Decision-making and Keynesian Uncertainty in Financial Markets: Brexit as a Case Study

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Abstract

This paper makes two contributions. Firstly, it explores the presence on fundamental uncertainty in financial markets and its impact on individuals' trading behaviour. Secondly, it tests the initial findings in practice, after a real world uncertain phenomenon, the announcement of Brexit. This research is based on two rounds of semi-structured interviews (before-and-after-Brexit-vote) with UK-based financial traders in 2016, and a 2017 online survey designed to validate interview results.

Financial traders acknowledge the presence of fundamental uncertainty in the markets, they describe it as unquantifiable, and they view the future as not entirely predictable. In the face of these knowledge limitations, traders consistently identify risk and uncertainty as separate concepts. One key result of our before-and-after Brexit-vote interviews, consistent with previous Post Keynesian research, is that traders recognise uncertainty as a key aspect of the market context they work in. Another result of our post-Brexit evidence, however, challenges the conventional wisdom that enhanced uncertainty invariably forces traders to reduce their risk-taking: after a period of time, traders increase their risk-taking, even knowing that they are trading under conditions that remain uncertain.

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Introduction

This paper examines an aspect of traders' behaviour in financial markets, which is centrally important in these markets' functioning, but has received little attention in the economics literature: the fundamental uncertainty. Fundamental uncertainty has an impact on trader's everyday decision-making. Hence, there is a need for further investigation, in order to gain a more complete and realistic view of financial markets' functioning. Fundamental uncertainty, while largely ignored in mainstream economics and finance, does hold a central place in Post Keynesian theory. However, most Post Keynesian economists' writing on financial markets and processes is based on theoretical insights, not on the actual observations and behaviour of agents engaged therein. In particular, little research has been done about agents' reaction when uncertain events occur.

Note that there is a rich literature on human behaviour, including behaviour in financial markets, by both psychologists and behavioural economists. This literature, however, uses the rational agent model of equilibrium-based economic theory -an unrealistic approach of individuals' behaviour- as its point of departure. Furthermore, this paper provides a real world example of fundamental uncertainty and its impact on agents' behaviour, the case study of the Brexit vote on whether Great Britain should remain within the European Union. The Brexit vote as a real-time, uncertain event allows us to test empirically the interview findings about decision-making under uncertainty. Additionally, it allows financial traders to make predictions about Brexit's future impact on the British economy and financial market, and reveal their decision-making process in real time.

Mainstream economics fails to capture the complexity of human nature. Its limited understanding of individuals' decision-making is expressed as a mathematically developed, yet an intuitively simplistic approach of ranking preferences. Particularly, Von Neumann and Morgenstern (1944) describe decision-making based on a utility maximisation framework, with a given set of preferences with respect to behavioural axioms, such as completeness, transitivity, continuity and independence. Any behavioural deviations from the rational choice model and market anomalies, such as underreaction and overreaction, are treated as short-term deviations from the equilibrium point, which is going to be reached in the long-term by markets' invisible hand (Fama, 1998). This stable economic equilibrium presupposes prefect information and hence, perfect foresight of future events, both from traders' and

consumers' point of view. Specifically, it assumes that prices fully reflect all the available information, also known as the Efficient Market Hypothesis (Fama, 1998). This approach though does not consider individuals' uncertain expectations. Once uncertainty of expectations is considered by economists, the scope of the research shifts from a steady state equilibrium analysis to a historical one (Robinson, 1974, p. 126).

Literature review

Decision-making under fundamental uncertainty

In Keynesian theory, the ways in which economic agents perceive uncertainty and form expectations play a key role in their behaviour. Specifically, it is the entrepreneurs' short-term expectations about their expected profit that dictate their decisions on production; while they also form long-term expectations about the general economic environment (Keynes, 1936, ch.12). It is fundamental uncertainty that leads the economic system to an inefficient equilibrium of underemployment. Long-term expectations depend both on the forecasts about future events and on economic agents' confidence (Keynes, 1936, p.148). In *The General Theory* confidence is defined as "how highly we rate our likelihood for our best forecast turning out wrong" (p.148), and it depends on agents' existing knowledge, which might be insufficient for accurately calculating mathematical expectations (p.152). Subsequently, future is uncertain and it cannot be perfectly predicted. Additionally, the time gap between the moment of decision-making and the outcome of the choice is a source of uncertainty, due to the unforeseen changes which might occur in the meantime (Keynes, 1936).

The environment in which the individuals act and make decisions has also an impact on their behaviour. In the Post Keynesian tradition, while individuals interact with their environment and the rest of the agents in it, they also find ways to cope with uncertainty, such in the form of animal spirits. For Keynes (1936, p. 161) decisions are not the outcome of multiplying a weighted average of utilities by probabilities in quantitative terms, but they are driven by the animal spirits, which make up for the lack of knowledge and confidence in their knowledge. Specifically, when individuals shape their expectations about future, they do not make choices only based on their personal beliefs, but they also get influenced by their expectations about the average opinion, also known as the beauty contest paradigm (Keynes, 1936, ch.13).

