

Article

Gender and Risk Aversion: Evidence from a Natural Experiment

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Abstract: The theoretical literature on risk aversion and Expected Utility Theory is extensive; however, the analysis of this behaviour with natural experiments could be more comprehensive. In this paper, we use data from 120 episodes of the Portuguese version of the TV game show *The Price is Right*, namely from *The Wheel* game, to explore risk aversion as well as the impact of gender in decision-making. *The Wheel* game has straightforward rules and huge expected payoffs. All contestants have access to the same information and distributions of uncertainty, making it a unique field laboratory to conduct an experimental test of rational decision theory. The objective is to infer the risk aversion levels of decision-makers from their choice to turn the wheel and the influence of gender on risk attitudes. There is a widespread view that women are more risk-averse than men. However, we could not reject the hypothesis that women and men have the same level of risk aversion. Nevertheless, we have evidence that contestants are more risk-averse than risk-seeking. The omission bias, loss aversion and regret can explain that behaviour.

Keywords: risk aversion; gender; decision-making; rationality; TV show; *The Price is Right*



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1. Introduction

There is a general view that women are more risk-averse than men. However, findings from laboratory experiments are less conclusive [1–3]. The ongoing discussion about which gender is more risk-tolerant motivates the present paper, which studies the implications of decisions under risk and uncertainty in a financial context and explores gender differences in risk-taking. Women may not be able to be promoted to the same levels as men because the position requires taking risks, and it is believed that women will not be able to handle such a position. If we conclude that men are less risk-averse than women, it has important implications for management. It can explain the underrepresentation of women in top management positions, which, therefore, could justify diversity measures imposed on governments and corporate boards.

For that purpose, we analyse the contestants' behaviour in *The Wheel* game from 120 episodes of the Portuguese TV game show *The Price is Right*. It is a game of simple rules and huge expected payoffs, which makes it a unique field laboratory to conduct an experimental test of rational decision theory. Since the stakes are high, it provides an economic incentive for contestants to play optimally. We base our analysis on the optimal no-bonus behaviour derived by [4], but in a different cultural context, and verify whether contestants follow that behaviour. As Ref. [5] shows, the cultural context influences the decisions of individuals, even in a controlled environment such as a TV contest. Different aspects of bidding behaviour, such as gender differences, risk aversion, loss aversion and psychological bias, are analysed to find if risk aversion and gender impact risky decisions.

Television game shows can offer an exceptional laboratory for observing decision-making behaviour. The use of game shows to study risk aversion and decisions under

uncertainty is well established in the economics and finance literature [6]. The study of decisions under uncertainty is essential to finance and modern economics. Most of the initial literature on this topic refers to North American individuals and does not include personal characteristics, such as gender [4,7–11]. Agents' decisions are systematically influenced by factors that do not relate to the characteristics of financial assets (risk and return), such as cognitive bias [12], age and individual differences [13], culture [14] and experience [15]. Even though *The Wheel* is an artificial game designed for entertainment, it is an interesting frame to study decision-making since it mirrors sequential decision problems that frequently arise in the economic context, such as search problems, inventory problems, gambling problems and 'secretary-type' problems [16].

In addition, we also study the contestants' decision to spin the wheel a second time or not. Several studies have found that women are more risk-averse than men [2,3,17–23]. Nevertheless, the literature is not conclusive, with other studies rebutting the stereotype [1,24–27]. The relationship between gender and risk aversion is complex, and may depend on various factors such as cultural norms, personality traits and socialisation. For instance, Ref. [26] argue that the presence and magnitude of gender differences may be task-specific.

This research studies the impact of gender on financial decisions under risk and uncertainty, contributing to the game show-based literature, specifically studies based on TV contests. First, we examine decision-making by individual contestants under risk and uncertainty. Second, we consider whether the contestant's gender has an impact on decisions. We also analysed the French version of the game to obtain more reliable conclusions.

The remainder of this paper develops as follows. In Section 2, we present a detailed literature review on risk aversion and gender in decision-making. In addition, some studies on risk aversion carried out in the context of a TV show are reviewed. Section 3 presents the sample considered in the empirical research and describes *The Wheel* game in greater detail. Section 4 presents the methodology: that is, the optimal strategy to be adopted by the contestants. Section 5 presents the results and discussions, and Section 6 provides concluding remarks, limitations and suggestions for future research.

2. Literature Review

2.1. Risk Aversion and Gender in Decision-Making

Attitudes toward risk are a vital subject of study because they are the basis for many decisions in several branches of finance. Existing empirical evidence on the impact of gender on risk tolerance and, consequentially, on decision-making concentrates on three main domains: finance (including gambling, investment and insurance), health and physical safety, and strategic decision-making in a professional work environment [23]. Nevertheless, research on organisational settings has not found significant differences between men's and women's risk attitudes [24,27,28].

There is a general view that women are more risk-averse than men when confronted with financial decisions [18,20,22,23,29]. Several studies explore gender differences in risk aversion in different finance branches, recurring to questionnaires. For instance, in investments, Ref. [2] concluded that women are significantly more risk-averse than men. According to survey responses by [30], women reported a lower propensity to risk than men when asked about their attitudes towards risky financial decisions. In a study involving postgraduate students in Portugal, Ref. [23] concluded that men are significantly more risk-tolerant than women, even after monitoring for factors such as the economic status and educational levels of the respondents' parents. Nevertheless, gender differences seem to be essentially driven by a higher proportion of males with high levels of risk tolerance. On the other hand, when the context is insurance against loss, Ref. [1] suggested that men's and women's choices are similar. Also, Ref. [26] argued that the likelihood of observing gender differences depends crucially on the characteristics of the task used to infer risk preferences.

