Flexibility of Transport Choice in a Real-Option Setting: An Experimental Case Study

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Abstract

We undertake an experimental study about road-hauliers’ choice between railways and roads. If road hauliers choose to load their truck on a train, they are not able to switch to using the road again until they reach the end of the line. On the contrary, highway choice is flexible in that the road haulier can change road at any time. Building upon the irreversibility of one of the two choices, we build a model where traffic levels are risky using both infrastructures. In the model, we find that hauliers’ choices depend upon the infrastructure price for railways and on the information level obtained by the haulier during travel. The flexible option is more valuable the more informed the agent is about traffic levels.

These theoretical predictions are tested by implementing two experimental treatments. In the first, agents gain no information during their travel; in the second they become perfectly informed about traffic conditions during the travel. Importantly, experimental payoffs are calibrated upon transport data about time and operating costs and infrastructure tariffs in France. From the experiment, we find that more risk averse agents assign more value to the flexible option. The second result is that subjects overreact to infrastructure price changes. We observe that, except at very low price levels, subjects tend to choose the flexible option more frequently, even when it is suboptimal.

* We thank two anonymous referees for their valuable remarks and suggestions. All errors remain our own.
The results are the following: as the model stands, price levels and information level are important explanatory variables of choice. The higher the price is for railways and the higher the information is, the more subjects give value to flexible option (highway), especially if subjects are risk averse.

The second result is that subjects overreact to infrastructure price modification. We observe that, except for low levels of price, subjects tend to choose the flexible option more frequently, even if it is suboptimal.

NB: instructions of the experiment and data are available on [http://sites.google.com/site/laurentdenantboemont/](http://sites.google.com/site/laurentdenantboemont/)

**Keywords:** Preference for flexibility; quasi-option value; experimental economics, travel behaviour; traffic information.

### 1. Introduction

When the channel tunnel opened in 1994, traffic forecasts were predicting 15.9 million passengers on Eurostar trains in 1995. Actual traffic in 1995 was 2.9 million passengers, i.e. 18% of passengers predicted. After more than six years of operations, in 2001, the number of passengers grew to 6.9 million, or 43 per cent of the original estimate for the opening year (Flyvbjerg et al. (2003)). That the forecast was so incorrect has multiple explanations, but one key aspect is that the channel tunnel system was a radically different choice for travellers relative to any option which existed prior to its construction. This essential point, the difficulty of establishing traffic forecasts in the presence of new options and technologies, motivates this paper.

Traditional travel behaviour frameworks described in the literature generally take into account the fact that individuals have access to limited information, have a limited capacity to process the information and attempt to find the best alternative within a time constraint (Dia (2002)). Some recent studies investigate the effect of travel time information on travellers’ learning under uncertainty, as Toledo, T., & Beinhaker, R. (2006), Avineri and Prashker (2006) or Denant-Boemont and Petiot (2003). But very few studies in travel demand analyze individual's knowledge of the route or lock-in effects of the choice of particular modes of
travel when uncertainty exists about traffic demand. Both dimensions, irreversibility and uncertainty, are essential to achieve correct traffic forecasts for transport projects.

In Europe, especially in France, the market share of freight transport travelling by rail has decreased over time: it was 46.7% of the total tons-km in 1970 be compared to 13.2% in 2003. During the same period, the share of tons-km transported by road increased from 44.8% to 78.7%. To remain competitive, the national railway company (SNCF) has developed new technical systems to decrease rail transport costs. One of the most ambitious and spectacular systems is Rail Motorway.

Rail Motorway (RM) consists in loading trucks on trains, enabling the lorry, the trailer and the driver to all be carried together. The French and Italian governments introduced this technology between Lyon and Torino.

In order to decrease generalized transport cost, the SNCF set tariffs for RM at roughly the level of those for tolled motorways. This tariff decision was based upon an assumption that road hauliers, who would save time with RM, would choose it on that basis (see Alpetunnel (1999)). Although there exist average travel time savings for hauliers, the actual amount of time saved in a particular trip is uncertain because of congestion for accessing the infrastructure. Travel costs depend on railway capacity and on traffic demand, as for any bottleneck. Moreover, in (RM), there is a pre-reservation system for road-hauliers where cancellation is costly (details are given below). This characteristic gives a certain level of irreversibility for RM. Tolled motorways, in contrast, are not irreversible. Drivers need not pay any cancellation fee if they suddenly decide to not take the tolled motorway and they can choose to exit the tolled motorway at any point during their trip.

The key question of this paper is: How do travellers facing uncertainty about the level of traffic, and subsequently about travel time, react to the uncertainty, and how do they deal with risky choices that do not have the same level of temporal flexibility?
The existence of Advanced Traveller Information Systems (AITS) now makes it possible for hauliers to have real-time information about traffic conditions (For detail about ATIS, see the special issue of the journal of ITS, 2009, 13(1)). This additional information could affect road hauliers’ tradeoffs. The consequence is that, from a theoretical point of view, one has to consider that these individuals are confronted with a dynamic choice with decreasing uncertainty.

As a consequence, this paper investigates the question of dynamic individual choice with a real option problem (see Arrow, Fisher (1974), Henry (1974), Chavas and Mullarkey (2002)) by building a theoretical model of behaviour which is then confronted with experimental data. The starting point of this paper is the microeconomic choice of road hauliers of infrastructure when the traffic level is uncertain. In such a risky context, the characteristics of flexibility for each choice are relevant, because an irreversible choice locks one in to a certain course of action which may subsequently turn out to be sub-optimal. We use the example of competition between road and rail infrastructures because the rail infrastructure can be viewed as a less reversible choice than the usual road one from the road haulier’s point of view. A dynamic model of individual choice is built in which the flexible decision gets a quasi-Option Value compared to the irreversible option of infrastructure use (real-option model).

In order to test this behavioural model, we implement different treatments based on experimental economic methods¹. Experimental economics has been a well-known empirical field in economics since the Nobel Prize was attributed to Vernon Smith in 2002, but is infrequently used in the travel-behaviour field. The main characteristic of experimental economics is that a subject makes choices in a laboratory and that her (or his) payments

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¹ Swee Tua, N.& al.(2006) conduct simulations about ATIS, here we use an experiment.
depend on her actual choices during the experiment. This condition ensures correct economic incentives (Smith (1976)), because the consequences of choices are real monetary rewards.

