A Work Project, presented as part of the requirements for the Award of a Master's degree in Business Analytics from the Nova School of Business and Economics.

BEHAVIORAL OPERATIONS

CONSTANÇA DA CUNHA DIAS
METELO REIS

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Abstract

Radical changes in the environment may result in decision makers changing their beliefs and behavior toward change. Throughout this work project, it will be analyzed how changes of beliefs affect decisions, such as the willingness to pay and accept of buyers and sellers and how it changes in stable environments with noisy signals and unstable environments with precise signals for both dreaded and desirable regime shifts. Generally, decision makers tend to update their beliefs as they see repeated signals of impending regime shifts, but their pattern of behavior depends on the kind of shift and type of environment and signals.

Keywords

regime shift, radical change, decision making, willingness to pay/accept, risk attitude, probability judgments

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Introduction

Decision makers often need to act and make decisions based on a limited number of signals and information. Insurance companies, for example, should know what the ideal price of an insurance is in order to maximize its profits and customers need to choose the company that offers the best conditions.

Decision making under regime shifts is extremely challenging to buyers and sellers. A regime shift can result in an undesirable outcome. To prevent and minimize risks, decision makers need to accurately evaluate the likelihood of a particular event happening. However, even if the decision makers' probability judgments are accurate, their behavior is what really matters.

This work project covers how the decision makers' beliefs influences their behavior and how these beliefs are updated when decision makers observe more signals. In terms of desirability, regime shifts are characterized as dreaded if the regime shifts from a good regime (where there are no losses) to a bad regime (where there are losses) and as desirable if the regime shifts from a bad to a good one. After the treatment and analysis of buyers' and sellers' pricing behavior for insurance, in stable environment with noisy signals and in unstable environment with precise signals, we observed different behaviors under dreaded and desirable regime shifts.

Our findings suggest that buyers beliefs about the shift Are updated to a higher extent in unstable environments with precise signals than in stable environments with noisy signals when observing repeated signals indicating a regime shift, if the regime is dreaded, and the opposite if the regime is desirable. A similar pattern is observed for sellers.

Also, buyers' willingness to pay for an insurance contract increases in dreaded regime shift and decreases in desirable regime shift when observing repeated signals indicating a regime

shift. When sellers' willingness to accept for an insurance contract decreases for stable environments with precise signals and increases for unstable environments with noisy signals.

Literature Review

Regime shifts, a reorganization in system structure influence the decision-making process and can be abrupt and persist over time (Crépin and Troell, 2012). Individuals must have the ability to detect and respond to these changes in a dynamic environment.

As a result, we ask do decision makers update their beliefs as they observe more signals indicative of regime shift?

In the search for finding how decision makers update their beliefs according to the signals, the system-neglect hypothesis has shown a pattern of underreaction in unstable environments with precise signals and of overreaction in stable environments with noisy signals (Massey and Wu, 2005). Similar logic of Griffin and Tversky (1992) with their strength and weight account to predict under- and overreaction. Also, as decision makers observe more signals, they get more confident and their beliefs get are updated to a higher extent (Glaze, Gold and Kable, 2015). However, the system-neglect hypothesis dictates that this belief revision is falls above the rational benchmark when decisions are made under stable environment with noisy signals and falls below the rational benchmark under the rational benchmark when decisions are made under unstable environment with precise signals. We are interested in the pattern of absolute belief revisions. In the context of our study, this question is exploratory in nature and we do not posit any specific pattern of belief revisions under the two environments.

Therefore, it is important to understand if decision makers also update their willingness to pay/accept in line with their beliefs.

The willingness to pay is characterized as the maximum price the buyer is willing to give for a number of goods or services and the willingness to accept is the minimum price the sellers are willing to accept for those goods or services. The asset prices get lower in "bad" regime shifts and higher in "good" regime shifts (Ang and Timmermann, 2011). We use these findings to argue that when a regime shifts from good to bad, buyers will be willing to pay more for an insurance when they believe that the shift has occurred. Accordingly, we hypothesize,

H2a. When buyers/sellers observe repeated signals of regime shift, their willingness to pay for an insurance contract increases when the regime shift is dreaded and it decreases when the regime shift is desirable.

Methods

This work project uses data that was collected as a part of a larger project on decision making under regime shift. In the experiment, the regimes were represented by two urns, green and red urns, containing a variable number of green and red balls. The green urn, a representation a "Good" regime, contained predominantly green balls, 60%, and the red urn, "Bad" regime, contained more red than green balls, 60% and 40%, respectively.

During the main study, 129 participants were recruited and were randomly assigned to buyer or seller role. They would play the game four times, where each game consisted in ten rounds. In each round, a ball would be taken from one of the urns, a signal, and they had to judge the probability of the ball coming from the "Good" regime (green urn) or the "Bad" regime (red urn), knowing that the ratio of balls in each urn remained the same throughout the rounds.

Buyers started with 100 experimental currency units (ECUs) that they could use to buy contracts through the rounds. Their task was to judge the probability of a ball coming from which regime and to say at which price they were willing to buy an insurance contract to prevent losses. If their willingness to buy was below the market price (randomly generated), the buyer would be uninsured for that round.