Other authors use real situations to study gender differences in risk aversion. Ref. [31] concluded that women weigh risk attributes more severely than men in their survey of professional investment managers. Ref. [32] found that following the hiring of a female CFO, there is a significant increase in the degree of accounting conservatism due to their risk aversion. However, conservatism is more likely to exist when firms have higher litigation risk, default risk, systematic risk or management turnover risk. Refs. [33–35] evidenced that the presence of women on the Board is associated with firms' more conservative management and higher risk aversion.

Furthermore; women are found to have less risky asset portfolios than men [18] and are more sensitive to losses than gains [36]. Ref. [29] found that women choose less risky alternatives. They are more risk-averse than men regardless of familiarity and framing, costs or ambiguity.

There are still other studies that compare the different analyses to draw a more reliable conclusion. For instance, Ref. [3] reviewed the literature on gender differences in several economic experiments. According to the authors, women are usually less prone to make higher valuations for gambles than men, and consequently, they are seen as the gender with a higher risk aversion. Likewise, Ref. [19] found that men take more risks than women in most of the risk categories of their meta-analysis.

However, Ref. [1] found that women are not that risk-averse under controlled economic conditions, and do not make less risky financial choices than men. They argue that the risk propensity of both genders depends on the decision frame, which is corroborated by [37] findings. These gender differences can be explained by how women and men weigh probabilities in their decisions [38]. Ref. [2] gave another explanation, emphasising that many studies of gender differences when agents face risk may be biased due to the absence of variables such as individual wealth. Furthermore, as noted by [39], using different methods to measure the preferences is an additional source of heterogeneity in the results. Ref. [25] attested that a flaw compromises the existing literature in favour of gender differences in risk attitudes: a failure to distinguish between disagreements regarding the individual level, that is, the categorical distinction between men and women, and patterns that appear only at the aggregate level, that is, differences in statistical distributions.

Ref. [3] offered three explanations for the observed differences: emotions, overconfidence and risk as challenges or threats. Women feel emotions more deeply than men: namely, more nervousness and fear in expectation of adverse outcomes, which can negatively affect their utility of a risky choice. On the contrary, in an identical situation, men tend to feel angry, leading them to evaluate a given gamble as less risky. Regarding the second explanation, there is evidence that men are more overconfident than women, which means that women will be less prone to go ahead with the gamble. A further possibility is that men are more likely to see a risky situation as a challenge, whereas women see the same situation as a threat. Finally, some studies show that an important factor in explaining why women are less likely to hold risky financial assets is that they are less confident about their financial skills (e.g., [40–42]).

2.2. Some Experimental Studies Using *The Price Is Right* TV Show

The analysis and evaluation of the impact of risk aversion in decisions under risk have been the subject of research, either using natural or laboratory experiments.

Several researchers based their research on field experiments, such as TV shows, in which agents were faced with high stakes. Most of the previous studies about financial decisions in the context of TV shows investigated loss aversion, risk aversion, gender and cultural differences, rationality, learning and other decision problems (e.g., [5,7–11,27,43–47]). In this section, we will present some experimental studies investigating risk aversion, learning and rationality issues in the specific context of *The Price is Right* TV show.

Ref. [8] studied how economic agents process information by determining whether players on *The Price Is Right* optimally use former information to formulate their bid strategies. Four players are called sequentially from the audience to take their place at

the initial bidding game. To continue to the next round, each contestant guesses the retail price of a given tangible good, and the one whose shot is closest to the actual price without exceeding it wins the auction. The focus of their study is the fourth bidder. They found that competitors are led toward more effective behaviour through learning, observing the previous three bids. However, they did not take advantage of their probability of winning.

Ref. [10] also analysed the first auction of 372 episodes of *The Price Is Right*. They considered that the show offers a unique experimental setting because the stakes are sufficiently high to guarantee that contestants have an economic incentive to play optimally. The main objective was to test both rational decision theory and bounded rationality, since they argued that bounded rationality explains why individuals deviate from optimal behaviour. The authors argued that the proof of the existence of bounded rationality is that the agents should adopt strategies that improve self-welfare by observing those strategies, which does happen. It means that contestants appear to learn. Even so, many of the contestants use suboptimal strategies. For instance, it is always optimal for the fourth contestant to bid higher than the other contestant, cutting him down, or instead, to bid the minimum possible value [11]. However, Ref. [10] observed that in over 43 per cent of cases, contestants do not choose this optimal strategy. In the subgame perfect equilibrium, agents bet in descending order [11], and in their experiments, agents only bid in descending order in 3.76 per cent of the games. Thus, their results prove that rational decision theory cannot explain contestants' behaviour on *The Price Is Right*.

Later, Ref. [11] developed an experiment replicating many empirical patterns identified by [10] in the first auction of *The Price is Right*. Their objective was to analyse the divergencies between the theoretical predictions and the actual evidence. In accordance with [10], they found patterns of suboptimal behaviour in their experiment. They changed the configuration of the auction to detect the location of the flaw of subgame perfection. They show that reducing the number of contestants from four to three makes the choices of previous contestants easier in the game since it is more likely that they believe that all following contestants will induct backwards. According to them, when contestants see repeated similar actions before they play, they can calculate better the best response to those actions, creating a common knowledge of rationality through earlier players. However, the three-player version also improves the decisions of the third contestant since there are fewer actions of earlier contestants to which the third player must answer. They assume that auctions with fewer contestants probably converge and reach perfect subgame results because it is easier to make it general knowledge that players are rational.

