Value of travel time reliability on French high-speed and regional services

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Abstract

As an infrastructure manager, Réseau Ferré de France must inform and consult the different stakeholders about its investments projects. In this context, socio-economic appraisal is of great importance. Regarding new line projects, the cost-benefit analysis is well established. However, for projects whose main functionality is to improve the reliability of services, it is less straightforward: it requires to value the delays that passengers would have experienced without the investment. In this paper, we propose values to assess an improvement of the punctuality of trains in France (high-speed and regional trains), estimated from two stated-preferences surveys, carried out by Stratec with the help of Significance and Rand Europe. This paper also estimates the value of information in case of disturbance and the cost of overcrowding. The Commissariat Général à la Stratégie et à la Prospective (advisory institution under the authority of the Prime Minister) recently recommended to use the values of punctuality estimated in this research to appraise transport infrastructure investments.

Keywords: punctuality, value of time, high-speed services, regional services

Résumé

En tant que gestionnaire d'infrastructure, Réseau Ferré de France doit informer et concerter avec les différentes parties prenantes de ses projets d'investissements. Dans ce contexte, l'analyse socio-économique joue un rôle important. Pour les projets de lignes nouvelles, l'analyse coûts-bénéfices est relativement bien établie. En revanche, pour les projets dont la fonctionnalité principale est d'améliorer la régularité des circulations, leur ponctualité notamment, cette évaluation se heurte à la difficulté de valoriser les retards évités grâce au projet. Cet article propose des valeurs pour valoriser une amélioration de la ponctualité des trains en France (TGV et TER), estimées à l'aide de deux enquêtes de préférences déclarées, réalisées par Stratec avec l'aide de Significance et Rand Europe. La valeur de l'information fournie aux voyageurs en cas d'incidents et la valeur du confort ont été également estimées. Le Commissariat Général à la Stratégie et à la Prospective a récemment recommandé d'utiliser les résultats de cette étude pour évaluer les futurs projets d'investissement dans les transports.

Mots-clé: régularité, valeur du temps, TGV, TER

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1. Introduction

Improving performance and quality of service is one of the key priorities for the French Railway infrastructure manager. Among the different issues concerning quality of service, reliability of railway operations is under strong scrutiny by the stakeholders and the final users. There have been strong demands to improve the reliability of railway operations. The French government created in 2010 an observatory of the reliability of different public transportation modes (aviation, rail, ship), with a dedicated website[a] communicating passengers' rights and detailed reliability statistics.

Reliability can be improved through different means, most of them being costly. In order to choose the most efficient solution, they should be compared through cost-benefit analyses. The delays that would have experienced by the passengers without the investment should be valued. Nevertheless, valuation of reliability is not straightforward. Numerous academic papers deal with the valuation of the punctuality or reliability for private or public transport. However, we found few papers about this matter in France. Kroes et al. (2006) is a notable exception. This study, carried out by the STIF (the administrative body which supervises and finances public transport for the Paris region), is a rare example of stated-preferences survey developed in order to investigate the value of reliability on suburban trains in France.

In the present paper, we intend to offer a new development to this literature. We purpose to estimate the value of travel time reliability on high speed trains and regional trains. This research, carried out by STRATEC, Significance and RFF, was organised in three stages: a review of the international literature, a qualitative research by means of focus groups, and quantitative analyses which involved two stated preferences surveys among rail passengers. Qualitative analyses and stated-preferences surveys were conducted separately for high-speed trains and regional trains. Different models were estimated. They enabled us to express the travel time reliability in equivalent minutes of on-board travel time. The analysis also estimates the value of the information given to the passengers in case of disturbance (cause and expected duration of the delay) and comfort (for regional trains).

In the following sections, we first present the approach we followed resulting from the conclusions of our literature review and qualitative research (section 2). In section 3, we describe the survey data. The estimations results are presented in section 4. Section 5 draws some conclusions.

