ON THE DISTANCE TARGET-COMPETITOR, SUSCEPTIBILITY, AND VALUATION OF DECOYS TO INFLUENCE PUBLIC TRANSPORT CHOICES.

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Abstract

The decoy effect is an irrational phenomenon, where the addition of a decoy redistributes the demand towards one of the pre-existent alternatives (Huber et al., 1982).

This work tests the decoy effect in a public transport context (where has never been studied) and postulate the influence of the distance between alternatives as a relevant factor. This kind of behavior was not described in previous literature but was found empirically and tasted later.

We did two surveys. In all question the target had more selection percentage in presence of the decoy, compared to a situation without it, which confirms this phenomenon.

Keywords: Discrete Choice, Decoy Effect, Public Transportation

1. INTRODUCTION

The decoy effect is a discrete choice behavioral phenomenon that consists in the addition of a third alternative to favor one of the preexistent options over the other (Huber et al., 1982). The alternative added is known as the decoy, the one favored by the decoy is known as the target, and the third alternative is known as the competitor. In the case of the asymmetrically dominated decoys, studied in this research, the decoy is worse in all features compared to the target, but not by the competitor, what somehow facilities the choice by making the target relatively more appealing. This "irrational" behavior implies a violation of the regularity assumption, and thus cannot be modeled with traditional Random Utility Models (RUM) like the logit but has been found to be reproducible by prospect theory models like the Random Regret Minimization Models (RRM) (Guevara and Fukushi, 2016). It is worth noting that RRM model has performed well even when the RUM model is valid (Chorus, 2010).

This phenomenon has been found in different contexts, from presidential elections to animal behavior, but, to the best of our knowledge, it has never been studied in public transportation. Due to the importance of public transportation in the sustainable developments of cities, and the difference between users and systems equilibrium on transportation systems, it is important to study the decoy effect in this context as a potential way to influence users' behavior.

This article has three main objectives. The first is to study if the decoy effect can influence the choices of public transportation options, specifically for bus and train. The second corresponds to study, for the first time, to the best of our knowledge, if the distance between the competitor and the target has an impact on the size of the decoy effect. The third is to contribute to the literature on the susceptibility and valuation of the decoy effect using discrete choice models. To pursue these goals, we developed two stated preferences surveys. Both surveys inquired about a hypothetical trip from the Chilean cities of Santiago (the capital) and Chillan (located some 400 Km south).

1.1 WHAT IS THE DECOY EFFECT?

In a discrete choice scenario, you can add a new alternative in order to make one of the pre-existent options more appealing, this is called decoy effect because the new option has no intention to be selected, just to change the perception of the other ones. This phenomenon has been show in different context, even out of human selections, such as frog behavior (Lea & Ryan, 2015), eating behavior of amoeboid (Latty & Beekman, 2011), etc.

Not any extra alternative generates a decoy effect, that alternative need to gather some characteristics. One example is adding an alternative that is dominated **only** by the alternative that we want to favor, named target, this will generate an "asymmetrically dominated decoy" (Huber et al., 1982), that's the name because the decoy is dominated by the target but not by the competitor, thus is "asymmetrically dominated". There are other kinds of decoys such as phantom decoy (Pratkanis & Farquhar, 1992) which consists in adding a dominant alternative that is no available, producing attraction to the closes alternative.

This work will only focus on asymmetrically dominated decoys and the next picture try to explain how the dimension of an alternatives should be placed in order to generate a decoy. The pre-existent alternatives names are, "Target" (if we want to favor the selection) and "Competitor" (alternative that will reduce its choice percentage), the new alternative is the decoy which shouldn't be selected at all, because is dominated by the target (all attributes of the target are better than the attributes of the decoy)

