Benefits of Travel Time Savings for Freight Transportation: beyond the Costs.

Abstract

The purpose of this presentation is to investigate whether current practices in Cost Benefit Analysis do not underestimate the actual benefits accruing to the economy when transport investment reduces transport time.

In a first section we define the different time related attributes of transport. In a second section we investigate the current practices in various European countries. We find that the overwhelming majority of countries estimate the benefits of improved network through the reduction in transport costs. In a third section we advocate the idea that the total benefits may exceed this mere cost reduction. We show that shippers exhibit a significant willingness to pay for faster deliveries and examine the cause of this situation. We demonstrate that a benefit analysis based on traditional definitions of surplus should take into account these additional effects. This question should be carefully distinguished from the recurrent question of indirect effects. Eventually we try to identify methods to measure these extra benefits and the likely magnitude of these effects. We review results obtained by previous attempts to measure this willingness to pay, based on RP data and SP exercises.

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Introduction

It is well known that time savings represent a very large part of the benefits accounted for in transportation projects' Costs Benefits analysis. This has been widely recognised in transport economics literature, for instance Ortuzar (94) indicates that time savings represent the most important benefits for transportation projects. It is usual to consider that in European countries time savings represent up to 80% of measured benefits of a project. Among these time savings, freight transportation represents an important part, although it is harder to find in economic literature formal estimates of corresponding share. Expert estimates from Banque Européenne d'Investissement, indicate that in the European Union around one third of time benefits are due to freight transportation, in other countries this share can reach 50% of time savings benefits. This implies that an incorrect estimate of freight value of time will provide biased Cost Benefit Analysis and misleading policy recommendations.

Still one should recognise that freight value of time has been significantly less investigated than passenger value of time and remains a field for further investigations. There are many reasons for this situation,. We will not here provide an in depth analysis of these reasons, but we will only list the main causes of this situation : the separation between the decider and the object that actually travels (the most visible difference is that in passenger transportation the traveller can decide himself while in good transportation it is not the case) ; the difficulty of identifying a single decision maker or to elicit the decision making process; the multiplicity of economic agents involved in the transport and the related difficulty to identify the agent that will take advantage of the time saving ; the instability of the shipment population, when as underlined by Fridstrom and Madslien (94) the shipment cease to exist as soon as it reaches its destination ; the intrinsic heterogeneity of shipments, transport operators and shippers, while it is likely that shipments transport have an higher number of characteristics or attributes than passenger trips. Last but not least a sound knowledge of freight transport is impelled by the scarcity of reliable and complete information in a context where confidentiality often matters.

The point here is that due to these factors, freight value of time still deserves more investigation. In this article we will focus on one single aspect of freight value of time, which is the usual practice to take into account only the reduction of transportation

service production costs or the so called "factor cost method". In this article we will investigate whether such practice is not omitting part of the benefits from transportation time reductions, those benefits that shippers place on faster delivery. This possible omission has already been questioned in recent transport economic literature (see for instance Wigan et al (98)), by government agencies (see for instance Boiteux (01)) or by international organisations like the World Bank.

We propose here to investigate this question in the framework of surplus analysis. We also make a point here that the question of shippers valuation of time savings is not the same question as the recurrent debate on indirect effects. Although it is not always clear how direct and indirect effects are defined, we usually find that indirect effects of infrastructure investments, are the one that do not appear in the changes of the quantity of good transported on this precise market. We should however recognise that the concept of indirect effects is not defined univocally, which makes it difficult sometimes to define that such or such effect is or is not part of indirect effect. However if we simply define indirect effects as the effects that are not reflected in the position of transport supply and demand curves, the extra benefits that we want to investigate in this article are not indirect effects.

Section 2 of this paper defines the different time dimensions of freight transportation services. Section 3 briefly demonstrates that current practices take into account only factor costs. Section 4 advocates the inclusion of other benefits. Section 5 investigates how to quantify these extra benefits.

1. Definition of Time Savings in Freight Transportation.

When investigating the value of freight travel time savings, one should recognise the multiplicity of time dimensions involved in goods transportation. The list hereafter illustrate the variety of concepts that one can link to the freight value of time.

- The value of reducing the time necessary for the transportation of the good.
- The value of the reliability in consignment hours.
- The value of the flexibility in organising consignment at shippers request.
- The value of the frequency for fixed schedule transport services.

- The value of the continuity of transport services (against meteorological conditions, strikes or any event that can impend the service).
- The value of information on the time attributes of transport services (real time information on the likely arrival time).

There is also a case that their is a more generic value of time, which corresponds to the value that economic operators associate to the possibility of having input factor available at date t. This is a generic value of time with respect to the fact that it somehow includes all others time dimensions of transportation. This also gives rise to a conception of transportation services as a way to resolve differentials in the "value" of goods with respect to space and to time. The existence of transportation arises from differential in the profitability or marginal utility of a good from one place to another ; the time dimensions of the transportation services result in turn from the differential of the value of good at origin and destination from one period to another.