2. Related literature

The concept of regularity or punctuality suggests a certain repetition and uncertainty. From one day to another, a commuter could experience different travel times, and, for a given trip, it is never known beforehand what will be the exact travel time. Travellers may experience irregularity through different ways: late departure, late arrival (when there is a time-table), longer waiting time in station for high-frequency services, etc.

The academic literature offers two approaches to include time reliability in the travellers' utility function: the scheduling approach and the reduced-form approach.

2.1. Scheduling approach

The scheduling approach is the standard Vickrey-Small model. This model is used to explain departure time choice given a Preferred Arrival Time (*PAT*). It explicitly distinguishes between the costs associated with late and early arrivals. Travellers dislike being early relative to their *PAT* (quantified as Schedule Delay early, *SDE*) or being late relative to *PAT* (quantified as Schedule Delay late, *SDL*). They also dislike spending time in traveling (*T*) and being late at their destination (D_{Late}).

This model is commonly summarised by the following utility function:

$$U = \alpha.T + \beta.SDE + \gamma.\ SDL + \delta.D_{Late}\ (1) \qquad (1)$$

[a] http://www.qualitetransports.gouv.fr

where U is the cost of scheduling for any given departure time and α, β, γ and δ are estimated parameters for the mean travel time (T), SDE, SDL and D_{Late}.

Faced with variability in travel time, travellers move their departure times in order to change the probability of arriving too late or too early. The consequences of being early or late are explicitly considered, typically leading travellers to limit or avoid the risk of being late due to uncertainty in travel times with the use of a "buffer time". For this reason, this approach is widely seen as the more appropriate approach to model the reaction to travel time variations and the cost associated with it.

However, this approach also has a number of disadvantages. First, it is not given that this is the best representation of the preferences of travellers. The utility expression is not additive over parts of a trip. The coefficients do not always have an intuitive interpretation. The traveller must be able to freely choose his departure time, which is not the case for a timetable based service such as trains. In addition, the schedule delay model cannot be used to estimate directly the consequences of travel time variability: this indeed requires the detailed simulation of travel timing decisions.

2.2. Reduced-form approach

The reduced-form approach is another option to include travel punctuality in the consumer utility function. Two main types of reduced-form approaches have been proposed in the literature. The first one is the mean-variance approach, which suggests that travellers endure costs when variability directly affects their travel time. In this approach, travel time variations are represented in the form of a variance or standard deviation of travel time (or delay), and are related to mean travel time (or delay) in the analysis.

The expected utility function has the following form:

$$E(U) = \alpha.E(T) + \beta.StDev(T) \tag{2}$$

where α, β and γ are the estimated parameters for the expected travel time ($E(T)$), the standard deviation of travel time ($StDev(T)$).

This approach is rather descriptive in nature. It does not really address the underlying behavioural mechanisms, or what people really do to limit the impact of travel time variations and uncertainty. It is better suited for private transport cases than with public transport, given that public transport travel time distributions are more skewed to the right due to the timetable operation.

By contrast, the mean-lateness approach, has been developed specifically for application to timetable based public transport, and is very convenient in its application. The utility function has the following expression:

$$E(U) = \lambda.Sched\text{-}T + \mu.L^{+} \tag{3}$$

where λ and μ are estimated parameters, *Sched-T* is the scheduled journey time, and $L+$ is the mean lateness at the destination train station.

In this case, no distinction is made between the frequency of delays and the length of delays. The distribution of delays is only reduced to the measure of the mean lateness.

Fosgerau et al. (2007), De Jong et al. (2007), Börjesson et al. (2011a) and Börjesson et al. (2011b) discuss in detail the question of reduced-form models. They show that under certain conditions reduced-form approaches can be derived as a special case of the scheduling approach. Börjesson et al. (2011a) investigate the use of mean lateness as a measure of train reliability. They found that the average delay as a performance indicator did not completely hold. It tends to underestimate the value of small risks of long delays relative to large risks for short delays.