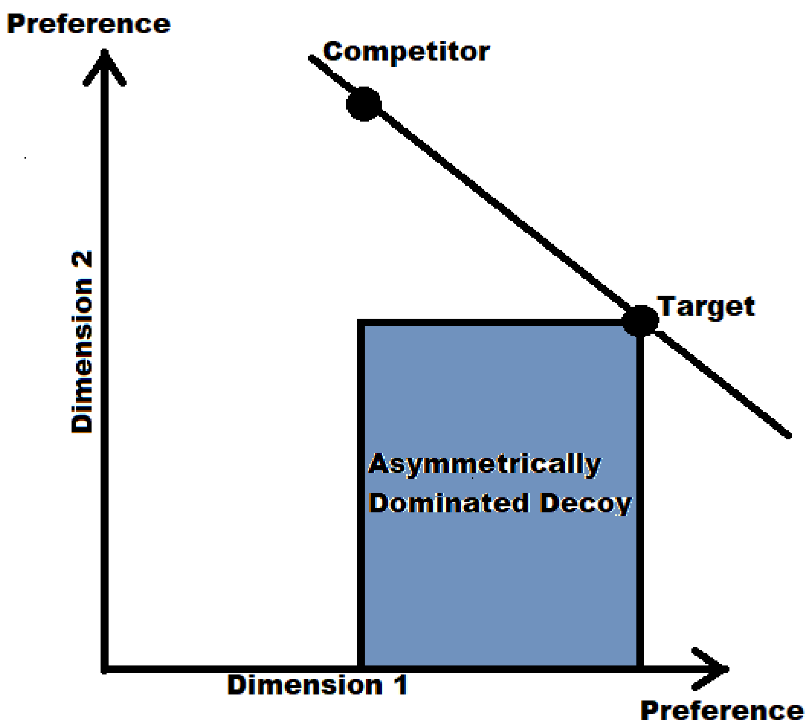

Figure 1: Asymmetrically Dominated Decoy Area

Is important to notice that the axes get far from zero as the preference grows, in this research we used time and cost as dimension so it will be decreasing through the axes. In any point of the painted rectangle the alternative will be better than the competitor in Dimension 1, but never better than the target in any dimension.

2. HOW TO TAKLE THIS STUDY

We run different surveys of stated preferences to find if the decoy exists, at least, theoretically. The whole idea behind this was to show the change in election when we added an asymmetrically dominated decoy. Sadly, an experiment was no possible, more thoughts about that are in the conclusions.

The following 4 chapters shows the surveys and its results. Is important to mention that we run some test, and focus group before the surveys presented here, what you will see is the final product.

3. SURVEY 1

3.1 METHOD SURVEY 1

The first survey was designed to prove the existence of the decoy effect in a public transport environment. To accomplish this goal, we randomly divided the sample in two groups, one was the control group, which answered a survey without the decoy alternative and the other was the treatment group, which answered the same survey, but with a third alternative, the decoy. This allows us to compare the behavior and use a chi-squared test to measure the differences, just like a new pill experiment. In theory the percentage of people who choose the target must be greater in presence of the decoy (treatment group).

The survey consisted of 7 questions where people got to choose a ticket in bus or train to go from Santiago de Chile to Chillan (Two cities separated by 400 km). Each option has two attributes, cost and travel time. First, we designed the question for the control group, by using values according to the current market state. Second, we designed the survey of the treatment group, by adding a decoy. Every decoy was an asymmetrically dominated decoy, so it must have been equal or worse than the target (Huber et al., 1982). We arbitrarily defined that the target will always be the most expensive option (as usual) in this case, the train.

The following table shows the alternatives and its attributes. This is the design, but the questions and the order of the alternatives are shown randomly, to avoid any pattern.

