively.[16]

Summing up, opposite views and arguments make the appraisal of the economic consequences of railways a very controversial issue in Portuguese historiography.

This paper is a contribution to the global discussion of the role of railways in small underdeveloped and peripheral countries. Worldwide, authors usually recognise sizeable benefits for large countries (such as the

[15] P. 190.
[16] Reis (1993).

United States, France, Germany, Canada, Russia and Spain) and particularly for continental regions.[17] The discussion is quite different for the Portuguese case, not only because of its small size, but also because of its geographical shape with a long coast along the Atlantic Ocean. As O'Brien observes "Countries badly endowed with navigable rivers, afflicted with a terrain hostile to the construction of canals, and with poor natural facilities and opportunities for coastal trade gained the most from their investment in railways. Railways alleviate the adverse economic effects on internal trade of an unfavourable natural endowment."[18] Traditionally, economic historians assess these benefits using the social savings concept.

The goal of New Economic Historians is to assess GDP growth resulting from the railways. Considering that only part of the resources used in the traditional transport sector was used in railways building, the rest could have been reallocated to other economic sectors[19].

This GDP growth is evaluated using the average price of all commodities and services produced in all other economic sectors except transportation, that is,

$P^{average}(Q-Q')$

where $P^{average}$ represents the average price of all commodities, and Q and Q' are the production in all the economic sectors with railways and without them, respectively.

It is clear that Q' is less than Q because it is assumed that without railways it should have been necessary to allocate more resources to the

[17] Mendoza (1982) p. 60, 61.
[18] O'Brien (1983) p. 12-13.
[19] Mendoza (1982) p. 43.

transport sector (instead of using them elsewhere) in order to provide the same services. Implicitly, this theory imposes two hypotheses, the volume of transportation in those two scenarios is constant and there is full employment of production factors. These two hypotheses are quite strong. On the one hand, lower transport prices resulting from a more efficient transport system stimulate production and transport demand; on the other hand, in most cases previous transportation systems would not allow transporting the quantities carried by rail, even if their capacity was improved through the investment of the same amount of resources that were applied to rail building. In practice the GDP growth resulting from railways has been estimated using the Social savings, which measures it in a different way. The Social savings can be defined as the saving in costs allowed by rail, being those costs evaluated at market prices. That is,

$$SS = (P^{alt} - P^{rail})\, Q^{rail}$$

where SS is the Social savings, P^{alt} the unit price in the best combination of alternative transports and P^{rail} the unit price in rail.

The use of market prices imposes an additional condition: perfect competition in the transport sector (price=marginal cost). Again, this is a strong hypothesis, as very high fixed costs in the railway sector lead to a *natural monopolistic market* structure. Moreover, being the Social savings "a static equilibrium analysis [that] cannot deal effectively with the dynamic effects of railways over time"[20]

From all the above it seems reasonable to argue that social savings is not a very accurate measure of the impact of railways. Perhaps we can say

that it is not worth trying to estimate it. As McClelland said about the question of knowing whether there was too much or too little capital invested in the railroad sector during the nineteenth century, "If it cannot be answered, perhaps it should no longer be asked"[21] This has led us to look for an alternative approach for measuring the rail impact. Instead of using a counterfactual analysis we decided, then, to follow the economists' way of assessing welfare.

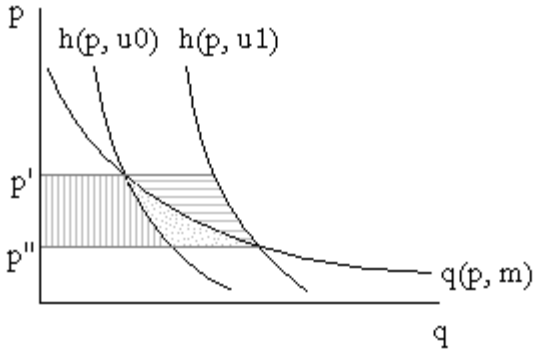
To assess welfare economists currently use the *compensating and equivalent variations* concepts. The compensating variation is the amount that can be taken (must be given to) an individual while leaving him just as well off as before a fall (rise) in prices[22]. It is usually interpreted as the maximum (minimum) amount that he or she would be willing to pay (accept) to consume at the new lower (higher) prices. The equivalent variation gives the minimum (maximum) amount that must be given (taken from) an individual to make him as well off as him would have been after a fall (rise) in prices[23]. It is usually interpreted as the minimum (maximum) amount that he or she would be willing to accept (pay) to consume at the initial higher (lower) prices. Both measures give the sum of areas to the left of compensated demand curves, between the initial and final prices. The compensated demand used for the compensating variation is evaluated at the initial utility level whereas the one used for the equivalent variation is evaluated for the final utility level.

