EMPIRICAL ESSAYS ON DYNAMIC DECISION MAKING

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Empirical Essays on Dynamic Decision Making

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Data Sources

The data used in Chapter 1 was in part collected from sources available on the web [http://www.rae.ac.uk/2001/, http://www.rae.ac.uk/, http://www.ref.ac.uk/2014/], in part from numerous academics who were contacted via e-mail, and in part provided by HEFCE (Higher Education Funding Council for England).

Empirical Essays on Dynamic Decision Making

Abstract

This thesis is a collection of empirical and experimental studies on dynamic decision making.

Chapter 1 studies the non-linear incentive of academics in economics departments of the U.K. high education institutions based on the data throughout the last four RAEs/REFs (i.e., RAE1996, RAE2001, RAE2008, REF2014). The time-discontinuity features of the RAEs/REFs and the constraints on job moving result in academics facing non-linear incentives. The data shows that in a harsh working environment with a periodical decline of the UK economics study, academic economists respond to such incentives by postponing the publication of their high-quality outputs to the beginning of the next assessment period, as expected.

Chapter 2 presents an experiment designed to study how people play a two-person two-stage dynamic game with incomplete information and uncertainty and to study the effect of different elicitation methods on equilibrium and level-k play. The experimental data shows that around half of the subjects are strategic thinkers and level-k thinking dominates in strategic thinking. Furthermore, the comparison between the direct-response and the strategy method reveals that the latter method has a negative effect on players' strategic thinking.

Chapter 3 is an experimental study of the intertemporal consumption and saving behaviour of agents who have a finite lifecycle in an endowment economy in the presence of two different time profiles of taxes. A series of farsighted models (i.e., rational expectation and adaptive learning) and myopic models are introduced to explain players' saving behaviour in the presence of a tax decrease in the middle of their lifecycle. In this setting, the data analysis shows that most of the subjects' behaviours are consistent with the suggestions of myopic models.

Contents

Chapter 1. Non-linear Incentives: An Empirical Study of the Academic Performance of UK Economics Academics in RAE/REF in 22 Years (1992-2014)[1]

1.1 Introduction

Some of the studies on non-linear incentive have pointed out that agents take advantage of the non-linear feature to benefit themselves by manipulating outcomes. The empirical study (Oyer, 1998) finds that the salespeople and executives control the pricing or hide essential information to "pull in" or "pull out" the next fiscal year's customers due to the periods of the fiscal years. The same result is emphasised by Larkin (2014) using the data of the Vendor's salespeople, which shows that the salespeople manipulate the timing of deal closure by lowing prices in the non-linear incentive scheme. Similarly, Oettinger (2002) empirically and theoretically demonstrate that nonlinear grading standard incentive diminishes students' study efficiency. A corruption study (DUGGAN and LEVITT, 2002) presents that the corruption of Japan sumo wrestling is caused by a sharp non-linear increasing of the paying function in the 8^{th} win, which motivates wrestlers to rig their matches when they reach seven times wins.

In general, the unwantedly distorted incentive caused by the non-linear feature usually brings adverse effects[2] against the original aims of the incentive. Our study in this chapter investigates the nonlinear incentive caused by the combination of the institutional features of the Research Assessment Exercise (RAE) /the Research Excellence Framework (REF), which is a periodic assessment exercise carried out by the four UK funding bodies[3], and the

[1] This chapter is joint work with Prof. Miguel Costa-Gomes.

[2] Lacetera and Macis (2010) show some kinds of rewards works better in prosocial behaviors under the nonlinear incentive background.

[3] The funding bodies are the Higher Education Funding Council for England (HEFCE), the Scottish Funding Council (SFC), the Higher Education Funding Council for Wales (HEFCW) and the Department for Employment

restricted rules, which are introduced by institutions to restrict free job moving of their staffs. Meanwhile, the stressful working background in the UK economics stimulates academics to seek strategies to benefit themselves. Then, a nonlinear incentive model is exhibited in our study to predict the strategy of academics submitted to the economics and econometric panel of the RAEs/REF. Similar to the salespeople, academics are noticed that they also “game” to the nonlinear incentive by “pull out” their better publications to the following RAEs/REF.

The RAE/REF assesses the research quality of the higher education institutions (HEIs) in the UK every 5-7 year, and the assessment is only related to the performance within a census period. The RAEs and REF have already been conducted seven exercises from 1986 to 2014. Based on the assessments provided by the RAEs/REF, the four funding bodies allocate their funds for the HEIs in the UK, and meanwhile, the assessments are published online (since 2001). The published information is also consulted by other funding organisations or individual investment. There were around five billion pounds allocated according to the assessment of RAE 2001.[4] As more funds support the HEIs to maintain and improve their research capabilities, which determine their ratings and performance in the RAEs/REF, these institutional features motivate HEIs in the UK to chase higher ratings and better-quality performance.

The main evaluating target of the RAEs/REF is the research quality of HEIs, which mainly consists of the outputs of the staffs submitted by HEIs[5]. In REF 2014, the weight of outputs in the evaluation has occupied a weighting of 65%[6]. In short, high-quality outputs bring HEIs high ratings. Lee, el (2013) pointed out that hiring decisions made by the economics schools

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and Learning, Northern Ireland (DEL).

[4] http://www.rae.ac.uk/2001/submissions/Introduction.htm
http://www.ref.ac.uk/about/
http://www.rae.ac.uk/aboutus/

[5] The RAE/REF categories outputs into several levels (see Appendix 1.A) and introduces the FTE (Full-time equivalent) score in each UoA (subject-based Units of Exercise) to rate the HEIs

[6] http://www.ref.ac.uk/pubs/2012-01/, “Part 1: Generic statement of assessment criteria and working methods”, (37.a.)

in HEIs were affected by the top economic journals. That is, the economics schools have a strong motivation to hire staff who have high-quality outputs published on the top economic journals and avoid their job hopping by signing contracts with constraint. Then the restricted rule prompts economic academics to strategically allocate their efforts and manipulate the publishing time of their outputs.

The following Section 1.2 describes the data collecting and data processing. In Section 1.3, we present a detailed description of the background of UK economics in the RAEs/REF from 1996 to 2014. In Section 1.3, we build a non-linear incentive model to prediction the academic's strategy and verify the prediction. The conclusion in Section 1.4 includes some limits of the study and proposes the following studies in the next stage.

1.2 Data Description

The data of 4 RAE/REF exercises are collected in the UoA economics and econometrics panel from 1996 to 2014[7]. The data of RAE1996 are provided by the HEFCE (Higher Education Funding Council for England) and the data of RAE2001, RAE2008 and REF2014, are collected from the RAEs/REF website.

The information collected from RAE2001 and REA2008 includes names of academics, titles of outputs submitted, published locations of outputs (journal titles, book names or publishers), dates of publication or output finishing, types of outputs (books, journal articles, working papers and so on), and names of co-authors (only record their internal but not external co-authors) in ''RA1 and RA2'' of UoA 38 of RAE2001 and ''RA1 and RA2 and RA5c'' of UoA 34 of RAE2008. The information from RAE1996 and REF2014 on the submitted outputs and the submitted staffs who had submissions in RAE1996/REF2014 are stored separately, so each output is matched to a specific academic in the same university (see Appendix 1.B.1). Then we build up the database for each exercise which identifies each staff who has submission(s) in the RAE(s)/REF with the information on HEIs that staff belong to

[7] A small proportion of data are also collected from other panels as needed.

and outputs submitted by the staff. To complete the database, we trace each academic's career map from 1992 to 2014 so that the four exercises data are merged (see Appendix 1.B.2). The integrated database identifies each academic by his outputs and his career map.

In order to uniform the measure of the quality of outputs, four reference systems are introduced to rank outputs. Keele (2003), ABS (2008) and ABS (2015) rank journals from 4 to 1, and Klaus Ritzberger (2008) ranks journals from A+ to C. We transform the letter in Klaus Ritzberger (2008) to the digits from 6 to 1. Based on a specific reference system, if the published locations of outputs are found in this specific reference system, we assign them based on the digit in the reference system. If the published locations of outputs are not found in this specific reference system and the outputs are published in the journals, we assign them as unranked outputs with 0 in this specific reference. If the types of outputs are book/ conference/ working paper/ report, we assign them as 0. However, the orders of the quality of outputs are sorted by ranked journal > unranked journal > book > Conference Proceedings > Working Paper > Report > others (software, database).

1.3 General Background

Before starting the inference of the model, the overview of the economics research of the UK is presented in this section, which helps understand the background of the model.

1.3.1 Overview of the performance in the UK economics

As the narrowing of the UK economics and the increasing concentration of the QR (quality research) funding pointed by Lee et al. (2013), economics schools face more and more rigorous surviving competition. *Table 1.1* shows that the numbers of economics schools submitting in the economics panel have fallen off from 50 institutions in RAE1996 to 28 institutions in REF2014. Meanwhile, the quantity of academics submitted to the economics panel by their institutions also has shown a declining trend. Along with the shrink in the economics panel, the scale of outputs submitted to the economics panel also appears wane. Moreover, the entries in the business and management panel are 94 in RAE2001, 90 in RAE2008 and 101 in REF2014.

Table 1.1. *Entries in the economics panel from 1996 to 2014*

	1996	2001	2008	2014
# of academics (submitted to the economics panel)[8]	948	843	876	797
# of institutions (submit to the economics panel)	50	41	35	28
# of disappeared institutions from the economics panel in the following exercise	13	7	7	-
# of newly added institutions to the economics panel in the current exercise	-	4[9]	1[10]	0
# of outputs submitted to the economics panel[11]	3646	3227	3021	2600
UOA code of the economics panel	38	38	34	18

On the one hand, the shrinking quantity may harm the competitiveness of UK economics in the international competition of economics research. On the other hand, the surviving economics schools and academics maintain the high quality of UK economics research, which boosts the competitiveness of UK economics. This benefit is demonstrated in *Table 1.2* and *Table 1.3*. The rules of the RAEs/REF from 1992 to 2014 required each academic to submit no more than four outputs. *Table 1.2* displays the boom of the elite academics whose four outputs are all published in the top 5 journals[12] /diamond list journals (including 27 journals) /4 or 4* rank list journals in ABS 2008 (including 17 journals) /4 or 4*rank list journals in ABS 2014 (including 23 journals). The shrink does not impede the boom of high-quality outputs. Conversely, the rising of elite academics is driven by economics schools which pursue high-quality publications.

[8] Since some academics were submitted by the two HEIs in one exercise, we have merged them as single academics but not two. The actual number of academics in our database is less than the total number of academics submitted by the institutions to the economics panel.
[9] Brunel University, Royal Holloway, University of London, University of Durham and University of Sheffield submitted to panel 43 “Business and Management Studies” in RAE 1996.
[10] Kingston University submitted in panel 43 “Business and Management Studies” in RAE 2001.
[11] Since some academics were submitted by the two HEIs in one exercise and their outputs were submitted twice by the two HEIs, in these cases we merge all the same outputs as single ones.
[12] American Economic Reviews, Econometrica, Review of Economic Studies, Journal of Political Economics and Quarterly Journal Economics

Table 1.2. *Number of Elite academics with four high-quality outputs*

	1996	2001	2008	2014
# of academics on Top 5 journals	4	3	9	12
% of academics from Five-Top economics schools[13] out of the academics on Top 5 journals	100%	66.7%	100%	91.7%
# of academics on Diamond list journals	42	59	76[14]	74
% of academics from Five-Top economics schools out of the academics on Diamond list journals	38.1%	32.2%	56.6%	59.5%
# of academics on 4 & 4* rank in ABS 2008 journals	9	9	25	32
% of academics from Five-Top economics schools out of the academics on 4 & 4* rank in ABS 2008 journals	66.7%	66.7%	92%	84.4%
# of academics on 4 & 4* rank on ABS 2015 journals	14	26	59[15]	66
% of academics from Five-Top economics schools out of the academics on 4 & 4* rank in ABS 2015 journals	50%	46.2%	72.9%	65.2%

 # Academics submitted in RAE2001, RAE2008 or REF2014 come from the HEIs which submitted to the economics panel at least once in those census period, and academics submitted in 1996 only come from the HEIs which submitted to the economics panel in both RAE1996 and RAE2001.
% Exclude academics who retired or died or was missing (x) or was "uncertainty academics".

Furthermore, *Table 1.3* presents the expansion of high-qualification academics. A high-qualification academic is defined as the academic who submits at least one output published in the top 5 journals out of his four submitted outputs. Additionally, *Table 1.2* and *Table 1.3* implies the concentration that more and more high-quality academics come from Five-Top economics schools.

[13] London School of Economics and Political Science, University College London, University of Cambridge, University of Oxford, and University of Warwick

[14] 2 academics retired in REF 2014 exercise.

[15] 2 academics retired in REF 2014 exercise.

Table 1.3. *Summary of outputs published in the Top 5 publications*

	1996	2001	2008	2014
# the academics who had 4 outputs published in the Top-5 journals	4	3	9/9	12
% of the academics from Five-Top economics schools out of the academics who had 4 outputs published in the Top-5 journals	100%(4)	66.%(2)	100%(9)	91.7%(11)
# the academics who had 3 outputs published in the Top-5 journals	4	7	14	19
% of the academics from Five-Top economics schools out of the academics who had 3 outputs published in the Top-5 journals	75%(3)	85.7%(6)	64.3%(9)	84.2%(16)
# the academics who had 2 outputs published in the Top-5 journals	11	27	31[16]	41
% of the academics from Five-Top economics schools out of the academics who had 2 outputs published in the Top-5 journals	63.6%(7)	51.9%(14)	74.2%(23[17])	73.2%(30)
# the academics who had 1 output published in the Top-5 journals	46[18]	79[19]	107[20]	102
% of the academics from Five-Top economics schools out of the academics who had 1 output published in the Top-5 journals	41.3%(19[21])	53.2%(42[22])	47.7%(51[23])	56.9%(58)
Total	65	116	161	174
% of the academics from Five-Top economics schools out of the academics who had at least one output published in the Top-t journals	50.8%(33)	55.2%(64)	57.1%(92)	66.1%(115)
% of the academics submitted at least one outputs published in the Top-5 journals out of the academics	8.4%	13.8%	18.4%	22.3%

[16] 1 academic retired in REF 2014 exercise.
[17] 1 academic retired in REF 2014 exercise.
[18] 3 academics missed in RAE 2001 exercise.
[19] 6 academics missed or retired in RAE 2008 exercise.
[20] 3 academics missed in REF 2014 exercise.
[21] 2 academics missed in RAE 2001 exercise.
[22] 4 academics missed in RAE 2008 exercise
[23] 1 academics retired in REF 2014 exercise.

who were submitted to the economics panel				
% of the academics from Five-Top economics schools submitted at least one outputs published in the Top-5 journals out of the academics who were from Five-Top economics schools were submitted to the economics panel	14.1%	28.6%	38.0%	46.6%

 # Academics submitted in RAE2001, RAE2008 or REF2014 come from the HEIs which submitted to the economics panel at least once in those census period, and academics submitted in 1996 only come from the HEIs which submitted to the economics panel in both RAE1996 and RAE2001
% Exclude academics who retired or died or was missing (x) or was "uncertainty academics".

To summarise the information from *Table 1.1* to *Table 1.3,* we generalise *Finding 1.1* on the background of UK economics:

Finding 1.1a. The quantity of UK economics is shrinking, but the quality of UK economics is progressing.

A visual impression on *Finding 1.1* is exhibited in *Figure 1.1*, which draws the trend of the average ratings of outputs by years submitted to the economics panel. The four lines represent the average ratings of the outputs by years based on four rank references, and the clustered columns represent the number of outputs by years (on the right axis). In general, the trend of the average rating lines shows moving up over exercises and the clustered columns of each exercise by years shows the shrinking trend over exercises. However, the lines of the average ratings show periodical downturns within exercises[24]. A series of T-tests are conducted to compare the distributions of the ratings of outputs submitted in the first three years with the rest of each exercise. Within each exercise, the T-test proves the significantly higher quality of the earlier outputs than the later outputs (P-values is 0).

[24] To avoid the undervaluation on some high-quality working papers, we rate the working papers, which are published in the later exercises, based on their later locations instead of rating them as 0. Appendix 1.D displays the same figure with rating all working papers as 0.

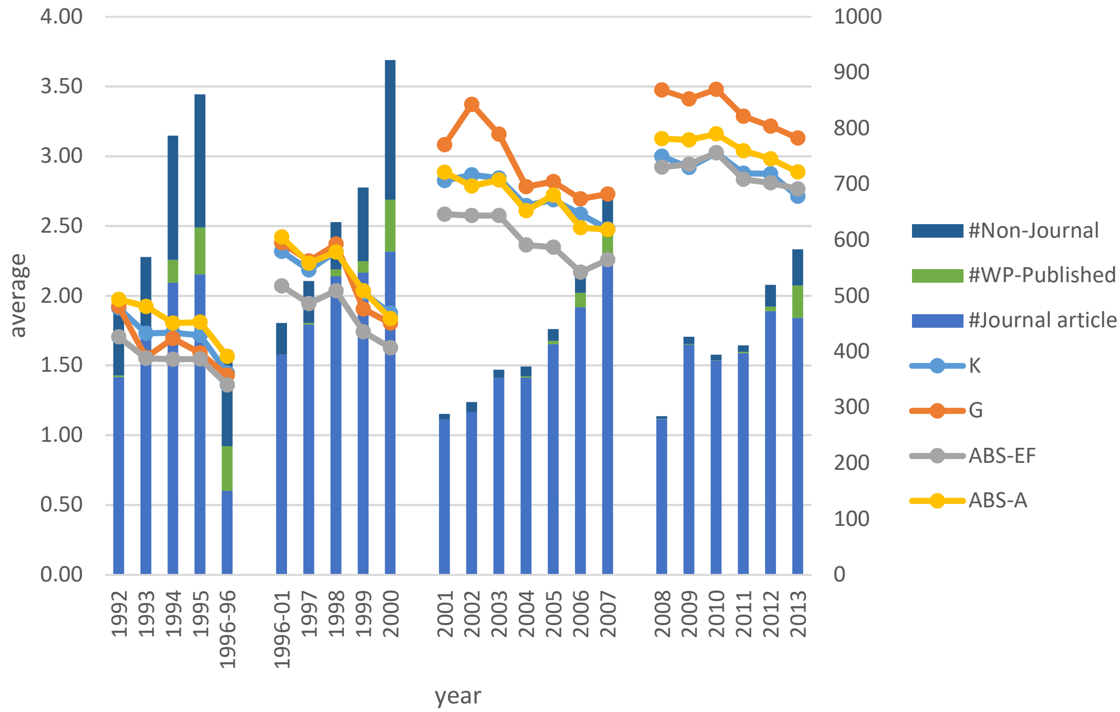

Figure 1.1 *The average rating of outputs by years submitted by staff who submitted in the economics panel*

 # Staff submitted to RAE2001, RAE2008 or REF2014 come from the HEIs which submitted in the economics panel at least once in those exercises, and staff submitted to 1996 only come from the HEIs which submitted in the economics panel in both RAE1996 and RAE2001[25]

Finding 1.1b. The quality of UK economics follows a periodical turndown across exercises.

Along with the increasing quantity of outputs within exercises, the decreasing average ratings within exercises implies that more outputs do not mean better overall quality and the high-quality outputs concentrate at the beginning of each exercise. One explanation is that in the later stage of an exercise, staff need to reach four outputs and it is a trade-off between quantity and quality. Therefore, it is reasonable that low-quality outputs appear more in the later stage of an exercise. Moreover, the model in Section 1.4 provides an alternative explanation for *Finding 1.1b*.

[25] Unlike other RAEs/REF, there are still some outputs published or finished in 1996 in RAE1996. Then we label 1996 in RAE1996 as “1996-96”. And based on the timeline of RAE2001, the start date of RAE2001 was from 1 January 1996, and then we label this 1996 in RAE2001 as “1996-01” in Figure 2.

1.3.2 Overview of the career of academics in the UK economics

Finding 1.1 implies a harsh environment in which there are fewer positions but higher standard. These pressures compel more academics to leave economics schools and join other related economics schools or research groups. Some academics leave the HEIs to work for companies, the government, research organisations, NGO and even to be writers, soldiers[26] or run themselves companies. Also, some academics move to the abroad HEIs. *Table 1.4* shows a summary on "Surviving ratio", which represents the ratios that how many academics stay in the economics panel between two adjacent exercises out of academics who submit to the economic panel in the former exercise[27].

Table 1.4. *Surviving ratio*[28]

	96-01	01-08	08-14
% of academics who submitted in the economics panel in the following exercises	69.8%	59.3%	50.0%
% of academics who submitted in other panels but not the economics panel in the following exercises (P)	6.1%	13.7%	8.9%
% of academics who stayed in the (same/another) UK HEIs but do not have submissions in the following exercise (Y)	11.0%	12.9%	25.0%
% of academics who left the UK HEIs but joined other abroad HEIs (A)	8.3%	12.1%	14.0%
% of academics who left the HEIs and worked in companies or governments in the UK or abroad (C)	4.8%	2.0%	2.1%

**One side Fisher exact test for the increasing trend among 69.8%, 59.3% and 50.0% is P=0.*
 # All academics had submissions in the economics panel in the former exercise and only come from the institutions which still had submissions in the economics panel in the following exercise.
#P: academics who submitted at least one output in the economics panel in the former exercises and submitted at least one output in RAE/REF panels except for the economics panels in the following exercises.
#Y: academics who submitted at least one output in the economics panel in the former exercises and were still employed by the HEIs as researchers in the latter exercise but did not have submissions in any RAE/REF panels;
#C: academics who submitted at least one output in the economics panel in the former exercises and left the HEIs to have new jobs in other places or stayed in the HEIs but were not employed by research economics schools.
#A: academics who submitted at least one output in the economics panel in the former exercises and left the UK HEIs to move abroad but still worked in abroad HEIs.

[26] The worst one went to jail.
[27] Academics here exclude staff who retired, died or "x" (no available information) during the later RAEs/REF exercise.
[28] The departments which have no entry to the economic panel in the later exercise are excluded.

There are only half academics who stay in the economic panel in REF2014 from RAE2008 to REF2014. More and more academics leave UK HEIs, move to other panels or have no submission. This implies that academics submitted to the economic panel in RAE2008 would only have half chance to keep their occupations in the economic panel in REF2014. A comparison between the senior academics, who have survived in the three adjacent RAEs/REF, and the junior academic, who have survived in the two adjacent RAEs/REF, is added. The surviving ratio of the junior academic in REF2014 (RAE2008) is 8% (12%) lower than the seniors, which points a harsher situation for the junior academics.

Furthermore, once academics who submitted in the former exercise have an absence in the following exercise, the chance of returning to the economic panel in the third exercise is cut down to around 27%-25% from 77%-60%. Then *Finding 1.2* generalises the background of the working environment in the UK economics:

Finding 1.2 The career life of academics in the UK economics becomes severer.

1.4 Academics' gaming cross exercises

The background shown by the findings above describes a stressful career environment for academics in UK economics schools. Then it is reasonable for academics to maximise their benefits and minimise their costs. In this section, a non-linear incentive model against the stressful environment is introduced to illustrate one possible strategy of academics.

1.4.1 Non-linear incentive model

Under the pressure of surviving, academics strategically allocate their efforts to manipulate outcomes so that they could benefit themselves against the constraining rules they face. Usually, an RAE/REF exercise is executed every five to seven years, and only outputs published within the assessment period[29] are eligible to be submitted. Meanwhile,

[29] RAE2001: 1 January 1996 to 31 December 2000; RAE2008: 1 January 2001 to 31 December 2007; REF2014: 1 January 2008 to 31 December 2013.

the FTE (Full-time equivalent) only rate staff who are submitted by the HEIs as Category A[30] research staff (RAE2001 also includes Category A* staff[31]). This rule means even if someone moves from HEI A to another HEI B just one day before the census date of an exercise, this staff is counted into HEI B. The FTE is the key rating to evaluate HEIs, so HEIs try to prevent their staff from leaving their positions. Some economic schools add the constraint into the employment contracts, which forbids staffs to leave their positions within a period of blocking time just before the incoming census date.