Table 1 Survey 1 Design

Questions of survey 1

	Train (target)		**Bus (competior)**		**Train (decoy)**	
Question	Cost Pesos	Time Hours and minutes	Cost Pesos	Time Hours and minutes	Cost Pesos	Time Hours and minutes
1	17.300	3:15	14.000	4:45	17.500	3:15
2	17.300	3:15	14.550	4:30	17.300	4:25
3	17.300	3:30	14.550	4:45	17.300	4:40
4	16.750	3:30	15.100	4:15	16.950	3:30
5	17.300	3:30	14.000	4:45	17.500	3:30
6	16.200	3:45	14.550	4:30	16.400	4:15
7	16.200	3:45	15.100	4:15	16.400	4:05

3.2 RESULTS SURVEY 1

The results of the survey 1 are shown in the next table and the effectiveness of the decoy is just the percentage of target selection in the treatment group minus the percentage of target selection in the control group, so if this number is positive, that means the decoy is influencing selection towards the target (as is should), and the magnitude shows how much this effect change things. It is important to notice that it only shows change, but not how hard is this change. For example, increasing a 95% of target selection to a 100% is much more difficult than a 5% target selection to a 10%, and the effectiveness is the same.

Table 2 Survey 1 Results

Question	Decoy's efectivneess Percentage [%]	Chi-Squared test Porcentaje [%]	Type of decoy
1	19.2	00.2	Range
2	12.9	03.9	Frequency
3	11.0	07.2	Frequency
4	03.1	52.8	Range
5	21.1	< 0.01	Range
6	13.2	03.3	Range- Frequency
7	01.7	76.7	Range- Frequency

The first thing to notice is that the percentage of target selection is always greater in presence of the decoy. The second thing worth noting is that the difference in the effectiveness of the decoy cannot be explained by the type of the decoy. After trying different options, we found out that the "distance" between target and competitor (how different the alternatives are to each other) may influence the decoy effect, this is what we called the distance effect and its in the next figure.

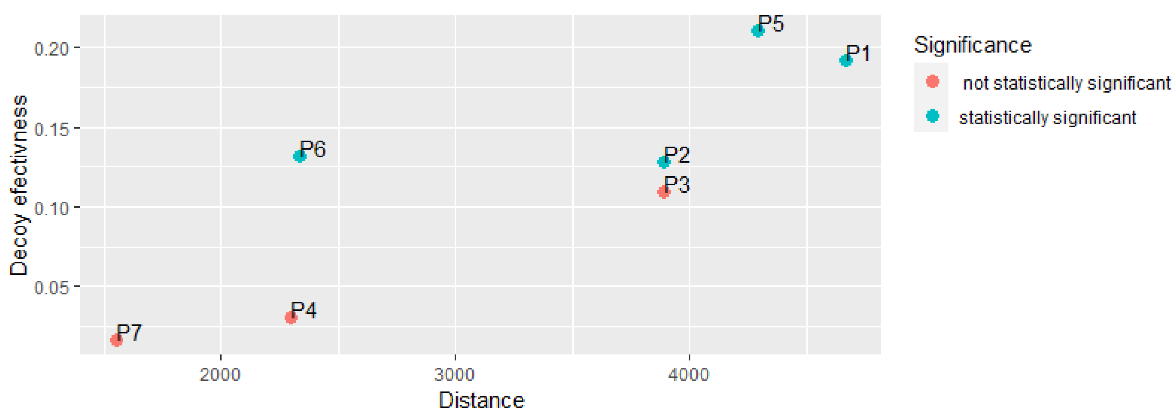

Figure 2: Distance vs Effectiveness charter.

In this case the distance is calculated as it follows:

1.- Transform the cost of each options intro money using the value of time.

2.- Calculate the Euclidean distance using the Pythagoras theorem.

The distance only matters to compare different situations, establishing in which situation the target and the competitor are more different to each other, the magnitude of distance itself don't provide any information.

Due the experiment was not designed to analyze the distance effect, there are more possible explanations to this behavior. To ensure that the distance could be an explanatory variable, we taste what happened on a random regret minimization (RRM) behavior. We selected RRM behavior because it has been proven that this model can incorporate the asymmetrically dominated decoy effect, (Schley, 2005) unlike the RUM model. This is caused for the violation of the regularity axiom that decoy implies.