In the current article we will concentrate on the most immediate aspect of time dimensions which is duration. We recognise that there is a case for studying other dimension, and that their is a growing interest in reliability, but this goes beyond the scope of this article.

However focusing on the duration dimension we also find that it is not an homogeneous concept and that one should take into account different definitions of transport time. The first one is the *travel* time, meaning the duration where the vehicle is actually moving the good from one location to another. But in many instances, this may represent only a part of the actual duration of transport operations. In many situations there will be other "delays" between the time the good leaves the shippers' depot and the time where the good is made available at destination. This will consist for instance in other logistical operations like cross-docking, intermediate warehousing, grouping - degrouping, or in other time consuming operations like border-crossing. This defines a second duration that can be referred to as *transportation time*. Eventually one could consider that the shipper and hauliers are also concerned with another duration of the transportation service. This is the duration between the instant where an arrangement is made about the transportation of a good and the moment where the good has to be available for loading. This ordering time added to transportation time can be referred to as *delivery time*. One should recognise that the term delivery time may be ambiguous,

and that the usage sometimes has it to label delivery time the duration between loading and unloading of the good. But for convenience purpose we propose to use the above defined nomenclature.

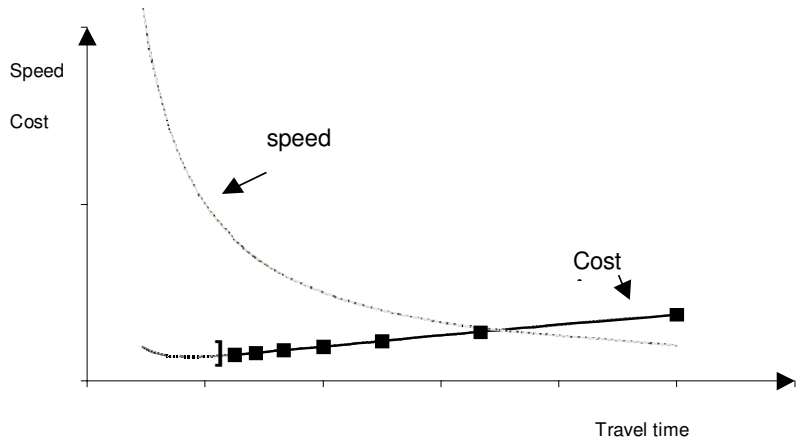
Based on this definition we can now present what is the current practice in Cost Benefit evaluation.

2. Current practice in freight time saving valuation.

2.1 Cost based valuation.

A brief survey of current practices in European countries and in international organisations shows that freight time savings valuation relies on factor cost. This is clearly illustrated by Cost Benefit Analysis methods in use in France (Ministère de l'équipement (98))or in England. In the latest, COBA Manual indicates two components : changes in Vehicle Operating Costs, and changes in Vehicle Occupants' value of time. These two components of Value of time can be affected in two ways, although in most of the projects the two effects will be combined : (i) by an increase in speed for a fixed distance, (ii) by a decrease in distance for fixed speed. This latest effect is reflected in COBA analysis by a decrease in km cost. The figure hereafter represents the aspect of total factor costs (vehicle operating costs and vehicle occupants costs) for different speed, when distance is fixed and when speed and time are changed. More details can be found in DETR (96).

Figure 1 : factor cost value of time based on D.E.T.R. methodology (fixed distance).



One can note that the cost function is truncated at the left representing the fact that some speeds are not available to the hauliers.

We find that in other countries the valuation of freight travel time savings is also based on transportation production costs savings. This is the case in France and in other European countries (a census of different evaluation practice in Europe can be found in Euret (94)) On can also find the same kind of approach in international organisation like Banque Européenne d'Investissement and the World Bank.