Sellers would start with 50 ECUs and had one insurance contract they could sell in each round. They would also be asked to judge the probability of a ball coming from the red urn and losses only occurred when the switch between regimes (urns) were made. Taken that into account, sellers would have to specify their willingness to accept and it would have to be higher than the market price in order for them to remain insured for that round.

Since the goal of the analysis was to analyze how changes in decision makes beliefs affect their willingness to pay/accept for both types of regime shifts, dreaded and desirable, and for stable environment with noisy signals and unstable environment with precise signals, the data was plotted.

First, on the X-axis was the period column and on the Y-axis the probability judgment or the willingness to pay/accept (WTP/WTA) columns. Then, to check the relation between decision makers beliefs and their behavior, the dependent variable was now the willingness to pay/accept and, the independent variable, the probability judgement. All the graphs and their respective linear regression equations are the Data Analysis & Insights section.

Data Analysis & Insights

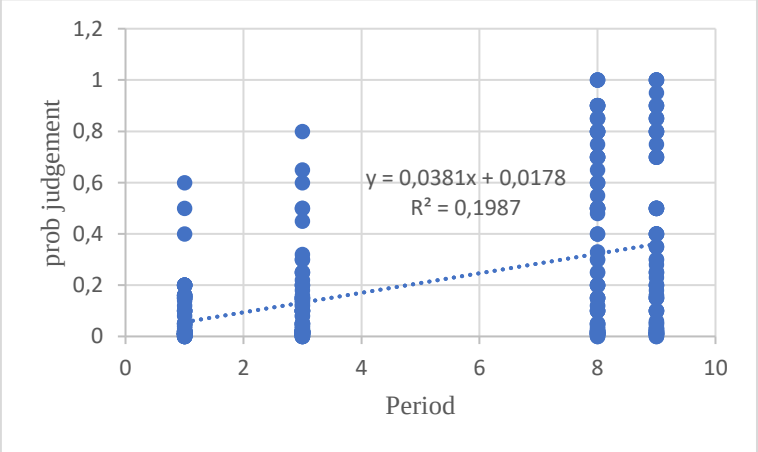
Results for buyers

For dreaded regime shift

The probability judgements tend to be similar in both unstable environment with precise signals and stable environment with noisy signals, observed through the slope of the regression equations and through the mean value of the belief (0,214 and 0,218, respectively).

Stable environment with noisy signals

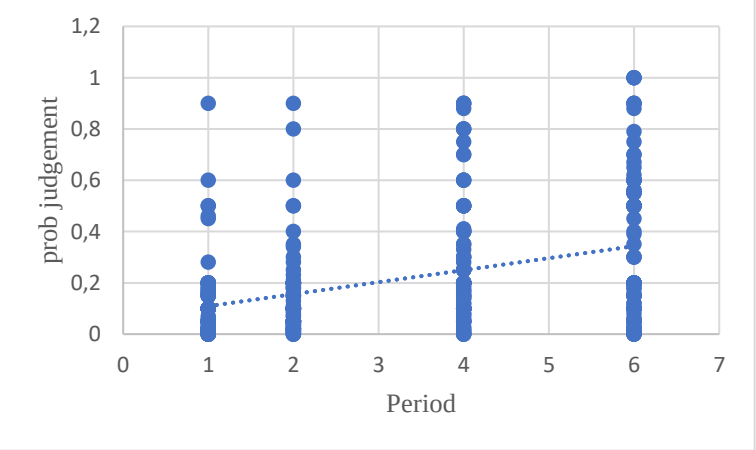
Prob judgement = 0,0381*Period + 0,0178
Equation 1



Graph 1

Unstable environment with precise signals

Prob judgement = 0,0468*Period + 0,0624
Equation 2

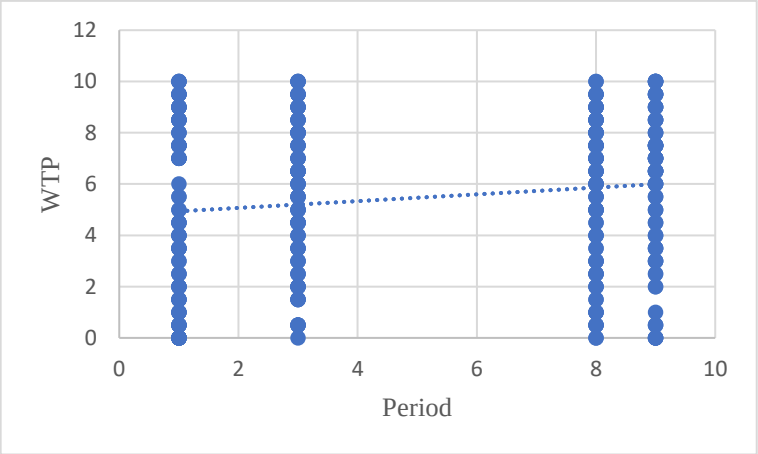


Graph 2

In both environments, buyers' willingness to pay for an insurance contract increases when observing repeated signals indicating a dreaded regime shift, the slope is positive for both equations.