Using the Portuguese Version of the TV Show *The Price is Right*, Ref. [46] tested the rationality of contestants' decisions in the first auction. The results show that contestants benefit from the game's sequential nature, making use of the learning capacity. However, the fourth player departs from the optimal behaviour, only bidding 27% of the rounds optimally. Moreover, the author found that men adopt optimal strategies more often than women. As well as [10], Ref. [46] found that rational decision theory cannot explain how individuals decide.

Ref. [4] studied the equilibrium contestants' behaviour in *The Wheel* game of the American version of *The Price is Right*, which is the last game of the TV show before the final *Showcase Showdown*. It is a game of perfect information with simple rules, high stakes and a primary source of uncertainty with an established distribution. Furthermore, in the American version of the game, when a contestant scores precisely 100 points, they win a bonus of \$1000, \$5000 or \$10,000. That is an interesting feature of this game since bonus payments are an essential determinant of contestants' strategies. The authors derived the unique subgame perfect Nash equilibrium for the game. They tested its predictive capacity using data from both 282 episodes of the TV show and data from a laboratory experiment where they reproduced the underlying conditions present in *The Wheel*. The main question is whether the contestants should spin the wheel again. Their results show that participants often depart from optimal behaviour whenever the difficulty level increases. The pattern of these deviations is highly independent of the game's stakes. However, they argue that

the deviations from the optimal behaviour cannot be due only to risk aversion but also to psychological biases such as the omission–commission bias or sudden death aversion. The increase in the difficulty level has to do with the score obtained in the first spin, affecting the decision to spin the wheel a second time.

Recently, Ref. [47] presented a thorough analysis, studying more than 40 years of data from *The Wheel* game’s American version. The authors found that contestants systematically deviate from the subgame perfect Nash equilibrium, simplifying the decision problem by adopting a myopic representation focused only on beating the next contestant. In summary, due to their unique conditions for observing decision-making behaviour, the utility of television game shows to study risk aversion and decision-making under uncertainty is well established in the finance literature. Thus, it also can be suitable to check gender-specific divergencies in financial decision-making.

3. Data

According to [48], in recent decades, there has been a change in the way researchers study causal effects. Researchers started using natural field experiments instead of laboratory experiments, because it makes it easier to validate theories and thus obtain more robust results about real phenomena that will help in decision-making. In a natural field experiment, people make choices without knowing that they are in an experiment, which can provide real results. TV game shows that offer huge rewards, like *The Price is Right*, can be considered a natural experiment.

3.1. The Game

This research aims to analyse the contestants’ risk aversion to the Portuguese version of the TV game show *The Price is Right*. Several versions were created around the world from its original North American version—*The Price is Right*. In Portugal, the current version was adapted from the British version in 2006, which continues to be broadcast today and is called *O Preço Certo*.

The Price is Right is a television game broadcast in Portugal six days a week. The contestants are called sequentially from the audience to take their place at the initial bidding game; however, they are only informed of their selection once the show’s announcer calls them. To continue to the next game on the Portuguese version of the TV Show, each of the four contestants guesses the retail price of a given tangible good, and the one whose shot is closest to the actual price without exceeding it wins the auction and plays a pricing game. After that, a new contestant is chosen from the audience, and the procedure repeats until there are three final contestants to compete in *The Wheel* game. *The Price is Right*’s objective is not to earn physical money but tangible goods or experiences. If in the auction game (first game) the bidder bids the exact price, a bonus of 50 euros is awarded to the winner.

To conduct our analysis, we chose the final game of the game show, *The Wheel*, whose winner will have the opportunity to bid for the final showcase. *The Wheel* game has straightforward rules, and all contestants have access to the same information and uncertainty distributions. In this game, the last three contestants, selected in previous games, sequentially spin a wheel divided into 20 parts numbered from 5 to 100 with values from 5 to 5 to accumulate points. They can spin the wheel twice, and the final score equals the sum of the first and second spins’ scores. However, turning the wheel the second time is not mandatory, so the contestants must decide if they should spin again or stop. If the contestants equal their scores, they have to spin the wheel once from 100 to establish the winner. The contestant with the right to bid for the final showcase has the score closest to 100 without surpassing it. The last showcase game consists of betting the showcase value, which is the more valuable prize of the entire game show, with the right to a margin of failure of 500, 1000, 1500, 2000 or 2500 euros, selected at random beforehand.

3.2. Data Collection and Sample

We downloaded from RTP Play a sample of 131 episodes broadcast between December 2021 and May 2022. All special editions and duplicate programs were removed from the dataset for analysis, resulting in a workable sample of 120 episodes. After the download, we watched the videos and manually inputted the data into a Microsoft Excel sheet. The gender of contestants, the scores obtained in each spinning of each contestant, the winner and the value of the final showcase (expected payoff) were recorded. In addition, the prize values from the first bidding game were recorded to see if there was any logical feature in the game sequence, such as a winnings–priority scheme. That can mean higher prizes for contestants who are less likely to win *The Wheel*. We do not record the value of the prizes of the second round of games because their value is only sometimes mentioned. Each episode has one round of *The Wheel* game, so 120 games were evaluated. Three contestants competed for the highest score; therefore, we analysed 360 decisions.

For a more reliable conclusion, we also analysed the French version of the game. The French version is very similar to the Portuguese one, and in *The Wheel*, there is no bonus payment either. We downloaded 105 episodes broadcast between 2011 and 2015 and made the same analysis for *The Wheel* to compare the results obtained. Furthermore, we compared the results of these empirical analyses with the ones obtained by [4] from the American version. That version implies bonus payment, which allows us to understand the influence of bonus payment in this game.

4. Methodology

In this section, we follow the optimal behaviour of a contestant in the game with no bonus derived by [4]. We also study whether contestants in the Portuguese version of the game follow this optimal behaviour.