Experimental techniques have been an important empirical tool in economics, especially in the field of game theory, market and auction design and individual behaviour towards risk (see Kagel and Roth (1995) for an extensive survey). In transport economics, recent experiments have been conducted for instance by Selten et al. (2004), Gabuthy et al. (2006) or by Rapoport and al. (2005) on congestion models. To our knowledge, no laboratory experimental study where participants face real monetary rewards or penalties has ever been made in the scope of individual decision-making towards risk applied to transport behaviour of road hauliers.

We believe that the experimental approach is superior to the usual revealed preference/stated preference (RP/SP) method for analyzing innovative transport projects. RP methods rely on observable trips, and therefore analyses are largely limited to observable states of the world (Hicks (2002)). As RM is a new technology without a comparable reference in reality, it would have been difficult to imply such RP methods. While SP methods present a possibility in this case, it is difficult to ensure correct economic incentives in a SP approach such that people's stated decisions actually reflect “real” individual behaviours in such a specific framework. The existence of real monetary payoffs over real tradeoffs using experimental economics should imply reasonable choices by subjects. We have chosen an experimental method combined with a suitable lab design as the way to provide sufficient incentives for agents to choose rationally among new choice possibilities.

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2 For example, if a subject has to choose between a B lottery, say 50% to win 1$ and 50% to win 90$, and a certain reward R of 20$, if she chooses B, random choice of a number will be made by a computer, giving 1$ if the number is between 1 and 50, and 90$ if the number is between 51 and 100.

3 But, as a referee noticed, it is fair to say that experimental economics could induce more rational behaviour than what would be observed in real life.
The important characteristics of this study are, first, we use available data about private costs or fees to calibrate our experiment. Secondly, we conduct, to our knowledge, one of the first experiments about real-option theory on the individual level. In the next section, we present the theoretical model of the real option choice. Then, the third section gives the theoretical predictions of the model and explains our choice of parameters for the calibration of experimental payoffs. A fourth section presents experimental results and the last section concludes.

2. The theoretical model: Real Option choice with increasing information

2.1. Transport choice framework

In France in the early 1990s, the SNCF (French National Society of Railway) developed an infrastructure project called “Autoroute Ferroviaire” (Rail Motorway, See SNCF (1992, 1993)). This project allows trucks to be loaded directly onto trains, enabling the lorry, the trailer and the driver to be transported together. The French and Italian governments introduced the new technology on the Lyon to Torino line in 2004 and began operating the technology in conjunction with the Modalohr system (see United Nations (2003)) in 2005. Indeed, road hauliers must now choose between this new technology and the existing infrastructure of roads.

In the theoretical model, we suppose that two networks are in competition: the motorway ($M$) and the rail motorway ($RM$). The driver coach has the choice between these two transport alternatives. But if the motorway system is used first, it’s possible to connect the Rail motorway in the middle of the trip.

From road-haulier’s point of view, one can consider Rail motorway as an irreversible choice and motorway as a flexible one. The main reason is that, if the driver observes congestion on motorway he will be able to change its choice and to reach Rail motorway system. But if he
has chosen the Rail Motorway first he will not be able to switch. In the case when the agent chooses rail infrastructure, he has to pre-determine the exit point, and then there is no possibility, at a reasonable cost, to change his choice. Irreversibility as a characteristic of choices highlights the fact that road hauliers will not be able, or at a high cost, to reconsider their travel choice if they want to change from one mode to another. Irreversibility for Rail Motorway is basically linked to loading/unloading time from road to rail and vice versa (30 mn), which represents a fixed cost. Moreover, in the Modalohr system operated between Lyon and Torino, the operator separates road tractors from road trailers, which increases this time. The loading/unloading time is then a sunk cost for road hauliers. Another problem concerning irreversibility of Rail Motorway’s choice is that road hauliers can modify or cancel their trip at most 2 hours before departure, which means that it is not possible to change from Rail to Road during the trip; otherwise a part of the price would be lost. Correspondingly, road hauliers do not have to make a reservation for motorway and are not charged if they want to modify their trip. Indeed, Rail Motorway suffers from both technical and economic irreversibility, which makes the changing very costly.

A last source of flexibility for highway is the possibility for the driver to go out and to use alternative routes in case of high traffic congestion on the highway. Of course, the relative level of choice irreversibility for Rail Motorway will be balanced by higher operating speed, in order to have a trade-off for road hauliers. That is the reason why relative price of rail is to be modified in the experimental design, enabling us to observe the empirical trade-off between flexibility and direct costs.

The characteristics of choice between options are summarised through two variables, which define the generalised transport cost: levels of toll for each option, and time costs. Moreover, choices are stochastic, i.e. we define states of traffic in order to deal with traffic congestion. The assumption is that travel time for option 2 (RM) is less than the travel time for option 1.
(M), because the operating speed of Rail Motorway should be around 120 km per hour, against 90 km/h for a truck (See annex for more details about calibration assumptions).

2.2. Irreversible versus flexible mode choice for road hauliers: A real option model

A subject has to go from point A (Lyon) to point C (Torino). He has to choose between two infrastructure options, RM (Rail Motorway) and M (Motorway), facing for each alternative one of two possible levels of traffic congestion $t_1$ (fluid traffic) and $t_2$ (congested traffic). The choice RM does not enable to reconsider route choice given any new information about the level of traffic congestion, while M enables to change it. Here, at point B (St Jean de Maurienne) in the middle of [A; C], he can switch from M to RM or he can stay on M. At the end, he sustains a level of transport cost, that is to say a travel time (which depends on the level of traffic he faced on each infrastructure) and a travel cost (the price for accessing any infrastructure he chose). The following model explains assumptions on travel times, on infrastructures tariffs and then derives individual’s optimal choice.

a) Travel time from A to C

The total travel times depends on the traffic level on each infrastructure

$$TT(t_j) = FT + VT(t_j)$$ (1)

Where $t_j$ is the traffic level in state $j$ ($t_j \in T = \{t_1, t_2\}$), $t_1$ corresponds to a low traffic level whereas $t_2$ corresponds to a high traffic level. $TT(t_j)$ is the travel time depending on traffic $t_j$, $FT$ the fixed travel time and $VT(t_j)$ the variable travel time depending on $t_j$. We consider that

$$VT(t_j) = \alpha'_i \left( \frac{d}{s_i} \right),$$

with $d$ the distance between A and B or C, $s_i$ the commercial speed of infrastructure $i$, and $\alpha'_i \geq 1$ being the congestion factor depending on traffic level ($\alpha'_1 = 1$;
\( \alpha_{RM}^2 = 3 \) and \( \alpha_{M}^2 = 2.5 \). For simplicity, we will assume uniform distribution concerning probabilities for traffic levels.

b) Infrastructure pricing and tariffs

Every price \( p \) paid by the user is linked to two parts, one being a “lump sum price” for infrastructure and the other depending on the number of kms.