We calculate the probability of choosing the target for a scenario with known parameters, in this case time and cost parameters were fixed. We choose an arbitrary target and an arbitrary asymmetrically dominated decoy and finally calculate the target's percentage selection, assuming RRM, for a large sample of competitors values, always keeping the same time-cost tradeoff (because we choose the time and cost parameters, we also known the time-cost tradeoff), is important to keep the same tradeoff line, other ways that could be the reason behind the different impact on the decoy.

Then, we calculate the probability of choosing the same target vs the same competitors, but without a decoy.

Finally, we subtract the decoy scenarios minus the not-decoy scenario, obtaining the effectiveness of the decoy for every competitor.

The result of this validation analysis is the following:

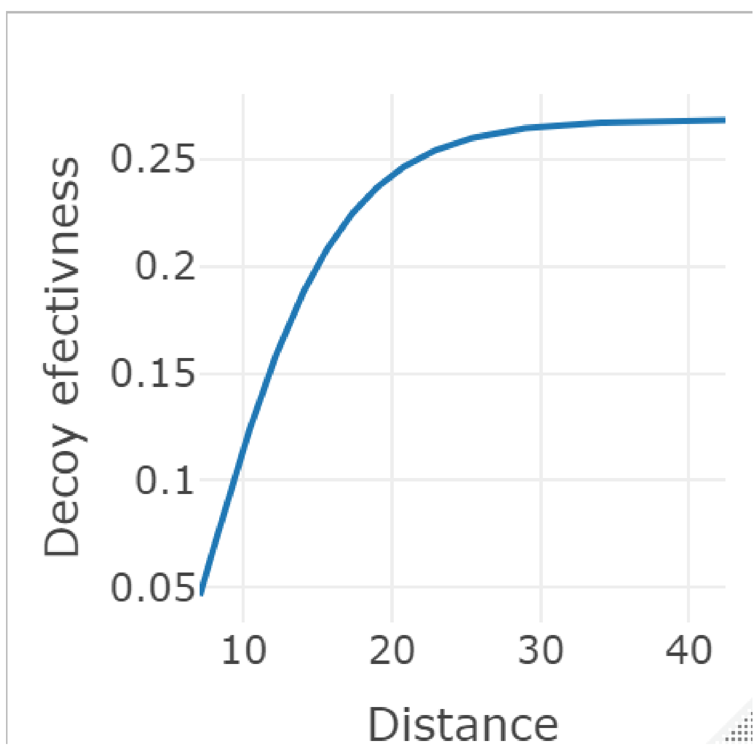

Figure 3 decoy effectiveness vs distance according to RRM.

To sum up. First, the data gathered in the survey shown that distance could possible explain why some decoy works better than other. Second, if RRM is how the election are made, distance will influence the decoy, this is proof by the analysis done before.

The next step is making an experiment that allow us to find and measure the effect of the distance.

4. SURVEY 2

4.1 METHOD SURVEY 2

The second survey was designed to analyze if the distance of the attributes between competitor and target influences the decoy effect, and to make a model with the information gathered. In order to accomplish this goal, 4 questions (Question N° 1 ,2 ,3 and 4) were designed using Ngene to grant us the possibility of estimating time and cost constants, and the other 4 questions to analyze distance (Just like survey 1, the number of the question is only relevant to design, people see them in random order).

To ensure that we are separating the distance effect from any other possible factor, we design the question number 5, 6, 7 and 8 as it follows:

1.- We fix the target at $12.800 cost and 4:30 of travel time.

2.- To design the first competitor. We add 20 minutes of travel time and reduce the cost in $1500 (this is the tradeoff according to the value of time form interurban travels).

3.-We repeat the step two but adding 10 more minutes each time. This way the time difference will be 20, 30, 40 and 50 minutes in question number 5, 6, 7 and 8.

This ensure that situation in question 5 has always less distance than question number 6, 7 or 8.

4.- To design the decoy we only add $500 pesos to the cost. This implies that all the decoys are asymmetrically dominated range ones. The goal of this is to ensure that any difference is not explained by something other than distance, as the type of the decoy. We choose to only ask for bus options for the same reason.