The wheel is unbiased and discretely uniform since it is randomly divided into 20 parts numbered from 5 to 100 [5, 10, 15, . . . , 100]. Furthermore, since there are no bonus payments in the Portuguese version, we consider that each contestant is risk-neutral, and they are just concerned with maximising their probability of winning. Moreover, each contestant knows the game's rules and can evaluate all their possibilities. It is assumed that all contestants are making decisions based on optimal behaviour, and are aware of whether the value of the first spin influences whether the contestant should spin again or stay with that value. Each one has an optimal strategy based on what order the contestants are spinning in. There is a number each contestant should obtain equal to or greater than for their final punctuation to ensure the highest probability of winning *The Wheel*. According to the order they get to spin the wheel, each contestant has a different probability of winning.

Let a_i and b_i denote the scores achieved by contestant i ($i = 1, 2, 3$) on their first and second spins, respectively. If no second spin is taken, $b_i = 0$. Thus, $t_i = a_i + b_i$ denotes the total score obtained by contestant i . Further, x_i is defined as the total minimum score that contestant i should achieve to win *The Wheel* game. Thus, since Contestant 1 spins the wheel first, $x_1 = 0$. This does not imply that Contestant 1 can abandon their second spin. Contestant 1 does not aim to beat any previous contestants and thus must set the target for the following contestants. Contestant 1 should only abandon the second spin if $a_1 > 70$. The strategy of Contestant 2 is more complex since they also have to decide what to do in the case of a tie. Contestant 2 will aim to beat Contestant 1 and spin a value high enough so that they are sure that Contestant 3 will be unable to obtain a higher value without going over 100. So, $x_2 = t_1 \times I_{\{t_1 \leq 100\}}$, where $I_{\{t_1 \leq 100\}}$ equals 1 if $t_1 \leq 100$ and 0 otherwise. If $a_2 < x_2$, Contestant 2 should spin a second time. If $a_2 = x_2$, Contestant 2 should not spin a second time if $a_2 > 65$. This score was derived by [4], since the risk of surpassing 100 points is very high but also sufficiently high to give the contestant a good opportunity to beat Contestant 3, if $a_2 > x_2$ does not mean that Contestant 2 abandons the second spin opportunity. Thus, Contestant 2, in this situation, should only abandon the second spin if $a_2 > 55$. Contestant 3 is even more complex than the other two contestants' strategies since it could happen in a two or three-way tie. However, Contestant 3 is simply spinning to beat

Contestants 1 and 2 and is only left with an option for spinning in the case of a one-way or two-way tie. Contestant 3 should spin a second time to increase the likelihood of winning if $a_3 < x_3$. If $a_3 > x_3$, Contestant 3 abandons their second spin. If $a_3 = x_3$, the decision to spin the wheel a second time depends on the number of competitors matching their and Contestant 3's own scores. If Contestant 3 ties with only one of the earlier contestants on their first spin and the score is less than the score of the remaining contestant, then they should spin again if $a_3 = x_3 \leq 50$. If Contestant 3 ties with both of the earlier players on their first spin, they should spin again if $a_3 = x_3 \leq 65$.

The optimal stopping rule gives equilibrium for each contestant: that is, z_1^* , z_2^* and z_3^* , representing the minimum score for which contestant i abandons the second spin chance. Thus, $z_1^* = 70$, $z_2^* = 55$ and z_3^* . From these assumptions, Ref. [4] present Proposition 1, which analyses whether contestants behave as predicted.

Proposition 1: *There exists an equilibrium to The Wheel game with no bonus payments that respects the following strategy:*

Contestant 1 spins twice if they obtain a score lower or equal to 65 points in their first spin.

Contestant 2 spins twice if they obtain a score lower or equal to 50 points in their first spin. If they obtain a score lower or equal to 65 on their first spin and tie with Contestant 1, or if they do not use their second spin, they are guaranteed to lose.

Contestant 3 spins twice if they obtain a score lower or equal to 50 points in their first spin and tie with one other contestant. If they obtain a score lower or equal to 65 on their first spin and tie with two other contestants, or if they do not use their second spin, they are guaranteed to lose.

The risk aversion analysis is conducted by checking Proposition 1. The behaviour of all contestants in each game round will be analysed, and these will be compared with the optimal behaviour defined previously. The objective is to verify whether there is a correct use of the second spin. There are two possible conclusions if the contestants need to use the second spin correctly. If a contestant underspins when it is optimal to do so, the contestant will be referred to as risk-averse. When the contestant overspins when it is optimal to stop after the first spin, the contestant will be referred to as risk-seeking.

Additionally, regarding the influence of gender in decision-making and to verify if the general idea of women being more risk-averse than men is correct and applicable in Portugal, we study if women are more risk-averse than men. This analysis was only conducted once the analysis of risk aversion was concluded: after we verified which risk-averse contestants were, we separated them into men and women.

5. Results and Discussion

We downloaded a workable sample of 120 episodes of the Portuguese version broadcasted between December 2021 and May 2022. *The Wheel* was the game chosen to conduct risk aversion analysis. In the Portuguese version, there are no bonus payments for contestants who attain 100 points; thus, contestants are only motivated to use their second spin to get to the *Showcase Showdown*. Table 1 contains descriptive statistics.

In *The Wheel* game, Contestant 1 wins 34.17% of the time, Contestant 2 wins 31.67% of the time, and Contestant 3 wins 34.17% of the time. A Chi-square test retains the hypothesis that the winning percentage is the same across the three contestants at better than the 5% significance level. Table 2 compares the winning percentage of each contestant in the Portuguese, French and American versions of *The Wheel*.