2.3. An approach distinguishing length and frequency of delay

For the reasons explained above, in this study, we choose to use an approach distinguishing duration and frequency (or risk) of delay. This is a very similar approach to the one used in Kroes et al. (2006). We specify and estimate the risk of delay for different duration of delays. This approach has numerous advantages from a methodological point of view. The main advantage is that the distribution of delay is not reduced to a unique indicator. It also matches well with the perceptions of public transport passengers (with timetables). There is no hypothesis of a symmetrical distribution (such as implicit in the use of a standard deviation). Furthermore, this approach gives a very intuitive interpretation of coefficient values. In addition, it connects well with the available operational statistics for public transport (useful for application) and it allows for the estimation of non-linear effects (e.g. non-linearity in risk perceptions).

Regarding the experiment it-self, different presentation of the SP-exercises were found in the literature. In some surveys, the method consists in presenting to passengers some distributions of delays expressed in the form of a small number of travels (typically 5 or 10) having an equal probability of occurring (Hjortger et al., 2011). Sometimes, to avoid speaking about probability, distribution of travel time representing each day of a week are presented instead (Hollander, 2005). Another option is to specify directly the frequency and duration of delays in relation to the timetable: e.g. 1 train out of 10 is 20 minutes late, the others are on time (Kroes et al, 2006).

In the present study, we choose to use the latter option, which provided very good results in the past (Kroes et al., 2006). A qualitative research, which takes the form of focus group discussions of rail passengers, was organized before the quantitative survey of our study. During this stage, we tested the SP-format. It confirms that this kind of presentation was well understood. We also learnt that the duration of delays is easier to take into account when we present a single value instead of an interval and that surprisingly the presentation of percentage of delays was better understood and preferred compared to a probability, expressed as x train about 5 or x train about 20. We also observed that the respondents were not able to deal with more than two durations of delays in a single question. All these conclusions were taken into account to use the most adequate SP-format.

3. Data

3.1. Survey Method

Two stated preferences surveys were conducted to appraise the value of travel time reliability. The first one concerns high-speed trains users and the second one, regional trains users (the services being respectively abbreviated HST and RT in the following).

Both surveys were organised in two steps. First, travellers were recruited according to pre-defined criteria (personal attributes of the travellers and of the observed trip) and asked a set of questions about their trip. A few days later, a stated-preferences survey, customised for each selected travellers, was addressed to them and self-administrated online. In both surveys, the individuals were spread over different segments, such as journey purpose, travel time, age, connection, etc.

For the HST survey, the recruitment was conducted on platforms of a selection of rail stations in France in February 2012. Regarding the RT survey, the travellers were not recruited in rail stations, but selected online through a panel in June 2013.

The HST and RT questionnaires were both organised in three exercises, with different kinds of questions. All the questions were pairwise choices. They described the risk for delays as some variation of “x out of y trains are z minutes late”.

In the HST questionnaire, the respondents answered 16 questions, divided up into 3 exercises: the first one included questions about risks of delays from 5 minutes to 60 minutes, the second exercise included questions about risk of delays above 60 minutes and risk of cancelled trains, and the third one was a simple trade-off between time and cost of fares.

Table 1. Attributes tested in the stated choice experiments

Experiments	Travel time	Risk of delays <30 min	Risk of delays 30<x<60	Risk of delays >60 min	Risk of cancelled trains	Level of information, if late arrival	Level of comfort	Cost of train fare
HST – Exercise 1	X	X	X	-	-	X	-	-
HST – Exercise 2	X	-	-	X	X	X	-	-
HST – Exercise 3	X	-	-	-	-	-	-	X
RT – Exercise 1	X	X	-	-	-	X	-	-
RT – Exercise 2	X	X	-	-	-	-	X	-
RT – Exercise 3	X	-	-	-	-	-	-	X

The RT questionnaire took a similar form with a second exercise addressing comfort issues instead of long-delays risk and cancelation risks (see table 1 for specification of the variables used in each exercise). In both cases, in order to help them to answer, the questions of the first two exercises were addressed progressively: each exercise was divided in 4 sub-sets, with some attributes constant across the alternatives (see example in table 2).