In this unpredictable world, individuals tend to trust conventional judgements rather than themselves, because they prefer to follow the better-informed masses. For example, money is a contractual mean of exchanges and a mean to store value in an uncertain world. Therefore, fundamental uncertainty leads people to hold more liquidity as a mean of security, also known as liquidity preference (Keynes, 1936). Shackle (1979) also describes the infinite regress problem, which paralyses the investor and prevents him/her from making a decision. Uncertainty, in this case, may be interpreted as a paralysing force and can lead individuals into holding greater liquidity.

Interpretations of uncertainty

An interpretation and extension of Keynes' ideas are Shackle's (1949) description of expectations' nature as the anticipation of an imagined future situation, which individuals treat as equivalent to an actual future event, even though it might never occur. This prediction has two basic characteristics; it is treated as if it is happening, and it depends on the degree of someone's belief that it will happen, or else the agent's confidence about the outcome as Keynes described it. This description of expectations develops into a focus-values conception, in which individuals make decisions based on judgments about future gains and losses. Individuals' focus on future gains reveals their desirability of the expected outcome, while their focus on loss possibilities is linked with their potential surprise. There is a range of possible choices between these two marginal points, which can be mapped as a Cartesian diagram, an indifference map of uncertainty, also called gambler's indifference curves. These alternative choices are weighted by individuals' degree of potential surprise, rather than mathematical probabilities. Shackle (1972) rejects the use of probabilistic measurements in entrepreneurial decision-making. According to him, the list of potential outcomes as a result of the entrepreneur's choices cannot be complete in principle, because his/her decision will shape the future state of the world, hence he/she cannot hold this knowledge a priori. Particularly he describes economic decisions as unique experiments, whose circumstances will differ once they take place (1949, p. 6).

The extent of the impact of fundamental uncertainty on decision-making might vary in intensity, while the same holds regarding individuals' awareness of it (Dow, 2015). In other words, the degree to which Keynesian uncertainty is recognised and admitted, and the attitude towards it are not given, they may vary across different groups and over time. Dow

(2004) recognises four different types of uncertainty. Firstly, she describes additive uncertainty as the variance of the error terms, and it rises from the randomness in nature and the availability of information. Second she describes the multiplicative uncertainty, measured by the variance of the parameters, which is the uncertainty linked with the model structure. The third type is the model uncertainty 1, measured by the spectral density of the non-random error term, and it occurs by the uncertainty about the model specification. And lastly, she describes the model uncertainty 2, which is the unmeasurable type, the so-called fundamental uncertainty.

Similarly, Huettel et al. (2006) also recognise three types of choices, depending on the level of the uncertainty regarding the outcomes. The first choice is the certain one, when there is only one possible outcome. The risky choice takes place when there are multiple outcomes with known probabilities. And the ambiguous or uncertain choice occurs when multiple outcomes with unknown or not well-defined probabilities exist. Huettel et al. (2006) suggest that different levels of available information, not only define the type of uncertainty individuals deal with, but they also have a different impact on their brain functioning in relation to decision-making, either in level or by region, or both. This interpretation of uncertainty is often found in neuroscience literature, which refers to the risk risen from multiple outcomes with calculable/estimated probabilities (Huettel et al., 2006).

Knightian uncertainty (1921) refers to the absence or inaccessibility of quantifiable probabilities, and makes a distinction between unmeasurable uncertainty and risk. Similarly, Hicks (1979, p. 115) suggests that there is insufficient evidence to establish a probability, and therefore it is impossible to shape a complete list of preference ordering. Often mainstream economists accept the limitations of rational expectation theory. For example, Sargent (1999), allows for the possibility of unquantifiable Knightian uncertainty and he admits that policy makers may not be aware of the true model.

Objective vs subjective probability theory

For Keynes probability should not be treated as a statistical frequency. Probability theory should take into consideration the degrees of belief from the available evidence while frequencies should be treated as a special case of evidence (1921, p. 109). The weight of the argument includes the amount of the relevant evidence, the degree of completeness of the

evidence, and the balance of absolute amounts of relevant knowledge and relevant ignorance (Runde, 1990). Decision-making under uncertainty depends both on the interpretation of the relative degrees of belief regarding the alternative outcomes (i.e. the probability distribution) and on the assessment of the absolute extent of the evidential base regarding the whole set of alternative propositions (weight of argument) (Fontana, and Gerrard, 2004). Therefore, mathematical expectations should not be concerned as a decision criterion. Therefore, from a Post Keynesian point of view, objective probability theory is only a reasonable approximation and not a general theory, as it implies that any individual in the exactly same position -ceteris paribus- would make the same judgment (Dow, 2014).