The length of the blocking time is varied across economics schools, which could be from 3 months to 12 months. It is reasonable that economics schools do not offer promotions or salary incentive to their staff during the blocking time. The blocking time and the assessing exercise's periodicity constitute the non-linear incentive. *Figure 1.2* presents a model to explain the non-linear incentive.

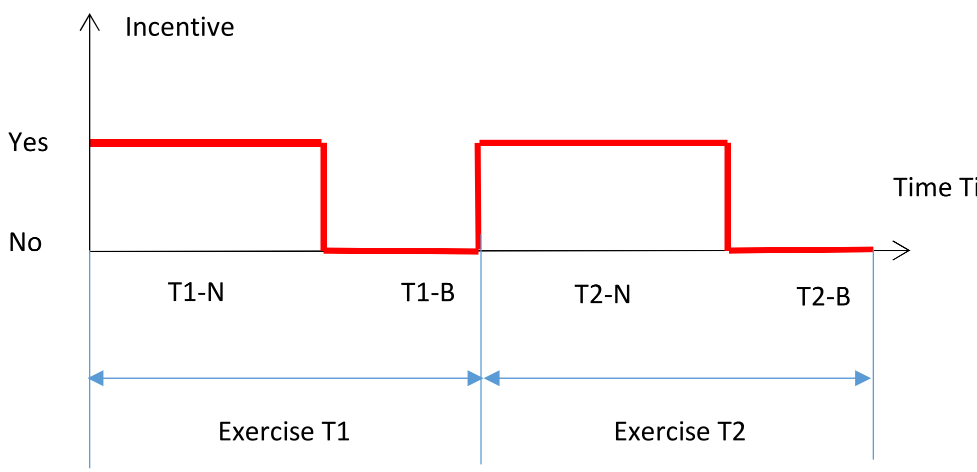

Figure 1.2. *Non-linear incentive*

The RAE/REF divides the continuous time into several exercise slots (Ti), such as T1 (RAE2001) and T2 (RAE2008). An exercise Ti is subdivided into Ti-N and Ti-B by the

[30] Category A staff includes the staff who are employed in the HEIs on the census date. The census date of RAE2001 is 31 Mar 2001. The census date of RAE2008 is 31 Oct 2007. The census date of REF2014 is 31 Oct 2013.
[31] Category A* staff transfer to new HEIs in the period between 1 April 2000 and 1 March 2001.

constraining rule. Ti-N represents the period in which staff can leave their positions freely, and Ti-B represents the blocking time in which staff cannot leave their current positions. The end date of Ti-B in the exercise Ti is the census data of the exercise Ti, and the length of Ti-B depends on the economics schools. In the period of Ti-N, it is beneficial for the economics schools to reward their staffs for their high-quality outcomes. As the rewards incentive their staff to put effort into their work and willing to stay in their positions. The economics schools strengthen their research competitiveness, keep their high-quality academics and attract new superior academics in the period Ti-N so that the schools could achieve high ratings in the current RAE/REF exercise. As the ratings of the schools tie to the funds provided by four High Education Funding bodies, we assume the existence of incentive for staffs in the Ti-N is "Yes". However, the constraint prevents current staffs from leaving in the period Ti-B, and thus there is a low incentive for economics schools to continue rewarding to their staff. Also, there is a low chance for economics schools to attract the new staff, as those staff may also be in their blocking time. So, we assume the existence of incentive to the staff in Ti-B is "No".

Now the incentive within an exercise Ti has the non-linear feature, like square waves, which drives staff to explore their optimal strategies. As staff cannot benefit from their high-quality outcomes in the period Ti-B, it is reasonable for them to manipulate their higher quality outcomes not to be published in the period Ti-B. If staff expect that their imminent outcomes will be high quality[32], either staff should put more effort on the work so that to "pull in" the publication time to the period Ti-N, or they should "pull out" the publication time to the next T(i+1)-N period, such as fully utilizing the R&R periods. Therefore, it is more likely that high-quality outputs appear in the early stage of an exercise. Postponing is an alternative explanation on the periodical turndown over exercises in *Finding 1.2*. As "pulling in" is a "positive" strategy and is aligned with the interest of the economics schools, the

[32] For example, some outputs have already received R&R responses.

investigation in our study focuses on the “negative” strategy, “pulling out”, which is against the interest of the economics schools.

Hypothesis 1.1: Academics tend to “pull out” their high-quality outcomes by postponing them to the next exercise.

1.4.2 Empirical evidence on a non-linear incentive model

In this section, a series of analyses are conducted to verify *Hypothesis 1.1* in Section 1.4.1. The rule of judging “pulling out” is the comparison between the **earliest output**[33] of an academic[34] in an exercise and the **worst output**[35] of the academics in its previous exercise.

Since the schools only can submit no more than four outputs for each academic, it is judicious for the schools to submit their staff’ best four outputs if the staff have more than four outputs (or all outputs if the staffs have less than four outputs). This means that a new outcome of an academic is worth to be considered by the school for the academic only when it is at least better than the current fourth-best output (or the current worst output) of the academic. Otherwise, a new outcome which is worse than the fourth-best (or the worst) output does not change the current submission plan of the academic (or the current overall quality of the submissions). That is, the schools should submit any new outcome for an academic which is expected to be better than the fourth-best output of the academic instead of the current fourth best. Then, the new submission plan can bring the school a higher rating than the previous one. If an academic determines to postpone a better

[33] In some case, more than one outputs are recorded in the earliest year. We pick up the one with the highest rating as the earliest output in that exercise. We check if staff postpone their high-quality outputs to the next exercise, so we always pick up the highest rating one in the same year.

[34] The time record of the earliest output of each staff selected in RAE/REF system is in the first two years of this exercise. For example, when we compare the worst output of one staff in RAE 1996 with his earliest output in RAE 2001, the time record of earliest output in RAE2001 system should be before 31 Dec 2002.

[35] The quality of outputs is sorted by ranked journal > unranked journal > book > Conference Proceedings > Working Paper (not published later) > Report > others (software, database). If an output is submitted as a working paper in one exercise but it is published in the later exercises, the working paper is still rated as a journal article in this exercise.

forthcoming outcome when the time is close to the end of an exercise, it should be valuable for the academic to do this. The model mentions that staffs usually do not get rewards when they are in the period Ti-B. If it has a high chance that the outcome is published in the period Ti-B, postponing is a dominant strategy. Otherwise, if the outcome has been completed before the census date, it is beneficial for the school to submit the outcome.

When an outcome is postponed, it will become the earliest output in the following exercise. In other words, the earliest output of an academic (within the first two years) in an exercise could have been completed in the previous exercise if the staff put more effort into it. Then, the comparison between the earliest output in an exercise and the worst output in its previous exercise is the evidence to detect the strategy of staff. If the earliest output is not worse than the worst one, the earliest one is potentially worth to be submitted by the school if it is completed in the previous exercise. So, we examine the pairs of the earliest and worst outputs of staff and get the **actual proportion** of possibly postponing for every two adjacent exercises. As there is an increasing trend of the quality of the outputs over exercises mentioned in *Finding 1.1a*, the outputs in the latter exercise are expected to perform better than the ones in the previous exercise. Meanwhile, as the worst output, it is highly possible to keep no better than any other outputs. Thus, a benchmark proportion is imported to exclude the alternative factors above. The benchmark proportion represents the **expected probability** $Prob(x \geq y)$ that the expected earliest output (x) is not worse than the expected worst output (y). The expected earliest output is an output randomly selected from the distribution $F(x)$ of all outputs submitted in the latter exercise, and the expected worst output is an output randomly selected from the distribution $F(y)$ of the worst outputs of all staff submitted in the former exercise. The procedure is describe as following:

$$F(x) = x_i, for\ x = i, i = 1\ to\ n\ (i\text{: }the\ order\ of\ staffs)$$

$$x_i = \frac{the\ sum\ of\ the\ outputs\ which\ are\ ranked\ as\ j}{\begin{array}{c}the\ sum\ of\ the\ outputs\ of\ staffs\\ submitted\ in\ the\ later\ exercise\end{array}}$$

$$F(y) = y_j, for\ y = j, j = 1\ to\ n\ (j{:}\ the\ order\ of\ staffs)$$

$$y_i = \frac{the\ sum\ of\ these\ worst\ outputs\ which\ are\ ranked\ as\ i}{\begin{array}{c} the\ sum\ of\ the\ worst\ outputs\ of\ staffs \\ submitted\ in\ the\ former\ exercise \end{array}}$$

Given a specific x,

$$Prob(x \geq y) = \begin{cases} \sum_{x_i=y}^{x} F(x_i), for\ x \geq y \\ 0, \qquad\qquad for\ x < y \end{cases}$$

Then, the expected probability is described as following:

$$Exp[Prob(x \geq y)] = \sum_{y_i=1}^{n} F(y_i) * [\sum_{x_i=y_i}^{x} F(x_i)]$$

Table 1.5a summarise the comparisons between the earliest ones and the worst ones. The first column shows the two adjacent exercises. The former exercises provide the worst outputs, and the following exercises provide the earliest outputs. The other four columns show the two percentages. The former one in each cell represents the **"expected probabilities",** and the latter one in each cell represents the **"actual proportions**. The result[36] shows that the quality of the earliest ones is significantly not worse than the quality of the worst ones in each comparison. This evidence justifies the existence of the "pulling out" strategy.

[36] The data comes from the part of staffs who have submissions in any two adjacent exercises in the Economics or Business panel and who have at least one submission in the economics panel in the former exercise.

Table 1.5a *Comparison between the earliest output and the worst output (Not worse)*[37]

	Expected probability / Actual proportion			
	K	G	ABS-EF	ABS-A
RAE96-RAE01	83%/96%***	82%/95%***	83%/96%***	84%/96%***
RAE01-RAE08	85%/94%***	81%/92%***	84%/94%***	86%/94%***
RAE08-RAE14	82%/88%**	76%/87%***	85%/91%**	86%/92%***

****P-value in one-side Fisher exact test is smaller than 0.01*

*** P-value in one-side Fisher exact test is smaller than 0.05 and larger than 0.01*

 # Staff submitted at least one output in the economics panel in the former exercise and submitted at least one output in economics or management panel in the following exercise

 # Staff in RAE1996 only come from the HEIs which submitted to the economics panel in both RAE1996 and RAE2001.

To support the evidence above, *Table 1.5b* and *Table 1.6* adds more evidence from other comparisons. *Table 1.5b* still reports the comparisons between the earliest ones and the worst ones. However, the former percentages in the cells represent $Exp[Prob(x > y)]$ and the latter percentages represent the proportion of the better pairs. The better pairs consist of two kind of pairs. If the output(s) of an academic in the former exercise are (is) not all rated as 4*/A+ and the earliest one in the latter exercise is better than the worst one in the former exercise, the pair is signed as a better pair. If the output(s) of an academic in the former exercise are (is) all rated as 4*/A+ and the earliest one is equal to the worst one, the pair is also signed as a better pair. The evidences provided by *Table 1.5b* is consistent with *Table 1.5a* for the first two adjacent exercises, but in the latest two exercises, the strategic behaviour is not statistically significant.

[37] Appendix 1.E represents "Comparison between earliest output and the worst output" of academics who submitted 4 journal-article outputs and shows the same result.

Table 1.5b *Comparison between the earliest output and the worst output (Better/Equal)*

	Expected probability / Actual proportion			
	K	G	ABS-EF	ABS-A
RAE96-RAE01	69%/75%*	70%/76%*	69%/74%	70%/74%
RAE01-RAE08	66%/75%**	69%/80%***	66%/74%**	69%/76%**
RAE08-RAE14	55%/61%	62%/66%	65%/66%	63%/70%**

****P-value in one-side Fisher exact test is smaller than 0.01*
*** P-value in one-side Fisher exact test is smaller than 0.05 and larger than 0.01*
** P-value in one-side Fisher exact test is smaller than 0.1 and larger than 0.05*
#Staff submitted at least one output in the economics panel in the former exercise and submitted at least one output in economics or management panel in the later exercise
#Staff in RAE1996 only come from the HEIs which submitted to the economics panel in both RAE 1996 and RAE 2001.

Table 1.6 introduces a stricter comparison. The output of an academic, which is also better than the average performance of all outputs submitted by the school, is more worthy for the school. Then, postponing this output can bring higher benefit for the staff. Meanwhile, it is also harder for the earliest output to be better than the average performance of the school. The left percentage in each cell represents the proportion of the better pairs, in which the average of the outputs of an academic submitted in the latter exercise is better than the average of the outputs of the school where the academic works in the former exercise. The right percentage in each cell represents the proportion of the better pairs, in which the earliest output of a staff submitted in the latter exercise is better than the average of the outputs of the school where the academic works in the former exercise. The evidence in *Table 1.6* is consistent with *Table 1.5a*, which approves the existence of the strategic behaviour.

Table 1.6 *Comparison of the averages (Better)*

	Average/ Earliest			
	K	G	ABS-EF	ABS-A
RAE96-RAE01	71%/78%**	59%/58%	67%/69%	71%/77%**
RAE01-RAE08	57%/85%***	50%/69%***	54%/78%***	62%/86%***
RAE08-RAE14	43%/67%***	43%/60%***	46%/77%***	46%/77%***

****P-value in one-side Fisher exact test is smaller than 0.01*
*** P-value in one-side Fisher exact test is smaller than 0.05 and larger than 0.01*
#Staff submitted at least one output in the economics panel in the former exercise and submitted at least one output in economics or management panel in the later exercise
#Staff in RAE1996 only come from the HEIs which submitted to the economics panel in both RAE 1996 and RAE 2001.

Furthermore, an extended investigation is imported to compare the magnitude of "gaming" behaviour between the junior staffs and the senior staffs. The junior staff are defined as the staff whose first submitting are in RAE2001 (or RAE2008), and the senior staff are defined as the staff whose first submitting are in RAE1996 (or RAE2001). Then *Table 1.7a* and *Table 1.7b* display the contrast on the strategic behaviour of the senior staff in their second two adjacent exercises census with the junior staff in their first two adjacent exercises in RAE2008 (or REF2014). The percentages in *Table 1.7* are drawn in the same way as ones in *Table 1.5a.*

Table 1.7a *Comparison between junior staffs and senior staffs (between RAE2001 and RAE2008)*

	Expected probability / Actual proportion			
	K	G	ABS-EF	ABS-A
Junior staff (x-01-08)	87%/94%	86%/95%**	87%/95%*	89%/95%
Gap between Expected probability and Actual proportion	7%	9%	8%	6%
Senior staff (96-01-08)	84%/94%***	79%/91%***	82%/94%***	85%/93%***
Gap between Expected probability and Actual proportion	10%	12%	12%	8%

****P-value in one-side Fisher exact test is smaller than 0.01*
*** P-value in one-side Fisher exact test is smaller than 0.05 and larger than 0.01*
** P-value in one-side Fisher exact test is smaller than 0.1 and larger than 0.05*
#Staffs submitted at least one output in the economics panel in the former exercise and submitted at least one output in economics or management panel in the later exercise
#Staffs in RAE1996 only come from the HEIs which submitted to the economics panel in both RAE 1996 and RAE 2001.

Table 1.7b *Comparison between junior staffs and senior staffs (between RAE2008 and REF2014)*

	Expected probability / Actual proportion			
	K	G	ABS-EF	ABS-A
Junior staff (x-08-14)	80%/86%	76%/86%**	85%/93%*	85%/93%**
Gap between Expected probability and Actual proportion	6%	10%	8%	8%
Senior staff (01-08-14)	83%/90%*	75%/87%***	85%/90%	87%/92%
Gap between Expected probability and Actual proportion	7%	12%	5%	5%

****P-value in one-side Fisher exact test is smaller than 0.01*

*** P-value in one-side Fisher exact test is smaller than 0.05 and larger than 0.01*

** P-value in one-side Fisher exact test is smaller than 0.1 and larger than 0.05*

#Staffs submitted at least one output in the economics panel in the former exercise and submitted at least one output in economics or management panel in the later exercise

#Staffs in RAE1996 only come from the HEIs which submitted to the economics panel in both RAE 1996 and RAE 2001.

Compliance with the result in *Table 1.5a*, both junior staff and senior staff in *Table 1.7a* and *Table 1.7b* significantly and consistently postpone their high-quality outputs to the latter exercise. Meanwhile, the gap of senior staff is consistently higher than the gap of junior staff in *Table 1.7a*. Moreover, the expected probabilities of the junior staff are consistently higher than the ones of the senior staff in *Table 1.7a*. This implies that the improvement of the performance of junior staff is larger than the senior staff in the earlier RAEs. One explanation is that senior staff enter a stable stage of their career life, so it is not necessary for them to achieve higher performance. Another explanation is that junior staff do not have enough experience to balance the quality and the quantity so to complete four outputs is paid more attention. However, *Table 1.7b* does not provide clear evidence like *Table 1.7a*. One explanation is that the criteria of assessment on senior staff are more rigorous than before. As the surviving pressure mentioned in *Table 1.4* is aggravating, senior staff need to demonstrate their sustainable improvement. Moreover, along with the improvement of international economics research, it is harder to produce high-quality outcomes for junior staff than before. Then the apparent gap between senior and junior staff fades away.

Therefore, *Result 1.1* is generalised from the analysis of the comparisons above, which verifies *Hypothesis 1.1*:

Result 1.1: Academics generally game with the non-linear incentive system by postponing their higher-quality outputs to latter exercises.

1.4.3. Academics in Five-Top economics schools

The overview in *Table 1.2* and *Table 1.3* of Section 1.3.1 demonstrates that high-quality academics concentrate on Five-Top economics schools (50%-66%). The proportions of academics from Five-Top economics schools are around 30%. Therefore, the strategic behaviour of academics from Five-Top economics schools is discussed in this section[38].

Table 1.8a provides consistent evidence with *Table 1.5*. In general, academics in Five-Top economic schools also follow the strategy of "pulling out" and additionally they show relatively stable proportions on carrying out the strategy. The overall result in *Table 1.2* implies a fall of the proportions on carrying out the strategy from RAE2008 to REF2014, but this fall does not appear for academics from Five-Top economics schools. To explore the divergence deeply, *Table 1.8b* provides the results of the stricter comparisons. Unlike *Table 1.5b, Table 1.8b* states the more significant strategy behaviours of the academics in Five-Top. Academics in Five-Top usually face stricter criteria, so the growing pressure from international economics does not have a significant effect on their strategic behaviour. *Table 1.8b* also implies that academics in Five-Top possess the better ability to balance the quality and the quantity of their outcomes according to their needs.

[38] Academics are defined as being employed by Five-Top economics schools according to the latter exercises in which they are submitted by Five-Top economics schools in two adjacent exercises. The paralleled results on academics submitted by Five-Top economic schools in the former exercises are provided in Appendix 1.E.

Table 1.8a *Comparison between the earliest output and the worst output (Not worse)*

	Expected probability / Actual proportion			
	K	G	ABS-EF	ABS-A
RAE96-RAE01	84%/95%***	83%/93%**	85%/98%***	85%/95%**
RAE01-RAE08	86%/92%	84%/92%	87%/97%**	90%/96%
RAE08-RAE14	81%/92%**	77%/94%***	86%/95%*	87%/92%

****P-value in one-side Fisher exact test is smaller than 0.01*

*** P-value in one-side Fisher exact test is smaller than 0.05 and larger than 0.01*

 # Staff submitted at least one output in the economics panel in the former exercise and submitted at least one output in economics or management panel in the following exercise

 # Staff in RAE1996 only come from the HEIs which submitted to the economics panel in both RAE1996 and RAE2001.

Table 1.8b *Comparison between the earliest output and the worst output (Better/Equal)*

	Expected probability / Actual proportion			
	K	G	ABS-EF	ABS-A
RAE96-RAE01	70%/77%	71%/77%	70%/78%	71%/78%
RAE01-RAE08	67%/78%	73%/85%	73%/81%	75%/87%*
RAE08-RAE14	54%/70%**	62%/80%**	65%/77%	62%/78%**

*** P-value in one-side Fisher exact test is smaller than 0.05 and larger than 0.01*

** P-value in one-side Fisher exact test is smaller than 0.1 and larger than 0.05*

#Staff submitted at least one output in the economics panel in the former exercise and submitted at least one output in economics or management panel in the later exercise

#Staff in RAE1996 only come from the HEIs which submitted to the economics panel in both RAE 1996 and RAE 2001.

1.5 Conclusion

In this chapter, we demonstrate a high-pressure working environment of UK economics academics and represent a non-linear incentive model to predict economics academics strategy in this high-pressure scenario. The data of the RAEs/REF from 1996 to 2014 verify our prediction: the staff "game" to the non-linear incentive causing by the institutional feature from the REAs/REF and the constraint on leaving positions from the HEIs by postponing their high-quality outcomes to the following exercises.

The "gaming" strategy indeed benefits to individual academics, but overall the results of this "gaming" may harm the UK economics. As the rating system of the RAE/REF ties the outputs with academics, this means that owning outputs is binding with owning academics. This tieing pushes the HEIs to "steal" academics but not cultivate academics.

This system ignores the contributions of the satisfactory research environment on high-quality outcomes. High-quality outcomes consist of the effort of academics and the support of HEIs. When an academic moves to a new HEI, his outputs will be counted as the outcomes of the new HEIs in the RAEs/REF system. In this case, evaluating the academic based on his outcomes is reasonable, but it is not convincing to evaluate the latter HEI based on the outcomes which are accomplished in the former HEI. In this scenario, there is no incentive for HEIs to assist academics in completing outcomes, but it encourages HEIs to set up the rules to prevent the leaving of academics. The improvement of research relies on both the effort of academics and the support of the environment. In the long run, the lack of support would bring a ceiling effect on the improvement of the UK economics, which is shown in this chapter that the ascent of the quality of outputs across exercises slows down.

Furthermore, if we conjecture that this "gaming" extends to other science subjects, the situation will become even worse. Academic research devotes itself to benefit the whole human being and improves social progress. Postponed outcomes could have helped some people in urgent needs or solved some fatal issues.

It may remit the issue above by weakening the ties between the census and academics and strengthen the ties between the census and HEIs, which could transform the non-linear incentives to the linear incentives. Linear incentives enhance the possibility of the consistency of the interests between academics and the HEIs.

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Appendix 1.A: Qualify level of RAEs/REF

RAE 2001:

- 5* (five star): Quality that equates to attainable levels of international excellence in more than half of the research activity submitted and attainable levels of national excellence in the remainder.
- 5: Quality that equates to attainable levels of international excellence in up to half of the research activity submitted and to attainable levels of national excellence in virtually all of the remainder.
- 4: Quality that equates to attainable levels of national excellence in virtually all of the research activity submitted, showing some evidence of international excellence.
- 3a: Quality that equates to attainable levels of national excellence in over two-thirds of the research activity submitted, possibly showing evidence of international excellence.
- 3b: Quality that equates to attainable levels of national excellence in more than half of the research activity submitted.
- 2: Quality that equates to attainable levels of national excellence in up to half of the research activity submitted.
- 1: Quality that equates to attainable levels of national excellence in none, or virtually none, of the research activity submitted.

RAE 2008:

- 4*: Quality that is world-leading in terms of originality, significance and rigour
- 3*: Quality that is internationally excellent in terms of originality, significance and rigour but which nonetheless falls short of the highest standards of excellence
- 2*: Quality that is recognised internationally in terms of originality, significance and rigour

- 1*: Quality that is recognised nationally in terms of originality, significance and rigour
- Unclassified: Quality that falls below the standard of nationally recognised work. Or work which does not meet the published definition of research for the purposes of this exercise

REF 2014

- 4*: Quality that is world-leading in terms of originality, significance and rigour.
- 3*: Quality that is internationally excellent in terms of originality, significance and rigour but which falls short of the highest standards of excellence.
- 2*: Quality that is recognised internationally in terms of originality, significance and rigour.
- 1*: Quality that is recognised nationally in terms of originality, significance and rigour.

Unclassified Quality that falls below the standard of nationally recognised work. Or work which does not meet the published definition of research for the purposes of this exercise.

Appendix 1.B: Data processing

B.1. Data Matching

Data of RAE 2001 and 2008 has already matched staff with their submissions. However, information of outputs of RAE 1996 and REF 2014 does not include the name of staff who submitted these outputs. So we have to match outputs with their authors.