Stable environment with noisy signals

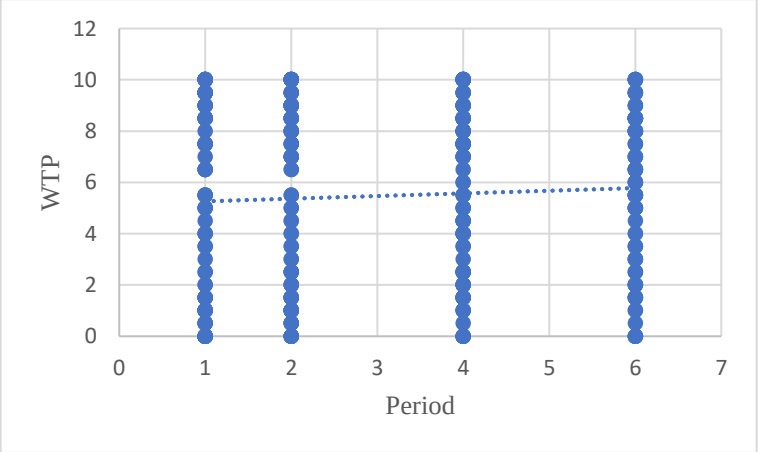
WTP = 0,1321*Period + 4,805
Equation 3



Graph 3

Unstable environment with precise signals

WTP = 0,1036*Period + 5,1578
Equation 4

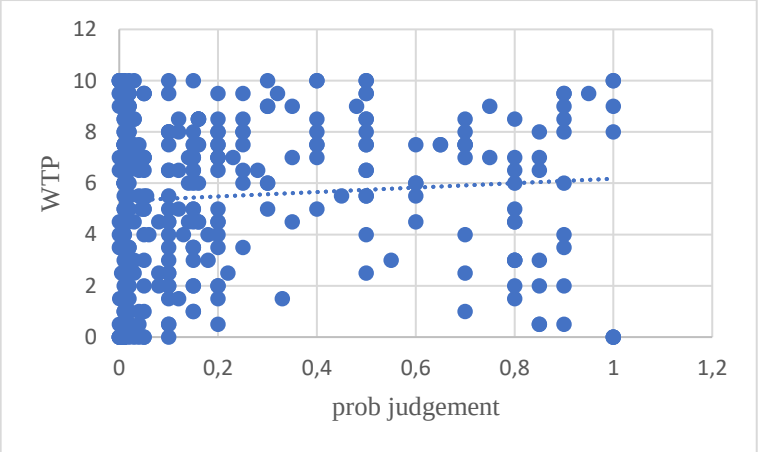


Graph 4

Also, as the probability judgment is updated to a higher extent, so does the willingness to pay of buyers.

Stable environment with noisy signals

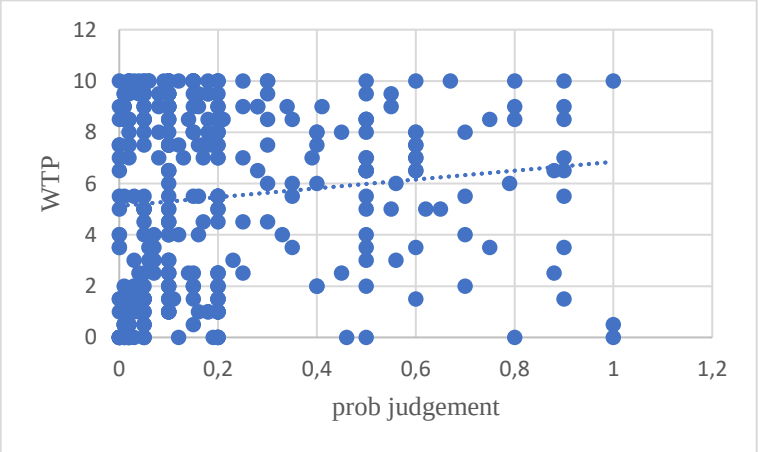
WTP = 0,8652*Prob judgement + 5,3102
Equation 5



Graph 5

Unstable environment with precise signals

WTP = 1,7207* Prob judgement + 5,1255
Equation 6



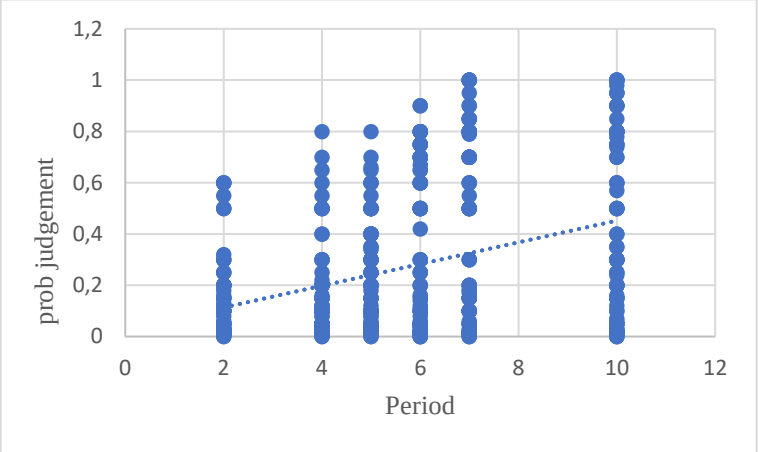
Graph 6

For desirable regime shift

The probability judgements tend to be higher in unstable environment with precise signals (mean: 0,549) than in stable environment with precise signals (mean: 0,269).