Under certain conditions consumers' surplus is a good welfare measure for it is a good approximation of the measures referred to above

[20] O'Brian (1983), pp.14.
[21] McClelland (1972) p.488.
[22] Johansson (1987) p.30-31.
[23] idem

(Willig, 1999). Consumers' surplus is the difference between what the individual would be willing to pay and the price actually paid. It is measured as the area below the Marshallian demand curve and above the horizontal price line.

Figure 2 – Compensating Variation, Equivalent Variation and Consumers Surplus



Compensating variation (area with vertical lines), consumer surplus (CV plus area with dots) and equivalent variation (CS plus area with horizontal lines) when price falls from p' to p''. [q(p,m) is the ordinary demand, h(p,u0) is the compensated demand at the initial utility level and h(p,u1) is the compensated demand at the final utility level]

The consumer surplus is Dupuit's contribution to Economics. It is interesting to note that it was developed precisely in the period of railway building in Europe[24]. However, Willig's result only applies for relatively small price variations.

Unfortunately, to measure railway benefits we have to compare an initial situation for which the price is high enough to drive the demanded quantity to zero – the choke-price - with the situation where the price is

[24] Dupuit (1844).

substantially lower. This is the methodology used in Environmental Economics to assess the value of a site.[25]

Therefore, we are dealing with large variations in prices, which means that the use of the consumers' surplus is not legitimate. This difficulty can be overcome though, if the income elasticity is zero. In this case ordinary demand and compensated demand coincide and, consequently, the three measures 'compensating variation', 'equivalent variation' and 'consumer's surplus' are identical.

For the Portuguese passengers' case, it is easy to accept that income elasticity is approximately zero. Travelling by rail was dictated by necessity of moving and not by leisure. In the first decades of the Portuguese railways they mostly responded to people's needs to travel to urban centres, whether for military enrolment and draft, business needs or emigration towards the New World through the seaports. For freight, this hypothesis is difficult to accept. In fact, higher GDP and GDP per capita implied more freight to be transported by rail.

For this reason, the consumer's surplus probably underestimates the welfare gains due to railways. Let us say, however, that some New Economic Historians tried to estimate the consumer's surplus without even questioning the accuracy of the consumer's surplus as a measure of welfare gains. Not only did they ignore that question, they used improper approaches to it. Fogel and Fishlow attempted to estimate consumer's surplus using the rise in land rents as a proxy for the fall in transportation prices that accompanied the railroad building. At most they were criticised

[25] In environmental economics, "The value of a recreation resource is the discounted present value of the flow of recreation services to those who visit the site, as measured by the area under the compensated demand curve for visits to the site." (Freeman, p.456). "To value the elimination of a site (…) the common convention is to equate elimination of access to a price change for the good sufficiently high to cause the individual to exit the market", that is, "a price high enough to eliminate the service flow". Braden and Kolstad (1991), p.232.

because their methodologies were not accurate for assessing the consumer's surplus. As McClelland (1972) observes "The consumer's surplus (…) cannot usefully be approximated by the Fogel/Fishlow measure of social saving. In theory it can be approximated by the rise in land rents associated with railroad building, but in practice the observed rise in land rents (…) remains a proxy with an uncertain bias."[26] It is worth noting that McClelland questions their methodology but not the pertinence to estimate the consumer's surplus.

At the same time there is also some confusion between the concepts of Social savings and consumers' surplus. Mendoza says that consumers' surplus may be used as an approximation to Social savings ("EC represents the consumers' surplus, that is to say, the additional benefits obtained by the rail users, and may be considered to be equal to social saving"[27]), even though he recognises that Social savings exceeds consumers' surplus, even if we do not consider the effect of externalities on Social savings. For McClelland (1972), the Social savings as defined above is, at most, an upper-bound estimate of consumers' surplus. It should be clear that our objective is only to estimate the rail users' welfare gains. Whether or not the consumers' surplus can be considered as the Social savings is another matter.