Based on the calculations and assumptions of the optimal behaviour, Contestant 3 has the highest probability of winning, and the first player has the lowest probability of winning. We only observe that situation in the American version. In the Portuguese version, Contestant 1 and Contestant 3 win most of the time. In France, Contestant 2 is the one who

goes to the final showcase more often. In the USA version, which incentivises players with bonus payments, Contestant 3 wins 35.82% of the time.

Table 1. Descriptive Statistics.

| Panel A: Contestant Winning Percentages on <i>The Wheel</i> | | | | |
|--|------------------------|--------------------|-------|--------------------|
| Contestant | Observations | Winning Percentage | | |
| 1 | 41 | 34.17 | | |
| 2 | 38 | 31.67 | | |
| 3 | 41 | 34.17 | | |
| Panel B: Euro value of prizes won by the winner of the <i>Showcase Showdown</i> | | | | |
| Average | 17 627.72 ^a | | | |
| Standard Deviation | 4 392.91 | | | |
| Minimum | 0 ^b | | | |
| Median | 18 350.00 | | | |
| Maximum | 23 050.00 | | | |
| Panel C: Euro Prizes Won by Contestants in the <i>Auction</i> ^c | | | | |
| Contestant | Auction | | | |
| | Minimum | Maximum | Mean | Standard Deviation |
| 1 | 18 | 99 | 52.17 | 21.73 |
| 2 | 20 | 95 | 46.78 | 16.43 |
| 3 | 18 | 99 | 49.68 | 22.03 |

^a This is only the average of the prizes won by contestants who effectively won the *Showcase Showdown*. The average value of the prizes put into play in the *Showcase Showdown* of all episodes studied is 21 333.08 euros. ^b No one won the *Showcase Showdown* 85.00% of the time. The minimum prize value effectively won by contestants 9 980.00 euros. ^c The *Auction* is the first bidding game of *The Price is Right*.

Table 2. Contestant winning percentage in Portugal, France and the USA.

| Contestant | Winning Percentage | | |
|------------|--------------------|--------|------------------|
| | Portugal | France | USA ^a |
| 1 | 34.17 | 29.52 | 30.14 |
| 2 | 31.67 | 37.14 | 34.04 |
| 3 | 34.17 | 33.33 | 35.82 |

^a In the American version, there are bonus payments. Data for the USA from [4].

Of the 120 winners of *The Wheel* in Portugal, 15.00% won the *Showcase Showdown*. The average prize value was 17,627.72 euros, which for the Portuguese population is a huge value. The average monthly salary of employees is 1,042.00 euros ¹. We collected the prizes won by Contestants 1, 2 and 3 in the auctions to verify if there is a logical distribution of the value of the prizes per contestant, such as a winnings–priority scheme. Still, we could not collect the value of the prizes of the pricing games since these are not always mentioned. We did not find a pattern in the distribution of prize values in the auctions. Nonetheless, we found that the most frequent value prize for Contestant 1 was 70 euros, for Contestant 2 was 30 euros and for Contestant 3 was 45 euros. In the American version analysed by [4], they verified that there are significant differences in the average value of the prizes won in the bidding game, with Contestant 1 being the one who wins prizes with lower value and Contestant 3 with higher value. This deviation is a consequence of the winnings–priority scheme used to classify the contestants. However, the authors do not link the success in the pricing games to the skills needed to play *The Wheel*.

Considering the frequency with which each point total is achieved for the 360 first spins by each Portuguese contestant in *The Wheel*, we statistically confirm that the wheel is unbiased ($\chi^2_{19,d.f} = 17.222$). The same conclusion was achieved by [4] with the American

version of the game, and we also reached the same conclusion for the French data. Stepping into the risk aversion analysis, we first analyse the extent to which each one of the contestants makes decisions in accordance with Proposition 1. Table 3 contains the decisions of Contestants 1 and 2 and if those are consistent with Proposition 1.

Table 3. The Decisions of Contestants 1 and 2 on The Wheel.

| First Spin | Contestant 1 | | | Contestant 2 ^a | | |
|----------------|--------------|---|------------------|---------------------------|------------------------------------|------------------|
| | Frequency | Correct Utilisation of Second Spin ^b | Per cent Correct | Frequency | Correct Utilisation of Second Spin | Per cent Correct |
| {5, ... ,40} | 46 | 46 | 100.00 | 9 | 9 | 100.00 |
| 45 | 6 | 6 | 100.00 | 2 | 2 | 100.00 |
| 50 | 10 | 9 | 90.00 | 1 | 1 | 100.00 |
| 55 | 7 | 4 | 57.14 | 5 | 2 | 40.00 |
| 60 | 8 | 5 | 62.50 | 5 | 3 | 60.00 |
| 65 | 4 | 1 | 25.00 | 3 | 2 | 66.67 |
| 70 | 5 | 5 | 100.00 | 5 | 5 | 100.00 |
| {75, ... ,100} | 34 | 34 | 100.00 | 28 | 28 | 100.00 |
| Total | 120 | 110 | 91.67 | 58 | 52 | 89.66 |

^a We only consider those cases in which Contestant 2 does not have to spin again to have a chance to win. Results for Contestant 3 are not analysed since Contestant 3 plays only according to the score obtained by Contestants 1 and 2. ^b We define a decision as correct if it corresponds to the optimal equilibrium behaviour derived in Proposition 1.

Contestant 1's decisions are consistent with Proposition 1 91.67% of the time. The deviations occur when $a_1 \in \{50,55,60,65\}$. For instance, Contestant 1 correctly used their second spin 9 of the 10 times they scored 50 on their first spin, but only 1 of the 4 times they scored 65 on their first spin. Thus, the percentage of incorrect decisions made by Contestant 1 after attaining 65 points on their first spin is significantly higher than that of incorrect decisions made by Contestant 1 after achieving 50 points (Fisher's Exact Test p -value = 0.041), for a significance level of 5%.