On the other hand, the Bayesian theory refers to uncertainty as a notion that can be captured by subjective probabilities, which are adjusted for decision-weights. The theory allows individuals to incorporate their perception of reality, depending on the context. Subjective probability theory could provide a better understanding of uncertainty, but still the incorporation of the notion of weight is insufficient (Neal, 1996). The future possibilities might not be known, and therefore it would be impossible to assign subjective probabilities that sum up to 1 (Dow, 2015). Moreover, Bayesian theory assumes that individuals have the capacity to make subjective probability estimates, so that unquantifiable risk is no longer relevant, while it treats fundamental uncertainty as a disturbance or an exogenous shock (Dow, 2015).

Bounded rationality theory

Bounded rationality theory considers agents' knowledge or its absence about the environment where they act in, and their ability to process this knowledge in order to make a decision and cope with uncertainty (Simon, 2000). Its founder, Herbert Simon, suggests that economics should built a general framework of rational decisions that would involve satisficing criteria, use of aspiration level analysis, attention mechanisms, and heuristics (Simon, 1955; 1956). Bounded rationality is the result of decision makers' time pressure and their limited cognitive hardware (Earl, 1990); it highlights individuals' constraints in their information-processing capacities, and potential limits of their rationality. Their limited cognitive capacity might rise from the uncertainty linked to the consequences that follow

each alternative, the incomplete information about the alternatives and the complexity in the functions used by individuals (Simon, 1972).

Individuals deal with their limited cognitive capacity by limiting the alternative choices and by using rules of thumb, such as conventional numerical values (Simon, 1972). Another popular decision-making process is the use of the satisficing criterion, when individuals stop searching for alternatives, as long as they find a choice that satisfies their aspiration level criterion (Simon, 1957). The drawback of bounded rationality theory is that although it introduces imperfect information, it still assumes perfect knowledge of the distribution of the random variables. Therefore, it concludes that the difficulty in decision-making is not necessarily driven by uncertainty, but by its own complexity (Simon, 1972).

Disaster myopia hypothesis

Uncertainty and risk are often misinterpreted as identical notions, although there is a significant distinction between them. Risk refers to the calculation of the probability of an event that might occur in the future. Uncertainty on the other hand, indicates our inability of perfectly foreseeing the future and unexpected events, which may occur. In other words, when individuals' confidence in estimation is high they refer to risk, while when their confidence is low they refer to uncertainty (Guttentag and Herring, 1986). Disaster myopia is defined as the systematic tendency to underestimate shock probabilities, which increases as time passes since the last economic shock took place (Guttentag and Herring, 1986). Based on this definition, the 2007-8 financial crisis is characterised a case of disaster myopia in housing and credit markets (Cornard and Gimet, 2011).

Disaster myopia may occur during the upturn of business cycles, when markets are driven by unrealistic optimism about asset prices and investors are overconfident about their trading abilities. It is interpreted by two behavioural heuristics; the availability bias and the threshold heuristic. The availability heuristic refers to the estimation of the probability of a shock, which is based on the available information associated with the event and what individuals can bring first in their minds. The threshold heuristic rises when a probability reaches such a critically low level, which is treated as if the probability was equal to zero (Guttentag and Herring, 1986). If more market participants tend to underestimate the

probability of a low frequency but of high importance crisis, then economic system becomes more vulnerable (Guttentag and Herring, 1986).

Methodology

Interviews with financial traders are the chosen methodology, in order to derive market professionals' opinions on financial uncertainty. A survey was released to increase the number of participants, as well as to allow for further quantitative analysis on the relationships among the variables. Two rounds of semi-structured interviews (before-and-after Brexit) were conducted in 2016, with financial traders in the UK (Ethics reference AREA 14-139). That allows us to compare traders' opinions about uncertainty and its impact on their behaviour, before and after a major uncertain event. The pre-Brexit interviews took place between February 2016 and May 2016, while the post-Brexit round of interviews were conducted between August 2016 and October 2016. Over the first round of interviews, fourteen financial traders answered questions related to financial uncertainty. The participants were initially approached through the Leeds University Alumni office, and the rest through snowball sampling. During the second rounds of interviews, the same group of participants were contacted, and ten of them answered questions about financial uncertainty with regards to Brexit. The number of interviewees is a sufficient sample for qualitative research (Bruine de Bruin and Bostrom, 2013). The interview questions are presented in appendix A[2].

After the completion of the semi-structured interviews, an online survey was released in June 2017 and was completed on the 28 of July 2017. This survey aimed financial traders, on a global scale. They were initially approached through the Leeds University Alumni office and more participants were recruited on internet platforms (i.e. LinkedIn) and professional groups of financial traders (trading forums). The sample size of the survey is 210 participants. The survey included questions with regards to financial uncertainty, its sources, Brexit as an uncertain event, and the impact of Brexit on the British economy. The survey questions can be found in appendix B.