4. Demand functions estimation and railway pricing

Demand functions estimation poses several problems. Ideally we should have cross section data, that is to say, several observations for the same moment of time. These would represent the willingness to pay of

[26] p. 487.
[27] "EC representa al excedente de los consumidores, es decir, los beneficios adicionales obtenidos por los usuarios del ferrocarril y puede suponerse igual al ahorro social." Mendoza (1982), p. 58.

different consumers. Unfortunately, we cannot ask nineteenth-century consumers what quantity of travel or freight would they be willing to consume at different prices. The only data we have is time series data from the companies and the Ministry of Public Works reporting how many people travelled and how many tons were transported each year by each rail company. Nevertheless, the use of time series to estimate demand functions is standard practice in Economics. [28]

Another potential problem is *endogeneity* as the observations we have are equilibrium points. "In competitive equilibrium theory, commodity prices and quantities are viewed as determined by sets of demand and supply relations. (…) These relations act jointly to simultaneously determine q_i^d, q_i^s and p_i." [29] In such a system these variables are jointly determined, i.e., they are endogenous variables because they are determined within the system[30]; the problem with *endogeneity* is that it turns the OLS estimator not consistent because the *orthogonality* between

[28] Berndt, Ernst R. (1991) The practice of Econometrics – Classic and Comtemporary. Ch.7 "Demand for electricity: structural and time-series approaches"; Ch.8 "Causality and simultaneity between advertising and sales".

[29] Judge et al (1993), pp.595.

[30] "The classic illustration of biases created by endogenous regressors is provided by Working (1927). Consider the following simple model of demand and supply:

$$q_i^d = \alpha_0 + \alpha_1 p_i + u_i \quad \text{(Demand equation)}$$

$$q_i^s = \beta_0 + \beta_1 p_i + v_i \quad \text{(Supply equation)}$$

$$q_i^d = q_i^s \quad \text{(Market equilibrium)}$$

(…)

We assume that $E(u_i) = 0$, $E(v_i) = 0$ and $Cov(u_i, v_i) = 0$ " (Hayashi (2000), p. 187- 188).

It is easy to see that the regressor p_i is endogenous in both equations, that is, price is a function of the two errors, u_i and v_i. Therefore, both $Cov(p_i, u_i)$ and $Cov(p_i, v_i)$ are different from zero. "In this example, *endogeneity* is a result of market equilibrium".

If we regressed quantity on a constant and price, would we estimate the demand curve or the supply curve? The answer is neither, because price is endogenous in both the demand and supply equations. So, "the OLS estimate is consistent neither for α_1 nor β_1. This phenomenon is known as the simultaneous equations bias or simultaneity bias" (Hayashi (2000), p. 187- 188).

the error term and regressors is not observed.[31] The solution would be the use of simultaneous equations.

However, the *endogeneity* problem does not exist if the prices were not given by the market. In order to estimate the demand functions for rail transportation the first step was, then, to study the pricing system.

As in most European experiences private rail companies in Portugal could not afford efficient railways and the government was required to participate by providing subsidies, guarantees for interest payment, building lines or even running the business. Huge theoretical and political discussions surrounded these issues. The government established legal prices, which were maximum prices. In Portugal, as in many other countries, pricing considered passenger trains (running at a higher speed) with three classes for travellers, and freight trains (running at a larger or lower speed) with four classes of goods, according to their nature. Classification of goods for this purpose gave origin to long and detailed lists of general prices and special prices. Special prices could be established for special goods (fertilisers or coal), special links, or exportation, for example. Children below three years of age rode free and children from 3 to 7 usually paid one half of the adults' price. Reduced prices were established for return trips, passes (for three or six months or annual), groups or passes for students. This meant that companies were not only monopolists, but also discriminating monopolists. As Dupuit noted, discriminated prices increased the companies' profits.[32]

Since the prevailing prices were established by the government and not by the market, we should not be concerned with the *endogeneity*

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[31] When a *regressor* is not orthogonal to the error term the variable is said to be endogenous.