2.2 Surplus representation of production cost reduction.

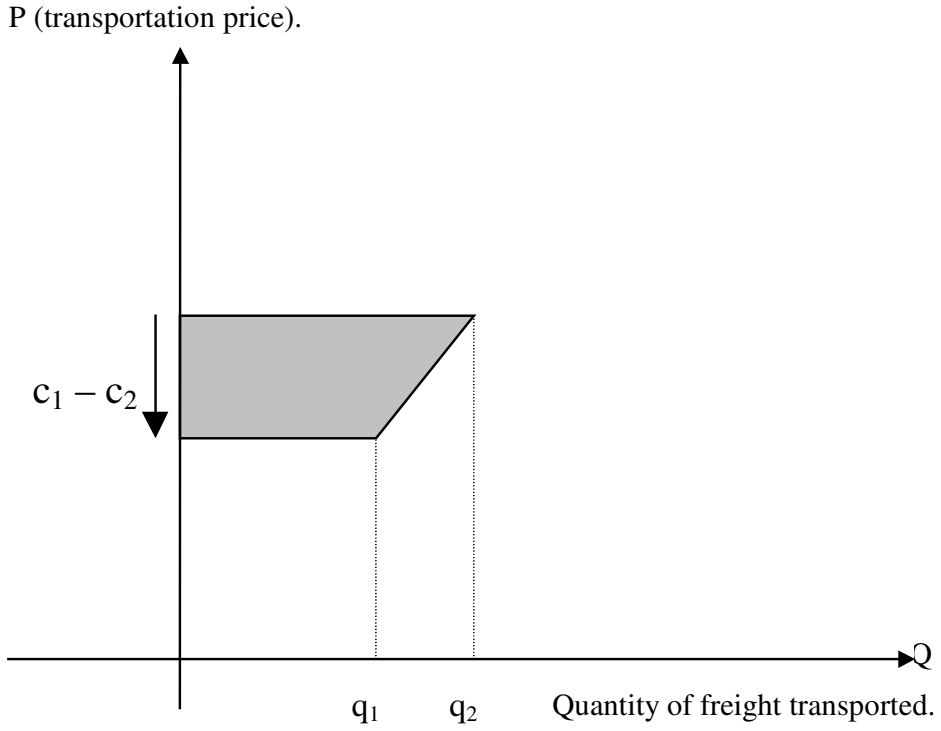
Often this definition of cost based valuation is included in a surplus approach. One should here recognise that surplus is in turn defined in a variety of ways, from the original work by Dupuit to the more contemporaneous contribution of Allais, passing through the milestones works of Marshall and Hicks. In the current paper we propose to discuss benefits based on the conventional Marshallian definition of surplus. We recognise that there could be a discussion on whether this Marshallian surplus is the best measure of benefits occurring thanks to infrastructure improvement. but for theoretical clarification purpose it seems better to separate the question on the best benefit measurement criteria and the question that is here in discussion about whether some benefits are not captured by current COBA practice.

One can represent the Marshallian surplus associated with travel time savings corresponding to the usual COBA practice. Figure 2 represents the Marshallian surplus (or actually the change in surplus) associated with the shift in the supply curve of freight transportation, where the ordinates q are the quantity of freight passing through the infrastructure, and p is the price paid for the transportation of the shipment. Note that p is not the generalised cost but only the monetary cost for transporting the freight.

The greyed area represents the term : $q_1*(c_1-c_2) + (q_2-q_1) * (c_1-c_2)/2$. Where :

- q_1 is the quantity of freight transported without the project;
- q_2 is the quantity of freight with the project;
- c_1 is the transportation production cost without the project;
- c_2 is the transportation production cost with the project.

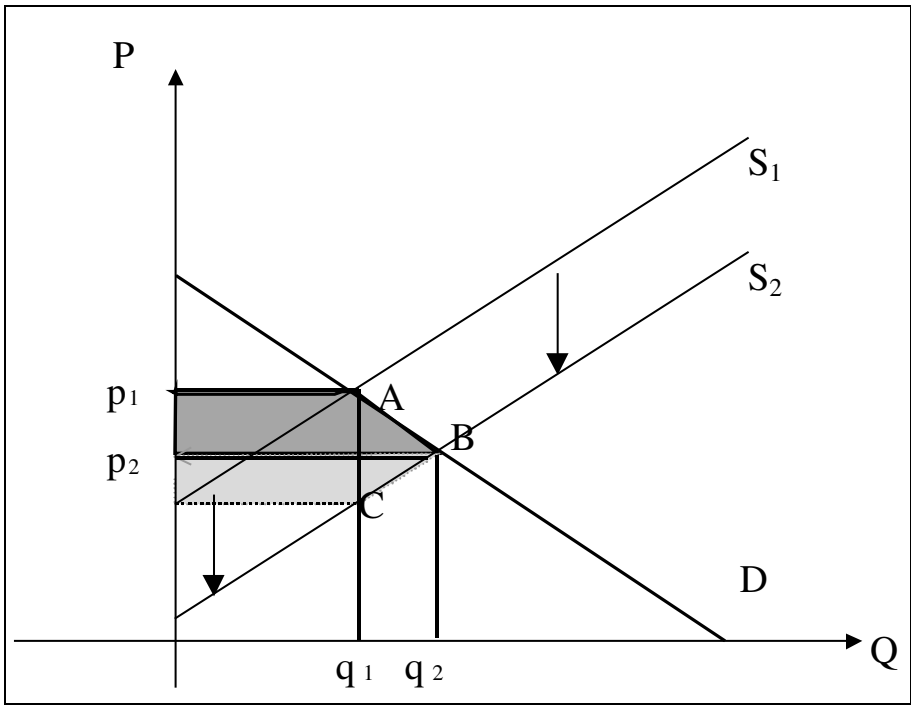
Figure 2 : Value of freight time savings based on production cost reduction.