The price for each infrastructure is

- for \( RM \) choice between A and C:
  \[
  p_{RM} = F_{RM} + c_{RM} N_{RM}
  \]
  \( (2) \)

- for \( M \) choice between A and C:
  \[
  p_{M} = F_{M} + c_{M} N_{M}
  \]
  \( (3) \)

- for \( M \) choice between A and B and \( RM \) from B to C:
  \[
  p_{M+RM} = 0.5(F_{M} + c_{M} N_{M}) + 0.5(F_{RM} + c_{RM} N_{RM})
  \]
  \( (4) \)

Where \( F \) is the contract price on each infrastructure \( RM \) or \( M \), \( c \) is the operating cost per km and \( N \) is the number of km on each infrastructure, the ratio \( \frac{AB}{AC} \) is assumed to be 0.5.

\( c_{M} \) is here considered as a price, but can be viewed as the road haulier direct private cost per km for travelling by motorway (fuel, maintenance costs, etc.).

c) Individual’s optimal choice

The expected gain of Rail Motorway choice in A is not affected by new information before choice in B, because \( RM \) in A is a strictly irreversible choice. For notation simplicity, \( G_j^i \) denotes the gain of choice \( d_i \) \( (d_i \in D = \{d_{RM}, d_{M}\}) \) in state of traffic \( t_j \), each state being equiprobable. An important point is that decision \( M \) gives a second chance to choose between \( M \) and \( RM \) in period 2.

The experimental individual decision tree is described below in figure 1.
In this figure, decision nodes correspond to squares, state nodes to circles and payoffs and probabilities are written for each branch of the decision tree. With such a representation, it is obvious to remark how Rail Motorway choice in A constrains possible choice in B compared to Motorway choice.

*) No Information level (NI)

The optimal choice depends on the levels of

\[ E(G^{RM}, NI) = 0.5(G_{1}^{RM} + G_{2}^{RM}) - P_{RM} \tag{5} \]

Where \( E(.,.) \) denotes the mathematical expectation operator, \( G_{i}^{j} \) the final payoff relative to decision \( i \) in traffic state \( j \), and \( p_{i} \) the price for choosing infrastructure \( i \). \( G_{i}^{j} \) corresponds to a net payoff for road hauliers, and equals to the difference between operating revenue for an additional freight minus private operating cost and time cost. Eqn (5) makes simply the difference between expected gain of choice \( RM \) in A and the tariff for accessing \( RM \) in A.

Concerning the choice \( M \) in A, one has to consider the ability to choose between \( M \) and \( RM \) in B. Then, we have

\[
E(G^{M}, NI) = \max \left[ 0.5(G_{1}^{M} + G_{2}^{M}) - p_{RM} \times 0.25 \times \left( \frac{G_{1}^{M} + G_{1}^{RM}}{2} + \frac{G_{1}^{M} + G_{2}^{RM}}{2} + \ldots \right) \right] \tag{6}
\]

Notations are the same than for eqn (5). More details will be given later concerning final payoffs in the experimental design section.
Using backward induction criteria, the expected value of the option between $M$ and $RM$ in B for the agent corresponds to the maximum of each expected gain $M$ or $RM$ minus the corresponding tariffs.

**) Perfect Information level (PI)**

In the case of perfect information, the agent knows before choosing in B both the state of the traffic in Motorway and Rail Motorway. For $RM$ choice, this additional information is not useful and then we have

$$E(G_{RM}, PI) = E(G_{RM}, NI)$$  \hspace{1cm} (7)

Eqn (7) shows simply that, when choice is strictly irreversible, information is not valuable for the agent.

Then, the value of the option corresponds to the expected value of the maximum gains between $RM$ and $M$ in each state. We have then

$$E(G^{M}, PI) = 0.25Max\left(G^M_1 - p_M, \frac{G^M_1 + G^M_{RM}}{2} - p_{M+RM}\right) + 0.25Max\left(G^M_1 - p_M, \frac{G^M_1 + G^{RM}_2}{2} - p_{M+RM}\right) + ...$$

$$... + 0.25Max\left(G^M_2 - p_M, \frac{G^M_2 + G^{RM}_1}{2} - p_{M+RM}\right) + 0.25Max\left(G^M_2 - p_M, \frac{G^M_2 + G^{RM}_2}{2} - p_{M+RM}\right)$$  \hspace{1cm} (8)

The difference between eqn (6) and eqn (5) is a Willingness-To-Pay (WTP) for flexible choice in No Information. Similarly the difference between eqn (8) and eqn (7) will be called WTP for flexible choice in Perfect Information. The Option Value could be measured by the difference between eqn (4) and eqn (2)\(^4\). In this model, Option Value is equal to expected information value for flexible decision, i.e. represents the WTP for perfect information.

\(^4\) As noted by Dixit and Pyndick (1995), this Option Value had been introduced by Arrow, Fisher (1974) and Henry (1974). This concept gives important developments over the recent years to environmental economics, following Kolstad (1992) and Hendricks (1992). For a discussion of this concept, see Fischer (2000).
3. Experimental design

3.1. Calibration and assumptions for the experimental setup

In our design, subjects are submitted to two levels of information. We have then two treatments, a “No Information” treatment and a “Perfect Information” treatment. In these two treatments, subjects have to choose between two options, RM and M, the first one being strictly irreversible and the second one perfectly flexible, and thus during two steps within an experimental period. At the end of the first step, they have (or not, depending on their first period choice) the opportunity to change their choice (if they choose M, they can choose M or RM in the second step, and if they RM, they could only choose RM). These choices are non-free, and they have to pay for access. During each experimental treatment, the relative cost of access between the two choices is changing. Implementing our real-option model, we get the following theoretical prediction: in “Perfect Information” treatment, subjects should choose less frequently the irreversible option that in “No Information” treatment, trade-off between options depending on price and information levels.