The majority of the participants were located in the UK (77.6%), and the rest were located in countries such as France, Singapore, the US, Canada, Australia and other countries. Sixty-

[2] The interview quotes are available upon request.

nine percent of the participants declared that they were trading in the UK financial markets. Their average age was 38.23 years (SD=9.83), and their average working experience on the trading floor was 10.3 years (SD=8.14). Most them were males (78.4%) and 21.6 per cent were females. Fifty-eight per cent held an advanced degree (MSc, Professional degree or PhD) and forty-two per cent held a Bachelors' degree or no degree at all.

Pre Brexit interview results

To start with, there is not one unique interpretation of financial uncertainty, but there is a common element found in almost all interviewees' answers. The fact that fundamental uncertainty exists and it is not necessarily measurable, as mainstream economic theory suggests. The future is not entirely predictable and there are limitations to our knowledge, even under the assumption of market cyclicality. This finding agrees with the bounded rationality theory (Simon, 1955), which challenges the mainstream theorem of rationality, due to cognitive limitations. Therefore, risk and uncertainty are identified as separate concepts. Specifically, uncertainty is described as the unknown, as the inability to predict the future. This is an inherent characteristic of finance, which cannot be avoided. Financial innovation, the release of news and information flows and the absence of market liquidity are also associated with financial uncertainty. Particularly, as the liquidity preference also suggests (Keynes, 1930), in periods of financial uncertainty, traders tend to hold more liquid assets in terms of maturity and structure.

Table 1. Financial traders' pre-Brexit interpretations of uncertainty on the trading floor

Uncertainty is the unknown, when you do not know how to react and cannot predict the market movement (6 participants)
There is always uncertainty in financial markets (6 participants)
Complex financial innovation can cause uncertainty (6 participants)
Uncertainty rises when news is released (3 participants)
Uncertainty is the absence of liquidity in the market (2 participants)

With regards to decision-making under uncertainty, theories of uncertainty often focus on the availability of probabilities or probability distributions, on the availability of a complete list of potential outcomes, or whether a true model exists. The pre-Brexit interview results

do not specifically link uncertainty with the ability to calculate probabilities. The complexity of financial decision-making leads to overreliance on algorithmic modelling from a trader's point of view, and to limited human intervention. Hence, human involvement in calculating probabilistic scenarios is limited. Additionally, when financial traders make investment decisions under uncertainty, they focus on the reasons behind financial uncertainty and price volatility, and how these reasons might influence their decisions.

Table 2. Traders' pre-Brexit decision-making under uncertainty on the trading floor

Market expectations should be taken into consideration (5 participants)
Other agents' trading decisions should be taken into consideration (5 participants)
Choose to exit the market and close my deals (4 participants)
It depends on the type of trade (4 participants)
Rely on financial modelling (4 participants)
It depends on the traders' personality (4 participants)
Try to remain calm and rational, search for more information (3 participants)
Hedge more (3 participants)
Staying passive, waiting for more information (2 participants)
Try to identify the reasons of the uncertainty (2 participants)
Follow the company's strategies (2 participants)
Set upper and lower limits of losses and profits, respectively (2 participants)
Simplify trades' maturity and structure-liquidity preference (2 participants)
Search for another professionals' advice (1 participant)
Recall similar experiences from the past (1 participant)

Although there is a rich literature on theorising uncertainty, there is not enough research about the sources of it. Financial decision-making requires understanding the causes of uncertainty. Non-systematic factors, such as natural disasters or important political decisions may give rise to financial uncertainty. Additionally, financial markets are electronic and global. Therefore, understanding macroeconomic phenomena in the European, the Asian or the American economies might have a substantial impact on trading within the UK, although it might seem irrelevant from a geographical point of view. These fundamentals

are often identified as a source of uncertainty by the interviewees, due to the fact that nowadays financial markets are digitised, globalised and dematerialised (Sassen, 2005). A change in the expectations on future events, and other traders' expectations may cause uncertainty, therefore, there is an interaction among financial individuals' decision-making. As the beauty contest paradigm suggests (Keynes, 1936), when individuals make decisions they also take into account other agents' expectations about the final outcome. New information, market volatility and human mistakes are also reported as potential sources. Moreover, human greed and competition are identified as sources of uncertainty, which are also connected with rogue trading, particularly the UBS rogue trading case.

Lastly, it is found that financial regulation plays a role as a source of uncertainty. A changing regulatory framework is a source of financial uncertainty, due to its unforeseen impact on the existing trades. As a result, agents tend to delay important investment movements, until they are aware of the new regulatory scheme. This time gap between a current decision and its future outcome, is also identified as a source of uncertainty in *The General Theory*, due to the unforeseen changes that may occur in the meantime (Keynes, 1936).