This representation is sometimes used without consideration of the underlying shifts in demand and supply curves, based on the idea that these production cost savings will anyhow benefit the participants to the market. Some other times it relies on the idea that the supply curve moves downward from a distance equal to c_1-c_2. This approach is for instance explicitly used in BTRE (99), and can be illustrated by figure 3. Obviously one of the necessary conditions for this representation to be correct is that the estimation of (q2-q1), the apparent induced traffic, is itself correct.

Two precisions should be made. First, one may eventually be surprised that the supply curve for faster transportation is shifted downward for faster services. The reason is that here we consider that the time saving is exogenous to transport operators. Second, one should prevent against a confusion between the surplus as presented above and the notion of hauliers surplus. In the figure above, it holds true that all surplus is related to a shift in hauliers supply function. But this does not mean that all surplus is haulier surplus. As is traditional in surplus analysis the decrease in price along the demand curve transfers part of the benefits to the shippers. As a result the surplus is represented graphically be two areas : the shippers surplus (dark grey area) and the hauliers surplus (clear grey).

Figure 3 : surplus related to transportation cost reduction.



Eventually, one should note that the freight transportation market has some peculiarities that may make the representation of surplus a bit more specific. It is likely that hauliers supply function is horizontal due to: (i) in medium and long term , the supplied quantities are perfectly elastic to the demand, and (ii) low differentiation of technological conditions among suppliers. Saying this we do not mean that there is one unique technology among suppliers to provide transport from one location to another. Segments exists among transport for instance : frozen transportation, container transportation, bulk transportation… but it still holds true that in each of these segments their are no likely durable production cost differentials when traded quantities increase. In these conditions, the shift of horizontal supply will transmit the full benefits of cost decrease to the shippers. But still this surplus will only be the counter part of cost changes and will not reflect other possible changes.

Moreover, the traditional representation is approximately correct in the situation where suppliers would shift their supply function only from a fraction of the reduction of production cost. In the latest situation, suppose the induced traffic is correctly estimated, the usual surplus measure estimates correctly the actual surplus for pre-existing traffic, but the rule of half can slightly overestimate the surplus on induced traffic. However such overestimates may be of limited importance if, as is the case in

many developed countries, competitive conditions in freight transportation will make unlikely that the hauliers can keep a significant amount of cost reductions.

The conclusion here is that the standard approach based on production cost reduction provides an acceptable estimate of Marshallian surplus when induced traffic is correctly estimated and when the only change occurring is a reduction of transport service production costs.

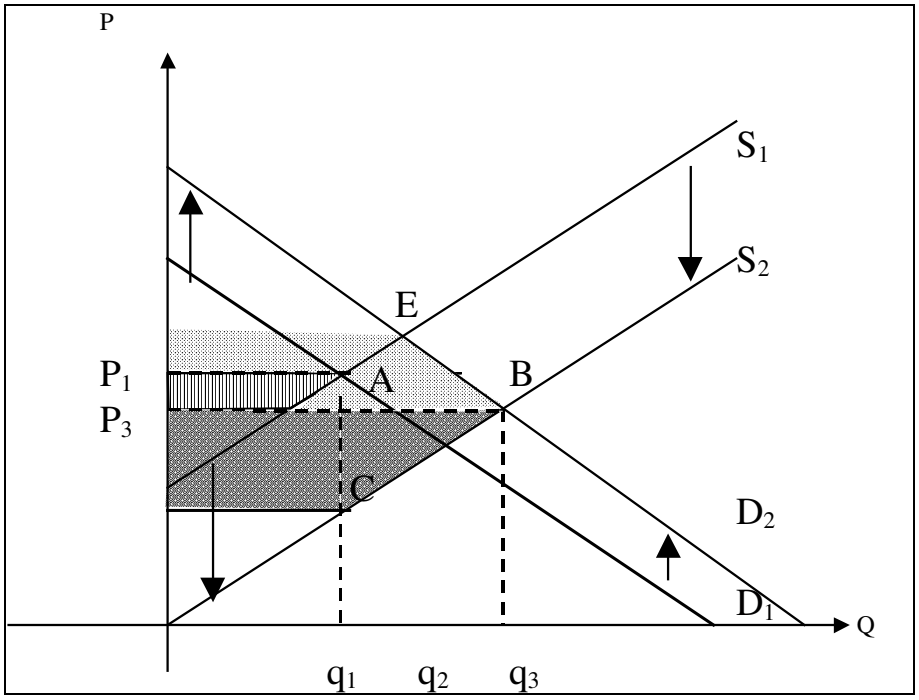
3. The case for extra benefits.