Contestant 2 also deviates from what is proposed by Proposition 1 when $a_2 \in \{55,60,65\}$, their decisions being consistent with Proposition 1 89.66% of the time. For instance, Contestant 2 correctly used their second spin 2 times of the 3 times they scored 65 on their first spin, and they correctly used 3 of the 5 times they scored 60 on their first spin.

The small sample sizes on the game show affect the statistical tests' low power. However, game show data exhibits the same pattern as in [4] analysis. Table 4 compares the results obtained in the three versions of the analysis.

Table 4. Comparison of Contestants' Decisions in Portugal, France and the USA ^a.

| First Spin | Contestant 1 | | | Contestant 2 | | |
|----------------|--------------|--------|--------|--------------|--------|--------|
| | Portugal | France | USA | Portugal | France | USA |
| {5, ... ,30} | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| {35, 40} | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 75.00 |
| 45 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| 50 | 90.00 | 100.00 | 90.00 | 100.00 | 100.00 | 75.00 |
| 55 | 57.14 | 100.00 | 73.00 | 40.00 | 0.00 | 50.00 |
| 60 | 62.50 | 83.33 | 53.00 | 60.00 | 100.00 | 75.00 |
| 65 | 25.00 | 66.67 | 21.00 | 66.67 | 100.00 | 100.00 |
| {70, ... ,100} | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Total | 91.67 | 97.14 | 91.84 | 89.66 | 97.92 | 93.70 |

^a The data relating to the Portuguese and French versions were calculated by us. In contrast, the data relating to the American version were taken from the paper by [4].

The differences in results can be due to the sample size of each version of the game. We worked with a sample of 120 plays of the Portuguese version of *The Wheel*, and 105 plays of the French version. Ref. [4] used 282 plays of the game. Although the sample size used to analyse the Portuguese and French versions are pretty similar, the results are not very different in terms of deviations from Proposition 1. French contestants seem to follow more what is proposed by Proposition 1 than Portuguese contestants. Comparing the three countries, a Chi-square test ($\chi^2_{1d.f} = 3.619$) retains the null hypothesis that the average probability of Contestant 1 correctly using the second spin is the same across the three countries at better than the 5% significance level ($p\text{-value} = 0.164$). The same conclusion was achieved for Contestant 2 ($\chi^2_{1d.f} = 2.985$; $p\text{-value} = 0.225$).

When bonus payments are made, the optimal behaviour is identical to the one without bonus payments, except that Contestant 2 spins twice if they obtain a score lower or equal to 55 points in their first spin. The rest is equal. Having that in mind, when contestants score 100 points, comparing the three countries, Portugal is the one that deviates more from the optimal behaviour. However, the behaviour of Portuguese and American Contestant 1s are very similar, so the results we obtained align with those of [4].

Table 5 shows that Portuguese men and women use the second spin correctly. Of the 360 contestants in *The Wheel*, 183 (50.83%) are women, and 177 (49.17%) are men. Contestant 1s (Panel A), who are women, deviate more from what is proposed by Proposition 1 than men. Men's correct utilisation of the second spin is correct 94.64% of the time, whereas women only spin a second time 89.06% of the time correctly. For instance, men correctly used the second spin 100% of the time when they scored 60 on their first spin, and women correctly used their second spin only 2 of the 5 times they scored 60 on their first spin. The critical situation for both genders is when contestants scored 65 on their first spin. In that situation, despite the small number of occurrences, men never used their second spin correctly, and women used their second spin only one of the three times correctly.

On the other hand, male Contestant 2s deviate more from what is proposed by Proposition 1 than women, contrary to what happens with Contestant 1. Men used the second spin correctly 86.67% of the time, and women 92.86% of the time. However, female Contestant 2s only confronted the critical situation of $a_2 \in \{50, 55, 60, 65\}$ five times, and those who are men faced the same situation nine times.

Although the data is insufficient to extract reliable conclusions in the French version, of the 315 contestants, 64.44% are women, and 35.56% are men. The last ones that play first in the game deviate more from what is proposed by Proposition 1. Analysing Contestant 2, men used correctly the second spin 100% of the time and women only 96.55%. Table 6 identifies the number of French men and women correctly using the second spin. These results could be linked to the difference in the number of men and women in the play. We were not able to compare these results with the American version studied by [4], since they did not analyse the influence of gender in decisions in *The Wheel* game.

To find if, in Portugal, women are more risk-averse than men, we test the hypothesis that women are not more risk-averse than men. All of the observations are independent; that is, there are no repeated contestants in play. The null hypothesis is that women are not more risk-averse than men, and therefore there is no connection between gender and risk aversion. Table 7 identifies Contestant 1 and Contestant 2, analysed in Table 5, and the only Contestant 3 (a man) that deviates from what is proposed by Proposition 1.

We cannot reject the null hypothesis at the 5% significance level of a Chi-square test ($\chi^2_{1d.f} = 0.018$), because we obtained a $p\text{-value} = 0.893 > 0.05$.