Table 2. Progressive approach we used in the first exercise of the HST survey

		Alternative A				Alternative B			
Sub-set	Quest.	Time	% Delay [5-25]	% Delay [30-60]	Level of information	Time	% Delay [5-25]	% Delay [30-60]	Level of information
A	1, 2	variable	variable	Base	/	variable	variable	Base	/
B	3, 4	variable	Base	variable	/	variable	Base	variable	/
C	5, 6	variable	variable	Base	variable	variable	variable	Base	variable
D	7, 8	variable	Base	variable	variable	variable	Base	variable	variable

3.2. Experimental design

In both surveys, for each sub-set of the 3 exercises (4 in the example showed in table 2), full factorial designs were built. Nonetheless, we choose to keep only realistic choice sets by eliminating dominant alternatives. We considered that, by doing so, the advantage in terms of increasing the credibility of the questionnaire and the interest of the collected information was higher than the disadvantage of departing from perfect orthogonality. Some questions were also excluded to avoid redundancies between sub-sets.

Time difference and fare difference between the two alternatives could take four different values each, depending on the time and fare declared by the respondents. The levels were chosen in order to show realistic travel times and in order to test the full range of potential parameters.
Regarding punctuality, the percentages of delay tested were varying between 5% and 25% for short delays (smaller than 30 minutes), and between 5% and 10% for longer delays. As the real punctuality is in average quite good on those services (see table 3), we were forced to test higher percentages of delays than the observed one (especially for the RT survey), in order to have enough variability across this variable and to show percentage that can be seized by the respondents (very small percentages are not easily interpreted).

Table 3. Punctuality of the high speed and regional services in 2011

(d = delay)	Period of observations	Train on time or with d<5	$5 \leq d < 10$ min	$10 \leq d < 30$ min	$30 \leq d < 60$ min	$d \geq 60$min
HST	Jan – Sept 2011	79.7%	9.1%	8.1%	2.2%	1.0%
RT	Year 2011	92.9%	3.7%	2.7%	0.7%	

The attributes “quality of information” and “level of comfort” took three levels each:
- Level of information: announcement of late arrival (level 1), announcement of late arrival and reason of the lateness (level 2), announcement of late arrival, reason of the lateness and expected delay duration (level 3).
- Level of comfort: seated (level 1), standing (level 2), standing in a crowded environment (level 3).

Prior to the SP-surveys, pilot surveys were performed to test the design (around 50 individuals answered in each pilot, which results in 864 observations in the HST pilot and 800 in the RT one). In both samples, we estimated simple models, which produced consistent results. The choices made by the individuals were also controlled, and some levels were adjusted to get more balanced choices between fast train with poor regularity and slower train with better punctuality.

3.3. Sample statistics

The answer of 2 261 individuals were used for the estimations (16 032 observations in the HST survey, 20 144 in the RT survey). Descriptive statistics of the sample are showed in table 4. The distributions among travel times obtained are consistent with the different services studied: the HST travellers who are making usually long-distance trip have longer travel times. We have a consistent representation of the different purposes: in particular, business travellers are less frequent in RT than in HST.

Table 4. Some descriptive statistics on the two samples

	HST survey	%	RT survey	%
Share of purposes	Commuters & Business	64	Commuters	25
	Personal activities	36	Business	16
			Personal activities	58
Share of travel time	< 30min	0	< 30min	21
	30 < t < 90	30	30 < t < 60	34
	90 < t < 180	53	60 < t < 120	28
	> 180 min	17	> 120 min	13
Other statistics	Women	48	Women	63
	Working	93	Working	73
	1st class	27	Inter-urban services	73
	Train connection	9	Train connection	10
			Peri-urban services	27

4. Estimation results

The observation provided by the two set of travellers in the surveys were analysed using discrete choice analysis methods – in this case, logit analysis based on maximum likelihood estimation. An extensive number of models were estimated using Alogit software. In both cases, the utility function was estimated with the observations of the three exercises together, using scale factors between the exercises. Non-linear effects were analysed using Gamma function and introduced for two variables: time and cost. The Gamma function has the following form:

$$Gamma(x) = c_{lin}.x + c_{log}.log(x) \quad (4)$$

Non-linear specifications were also tested on risk of delays (piecewise linear function and gamma function), but this did not lead to fully consistent models and they were therefore not retained.