First, we put each output in “google scholar” or “google scholar” to get the name(s) of author(s). Second, we check each author’s name with the name list of the same institution to pick up the author(s) who had the same institution with the output. After we check all outputs in one institution and find at least one author for each output belonging to this institution, we match the outputs with their author(s). (In some case, some outputs cannot be found online or cannot be recognised authors, and then we have to drop these outputs as invalid outputs. Similarly, there are some invalid staff due to no matched outputs.)

Second, we connect outputs with their authors and count how many connections each staff has. If an output only has a single author in the same institution, then we sign this author submitted this output. Since as the rule, each staff only can submit no more than 4 output. Based on this rule, we pick up all single author’s outputs and check if any staff already satisfied with 4 outputs . If a staff has more than 4 connections or has some connected outputs with more than one author, we use 4 submission rule to exclude impossible combinations. If only one combination is left, then we could match those outputs with their authors. If more than one combination is left, we sign all these outputs as “uncertainty” and these staff as “uncertain staff”. We assign each “uncertain staff” own all outputs which connect with her/him. This means some staff has more than 4 outputs and some outputs appear more times than the number of times they were submitted.

There is another important detail we need notice, which is that some staff may submit the same papers in different institutions in the same RAE period. If the same staff submits the same outputs in two different institutions (e.g. 2 for York, 2 for Essex) and all information on outputs is the same, we drop off the repeated outputs and just keep every output appear once. However, if the same staff submits difference outputs in different institutions in the same RAE period, we keep all the outputs.

B.2. Identification and Merge

After we have matched staff with their submissions, we have each staff's profile in a single period. In order to create a career map for each staff, we have to identify each staff in each RAE or REF period.

We first use information in the economics panel of RAE 1996 to describe each staff who had submission(s) in this period, and next, we trace these staff's footprint in following period, RAE 2001. That is, we identify a staff in RAE 1996 by her/his full name and her/his submitted output(s), and then we trace this staff's name to check if there are submission(s) with this name appearing in some panel in RAE 2001. if there is only one same name in the same institution in RAE 2001, we treat the one in RAE 2001 as the same staff in RAE 1996. If we find a same name in a different institution or find more than one same names in RAE 2001, we use "Ideas", their personal websites or some other ways to find the staff in RAE 2001 who holds both outputs in RAE 1996 and outputs in RAE 2001. Then we also treat this staff in RAE 2001 as the same one in RAE 1996. After this procedure, we identify a staff in both RAE 1996 and RAE 2001.

Some staff whose name cannot be found in RAE 2001 in the economics panel or other possible panels is signed as "x" in RAE 2001. And we use the same procedure to trace all staff in RAE 1996 to check their appearance in RAE 2008 and REF 2014. Staff whose name cannot be found in a period is also signed as "x" in that period. The tracing procedures of the following periods for RAE 2001, RAE 2008 are similar to the one for RAE 1996. Further, staff in the economic panel of RAE 2001, RAE 2008 and REF 2014 also need tracing procedures of previous periods. Tracing procedures of previous periods are similar to the one of the following periods. For staff in the economic panel of RAE 2001, we only need to trace the staff who are not identified in the tracing procedures of following periods of RAE 1996, and check if there are some outputs with those authors' names in some panels in RAE 1996. If found, we identify them. If not, we still sign them "x" in RAE 1996. For staff in economic panel of RAE 2008 or REF 2014, they need to be traced for two or three previous periods.

After we trace all staff in economic panel of each period, we draw academic career maps from 1996 to 2014 of all staff who submitted at least one output in the economics panel, which includes staff's appearance in each periods and staff's submissions in each period.

Since in the tracing procedure there are staff signed as "x" in some period(s), we have to check their career status in that period. We use "LinkedIn", "Ideas", their personal website or some other ways to find where and when those staff was and separate them to several categories. If a staff still worked in the same institution as the one, which s/he stayed in the previous RAE period, (but just did not submit any output), we sign "x-YS" to substitute for the "x" in that period. If a staff worked in a different institution with the one, which s/he stayed in the previous RAE period, (but still did not submit any output in that new), we sign "x-YC" to substitute for the "x" in that period and record the time when s/he moved to the new institution. If a staff moved to abroad but still worked in an abroad academic institution, we sign "x-Abroad" to substitute for the "x" in that period and record the time when s/he moved to abroad. If a staff retired or died, we sign "x-Retire/Dead" to substitute for the "x" in that and all following periods and record the time when s/he retired or died. If a staff moved to work in a place which is not included by RAE or REF, we sign "x-Company" to substitute for the "x" in that period and record the time when s/he moved to the new place.

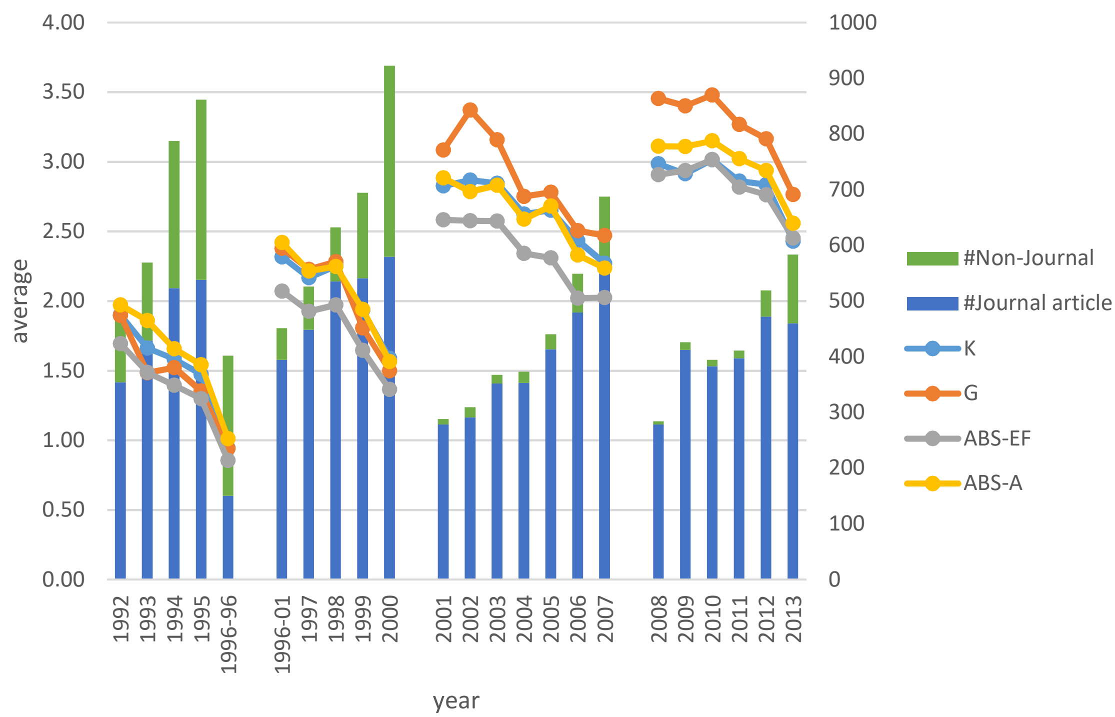
Appendix 1.C: Rating

In this study, we use 4 references to rate outcomes. The first rank named as “K” in our database is based on “Keele List”, which is wrote by Tim Worrall (2006 version) and covers 442 journals. The second rank named as “G” is created by Ritzberger K. (2008), which includes 175 journals. The third and fourth ranks come from “Academic Journal Guide” of ABS (2008) and ABS (2015). “Academic Journal Guide” classify journals into several subjects, such as Economics, Finance, Management and so on. ABS (2015) includes 1401 journals in total, and there are 319 journals categorized to economics and 105 journals to finance.

We use “K” and “G” rank to rate all submission from RAE 1992 to REF 2014. Meanwhile, considering on the disappearing of some journals, devaluing of some journals and quality promotion of some quality, we use ABS (2015) rank to rate REF 2014 and use ABS (2008) rank to rate RAE 1996, RAE 2001 and RAE 2008 so as to be close to the evaluation to journal made by staff who worked in the early time. Since ABS rank categories journals into several subjects which all relate to social science, we combine journals of category Economics and Finance category as “ABS-EF” rank and use journals in all categories as “ABS-A” rank.

Then in all rating, we always use 4 ranks to rate journals. If a journal cannot find in one rank, then we rate this journal as “n”, and the value is 0.

Appendix 1.D. The average rating of outputs by years



 # Staff submitted in RAE2001, RAE2008 or REF2014 come from the HEIs which submitted to the economics panel at least once in those census period, and staff submitted in 1996 only come from the HEIs which submitted to the economics panel in both RAE1996 and RAE2001

 # Working paper is rated as 0.

Appendix 1.E. Results on academics submitted by Five-Top economics schools in the former exercises

Table 1.A.1 *Comparison between the earliest output and the worst output (Not worse)*

	Expected probability / Actual proportion			
	K	G	ABS-EF	ABS-A
RAE96-RAE01	84%/95%***	83%/93%**	85%/96%***	85%/95%**
RAE01-RAE08	86%/93%	83%/93%**	86%/95%**	89%/94%
RAE08-RAE14	82%/91%	78%/94%***	87%/95%*	88%/94%

****P-value in one-side Fisher exact test is smaller than 0.01*
*** P-value in one-side Fisher exact test is smaller than 0.05 and larger than 0.01*
 # Staff submitted at least one output in the economics panel in the former exercise and submitted at least one output in economics or management panel in the following exercise
 # Staff in RAE1996 only come from the HEIs which submitted to the economics panel in both RAE1996 and RAE2001.

Table 1.A.2 *Comparison between the earliest output and the worst output (Better/Equal)*

	Expected probability / Actual proportion			
	K	G	ABS-EF	ABS-A
RAE96-RAE01	70%/78%	71%/77%	70%/76%	71%/76%
RAE01-RAE08	68%/80%	73%/84%	72%/82%	74%/86%*
RAE08-RAE14	56%/70%*	63%/75%*	66%/77%	64%/80%**

*** P-value in one-side Fisher exact test is smaller than 0.05 and larger than 0.01*
** P-value in one-side Fisher exact test is smaller than 0.1 and larger than 0.05*
#Staff submitted at least one output in the economics panel in the former exercise and submitted at least one output in economics or management panel in the later exercise
#Staff in RAE1996 only come from the HEIs which submitted to the economics panel in both RAE 1996 and RAE 2001

Level-k Analysis on Dynamic Game with Incomplete Information and Uncertainty: An Experimental Study

2.1 Introduction

Level-k analysis, first introduced by Stahl and Wilson (1994, 1995) and Nagel (1995), is a powerful non-equilibrium model to explain boundedly rational behaviours. A standard level-k analysis assumes that a level-k (k>=1) player best responds to his belief. That is, his rival behaves as a level-(k-1) player, and a level-0 player follows a simply non-strategic decision rule, i.e., randomly choosing.

A series of experimental studies demonstrate the prominent performance of level-k analysis on modelling behaviours deviated from equilibrium predictions on many strictly competitive "simple" mutual games. Normal games with complete information and certainty are studied by Costa-Gomes et al. (2001), Costa-Gomes and Crawford (2006) and Crawford and Iriberri (2007a). Normal games with incomplete information and certainty are investigated by Crawford and Iriberri (2007b) and Brocas, et al. (2014). Dynamic games with complete information and certainty are explored by Burchardi and Penczynski (2010), Kawagoe and Takizawa (2012) and Ho and Su (2013). Moreover, dynamic games with incomplete information and certainty are discussed by Kawagoe and Takizawa (2009).

Currently, there are rarely experimental studies on the level-k analysis in dynamic games with incomplete information and uncertainty. Incomplete information and uncertainty are two common features in reality, such as in the stock market and insurance market. The primary purpose of the study in this chapter is to enrich the application of the level-k analysis by exploring the performance of the level-k analysis in a specific game with incomplete information and uncertainty. In order to examine the performance of the level-k analysis thoroughly, the experimental design in this study includes both the direct-response method and the strategy method. The direct-response method is the usual design in a dynamic game, and the strategy method reveals more information on the players' intended behaviours.

Furthermore, the other purpose of the two-method design is to investigate the effect of the experimental description on players' strategic reasoning. A natural expectation is that the strategy method induces players to make more thoughtful and comprehensive decisions. However, Brandts and Charness (2011) summarised a series of experimental studies on the two-game described methods and reported that a majority of experimental studies do not find significant differences of behaviours between these two methods. Though some studies found different behaviours between the two methods, the differences mostly appeared on punishment and cooperation behaviours, as mentioned in Brandts and Charness (2003), Brosig et al., (2003), Murphy et al. (2006) and Murphy et al. (2007). And the studies related with strategic behaviours show no significant difference between behaviours in the two methods, e.g., studies on the repeated prisoner dilemma by Reuben and Suetens (2012), Centipede Games by Kawagoe and Takizawa (2012) and Garcia-Pola et al. (2016).

Gambling games in casinos, such as Black Jack and Texas hold'em Poker, usually include incomplete information and/or uncertainty. Instinctively, players think strategically facing these games (or think that the rules they follow are strategic). Thus, it is accessible and reasonable to first extend the level-k analysis on games similar to the ones found in Casinos. Therefore, the game designed in this study is a two-stage two-person dynamic game with incomplete information and uncertainty generalised from Black Jack.

In a complex game, it is neither easy nor necessary for players to employ strategic thinking. Therefore, some alternative non-strategic models are introduced to compete with the strategic thinking models (the level-k analysis and the equilibrium analysis). Referring to the classification in CG's work (Costa-Gomes et al., 2001) on strategic and non-strategic thinking types, players' thinking types are separated into two categories, non-strategic thinking category I (C1) and strategic thinking category II (C2). These categories are based on whether players utilise their opponents' incentive to predict their actions and best respond to them. To elaborate, C1 players either hold non-strategic beliefs (no belief or a uniform belief) on their opponents' actions or cannot respond best to their beliefs. Category I (C1) as non-strategic thinking includes four types: Level-0 (L0), Level-1 (L1), Safety type (SA), and Expected value calculation (Exp). Paralleled with C1, Level-k (k>1, e.g. L2), Equilibrium (Eq) and other Level-k analyses which best respond to SA or Exp (e.g., L1(SA) or L1(Exp)), are classified into Category II (C2) as strategic thinking types. Players in C2 hold their specific beliefs and make strategies which respond best to their beliefs. Furthermore, C1 players do not consider that their actions have effects on their opponents' strategies, while C2 players apply Bayes' Rule in their strategies in the games.

Some types are the foundations of other types, e.g. L0, which exists in the L1 player's belief. In this study, an additional step where the players state their beliefs is added in the experimental design. This additional step provides extra information to investigate players' thinking types. Our approach of the belief elicitation adheres to M&G's proper scoring rule (Costa-Gomes and Weizsacker, 2008). Players report their estimations on their opponents' actions and are rewarded for the accuracy of their stated beliefs according to a quadratic loss function.

Corresponding to the two purposes of the experiment, we obtained two main findings. One of the main findings indicates that around half of the players behave as strategic thinking types, and among strategic players, level-k thinking is dominant. This finding is consistent with previous experimental results. The other main finding implies that the strategy method impedes strategy thinking. In other words, more players behave as strategic thinking types in the direct-response method treatment than in the strategy method treatments. This finding is contrary to most of the previous experimental results on strategic behaviours (Reuben and Suetens in 2012, Kawagoe and Takizawa in 2012 and Garcia-Pola et al. in 2016).

The upcoming section (Section 2.2) describes the game used in the experiments. Section 2.3 demonstrates a series of theoretical analyses on the strategies and beliefs of the game while Section 2.4 reports the experimental design in detail. Section 2.5 further discusses the non-parameter and the parameter econometrical analysis on the experimental data. Section 2.6 is the conclusion.

2.2 Game design

Black Jack (21 points) and Texas hold'em poker are popular games in Casino. Players usually need strategic thinking and luck to win. In our experiment, we simplify Black Jack and Texas hold'em poker to a two-person dynamic game with two stages.

Two players play the game. One is the First-Mover (FM), and the other one is the Second-Mover (SM). At the beginning of the game, each player gets two cards, 1st card (public card) and 2nd card (private card). There is a number, randomly drawn from 1 to 4, printed on each card. The number on the 1st card is public information, which is known by two players, and the number on the 2nd card is private information, which only can be known by the card owner. These 4 cards identify a specific game, which is one of 256 possible combinations. After both players get their cards, the FM chooses his action first and next the SM chooses her action. Actions are either to call a 3rd card or not to call a 3rd card. If a player chooses to call a 3rd card, this player will get a 3rd card privately (that is, only the cardholder could see the number on this card), on which the number is also randomly drawn from 1 to 4.

After both players choose their actions, the sum of the numbers on each player's cards will be calculated. If a player chooses to call a 3rd card, then the sum of this player consists of 3 numbers (including the number on the 3rd card). If a player does not choose to call a 3rd card, then the sum of this player consists of 2 numbers. The winner will be picked out according to the following rules:

a) If Sum(FM) < Sum(SM) $\leq$ 9, SM wins;

b) If Sum(SM) < Sum(FM) $\leq$ 9, FM wins;

c) If Sum(SM) $\leq$ 9 < Sum(FM), SM wins;

d) If Sum(FM) $\leq$ 9 < Sum(SM), FM wins;

e) If 9 < Sum(FM) and 9 < Sum(SM), both lose;

f) If Sum(SM) = Sum(FM) $\leq$ 9, the winner is randomly chosen.

According to the winning rules, there is an obviously weakly dominant strategy in some specific games, which weakly dominates all of the player's other strategies. That is, when the sum of 1st and 2nd cards is smaller than or equal to 5, "Not call a 3rd card" is always weakly dominated by "Call a 3rd card". In this scenario, "Call a 3rd card" always enhances the winning probability but never leads the sum of all three cards larger than 9.

2.3 Theoretical analysis

This section discusses a series of theoretical strategies that non-strategic and strategic players follow, and beliefs that non-strategic and strategic players build their strategies based on.

Referring to the game design, we use FN1, FN2, SN1 and SN2 to represent, respectively, the number on the 1st card of the FM, the number on the 2nd card of the FM, the number on the 1st card of the SM, and the number on the 2nd card of the SM. Then the information set of the FM is $I^F = \{FN1, FN2, SN1\}$ and the information set of the SM is $I^S = \{SN1, SN2, FN1, FA\}$. If the FM calls a 3rd card, the SM updates her information set to $I^S = \{SN1, SN2, FN1, FA = C\}$ after knowing the FM's action (or conditional on the FM's action as call a 3rd card). If the FM does not call a 3rd card, the SM updates her information set to $I^S = \{SN1, SN2, FN1, FA = N\}$ after knowing the FM's action (or conditional on the FM's action as not call a 3rd card).

2.3.1 Equilibrium analysis

In our game, the FM's strategy space includes 2^{64} strategies and the SM's strategy space includes 2^{128} strategies before they know two public cards[39]. To simplify the procedures of finding equilibrium(s), we reduce the integrated extensive game to specific normal-form games. After both players know their two public cards in a specific game, the FM only faces possibilities that are the four possible numbers on his 2nd card. Then the strategy space of the FM in the specific games reduces to 2^4=16 strategies, which could be represented as (AAAA). Meanwhile, the strategy space of the SM reduces to 2^ (4*2) =256 strategies, which could be represented as (AAAA, AAAA).[40]

Then, each specific normal-form game with certain two 1st cards has a payoff matrix. To lessen the computation of payoffs in each matrix, a trim of each specific game's strategy space is conducted by excluding the dominated strategies. When the sum of the 1st card and the 2nd card of a player is smaller than or equal to 5, "No Call" is always weakly dominated by "Call", such as that if the 1st card is 2, "No Call" is a weakly dominated strategy when the 2nd card is 1, 2, or 3. Thus, the player should always ask for a 3rd card when his 2nd card is 1, 2, or 3. In this case, the trimmed strategy space of the player only has two possibilities, {(CCCC), (CCCN)}. By performing one round of elimination of weakly dominated

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[39] Before they know both showing cards, the information set of FM, $I^F = \{FN1, FN2, SN1\}$, has 4*4*4=64 combinations and the information set of SM, $I^S = \{SN1, SN2, FN1, FA\}$, has 4*4*4*2=128 combinations. In each combination, there are two choices of each player. Thus, FM has 2^{64} strategies and SM has 2^{128} strategies.

[40] "AAAA" indicates the FM's strategy combinations given the four possible numbers on his 2nd card. "A" in the first entry denotes the FM's action when the number on the 2nd card is "1", either "C" as "Call" or "N" as "No Call". "A" in the second entry denotes the FM's action when the number on the 2nd card is "2". "A" in the third entry denotes the FM's action when the number on the 2nd card is "3". And "A" in the last entry denotes the FM's action when the number on the 2nd card is "4". In the same way, "AAAA, AAAA" indicates the SM's strategy combinations given the four possible numbers on her 2nd card and her FM's choices. "A" in the first entry denotes the SM's action when the number on her 2nd card of SM is "1" and her FM's action is "Call". "A" in the second entry denotes the SM's action when the number on her 2nd card of SM is "2" and her FM's action is "Call". "A" in the third entry denotes the SM's action when the number on her 2nd card of SM is "3" and her FM's action is "Call". "A" in the fourth entry denotes the SM's action when the number on her 2nd card of SM is "4" and her FM's action is "Call". The entries after the comma, "A" in the fifth entry, denotes the SM's action when the number on her 2nd card of SM is "1" and her FM's action is "No Call".

strategies[41], the trimmed strategy space of each specific game is reduced (to as shown in *Appendix 2.1*).

Then, for any pair of the strategies of the two players in the payoff matrix, the payoff of each player is represented by the expected winning probability. To complete the payoff matrix of each specific game, we need to compute the expected winning probability of each pair of the strategies from each trimmed strategy space. (Full procedure of computing expected winning probabilities is described in Appendix 2.2.)

After figuring out the payoff matrix of a specific game, we use 2 to 5 steps of iterative elimination of (weakly) dominated strategies for both players to find the equilibrium/ equilibria of the game. For example, the payoff matrix of the game $\{FN1 = 3, SN1 = 2\}$ is below (*Table 2.F in Appendix 2.2*). (CCCN) is an obvious dominant strategy, as its wining probability is always higher than the other 3 possible strategies given each strategy of the SM. After that, by checking the SM's possible strategies, (CCCC, CCCC) is also an obvious dominant strategy. Then the equilibrium in the red box in this specific game is found by 2 steps of iterative elimination of (weakly) dominated strategies.

Table F*. FN1=3, SN1=2*

SM-strategy (AAAA, AAAA) FM-strategy (AAAA)	CCCC, CCCC	CCCC, CCCN	CCCN, CCCC	CCCN, CCCN
CCCC	(0.5000 0.4688)	(0.5000 0.4688)	(0.5508 0.2500)	(0.5508 0.2500)
CCCN	(0.5664 0.5469)	(0.6211 0.3906)	(0.6016 0.3438)	(0.6563 0.1875)
CCNC	(0.3867 0.5859)	(0.4648 0.5234)	(0.4023 0.4375)	(0.4805 0.3750)
CCNN	(0.4531 0.6172)	(0.5859 0.3984)	(0.4531 0.4688)	(0.5859 0.2500)

We find that 14 games have unique equilibriums with 2 to 5 steps of iterative elimination of (weakly) dominated strategies, while the other 2 games[42] have two equilibria,

[41] There is no dominant strategy in any specific game.
[42] The combinations of these two games on (FN1, SN1) are (3,3) and (4,3).

in which the FM's action is the same, and the SM's actions yield the same payoff. The summaries in *Table 2.1* and *Table 2.2* show the equilibrium strategies of the FM and the SM in each specific game.

Table 2.1 *Strategy Matrix of Eq FM*

SN1 / FN1+FN2	1	2	3	4
2	Call	Call	Call	Call
3	Call	Call	Call	Call
4	Call	Call	Call	Call
5	Call	Call	Call	Call
6	Call	Call	Call	Call
7	No Call	No Call	No Call	Call
8	No Call	No Call	No Call	No Call

Table 2.2 *Strategy Matrix of Eq SM*

FN1 / SN1+SN2	1	2	3	4
FA=N:				
2	Call	Call	Call	Call
3	Call	Call	Call	Call
4	Call	Call	Call	Call
5	Call	Call	Call	Call
6	Call	Call	Call	Call
7	No Call	No Call	Call/No Call[43]	Call
8	No Call	No Call	No Call	No Call
FA=C:				
2	Call	Call	Call	Call
3	Call	Call	Call	Call
4	Call	Call	Call	Call
5	Call	Call	Call	Call
6	Call	Call	Call	Call
7	No Call	No Call	No Call	Call/No Call[44]
8	No Call	No Call	No Call	No Call

[43] When L2 SM faces {SN1=3, SN2=4, FN1=3, FA=N}, the winning probability of "Call" is equal to the winning probability of "No Call". When L2 SM faces {SN1=4, SN2=3, FN1=3, FA=N}, the winning probability of "Call" is lower than the winning probability of "No Call".