Table 5. Men and Women’s Decisions on The Wheel.

| Panel A: The Decisions of Contestant 1 | | | | | | |
|--|-----------|---|------------------|-----------|------------------------------------|------------------|
| Contestant 1 | | | | | | |
| | Men | | | Women | | |
| First Spin | Frequency | Correct Utilisation of Second Spin ^a | Per cent Correct | Frequency | Correct Utilisation of Second Spin | Per cent Correct |
| {5, . . . ,40} | 26 | 26 | 100.00 | 20 | 20 | 100.00 |
| 45 | 2 | 2 | 100.00 | 4 | 4 | 100.00 |
| 50 | 4 | 4 | 100.00 | 6 | 5 | 83.33 |
| 55 | 4 | 2 | 50.00 | 3 | 2 | 66.67 |
| 60 | 3 | 3 | 100.00 | 5 | 2 | 40.00 |
| 65 | 1 | 0 | 0.00 | 3 | 1 | 33.33 |
| 70 | 1 | 1 | 100.00 | 4 | 4 | 100.00 |
| {75, . . . ,100} | 15 | 15 | 100.00 | 19 | 19 | 100.00 |
| Total | 56 | 53 | 94.64 | 64 | 57 | 89.06 |

| Panel B: The decisions of Contestant 2 | | | | | | |
|--|-----------|---|------------------|-----------|------------------------------------|------------------|
| Contestant 2 | | | | | | |
| | Men | | | Women | | |
| First Spin | Frequency | Correct Utilisation of Second Spin ^a | Per cent Correct | Frequency | Correct Utilisation of Second Spin | Per cent Correct |
| {5, . . . ,40} | 6 | 6 | 100.00 | 3 | 3 | 100.00 |
| 45 | 0 | 0 | 100.00 | 2 | 2 | 100.00 |
| 50 | 1 | 1 | 100.00 | 0 | 0 | 100.00 |
| 55 | 4 | 2 | 50.00 | 1 | 0 | 0.00 |
| 60 | 3 | 2 | 66.67 | 2 | 1 | 50.00 |
| 65 | 1 | 0 | 0.00 | 2 | 2 | 100.00 |
| 70 | 2 | 2 | 100.00 | 3 | 3 | 100.00 |
| {75, . . . , 100} | 13 | 13 | 100.00 | 15 | 15 | 100.00 |
| Total | 30 | 26 | 86.67 | 28 | 26 | 92.86 |

^a We define a decision as correct if it corresponds to the optimal equilibrium behaviour derived in Proposition 1.

Table 6. Gender Influence in Risk Aversion of French Contestants.

| | Correct Use | Incorrect Use | Total |
|-------|-------------|---------------|-------|
| Women | 100 | 3 | 103 |
| Men | 49 | 1 | 50 |
| Total | 149 | 4 | 153 |

Table 7. Chi-Square Test of Gender Influence in Risk Aversion ^a.

| | Correct Use | Incorrect Use | Total |
|-------|-------------|---------------|-------|
| Women | 83 | 9 | 92 |
| Men | 79 | 8 | 87 |
| Total | 162 | 17 | 179 |

^a Includes the contestants studied in Table 5, that is, Contestant 1 and Contestant 2, and the only Contestant 3 that deviates from what is proposed by Proposition 1.

Based on the contestants who did not follow the optimal behaviour proposed by Proposition 1, we could verify those who were risk-averse and those who were risk-seeking. The risk-averse contestants are those who should spin twice, according to Proposition 1 but failed in following that behaviour. On the other hand, risk-seeking are those who should

not spin a second time according to the same Proposition, but they did. Table 8 shows the number of women and men who are risk-averse and risk-seeking. The results indicate that 4.37% of women are risk-averse, compared to 2.82% of men. Also, 1.69% of men are risk-seeking compared to 0.55% of women who are prone to take risks. The small sample does not recommend testing for significant differences, but we can tentatively say that Portuguese contestants seem more risk-averse than risk-seeking.

Table 8. Risk Aversion and Gender ^a.

| | Risk-Averse | Risk-Seeking |
|-------|-------------|--------------|
| Women | 8 | 1 |
| Men | 5 | 3 |

^a Includes the contestants studied in Table 3, that is, Contestant 1 and Contestant 2, who do not have to spin again to have a chance to win, and the only Contestant 3 that deviates from what is proposed by Proposition 1.

According to Rational Finance, individuals make decisions according to the Expected Utility Theory [49] if the objective probabilities are known or according to the subjective expected utility theory [50] if the probabilities are unknown but can be estimated subjectively. Moreover, people are expected to maximise their expected utility. These two theories provide the theoretical framework for decision-making in risk and uncertainty. We assumed that the contestants were able to evaluate all their possibilities in the game: thus, that they would act rationally. Of course, it is impossible for all individuals to be experts on all subjects; therefore, decisions are made based on incomplete information [51]. Not all individuals act as proposed by Proposition 1; thus, the results suggest that individuals do not behave following the rules of axiomatic rationality. Refs. [4,47] link their results to the Quantal Response Equilibrium [52], which is based on an idea of bounded rationality and implies that contestants are incapable of ideally evaluating their expected payoff. However, in the Portuguese version, there is no bonus payment, so we cannot link our results to the Quantal Response Equilibrium approach.

Table 8 shows that most incongruencies with Proposition 1 are under-spinning rather than over-spinning. Thus, contestants are more risk-averse than prone to take the risk, especially when they are faced with a difficult decision: that is, when they score 50, 55, 60 or 65 in the first spin. One explanation for that is the omission bias. According to [4,47], individuals tend to prefer omission (failure to act) rather than commission (explicit act) when equally bad outcomes can occur. Moreover, combined with loss aversion, when the reference point is a feeling of regret can cause the omission and contestants' behaviour. This is a more plausible explanation for our results. Another explanation is the visibility given to the contestant who loses for exceeding 100 points or who loses for not using the second spin. When a contestant surpasses 100 points and eliminates himself, the visibility is higher, and there is more public reaction. When that happens, a feeling of inferiority and of being a loser can be developed, which can be a reason for under-spinning.

Table 4 shows that the pattern of play in Portugal and the USA is very similar, which suggests that the bonus payment does not play a significant role in explaining behaviour in *The Wheel*. Furthermore, Ref. [4] achieved a similar conclusion, and they concluded that the difference in stakes in the real game and the laboratory experiment could better impact contestants' decisions. In conclusion, our results are in accordance with that of [4], which favour the view that contestants' behaviour depends on decision-making bias.