In this section we want to show that their exist extra direct benefits when transportation time are reduced. These changes are linked with an upward shift in the demand curve, reflecting the fact that a shipper can be willing to spend more for a faster service.

3.1 The shift in demand curve

In such occurrences we find that there is an extra surplus for the time saving which corresponds to the shift in shippers demand curve multiplied by the quantities before the time saving + half of the induced quantities.

Figure 4 : Marshallian surplus for a shift in freight transportation supply and demand.



Interestingly, one should note that the underestimate of standard COBA practice takes place even when the induced quantities are correctly estimated. Suppose that the planning agency has sufficient good experience of transport project so that it can forecast accurately the quantities q_3 regardless of any omission of demand shift. In such occurrences standard practice will only consider the surfaces $AC^*q_1 + AC^*(q_3-q_1)/2$, where AC is also equal to $(c_1 – c_2)$. This surface underestimates the total surplus.

3.2 Why do shippers value time ?

The point here is to identify the reasons for which the shippers value time. McKinnon (95) proposed that the value placed by shipper on faster transportation were linked with a threefold phenomenon : (i) Spatial concentrations, more reduced transportation can permit to concentrate productions and distribution in less locations, providing potential economics ; (ii) tighter scheduling ; Mc Kinnon also quotes a third factor that is (iii) market expansion, which we will not include as a reason explaining the shift in supply curve, as from our point of view, it is not a cause of the shift but is another way to name this shift.

We propose here to provide a two sided explanation to this shift in demand. Shippers shift their demand on the freight market on the one hand because (non transport) costs are reduced, and on the other hand because revenues are increased.

First, non-transport production costs are correlated to transportation services duration. These phenomenon have been investigated for instance by Aschauer (82), Allen et al. (94), Quarmby (89) and BTRE (99) ; although these inquiries usually do not distinguish whether the non-transport costs decrease in relation to transport cost, or in relation to transport time. The difficulty here is that economy bearing time reduction are collinear to economy bearing transport cost reduction. Still one should consider that when transport cost remain the same, shippers' production cost exhibit transport time related economies. Transportation time related economies for the shipper are due to the reorganisation of production and distribution process that can take place among shippers, when transport conditions are changed. This can occur through consolidation of intermediate warehouses. Suppose that a firm wants to have all customer within reach of a maximum delay, then a reduction of travel time will allow to use less locations and let the firm take advantage of concentration economies. Also one should recognise that such effects will be significant only when the time change is important. In the other case

the effect of time saving on cost, will be to allow substitution of more time to other priced input in the production process. This means that in some occurrences the shipper can prefer to have his good leaving its factory latter, because, taking advantage of this extra delay, he will be able to use cheaper production combination. One should however recognise that such trade off between production costs and goods departure time is likely to happen only when production is made on request or when the producer is facing demand whose quantity is not constant over time. As pointed out by Baumol and Vinod (70), when a firm faces a constant demand and when the good is similar from a shipment to another, then transportation time has no impact on costs and revenues for both the firm and its client, and cost minimising will prevail in the choice of transportation services. In other occurrences however the producer will be able to make trade off between time and cost in the choice of the haulier.

Second, shippers revenues are correlated with transportation service duration. This is mainly due to the fact that shippers can provide their customer with time benefits. The shipper who uses faster transportation can provide his client faster and provide them more satisfaction if they attach importance to these time dimensions of the good. The willingness to pay of the shipper will partly reflect the willingness to pay of its clients. This can be the case for instance when final customers utility function is sensitive to the time at which goods are available. This will then be reflected in consumers willingness to pay for faster transportation and, if the shipper has to pay for the transport, in the shippers willingness to pay for faster transportation. Eventually this can pass through different intermediates that deal with the good between the shipper and the final customer. Time depending revenues of the shipper can also be linked with the cost of an intermediate recipient firm. If the cost of these firm are increasing with arrival time at destination, extra revenues can be gained by the shipper when time savings occur.

3.3 The issue of double counting.

There should be here a case to consider more carefully the issue of double counting. We think that the main source of misunderstanding about the question of additivity of demander and suppliers valuation of time savings comes from the confusion of different categorisations:

- The surpluses defined by the side of the market it originates from : demand or supply curves ;
- The surpluses defined by the nature of the economic change it originates from : time depending transport production costs savings or the surplus related to other economic effects.
- The surpluses defined in relation with the agent it accrues to : shippers or transport operators.

The important thing here is that additivity holds only inside each of these categories, but is misleading, unless specific assumption are made, when one wants to add surpluses measures based on several categorisations. As can be seen on the graphs above, surplus of the shippers can be added to surplus of the transport operator, the surplus due to demand shift can be added to the surplus due to the supply shift, the surplus linked with transport service production cost can be added to the surplus linked to other phenomenon, but addition of one of these terms to the term of another category is misleading.