Stable environment with noisy signals

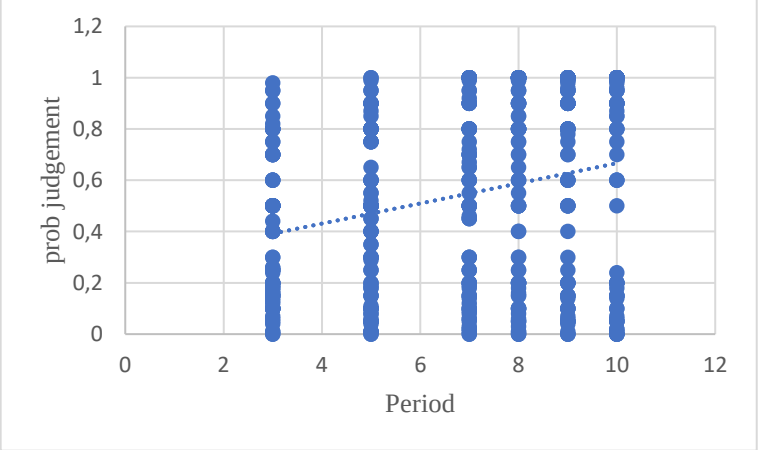
Prob judgement = 0,0424*Period + 0,0285
Equation 7



Graph 7

Unstable environment with precise signals

Prob judgement = 0,0392*Period + 0,2741
Equation 8

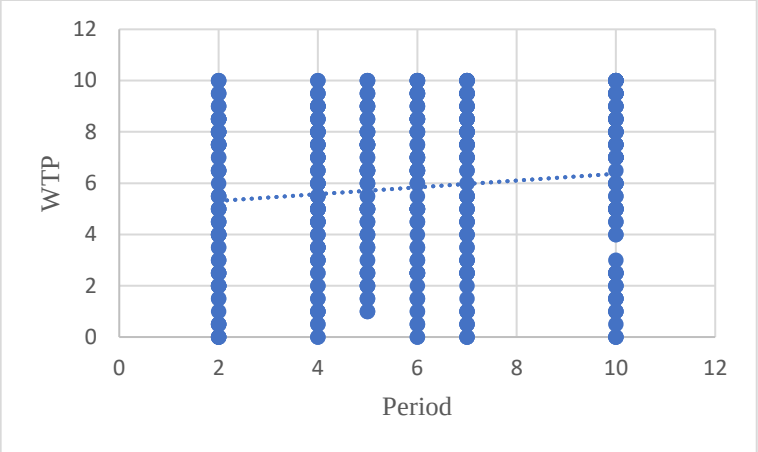


Graph 8

Buyers' willingness to pay for an insurance contract increases in stable environment with noisy signals and decreases in unstable environment with precise signals, when observing repeated signals indicating a desirable regime shift, the slope is positive stable environment with noisy signals and negative for unstable environment with precise signals.

Stable environment with noisy signals

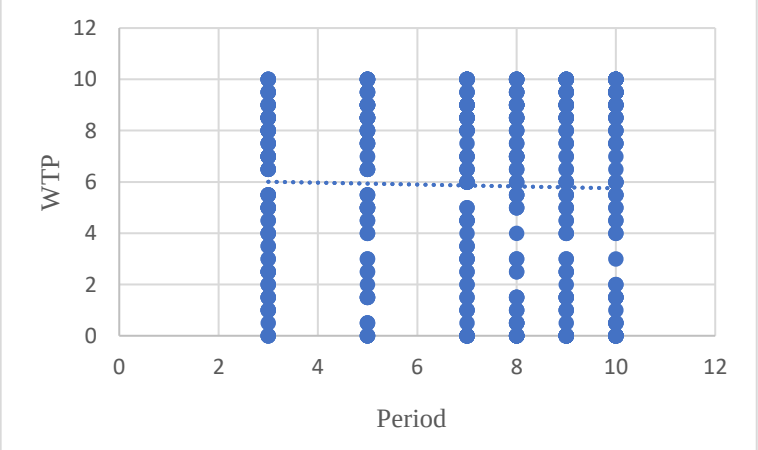
WTP = 0,1325*Period + 5,0418
Equation 9



Graph 9

Unstable environment with precise signals

WTP = -0,0366*Period + 6,1164
Equation 10

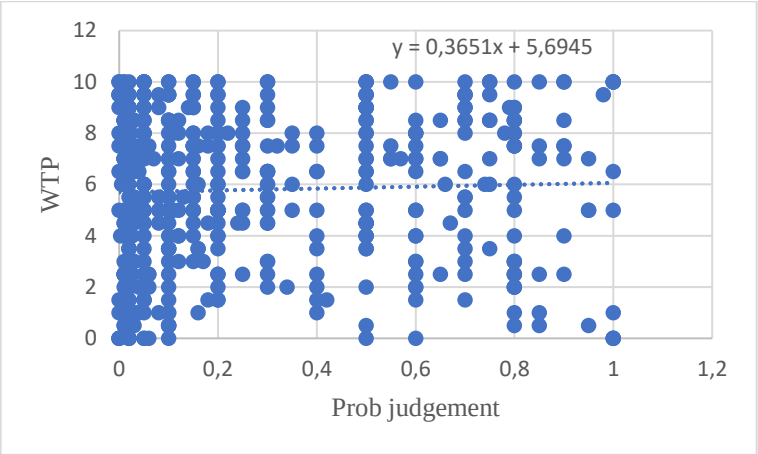


Graph 10

For unstable environment with precise signals, buyers' willingness to pay tend to increase more than for stable environments with noisy signals as their beliefs are updated to a higher extent.