a) Basic assumptions about transport costs and choices’ payoffs

Assumptions about travel times and congestion levels are explained in annex. Travel times depend first from operating speed for each infrastructure, on loading/unloading time and from distances between origin and destination. Such parameters results from different studies (especially Alpetunnel (1999) and SNCF (1992)). Concerning congestion levels, we have assumed that travel time (without loading/unloading time) is multiplied by a factor $f$ which differs for RM and M. Moreover, relative operating prices have been carefully studied in SNCF (1992). The following table gives values for our essential parameters:

Insert table 1 about here
Considering SNCF (1992) value for operating cost (and price) $c_{RM}$ for Rail Motorway, we decide to implement two other possible values by increasing or decreasing it from 15% in order to test traffic demand sensitivity to price. Such scenarios will refer to our price levels $P_1$ (low price), $P_2$ (medium price or SNCF reference price) and $P_3$ (high price). That is the reason why we have three levels of price of each possible option (choice $M$ or $RM$ or $M+RM$). As we build three scenarios, obviously, the optimal choice does change in each pricing scenario.

b) Player’s gains and payoffs

Higher the travel time is, the less is the player’s gain. Moreover, the final payoff or reward depends on infrastructure costs for players. Then, the experimental reward $R$ in Euros is simply

$$ R^i_j = \frac{G^i_j - p_i}{x} = \frac{[b - aTT(T_j)] - p_i}{x} $$

(9)

Where $R^i_j$ is the final payoff for choice $i$ given traffic state $j$. Here $a$ is negative, $b$ positive and corresponds to the net payment perceived by road haulier for freight transport, $TT$ is the time travel in mn (depending on $T_j$, the traffic level in state $j$) and $p_i$ is the tariff paid for accessing infrastructure $i$ (see above). $x$ is the experimental exchange rate in Euros per point. In our experiment $x$ was 200 points per €.

The parameter $a$ can be viewed as the cost of travel time for a road-haulier per unit of time. In the experiment, we have considered that $a = -2$, i.e. the cost of travel time is 120 points per hour$^5$. The parameter $b$ is equal to 1600$^6$.

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$^5$ See Ministère des transports (1998). In France, the official recommendation is to consider 30€ per hour. But for other studies (COMMISSARIAT GENERAL DU PLAN (2001)), this cost should vary from 4.5 to 38€/h per hour, which means an average of 21€ per hour. For our experiment, we choose 120 points per hour (i.e. 28,4€). The study of INSEE (2004) estimates average price per km for a truck around 1,259€/km with an average load rate of 75%. That gives revenue around
Moreover, the players get an initial endowment of 250 points.

c) Theoretical predictions

Considering parameters specific values and pricing scenarios during the experiment, and given individual optimisation put in section 2, it is possible to give theoretical forecasts about *ex ante* choices (see table 2).

The comparison between options gives a higher expected utility for *RM* in the case of P1 and P2 in the No Information situation, whereas *RM* is the best choice only in P1 case in the Perfect Information situation.

3.2. Experimental sessions

Experimental sessions have been held at Rennes University (LABEX) and 64 subjects, mostly first-year licence students, have participated in May of 2003 and June of 2004. The average duration of a session was about 1.5 hour and the average payoff was around 15€.

In each session, subjects have to make the same option choice among lotteries during 24 periods, with a random level for *RM* infrastructure price in each period (P1, P2 or P3). A first information about the price was given to all subjects at the beginning of each period, before they choose. Finally, all subjects have been confronted to the same sequence of prices. Subjects were not informed about the final number of periods. Before that, they have to

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378€ for a route of 300km (which corresponds to 1600 points in our experimental calibration). Then, we choose 120 points *i.e.* 28.4€ per hour as time cost.

6 Indeed, the “generalised transport cost” is $GTC = (time value) \times (travel time) + (average private cost) + fee$. In the design, the average GTC is 1600, and then the average payoff should be 1600, which implies that players can have losses or gains.
answer to questions controlling comprehension and enabling elicitation of individual risk preferences, based on Levy and Levy (2001). Each subject has an initial endowment of 250 points and the experimental exchange rate was 200 points for 1€.

4. Experimental results

Here, we will focus on experimental individual choice for step 1 (at point A). The reason is that our subjects are not in symmetrical situation: people in No Information treatment make a strictly random lottery choice when they choose in step 1 (at point A) and in step 2 (at point B), but people in Perfect information treatment do not make a random lottery choice in step 2 (at point B). They just have to maximise their payoff given step 1’s choice. In order to compare our treatments on the same base, we limit our comparison to first step choices.

4.1. Impact of infrastructure pricing and information level

The aim of this section is to identify the relative impact of infrastructure pricing given different information levels. Graph 1 shows the frequency of the choice $M$ in each price scenario (P1, P2 or P3). For each price level, the periods are given in the order during session (for example, concerning P1 situations, subjects play first period 1, then period 2 then period 9, etc.). Of course, price levels were randomly determined, and subjects do not face first 8 periods of P 1, then 8 periods of P2 etc.

Insert Graph 1

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For that, we use the methodology of Levy and Levy (2001), based on First and Second Order Stochastic Dominance Criteria. For more details, see Levy and Levy (2001). An appendix is available on http://sites.google.com/site/laurentdenantboemont/.
The first evidence is quite trivial: The number of $M$ choices increases when relative price of $RM$ grows (all the differences between number of $M$ choice for each price level are significant within each treatment at the 1% level, Wilcoxon tests). The most important point is that on average, there is no big difference between NI situations and PI situations, except for intermediate price scenario (P2). On average, $M$ choices represent 53% of the total choices in NI treatment and 60% in PI treatment. A non parametrical bilateral Mann-Whitney test shows that the number of $M$ choices is not significantly different from NI treatment to PI treatment ($z=-1.483, p=0.069$). Table 3 reports tests’ results.

Insert table 3

Another graphical observation concerns the difference between the different levels of price. Choices $M$ seem to be more numerous in the PI case than in the NI case for P2 level, but not for P1 and P3. Such results are confirmed by Wilcoxon tests (see table 3): for P2, the difference is significant at the 5% level. This empirical fact is consistent with theoretical predictions of the real option model, because Motorway is more valuable than Rail Motorway in PI than in NI.

These two results (price impact and information impact) are confirmed by a Probit regression where:

$$\Pr(d'_1 = M) = \beta^t + \alpha_1 p^t + \alpha_2 G^{t-1} + \alpha_3 I^t + \epsilon^t$$

(10)

Where $\Pr(d'_1 = M)$ is the probability of choosing $M$ at first step in period t, $p^t$ is the relative price of $RM$ in period $t$, $G^{t-1}$ the subject’s payoff in period (t-1) and $I^t$ the information given to the subject in $t$. The results are given in the table 4 to follow:

Insert table 4 about here
Higher are the price for RM and the information level, the bigger the probability of choosing M is. Payoff in \((t-1)\) increases also the probability of choosing \(RM\), which could be interpreted as some kind of “endowment effect”, because a subject who obtained higher payoffs in the past is more likely to take some risk implied by \(RM\) choice.