Table 3. Pre-Brexit sources of uncertainty

Non-systematic factors, i.e. natural disasters, political decisions, terrorist attacks, big accidents (6 participants)
Macroeconomic phenomena-fundamentals (5 participants)
Change in market expectations about future events (4 participants)
Continuous news release (4 participants)
Rogue trading (4 participants)
Human element and cognitive limitations (3 participants)
Absence of counterparty's good reputation (2 participants)
Market volatility (2 participants)
Greed and competition (2 participants)
Changing financial regulatory scheme (2 participants)

Post Brexit interview results

Despite the fact that the initial round of interviews took place four months before the EU referendum, none of the participants referred to Brexit as a case of financial uncertainty. This is known as the threshold heuristic, which rises when a probability reaches such a critically low level that is treated as if it was equal to zero (Guttentag and Herring, 1986). On the other hand, during the post-Brexit interviews, and despite the fact that exactly the same questions were asked, all of the interviewees gave the example of Brexit as a case of uncertainty on the trading floor. This is known as the availability heuristic, which refers to the estimation of the probability of a shock, based on what individuals bring first in their minds. This is a case of disaster myopia in markets, when the systematic tendency to underestimate shock probabilities, increases as time passes since the last economic shock (Guttentag and Herring, 1986).

Specifically, after the announcement of Brexit financial traders tend to give higher probabilities to uncertain events to occur, such as the possibility of an Italian referendum, the American presidential elections, the Turkish coup, the European banking stress tests and the Deutsche Bank crisis, as described by the interviewees. Both the UK market as a whole, and financial traders as individual units, became hypersensitive to potential unknown risks and uncertain events after the announcement of the EU referendum outcome. As a result, further price volatility and a state of financial instability occurred. During the pre-Brexit interviews, on the other hand, none of the participants referred to real future events as sources of uncertainty. Particularly, the pre-Brexit examples of uncertainty are consisted either of past events (i.e. UBS rogue trading, 9/11 terrorist attack) or hypothetical scenarios of non-repetitive events (i.e. natural disasters).

Table 4. Financial traders' interpretations of uncertainty with respect to Brexit

Brexit was not expected to happen (8 participants)
The market did not forecast correctly the outcome of the elections (4 participants)
Brexit is still uncertain because of the future agreement between the UK and the EU (3 participants)

Brexit allows us to explore financial traders' decision-making process under uncertainty in real time. In this case, traders' decision-making process does not focus on whether they know, or they are able to calculate, the probabilities of future events, or if they have a complete list of these future possibilities. The majority of financial traders reacted to the announcement of Brexit by remaining calm and sometimes passive, by trying to avoid mistakes and by simplifying the structure of their trades. Some of them decided to exit the market and to avoid exposure to price fluctuations, while others hedged their positions in advance and tried to minimise their losses. The market was frozen before and after the EU referendum, big trades were postponed and trading floors were unusually quiet. Market inertia was the main characteristic on the trading floor, as the majority of the participants report. Financial uncertainty played the role of a paralysing force, and led individuals into holding greater liquidity (Shackle, 1979). Particularly, the market's liquidity preference changed as financial professionals moved towards short-term investments to anticipate the unknown future. Traders' reaction to uncertainty also depends on the type of trade they hold on their portfolios. Lastly, all the post-Brexit findings with respect to traders' decision-making uncertainty verify the pre-Brexit results.

Table 5. Post-Brexit traders' decision-making under uncertainty

After Brexit, financial traders remained passive, not knowing what to do, and trying not to make mistakes (5 participants)
After Brexit, financial traders shortened the maturity, simplified their trades and avoided risk taking (4 participants)
After Brexit, financial traders did not keep any position, and exited the market (3 participants)
Before Brexit, financial traders hedged their positions (3 participants)
It depends on the type of trade (3 participants)
After Brexit, financial traders moved into short-term investments, instead of long-term trades; their liquidity preference got influenced (2 participants)

Lastly, with respect to the interviewees' answers about Brexit's impact on the British economy and financial markets, there is a common element, regardless their views on the

results of the referendum. They make a distinction between short-term and long-term effects, which provides a better understanding of their thinking process against the unknown. They identify the pound devaluation and the cut of EU funding intended for the British economy as the short-term effects, while changes in financial regulation and a soft or a hard Brexit are identified as the long-term effects. It is suggested that the long-term effect also depends on the outcome of the current negotiations. Additionally, financial traders suggest that the market is more sensitive to uncertain events, and some of them express their belief that in the long-run financial markets will equilibrate at the pre-Brexit levels. Overall, there is a list of possible future events, which all depend on the trade-off between free movement of labour and the access to the EU financial markets and trades. The relative weights given to each of these potential future events are depended on each individual's opinion, rather than on calculated probabilities based on past data.