Stable environment with noisy signals

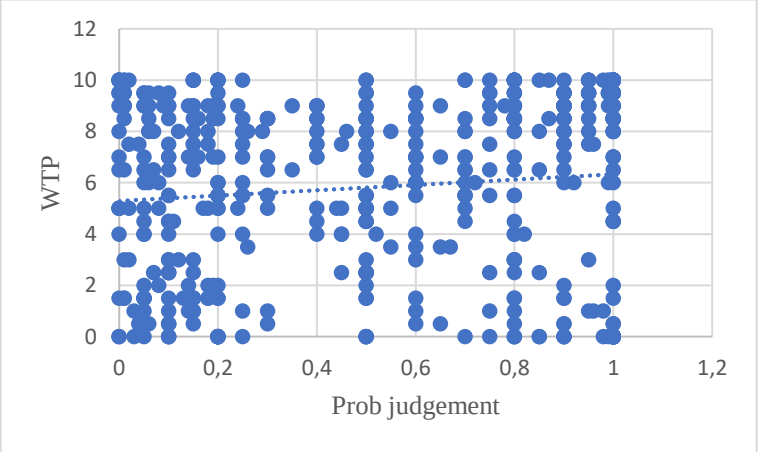
WTP = 0,3651*Prob judgement + 5,6945
Equation 11



Graph 11

Unstable environment with precise signals

WTP = 1,0391*Prob judgement + 5,29
Equation 12



Graph 12

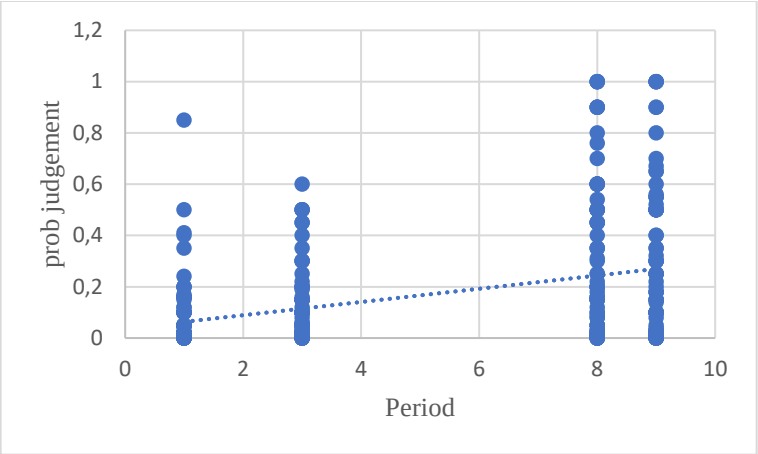
Results for sellers

For dreaded regime shift

Sellers' probability judgements tend to be higher in unstable environment with precise signals (mean: 0,21) than for stable environments with noisy signals (mean: 0,173).

Stable environment with noisy signals

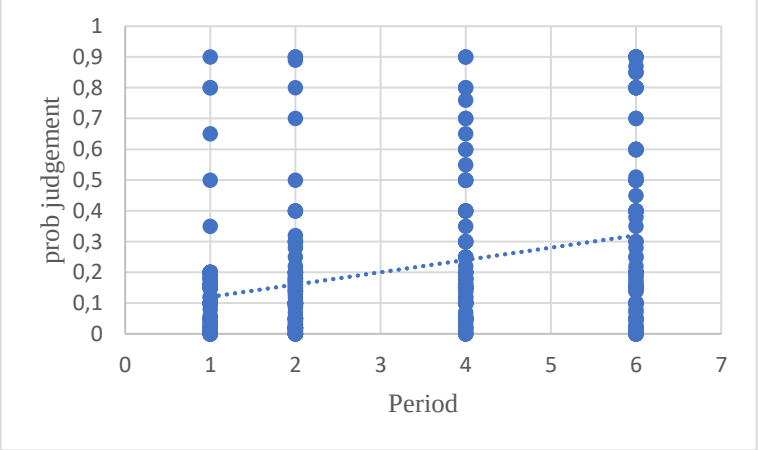
Prob judgement = 0,0258*Period + 0,0375
Equation 13