[44] When L2 SM faces {SN1=3, SN2=4, FN1=4, FA=C}, the winning probability of "Call" is equal to the winning probability of "No Call". When L2 SM faces {SN1=4, SN2=3, FN1=4, FA=C}, the winning probability of "Call" is lower than the winning probability of "No Call".

2.3.2 Level-k analysis

The theoretical study (Rothschild et al., 2012) combined level-k analysis with the Bayesian approach to model player's behaviours in a continuous-strategy-space two-stage dynamic defend-attack game with incomplete information and uncertainty.

Level-k analysis models human being's behaviour as a hierarchy and the strategies of higher level (Lk) players respond best to their one level lower (Lk-1) players' strategies. In the level-k analysis, high level players generally anchor their beliefs in L0 player, who chooses randomly from the strategy set. That is, L0 does not use his opponent's information to choose action. Furthermore, L0 does not care about the information he owns. This implies that L0 has a chance to choose dominated strategies. Since L0 player's strategy implies that he does not fully understand the winning rules of the game, L0 is just treated as a kind of belief which L1 player holds.

Following CG's work, L1 is called naïve categorised into non-strategic types (C1). In our games with incomplete information and uncertainty, L1 uses both his public and private information and his opponent's public information to make his choice, but L1 assumes that his opponent, L0, does not understand the games. That is, L1 does not think that the strategy of his opponent is related to his opponent's information set and incentive of winning. The strategy that L1 player follows is to choose the action which has a higher winning probability given two public 1st cards and his private 2nd card. L1 player assumes the number on his opponent's 2nd card has 25% as 1, 2, 3 or 4 and his opponent has 50% to calls a 3rd card. Furthermore, Lk (k=2, 3…) players categorised into strategic types (C2) share the same strategy matrixes with Eq player in our games, but L2 player holds a different belief on his opponent with Eq's. In the following, we explain the strategy matrixes used by Lk (k=1, 2) and beliefs how Lk (k=1, 2) generalises in detail.

Level-k analysis in our game is based on three assumptions:

Assumption 1: All players are risk-neutral and maximise their expected earnings except L0.

Assumption 2: Players whose levels are above 0 hold belief that L0 player randomly chooses between "Call" (call a 3rd card) and "No Call" (not call a 3rd card).

Assumption 3: Level-k players utilise Bayes' Rule for k=2, 3, …

2.3.2.1 L1 player

Based on *Assumption 2*, L1 player believes that his opponent is L0 player. That is, if L1 player is the FM, then he chooses actions without caring about whether his actions will affect his opponent's actions. If L1 player is the SM, then she chooses actions without caring about the information implied by her opponent's actions. Based on *Assumption 1*, L1 player chooses an action which leads to a higher probability to win the game. When the L1 player is the FM, he predicts the SM chooses "Call" as 50% possibility. When the L1 player is the SM and she knows or equates with knowing the FM's action, she understands that her opponent, FM, randomly selects actions and her opponent's 2nd card is uniformly distributed from 1 to 4. (The detailed procedure of the analysis on the L1 players' strategies is described in *Appendix 2.3*.)

Table 2.3 and *Table 2.4* present the strategy matrixes of L1 FM and L1 SM. Since L1 FM does not think his action has an effect on SM's action and L1 SM also does not think FM's action implies extra information, L1 players do not apply Bayes' Rule on their strategy.

***Table 2.3**. Strategy Matrix of the L1 FM*

SN1 / FN1+FN2	1	2	3	4
2	Call	Call	Call	Call
3	Call	Call	Call	Call
4	Call	Call	Call	Call
5	Call	Call	Call	Call
6	No Call	Call	Call	Call
7	No Call	No Call	No Call	Call
8	No Call	No Call	No Call	No Call

Table 2.4. *Strategy Matrix of L1 SM*

SN1+SN2 \ FN1	1	2	3	4
FA=N:				
2	Call	Call	Call	Call
3	Call	Call	Call	Call
4	Call	Call	Call	Call
5	Call	Call	Call	Call
6	No Call	No Call	Call	Call
7	No Call	No Call	No Call	No Call
8	No Call	No Call	No Call	No Call
FA=C:				
2	Call	Call	Call	Call
3	Call	Call	Call	Call
4	Call	Call	Call	Call
5	Call	Call	Call	Call
6	Call	Call	Call	Call
7	No Call	No Call	Call	Call
8	No Call	No Call	No Call	No Call

2.3.2.2 L2 player

In the level-k analysis, L2 player knows L1 player's strategies (in *Table 2.3* and *Table 2.4*), so L2 player makes the best response to L1 player's strategy. In the games, if L2 player is the FM, then he knows that his L1 opponent chooses actions based on his actions. If the L2 player is the SM, she knows that her L1 opponent chooses actions based on I^F. L2 SM chooses actions after she knows her FM's action. Then using Bayes' rule, L2 SM updates her prior distribution, which is the same as L1's prior distribution, to the posterior probability on the distribution of FN2 according to the FM's action.

For example, in a scenario of {FN1=3, SN1=1, SN2=3, FA=C}, before L2 SM knows her FM's action, the prior distribution of FN2 is a uniform distribution from 1 to 4. However, after L2 SM is informed that her FM's action is "Call", L2 SM updates her belief to the posterior distribution of FN2 based on Bayes' Rule by checking *Table 2.3*. As FN1=3, then the {FN1+FN2} only could be 4, 5, 6, or 7. Meanwhile, SN=1, then the first column of *Table 2.3* shows that there are only two cases in which L1 FM calls a 3rd card: either {FN1+FN2=4} or {FN1+FN2=5}. Then L2 SM knows L1 FM's FN2 only could be 1 or 2. The posterior distribution of FN2 of the L1 FM is 50% chance to be 1 or 2 and 0% chance to be 3 or 4.

L2 player chooses an action with a high winning probability between "Call a 3rd card" and "Not call a 3rd card", similar to L1 player. (The procedure of computing the winning probability is described in *Appendix 2.4*.) *Table 2.1* shows the strategy matrix of L2 FM and *Table 2.2* shows the strategy matrix of L2 SM in each specific game. (As the strategy of L2 players in each specific game is coincident with the equilibrium)[45].

2.3.2.3 Level-k thinking and equilibrium

Herbert and Heitmann (2014) apply the level-k analysis on a two-stage Cournot game and show that when k goes to infinite, the results converge to sub-game perfect Nash equilibrium. In our game, the equilibrium in each specific game deduced by iterative elimination of (weakly) dominated strategies is (are) coincident with the equilibrium reached by level-3 player converged to by level-k analysis.

That is, after knowing L2 players' strategy matrix (*Table 7* and *Table 8*), L3 players make their best response to L2 players' strategy just as L2 players do. The result shows that the strategy matrix of L3 player is the same as the one of L2 player. Furthermore, the strategy matrix of L4 player is the same as the one of L3 player by conducting the same procedure. That means, given L3 player's strategy matrix, L4 player has no incentive to deviate from this L4 strategy matrix. Meanwhile, since L4 strategy matrix is the same as L2 strategy matrix, given L4 (L2) strategy matrix, L3 player has no incentive to deviate from his L3 strategy matrix. Then we get an Equilibrium, which is reached by L3 player.

Generally, based on *Assumption 1* and *Assumption 2*, there are a series of predictions on other level players:

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[45] Based on the previous deducing, the L2 players' and Equilibrium players' beliefs could be represents as described in the Appendix 2.4.

Prediction 1: L1 FM does not think his actions affect his opponent's actions, and L1 SM takes her opponent's actions into account, but L1 SM does not think her opponent's actions include meaningful information. That is, L1 players do not use Bayes' rule.

Prediction 2: L2 FM knows his opponent takes his actions into account, and L2 SM not only takes her opponent's actions into account but also applies Bayes' Rule to update her belief on her opponent's private information according to her opponent's actions.

Prediction 3: L3 plays Equilibrium, which L2's strategy is coincident with.

Prediction 3 gives us a new view on how to find equilibrium on games with a large strategy space, which is that using level-k analysis could simplify the procedure of finding out an equilibrium.

2.3.3 Safety type (SA) and Expected value calculation type (Exp)

SA player in our games is specified as a player who always chooses actions which have no chance directly to lead losing by himself without considering the opponent's actions. That is, SA player only calls a 3rd card when the sum of his 1st card and 2nd card is smaller than or equal to 5. This means that SA player never plays dominated strategies and only care his own information when he chooses actions but never cares his opponent's public information. Following this strategy, SA player has no chance to exceed the upper bound "9". This brings SA player no chance to regret his actions. Then all possible scenarios in which SA player loses games are due to his opponent's actions. Since SA player does not take account his opponent's information into his strategy, theoretically SA player has no specific belief on his opponent's action and has a uniform prior distribution on his opponent's 2nd card.

Exp player represents a player who chooses actions which have higher expected value (winning probability) among all selectable actions without considering opponents' actions. That is, Exp player calculates the expected sum of 3 cards if to call a 3rd card and compares with 9. If the sum is smaller or equal than 9, Exp calls a 3rd card. Otherwise, Exp player does not call a 3rd card. The expected value of a 3rd card is 2.5, e.g. (1+2+3+4)/4. That is, if the sum of his 1st card and 2nd card is <=6, Exp player will call a 3rd card. If the sum of his 1st and 2nd card is 7 or 8, the expected sum will be 9.5 or 10. In these cases, the expected sum is over 9. Then Exp player will not call a 3rd card. Similar with SA, the information Exp player uses in his strategy only relates to his own cards but not to his opponent's 1st card, and then theoretically Exp player also has no specific belief on his opponent's action and has a uniform prior distribution on his opponent's 2nd card.

Furthermore, Level-k analysis in our game is based on *Assumption 2* that L0 chooses actions randomly. Besides, if we relax *Assumption 2* to let Exp or SA as L0(Exp) or L0(SA), then the L1(Exp) or L2(SA), which is two-step best response to Exp or SA, is also coincided with Eq strategy. L1(Exp), L1(SA)[46] and L2(SA) are also strategic types (in C1). L1(Exp), L1(SA) and L2(SA) follow Bayes' Rule to build up their beliefs on their opponents' actions and their opponents' private information. Moreover, L1(Exp), L1(SA) and L2(SA) know their actions affect their opponents' actions. The beliefs that L1(Exp), L1(SA) and L2(SA) build also follows formulas in *Appendix 2.4* from a) to c).

2.4. Experimental design

In this section, we describe the procedure of the experiment in detail and explain the theoretical predictions for the games.

2.4.1 Overview

Our experiment consisted of two treatments: direct-response treatment (DRT) and strategy method treatment (SMT). Each treatment had three sessions. All subjects (54

[46] See *Appendix 2.5*. L1(SA) is coincident with Exp on FM's strategy and Exp is a subset of L1(SA) on SM's strategy. So L1(SA) and Exp cannot be separated by actions but their beliefs on their opponents are still different, and then L1(SA) and Exp could be separated by stated beliefs.

subjects in DRT and 54 subjects in SMT) were students and employees from the University of St Andrews. The experiment took place in 2018.

Each session includes 12 games. At the beginning of a session, subjects were randomly signed to roles, FM or SM, which stayed the same in 12 games. Following CG's work, to avoid repeated-game effect and learning apart from introspective transfer learning, subjects got no feedback between games until 12 games finished, and FM and SM randomly paired anew after each game.

To identify different types of subjects, we select 12 specific games based on some rules shown in *Table 2.5* from 256 possibilities of card combinations:

Table 2.5 *Games*

	FM		SM	
Games	1st Card	2nd card	1st Card	2nd card
1	2	4	1	2
2	4	2	4	3
3	4	4	3	4
4	1	2	2	1
5	4	3	4	3
6	3	1	3	4
7	1	1	3	2
8	3	4	3	4
9	3	3	1	2
10	4	2	1	1
11	3	3	1	1
12	4	1	4	3

As numbers on 1st cards are public information, whether to appear as a uniform distribution does not affect subjects' beliefs, and then there was no constraint on numbers on 1st cards. However, the numbers on 2nd cards are private information, which is related to subjects' beliefs, and thus, to build up a proper belief on the distribution of numbers on 2nd cards, each number (1, 2, 3 or 4) appears three times as the number on 2nd card in 12 games, which was known by subjects. Since a player only has two optional actions, it is highly possible that more than one type shares the same optimal action in a game. Then to separate the optimal actions and beliefs of different types (e.g. Exp, L1 and L2) as much as possible, these 12 games were picked out based on the strategy spaces of types. Furthermore, the order of 12 games was fixed across sessions, which was designed to avoid the SM inferring the number on the FM's 2nd card under the assumption the FM played Eq.

In each game, the FM chooses his action first, and next stated his belief that the SM would call a 3rd card after he chooses his action. Then in the DRT, the SM first states her belief that the FM would call a 3rd card before she chooses her action without knowing the FM's action and next chooses her action after knowing the FM's action. After that, the SM states her belief that the number on the FM's 2nd card was 1, 2, 3 or 4. In SMT, the SM first states her belief that the FM will call a 3rd card before she chooses her action without knowing the FM's action and next the SM chose actions twice, one for each of the FM's feasible actions. After that, the SM states her belief that the number on the FM's 2nd card was 1, 2, 3 or 4.

2.4.2 Belief elicitation

Since players' strategies rely on their beliefs on their opponents' strategies, stated beliefs in the experiment also could be used to identify subjects' types. To elicit subjects' beliefs properly, the rules used in the experiment is a quadratic scoring rule (Costa-Gomes and Weizsacker, 2008), which is incentive compatible under risk-neutral expected utility.

The stated belief that the opponent will call a 3rd card should be an integral number between 0 to 100. If a subject states his belief as $b1$, the earnings of the stated belief are determined as following:

If his opponent chooses to call a 3rd card,

$$earnings\ (£) = \frac{400 - 0.04 \times (b1 - 100)^2}{100}$$

If his opponent does not choose to call a 3rd card,

$$earnings\ (£) = \frac{400 - 0.04 \times (b1)^2}{100}$$

The stated beliefs that the number on FM's 2nd card is 1, 2, 3 or 4 should be four integral numbers between 0 to 100 and the sum of these four integral numbers should be 100. If a subject states her belief as $b2(1)$, $b2(2)$, $b2(3)$ and $b2(4)$, the earnings of the stated belief are determined as following:

$$earnings\ (£) = \frac{400}{100} - \frac{0.02 \times (b2(1) - A)^2}{100} - \frac{0.02 \times (b2(1) - B)^2}{100} - \frac{0.02 \times (b2(1) - C)^2}{100} - \frac{0.02 \times (b2(1) - D)^2}{100}$$

If the number on FM's 2nd card is 1, then A=100, B=C=D=0; If the number on FM's 2nd card is 1, then B=100, A=C=D=0; If the number on FM's 2nd card is 1, then C=100, A=B=D=0; If the number on FM's 2nd card is 1, then D=100, A=B=C=0.

2.4.3 Strategy and belief in specific games

To identify different types, a series of games are picked out from 256 possibilities, which lead various paths of actions and beliefs across different types. For the FM, Game 4,6,7 and 12 have dominated strategies, which are used to check if subjects understand the winning rules; for the SM, Game 1,4,7,9,10 and 11 have dominated strategies, which are used to check if subjects understand the winning rules. *Table 2.6a* represents the FM's theoretical actions of different types choose in each game and *Table 2.6b* represents the SM's theoretical actions of different types choose in each game.

Table 2.6a. *FM's Actions of different types in games*

Game	SA	Exp/L1(SA)	L1	L2/Eq/L1(Exp)
1	N	C	N	C
2	N	C	C	C
3	N	N	N	N
4	C	C	C	C
5	N	N	C	C
6	C	C	C	C
7	C	C	C	C
8	N	N	N	N
9	N	C	N	C
10	N	C	N	C
11	N	C	N	C
12	C	C	C	C

Note: C means "Call a 3rd card"; N means "Not call a 3rd card".

Table 2.6b. *SM's Actions of different types in games*

Game	SA/Exp	L1-C	L1-N	L2/Eq/L1(Exp)-C	L2/Eq/L1(Exp)-N
1	C	C	C	C	C
2	N	C	N	N	C
3	N	C	N	C/N	C
4	C	C	C	C	C
5	N	C	N	N	C
6	N	C	N	N	C/N
7	C	C	C	C	C
8	N	C	N	N	C/N
9	C	C	C	C	C
10	C	C	C	C	C
11	C	C	C	C	C
12	N	C	N	N	C

*Note: "L1-C" and "L2/Eq/*L1(Exp)*-C" in the second row mean that her FM called a 3rd card; "L1-N" and "L2/Eq/*L1(Exp)*-N" in the second row mean that her FM did not call a 3rd card. "C/N" means the expected winning probabilities of two actions are the same.*

If a player holds a belief on his opponent, *Table 2.7* represents the possible beliefs players could hold. SA play means a player thinks his opponent behaves like SA; Exp play means a player thinks his opponent behaves like Exp; L1 means an L1 player thinks his opponent behaves like L0; L2 means an L2 player thinks his opponent behaves like L1; L3/Eq means an L3/Eq player thinks his opponent plays equilibrium.

If a player thinks his opponent plays as SA, he knows his opponent only calls a 3rd card when the sum of his opponent's 1st and 2nd cards is smaller than or equal to 5. Then considering his opponent's 1st card, the player needs to infer which number(s) on his opponent's 2nd card can lead his opponent to call a 3rd card. Since each number appears with 25% possibility, the player can calculate his belief. To get belief on Exp Play follows the same procedure as SA Play. The L1 player always predicts that L0 chooses each action with 50% probability.

Even L2 plays the same strategy with L3 and Eq, L2 and L3/Eq have different beliefs. L2 predicts his opponent plays as L1, but L3 and Eq predict their opponents play equilibrium (or L2 which is coincided with equilibrium), which is different from L1's strategy. Based on formulas a) b) c) in 3.3.2, L2 or L3/Eq could infer his belief on his opponent based on the public information and the strategy matrix his opponent should follow.

2.4.4 Procedure and payment

Subjects first read the instructions (in *Appendix Instructions*) on the experiment, and next had to pass two understanding tests (in *Appendix Understanding Test*) of the game and belief elicitation rule. Failure leads to dismissal. After that, left subjects were signed as the FM and the SM randomly and played three different practice periods without feedback. After 12 games, subjects took the bomb task (Crosetto & Filippin, 2013) on risk aversion (see *Appendix Instruction on Bomb Task & CRT*) and Cognitive Reflection Test (CRT) (Frederick, 2005) in 5 minutes (see *Appendix CRT*[47]).

[47] CRT includes three questions. In our experiment, the order of three questions are randomly determined in each session.

Table 2.7. *Beliefs of different types in games*

Game	FM							SM				
	SA Play	Exp play	L1	L2-C	L2-N	L3/Eq-C	L3/Eq-N	SA Play	Exp play	L1	L2	L3/Eq
1	100	100	50	100	100	100	100	75	100	50	75	100
2	25	50	50	75	50	50	75	25	50	50	75	75
3	50	75	50	100	75	87.5	75	25	50	50	50	50
4	75	100	50	100	75	100	100	100	100	50	100	100
5	25	50	50	75	50	50	75	25	50	50	75	75
6	50	75	50	100	75	75	87.5	50	75	50	75	75
7	50	75	50	75	50	75	75	100	100	50	100	100
8	50	75	50	100	75	75	75	50	75	50	75	75
9	100	100	50	100	100	100	100	50	75	50	50	75
10	100	100	50	100	100	100	100	25	50	50	25	50
11	100	100	50	100	100	100	100	50	75	50	50	75
12	25	50	50	75	50	50	75	25	50	50	75	75

Subjects were paid according to their actions, answers and chance as following. The fix payoff show-up fee was £4. The variable payoff includes four parts, prizes of games, earnings of belief, earnings of bomb task and earnings of CRT. The prize of a game was £4. That is, if the subject wins in a game, he could get £4. Otherwise, he could get £0. And 3 out of the 12 games were drawn for each subject to win prizes. For FM, 1 out of 12 games drawn for each subject was paid for the belief of whether her SM would call the 3rd card (Maximum pay £4). For SM, 1 out of 9 games (excluding three games for the prize) drawn for each subject was paid for beliefs and next 1 out of 2 beliefs of, whether FM called the 3rd card or the number on FM's 2nd card, was selected to be paid (Maximum pay £4).

2.5 Data Analysis

This section analyses the subjects' actions and beliefs in the experiment. First, we report the non-parametric analysis, which is the overview of results. In this part, the deviations from the equilibrium predictions (/L2 predictions) are examined and whether subjects' actions best respond to their stated beliefs is checked. Second, we present a parametric analysis. In this part, a series of maximum likelihood estimations of mixture type models are introduced to identify different thinking types. The MLE of the mixture type model with error-rates conducted by CG (Costa-Gomes, 2001) in Section 2.5.2.1 identifies 7 thinking types using action data. Then, the MLE of the mixture type model with payoff-sensitive conducted by CG&W (Costa-Gomes and Weizsacker, 2008) in Section 2.5.2.2 is generalised to identify stated beliefs on 5 belief types. Furthermore, by combining actions and beliefs, the MLE of the mixture type model with integrated payoff-sensitive and error-rates conducted by CG&C (Costa-Gomes and Crawford, 2006) in Section 2.5.2.3 identifies 9 thinking types. Section 2.5.3 discusses whether the subject's strategic think is related to the subject's cognitive reflection and the subject's risk attitude.

2.5.1 Non-parametric analysis

In this section, we report a series of statistic overviews on subjects' actions and beliefs comparing with theoretical predictions.

2.5.1.1 Overview of rationality

In our experiment, the games are grouped by whether there are dominated strategies in the games. The FM has the dominated action in the Game 4,6,7 and 12, "Not call a 3rd card", and the SM has the dominated action in the Game 1,4,7,9,10 and 11, "Not call a 3rd card". As discussed in Section 2.2, if a player fully understands the winning rules, he will never play the dominated action. Then, in the games with the dominated strategies, players should more easily comply with equilibrium than in the games without dominated strategies.

Table 2.8 reports the summary of players' rates of equilibrium compliance in the games with and without the dominated strategy. The rates in the table represent the proportions of actions which comply with equilibrium in the specific games. Players' compliance rates are similar across the roles and the treatments in the game with dominated strategies. However, the compliance rates show a significant difference between the games with and without dominated strategies within the roles and the treatments. Furthermore, the compliance rates also show significant difference across the roles within the treatments in the games without dominated strategies.

Table 2.8 *Overview of Actions in Equilibrium*[48]

	Game with Dominant Strategy		Game without Dominant Strategy		*Fisher exact test*
	%	Obs	%	Obs	
DRT					
FM	99.07%	(107/108)	83.33%	(180/216) 0	***
SM	97.53%	(158/162)	64.81%	(105/162) 0	***
Fisher exact test			***		
SMT					
FM	97.22%	(105/108)	82.41%	(178/216) 0	***
SM	97.84%	(317/324)	62.96%	(204/324) 0	***
Fisher exact test			***		

**** represents the p-value of Fisher exact test is smaller than 0.01.*

As games with dominated strategies can be used to check the understanding of players on the winning rules of the game, the other summary reported by *Table 2.9* investigates the deviation rate of actions and the deviation rate of beliefs. The deviated actions do not comply with equilibrium in the games with dominated strategies, and the deviated beliefs are the thought that their opponents will not comply with equilibrium in the games with dominated strategies (Not to call a 3rd card when the sum of the 1st and the 2nd card is smaller than or equal to 5). In a specific game, when a player is informed that his opponent's 1st card is 1, the player who believes his opponent understands the rules of the game should state the probability of his opponent to choose "Call a 3rd card" as 100%.