An interesting result is about the relationship between individual choice of \(M\) and risk aversion (an individual is risk averse if he is willing to pay in order to transform a high risky payoff from choice \(i\) to become a less risky payoff from choice \(i'\), even if the expected payoff of \(i\) and \(i'\) are the same). Risk aversion is treated as a dummy variable in the parametric model (see table 5). 30 of the 64 subjects were “risk averse” and 13 have played the NI treatment compared to 17 who played the PI treatment. So, there is more people being risk averse in the perfect information situation. Table 5 gives the results of a Probit analysis about the impact of Risk Aversion on probability for choosing \(M\), the flexible choice. Being Risk Averse is non-significant on probability for choosing \(M\) for the whole dataset, but this is not the case if treatments are distinguished. For PI treatment, being risk averse increases the probability of choosing \(M\), which is quite intuitive. The flexibility given by choice \(M\) in a situation where information grows over time is much valued by risk-averse people. For NI treatments, risk aversion is not significant and the sign is the opposite as in PI treatment\(^8\).

Insert table 5

\(^8\) The variable “context”, which equals to 0 or 1, refers to the kind of instructions we use. In one case, we use “transport-framed” instructions (Context=1), and in the other case “lottery-based” instructions (Context=0).
4.2. Empirical relevancy of the experimental model

69% of subjects’ actual choices are in conformity with theoretical prediction, and there is no significant difference between the treatments (purely random choice leads to 50% of success rate). But if price levels are to be considered, differences could be important, as it is showed in graph 2:

Graph 2 suggests some kind of « U » form for empirical relevancy given price level for RM. The frequency of optimal choice is around 57% in P2 against 81% in P3 and 68% in P1. These differences are not significant between the treatments for P1 and P3 prices, but for P2 price, optimal choice frequency is around 64% in PI treatment and around 50% for NI treatment (this difference is significant at the 10% level, see table 6). Such observations tend to show that first, the experimental relevancy is lower when the trade-off between the options is tightened and second, that information helps subjects to make a good choice.

Then, we have to conclude that information does not improve significantly theoretical relevancy of the model, except in the case of P2. It has to be remembered that P2 is the tariff chosen by French operating society for actual Rail Motorway project.

4.3. Overreaction or underreaction?

The aim of this section is to determine how people update option valuation when they become informed about the price to be applied for infrastructure RM. In the experimental setting, subjects obtain in each period the current level of price for RM and then have to choose
between the flexible choice \( M \) and the irreversible one \( RM \). The question is then: Do subjects update expected payoff with conformity to theoretical model or do they overreact to price information, for example by expecting too much gain of \( M \) choice if price for \( RM \) is high. An overreaction situation occurs when price variation linked to an exogenous shock is bigger than “fundamental” value variation (see de Bondt and Thaler (1985, 1987) for a theoretical framework, Offerman and Sonnemans (2000) for an experimental study).

Here, in our “option design”, a high level price for \( RM \) is “good news” for \( M \) choice because it gives an additional expected payoff to \( M \) and, similarly, a low level of price is “bad news” for \( M \) choice. Then, the WTP for flexible choice should be greater in P3 than in P1, whatever information level.

In the experiment, subjects are confronted to binary choice and then, it is possible to compare theoretical WTP in each treatment to an approximation of the revealed WTP for flexible choice. The Theoretical WTP for flexible choice is simply the difference between the expected payoff of \( M \) choice minus the expected payoff of \( RM \) choice.

This revealed WTP is simply the expected opportunity cost of the player’s decision. For example, take period 5 for subject 1 in No Information Treatment. The price for \( RM \) was P2. This subject chose \( M \) in step 1 and \( RM \) in step 2, instead of optimal choice \( RM \) at step 1. The expected net payoff of her choice (\( M+RM \)) for this price level was 10 points, and it was 20 points for \( M+M \), whereas the expected (optimal) payoff of \( RM \) was 60 points. Then, the theoretical WTP for flexible choice was here of -40 (= Max(+10:+20) - (+60)). Because she chose \( M+RM \), she was at least ready to pay 50 points to have choice flexibility (i.e. \( 60 - 10 \)). Therefore, if actual choice corresponds to theoretical optimal choice, revealed WTP is equal
to theoretical WTP. In the other case, revealed WTP represents the *expected opportunity cost of her decision*\(^9\).

We implement this method for all individual choices. Graphs 3, 4 and 6 give the results of average individual WTP for each period.

Insert graph 3

In No Information treatment, revealed WTP for flexible option is higher than theoretical WTP (3.4 points *vs* -23.3 points). On the contrary, in Perfect Information, the revealed WTP is lower than theoretical one (26.3 against 40.8). Non parametrical Mann Whitney tests compare theoretical WTP in a *fictive* sample of rational players to individual revealed WTP in the *experimental* samples. Differences between samples are significant at the 1% level (\(z = -5.126\) in NI treatment, \(z=+4.136\) in PI treatment). That means: subjects give too much weight to option flexibility in NI treatment and in particular when price of irreversible choice is low (see graph 3). For PI treatment, on average, they undervalue flexibility especially when irreversible choice is very costly (see graph 4). But comparing average WTP is not sufficient to determine if subjects over or underreact. The overall impression given by graphs 3 and 4 is that average revealed WTP is under theoretical WTP, which could lead to the conclusion that subjects underreact to information price given at the beginning of each period.

Subjects receiving price information do hesitate to revise drastically their beliefs about expected values for each possible choice. But on average in NI, this update process gives more value to flexible choice\(^10\).

\(^9\) In our example, she (subject 1) chose to have an expected gain of 10 instead of maximum expected gain of 60, i.e. the expected opportunity cost of flexibility is 50.

\(^{10}\) But such a conclusion should be taken with care, because the fact that revealed WTP is in most cases under theoretical WTP is the consequence of the calculus method, based on binary choice. It implies that revealed WTP are restricted by...
Graph. 5 enables to compare average individual WTP for each price scenario. The lower the price for RM is, the higher the difference is between revealed WTP and theoretical WTP.