One can also note that additivity holds under general conditions and also in particular cases, for instance when competitive conditions are so that the transport operators have to transmit all the production cost decrease to their clients, or when the supply curve is a horizontal. If those two conditions combine the transport operator surplus can tend toward 0 and all surplus is shipper surplus.

4. Quantification of extra benefits.

Once established the existence of such extra benefits, one needs to assess their magnitude. There are two questions here, how to measure these extra benefits ? and what is their likely magnitude ?

4.1 How to measure extra benefits ?

Regarding the measurement problem, each of the above listed categorisation of the surplus could be used to measure these extra benefits, but some of these decomposition could not provide workable approach. For instance, a direct way would be (i) to measure all the benefits that are not linked with time depending transportation costs. But the difficulty is that unless more assumptions are made, it is a very uncertain task to sort

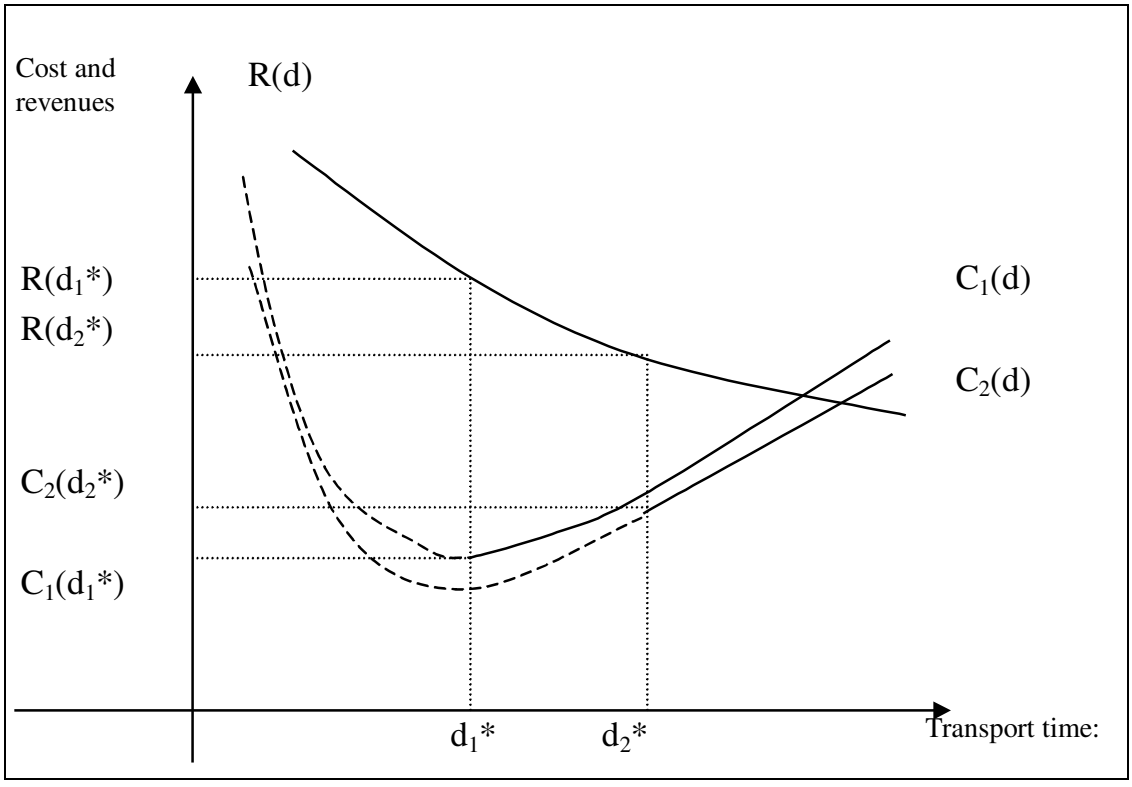
out what benefits are linked with production cost changes and what benefits are linked with other effects. (ii) The second possibility is to measure the shifts in supply and demand curves, that occur when transport time changes. This approach can be readily simplified if we suppose that the supply curve is horizontal and is shifted downward exactly from the time depending cost variation of transport operator. If such assumption holds then we find ourselves in the same situation as (i), but with the extra simplifying hypothesis that all non transport cost related benefits can be found in the demand curve shift. In this case, one can think about using the usual tools of economic analysis, like RP and SP, to measure the shift in demand curve. This gives rise to the use of shippers interview data. One should however note that many shipper interviews address a mixed population of shippers and own account transport. One should then (i) rely on samples consisting only of shippers (like in Fowkes, Nash et Tweddle, (89); Wigan, et al (98)) or (ii) exclude own account transport from the elaboration of shippers value of time estimates (see for instance De Jong, Van De Vyvere, Inwood (95); De Jong, Gommers and Bergkvist (96); Fridstrom and Madslein (94); Widlert and Bradley (92); Jiang (98), or De Jong, Velay et Houée (99)). Eventually (iii) the third possibility would rely on the decomposition of the surplus based on the agent that takes advantage of them : shipper of hauliers. This solution seems to offer no advantage compared with the others and requires the formulation of hypotheses on the elasticity of price to production cost changes.