The right-part columns "Deviated Stated Belief" in *Table 2.9* shows the summary on deviations of stated beliefs. Furthermore, 21 FMs in DRT state all four beliefs equal to 100 out of 27 FMs. 20 SMs in DRT state both two beliefs equal to 100 out of 27 SMs. Moreover, 23 FMs in SMT state all four beliefs equal to 100 out of 27 FMs. 25 SMs in SMT state both two beliefs equal to 100 out of 27 SMs. *Table 2.9* shows that players hardly play dominated actions, which implies that players understand the rules of the game well. Also, most of the

[48] For the FM, there are 108 (27 subjects x 1 action x 4 games) observations in Game 4, 6, 7, and 12. For the SM in DRT, there are 162 (27 subjects x 1 action x 6 games) observations in Game 1,4,7,9,10 and 11. For the SM in SMT, there are 324 (27 subjects x 2 conditional actions x 6 games) observations in Game 1,4,7,9,10 and 11.

subjects believe that their opponents do not play dominated actions. Meanwhile, a series of tests on the comparisons of rates of the deviated actions and the deviated beliefs implies that subjects show less trust in their opponents' understanding of the winning rules.

Table 2.9. *Deviation Summary*

	Deviated Action		Deviated Stated Belief[49]		*Fisher exact test*
	%	Obs	%	Obs	
DRT					
FM	0.93%	(1/108)	19.44%	(21/108)	***
SM	2.47%	(4/162)	11.11%	(6/54)	**
SMT					
FM	2.78%	(3/108)	14.81%	(16/108)	***
SM	2.16%	(7/324)	7.41%	(4/54)	*

**** represents the p-value of Fisher exact test is smaller than 0.01.*
*** represents the p-value of Fisher exact test is smaller than 0.05.*
** represents the p-value of Fisher exact test is smaller than 0.1.*

2.5.1.2 Action and stated belief of FM

As the discussion in section 2.3 shows how beliefs affect players' strategies, in this section, we investigate how the FM responds to his belief in the 8 games without dominated actions. Since the FM states his belief on the SM's action after he chooses his action, the belief of the other opposite action without chosen could not be elicited. To investigate the relations between the chosen actions and the stated beliefs, we make two comparisons. One comparison is between the current probability of winning given the FM's action and his stated belief with the probability of winning if the FM chooses the opposite action (i.e. instead of calling the 3rd card, he would not call it) and SM calls the 3rd card. The other one is between the current probability of winning given the FM's action and his stated belief with the probability of winning if the FM chooses the opposite action (i.e. instead of calling the 3rd card, he would not call it) and SM does not call the 3rd card. If the current probability

[49] In the experiment, 1st card of the FM's opponent is 1 in Game 1, 9, 10 and 11; 1st card of the SM's opponent is 1 in Game 4 and 7. So the observations of the FM are 108 (27 subjects x 1 belief x 4 games) and the observations of the SM are 54 (27 subjects x 1 belief x 2 games).

of winning is larger in both comparisons, the current action is defined as “Best Action”. If the current probability of winning is smaller in both comparisons, the current action is defined as “Worst Action”. If the current probability of winning is larger in one comparison and smaller in the other comparison, the current action is defined as “Better Action”. Table 2.10 shows the summary of comparisons in both treatments.

Furthermore, we conduct these comparisons based on three possible beliefs. Uniform represents belief without Bayes’ Rule, in which actions do not include extra information. That is, when the FM predicts his SM’s action, the FM thinks that his SM’s action is independent with his SM’s 2nd card, which implies all 4 numbers are equally likely on the SM’s 2nd card. Exp and SA, which are the first and second most possible beliefs over 5 beliefs reported in *Table 2.17* in Section 2.5.2.2, represent beliefs with Bayes’ rule, in which information on the SM’s 2nd card is contained by the SM’s action.

For example, the Exp FM predicts his SM calls a 3rd card as 75% possibility when the FM does not call a 3rd card and his SM’s 1st card is 2. According to Bayes’ Rule, if his SM calls a 3rd card, then his SM’s 2nd card only could be randomly drawn from 1, 2 and 3. If his SM does not call a 3rd card, then his SM’s 2nd card must be 4. That means, when the FM calculates his probability of winning in this case, the sum of his SM’s 2nd card and 3rd card when his SM calls a 3rd card only has 6 possibilities but could never reach 8, and the distribution from 2 to 7 is {1/12, 2/12, 3/12, 3/12, 2/12, 1/12}. Comparing with Uniform belief, the sum of SM’s 2nd card and 3rd card when SM calls a 3rd card always has 7 possibilities, and the distribution from 2 to 8 is {1/16, 2/16, 3/16, 4/16, 3/16, 2/16, 1/16}.

Table 2.10 shows the summary of comparisons of each belief in both treatments. In general, comparisons across treatments have similar tendency out of 216 observations (8 games x 1 comparison x 27 FM in each treatment). Furthermore, 48 observations out of 216 are defined as the Best Action across three beliefs, and 9 observations are defined as the Worst Action in DRT; 47 observations out of 216 are defined as Best Action across three beliefs, and 10 observations are defined as Worst Action in SMT.

Table 2.10. *Actions Respond to Stated Beliefs*

	FM in DRT			FM in SMT		
	Uniform	Exp	SA	Uniform	Exp	SA
Best Action	82	59	73	86	57	80
Better Action	110	129	126	107	129	120
Worst Action	24	28	17	23	30	16

2.5.1.3 Action and stated belief of SM

In this section, we first examine whether the SM estimates of the FM's 2nd card's number consistent with Bayes' rule and next check if the actions of the SM best respond to his beliefs in 6 games without dominated strategies.

We measure the deviations of stated estimates from a specific rule as below:

$$Dev^k = \frac{1}{12}\sum_{g=1}^{12}\frac{1}{4}\sum_{i=1}^{4}[\frac{bp(i)_g}{100} - \frac{bp(i)_g^k}{100}]^2$$

$bp(i)_g$ represents the stated estimate that the number on FM's 2nd card is i in game g. $bp(i)_g^k$ represents the rule k's estimate that the number on FM's 2nd card is i in game g. We compare Dev^k across 5 rules and pick up the minimal Dev^k to represent the rule that subjects followed. As the number on player's 2nd card is drawn randomly from 1 to 4, the prior distribution should be {25, 25, 25, 25} when there is no more information on the number on FM's 2nd card. Then "Uniform" represents the rule, {25, 25, 25, 25}, in which players do not use Bayes' Rule to update their beliefs when they are informed of the FM's actions. The other 4 rules include Bayes' Rule. That is, players who follow one of these 4 rules update their information on numbers of the FM's 2nd card. "SA Play" means that the SM thinks her FM plays as SA type, so the SM who follows SA Play rule could update her belief based on the formula in Section 2.3.3). "Exp Play" represents the belief that the SM thinks her FM plays as Exp type. Similarly, "L1 Play" represents the belief that the SM thinks her FM plays as L1 and “Eq Play” represents the belief that the SM thinks her FM plays as Eq.

Table 2.11 shows the distribution of the rules which the SM subjects followed in both treatments. Most of the subjects follow Bayes’ Rule in both treatments and the most popular rules subjects follow is “Exp Play”.

Table 2.11 *Stated Beliefs’ Rules*

	Uniform	Bayes’ Rule			
		SA Play	Exp Play	L1 Play	Eq Play
DRT	4	2	12	1	8
SMT	3	4	16	2	2

Furthermore, we check whether subjects best respond to their beliefs by comparing the winning probability between actions, “Calla 3rd card” and “Not call a 3rd card”, in 6 games without dominated strategies. In DRT, there are 62 observations out of 162 observations (27 subjects x 6 games) which did not best respond to the corresponding beliefs. In SMT, there are 54 observations out of 162 observations which did not best respond to the corresponding beliefs. (The p-value of the chi-square statistic is 0.3539 between treatments.) There are no less than 1/3 cases in which subjects fail to choose the best responses to their beliefs. Comparing with the FM, whose “Worst Actions” chosen are less than 15% cases, it is more difficult for the SM to comply with their beliefs.

2.5.2 Parametric analysis

In this section, we discuss the findings of the maximum likelihood estimations of several finite mixture models using subjects’ actions and stated beliefs.

2.5.2.1 Models on the action data

In this section, we conduct a mixture type analysis with error-rates of actions of the FM and the SM in DRT and SMT, by which each thinking type should be identified using the subjects’ actions without any other individual information. Recall that the types we mentioned in Section 2.3 are divided into two categories, non-strategic types (C1), which includes SA, Exp, L0 and L1, and strategic types (C2), which includes L1(Exp), L1(SA), L2 and Eq.

The summary in Section 2.5.1 shows that subjects hardly play dominated actions. This indicates that L0 hardly exists, and L0 cannot be separated in our games. Thus, L0 is excluded from the mixture model as types of actions. Meanwhile, SA and Exp cannot be separated for the SM in our games, so SA is merged into Exp for the SM. Furthermore, L1(Exp) and L2 are merged into Eq, since L1(Exp) and L2 converge to Eq, which means that we cannot separate these 3 types only by actions. Next, since L1(SA) FM is coincident with Exp FM and the strategy matrix of Exp is a subset of L1(SA)'s, Exp is also merged into L1(SA).

Then in this section, these types are identified by the MLE of a mixture model with error-rate, in which each subject's type is determined by a common prior distribution over these types. Each subject's type remains constant for all 12 games. We pool the action data of each subject and aggregate the number of the periods separately in which the subject's actions coincide with the suggestions of SA/L1(SA)/L1/Eq according to *Table 2.6*. In our error-rate model, subjects who follow one specific type choose actions which comply with this type's strategy with an error with probability from 0 to 1, which is used to explain the variance of subject's actions from his theoretical predictions. Since different types require different cognitive difficulties, errors are type-dependent but independently and identically distributed (i.i.d.) over subjects and games. Formula (2.5.1) and (2.5.2) present the MLE of a mixture type model with error-rate,

(2.5.1)

$$L_i^k\left(e^k \middle| x_i^k\right) = (1 - e^k)^{x_i^k}(e^k)^{G - x_i^k}$$

which denotes the probability of a particular observation x_i^k of a type k subject i:

(2.5.2)

$$\ln\mathrm{L}(p,e|x)=\sum_{i=1}^{N}\ln[\sum_{k=1}^{K}p^kL_i^k(e^k|x_i^k)]$$

which denotes the log-likelihood function for the series of observations of x_i^k.

Let $i=1,\dots,N$ index subjects on a role of a treatment and let $k=1,\dots,K$ represent the types. In this Section, N equals to 27 and K equals to 4 for the FM, or 3 for the SM. x_i^k represents the number of games out of G games in which subject i follows type k's strategy, and $x_i\equiv(x_i^1,\dots,x_i^K)$ and $x\equiv(x_1,\dots,x_N)'$. G represents the number of games which are used to identify subjects. Subjects play 12 games for the FM and for the SM in DRT, and subjects play 24 games for the SM in SMT, since the SM in SMT makes two conditional choices in one game. Furthermore, out of 12 games, there are 4 games which have dominant action, "Call a 3rd card" for the FM and 6 games for the SM. Thus, G equals to 12 in "All periods" columns in Table 2.16, equals to 8 in "Exclude…" column for the FM, equals to 6 in "Exclude…" column for the SM in DRT and equals to 12 in "Exclude…" column for the SM in SMT e^k means type k's error rate, a probability $e^k\in[0,1]$, with which type k subject's actions deviate from type k's prediction, and $e\equiv(e^1,\dots,e^K)$. Let p^k represents the common prior probability of type k, where $\sum_{k=1}^{K}p^k$ and $p\equiv(p^1,\dots,p^K)$.

Table 2.12 shows the estimated type probabilities p^k and type-dependent error rates e^k. The left-part columns "All games (12)" give the estimates on all 12 games (24 games for the SM in SMT). And the right-part columns "FM (8)" give the estimates on 8 games for the FM, in which the sum of 1st card and 2nd card of the FM is equal to or smaller than 5; the column "SM (6)" gives the estimates on 6 games, in which the sum of 1st card and 2nd card of the SM in DRT is equal to or smaller than 5; the column "SM (12)" gives the estimates on 6 pairs of actions in 6 games, in which the sum of 1st card and 2nd card of the SM in SMT is equal to or smaller than 5. The analysis of right-part columns target on the games without dominant action. As the previous summary shows that fewer subjects play dominated actions, excluding games with dominated action helps to estimate parameters more accurately. The results between the two analyses show consistency.

Table 2.12 *Parameter Estimates for 4 Types Mixture Model for Action Data for All games and games without dominant strategy*

	All games (12)				Exclude games in which the sum of 1st and 2nd cards is <=5			
	DRT		SMT		DRT		SMT	
Type	FM	SM	FM	SM (24)	FM (8)	SM (6)	FM (8)	SM (12)
SA								
p^k	0.11	--	0.04	--	0.00	--	0.01	--
e^k	0.00	--	0.51	--	--	--	0.52	--
Exp, L1(SA)								
p^k	0.59	0.87	0.72	0.78	0.67	0.89	0.75	0.81
e^k	0.08	0.20	0.11	0.14	0.15	0.35	0.16	0.23
L1								
p^k	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.07
e^k	--	--	--	0.22	--	--	--	0.51
L1(Exp), L2, Eq								
p^k	0.30	0.13	0.24	0.13	0.33	0.11	0.23	0.12
e^k	0.19	0.27	0.16	0.08	0.26	0.57	0.26	0.15
lnL	-80	-111	-90	-181	-76	-79	-75	-130

Finding 2.A1: p^k *of Exp and L1(SA) shows the highest value across all roles of both treatments.*

Finding 2.A2: SM in SMT has the positive probability of L1 and meanwhile all the other roles in both treatments hardly play as L1.

The previous summary in *Table 2.9* reports some of the subjects do predict their opponents not to play the dominant action in the games with the dominant action, which is partly consistent with *Finding 2.A2*. However, the FMs in *Table 2.9* show higher proportions of untrusting than the SMs in both DRT and SMT, and *Table 2.12* does not imply the existence of L1 FMs.

Finding 2.A3: p^k *of Eq has no significant difference between DRT and SMT.*

As Exp and L1(SA) cannot be separated from this section, we cannot compare non-strategy thinking (C1) and strategy thinking (C2). In the next section, beliefs are introduced to provide more information.

2.5.2.2 Models on the stated belief data

In this section, a maximum likelihood analysis of subjects' stated beliefs with payoff-sensitive following the model in Section 2.4 of M&G (2008) is introduced to estimate the common prior distribution of 5 belief types. In this analysis, we assume subjects hold one of 5 beliefs based on a common prior distribution on their opponents' play: SA play, Exp play, L0 play (of L1 type), L1 play (of L2 type) or Eq (of Eq type). Subjects keep their beliefs for all 12 games.

Let $g = 1, \dots, 12$ index 12 games, let $i = 1, \dots, N$ index subjects on a role of a treatment and let $k = 1, \dots, K$ represent the belief types. $y_{i,g}$ represents subject i's stated belief on how possible he estimates his opponent calls a 3rd card in game g, where $y_i \equiv (y_i^1, \dots, y_i^K)$ and $y \equiv (y_1, \dots, y_N)$, and b_g^k represent the theoretical belief on what possibility a subject who holds k belief estimates that his opponent calls a 3rd card in game g. In the model, a positive parameter λ is used to measure the precision of entire stated beliefs across all belief types in a set associated with their corresponding theoretical beliefs. As $\lambda \to \infty$, $y_{i,g} \to b_g^k$ and as $\lambda \to 0$, $y_{i,g}$ is more likely randomly drawn. Formula (2.5.3) to (2.5.5) present the model:

(2.5.3)

$$L_{i,g}^k\left(\lambda \middle| y_{i,g}, b_g^k\right) = \frac{e^{\lambda(400-0.04b_g^k(y_{i,g}-100)^2-0.04(1-b_g^k)(y_{i,g})^2)}}{\int_0^{100} e^{\lambda(400-0.04b_g^k(z-1\quad)^2-0.04(1-b_g^k)(z)^2)}dz}$$

which denotes the density function of type k belief of $y_{i,g}$ given a λ. Given a λ, the closer $y_{i,g}$ is to b_g^k, the larger $L_{i,g}^k$ is. In this function, $b_g^k \in [0,1]$, and according to the quadratic scoring rule in Section 2.2.3, $y_{i,g} \in [0,100]$.

(2.5.4)

$$\ln \mathrm{L}_i(p,\lambda|y_i) = \ln \sum_{k=1}^{\mathrm{K}} p^k \left[\prod_{g=1}^{12} L_{i,g}^k\left(\lambda \middle| y_{i,g}, b_g^k\right) \right]$$

which denotes the individual log-likelihood function for the 12 games of subject i, and

(2.5.5)

$$\ln \mathrm{L}(p,\lambda|y) = \sum_{i=1}^{N} \ln \mathrm{L}_i(p,\lambda|y_i)$$

which denotes the log-likelihood function for the 12 games of entire subjects.

Table 2.13 presents the estimated parameters, the common prior probabilities of 5 belief types and precision parameter λ. The left-hand column shows the 5 belief types: "SA-Play" belief represents players think their opponents play as "SA" type; "Exp-Play" belief represents players think their opponents play as "Exp" type; "L0-Play" belief represents players who think their opponents play as L0; "L1-play" belief represents players who think their opponents play as L1 and "Eq-play" belief represents the players who think their opponents play as Eq. The left-part columns "DRT" give the estimates on direct-response treatment and the right-part "SMT" columns give the estimates on strategy-method treatment. "FM" columns give estimates on the FM's stated beliefs, and "SM" columns give estimates on the SM's beliefs. In this model, all beliefs in 12 games are used.

Finding 2.B1: The probability of the Exp-play belief of each role is the highest over all belief types of each role in each treatment.

Since Exp play cannot be separated with L1(SA) play in the games, we could not infer whether a subject, who predicts his opponent as Exp play, thinks that his opponent is a C1 player (Exp type) or a C2 player (L1(SA) type). In the next Section, this separation will be conducted by combining the data of actions and beliefs.

Table 2.13 *Parameter Estimates for 5 Types Mixture Model for Stated Belief Data for FMs and SMs in DRT and SMT*

	DRT		SMT	
Type	FM	SM	FM	SM
SA Play	0.21	0.47	0.27	0.26
Exp Play	0.63	0.50	0.68	0.64
L0 Play	0.04	0.00	0.00	0.06
L1 play	0.12	0.00	0.05	0.00
Eq Play	0.00	0.03	0.00	0.04
λ	0.06	0.03	0.07	0.04
lnL	-1250	-1352	-1224	-1343

Finding 2.B2: The probabilities of L0-Play and Eq-Play beliefs are close to 0 across all roles and treatments.

As the summary mentioned in *Table 2.9*, subjects hardly play the dominated action and predict their opponents to play the dominated action with low probabilities. *Finding 2.B2* is consistent with this summary.

Finding 2.B3: λ of FM is larger than SM.

A larger λ implies that the FMs generally have more accurate stated beliefs than the SMs. One possible explanation is that FMs state their beliefs after they choose their actions, and SMs state their beliefs before they choose their actions, which may cause the difference in their precision.

Furthermore, we add one more belief, "No Belief" represented by $L_{i,g}^{k} = \frac{1}{101}$, into the model. Since a stated belief is an integer number from 0 to 100, there are 101 choices from which subjects pick out their beliefs. If a subject randomly picks out his belief, then the probability of each choice picked out is $\frac{1}{101}$. The tendency of estimates in *Table 2.14* is almost consistent with the tendency in *Table 2.13.*

Finding 2.B4: The probabilities of No Belief of SM are higher than FM in both treatments.

SM knows that she will be told about the action of her FM when she states her belief, which may weaken the incentive on estimating her FM's action carefully for the SM. Even though SM fails to predict her FM's action correctly, the SM still can amend her action with accurate information on her FM's action when she chooses her action.

***Table 2.14** Parameter Estimates for 6 Types Mixture Model for Stated Belief Data for FMs and SMs in DRT and SMT*

	DRT		SMT	
Type	FM	SM	FM	SM
No Belief	0.05	0.16	0.00	0.19
SA Play	0.22	0.43	0.27	0.19
Exp Play	0.59	0.36	0.68	0.54
L1	0.04	0.00	0.00	0.04
L2	0.10	0.00	0.05	0.00
Eq	0.00	0.05	0.00	0.04
λ	0.07	0.06	0.07	0.07
lnL	-1246	-1317	-1224	-1324

2.5.2.3 Models for Action and Stated Belief Data

In this section, a maximum likelihood model with payoff-sensitive and error rate works on subjects' actions and stated beliefs to identify 7 thinking types. Each thinking type consists of a specific path of actions and beliefs over 12 games.

C1 includes three non-strategic types: Exp-No belief, SA-No belief and L1 play. Exp-No belief represents the type of subjects who choose actions based on the strategy matrix of Exp and have no specific belief on their opponents' actions. SA-No belief represents the type of subjects who choose actions based on the strategy matrix of SA and have no specific belief on their opponents' actions. That is, Exp-No belief and SA-No belief state belief randomly. Since SA and Exp players do not take their opponents' incentive and information into account on their strategies, any specific belief does not affect SA and Exp players' strategies. The last type in C1 is L1, which follows the regular definition of level-k analysis. Play as L1 and best respond to his belief that his opponent is an L0 player, who randomly choose actions.

The other four types belonging to C2 are L2, L1(SA), L1(Exp) and Eq. Types in C2 include Bayes' Rule into their strategies and best respond to their beliefs. L2 following the regular level-k analysis represents subjects who predict their opponents as L1 and respond best to L1's strategy. L1(SA) is built on a similar hierarchy analysis, which predicts his opponent play SA's strategy and responds best to his prediction. Similarly, L1(Exp) predicts his opponent is Exp type without any belief and responds best to his prediction. Eq describes the classic equilibrium analysis, in which players play equilibrium and think their opponents also play equilibrium.

Coincidences on actions among different types mentioned in Section 2.5.1 lead some types cannot be separated. In this section, two dimensions, action and belief, are combined to identify types, since the combinations of actions and beliefs give more possibilities of types. Following the notations and formulas in Section 2.5.1 and 2.5.2, the maximum likelihood model with payoff-sensitive and error rate is described as:

(2.5.6)

$$L_i(e,p,\lambda|x_i,y_i) = \sum_{k=1}^{K}[p^k L_i^k\left(e^k\middle|x_i^k\right)\prod_{g=1}^{G=12} L_{i,g}^k\left(\lambda\middle|y_{i,g},b_g^k\right)]$$

(2.5.7)

$$\mathrm{lnL}(e,p,\lambda|x,y) = \sum_{i=1}^{N}\mathrm{ln}L_i(e,p,\lambda|x_i,y_i)$$

When type k represents Exp-No belief type, $L_{i,g}^k\left(\lambda\middle|y_{i,g},b_g^k\right) = \frac{1}{101}$.

Table 2.15 reports the parameter estimates of 7 thinking types. The left-part columns "All games (12)" shows the estimates on actions and beliefs of all 12 games (24 games for the SM in SMT). And the right-part columns "FM (8)" give the estimates on actions of 8 games and beliefs of all 12 games for the FM; the column "SM (6)" gives the estimates on actions of 6 games and beliefs of all 12 games for the SM in DRT; the column "SM (12)" gives the estimates on 6 pairs of actions in 6 games and beliefs of all 12 games. The results between the two parts are almost consistent.