Regarding the influence of gender in decision-making, we could not reject the hypothesis that women misuse the wheel differently from men. In the French version, we were also unable to obtain reliable conclusions about the influence of gender in decision-making since the sample is smaller, with few cases where contestants deviate from the optimal behaviour. Even so, in the French version, there is a much higher percentage of women in the game than men, indicating that French women are more predisposed to participate in contests.

Ref. [46] also analysed the Portuguese version of *The Price is Right*. In his study of the auction game, he concluded that contestants generally used the informational advantage for their profit but did not typically follow the optimal strategy. Moreover, the author concluded that men adopt more aggressive behaviours in bidding games which agrees with the general view that men are less risk-averse than women in the financial decision context. However, our results are unable to confirm that. Also, we concluded that the payment of a bonus does not significantly impact the contestants' behaviour. Ref. [46] achieved a similar conclusion, concluding that the prize's retail price does not seem important to the contestant's behaviour, which corroborates the result obtained by [4].

6. Conclusions

The analysis of agents' decisions, when faced with situations of risk and uncertainty, is crucial for finance and modern economics. This paper contributes to developing empirical literature on the attitudinal risk behaviour of individuals using natural experiments. Moreover, we analysed the impact of gender on decision-making. Although *The Wheel* game is relatively unexplored, it meets all the conditions to obtain reliable conclusions about individuals' risk aversion. First, it is a game with simple rules. All contestants have access to the same information and uncertainty distributions. Second, the expected payoff is high, which we cannot find in laboratory experiments. *The Price is Right* was adapted in several international formats around the world. This paper's objective was to analyse the Portuguese contestants' behaviour. However, we also examined the French version, similar to the Portuguese one, to obtain more reliable conclusions. The number of contestants was crucial in choosing which versions of the game to explore. We would only have the optimal behaviour defined for the game with three participants. For instance, in the Vietnamese and Argentine versions, five competitors participate.

A significant limitation of the data collected was the sample size. It is difficult to draw robust conclusions with a sample of only 120 episodes and, thus, 360 contestants. Moreover, from the 360 contestants, we only could conclude the decisions made by 240 contestants, that is, from Contestant 1 and Contestant 2, since Contestant 3 played only according to the score obtained by Contestant 1 and Contestant 2 because their only objective was to score more than those contestants.

A disadvantage of the Portuguese version compared to the American version is that in the former, there is no bonus payment when contestants accumulate a score of 100, which does not encourage the contestant to use their second spin. This bonus guarantees participation in the *Showcase Showdown* and has value in its own right. As in the Portuguese version, there is no bonus payment. Contestant 3's decision to use the second spin is motivated solely by the objective of winning the *Showcase Showdown*. We cannot observe high levels of risk aversion in this study because there are no bonus payments in the Portuguese version of the game, and the value of the final showcase is lower than in versions from other countries. Individuals exhibit aversion only towards more significant risks, and when risks are small, behaviour is roughly risk-neutral [53]. Another reason is that individuals who dare to appear on TV are likely to be more self-confident, outgoing and risk-loving or risk-neutral individuals in the general population [54].

One of the significant limitations of using a game show as a study framework is the need for more personal information and observable characteristics; hence, the incapacity to use that information to examine the contestants' behaviour. In the Portuguese version of *The Price is Right*, we have only access to the names of the contestants and little else. Sometimes we have access to contestants' ages and jobs, but only occasionally. If we had access to personal information such as age, job and marital status, we could better categorise the contestant's behaviour. For instance, we would be able to verify if women with a higher level of education exhibit similar risk-taking to men, that is, if the difference in risk aversion remains in the gender or if it remains in the level of education. This is an important issue because, as discussed earlier in this paper, women are discriminated

against and treated differently in the workplace, preventing them from achieving higher positions in companies where they are often more deserving than men.

Family and friends are likely to influence contestants' decisions significantly. The audience, made up mainly of the family and friends of the contestants, has the right to give their opinion on whether or not the contestant should spin the wheel the second time. The influence they have on competitors' decisions is remarkable. Thus, contestants' decisions are moved by their risk aversion and family and friends' opinions.

Even though the sample size and the impossibility of getting statistically significant results, namely regarding the impact of gender on risk aversion, do not mean that the results are irrelevant. First, in the first part of the results regarding the contestants' risk aversion, independent of whether they were men or women, we obtained results in line with what was concluded by [4]. Contestants deviate more from what is proposed by Proposition 1 when they score 50, 55, 60 or 65 in their first spin: that is, when the decision is more complex. Regarding the impact of gender on risk aversion, we were unable to find statistically significant results, and thus overall, the amount of risk taken does not exhibit a significant difference concerning gender. Of course, one has to be careful regarding the generalisation of these results because our study has several significant limitations, such as the small sample size, no bonus payments being made and some potential sample bias. We do not know the criteria upon which contestants are selected from the audience, so it is acceptable to assume that those individuals are more confident and risk-loving than general Portuguese individuals.

For further research, we suggest analysing natural settings where one could access more personal information, such as job, educational level, marital status and age. That would allow verifying that the behaviour differences between women and men are due to gender differences rather than other characteristics. Moreover, if one can work with a larger sample, it would be advantageous. Another suggestion is to analyse the contestants' entire trajectory in the previous games, that is, analyse what the contestant won or not during the show and see how this impacted their aversion to risk in the last game. The final suggestion is to investigate the impact of culture on decisions in the context of the TV show.

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Notes

¹ <https://www.pordata.pt>, accessed on 15 March 2023.

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