All the differences between revealed WTP for each price scenario are significant at the 1% level (Wilcoxon tests, see table 7), with a consistent sign for z: the higher is the price, the bigger the absolute value of Z (which is always negative). It means that average individual WTP is significantly lower when price is weaker in the first sample.

A last point concerns comparison between revealed WTP for flexible option between the treatments. The average individual WTP are plotted in graph 6. Theoretical model predicts that WTP for flexible choice are higher in Perfect information situations than in No Information ones, which is in conformity with experimental data.

A Mann Whitney test shows a significant difference at the 1% level between an individual revealed WTP across the treatments (Z = -3.626 ; p value= 0.000).

expected theoretical payoffs of the two choices. That is to say, revealed WTP depends on theoretical expected utilities, which constraint the possible values to a narrow range.
At the end, an OLS is made to explain revealed WTP. The results are given in table 8. WTP is an increasing function of price level with a coefficient bigger in PI than in NI treatment: subjects are willing to pay for flexibility especially if they obtain new information about states of nature.

5. Concluding comments

The aim of this study was to analyse the trade-off of road hauliers confronted with a choice between two infrastructures when traffic levels are risky. If current possible choices constraint the set of future possible choices, road hauliers may value flexibility in route choice. To this end, we develop a real option model with two periods where individuals have to go from point A to point C via point B and could suffer from congestion and be confronted by different levels of price. This model is calibrated with transport freight data available in France concerning generalized transport cost (time cost plus price) for rail and road. With this particular set of parameters, theoretical predictions show that the level of information available before the second period is a key variable for choice. Indeed, for an intermediate level of price, if individuals know that they will be perfectly informed later in time, they should choose road infrastructure, because it is flexible and allows them to switch from one infrastructure to the other at some point between the origin and destination points. This is not the case if individuals do not gain information. To test this model, two experimental treatments are conducted, which correspond to extreme information level scenarios. The results are that more information leads to greater preference for the flexible (road) option. In all cases, subjects exhibit a preference for flexibility, irrespective of prices or information.
levels. They are willing to pay to maintain the availability of both choices. This is suggested by choice analysis: subjects choose more frequently the flexible choice when it was suboptimal than they choose the irreversible one when it was suboptimal: a significant number of errors occur because individuals want to keep the opportunity to choose later. Such an empirical result could be explained by Kreps’ concept of preference for flexibility (see Kreps (1979)).

The prospect of increased information in the future gives additional value to flexibility. Nevertheless, subjects are not willing to pay infinite amounts to keep flexibility in their choice. We also find that when the infrastructure price is changing, agents underreact to price information more than they overreact.

An experiment of the type conducted in this study can aid in decision-making, especially for transport planning.

Traffic forecasts models tend to minimize the fact that travel behaviour is intrinsically dynamic, and that choices are determined in a changing information context. Moreover, such models do not integrate the important aspect of flexibility with respect to available alternatives when congestion can occur. Our theoretical model considers both flexibility and information, and their consequences on rational behaviour. It shows that irreversible alternatives are costly for travellers, and that they are willing to pay to avoid them. When a transport planner investigates traffic demand for alternate transport systems, he should consider the relative level of flexibility between alternatives and trip characteristics. This missing dimension of analysis could explain some of the inaccuracy in traffic forecasts. Individual responses to innovative, but irreversible, alternatives have not been taken fully into account, especially when individuals obtain real-time information concerning trip conditions. Nevertheless, our experiment shows the relevancy of the theoretical model but also its weakness, because individual behaviour tends to exhibit some inertia. This study is an initial
investigation into temporal flexibility and individual choice with important lessons for those analyzing the costs and benefits of public projects and public decision-making.

References


Tables, graphs and figures to be included in the text

### Table 1. Main parameters’ values in experimental design

<table>
<thead>
<tr>
<th>Parameter</th>
<th>$P_M$</th>
<th>$P_{RM}$</th>
<th>$P_{M+RM}$</th>
<th>$\pi_{1}^{RM} = \pi_{2}^{RM} = \pi_{1}^{M} = \pi_{2}^{M}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>880</td>
<td>760/880/1000</td>
<td>820/880/940</td>
<td>0.5</td>
</tr>
<tr>
<td>Parameter</td>
<td>$G_{1}^{RM}$</td>
<td>$G_{2}^{RM}$</td>
<td>$G_{1}^{M}$</td>
<td>$G_{2}^{M}$</td>
</tr>
<tr>
<td>Value</td>
<td>1240</td>
<td>640</td>
<td>1200</td>
<td>600</td>
</tr>
</tbody>
</table>

NB: $P_M$, $P_{RM}$, $P_{M+RM}$ are respectively the access prices for choices M, RM and M+RM, $G_{1}^{RM}$, $G_{2}^{RM}$ are respectively the gross payoffs in points for RM choice for traffic level 1 and traffic level 2. Finally, $G_{1}^{M}$ and $G_{2}^{M}$ are respectively the gross payoffs for M choice for each traffic level.

### Table 2. Theoretical predictions about optimal infrastructure choice

<table>
<thead>
<tr>
<th>Information treatment</th>
<th>Pricing scenarios</th>
<th>Optimal choice (Rail Motorway or Motorway in A)</th>
<th>Expected gain in points</th>
</tr>
</thead>
<tbody>
<tr>
<td>No information treatment</td>
<td>P1</td>
<td>RM</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>RM</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>P3</td>
<td>M</td>
<td>20</td>
</tr>
<tr>
<td>Perfect Information treatment</td>
<td>P1</td>
<td>RM</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>M</td>
<td>92.5</td>
</tr>
<tr>
<td></td>
<td>P3</td>
<td>M</td>
<td>77.5</td>
</tr>
</tbody>
</table>

NB: P1 is the low level of price for RM, P2 the medium level and P3 is the high level.
### Table 3. Non Parametrical Tests about $M$ choice frequency for individuals

<table>
<thead>
<tr>
<th>HO</th>
<th>Number of independent data in each sample</th>
<th>$z$</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of $M$-IN=$%$ of $M$-IP in P1 (W)</td>
<td>32</td>
<td>-0.619</td>
<td>0.268</td>
</tr>
<tr>
<td>% of $M$-IN=$%$ of $M$-IP in P2 (unilateral W)</td>
<td>32</td>
<td>-1.834</td>
<td>0.033**</td>
</tr>
<tr>
<td>% of $M$-IN=$%$ of $M$-IP in P3 (W)</td>
<td>32</td>
<td>0.670</td>
<td>0.251</td>
</tr>
<tr>
<td>% of $M$-IN=$%$ of $M$-IP (MW)</td>
<td>32</td>
<td>-1.483</td>
<td>0.069*</td>
</tr>
</tbody>
</table>