Table 2.15 *Parameter Estimates for 7 Types Mixture Model for Action & Stated Belief data for All games and games without a dominant strategy*

	All games (12)				Exclude games in which the sum of 1st and 2nd cards is <=5			
	DRT		SMT		DRT		SMT	
Type	FM	SM	FM	SM	FM (8)	SM (6)	FM (8)	SM (12)
SA-No belief								
p^k	0.04	--	0.00	--	0.00	--	0.00	--
e^k	1.00	--	--	--	--	--	--	--
Exp- No belief								
p^k	0.09	0.13	0.06	0.16	0.11	0.17	0.08	0.04
e^k	0.49	0.08	0.49	0.33	0.13	0.08	0.49	0.09
L1								
p^k	0.13	0.00	0.06	0.00	0.12	0.00	0.05	0.00
e^k	1.00	--	1.00	--	1.00	--	1.00	--
C1								
e^k	*0.26*	*0.13*	*0.12*	*0.16*	*0.23*	*0.17*	*0.13*	*0.04*
L1(SA)								
p^k	0.39	0.48	0.43	0.65	0.35	0.45	0.41	0.42
e^k	0.01	0.07	0.10	0.06	0.01	0.13	0.11	0.08
L1(Exp)								
p^k	0.19	0.22	0.45	0.13	0.20	0.22	0.46	0.47
e^k	0.14	0.18	0.10	0.05	0.20	0.36	0.16	0.44
L2								
p^k	0.00	0.17	0.00	0.05	0.04	0.15	0.00	0.07
e^k	--	0.50	--	0.50	0.68	0.50	--	0.49
Eq								
p^k	0.16	0.00	0.00	0.00	0.18	0.00	0.00	0.00
e^k	0.11	--	--	--	0.16	--	--	--
λ	0.06	0.06	0.06	0.03	0.06	0.06	0.06	0.04
lnL	-1325	-1426	-1323	-1571	-1316	-1393	-1304	-1506

Finding 2.D1: p^k *of either L1(SA) or L1(Exp) of both roles has the highest value in both treatments.*

This finding is consistent with *Finding 2.A1* in Section 2.5.2.1. L1(SA) and L1(Exp) occupy the most proportion, and C2 dominates subjects' strategies mostly.

Finding 2.D2: p^k *of L1 for the FM is above 0 and for the SM is 0.*

As the SM knew the FM's action, the SM could correct her strategy by updating her belief. Summary in Section 2.5.1.1 shows the FM hardly play dominated action, so after the SM saw her FM's action, she could choose the best response to the FM's action but not her previous belief. However, the FM has no chance to know his SM's action in advance. The summary in Section 2.5.1.1 shows that the FM appears more distrustful to the SM than the SM to the FM and predicts the SM will play dominated action sometimes. This consists of *Finding 2.D2*.

Finding 2.D3: p^k *of L2 for the SM is above 0 and for the FM is close to 0.*

Following *Finding 2.D2*, the proportions of L2 SM in both treatments are close the proportions of the corresponding L1 FM. Since L2 best responds to L1, L2 SM in our games almost correctly predicts the proportion of her FM's type

Currently, there is no obvious difference for both roles for comparison on C1 and C2 between two treatments. Then besides 7 types we have discussed before, the other two types are added into the mixture type model to broaden the possible strategies subjects could follow. "SA-SA Play" and "Exp-Exp Play" are categorised into C1* with other previous C1 types, which have non-randomly specific beliefs but cannot best respond to their beliefs as their intelligence limit. "SA-SA Play" play as SA and thinks his opponent also plays as SA. "Exp-Exp Play" plays as Exp and thinks his opponent also plays as Exp. As Exp-No belief or Exp-Exp plays do not take his opponent's information and actions account in his strategy, their playing strategy has no difference. Then L1(Exp) only predicts his opponent's playing strategy but not beliefs, so it has no difference on whether the prediction of L1(Exp) is Exp-No belief or Exp-Exp. And the same as L1(SA). *Table 2.16* reports the parameter estimates of 9 thinking types.

Finding 2.D4: Except for the SM in DRT, p^k *of Exp-Exp play has the highest probability across all roles of both treatment;* p^k *of L1(SA) has the highest probability for the SM in DRT.*

This finding overturns *Finding 2.D1* as the decrease of L1(Exp). However, the belief of Exp play still occupies the dominant proportion except for the SM in DRT, which is consistent with *Finding 2.B1*.

Finding 2.D5: Finding 2.D2 on p^k of L1 and Finding 2.D3 on p^k of L2 still hold in the analysis on 9 types.

However, the values of e^k of L1 and L2 are obviously higher than the values of other types' e^k across all roles in both treatments in both 7-type model and 9-type model. Meanwhile, the values of e^k of L1(SA) and L1(Exp) are relatively acceptable. This implies that it's generally hardly to use level-k analysis based on classic L0 assumption in this game, but level-k thinking works well by anchoring the fundamental level (new L0) on a properly

Finding 2.D6: The proportion of C2 for the SM in DRT is significantly higher than the one for the SM in SMT (P-value of Fisher exact test is 0.035 for columns "All games".) Meanwhile, the proportion of C2 for the FM in DRT is no significant difference from the one for the FM in SMT.

In general, the proportion of C1* in DRT is less than in SMT. The finding is counterintuitive, which implies the strategy method impedes strategy thinking. (More discussions are displayed in the Section 2.5.4.) Meanwhile, the proportion of C1* for the SM is less than for the FM. That is, the SM shows more strategic thinking. (Each subject's type is identified in the Appendix 2.6.)

Table 2.16 *Parameter Estimates for 9 Types Mixture Model for Action & Stated Belief data for All games and games without a dominant strategy*

	All games (12)				Exclude games in which the sum of 1st and 2nd cards is <=5			
	DRT		SMT		DRT		SMT	
Type	FM	SM	FM	SM	FM (8)	SM (6)	FM (8)	SM (12)
SA-No belief								
p^k	0.04	--	0.00	--	0.00	--	0.00	--
e^k	1.00	--	--	--	--	--	--	--
Exp- No belief								
p^k	0.08	0.13	0.05	0.11	0.10	0.18	0.07	0.00
e^k	0.50	0.08	0.45	0.33	0.13	0.08	0.36	0.38
SA-SA Play								
p^k	0.00	--	0.04	--	0.00	--	0.03	--
e^k	--	--	0.26	--	--	--	0.26	--
Exp- Exp Play								
p^k	0.34	0.00	0.50	0.33	0.32	0.09	0.48	0.48
e^k	0.05	--	0.02	0.13	0.07	0.63	0.04	0.28
L1								
p^k	0.12	0.00	0.06	0.00	0.11	0.00	0.06	0.00
e^k	1.00	--	1.00	--	1.00	--	1.00	--
*C1**								
p^k	*0.58*	*0.13*	*0.65*	*0.43*	*0.53*	*0.27*	*0.64*	*0.48*
L1(SA)								
p^k	0.26	0.48	0.32	0.30	0.25	0.46	0.33	0.30
e^k	0.00	0.07	0.09	0.03	0.00	0.13	0.11	0.09
L1(Exp)								
p^k	0.00	0.22	0.03	0.16	0.00	0.11	0.03	0.06
e^k	--	0.18	0.09	0.08	--	0.26	0.14	0.13
L2								
p^k	0.00	0.17	0.00	0.11	0.04	0.15	0.00	0.16
e^k	--	0.51	--	0.50	0.63	0.50	--	0.50
Eq								
p^k	0.16	0.00	0.00	0.00	0.18	0.00	0.00	0.00
e^k	0.11	--	--	--	0.16	--	--	--
λ	0.07	0.06	0.07	0.05	0.07	0.06	0.07	0.05
lnL	-1313	-1426	-1301	-1558	-1306	-1393	-1287	-1496

2.5.3 CRT and Bomb Task

This section discusses how subjects' strategic thinking relates to their cognitive reflection test score and elicited risk attitude.

2.5.3.1 CRT

We compare the distribution of thinking types of subjects with high cognitive reflection score (HC subjects) with the one that includes all subjects. Subjects answer three questions in CRT, and their scores are equal to the numbers of correct answers, which vary between 0 and 3. If a subject answers more than two questions correctly, we assign this subject to HC subject.

Table 2.17 reports the estimates for two subject groups. In general, there is no obvious difference between the all subject group and the HC subject group in DRT. However, there is a slight increase of the proportion of C2 in SMT for the group of HC subjects.

In general, CRT score in *Table 2.18* has no obvious correlation with the strategic thinking of FMs, but meanwhile, the CRT score has a positive correlation with the strategic thinking of SMs.

Table 2.17 *Parameter Estimates on 9-Types between All subjects and HC subjects*

	All subjects				HC subjects (CRT=2 or 3)			
	DRT		SMT		DRT		SMT	
Type \ Role	FM	SM	FM	SM	FM (8)	SM (6)	FM (8)	SM (12)
# of Subjects	27	27	27	27	23	19	19	16
SA-No belief								
p^k	0.04	--	0.00	--	0.05	--	0.00	--
e^k	1.00	--	--	--	1.00	--	0.49	--
Exp- No belief								
p^k	0.08	0.13	0.05	0.11	0.05	0.00	0.00	0.00
e^k	0.50	0.08	0.45	0.33	1.00	0.50	0.49	0.50
SA-SA Play								
p^k	0.00	--	0.04	--	0.00	--	0.00	--
e^k	--	--	0.26	--	0.47	--	0.47	--
Exp- Exp Play								
p^k	0.34	0.00	0.50	0.33	0.33	0.05	0.54	0.28
e^k	0.05	--	0.02	0.13	0.04	0.00	0.01	0.13
L1								
p^k	0.12	0.00	0.06	0.00	0.14	0.00	0.00	0.00
e^k	1.00	--	1.00	--	1.00	1.00	1.00	1.00
C1*								
p^k	0.58	0.13	0.67	0.55	0.59	0.16	0.59	0.42
L1(SA)								
p^k	0.26	0.48	0.32	0.30	0.24	0.52	0.34	0.30
e^k	0.00	0.07	0.09	0.03	0.00	0.08	0.10	0.03
L1(Exp)								
p^k	0.00	0.22	0.03	0.16	0.00	0.21	0.00	0.22
e^k	--	0.18	0.09	0.08	0.25	0.14	0.26	0.12
L2								
p^k	0.00	0.17	0.00	0.11	0.00	0.11	0.07	0.07
e^k	--	0.51	--	0.50	0.00	0.50	0.42	0.50
Eq								
p^k	0.16	0.00	0.00	0.00	0.17	0.00	0.00	0.00
e^k	0.11	--	--	--	0.11	0.50	0.54	0.50
λ	0.07	0.06	0.07	0.05	0.07	0.07	0.08	0.06
lnL	-1313	-1426	-1301	-1558	-1113	-980	-895	-883

Table 2.18 *Mean of CRT Scores*

	DRT		SMT	
	FM	SM	FM	SM
C1*	2.27	1.67	2.00	1.36
C2	2.31	2.14	2.00	2.06

2.5.3.2 Bomb Task

In this section, we introduce the risk attitude of subjects into the analysis with models. Following the study of Crosetto and Filippin (2013), we use a dynamic visual version to elicit subjects' risk attitudes. Then the coefficient of risk aversion, "r", is determined by the number (k) of boxed collected. That is,

$$k = \frac{100r}{1 + r}$$

Then,

$$r = \frac{k}{100 - k}$$

Subjects who collected no more than 49 boxes are risk-averse. Subjects who collected 50 boxes are risk neutral. Subjects who collected more than 50 boxes are risk seeker.

We compare the distribution of thinking types of risk-averse and risk-neutral subjects with the one that includes all subjects. *Table 2.19* reports the estimates of two groups of subjects. There is a slightly increase of the proportion of C1* in the group of not-risk-seek subjects for all roles except the SM in SMT. Meanwhile, P-value of Fisher exact test on comparison of the distributions of C1* and C2 between two groups for the SM in SMT is 0.051. This implies that risk attitude has a significantly negative correlation with strategic thinking for the SM in SMT.

Table 2.19 *Parameter Estimates for 9-Types Mixture Model for All subjects and Not risk-seekers*

	All subjects				Not risk-seeker (Boxes Collected<=50)			
	DRT		SMT		DRT		SMT	
Type \ Role	FM	SM	FM	SM	FM (8)	SM (6)	FM (8)	SM (12)
# of Subjects	27	27	27	27	23	19	19	16
SA-No belief								
p^k	0.04	--	0.00	--	0.06	--	0.00	--
e^k	1.00	--	--	--	1.00	--	0.50	--
Exp- No belief								
p^k	0.08	0.13	0.05	0.11	0.11	0.16	0.07	0.00
e^k	0.50	0.08	0.45	0.33	0.50	0.06	0.49	0.22
SA-SA Play								
p^k	0.00	--	0.04	--	0.00	--	0.00	--
e^k	--	--	0.26	--	0.49	--	0.43	--
Exp- Exp Play								
p^k	0.34	0.00	0.50	0.33	0.33	0.00	0.63	0.27
e^k	0.05	--	0.02	0.13	0.03	0.33	0.03	0.08
L1								
p^k	0.12	0.00	0.06	0.00	0.13	0.00	0.07	0.00
e^k	1.00	--	1.00	--	1.00	1.00	1.00	1.00
C1*								
p^k	0.58	0.13	0.67	0.55	0.63	0.16	0.77	0.27
L1(SA)								
p^k	0.26	0.48	0.32	0.30	0.17	0.46	0.23	0.28
e^k	0.00	0.07	0.09	0.03	0.00	0.05	0.06	0.04
L1(Exp)								
p^k	0.00	0.22	0.03	0.16	0.00	0.19	0.00	0.26
e^k	--	0.18	0.09	0.08	0.29	0.22	0.46	0.09
L2								
p^k	0.00	0.17	0.00	0.11	0.00	0.19	0.00	0.19
e^k	--	0.51	--	0.50	0.00	0.50	0.51	0.50
Eq								
p^k	0.16	0.00	0.00	0.00	0.00	0.19	0.00	0.19
e^k	0.11	--	--	--	0.00	0.50	0.51	0.50
λ	0.07	0.06	0.07	0.05	0.06	0.07	0.07	0.05
lnL	-1313	-1426	-1301	-1558	-891	-781	-941	-907

Table 2.20 reports the mean of boxes collected by each subject of each category for each role in each treatment. C1* subject for the FM in SMT shows more risk-averse than C2.

However, there is no statistically significant difference in the means between two categories in any role of treatments.

Table 2.20 *Mean of Number of Boxes Collected*

	DRT		SMT	
	FM	SM	FM	SM
C1*	45.91	46.33	39.00	44.93
C2	44.13	47.83	44.67	44.42

2.5.4 Further Discussions on the Two Treatments

In contrast with the previous experimental studies on strategic thinking in two described methods (Reuben and Suetens, 2012, Kawagoe and Takizawa, 2012 and Garcia-Pola et al., 2016), *Finding 2.D6* in Section 2.5.2.3 indicates that strategic behaviours are affected by the game described methods and that the strategy method has a negative effect on strategic thinking. Unlike the previous studies, the game used in our study is the first game with incomplete information and uncertainty, and therefore the complexity of the game is more than games in the studies before. Then in this section, further discussions are presented to investigate that whether the lower probability of strategic behaviours in the strategy-method treatment does exist and that if so, how the complexity of the game influences the strategic thinking.

2.5.4.1 Robust analysis of the existence

Before investigating the explanations on the weakened strategic thinking in the SMT, a series of robust analyses are done to verify the existence of *Finding 2.D6*.

Table 2.21 demonstrates three series of estimates for the 9 types mixture model for the SM in SMT. The estimates in the column, named “24G” (the same as the results in the *Table 2.16* in the Section 2.5.2.3), are gotten by using all 24 choices of the SM in the SMT into the formula (2.5.6), G=24. The estimates in the column, named “12G (DRT-FM)”, are gotten by using 12 choices of the SM in the SMT determined by the corresponding FM’s choices into the formula (2.5.6), G=12. The estimates in the column, named “12G (SMT-

FM)", are gotten by using 12 choices of the SM in the SMT determined by the choices of corresponding the FM in the DRT, whose corresponding SM in the DRT has the same order as the SM in the SMT.

***Table 2.21**. Parameter Estimates for 9 Types Mixture Model for Action & Stated Belief data for SM in SMT*

Type	24G	12G (DRT-FM)	12G (SMT-FM)
SA-No belief			
p^k	--	--	--
e^k	--	--	--
Exp- No belief			
p^k	0.11	0.08	0.10
e^k	0.33	0.26	0.27
SA-SA Play			
p^k	--	--	--
e^k	--	--	--
Exp- Exp Play			
p^k	0.33	0.42	0.36
e^k	0.13	0.13	0.12
L1			
p^k	0.00	0.00	0.00
e^k	--	--	--
*C1**			
p^k	*0.43*	*0.50*	*0.46*
L1(SA)			
p^k	0.30	0.27	0.28
e^k	0.03	0.04	0.02
L1(Exp)			
p^k	0.16	0.06	0.12
e^k	0.08	0.00	0.07
L2			
p^k	0.11	0.16	0.15
e^k	0.50	0.51	0.51
Eq			
p^k	0.00	0.00	0.00
e^k	--	--	--
λ	0.05	0.06	0.06
lnL	-1558	-1442	-1438

These three series of estimates show similar distributions. The proportions of C1* are 0.43, 0.5 and 0.46. The column "24G" implies that more observations bring more chances for the SMs to be identified as strategic thinking types. As the comparison of the C1* proportions between two treatments (0.13 of DRT and 0.43 of SMT) shows a significant difference in the previous section. If we consider the robust tests between 0.13 and 0.5/0.46, the difference between two treatment can be more significant.

2.5.4.2 Effecting Factors analysis

After justifying the existence of the significant difference, we check a series of possible effecting factors which may affect strategic behaviours.

Firstly, the distributions of types of the FM in two treatment are compared to examine whether the weakened strategic thinking of the SMs in the SMT is caused by the different distributions of the FMs. The proportion of C1* of the FM in DRT is 0.58, which is not significantly lower than 0.65 of the FM in SMT in Fisher exact test. Then it is reasonable to assume that the SMs in both treatments face similar distributions of strategic thinking types of FMs. Then we can exclude the constitution of the FMs from the effecting factors.

Secondly, by comparing *Table 2.15* and *Table 2.16,* adding two more types, SA-SA play and Exp-Exp play, brings the conflict between 7-type model and 9-type model, which concentrates on the transferring from L1(Exp) and L1(SA) to Exp-Exp play. Except for the SM in DRT, all the other groups of subjects transfer more than 30% from L1(Exp) and L1(SA) to Exp-Exp play between the 7-type model and the 9-type model. The proportions of all the other types almost have no change between the two models. Then the following analyses focus on these three types.

As shocking may affect the strategic thinking, we check that how many times the SMs identified as these three types (in Table A2.6.2 in Appendix 2.6) meet their stated beliefs on the FM's action against to their FMs' actual actions. The average of the number of the against of SMs in DRT is 4.3, and the one of SMs in SMT is 4.1 out of 12 stated beliefs of each subject. There is no significant difference. Then shocking from FMs' actions is excluded from the effecting factors.

Furthermore, *Table 2.22*, summarising the information from *Table 2.14* and *Table 2.16*, shows that the SMs in both treatments hold similar sums of the two beliefs on their FMs' actions. However, when we check the three thinking types (L1(Exp) and L1(SA) to Exp-Exp play), which can be leaded by these two beliefs (SA play and Exp Play), the SM in SMT shows a higher relative proportion of Exp-Exp play type than the SM in DRT out of the two types with the Exp-play belief. As Exp-Exp play type and L1(Exp) type both hold the Exp-play belief on their opponents, but only L1(Exp) type chooses actions which are best responses to their beliefs, then this implies that the higher proportion of the SMs holding the Exp-play belief in SMT fail to make their best responses to their beliefs. This means that when the SMs in the two treatments holds similar belief distributions, more SMs in SMT do not choose the best responses but think that their FMs play the same as themselves.

Table 2.22 *Summary on the distribution of the three types and the two beliefs*

Type	SM in DRT	SM in SMT
Exp-Exp play	0	0.33
L1(SA)	0.48	0.3
L1(Exp)	0.22	0.16
Sum	*0.7*	*0.79*
SA-play belief	0.43	0.19
Exp-play belief	0.36	0.54
Sum	*0.79*	*0.73*

To replenish the implication above, we check the individual SM subject's thinking type and individual SM subject's belief type (in *Table A2.6.2* in *Appendix 2.6*) and select SM subjects who hold the Exp-play belief (23 subjects) to study their responses to the Exp-play belief. *Table 2.23* presents the distribution of 23 SM subjects, in which the number in each cell represents the number of subjects of each role in each treatment. Fisher Exact test shows a significant difference (p-values are 0.067) for the distributions of the SMs between DRT and SMT. The capability of responding best to beliefs has a significant effect on strategic thinking.

***Table 2.23**. Summary of the Exp-Play Belief*

	SM in DRT	SM in SMT
Exp-Exp play	1	8
L1(Exp)	7	5
Other C1* types	0	0
Other C2 types	2	1

Thirdly, we examine the effect of intelligence on the failure of responding best. We calculate the average of CRT of the SMs in the three types in Table 2.24. There is no obvious difference of the average CRT of each type between the two treatments. Then intelligence is excluded from the effecting factors.

***Table 2.24**. Summary of the Exp-Play Belief*

	SM in DRT	SM in SMT
Exp-Exp play	1.5	1.75
L1(Exp)	2	2

2.5.4.2 Alternative explanation

There are some other factors which may result in the weaken strategic behaviours, but in our current experiment design, these factors cannot be investigated. One possible factor is decision duration. As the total duration of the sessions between both treatments is similar, that means that the SM in SMT may use shorter time on each choice. This may cause a lower proportion of strategic behaviours. Meanwhile, facing more questions and more complex questioning may cause tired or bored. This also could impede players' careless thinking.

2.6 Conclusion

This paper reports the findings of the experiment designed to investigates the player's strategic behaviours and discusses the performance of level-k analysis on explaining players' behaviours in the game with incomplete information and uncertainty. The experiment requires subjects to play a series of 12 two-person two-stage dynamic games and to state a series of their beliefs. Then a series of maximum likelihood estimations of mixture type models are introduced to identify subjects' behavioural types, which are separated into non-strategic thinking types and strategic thinking types. Our findings show that around 50% of subjects play as strategic thinking types and the level-k analysis is the dominant analysis across all strategic thinking types.

Furthermore, the two methods of game description are compared to study how the description method influences subjects' behaviours. A counterintuitive finding is found that the direct-response method is more helpful for subjects to play as strategic thinking types than the strategy method for the Second Mover. This finding is helpful for experimental design when subjects are needed to show more strategic thinking. As the Second Mover in the strategy method treatment makes conditional choices, the procedure that more decisions are made may distract subjects' mentality. Then, subjects are hard to make both choices properly. However, the Second Mover is generally more strategic thinking than the First Mover. This implies that getting more information facilitates subjects to make more accurate responses. Also, this means different roles in a multi-stage dynamic game leads to different thinking types. Moreover, it is demonstrated that the Second Mover in direct-response treatment benefiting from a proper game-describing method and more information shows the best capability on making the best response to beliefs.

A cognitive reflection test and risk attitude test are conducted in the experiment to elicit more features of subjects, which are used to study on factors that have related to subjects thinking types. The findings show that cognitive reflection and risk attitude are only statistically related to the SM in SMT. Higher cognitive reflection prompts strategic thinking and more risk averse brings higher possible to play as strategic thinking types.