The design of the 8 questions ends up as it follows:

Table 3 Survey 2 Design

	Bus 1 (target)		**Bus 2 (competitor)**		**Bus 3 (decoy)**	
Question	Cost Pesos	Time Hours and minutes	Cost Pesos	Time Hours and minutes	Cost Pesos	Time Hours and minutes
1	12.000	4:40	9.500	5:00	12.500	4:40
2	12.000	5:00	10.500	5:30	12.500	5:00
3	12.000	4:40	10.500	5:00	12.500	4:40
4	10.500	4:40	9.500	5:30	11.000	4:40
5	12.800	4:30	11.300	4:50	13.300	4:30
6	12.800	4:30	10.500	5:00	13.300	4:30
7	12.800	4:30	9.800	5:10	13.300	4:30
8	12.800	4:30	9.000	5:20	13.300	4:30

The model chosen for this experiment is a mix logit with two latent classes: The first, is meant to represent people who do not change their preference under the presence of a decoy, so its behavior should follow a simple logit model. The second represents people whose target 's utility seems increased by the presence of a decoy, so their behavior should follow a emergent value model, explained in (Wedell & Pettibone, 1996) which is basically an utility model that add some extra utility to the target only if there is a decoy, explaining the change in choose proportions due the decoy.

4.2 RESULTS SURVEY 2

The result is shown in the next table:

Table 4 Survey 2 Result

Question	Decoy's Efectivness	Chi-Squared test	Type of decoy
	Percentage [%]	Percentage [%]	
1	07.5	22.7	Ranged
2	15.1	02.7	Ranged
3	11.3	08.4	Ranged
4	09.4	08.5	Ranged
5	09.4	15.7	Ranged
6	12.3	07.2	Ranged
7	02.8	67.8	Ranged
8	15.1	02.3	Ranged

The first thing to notice is that the percentage of target selections is always greater in presence of the decoy.

We also estimate a latent class model with the data collected on the survey 2.

The first class is defined as it follows:

$$V_{i\ class\ 1\ p} = \beta_{cost} \cdot Cost_{ip} + \beta_{tieme} \cdot Tieme_{ip} + \beta_{decoy\ 20-30} \cdot decoy_{20-30\ p} + \beta_{dcecoy\ 40-50} \cdot decoy_{40-50\ p}$$

Where:

- $V_{i\ class\ 1\ p}$ is the systematic utility of alternative i and question p.
- β_{cost} cost constant.
- $Cost_{ip}$ how much cost the ticket of alternative i question p.
- $Time_{ip}$ travel time, in minutes, of alternative i question p.

- β_{time} travel time constant.
- $\beta_{decoy\ 20-30}$ decoy constant for a 20-30 minutes difference of time scenario.
- $decoy_{20-30\ p}$ dichotomous variable, with value 1 in presence of a decoy in a 20-30 minutes difference scenario and 0 in any other case.
- $\beta_{decoy\ 40-50}$ decoy constant for a 40-50 minutes difference of time scenario.
- $decoy_{40-50\ p}$ dichotomous variable, with value 1 in presence of a decoy in a 40-50 minutes difference scenario and 0 in any other case.

The second class is defined as it follows:

$$V_{i\ class\ 2\ p} = \beta_{cost} \cdot Cost_{ip} + \beta_{time} \cdot Tieme_{ip}$$

Where:

- $V_{i\ class\ 2\ p}$ systematic utility for alternative *i*, class 2, question *p*.
- β_{cost} cost constant.
- $Cost_{ip}$ how moch cost the ticket of alternative i question p.
- $Time_{ip}$ travel time, in minutes, of alternative i question p.
- β_{time} travel time constant.