Graph 13

Unstable environment with precise signals

Prob judgement = 0,04*Period + 0,0803
Equation 14

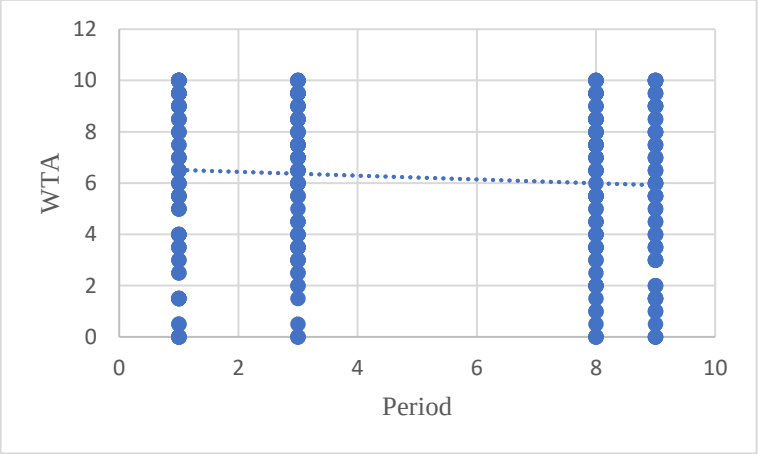


Graph 14

For both types of environments and signals, sellers' willingness to accept for an insurance contract decreases when observing repeated signals indicating a dreaded regime shift.

Stable environment with noisy signals

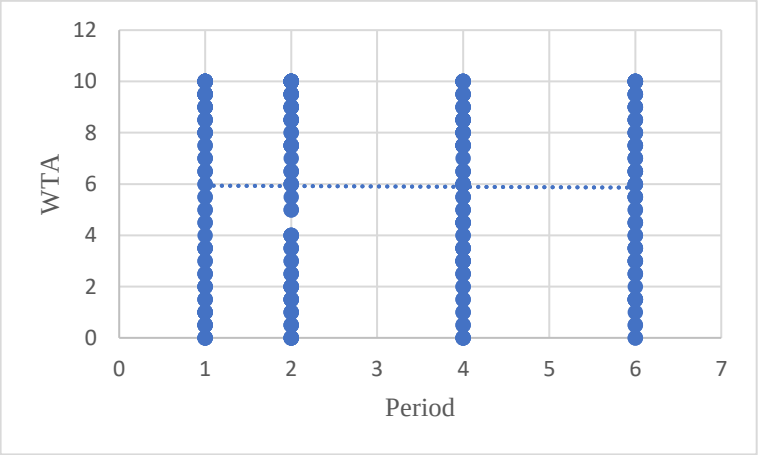
WTA = -0,0744*Period + 6,5864
Equation 15



Graph 15

Unstable environment with precise signals

WTA = -0,0152*Period + 5,9507
Equation 16

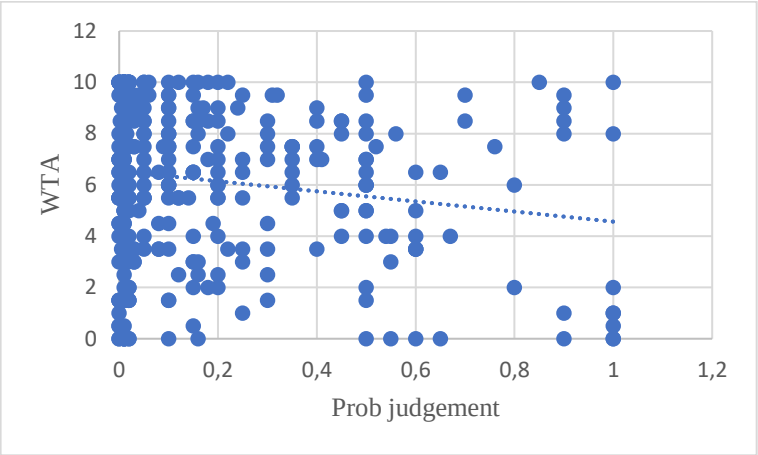


Graph 16

For both types of environments and signals, as the probability judgment is updated to a higher extent, sellers' willingness to accept decreases.

Stable environment with noisy signals

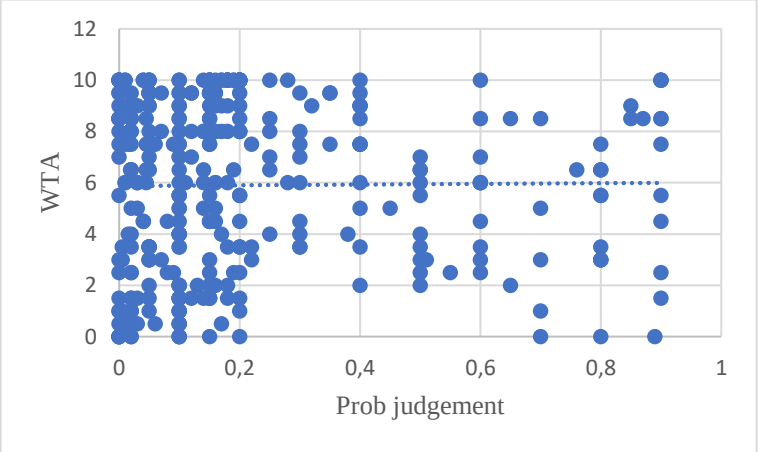
WTA = -1,9703*Prob judgement + 6,5364
Equation 17