Tables 5 and 6 indicate the final estimates of the models. All estimated coefficients obtained in the final models have the expected sign and a plausible size. The t-ratios indicate that they are statistically different from zero with a 95% level of confidence.

Regarding the scale parameters (estimated in reference to the first exercise), we can see that they are different from 1 with a 95% level of confidence, which reflected a higher level of dispersion of preferences in the exercises 2 and 3 (scale factor is inversely proportional to the unexplained error). Different hypotheses can be made to explain these scale factors. The respondents could have had some difficulties with the second exercise in HST survey as it deals with risk of cancellation, or it can be interpreted as a fatigue effect. Regarding the third exercise of the HST survey, the game was a priori easier, with only two variables to trade. It might be that the higher level of dispersion of behaviours is due to the introduction of the cost variable.

Table 5. Estimation results of the HST model.

Model Statistics			Observations	16 032	
			Final log (L)	-9 991,1	
			Rho²(0)	0,101	
Parameter	Value	T-stat	Parameter	Value	T-stat
c-lin – time (perso)	-0,0307	-11,5	c-lin – cost (perso)	-0,0738	-3,2
c-log – time (perso)	-1,3718	-4,7	c-log – cost (perso)	-5,5209	-5,1
c-lin – time (commuters, busin.)	-0,0313	-11,5	c-lin – cost (commuters, busin.)	-0,0300	-2,0
c-log – time (commuters, busin.)	-1,6885	-6,7	c-log – cost (commuters, busin.)	-3,7365	-4,4
Time, penalty 1st class & business	-0,0045	-1,7	Cost, penalty 1st class	0,0258	2,2
1% risk of delay of 5 min	-0,0639	-9,4	1% risk of cancelation (perso)	-0,5181	-15,5
1% risk of delay of 10 - 20 min	-0,0949	-19,2	1% risk of cancelation (business	-0,4636	-16,9
1% risk of delay of, 25 - 30 min	-0,1180	-18,2			
1% risk of delay of, 40 - 50 min	-0,1658	-21,1	Information (level 1)	-0,2679	-5,4
1% risk of delay of, 60 - 75 min	-0,1976	-18,3	Information (level 2)	0,5518	11,0
1% risk of delay of, 90 - 120 min	-0,3259	-12,4			
1% risk of delay, penalty when					
1st class and business	-0,0099	-1,2			
Travel time >2h.	0,0125	2,3	*Scale Exercise 2*	*0,5063*	*-10,2*
Connection	-0,0155	-2,0	*Scale Exercise 3*	*0,6191*	*-9,2*

In both models, durations of delays are gathered in intervals. Those intervals were not decided a priori, but are the result from the estimations we made (we checked whether the coefficients associated to different delay durations were significantly different, at a 95% confidence level).

Table 6. Estimation results of the RT model.