NB. * : significant at 10% , ** : sign. at 5%, *** : sign. at 1%

### Table 4. Probit analysis about $M$ choice in step 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>All treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant $\beta$</td>
<td>-4.3251*** (0.2969)</td>
</tr>
<tr>
<td>Price level $p$ for RM</td>
<td>1.7099*** (0.1120)</td>
</tr>
<tr>
<td>Payoff $G$ in (t-1)</td>
<td>0.0004*** (0.0001)</td>
</tr>
<tr>
<td>Information I (=0 if NI or =1 if PI)</td>
<td>0.1877*** (0.0700)</td>
</tr>
</tbody>
</table>

| Number of obs. | 1472 |
| $R^2$ (adj. $R^2$) | 0.187 (0.142) |

NB: * : significant at 10% , ** : sign. at 5%, *** : sign. at 1%
Table 5. Probit analysis on $M$ choice probability

<table>
<thead>
<tr>
<th>Variable</th>
<th>NI treatment</th>
<th>PI treatment</th>
<th>All treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-4.560***</td>
<td>-3.915***</td>
<td>-4.276***</td>
</tr>
<tr>
<td></td>
<td>(0.404)</td>
<td>(0.3970)</td>
<td>(0.2855)</td>
</tr>
<tr>
<td>Price level for $RM$</td>
<td>1.818***</td>
<td>1.6234***</td>
<td>1.709***</td>
</tr>
<tr>
<td></td>
<td>(0.1535)</td>
<td>(0.1530)</td>
<td>(0.1079)</td>
</tr>
<tr>
<td>Context</td>
<td>0.0550</td>
<td>-0.3142***</td>
<td>-0.1284*</td>
</tr>
<tr>
<td></td>
<td>(0.0968)</td>
<td>(0.0973)</td>
<td>(0.0681)</td>
</tr>
<tr>
<td>Risk Aversion (1 or 0)</td>
<td>-0.2440</td>
<td>0.2710***</td>
<td>-0.0168</td>
</tr>
<tr>
<td></td>
<td>(0.0987)</td>
<td>(0.0973)</td>
<td>(0.0689)</td>
</tr>
<tr>
<td>Information (0 or 1)</td>
<td>/</td>
<td>/</td>
<td>0.1967***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0688)</td>
</tr>
<tr>
<td>Number of obs.</td>
<td>768</td>
<td>768</td>
<td>1536</td>
</tr>
<tr>
<td>$R^2$ (adj. $R^2$)</td>
<td>0.1935 (0.149)</td>
<td>0.1751 (0.1328)</td>
<td>0.1685 (0.1327)</td>
</tr>
</tbody>
</table>

NB: * : significant at 10% , ** : sign. at 5% , *** : sign. at 1%
Table 6. Non parametrical tests about optimality of individual choices

<table>
<thead>
<tr>
<th></th>
<th>Within treatments (Wilcoxon)</th>
<th>Between treatments (Mann Whitney NI vs PI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NI</td>
<td>PI</td>
</tr>
<tr>
<td>P1 vs P2</td>
<td>3.208 (0000***</td>
<td>0.160 (0.436)</td>
</tr>
<tr>
<td>P2 vs P3</td>
<td>-3.477 (0.000***</td>
<td>2.521 (0.006**)</td>
</tr>
<tr>
<td>P1 vs P3</td>
<td>-2.008 (0.022**)</td>
<td>-3.074 (0.001**)</td>
</tr>
</tbody>
</table>

NB: Z+: more optimal choices in first sample ; Z-: more optimal choices in second sample (p value in parenthesis).

*: significant at 10% , **: sign. at 5%, ***: sign. at 1%

Table 7. Wilcoxon tests about revealed WTP for flexible option between price levels

<table>
<thead>
<tr>
<th></th>
<th>NI treatment</th>
<th>PI treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 vs P2</td>
<td>Z=-3.1666</td>
<td>Z=-3.442</td>
</tr>
<tr>
<td></td>
<td>P 0.000***</td>
<td>P 0.000***</td>
</tr>
<tr>
<td>P2 vs P3</td>
<td>Z=-4.180</td>
<td>Z=-4.818</td>
</tr>
<tr>
<td></td>
<td>P 0.000***</td>
<td>P 0.000***</td>
</tr>
<tr>
<td>P1 vs P3</td>
<td>Z=-4.602</td>
<td>Z=-4.631</td>
</tr>
<tr>
<td></td>
<td>P 0.000***</td>
<td>P 0.000***</td>
</tr>
</tbody>
</table>

*: significant at 10% , **: sign. at 5%, ***: sign. at 1%
Table 8. OLS about revealed WTP for flexible option

<table>
<thead>
<tr>
<th>Variable</th>
<th>NI Treatment</th>
<th>PI treatment</th>
<th>All treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-292.6472***</td>
<td>-307.2704***</td>
<td>-311.1356***</td>
</tr>
<tr>
<td></td>
<td>(22.1451)</td>
<td>(20.7363)</td>
<td>(15.2769)</td>
</tr>
<tr>
<td>RM price level »</td>
<td>115.5762***</td>
<td>127.2461***</td>
<td>121.4111***</td>
</tr>
<tr>
<td></td>
<td>(8.4063)</td>
<td>(7.8446)</td>
<td>(5.7556)</td>
</tr>
<tr>
<td>Information (« 0 » or « 1 »)</td>
<td>/</td>
<td>/</td>
<td>23.2383***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3.7893)</td>
</tr>
<tr>
<td>Risk Aversion</td>
<td>-10.8957*</td>
<td>5.1806</td>
<td>-2.7295</td>
</tr>
<tr>
<td></td>
<td>(5.5902)</td>
<td>(5.1341)</td>
<td>(3.7968)</td>
</tr>
<tr>
<td>Number of obs.</td>
<td>768</td>
<td>768</td>
<td>1536</td>
</tr>
<tr>
<td>$R^2$ (adj. $R^2$)</td>
<td>0.2013 (0.1992)</td>
<td>0.2567 (0.2547)</td>
<td>0.2397 (0.238)</td>
</tr>
</tbody>
</table>

* : significant at 10%  , ** : sign. at 5% , *** : sign. at 1%
Figure 1. Decisions trees for the experimental choice