Table 6. Financial traders' predictions on the future impact of Brexit on the British economy and financial markets

Further Sterling Pound devaluation; short-term effect (6 participants)
The market became more sensitive to uncertainty (5 participants)
The legal framework has to be adjusted by the British regulator (4 participants)
UK-based financial institutions might lose their passporting rights (4 participants)
In the long-run financial markets will equilibrate at the pre-Brexit levels (3 participants)
Hard Brexit is identified as a possible future outcome (2 participants)

Survey results[3]

Regarding decision-making after Brexit, the majority of survey participants took precautionary measures in order to protect themselves from potential losses, or at least limit them to the extend it was possible, before the EU referendum. The post-Brexit reactions though do not agree with the interview results. Although in the late 2016 interviews, traders reported that the market was frozen, and the value of trades had fallen significantly under a veil of fear in financial markets, the 2017 survey data shows that the majority of financial traders disagree with them. Particularly, they disagree with all four statements that reflect post-Brexit risk aversion. One reason might be the time gap between traders' reaction to Brexit (summer of 2016) and the survey release date (summer 2017). This result builds on the disaster myopia hypothesis (Guttentag and Herring, 1986), which was also identified in the comparative analysis among the pre and the post-Brexit interview analyses. According to it, there is a systematic tendency to underestimate shock probabilities, which increases as time passes since the last economic shock that took place. Hence, it is possible that financial traders underestimated their reaction to the announcement of Brexit, due to the time gap between the EU referendum and the time they were asked about their reaction to it.

The most commonly reported reaction to Brexit from a trader's point of view is to hedge his/her positions, with a mean significantly higher than the mid-point (on the Likert scale; Neither agree nor disagree (3)). The participants disagree with the statement that they simplified their trades after Brexit, although it is not statistically different than the mid-point. They also disagree that they remained passive, they avoided risk and that they exited the market. These means are significantly lower than the mid-point. All variables are summarised under the title "After and before Brexit I minimised my risk". The data shows that traders reacted beforehand, trying to limit their potential losses by hedging their deals in advance, but they did not avoid risk-taking.

[3] The means are interpreted on the Likert scale [strongly disagree (1), disagree (2), neither agree nor disagree (3), agree (4), strongly agree (5)]. It is also reported whether the means of the variables are significantly different from the neutral value (mid-point 3).

Table 7. Decision-making after Brexit-survey results

Variables	Mean	Standard deviation
Before the EU referendum I hedged my positions	3.46**	1.00
After the announcement of Brexit, I simplified my trades	2.87	1.03
After the announcement of Brexit, I remained passive	2.62**	1.10
After the announcement of Brexit, I avoided risk taking	2.39**	1.03
After the announcement of Brexit, I exited the market	2.01**	0.92
Summary variable		
After and before Brexit, I minimised my risk	2.67**	0.63

N=209

**Significantly different from value test 3 at 0.01 level (2-tailed)

With regards to traders' beliefs about the future impact of Brexit on the British economy and financial markets, their decision-making process is revealed in real-time. Studying Brexit as a case study allows financial traders to make a judgement about the future. After applying a factor analysis[4], there are found two categories with regards to Brexit's effects, and they are both determined by their time horizon. Specifically, they classify their predictions as short-term and long-term effects. Although, they identify negative short-term effects for the British economy, they also predict positive effects in the long-run. This result is also found in the post-Brexit interview analysis, and it provides evidence about how people evaluate future and uncertain events.

Participants agree that after Brexit, the UK financial companies might lose their EU passporting rights and that financial markets became more sensitive to uncertainty after the

[4]A factor analysis on the survey data is conducted in order to reduce the number or variables and to group them into categories based on the varimax and oblimin rotations [Tabachnick and Fidell, 1989].

announcement of Brexit. Sterling Pound devaluation is a common belief among traders, as a result of Brexit. They also agree that the regulation should be adjusted in the future and that in the long-run the market will equilibrate at the pre-Brexit levels. These results are categorized into short-term effects, and long-term ones. The survey participants agree that Brexit is going to have a negative short-term impact on the British economy, but they also agree that in the long run the market will equilibrate again. To conclude, traders' predictions about post-Brexit phenomena are organised based on the time horizon of their effects. All means are significantly higher from the mid-point.