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Appendix 2.1 Trimmed Strategy Space of Each Specific Game

Combination of (FN1, SN1)	Number of Possibilities on FM's Strategies	Number of Possibilities on SM's Strategies
(1,1)	1	1
(2,1)	2	1
(3,1)	4	1
(4,1)	8	1
(1,2)	1	2
(2,2)	2	4
(3,2)	4	4
(4,2)	8	4
(1,3)	1	4
(2,3)	2	16
(3,3)	4	16
(4,3)	8	16
(1,4)	1	8
(2,4)	2	64
(3,4)	4	64
(4,4)	8	64

Appendix 2.2 Payoff Matrix

Generally, when we compute a winning probability of a strategy (AAAA) of the FM in a specific scenario given the two 1st cards and the SM's strategy (AAAA, AAAA), we compute as the following function[50]:

$$P^F(win|FN1, SN1, (AAAA), (AAAA, AAAA)) = \sum_{s=1}^{4}[P^F(win|FN1, SN1, (AAAA), (AAAA, AAAA), FN2 = s) * P^F(s)]$$

$P^F(s)$ is the probability of a specific number on the 2nd card of the FM and $P^F(s) = \frac{1}{4}$. $P^F(win|FN1, SN1, (AAAA), (AAAA, AAAA), FN2 = s)$ represents the expected winning probability of the FM in the specific scenario, $\{FN1, SN1, (AAAA), (AAAA, AAAA), SN2 = s\}$. Given the specific scenario, (AAAA) indicates the specific action, "Call" or "Not Call", according to the specific "s". Then the wining probability of a (AAAA) is computed as following:

$$\begin{aligned} P^F(win|FN1, SN1, (AAAA), (AAAA, AAAA), FN2 = s) \\ &= P^F(win|FN1, SN1, (AAAA), (AAAA, AAAA), FN2 = s) \\ &= \sum_{i=1}^{8}\big[P^F(win|FN1, SN1, (AAAA), FN2 = s,\ i) \\ &\quad * P^S\big(i|\ SN1, (AAAA, AAAA)\big)\big] \end{aligned}$$

$P^F(win|FN1, SN1, (AAAA), FN2 = s,\ i)$ represents if the FM wins in the specific scenario $\{\ FN1, FN2, (AAAA), SN1, i\ \}$. "$i$" is the sum of 2nd card and possible 3rd card of the SM. Then given the known sum of the SM ($SN1 + i$), the conditional sum of the FM is computed as following according to the specific strategy "AAAA":

[50] In the following functions, "j" represents the number on the 3rd card if a player asks for a 3rd card and "s" represents the number on the 2nd card of a player. (Then $i = s + j$.)

$$P^F(win|FN1, SN1, (AAAA), FN2 = s,\ i) = \sum_{j=0}^{4}[P^F(FN3 = j|FN1, SN1, (AAAA), FN2 = s,\ i) * P^F(win|FN1, SN1, (AAAA), FN2 = s,\ i, j)]$$

Given the information $\{ FN1, SN1, (AAAA), FN2 = s,\ i \}$, the probability of the number on the possible 3rd card is given by $P^F(FN3 = j|FN1, SN1, (AAAA), FN2 = s,\ i)$. "$j = 0$" means the strategy A is "No Call". And given $\{ FN1, SN1, FN2 = s,\ i, j \}$, the sum of the two players could be known. Then $P^F(win|FN1, SN1, (AAAA), FN2 = s,\ i, j)$ is 1 or 0, which means whether the FM wins in this scenario $\{FN1, SN1, (AAAA), FN2 = s,\ i, j\}$. The whole function of the expected winning probability of the FM is described as following:

$$P^F(win|FN1, SN1, (AAAA), (AAAA, AAAA)) = \sum_{s=1}^{4}\left[\left(\sum_{i=1}^{8}\left\{\left[\sum_{j=0}^{4}[P^F(FN3 = j|FN1, SN1, (AAAA), FN2 = s,\ i) * P^F(win|FN1, SN1, (AAAA), FN2 = s,\ i, j)]\right] * P^S\big(i|\ SN1, (AAAA, AAAA)\big)\right\}\right) * P^F(s)\right]$$

Similarly, the SM's winning probability function is described as the following:

$$P^S(win|FN1, SN1, (AAAA), (AAAA, AAAA))$$

$$= \sum_{s=1}^{4}\left[\left(\sum_{i=1}^{8}\left\{\left[\sum_{j=0}^{4}[P^S(SN3 = j|FN1, SN1, (AAAA, AAAA), SN2 = s,\ i) * P^S(win|FN1, SN1, (AAAA, AAAA), SN2 = s,\ i, j)]\right] * P^F(i|\ FN1, (AAAA))\right\}\right) * P^s(s)\right]$$

As players only need to consider the strategies which are not weakly dominant, we only discuss the cases in which players have no weakly dominant strategies when we compute the expected winning probability. For example, in a specific game, the 1st card of the FM is 3, and the 1st card of SM is 2. Then the trimmed strategy space of the FM is {(CCCC), (CCCN), (CCNC), (CCNN)} as only when the 2nd card of the FM is 3 or 4, the FM needs to consider whether to call a 3rd card or not. Likewise, the trimmed strategy space of the SM is {(CCCC, CCCC), (CCCC, CCCN), (CCCN, CCCC), (CCCN, CCCN)}. Then when the 2nd card "s" is 1 or 2, the expected winning probability

$$P^F(win|FN1, SN1, (AAAA), (AAAA, AAAA), FN2 = s)$$

is always the same across all strategies in the trimmed strategy space for the same "s". As the process of iterative elimination of (weakly) dominated strategies in a game is only related with the ranks of the payoffs of the strategies within a player, it does not change the ranks of strategies by excluding the same part from the payoffs of the strategies. Then to lessen the computation, we also cut down the cases within the games with the same two 1st cards in which there are dominant strategies. In the example, when we compute the expected winning probability, we assume $P^F(s = 1|FN1 = 3) = P^F(s = 2|FN1 = 3) = 0$ and $P^F(s = 3|FN1 = 3) = P^F(s = 4|FN1 = 3) = \frac{1}{2}$. Then the following example demonstrates how to compute the FM's expected winning probability in the case, {FN1=3, SN1=2, (CCCN), (CCCC, CCCN)}:

$$P^F\big(win\big|FN1 = 3, SN1 = 2, (CCCN), (CCCC, CCCN)\big)$$
$$= \sum_{s=1}^{4}\left[\left(\sum_{i=1}^{8}\left\{\left[\sum_{j=0}^{4}[P^F(FN3 = j|FN1 = 3, SN1 = 2, (CCCN), FN2 = s,\ i)\right.\right.\right.\right.$$
$$\left. * P^F(win|FN1 = 3, SN1 = 2, (CCCN), FN2 = s,\ i, j)]\right]$$
$$\left.\left.\left. * P^S\big(i|\ SN1 = 2, (CCCC, CCCN)\big)\right\}\right) * P^F(s|FN1 = 3)\right]$$

When $s = 4$, the FM will choose to "No Call" according to the strategy, ($CCCN$). Then,

$$P^F(FN3 = j|FN1 = 3, SN1 = 2, (CCCN), FN2 = 4,\ i) = 0, for\ j = 1\ to\ 4$$

$$P^F(FN3 = j|FN1 = 3, SN1 = 2, (CCCN), FN2 = 4,\ i) = 1, for\ j = 0$$

For each combination of "i" and "j", the sums of the FM and the SM are determined. For example, when $i = 4$ and $j = 0$, the sum of the FM is 6 (=FN1+FN2+j=3+3+0) and the sum of the SM is 6 (=SN1+i=2+4). Then the FM wins in this case, so

$$P^F(win|FN1 = 3, SN1 = 2, (CCCN), FN2 = 4,\ i, j) = \frac{1}{2}, as\ tie$$

Next, we need to check the probability of the appearance of ($i = 4$). As the FM calls a 3rd card, the SM will call a 3rd card if SN2 is 1, 2, or 3 but will not call a 3rd card when SN2=4. Then if $i = 4$, it could be (SN2=1, SN3=3), (SN2=2, SN3=2), (SN2=3, SN3=2) or (SN2=4, SN3=0). There are 4 possible cases in which $i = 4$ and each case happens as 25%:

$$P^S\big(i = 4|\ SN1 = 2, (CCCC, CCCN)\big) = \frac{1}{4} * \frac{1}{4} + \frac{1}{4} * \frac{1}{4} + \frac{1}{4} * \frac{1}{4} + \frac{1}{4} * \frac{1}{4} = \frac{1}{4}$$

Based on the information above, we could know the value of the wining probability of the case, $\{FN1 = 3, SN1 = 2, (CCCC), FN2 = 4, i = 4\}$,

$$P^F(win|FN1 = 3, SN1 = 2, (CCCC), FN2 = 4, i = 4)$$
$$= P^F(win|FN1 = 3, SN1 = 2, (CCCC), FN2 = 4, i = 4, j = 0) = \frac{1}{2}$$

And the expected wining probability of the case, $\{FN1 = 3, SN1 = 2, (CCCC), FN2 = 4, i = 4\}$, is as following:

$$\big[P^F(win|FN1 = 3, SN1 = 2, (CCCC), FN2 = 4, i = 4)$$
$$* P^S\big(i = 4|\ SN1 = 2, (CCCC, CCCN)\big)\big] = \frac{1}{2} * \frac{1}{4} = \frac{1}{8}$$

Repeating the procedure above, we get the full payoff matrix of each specific normal-form game (described as following: Table 2.A to Table 2.O).

***Table 2.A**. FN1=2, SN1=1*

SM-strategy (AAAA, AAAA) / FM-strategy (AAAA)	CCCC, CCCC
CCCC	0.6406
CCCN	0.5000

**The probabilities in this table is the winning probability of first mover in each specific game. Since SN1=1, there is only one strategy left for second mover after deleting dominated strategies. Then there is no need to show the winning probability or the second mover.*

***Table 2.B**. FN1=3, SN1=1*

SM-strategy (AAAA, AAAA) / FM-strategy (AAAA)	CCCC, CCCC
CCCC	0.5508
CCCN	0.6797
CCNC	0.4805
CCNN	0.6094

***Table 2.C**. FN1=4, SN1=1*

SM-strategy (AAAA, AAAA) / FM-strategy (AAAA)	CCCC, CCCC
CCCC	0.4479
CCCN	0.6589
CCNC	0.5339
CCNN	0.7448
CNCC	0.4010
CNCN	0.6120
CNNC	0.4870
CNNN	0.6979

Table 2.D. *FN1=1, SN1=2*

SM-strategy (AAAA, AAAA) / FM-strategy (AAAA)	CCCC, _ _ _ _	CCCN, _ _ _ _
CCCC	0.6406	0.5000

**First mover never chooses "No Call" in this game, so there is no need to show the possible strategy of second mover in the part after the comma. The matrix only shows the winning probabilities of the SM, since the FM only has one strategy.*

Table 2.E. *FN1=2, SN1=2*

SM-strategy (AAAA, AAAA) / F-strategy (AAAA)	CCCC, CCCC	CCCC, CCCN	CCCN, CCCC	CCCN, CCCN
CCCC	(0.5703 0.5703)	(0.5703 0.5703)	(0.6406 0.3438)	(0.6406 0.3438)
CCCN	(0.3438 0.6406)	(0.4063 0.4063)	(0.3438 0.6406)	(0.4063 0.4063)

**Probabilities displayed at the top inside each parentheses denote the winning probability for the FM and probabilities displayed at the bottom denote the winning probability for the SM.*

Table 2.F. *FN1=3, SN1=2*

SM-strategy (AAAA, AAAA) / FM-strategy (AAAA)	CCCC, CCCC	CCCC, CCCN	CCCN, CCCC	CCCN, CCCN
CCCC	(0.5000 0.4688)	(0.5000 0.4688)	(0.5508 0.2500)	(0.5508 0.2500)
CCCN	(0.5664 0.5469)	(0.6211 0.3906)	(0.6016 0.3438)	(0.6563 0.1875)
CCNC	(0.3867 0.5859)	(0.4648 0.5234)	(0.4023 0.4375)	(0.4805 0.3750)
CCNN	(0.4531 0.6172)	(0.5859 0.3984)	(0.4531 0.4688)	(0.5859 0.2500)

Table 2.G. FN1=4, SN1=2

SM-strategy (AAAA, AAAA) / FM-strategy (AAAA)	CCCC, CCCC	CCCC, CCCN	CCCN, CCCC	CCCN, CCCN
CCCC	(0.4115 0.5078)	(0.4115 0.5078)	(0.4479 0.4063)	(0.4479 0.4063)
CCCN	(0.5938 0.45313)	(0.6250 0.3594)	(0.6276 0.3125)	(0.6589 0.2188)
CCNC	(0.4557 0.5391)	(0.5078 0.3828)	(0.4818 0.4375)	(0.5339 0.2813)
CCNN	(0.6380 0.4844)	(0.7214 0.2344)	(0.6927 0.3438)	(0.7448 0.0938)
CNCC	(0.3359 0.5781)	(0.3568 0.5156)	(0.3490 0.5313)	(0.3698 0.4688)
CNCN	(0.5182 0.5234)	(0.5703 0.3672)	(0.5286 0.4375)	(0.5807 0.2813)
CNNC	(0.3802 0.6094)	(0.4531 0.3906)	(0.3828 0.5625)	(0.4557 0.3438)
CNNN	(0.5625 0.5547)	(0.6667 0.2422)	(0.5625 0.4688)	(0.6667 0.1563)

***Table 2.H**. FN1=1, SN1=3*

FM-strategy (AAAA) \ SM-strategy (AAAA, AAAA)	CCCC, ----	CCCC, ----	CCCN, ----	CCCN, ----
CCCC	0.5508	0.6797	0.4805	0.6094

***Table 2.I**. FN1=2, SN1=3*

FM-strategy (AAAA) \ SM-strategy (AAAA, AAAA)	CCCC, CCCC	CCCC, CCCN	CCCC, CCNC	CCCC, CCNN	CCCN, CCCC	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN
CCCC	(0.4844 0.5352)	(0.4844 0.5352)	(0.4844 0.5352)	(0.4844 0.5352)	(0.5469 0.5898)	(0.5469 0.5898)	(0.5469 0.5898)	(0.5469 0.5898)
CCCN	(0.3125 0.5859)	(0.1875 0.6484)	(0.3750 0.5547)	(0.2500 0.6172)	(0.3125 0.6406)	(0.1875 0.7031)	(0.3750 0.6094)	(0.2500 0.6719)

FM-strategy (AAAA) \ SM-strategy (AAAA, AAAA)	CCNC, CCCC	CCNC, CCCN	CCNC, CCNC	CCNC, CCNN	CCNN, CCCC	CCNN, CCCN	CCNN, CCNC	CCNN, CCNN
CCCC	(0.5547 0.3984)	(0.5547 0.3984)	(0.5547 0.3984)	(0.5547 0.3984)	(0.6172 0.4531)	(0.6172 0.4531)	(0.6172 0.4531)	(0.6172 0.4531)
CCCN	(0.3125 0.4766)	(0.1875 0.5391)	(0.3750 0.4453)	(0.2500 0.5078)	(0.3125 0.5313)	(0.1875 0.5938)	(0.3750 0.5000)	(0.2500 0.5625)

Table 2.J. *FN1=3, SN1=3*

SM-strategy (AAAA, AAAA) / FM-strategy (AAAA)	CCCC, CCCC	CCCC, CCCN	CCCC, CCNC	CCCC, CCNN	CCCN, CCCC	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN
CCCC	(0.2285 0.2285)	(0.2285 0.2285)	(0.2285 0.2285)	(0.2285 0.2285)	(0.2441 0.2461)	(0.2441 0.2461)	(0.2441 0.2461)	(0.2441 0.2461)
CCCN	(0.2461 0.2441)	(0.2461 0.2441)	(0.2852 0.2051)	(0.2852 0.2051)	(0.2539 0.2539)	(0.2539 0.2539)	(0.2930 0.2148)	(0.2930 0.2148)
CCNC	(0.1777 0.2539)	(0.1465 0.2852)	(0.1934 0.2383)	(0.1621 0.2695)	(0.1855 0.2715)	(0.1543 0.3027)	(0.2012 0.2559)	(0.1699 0.2871)
CCNN	(0.1953 0.2695)	(0.1641 0.3008)	(0.2500 0.2148)	(0.2188 0.2461)	(0.1953 0.2793)	(0.1641 0.3105)	(0.2500 0.2246)	(0.2188 0.2559)

SM-strategy (AAAA, AAAA) / FM-strategy (AAAA)	CCNC, CCCC	CCNC, CCCN	CCNC, CCNC	CCNC, CCNN	CCNN, CCCC	CCNN, CCCN	CCNN, CCNC	CCNN, CCNN
CCCC	(0.2539 0.1777)	(0.2539 0.1777)	(0.2539 0.1777)	(0.2539 0.1777)	(0.2695 0.1953)	(0.2695 0.1953)	(0.2695 0.1953)	(0.2695 0.1953)
CCCN	(0.2637 0.2305)	(0.2637 0.2305)	(0.3027 0.1914)	(0.3027 0.1914)	(0.2715 0.2402)	(0.2715 0.2402)	(0.3105 0.2012)	(0.3105 0.2012)
CCNC	(0.1855 0.2168)	(0.1543 0.2480)	(0.2012 0.2012)	(0.1699 0.2324)	(0.1934 0.2344)	(0.1621 0.2656)	(0.2090 0.2188)	(0.1777 0.2500)
CCNN	(0.1953 0.2324)	(0.1641 0.2637)	(0.2500 0.1777)	(0.2188 0.2090)	(0.1953 0.2422)	(0.1641 0.2734)	(0.2500 0.1875)	(0.2188 0.2188)

Table 2.K. *FN1=4, SN1=3*

SM-strategy (AAAA, AAAA) / FM-strategy (AAAA)	CCCC, CCCC	CCCC, CCCN	CCCC, CCNC	CCCC, CCNN	CCCN, CCCC	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN
CCCC	(0.3802 0.4453)	(0.3802 0.4453)	(0.3802 0.4453)	(0.3802 0.4453)	(0.4036 0.5039)	(0.4036 0.5039)	(0.4036 0.5039)	(0.4036 0.5039)
CCCN	(0.5339 0.4141)	(0.5651 0.3672)	(0.5651 0.3672)	(0.5964 0.3203)	(0.5547 0.4297)	(0.5859 0.3828)	(0.5859 0.3828)	(0.6172 0.3359)
CCNC	(0.4036 0.4766)	(0.4036 0.4766)	(0.4557 0.3984)	(0.4557 0.3984)	(0.4167 0.5195)	(0.4167 0.5195)	(0.4688 0.4414)	(0.4688 0.4414)
CCNN	(0.5573 0.4453)	(0.5885 0.3984)	(0.6406 0.3203)	(0.6719 0.2734)	(0.5677 0.4453)	(0.5990 0.3984)	(0.6510 0.3203)	(0.6823 0.2734)
CNCC	(0.3125 0.4961)	(0.2708 0.5586)	(0.3333 0.4648)	(0.2917 0.5273)	(0.3255 0.5547)	(0.2839 0.6172)	(0.3464 0.5234)	(0.3047 0.5859)
CNCN	(0.4661 0.4648)	(0.4557 0.4805)	(0.5182 0.3867)	(0.5078 0.4023)	(0.4766 0.4805)	(0.4661 0.4961)	(0.5286 0.4023)	(0.5182 0.4180)
CNNC	(0.3359 0.5273)	(0.2943 0.5898)	(0.4089 0.4180)	(0.3672 0.4805)	(0.3385 0.5703)	(0.2969 0.6328)	(0.4115 0.4609)	(0.3698 0.5234)
CNNN	(0.4896 0.4961)	(0.4792 0.5117)	(0.5938 0.3398)	(0.5833 0.3555)	(0.4896 0.4961)	(0.4792 0.5117)	(0.5938 0.3398)	(0.5833 0.3555)

(Continue)

(Continuation)

SM-strategy (AAAA, AAAA) / FM-strategy (AAAA)	CCNC, CCCC	CCNC, CCCN	CCNC, CCNC	CCNC, CCNN	CCNN, CCCC	CCNN, CCCN	CCNN, CCNC	CCNN, CCNN
CCCC	(0.4167 0.3945)	(0.4167 0.3945)	(0.4167 0.3945)	(0.4167 0.3945)	(0.4401 0.4531)	(0.4401 0.4531)	(0.4401 0.4531)	(0.4401 0.4531)
CCCN	(0.5677 0.3438)	(0.5990 0.2969)	(0.5990 0.2969)	(0.6302 0.2500)	(0.5885 0.3594)	(0.6198 0.3125)	(0.6198 0.3125)	(0.6510 0.2656)
CCNC	(0.4297 0.4258)	(0.4297 0.4258)	(0.4818 0.3477)	(0.4818 0.3477)	(0.4427 0.4688)	(0.4427 0.4688)	(0.4948 0.3906)	(0.4948 0.3906)
CCNN	(0.5807 0.3750)	(0.6120 0.3281)	(0.6641 0.2500)	(0.6953 0.2031)	(0.5911 0.3750)	(0.6224 0.3281)	(0.6745 0.2500)	(0.7057 0.2031)
CNCC	(0.3255 0.4727)	(0.2839 0.5352)	(0.3464 0.4414)	(0.3047 0.5039)	(0.3385 0.5313)	(0.2969 0.5938)	(0.3594 0.5000)	(0.3177 0.5625)
CNCN	(0.4766 0.4219)	(0.4661 0.4375)	(0.5286 0.3438)	(0.5182 0.3594)	(0.4870 0.4375)	(0.4766 0.4531)	(0.5391 0.3594)	(0.5286 0.3750)
CNNC	(0.3385 0.5039)	(0.2969 0.5664)	(0.4115 0.3945)	(0.3698 0.4570)	(0.3411 0.5469)	(0.2995 0.6094)	(0.4141 0.4375)	(0.3724 0.5000)
CNNN	(0.4896 0.4531)	(0.4792 0.4688)	(0.5938 0.2969)	(0.5833 0.3125)	(0.4896 0.4531)	(0.4792 0.4688)	(0.5938 0.2969)	(0.5833 0.3125)

Table 2.L. *FN1=1, SN1=4*

S-strategy (AAAA, AAAA) / F-strategy (AAAA)	CCCC, ____	CCCN, ____	CCNC, ____	CCNN, ____	CNCC, ____	CNCN, ____	CNNC, ____	CNNN, ____
CCCC	0.4479	0.6589	0.5339	0.7448	0.4010	0.6120	0.4010	0.6979

Table 2.M. *FN1=2, SN1=4*

S-strategy (AAAA, AAAA) / F-strategy (AAAA)	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN	CCNC, CCCC	CCNC, CCCN	CCNC, CCNC	CCNC, CCNN	CCNN, CCCC
CCCC	(0.4531 0.5938)	(0.4531 0.5938)	(0.4531 0.5938)	(0.5391 0.4557)	(0.5391 0.4557)	(0.5391 0.4557)	(0.5391 0.4557)	(0.4844 0.6380)
CCCN	(0.2188 0.6589)	(0.2813 0.6380)	(0.0938 0.7005)	(0.4063 0.4922)	(0.2188 0.5547)	(0.2813 0.5339)	(0.0938 0.5964)	(0.4063 0.6406)

S-strategy (AAAA, AAAA) / F-strategy (AAAA)	CCNN, CCCN	CCNN, CCNC	CCNN, CCNN	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN	CCNC, CCCC	CCNC, CCCN
CCCC	(0.4844 0.6380)	(0.4844 0.6380)	(0.4844 0.6380)	(0.4531 0.5938)	(0.4531 0.5938)	(0.4531 0.5938)	(0.5391 0.4557)	(0.5391 0.4557)
CCCN	(0.2188 0.7031)	(0.2813 0.6823)	(0.0938 0.7448)	(0.2188 0.6589)	(0.2813 0.6380)	(0.0938 0.7005)	(0.4063 0.4922)	(0.2188 0.5547)

(continue)

(Continuation)

S-strategy (AAAA, AAAA) / F-strategy (AAAA)	CNCN, CCCN	CNCN, CCNC	CNCN, CCNN	CNNC, CCCC	CNNC, CCCN	CNNC, CCNC	CNNC, CCNN	CNNN, CCCC
CCCC	(0.5234 0.5182)	(0.5234 0.5182)	(0.5234 0.5182)	(0.6094 0.3802)	(0.6094 0.3802)	(0.6094 0.3802)	(0.6094 0.3802)	(0.5547 0.5625)
CCCN	(0.2188 0.6016)	(0.2813 0.5807)	(0.0938 0.6432)	(0.4063 0.4349)	(0.2188 0.4974)	(0.2813 0.4766)	(0.0938 0.5391)	(0.4063 0.5833)

S-strategy (AAAA, AAAA) / F-strategy (AAAA)	CNNN, CCCN	CNNN, CCNC	CNNN, CCNN	CNCN, CCCN	CNCN, CCNC	CNCN, CCNN	CNNC, CCCC	CNNC, CCCN
CCCC	(0.5547 0.5625)	(0.5547 0.5625)	(0.5547 0.5625)	(0.5234 0.5182)	(0.5234 0.5182)	(0.5234 0.5182)	(0.6094 0.3802)	(0.6094 0.3802)
CCCN	(0.2188 0.6458)	(0.2813 0.6250)	(0.0938 0.6875)	(0.2188 0.6016)	(0.2813 0.5807)	(0.0938 0.6432)	(0.4063 0.4349)	(0.2188 0.4974)