Graph 17

Unstable environment with precise signals

WTA = 0,1353*Prob judgement + 5,8729
Equation 18



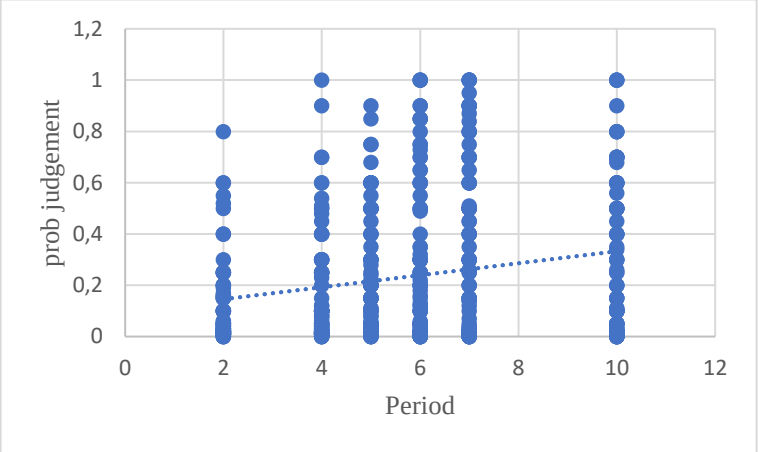
Graph 18

For desirable regime shift

Sellers' probability judgements tend to be higher in unstable environment with precise signals (mean: 0,479) than for stable environments with noisy signals (mean: 0,231).

Stable environment with noisy signals

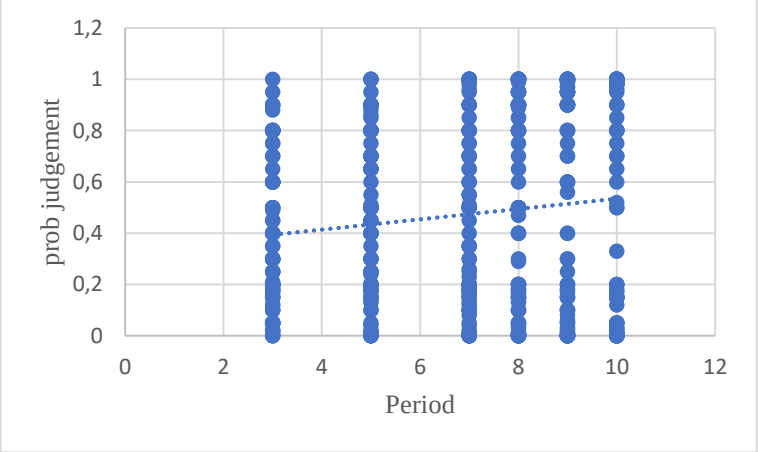
Prob judgement = 0,0234*Period + 0,0987
Equation 19



Graph 19

Unstable environment with precise signals

Prob judgement = 0,0201*Period + 0,333
Equation 20

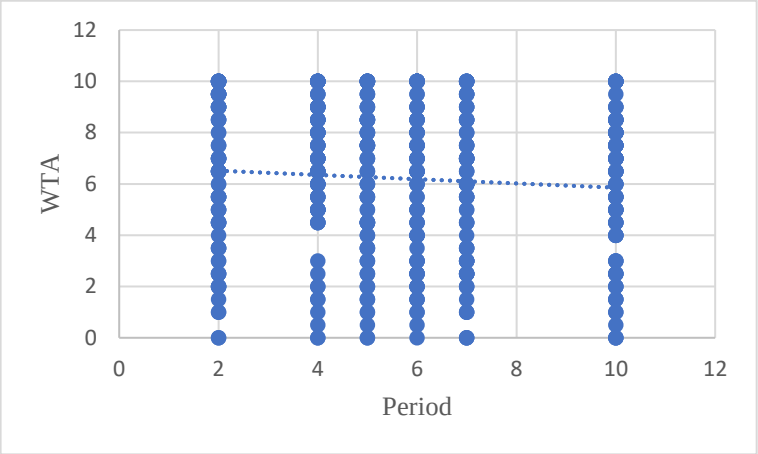


Graph 20

For both types of environments and signals, sellers' willingness to accept for an insurance contract decreases when observing repeated signals indicating a desirable regime shift.

Stable environment with noisy signals

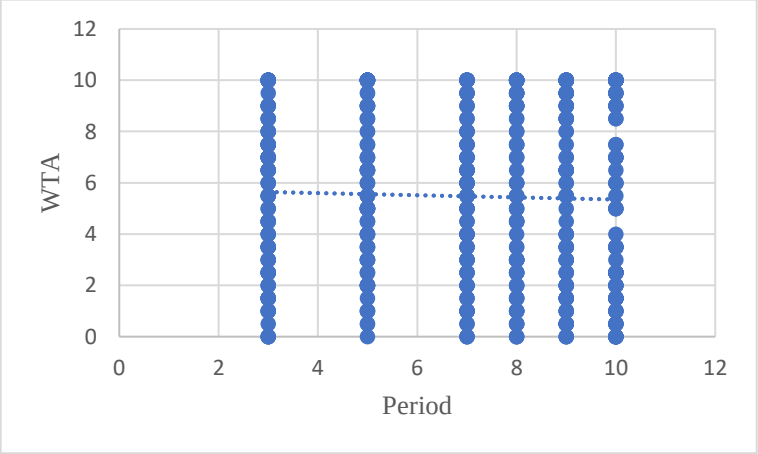
WTA = -0,0827*Period + 6,6806
Equation 21