Table 8. Predicting the future impact of Brexit-survey results

Variables	**Mean**	**Standard deviation**
After Brexit, UK companies might lose their EU passporting rights	3.54**	0.95
The market became more sensitive to uncertainty after the EU referendum	3.45**	1.01
Brexit will lead to further Sterling Pound devaluation	3.41**	0.99
After Brexit, EU financial regulation must be adjusted by the British regulator	3.37**	0.96
In the long-run financial markets will equilibrate at the pre-Brexit levels	3.17**	1.06
Summary variables		
In the short-term there will be a negative impact on the British economy	3.46**	0.69
In the long-term the market will equilibrate	3.27**	0.78

N=208, **Significantly different from value test 3 at 0.01 level (2-tailed)

Lastly, when financial traders had to make immediate decisions shortly after the announcement of Brexit, they took into consideration only its short-term effects. There is significant, positive relationship between the short-term effects of Brexit and traders' reaction to it [$r(208)=0.21$, $p<0.01$]. There is also a positive relationship between the long-term effects of Brexit and participants' reaction to it, which is not statistically significant [$r(208)=0.66$, $p>0.05$]. A regression analysis, verifies these results and can be found in appendix C. Overall, financial traders took into consideration the short-term, negative effects when they had to react immediately to the announcement of Brexit. On the contrary, they did not take into account the positive, long-term effects of Brexit, the moment they faced uncertainty.

Conclusions

Literature often focuses on the individuals' ability to calculate probabilities, either because they are constrained from their environment (Simon, 1955), or because they do not have access to them (Knight, 1921). Individuals might not have sufficient evidence to establish probabilities (Hicks, 1979; Dow, 2015), or they might not have enough information about the future states of the world (Shackle, 1972), due to the fact that they live in a constantly changing environment. Given these limitations, the Bayesian theory suggests that individuals shape subjective probabilities, adjusted for decision-weights. Similarly, Keynes (1921) suggests that the degrees of belief and the confidence on it should be incorporated into the theory of probabilities.

Based on our findings, decision-making in financial markets does not require direct probability calculations by individual traders, because this process is generated by financial models. This research though adds value to the existing literature by highlighting a variety of traders' reactions to financial uncertainty. I.e. market expectations play a role in their decision-making, because they take into account other traders' movements as well. They may decide to exit the market under uncertainty, or set up boundaries for losses and profits. It is often suggested that they usually try to remain calm and understand the sources of the uncertainty. It is reported that uncertainty might have an impact on their liquidity preference as well. Also, traders' reaction to uncertainty depends on the type of trade they hold on their portfolios, as well as on their personality. Additionally, they might be constricted by the implemented strategies of the financial institutions they are working for.

There is a variety of sources that might give rise to financial uncertainty. Non-systematic factors, such as natural disasters, political decisions, terrorist attacks, and big accidents are the most commonly reported sources of uncertainty. Changes in financial regulation is another reported source of uncertainty, due to its impact on the profitability of past investment movements. This might result to delays in traders' decision-making. Lastly, changes in market expectations, human limitations and news release are linked with an uncertain financial environment.

According to the disaster myopia hypothesis (Guttentag and Herring, 1986), there is a systematic tendency to underestimate shock probabilities, which increases as time passes since the last economic shock took place. There is supporting evidence based on the pre and post-Brexit interview findings and the survey results. To start with, while the pre-Brexit interviews took place four months before the EU referendum, none of the interviewees referred to Brexit as a case of uncertainty, as opposed to the post-Brexit interviews. This is known as the availability heuristic, when individuals shape their opinion based on the information they can first bring to their minds (Guttentag and Herring, 1986). Also, the survey data suggests an underestimation of Brexit's impact on traders' decision-making and risk aversion. This is known as the threshold bias in behavioural economics literature, when a probability reaches such a critically low level, which is treated as if the probability was equal to zero (Guttentag and Herring, 1986). Particularly, during the post-Brexit interviews all the interviewees reported some degree of risk aversion. This was expressed by shortening structure and maturity of trades, by adopting hedging strategies and by remaining passive or exiting the market.

On the contrary, the survey data shows an underestimation of this risk aversion, hence an underestimation of the market panic. Specifically, the survey participants, on average, expressed their disagreement with all the statements regarding reducing the undertaken risk after the announcement of Brexit. They only agreed that on average they applied hedging strategies before the EU referendum. One possible reason for this disagreement is the time gap of one year between the Brexit vote and the release of the online survey, which is aligned with the disaster myopia hypothesis.

Policy recommendations

Central banks and financial regulators should be aware of the impact of uncertainty on financial professionals' decision-making, and incorporate it in policy-making. During periods of fundamental uncertainty, financial traders lose confidence over their own judgments, and they tend to follow the market movements, driven by animal spirits and other agents' decisions. This may lead to systematic mistakes and to a burst of a financial bubble. Therefore, in periods of financial uncertainty regulators should provide a framework of how they are willing to anticipate financial instability and particularly the short-term effects of it, as these are the ones that financial traders take into account in their decision-making process.