4.2 Willingness to pay of the hauliers for time saving : a paradox ?

Eventually one should note that the measure of hauliers benefits raises some paradoxes. If the supply curve is horizontal, hauliers should have no increase in surplus when time savings occur. The paradox here is that SP or RP exercises elicit a willingness to pay of the hauliers for time savings. It could be tempting to explain such phenomenon by myopia of the operators. Transport operators could give answers to interview in a short term context, where price may not be already adjusted to the change in cost ; or operators could have a preference for risk, meaning that if production conditions change this is an opportunity to increase market share, and this increase could be reflected in a willingness to pay. These reasons cannot be completely rejected but one can also consider that there is another cause for this paradox. Hauliers elicited

willingness to pay for time savings relates to trade-off between costs and revenues for a *fixed infrastructure* endowment or equivalently for *fixed time depending revenue*. Typically in itinerary choice, hauliers choose duration to maximise the transportation time depending profit $P_i(d) = R(d_i) - C_i(d_i)$, where revenues R(d) depend on transport duration and C_i that are available defined on each possible itinerary. This is illustrated on the graph hereafter which represents two cost functions for two distinct itineraries. These costs functions are truncated to represent the fact that maximum available speed on each itinerary is constrained. So the dashed part of each cost function is not available to hauliers. The graph also represents a transport time depending hauliers revenue. There could be a discussion here on the aspect of this revenue curve. This curve could be non differentiable, it could exhibit threshold, it could also be very close to the cost curve reflecting the fact that profit in transport industry are usually low. For simplification purpose we suppose a continuous R curve as represented below.

Figure 5 : willingness to pay and profit of transport operator for itinerary choice .

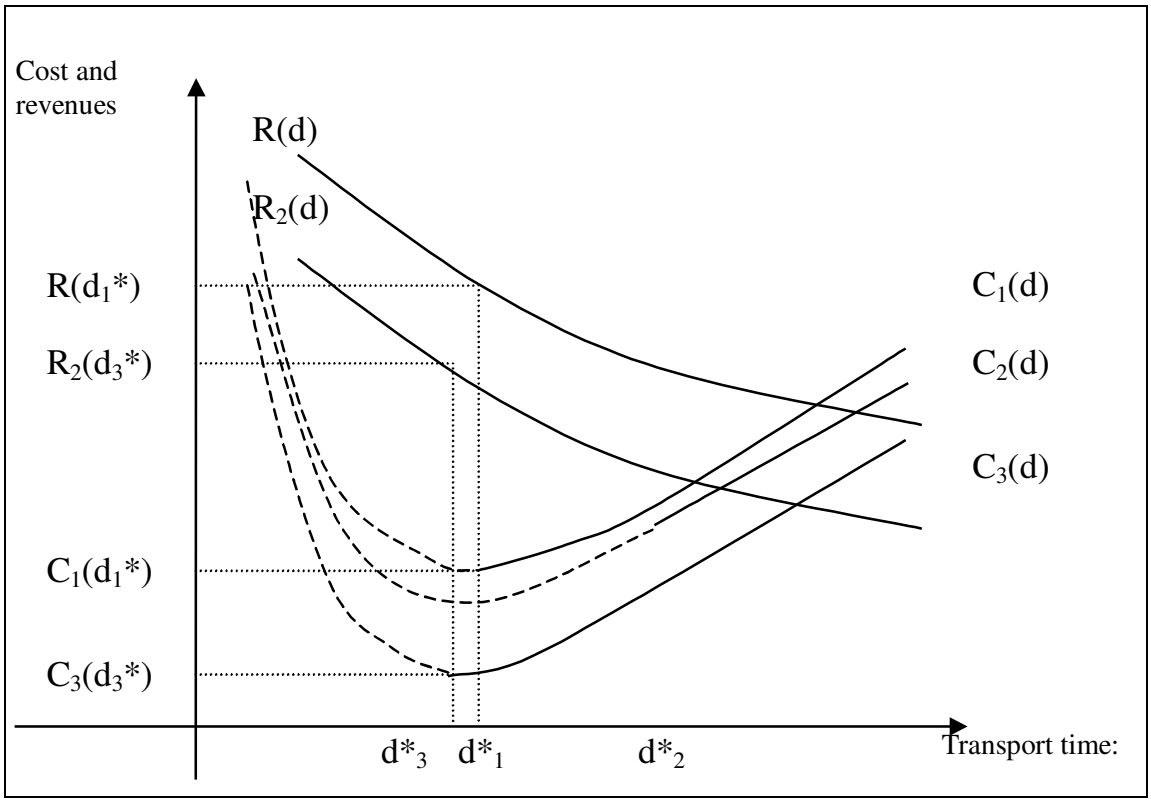


In this context, the Willingness to Pay that is expressed by hauliers in SP or RP itinerary choice, corresponds to the difference of profit $(R(d_1^*) - C_1(d_1^*)) - (R(d_2^*) - C_2(d_2^*))$ between two itineraries for a fixed R function or equivalently for a fixed market freight rate. Note that this extra profit incorporates all the cost and revenue