[32] O'Brien, (1983) p. 42; Ekelund, (1975), p. 224-225; Dupuit (1849).

problem. On the other hand, these were the announced prices and consumers reacted to them, which still allows us to estimate the demand functions.

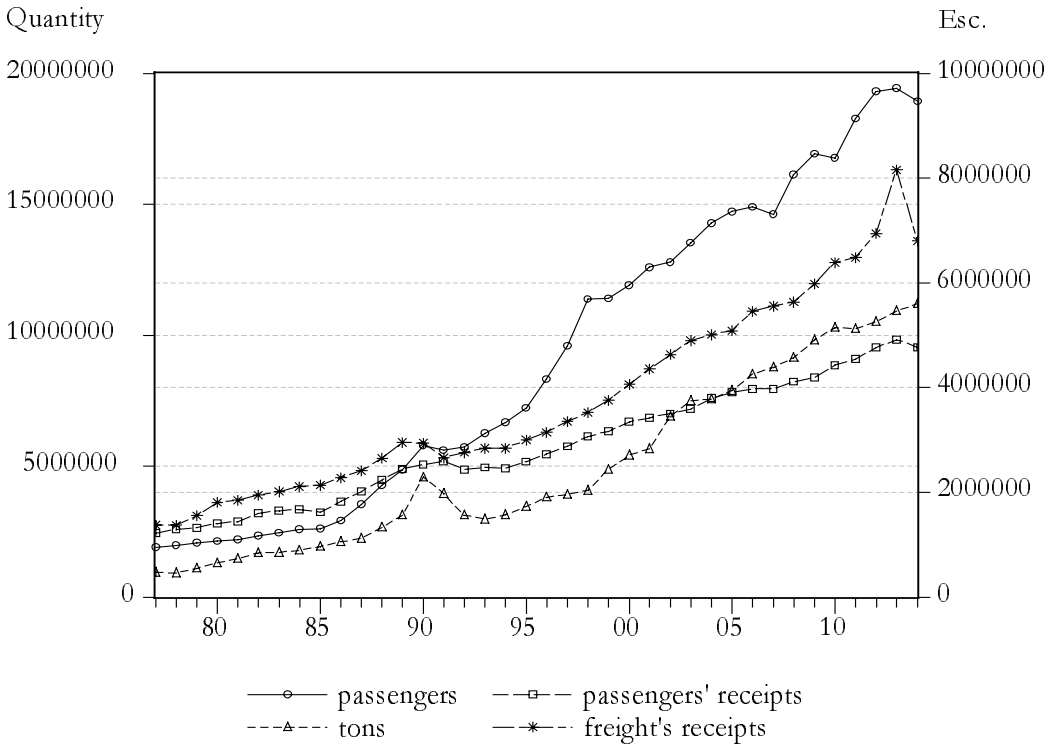
The time series character of historical data requires some caution when using the OLS model for the estimation of demand functions, as the assumptions of the regression model necessitate the series to be *stationary* and the errors to have zero mean and finite variance. If the *stationarity* condition is not observed, we could have spurious regressions and the OLS estimators are not consistent. Consequently, results are meaningless. So, we will check the *stationarity* of each time series using the Augmented Dickey Fuller test. When the series are *non-stationary*, the OLS can only be used if they are *co-integrated*, which requires that they have the same *order of integration*. To test *cointegration* we used the Johansen *cointegration* test.

5. Data description

Data on freight and passengers are scanty. A Historical Archive for railways is now being organised in Portugal; we are grateful to the rail company CP for providing these data as requested.

Data used come from several issues of the *Mappas estatisticos do trafego dos caminhos de ferro portugueses, Ministerio das Obras Publicas, Commercio e Industria*. These documents provide the number of passengers, the number of transported tons and the financial receipts produced by the transportation of passengers and freight for each railway line and for the entire network, annually, from 1877 to 1914.

Figure 3: Entire network, 1877-1914



The time series are therefore continuous and homogeneous. Unfortunately, data on the passengerkm and freightkm are not available.[33] In fact, it is quite different to consider a ton that travelled for 20km or one that travelled for 500km. The same problem applies to the counting of a passenger who travelled 5 km or 200 km.