Especially in the case of the Brexit, a changing financial regulatory framework is identified as a source of uncertainty, because its future impact on the existing trades cannot be foreseen. Changes in financial regulation have an impact on liquidity preference as well, because agents tend to delay important investment movements, until they are aware of the new rules. This forces financial traders to move from long-term to short-term investment, in order to anticipate expectations on changing regulation regime. Furthermore, asymmetric regulation between financial centres worldwide is reported as another source of financial uncertainty. These findings suggest that Bank of England should signal or provide a framework of the ways the post-Brexit financial regulations will adjust to the British law, and discuss with the main market participants the extent and the impact of these changes. Particularly, the post-Brexit loss of passporting rights by the British financial institutions is the main concern of market professionals. That would lead to the loss of job positions in the City, due to the fact that the major banking firms will move their headquarters to the EU based financial centres.

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Appendix A

How do financial traders behave in an uncertain environment? Pre-Brexit interview questions

Could you please describe a situation of uncertainty/unknown risks on the trading floor?

Can you describe what made that situation uncertain?

How did you respond to this uncertain event? How did others respond?

How do financial traders behave in an uncertain environment? Post-Brexit interview questions

Could you please describe a situation of uncertainty/unknown risks on the trading floor?

Can you describe what made that situation uncertain?

How did you respond to the announcement of Brexit? How did others respond?

What do you think is going to be the future impact of Brexit on the British economy and financial markets?

Appendix B

The questionnaire was designed on Qualtrics software, version May 2017 of Qualtrics (2017), and took approximately 15 minutes to complete. The questions were organised in two sections and each section corresponded to one of the research questions. Each section included multiple screens. The statements were derived from the interview findings and they followed the same themes.

The first section, which is consisted of three screens, answered the first research question: How do financial traders behave in an uncertain environment? The first screen presented the questions about traders' interpretations of uncertainty, as described by the interviewees. On the second screen, the participants were asked their opinion about the sources of uncertainty. And the third screen explored financial traders' decision-making process under uncertainty on the trading floor. The questions had the form of statements, and the participants had to describe their degree of agreement in the scale of five options (Likert scale); Strongly disagree (1), Disagree (2), Neither agree nor disagree (3), Agree (4),

Strongly agree (5). Table 4 in appendix B presents the questions of the first section of the survey.

The second section answered the second research question: How did financial traders behave after the announcement of Brexit? The fourth screen included the reasons why Brexit might have been an uncertain event. The fifth screen explored traders' decision-making before and after the announcement of Brexit. And lastly, the sixth screen presented the statements about traders' opinion on Brexit's future impact on the British economy and financial markets. The statements were derived from the interview analysis, which took place in advance. The participants were asked to express their degree of agreement on a five point Likert scale; Strongly disagree (1), Disagree (2), Neither agree nor disagree (3), Agree (4), Strongly agree (5). Table 5 in appendix B presents the questions of the second section of the survey.

Appendix C

Linear regression analysis is used to test if the future impact of Brexit (both short and long term), along with the demographic variables, significantly predict decision-making before and after Brexit. Due to multicollinearity, the explanatory variables will be tested separately. Particularly, the short and the long terms effects are correlated to each other ($r(208)=-0.15$, $p<0.01$).

Models 1 and 2

Dependent variable: After and before Brexit I minimised my risk

	Model 1	Model 2
Constant	2.09**	1.95**
In the short-term there will be a negative impact on the British economy	0.16*	0.15*
Gender		0.17
Education		0.20*
Years of experience		0.00
Trading in the UK markets		0.00
R^2	0.03	0.06
F statistics	F(1,197)=6.64	F(5,193)=2.72
p	0.01	0.02

**p<0.01
* p<0.05

In model 1 Brexit's negative, short-term effects on the British economy are a significant predictor of traders' decision-making before and after Brexit ($p<0.05$), and they explain 3.3% of the variance. In model 2, the short-terms effects remain a significant predictor ($p<0.05$), along with traders' educational background ($p<0.05$). The independent variables explain 6.6% of the variance.

Models 3 and 4

Dependent variable: After and before Brexit I minimised my risk

	Model 3	Model 4[5]
Constant	2.48**	2.47**
In the long-term the market will equilibrate	0.06	0.05
Gender		0.14
Years of experience		0.00
Trading in the UK markets		0.00
R^2	0.00	0.01
F statistics	F(1,198)=1.11	F(4,195)= 0.70
p	0.29	0.59

**p<0.01
* p<0.05

Model 3 shows that Brexit's long-term effects on the British economy are not a significant predictor of decision-making before and after Brexit (p>0.05), and they explain 0.6% of the variance. Model 4 shows again that Brexit's long-term effects on the British economy are not a significant predictor and, neither are any of the demographic variables (p>0.05). The independent variables explain 1.4% of the variance.

[5] The independent variable education is omitted purposefully, due to significant correlation with the variable "In the long-term the market will equilibrate"