differences between the two itineraries, like duration difference but also distance difference, meaning that only part of this willingness to pay is value of time. To obtain the willingness to pay for time savings, one needs to isolate the time based effect from other effects. But this light complication can be omitted here for simplification purpose.

The important point here is that the willingness to pay elicited in itinerary choice gives no indication on the actual benefits that hauliers would get from a shift in the infrastructure endowment. This is illustrated in the following graph where a new cost function C_3 appears and the revenue function can be shifted to a new position R_2. As can be seen on this representation, the shift in revenue curve can make the benefits of the haulier ($R_2(d_3^*) - C_3(d_3^*)$) unchanged compared with ($R(d_1^*) - C_1(d_1^*)$) if this shift is equal to the difference in cost. The conclusion here is that, unless very specific and unlikely hypotheses are made, the willingness to pay of the haulier in the context of a new infrastructure, will be different from the willingness to pay for itinerary choice.

Figure 6 : willingness to pay and hauliers profit for changed infrastructure endowment.



4.3 Magnitude of the extra benefits.

Eventually one should discuss the likely magnitude of these benefits. One should consider three elements :

First the value elicited by shippers for faster transportation may be disappointing low, compared with the 30 euro per hour and per vehicle that one find for instance in France based on factor cost method. DeJong Velay et Houée (99) find value around 6 to 8 euro /hour and per shipment. Wigan and al find lower values, from 0,66 AU$/pallet.hr for Intercapital Full Truck Load (FTL) to 1,30 AU$/pallet.hr for Metropolitan FTL, and 1,40 AU$/delivery.hr Metropolitan Multidrop. Noting however that such results reflect only short term values of transportation time reduction, one should also consider that medium and long term adjustments can make the final benefits of trip time reduction larger than short term value.

Second, it is likely that the shippers valuation of marginal transport time savings may be decreasing. This relates to a twofold phenomenon : (i) time saving depending shippers production cost economy are probably decreasing because the most effective changes in production and logistical process will be made when the first time saving occur. Discontinuity in transportation time saving depending production cost economy may alter the regularity of this phenomenon but will probably not change the overall relation between time savings and cost decrease (ii) time savings in themselves are limited, and the magnitude of future time savings is decreasing in relation to accumulated time savings. Transport duration can tend toward 0, but the achievement of time savings becomes harder when this 0 limit is getting closer. As underlined by McKinnon (95) it is likely that time the construction of a road network be an unique event in history, and that the related logistic consolidation effects are also unique in history.

Third, and most important, value of *transport* time savings cannot be applied as is to *travel* time savings generated by infrastructure improvement. The reason again is that shippers experience transport time savings that can be quite different from travel time savings that take place on the road. This relates to the productive conditions of the hauliers that can make them prefer to internalise part of the travel time savings and not to transmit all of them to the benefit of the users. To sort out this question one needs to set up a model where a profit maximising transport operator faces transport time and travel time depending costs and transport time depending revenues, and to derive from

this model an analysis of travel time savings conversion into transport time savings. Such analysis is however beyond the scope of present article.

5. Conclusion and further comments.

In this contribution we have shown, using Marshallian definition of the surplus, that standard practice in the valuation of freight travel time savings does not capture the full benefits that occur in freight markets. Extra benefits due to shift in demand function should also be taken into account. Additivity can be implemented when one considers adding surplus that relate to a univocally defined categorisation of surplus, but can be misleading when one wants to add benefits that come from different categorisations. Simplifying assumption can however be used to make additivity problem workable. When one assumes that the shift in supply function reflects completely the change in transport services cost, and that supply function is not altered by any other economic phenomenon, one can add shippers value for travel time savings to transport production cost economies.

One needs however to recognise that the magnitude of the extra benefits to take into account may not be considerable. Moreover, one should recognise that the addition of shippers value of time savings to other benefits has to take into account the discrepancy between travel time and transport time savings. This point probably needs to receive extra attention.

Eventually one should recognise that more and more premium is put by shippers not only on travel time savings but on reliability. This raises other interrogations that go beyond the scope of this article but certainly deserve attention in future research.

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