Statistical Yearbooks[34] and Pimentel (1892) provide annual data on the average distance travelled by passengers and freight, line by line, but only for some years. Some missing points between observations were estimated by linear interpolation. Missing points before the first observation or after the last observation were calculated assuming that the average distance travelled was proportional to the length of the railway line. The latter procedure was used whenever the forecasted average distances were not acceptable. The idea was to assume that lines that were

[33] The same occurs in Pinheiro, Magda, section I, Chapter 4, in Valério, 2001.

still being built were supplying new opportunities for moving, while those already established provided always the same opportunities. A weighted average of the annual average distances, line by line, provided the average annual distance travelled for the whole country. In this way different regional habits are considered. The weights used were the number of passengers and tons, respectively, line by line. This national average distance was then used to obtain the annual time series for passengerkm and freightkm.

Unfortunately, regarding prices, no time series are available for freight. In order to estimate the demand we had to construct them, as explained below. In the passengers case a *tarifa geral* is available in several issues of the *Almanach Commercial* and *Annuario Commercial.* However, the *tarifa geral* does not correspond to the prices actually paid. There were several special prices, particularly for children, families, groups, workers or students, as explained before. This means that prices actually paid were lower than those announced in the *tarifa geral.* Furthermore, as prices were approved in contracts established with companies and prevailed for long periods, they do not present enough variation. These facts led us to construct a time series for passengers' prices, as well.

The easiest solution would be to use the average passenger price and ton price. They would be calculated dividing the financial receipts by the respective transported quantities. However, these ratios provide the average expenditure by passenger and ton, whatever the distance they travelled. Moreover, as we want to explain the demanded quantity, the use of these ratios would also create an *endogeneity* problem.

To overcome this problem we divided the average financial receipts by the average distance travelled, which is an exogenous variable. In this

[34] 1885,1886 and 1892. These yearbooks provide retrospective data for several years.

way we overcame the *endogeneity* problem[35] and at the same time we obtained a price per passenger or ton per km.

Usually the *regressors* included in the demand functions are not only the railways' prices, but also the consumers' income and the prices for other goods. As the demand function is being estimated for the whole country, the consumers' income was assessed through the GDP per capita and the prices for other goods were assessed through the cost of living index.[36]

6. Estimating Demand Functions

The demand functions for passengers and freight we wanted to estimate are, respectively,

$$PassKm = \alpha_1 + \alpha_2 Ppkm + \alpha_3 GDPpc + \alpha_4 NIP$$

$$TonKm = \beta_1 + \beta_2 Ptonkm + \beta_3 GDPpc + \beta_4 NIP$$

where Ppkm is the price per passenger and km, Ptonkm is the price per ton and km, GDPpc is the Gross Domestic Product per capita and NIP, the Cost of Living Index. The Cost of Living Index was used to represent the prices for goods, other than railways.

As explained above, only after checking the *stationarity* of the series can we estimate the demand functions. For passengers, both Passkm and Ppkm are *stationary*. For freight, both Tonkm and Ptonkm are *integrated of order one.*

[35] Greene, p.713.
[36] Valério, (1998).

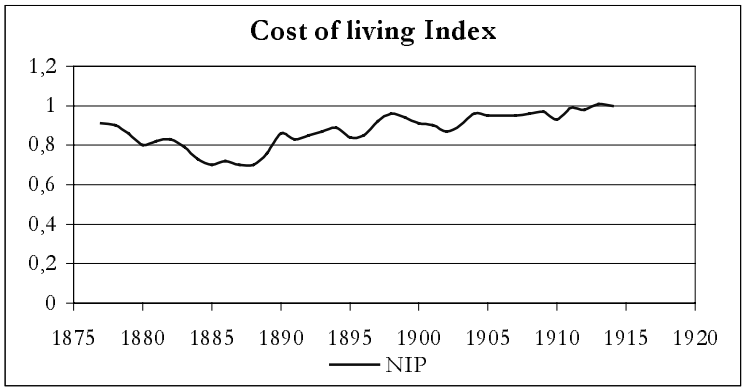
As the NIP is *stationary* and the GDPpc is *integrated of order one*, the first can only be included as an additional *regressor* in the passengers' demand equation, and the latter, in the freight demand equation. Nonetheless, the first difference of GDPpc could be used as a *regressor* in the passengers' demand equation. Yet, it is not significant (see appendix). So, estimated demand functions are