Finally, this Is how the pertinence to each class is defined:

$$V_{Class\ 1} = K_1 + \beta_{age} \cdot Age + \beta_{RT} \cdot RT$$

Where:

- $V_{Class\ 1}$ systematic utility of class 1.
- K_1 class 1 constant.
- β_{age} age constant.
- Age age of the surveied.
- β_{RT} response time constant.
- RT response time in seconds.

The result of this model is shown in the next table:

Table 5 Model Results

	Constants	T-Ratio
Election Model		
Mean beta Time	-2.606285	-26.02561
Beta Cost	-0.001384	-13.90882
Beta decoy 20-30 min distance	0.044888	0.17626
Beta decoy 40-50 min distance	2.655374	6.07956
Class		
Class constant	-0.23276	-0.03024
Age	12.66309	4.68862
Response time	-0.295041	-0.21829
Parámetros generales del modelo		
Value of time	$3200/hora	
Sutituion rate decoy/money	$1919	
Sustituion rate Decoy/time	36 minutos	
Probability of class 1	75.46%	
Log-likelihood	-857.092	
Rho squered	0.2638	
AIC	1730.18	
BIC	1773.77	
Surveyed contro group	106	
Surveyed treatmen group	106	

As you can see, instead of having just one constant related to the decoy effect, we add two, one for the questions with less distance and the other for the question with more distance. The explanation to the difference in these two parameters is the distance effect, making more relevant a decoy when the distance between attributes is greater.

Is important to notice that the value of the decoy is positive, proving that it increases the utility of the target (making it more attractive), and its magnitude is bigger when the distance between attributes is greater.

5. CONCLUSIONS

The information gathered in this work shows plenty of evidence supporting the existence of decoy effect in public transport context. From a total of 15 questions, all of them had more target selections in presence of a decoy. The model confirms this conclusion because the decoy's constant result positive, implying extra utility just because there is a decoy.

About the distance effect, the model results show that is a possible explanation, but this experiment is not able to determinate the whole phenomenon, leaving with some important questions, such as: when it's starts, what's the limit, is consistent among other scenarios different from transport, etc. Is important to remember that this is the first time the distance effect is documented and must be seen as a first step into a new decoy's layer to fully understand the decoy effect.

One of the key aspects of distance effect is that, when fully comprehended, will allow us to compare scenarios beforehand, avoiding decoys experiments in unfavorable situations that leads to concluding weak or non-existing decoy effect.

For future investigation, the next step could be a revealed preferences experiment, with wider range of attributes or gathering even more data to explore all the different question made before. Is important to search for online purchase of travel ticks or items because this is a growing field since pandemic, and it has been proposed as a potential perfect environment for the decoy effect.

6. COMMENTARIES

One way to improve the same experiment is finding the values to keep all alternatives in the same tradeoff line for the control group. For example, if in the control group, across all questions, the target was always chosen by the 55% (ideally 50, but no strictly necessary) you will be tackling the distance effect more precisely, because in this experiment can be noise produced by the changing of the base situation in each question. Ideally 50%, because is a fair point, if the target selection's percentage is too high, is harder for the decoy to make it even greater, on the other hand if it is too low, is easer to have an impact.

There are no evident spots to use decoy in public transportation. Flights with different prices is one possible place, this kind of transaction gather all that is required, different prices, see al alternatives, change quality (in form of extra luggage, choose sits, higher class, etc). Another spot could be the selling of travelcards for different time, for example make the monthly travelcard the target and the weekly travelcard the decoy in order to encourage the uses of this kind of transport. Using travelcards was the original idea in this research, even some surveys were made, but here in Chile there is no travel cards, only single tickets, this made things a lot harder for people to understand how this work on a online survey, and for us to choosing prices for a not existing travelcard.

There has been a lot of commentaries about if the decoy is "good" or "bad" since change perception, my personal point of view is that you can't use the decoy for important decisions, only for simple things, maybe a decoy just allow us to take not real important decisions easily, reducing the burden in our brains of constant decision across the day.

Any doubt, comment or question about the research feel free to contact me directly at diego.fuentealba@ug.uchile.cl

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