Model Statistics			Observations	20 144	
			Final log (L)	-11 191.5	
			Rho2(0)	0.199	
Parameter	Value	T-stat	Parameter	Value	T-stat
c-lin – time (commuters, business)	-0.0878	-22.1	c-lin – cost (commuters)	-0.7444	-11.8
c-log – time (commuters, busin.)	-1.0525	-6.9	c-log – cost (commuters)	-3.6396	-13.0
c-lin – time (perso)	0.0633	-20.9	c-lin – cost (business, perso)	-0.4308	-14.9
c-log – time (perso)	-1.9035	-13.3	c-log – cost (business, perso)	-5.5202	-14.9
Time, penalty when peri-urban	-0.0188	-4.4	Cost, penalty when peri-urban	-0.2451	-3.8
1% risk of delay of 5-10 minutes	-0.0909	-17.9	Comfort - level 1 (commuters)	1.5054	7.7
1% risk of delay of 10-15 minutes	-0.1102	-22.3	Comfort - level 1 (busi., perso)	2.4695	12.1
1% risk of delay of 20-30 minutes	-0.1616	-25.0	Comfort - level 3 (commuters)	-1.4212	-9.2
1% risk of delay, penalty when connection	-0.0392	-5.1	Comfort - level 3 (busi., perso)	-1.9531	-11.3
Information (level 1)	-0.3243	-7.5	Time x Comfort, level 1	0.0138	7.8
Information (level 2)	0.4243	9.7	Time x Comfort, level 1	-0.0042	-2.9
Scale Exercise 2	1.0469	0.9			
Scale Exercise 3	0.5401	-14.3			

From the estimation results, we computed the ratio between marginal utilities: value of time, value of one percentage of risk of delay (see table 7).

We observed that time coefficient and cost coefficient are significantly different for the two or three journey purposes. In both cases we find the expected hierarchy between purposes: the value of time for people travelling with business purposes is higher than for the other purposes. The values of time of the travellers in high speed trains are also much higher than the values of time of RT travellers, but this is consistent with the ticket prices paid by the travellers in this different services. The difference in value of time is also partly explained by the differences in the distances travellers: HST users travel on average longer distances than RT users, and the value of time increases with distance, as showed by the models (this is expressed in the models by the non-linear terms in time and cost).We found in particular that the commuters' value of time in the RT model is low, but once again, this is consistent with the fares they paid as a high share of these travellers has an annual or monthly pass.

Table 7. Values of time and time-equivalent computed from the HST and RT models. These indicators are calculated with the average times and fares stated by the respondents (HST model: Business [126min,58 €], Personal activities [142min/45 €] – RT model : business [73min/ 14€], personal activities [77min/14 €], commuters [45 min/ 5€]). Value of time and time-equivalent are expressed respectively in €/hour and /min. The values and time-equivalent computed here do not take into account the different penalty estimated in the model (e.g. time penalty when peri-urban).

HST model	busin.	perso
Value of time	28.4	12.3
Time-equiv. of info (level 1)	6.0	6,7
Time-equiv. of info (level 3)	-12,3	-13,7
Time-equivalent of 1% risk of delay of		
5 min	1.4	1.6
10-20 min	2.1	2.4
25-35 min	2.6	2.9
40-50 min	3.7	4.1
60-75 min	4.4	4.9
90-120 min	7.3	8.1
Time-equiv. of 1% risk of cancelled trains	10.4	12.8

RT model	busin.	perso	commuter
Value of time	7.4	6.4	4.5
Time-equivalent of info (level 1)	3.2	3.7	2.9
Time-equivalent of info (level 3)	-4.2	-4.8	-3.8
Time-equivalent of 1% risk of delay of			
5 min	0.9	1.0	0.8
10-15 min	1.1	1.3	1.0
20-30 min	1.6	1.8	1.5
Time-equiv. of comfort (level 1)	-24.2	-28.1	-13.5
Time-equiv. of comfort (level 3)	13.9	22.2	12.8

Regarding the value of delay, the results should be read as the following: "a traveller on a business trip in a high-speed train, values a 1% risk of having a delay of 10 minutes equal to 2.12 minutes of travel time". In both models, as expected, the values of time-equivalent of delay increase with their duration. We also found that business travellers have a lower time-equivalent for the delay than the other travellers. This is consistent with the value of time estimated for the different purposes: business travellers have a higher value of time, but the same sensitivity to delays (same coefficient), which results eventually in a lower sensitivity to delay compared to travel time. Altogether, we observed here that the disutility incurred by delays is quite high, which seems to indicate that travellers request an excellent quality of service.

In both cases, information given by the operators in case of disturbance was found to be highly valued by travellers: extra information about the cause of the disturbance and/or about the duration of the delay is equivalent to a reduction of travel time by a few minutes.