No Information treatment

Perfect Information Treatment

NB: RM for Rail Motorway, M for Motorway, A for origin, C for destination, B for middle point, $G^i_j$ the gain of choice $d_i$ if traffic $t_j$.
**Graph 1. Frequency of M choice by price scenario in each period**

![Graph 1](image1)

**Graph 2. Frequency of optimal choice by price level**

![Graph 2](image2)
Graph. 3. Theoretical WTP for flexible option compared to Revealed WTP (No Information treatment)
Graph 4. Theoretical WTP for flexible option compared to Revealed WTP (Perfect Information treatment)
Graph. 5. Average individual WTP in each information treatment for each price scenario

Graph. 6. Revealed WTP for flexible choice in NI and PI treatments
Annex: Calibration of transport parameters for the experimental setup

Modelling assumptions are the following: we consider that Rail Motorway commercial speed is about 120 km per hour plus a time of 30 minutes (mn) for loading and unloading\textsuperscript{11}. For Motorway, it has been assumed that commercial speed is about 80 km per hour. The ratio between distance AB and distance AC equals to 0.5 because, in the project, the distance between Lyon and Torino (AC) is around 300 km and AB (Lyon- St Jean de Maurienne) represents approximately near 150 km.

Then, to reach Torino from Lyon (300 km), the driver coach spends 180 mn (150+30) if he uses Rail motorway and 200 mn if he stays on motorway, \textit{if there is no traffic congestion in each infrastructure.} In this case of no traffic congestion, the Rail motorway infrastructure is always the best solution.

But if we introduce congestion assumption (uncertainty about traffic demand) the comparison between the two projects is changing. We suppose that if the two networks are congested the total travel time reaches 500 mn for motorway and 480 for rail motorway (450 + 30). Then, total time losses are respectively around 300 mn (for Rail motorway and 225 for motorway).

We suppose that there is only one possible connection between Lyon and Torino. If motorway is congested the driver can change its choice and switches to the Rail Motorway system at middle course near St Jean de Maurienne (after 150 km). In this case, the time he spends reaches 480 mn if Rail motorway is also congested and 330 mn if rail traffic is not congested\textsuperscript{12}.

Concerning prices, we assume the same tariff for the two networks \textit{i.e.} 134\textcurrency per 300 km. But we introduce a discriminatory access tariff, \textit{i.e.} a fixed cost for access and a variable cost linked to distance. This access price is supposed to be 15.2\textcurrency for Rail Motorway and 6.10\textcurrency for

\textsuperscript{11} Alpetunnel (1999).
\textsuperscript{12} Respectively 0.5X 450 + (1-0.5) X 450 + 30 and 0.5X 450 + (1-0.5) X 150 + 30.
Motorway (i.e. a price per km about 0.4€ for rail and 0.43€ for road). Those prices are respectively corresponding to average price expected by SNCF for Rail-Motorway, and to the average road haulier private cost for motorway (including toll, fuel and maintenance costs). It is important to note that the level of rail motorway tariff (0.4€/km) has to be changed in the economic experiment in order to test behavioural responses to price (+- 15%).

The calibration for rail-motorway project gives us an operating cost of approximately 0.4€/km$^{13}$, which represents the basic value of $c_{RM}$ in our experiments. As we try to test the impact of rail-motorway tariffs compared to motorway ones on road haulier choice, we should implement changing tariffs for $RM$ by increasing $c_{RM}$ to 0.46€/km and by decreasing it to 0.34€/km. These two values represent respectively high and low values about operating costs for $RM$. In the experiments, the parameters (in Euros, for baseline P2 scenario) were $F_{RM} = 15.2$, $F_M = 6.1$ and $c_M = 0.43$, $c_{RM} = 0.4$. In this case, the monetary cost of travelling by $RM$ was 134€, equal to the cost of travelling by motorway. But the price of $RM$ is to be changed in the different groups of players (+-15% compared with P2), with $c_{RM}$ growing to 0.46€ per km (P3) or decreasing to 0.34€/km (P1).

Appendix (available on http://sites.google.com/site/laurentdenantboemont/, not to be published).

$^{13}$ See SNCF (1992).
Method for eliciting risk preference of experimental subjects

At the beginning of the experiment, we elicited risk preference of our subjects by using Levy and Levy (2001) method. They use a Stochastic Dominance approach in order to characterize risk preference by defining first (FSD) and second order stochastic dominance (SSD).

Their questionnaire (translated in french language, see below) had been given to our subjects and the results are given in the data file available on http://sites.google.com/site/laurentdenantboemont/.

“Suppose that you decided to invest €10,000 either in stock F or in stock G. Which stock would you choose, F, or G, when it is given that the euro gain or loss one month from now will be as follows:

Task 1. Which would you prefer, F or G, if the euro gain or loss one month from now will be as follows:

<table>
<thead>
<tr>
<th></th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain or loss</td>
<td>Probabilité</td>
<td>Gain or loss</td>
</tr>
<tr>
<td>- 500</td>
<td>1/3</td>
<td>- 500</td>
</tr>
<tr>
<td>+ 2500</td>
<td>2/3</td>
<td>+ 2500</td>
</tr>
</tbody>
</table>

Please write  F or G: _______

Task 2 : Which would you prefer, F or G, if the dollar gain or loss one month from now will be as follows:
<table>
<thead>
<tr>
<th></th>
<th>F</th>
<th></th>
<th>G</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gain or loss</strong></td>
<td><strong>Gain or loss</strong></td>
<td><strong>Probability</strong></td>
<td><strong>Probability</strong></td>
<td></td>
</tr>
<tr>
<td>- 500</td>
<td>0</td>
<td>$\frac{1}{4}$</td>
<td>0</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>+ 500</td>
<td>0</td>
<td>$\frac{1}{4}$</td>
<td>0</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>+ 1000</td>
<td>0</td>
<td>$\frac{1}{4}$</td>
<td>+ 1500</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>+ 2000</td>
<td>0</td>
<td>$\frac{1}{4}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1 provides the cumulative distributions corresponding to the two alternatives in each of the two tasks. From Fig. 1 and the Stochastic Dominance rules it is easy to verify that in Task I alternative F dominates G by FSD, and then all subjects who prefer more over less and act rationally should choose F. In Task 2, G dominates F by SSD, and if risk-aversion prevails, G should be selected.
Figure 1. Cumulative distributions of Tasks 1 and 2