$$PassKm = 3.57 * 10^8 - 82612948 Ppkm + 8.04 * 10^8 NIP$$

$$TonKm = -13558900 - 19690980 Ptonkm + 4333 GDPpc$$

As expected, both Passkm and Tonkm are inversely related to the railway price, and Passkm is positively related to the NIP. This Index was constructed using mainly prices for foodstuffs gathered in Justino (1989). Looking at this series we can see that those prices were smoothly increasing during the period in question (fig. 4). Justino relates the behaviour of the foodstuffs' prices with the formation of a national market. As population and urbanisation were increasing, the necessity of moving was being created. Therefore, the demand for railway travel was increasing.

Figure 4



As a curiosity, we calculated the demand elasticity for 1914. For passengers the demand elasticity is 0.54, and for freight, 0.19, which means that, for 1914, the demand for railways was inelastic both for passengers and goods. These results can easily be explained. For passengers, railways killed all the alternative land transport, according to Ferreira (1946). Railways' success for travellers is very well documented in nineteenth-century literature. According to it, as soon as a rail link was available, the alternative stagecoach transportation disappeared. The same occurred with freight, although rivers and seacoast navigation continued to be used for this kind of transport. However, only 260km from 885 km of waterways were navigable all over the year[37]. The Mediterranean character of the Portuguese climate explains the small caudal in Summer. Seacoast navigation was very dangerous. Moreover the access to the harbours was very difficult. As Lord Crowford reported to London in September 1866 "The Douro mouth is frequently considered as one of the most formidable impediments to international trade"[38]. As for the Tagus navigation it is worth to say that it was only possible for about 1/3 of its Portuguese length and declined from the 1860s on, when the Eastern railway became available. It was rational to avoid costs on combined road-river transport. It is also understandable that passengers demand elasticity was higher than freight demand elasticity, as it was possible to walk or to ride small distances.

[37] Vieira (1983), p.60.
[38] idem, p.62.

7. Estimating the consumers' surplus

Having the estimated demand functions, the consumers' surplus is easily calculated as

$$\int_{p^*}^{\tilde{p}} q(p)dp$$

where p* corresponds to the price in a given year and $\tilde{p}$ to the choke-price.

Note that this consumers' surplus is the variation of the consumers' surplus that results from the comparison between a final situation (where the railway exists and the price is p*) with an initial situation (where the railway does not exist and the price is $\tilde{p}$), as in the latter the consumers' surplus is zero. Consequently, the consumers' surplus gives us the welfare gains due to the railway (in a given year).

We choose to calculate the consumers' surplus for 1914 because at this time the entire network was already built and in operation.

For passengers the consumers' surplus was 3440 *contos* and for freight, 11272 *contos* .[39]

These figures represent the value of railways for consumers. This is the amount that users would be willing to pay to preserve railways at work. Although we cannot establish a comparison with other economic sectors, the calculated surplus values for passengers and freight may be appraised

considering their comparison with the financial receipts produced by the transportation of passengers and freight, respectively, and total rail profits, for the entire network in the beginning of the First World War.

Receipts from passengers	4 762 *contos*
Receipts from freight	6 797
Total receipts	11 559
Total expenditures	7 133
Profits	4 426

Source: Ministério das Finanças, Direcção Geral de Estatística, Caminhos de Ferro, Dados referentes aos anos de 1914-1921, *Quadro Resumo do Tráfego no Continente da República*, p. 5.

The financial receipts are just the amount of money paid by passengers and freight for using the railways. The consumers' surplus for passengers in 1914 represents 72% of the amount of money they paid to travel. The consumers' surplus for freight in 1914 represents 166% of the amount of money paid for them to travel. In average, the consumers' surplus for passengers and freight represented 127% of the amount they paid for moving. Considering rail profits, the consumers' surplus for passengers and freight represented 332% of profits. These are strong results.