Regarding the HST model, one can notice that business travellers in first class have a higher value of punctuality, which is consistent once again with intuition, as first class travellers tends to be more demanding, and often have stronger constraints at their arrival (e.g. meeting). We also note that travellers with travel times higher than 2 hours are less sensitive to a given delay (all other things being equal). Travellers with a train connection tend to have a higher value of punctuality (see penalty when connection), which is consistent with intuition, as missing a train connection can lead to a much longer delay at the end.

In the RT survey, we introduced a comfort attribute with three levels (as presented before). It appears that travellers value comfort and the cross-term between time and comfort shows that the longer the travel is, the higher the value of comfort is. We also observed that travellers in peri-urban services have a higher value of time and disutility of delays.

In addition to those estimations, we also calculated the reliability multipliers (abbreviated RM in the following) for each class of length of delays. RM can be defined as the ratio between the equivalent travel time perceived by the users, for a given delay, and the actual delay (not the risk of delay, but the delay itself). The results are in table 8. They show that the RM falls with duration of delay (consistent with time-equivalent).

Table 8. Reliability multipliers computed from the HST and RT models. They are calculated with the average travel times stated by the respondents (HST model: Business [126min], Personal activities [142min] – RT model : business [73min] personal activities [77min], commuters [45 min]).

HST model	Business	Personal activities
RM (delay of 5 min)	28.6	31.6
RM (delay of 10-20 min)	14.1	15.7
RM (delay of 25-35 min)	8.8	9.7
RM (delay of 40-50 min)	8.2	9.1
RM (delay of 60-75 min)	6.5	7.3
RM (delay of 90-120 min)	6.9	7,7

RT model	Business	Personal activities	Commuters
RM (delay of 5 min)	18.0	20.0	16.0
RM (delay of 10-15 min)	8.8	10.4	8.0
RM (delay of 20-30 min)	6.4	7.2	6.0

The values obtained here are only approximations, as they are derived from a specification not initially made to compute them. In addition, we should note that RM for short delays are quite high. We learnt from the qualitative research that short delays were not well perceived by travellers. During the focus group, we tried to understand if there was any threshold in the acceptability of a delay. We learnt that for HST services, delays beyond 30 minutes are felt inacceptable, but that travellers do not perceive delays shorter than 10 minutes. For regional services, the acceptability threshold can fall to 5-10 minutes when the journey is short. For these reasons we would recommend not to use the RM for delays of 5 minutes to value time savings, but to concentrate on delays equal or above to 10.

Table 9. Some reliability multipliers in the literature

Article	RM
Wardman (2001), meta-analysis	Mean of 7.4 80% range of 2 – 14
Abrantes and Wardman (2011)	Mean of 6.4 Standard deviation of 3.8
Börjesson et al (2011a)	[4 – 17] for risk delay above 5%
Börjesson et al (2011a) - calculated with the values from Kroes et al. (2006)	Commuters : [3.5 – 9.2] Other personal purposes : [3.8 – 12.4]

Values of RM for other studies can be found in the literature and are quite consistent with our results. We present in table 9 the reliability multiplier summarised by Börjesson et al. (2011a).

5. Conclusions

Our research provided very satisfactory results, consistent with the values found in the literature and especially literature on other French railway case (Kroes et al., 2006). We estimated the disutility of one per cent risk of delay in equivalent on-board travel time, for different duration of delay. Finally, our results give values (depending on the purposes and the length of the delay and without taking into account the different penalties) in the range of 1.4 – 8.9 for the HST users and 0.9 – 1.8 for the RT users. Reliability multipliers were estimated and presented in this article as well, and can be used when available statistics only contain mean-lateness indicators.

In 2012 the new French government decided to review the framework for transport appraisal. After more than a year of debates, auditions and literature reviews, the new framework was issued in September 2013. The results of our study have been introduced in this framework and will be implemented as one of the key parameter of rail investments assessment. Some tests are currently in progress to analyse the impact of this new values on economic assessment.

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