Graph 21

Unstable environment with precise signals

WTA = -0,0417*Period + 5,7648
Equation 22

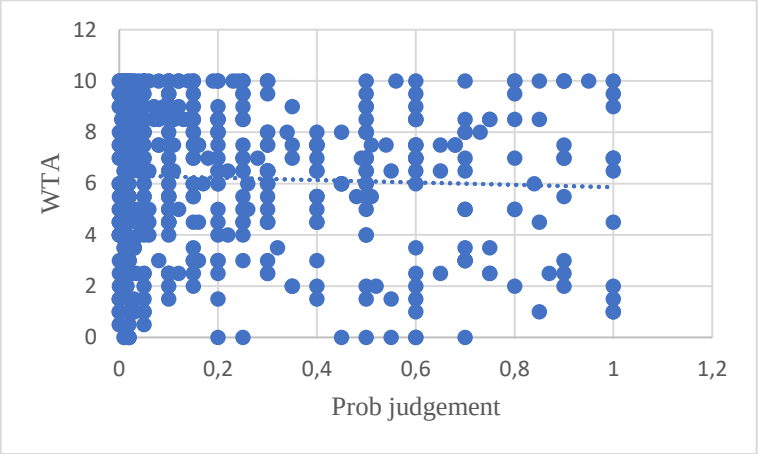


Graph 22

For both types of environments and signals, as the probability judgment is updated to a higher extent, sellers' willingness to accept decreases.

Stable environment with noisy signals

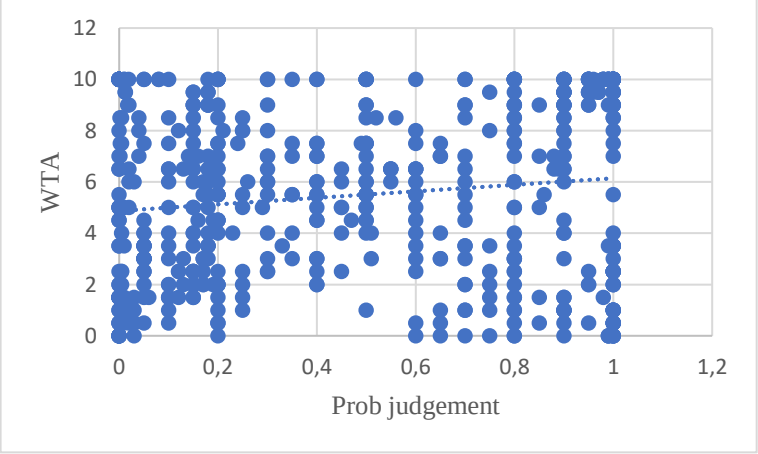
WTA = -0,4603*Prob judgement + 6,3184
Equation 23



Graph 23

Unstable environment with precise signals

WTA = 1,2707*Prob judgement + 4,8709
Equation 24



Graph 24

Conclusion

This work project research shows that, as decision makers observe more signals, their beliefs are updated to a higher extent.

In case of buyers, as their beliefs are updated to a higher extent, their willingness to pay for an insurance contract also increases for dreaded regime shift and for desirable regime shift, for both stable environment with noisy signals and unstable environment with precise signals.

Regarding sellers, as their beliefs are updated to a higher extent, their willingness to accept for an insurance contract decreases for stable environment with noisy signals and increases for unstable environment with precise signals. This is true for both dreaded and desirable regime shift.

Also, when buyers observe repeated signals of regime shift, their willingness to pay for an insurance contract increases for both regime shifts and for stable environment with noisy signals and unstable environment with precise signals. On the other hand, sellers' willingness to accept for an insurance contract decreases for stable environments with noisy signals for both dreaded and desirable regime shift.

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Appendix

condition	signal	role	WTP/WTA	period	pr_t
LL	0	0	0,5	1	0,01
LL	1	0	4	2	0,02
LL	0	0	6,5	3	0,04
LL	1	0	7,5	4	0,02
LL	1	0	9	5	0,01
LL	1	0	6	6	0,05
LL	1	0	9	7	0,01
LL	0	0	5,5	8	0,04
LL	0	0	9	9	0,01
LL	1	0	9,5	10	0
HH	0	0	0	31	0,2
HH	0	0	2	32	0,4
HH	1	0	9,5	33	0,5
HH	0	0	0	34	0,8
HH	1	0	9,5	35	0,9
HH	0	0	2,5	36	0,2
HH	1	0	9	37	0,9
HH	1	0	9,5	38	0,2
HH	1	0	9,5	39	0

Table 1: Data (first 20 rows)

Legend

condition: LL - stable environment and noisy signals
HH - unstable environment and precise signals

signal: 1 for desirable regime shift
0 for dreaded regime shift

WTP/WTA: willingness to pay of buyers and willingness to accept of sellers

role: 0 if buyer
1 if seller

pr_t: buyer's reported probability of shift on a scale of 0-1
seller's reported probability of shift on a scale of 0-1