We already knew that the government spent a great deal with the purpose of providing transportation facilities for Portuguese economic activities. In fact, huge public deficits occurred throughout the period because of this policy of transportation facilities, which sometimes even included government railway building, but the assessment of people's

[39] The variation in the consumers' surplus can be interpreted as the utility's variation expressed in monetary units.

welfare improvement was an unknown aspect. As public deficits translated into a huge domestic and foreign public debt, and even into a partial government bankruptcy in 1892 in the wake of the 1891 global crisis, this improvement in railways users' welfare also meant that future generations would pay later for the private increased welfare of nineteenth-century railway users. Esteves (2001) explored the crowding-out effects and cost generation transfers.[40] These effects and nineteenth-century increased welfare for railway users are two faces of the same coin, which is to say, the two consequences of the Portuguese *Fontismo.*

It makes no sense to compare the consumers' surplus with GDP (0.32% for passengers and 1% for freight), as we did not estimate the effect of railways on GDP. Moreover, the weight of the financial receipts produced by the transportation of passengers and freight was very small in the Portuguese economy, as they only represented 0.4% and +0% of Portuguese GDP, respectively. Whatever their multiplier effects may be on the economic activity, those effects cannot be captured with this methodology, moreover because the small dimension of the railway sector is being assessed through the receipts resulting from administrative pricing, which are small because costs were partially supported by government subsidies and other financial support provided by the Portuguese central state. Consumers' surplus was very high, indicating a very significant increase in private welfare for users thanks to the government policy towards a volunteer provision of a good that was considered a public good.

If low administrative prices allowed high consumers' surplus, why was not demand even larger? A good reason may be the low Portuguese

[40] Esteves (2001).

standards of living before the First World War. According to O'Brien (1983) this is the explanation for Southern European countries:

"Unfortunately there are many parts of Europe (particularly in southern and eastern Europe) whose people remained too poor to take advantage of the opportunities for cheaper and more variegated consumption provided by railways. Their capacity to respond to the widening of markets continued to be restrained by unfavourable resource endowments and rising marginal costs of production.

For these regions the gain of railways before 1914 were positive but more limited than the gains that accrued to North Western Europe and the United States" [41]

We hope to improve the estimation if more appropriate data become available.

8. Conclusions

This methodology is useful for discussing private benefits versus social costs. Of course welfare improvement is not a whole measure of rail social benefits. Traditional controversies on the economic effects of Portuguese railways may result from different purposes on the assessment of the economic effects of railways. This methodology can only capture the effects on welfare for the railway users, but not for all of the Portuguese population. Our estimations measured the increased utility of those who travelled or sent freight, but positive externalities also exist for the entire population, even for those who never used it. In fact, even though not travelling or sending freight on the railways, nobody could escape the

[41] O'Brien (1983), p.22.

effects of the railways operation on the Portuguese society (lower consumer's prices, lower transportation costs and lower information costs). There were positive externalities for everybody as lower transportation costs translated into lower consumption costs for commodities in general and probably increased consumers' welfare for consuming them at those prices. The assessment of all those social benefits was not considered in this paper and provides direction for future work.

Appendix

Augmented Dickey Fuller Unit Root Tests						
estimated equation	Passengers		Freight		NIP	GDPpc
	passkm	ppkm	tonkm	ptokm		
$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \beta \Delta y_{t-1} + \varepsilon_t$	RH_0 at 10%[1]	NRH_0	NRH_0	RH_0 at 10%	RH_0 at 10%[1]	NRH_0
——		NRH_0	NRH_0	NRH_0		NRH_0
$\Delta y_t = \gamma y_{t-1} + \beta \Delta y_{t-1} + \varepsilon_t$		RH_0 at 5%	NRH_0 at 10%	NRH_0 at 5%		NRH_0

[1] RH_0 $a_2=0$ at 5% and γ is not using normal distribution. Therefore, we can conclude there is no unit root

Estimated demand functions				
		passkm		tonkm
		mod.1	mod.2	
	obs	38	37	38
——	ppkm	**-82612948** (-8,076205)	**-8E+07** (-6,720064)	
——	NIP	**8,04*10^8** (4,119895)	**8,89*109** (4.015045)	
——	dGDPpc		-260 (-0,080898)	
	constant	3,57*10^8 (1,528870)	2,43*10^8 (0,890869)	-135589000 (-0.417598)
——	ptonkm			**-19690980** (-2.756077)
——	GDPpc			**4333** (3.218549)
	R^2	0.864448	0.864992	0.789961

Note: t-statistics in brakets. The coeficients in bold are significant at a 5% level

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