S-strategy (AAAA, AAAA) / F-strategy (AAAA)	CCCN, CNCN	CCCN, CNNC	CCCN, CNNN	CCNC, CNCC	CCNC, CNCN	CCNC, CNNC	CCNC, CNNN	CCNN, CNCC
CCCC	(0.4531 0.5938)	(0.4531 0.5938)	(0.4531 0.5938)	(0.5391 0.4557)	(0.5391 0.4557)	(0.5391 0.4557)	(0.5391 0.4557)	(0.4844 0.6380)
CCCN	(0.2813 0.6380)	(0.3438 0.6172)	(0.1563 0.6797)	(0.4688 0.4714)	(0.2813 0.5339)	(0.3438 0.5130)	(0.1563 0.5755)	(0.4688 0.6198)

S-strategy (AAAA, AAAA) / F-strategy (AAAA)	CCNN, CNCN	CCNN, CNNC	CCNN, CNNN	CCCN, CNCN	CCCN, CNNC	CCCN, CNNN	CCNC, CNCC	CCNC, CNCN
CCCC	(0.4844 0.6380)	(0.4844 0.6380)	(0.4844 0.6380)	(0.4531 0.5938)	(0.4531 0.5938)	(0.4531 0.5938)	(0.5391 0.4557)	(0.5391 0.4557)
CCCN	(0.2813 0.6823)	(0.3438 0.6615)	(0.1563 0.7240)	(0.2813 0.6380)	(0.3438 0.6172)	(0.1563 0.6797)	(0.4688 0.4714)	(0.2813 0.5339)

(continue)

(Continuation)

S-strategy (AAAA, AAAA) / F-strategy (AAAA)	CNCN, CNCN	CNCN, CNNC	CNCN, CNNN	CNNC, CNCC	CNNC, CNCN	CNNC, CNNC	CNNC, CNNN	CNNN, CNCC
CCCC	(0.5234 0.5182)	(0.5234 0.5182)	(0.5234 0.5182)	(0.6094 0.3802)	(0.6094 0.3802)	(0.6094 0.3802)	(0.6094 0.3802)	(0.5547 0.5625)
CCCN	(0.2813 0.5807)	(0.3438 0.5599)	(0.1563 0.6224)	(0.4688 0.4141)	(0.2813 0.4766)	(0.3438 0.4557)	(0.1563 0.5182)	(0.4688 0.5625)

S-strategy (AAAA, AAAA) / F-strategy (AAAA)	CNNN, CNCN	CNNN, CNNC	CNNN, CNNN	CNCN, CNCN	CNCN, CNNC	CNCN, CNNN	CNNC, CNCC	CNNC, CNCN
CCCC	(0.5547 0.5625)	(0.5547 0.5625)	(0.5547 0.5625)	(0.5234 0.5182)	(0.5234 0.5182)	(0.5234 0.5182)	(0.6094 0.3802)	(0.6094 0.3802)
CCCN	(0.2813 0.6250)	(0.3438 0.6042)	(0.1563 0.6667)	(0.2813 0.5807)	(0.3438 0.5599)	(0.1563 0.6224)	(0.4688 0.4141)	(0.2813 0.4766)

Table 2.N. *FN1=3, SN1=4*

F-strategy (AAAA) \ S-strategy (AAAA, AAAA)	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN	CCNC, CCCC	CCNC, CCCN	CCNC, CCNC	CCNC, CCNN	CCNN, CCCC
CCCC	(0.2226 0.2852)	(0.2226 0.2852)	(0.2226 0.2852)	(0.2226 0.2852)	(0.2070 0.4004)	(0.2070 0.4004)	(0.2070 0.4004)	(0.2070 0.4004)
CCCN	(0.2520 0.3027)	(0.2051 0.3496)	(0.2520 0.3027)	(0.2051 0.3496)	(0.2383 0.3926)	(0.1914 0.4395)	(0.2383 0.3926)	(0.1914 0.4395)
CCNC	(0.1973 0.3125)	(0.1504 0.3594)	(0.1660 0.3438)	(0.1191 0.3906)	(0.1953 0.4023)	(0.1484 0.4492)	(0.1641 0.4336)	(0.1172 0.4805)
CCNN	(0.2266 0.3301)	(0.1328 0.4238)	(0.1953 0.3613)	(0.1016 0.4551)	(0.2266 0.3945)	(0.1328 0.4883)	(0.1953 0.4258)	(0.1016 0.5195)

F-strategy (AAAA) \ S-strategy (AAAA, AAAA)	CCNN, CCCN	CCNN, CCNC	CCNN, CCNN	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN	CCNC, CCCC	CCNC, CCCN
CCCC	(0.2382 0.3027)	(0.2382 0.3027)	(0.2382 0.3027)	(0.2382 0.3027)	(0.2226 0.4180)	(0.2226 0.4180)	(0.2226 0.4180)	(0.2226 0.4180)
CCCN	(0.2598 0.3125)	(0.2129 0.3594)	(0.2598 0.3125)	(0.2129 0.3594)	(0.2461 0.4023)	(0.1992 0.4492)	(0.2461 0.4023)	(0.1992 0.4492)
CCNC	(0.2051 0.3301)	(0.1582 0.3770)	(0.1738 0.3613)	(0.1270 0.4082)	(0.2031 0.4199)	(0.1563 0.4668)	(0.1719 0.4512)	(0.1250 0.4980)
CCNN	(0.2266 0.3398)	(0.1328 0.4336)	(0.1953 0.3711)	(0.1016 0.4648)	(0.2266 0.4043)	(0.1328 0.4980)	(0.1953 0.4355)	(0.1016 0.5293)

(continue)

(Continuation)

F-strategy (AAAA) \ S-strategy (AAAA, AAAA)	CNCN, CCCN	CNCN, CCNC	CNCN, CCNN	CNNC, CCCC	CNNC, CCCN	CNNC, CCNC	CNNC, CCNN	CNNN, CCCC
CCCC	(0.2480 0.2344)	(0.2480 0.2344)	(0.2480 0.2344)	(0.2480 0.2344)	(0.2324 0.3496)	(0.2324 0.3496)	(0.2324 0.3496)	(0.2324 0.3496)
CCCN	(0.2695 0.2520)	(0.2227 0.2988)	(0.2695 0.2520)	(0.2227 0.2988)	(0.2559 0.3418)	(0.2090 0.3887)	(0.2559 0.3418)	(0.2090 0.3887)
CCNC	(0.2051 0.2754)	(0.1582 0.3223)	(0.1738 0.3066)	(0.1270 0.3535)	(0.2031 0.3652)	(0.1563 0.4121)	(0.1719 0.3965)	(0.1250 0.4434)
CCCN	(0.2266 0.2930)	(0.1328 0.3867)	(0.1953 0.3242)	(0.1016 0.4180)	(0.2266 0.3574)	(0.1328 0.4512)	(0.1953 0.3887)	(0.1016 0.4824)

F-strategy (AAAA) \ S-strategy (AAAA, AAAA)	CNNN, CCCN	CNNN, CCNC	CNNN, CCNN	CNCN, CCCN	CNCN, CCNC	CNCN, CCNN	CNNC, CCCC	CNNC, CCCN
CCCC	(0.2637 0.2520)	(0.2637 0.2520)	(0.2637 0.2520)	(0.2637 0.2520)	(0.2480 0.3672)	(0.2480 0.3672)	(0.2480 0.3672)	(0.2480 0.3672)
CCCN	(0.2773 0.2617)	(0.2305 0.3086)	(0.2773 0.2617)	(0.2305 0.3086)	(0.2637 0.3516)	(0.2168 0.3984)	(0.2637 0.3516)	(0.2168 0.3984)
CCNC	(0.2129 0.2930)	(0.1660 0.3398)	(0.1816 0.3242)	(0.1348 0.3711)	(0.2109 0.3828)	(0.1641 0.4297)	(0.1797 0.4141)	(0.1328 0.4609)
CCCN	(0.2266 0.3027)	(0.1328 0.3965)	(0.1953 0.3340)	(0.1016 0.4277)	(0.2266 0.3672)	(0.1328 0.4609)	(0.1953 0.3984)	(0.1016 0.4922)

(continue)

(Continuation)

F-strategy (AAAA) \ S-strategy (AAAA, AAAA)	CCCN, CNCN	CCCN, CNNC	CCCN, CNNN	CCNC, CNCC	CCNC, CNCN	CCNC, CNNC	CCNC, CNNN	CCNN, CNCC
CCCC	(0.2227 0.2852)	(0.2227 0.2852)	(0.2227 0.2852)	(0.2227 0.2852)	(0.2070 0.4004)	(0.2070 0.4004)	(0.2070 0.4004)	(0.2070 0.4004)
CCCN	(0.2910 0.2637)	(0.2441 0.3105)	(0.2910 0.2637)	(0.2441 0.3105)	(0.2773 0.3535)	(0.2305 0.4004)	(0.2773 0.3535)	(0.2305 0.4004)
CCNC	(0.2129 0.2969)	(0.1660 0.3438)	(0.1816 0.3281)	(0.1348 0.3750)	(0.2109 0.3867)	(0.1641 0.4336)	(0.1797 0.4180)	(0.1328 0.4648)
CCCN	(0.2813 0.2754)	(0.1875 0.3691)	(0.2500 0.3066)	(0.1563 0.4004)	(0.2813 0.3398)	(0.1875 0.4336)	(0.2500 0.3711)	(0.1563 0.4648)

F-strategy (AAAA) \ S-strategy (AAAA, AAAA)	CCNN, CNCN	CCNN, CNNC	CCNN, CNNN	CCCN, CNCN	CCCN, CNNC	CCCN, CNNN	CCNC, CNCC	CCNC, CNCN
CCCC	(0.2383 0.3027)	(0.2383 0.3027)	(0.2383 0.3027)	(0.2383 0.3027)	(0.2227 0.4180)	(0.2227 0.4180)	(0.2227 0.4180)	(0.2227 0.4180)
CCCN	(0.2988 0.2734)	(0.2520 0.3203)	(0.2988 0.2734)	(0.2520 0.3203)	(0.2852 0.3633)	(0.2383 0.4102)	(0.2852 0.3633)	(0.2383 0.4102)
CCNC	(0.2207 0.3145)	(0.1738 0.3613)	(0.1895 0.3457)	(0.1426 0.3926)	(0.2188 0.4043)	(0.1719 0.4512)	(0.1875 0.4355)	(0.1406 0.4824)
CCCN	(0.2813 0.2852)	(0.1875 0.3789)	(0.2500 0.3164)	(0.1563 0.4102)	(0.2813 0.3496)	(0.1875 0.4434)	(0.2500 0.3809)	(0.1563 0.4746)

(continue)

(Continuation)

F-strategy (AAAA) \ S-strategy (AAAA, AAAA)	CNCN, CNCN	CNCN, CNNC	CNCN, CNNN	CNNC, CNCC	CNNC, CNCN	CNNC, CNNC	CNNC, CNNN	CNNN, CNCC
CCCC	(0.2480 0.2344)	(0.2480 0.2344)	(0.2480 0.2344)	(0.2480 0.2344)	(0.2324 0.3496)	(0.2324 0.3496)	(0.2324 0.3496)	(0.2324 0.3496)
CCCN	(0.3086 0.2129)	(0.2617 0.2598)	(0.3086 0.2129)	(0.2617 0.2598)	(0.2949 0.3027)	(0.2480 0.3496)	(0.2949 0.3027)	(0.2480 0.3496)
CCNC	(0.2207 0.2598)	(0.1738 0.3066)	(0.1895 0.2910)	(0.1426 0.3379)	(0.2188 0.3496)	(0.1719 0.3965)	(0.1875 0.3809)	(0.1406 0.4277)
CCCN	(0.2813 0.2383)	(0.1875 0.3320)	(0.2500 0.2695)	(0.1563 0.3633)	(0.2813 0.3027)	(0.1875 0.3965)	(0.2500 0.3340)	(0.1563 0.4277)

F-strategy (AAAA) \ S-strategy (AAAA, AAAA)	CNNN, CNCN	CNNN, CNNC	CNNN, CNNN	CNCN, CNCN	CNCN, CNNC	CNCN, CNNN	CNNC, CNCC	CNNC, CNCN
CCCC	(0.2637 0.2520)	(0.2637 0.2520)	(0.2637 0.2520)	(0.2637 0.2520)	(0.2480 0.3672)	(0.2480 0.3672)	(0.2480 0.3672)	(0.2480 0.3672)
CCCN	(0.3164 0.2227)	(0.2695 0.2695)	(0.3164 0.2227)	(0.2695 0.2695)	(0.3027 0.3125)	(0.2559 0.3594)	(0.3027 0.3125)	(0.2559 0.3594)
CCNC	(0.2285 0.2773)	(0.1816 0.3242)	(0.1973 0.3086)	(0.1504 0.3555)	(0.2266 0.3672)	(0.1797 0.4141)	(0.1953 0.3984)	(0.1484 0.4453)
CCCN	(0.2813 0.2480)	(0.1875 0.3418)	(0.2500 0.2793)	(0.1563 0.3730)	(0.2813 0.3125)	(0.1875 0.4063)	(0.2500 0.3438)	(0.1563 0.4375)

Table 2.O. *FN1=4, SN1=4*

F-strategy (AAAA) \ S-strategy (AAAA, AAAA)	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN	CCNC, CCCC	CCNC, CCCN	CCNC, CCNC	CCNC, CCNN	CCNN, CCCC
CCCC	(0.2773 0.2773)	(0.2773 0.2773)	(0.2773 0.2773)	(0.2773 0.2773)	(0.2637 0.3867)	(0.2637 0.3867)	(0.2637 0.3867)	(0.2637 0.3867)
CCCN	(0.3867 0.2637)	(0.3711 0.2793)	(0.4102 0.2402)	(0.3945 0.2559)	(0.3711 0.3398)	(0.3555 0.3555)	(0.3945 0.3164)	(0.3789 0.3320)
CCNC	(0.3066 0.2949)	(0.2598 0.3418)	(0.3066 0.2949)	(0.2598 0.3418)	(0.2949 0.3789)	(0.2480 0.4258)	(0.2949 0.3789)	(0.2480 0.4258)
CCNN	(0.4160 0.2813)	(0.3535 0.3438)	(0.4395 0.2578)	(0.3770 0.3203)	(0.4023 0.3320)	(0.3398 0.3945)	(0.4258 0.3086)	(0.3633 0.3711)
CNCC	(0.2520 0.3047)	(0.2051 0.3516)	(0.2207 0.3359)	(0.1738 0.3828)	(0.2520 0.3887)	(0.2051 0.4355)	(0.2207 0.4199)	(0.1738 0.4668)
CNCN	(0.3613 0.2910)	(0.2988 0.3535)	(0.3535 0.2988)	(0.2910 0.3613)	(0.3594 0.3418)	(0.2969 0.4043)	(0.3516 0.3496)	(0.2891 0.4121)
CNNC	(0.3203 0.3223)	(0.2266 0.4160)	(0.2891 0.3535)	(0.1953 0.4473)	(0.3223 0.3809)	(0.2285 0.4746)	(0.2910 0.4121)	(0.1973 0.5059)
CNNN	(0.4297 0.3086)	(0.3203 0.4180)	(0.4219 0.3164)	(0.3125 0.4258)	(0.4297 0.3340)	(0.3203 0.4434)	(0.4219 0.3418)	(0.3125 0.4512)

(continue)

(Continuation)

S-strategy (AAAA, AAAA) / F-strategy (AAAA)	CCNN, CCCN	CCNN, CCNC	CCNN, CCNN	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN	CCNC, CCCC	CCNC, CCCN
CCCC	(0.2949 0.3066)	(0.2949 0.3066)	(0.2949 0.3066)	(0.2949 0.3066)	(0.2813 0.4160)	(0.2813 0.4160)	(0.2813 0.4160)	(0.2813 0.4160)
CCCN	(0.4023 0.2715)	(0.3867 0.2871)	(0.4258 0.2480)	(0.4102 0.2637)	(0.3867 0.3477)	(0.3711 0.3633)	(0.4102 0.3242)	(0.3945 0.3398)
CCNC	(0.3164 0.3164)	(0.2695 0.3633)	(0.3164 0.3164)	(0.2695 0.3633)	(0.3047 0.4004)	(0.2578 0.4473)	(0.3047 0.4004)	(0.2578 0.4473)
CCNN	(0.4238 0.2813)	(0.3613 0.3438)	(0.4473 0.2578)	(0.3848 0.3203)	(0.4102 0.3320)	(0.3477 0.3945)	(0.4336 0.3086)	(0.3711 0.3711)
CNCC	(0.2617 0.3340)	(0.2148 0.3809)	(0.2305 0.3652)	(0.1836 0.4121)	(0.2617 0.4180)	(0.2148 0.4648)	(0.2305 0.4492)	(0.1836 0.4961)
CNCN	(0.3691 0.2988)	(0.3066 0.3613)	(0.3613 0.3066)	(0.2988 0.3691)	(0.3672 0.3496)	(0.3047 0.4121)	(0.3594 0.3574)	(0.2969 0.4199)
CNNC	(0.3223 0.3438)	(0.2285 0.4375)	(0.2910 0.3750)	(0.1973 0.4688)	(0.3242 0.4023)	(0.2305 0.4961)	(0.2930 0.4336)	(0.1992 0.5273)
CNNN	(0.4297 0.3086)	(0.3203 0.4180)	(0.4219 0.3164)	(0.3125 0.4258)	(0.4297 0.3340)	(0.3203 0.4434)	(0.4219 0.3418)	(0.3125 0.4512)

(Continue)

(Continuation)

S-strategy (AAAA, AAAA) / F-strategy (AAAA)	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN	CCNC, CCCC	CCNC, CCCN	CCNC, CCNC	CCNC, CCNN	CCNN, CCCC
CCCC	(0.3047 0.2520)	(0.3047 0.2520)	(0.3047 0.2520)	(0.3047 0.2520)	(0.2910 0.3613)	(0.2910 0.3613)	(0.2910 0.3613)	(0.2910 0.3613)
CCCN	(0.4121 0.2285)	(0.3965 0.2441)	(0.4355 0.2051)	(0.4199 0.2207)	(0.3965 0.3047)	(0.3809 0.3203)	(0.4199 0.2813)	(0.4043 0.2969)
CCNC	(0.3262 0.2695)	(0.2793 0.3164)	(0.3262 0.2695)	(0.2793 0.3164)	(0.3145 0.3535)	(0.2676 0.4004)	(0.3145 0.3535)	(0.2676 0.4004)
CCNN	(0.4336 0.2461)	(0.3711 0.3086)	(0.4570 0.2227)	(0.3945 0.2852)	(0.4199 0.2969)	(0.3574 0.3594)	(0.4434 0.2734)	(0.3809 0.3359)
CNCC	(0.2617 0.2930)	(0.2148 0.3398)	(0.2305 0.3242)	(0.1836 0.3711)	(0.2617 0.3770)	(0.2148 0.4238)	(0.2305 0.4082)	(0.1836 0.4551)
CNCN	(0.3691 0.2695)	(0.3066 0.3320)	(0.3613 0.2773)	(0.2988 0.3398)	(0.3672 0.3203)	(0.3047 0.3828)	(0.3594 0.3281)	(0.2969 0.3906)
CNNC	(0.3223 0.3105)	(0.2285 0.4043)	(0.2910 0.3418)	(0.1973 0.4355)	(0.3242 0.3691)	(0.2305 0.4629)	(0.2930 0.4004)	(0.1992 0.4941)
CNNN	(0.4297 0.2871)	(0.3203 0.3965)	(0.4219 0.2949)	(0.3125 0.4043)	(0.4297 0.3125)	(0.3203 0.4219)	(0.4219 0.3203)	(0.3125 0.4297)

(Continue)

(Continuation)

F-strategy (AAAA) \ S-strategy (AAAA, AAAA)	CCNN, CCCN	CCNN, CCNC	CCNN, CCNN	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN	CCNC, CCCC	CCNC, CCCN
CCCC	(0.3223 0.2813)	(0.3223 0.2813)	(0.3223 0.2813)	(0.3223 0.2813)	(0.3086 0.3906)	(0.3086 0.3906)	(0.3086 0.3906)	(0.3086 0.3906)
CCCN	(0.4277 0.2363)	(0.4121 0.2520)	(0.4512 0.2129)	(0.4355 0.2285)	(0.4121 0.3125)	(0.3965 0.3281)	(0.4355 0.2891)	(0.4199 0.3047)
CCNC	(0.3359 0.2910)	(0.2891 0.3379)	(0.3359 0.2910)	(0.2891 0.3379)	(0.3242 0.3750)	(0.2773 0.4219)	(0.3242 0.3750)	(0.2773 0.4219)
CCNN	(0.4414 0.2461)	(0.3789 0.3086)	(0.4648 0.2227)	(0.4023 0.2852)	(0.4277 0.2969)	(0.3652 0.3594)	(0.4512 0.2734)	(0.3887 0.3359)
CNCC	(0.2715 0.3223)	(0.2246 0.3691)	(0.2402 0.3535)	(0.1934 0.4004)	(0.2715 0.4063)	(0.2246 0.4531)	(0.2402 0.4375)	(0.1934 0.4844)
CNCN	(0.3770 0.2773)	(0.3145 0.3398)	(0.3691 0.2852)	(0.3066 0.3477)	(0.3750 0.3281)	(0.3125 0.3906)	(0.3672 0.3359)	(0.3047 0.3984)
CNNC	(0.3242 0.3320)	(0.2305 0.4258)	(0.2930 0.3633)	(0.1992 0.4570)	(0.3262 0.3906)	(0.2324 0.4844)	(0.2949 0.4219)	(0.2012 0.5156)
CNNN	(0.4297 0.2871)	(0.3203 0.3965)	(0.4219 0.2949)	(0.3125 0.4043)	(0.4297 0.3125)	(0.3203 0.4219)	(0.4219 0.3203)	(0.3125 0.4297)

(Continue)

(Continuation)

S-strategy (AAAA, AAAA) / F-strategy (AAAA)	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN	CCNC, CCCC	CCNC, CCCN	CCNC, CCNC	CCNC, CCNN	CCNN, CCCC
CCCC	(0.2773 0.2773)	(0.2773 0.2773)	(0.2773 0.2773)	(0.2773 0.2773)	(0.2637 0.3867)	(0.2637 0.3867)	(0.2637 0.3867)	(0.2637 0.3867)
CCCN	(0.4102 0.2402)	(0.3945 0.2559)	(0.4336 0.2168)	(0.4180 0.2324)	(0.3945 0.3164)	(0.3789 0.3320)	(0.4180 0.2930)	(0.4023 0.3086)
CCNC	(0.3457 0.2559)	(0.2988 0.3027)	(0.3457 0.2559)	(0.2988 0.3027)	(0.3340 0.3398)	(0.2871 0.3867)	(0.3340 0.3398)	(0.2871 0.3867)
CCNN	(0.4785 0.2188)	(0.4160 0.2813)	(0.5020 0.1953)	(0.4395 0.2578)	(0.4648 0.2695)	(0.4023 0.3320)	(0.4883 0.2461)	(0.4258 0.3086)
CNCC	(0.2676 0.2891)	(0.2207 0.3359)	(0.2363 0.3203)	(0.1895 0.3672)	(0.2676 0.3730)	(0.2207 0.4199)	(0.2363 0.4043)	(0.1895 0.4512)
CNCN	(0.4004 0.2520)	(0.3379 0.3145)	(0.3926 0.2598)	(0.3301 0.3223)	(0.3984 0.3027)	(0.3359 0.3652)	(0.3906 0.3105)	(0.3281 0.3730)
CNNC	(0.3359 0.2676)	(0.2422 0.3613)	(0.3047 0.2988)	(0.2109 0.3926)	(0.3379 0.3262)	(0.2441 0.4199)	(0.3066 0.3574)	(0.2129 0.4512)
CNNN	(0.4688 0.2305)	(0.3594 0.3398)	(0.4609 0.2383)	(0.3516 0.3477)	(0.4688 0.2559)	(0.3594 0.3652)	(0.4609 0.2637)	(0.3516 0.3730)

(Continue)

(Continuation)

S-strategy (AAAA, AAAA) / F-strategy (AAAA)	CCNN, CCCN	CCNN, CCNC	CCNN, CCNN	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN	CCNC, CCCC	CCNC, CCCN
CCCC	(0.2949 0.3066)	(0.2949 0.3066)	(0.2949 0.3066)	(0.2949 0.3066)	(0.2813 0.4160)	(0.2813 0.4160)	(0.2813 0.4160)	(0.2813 0.4160)
CCCN	(0.4258 0.2480)	(0.4102 0.2637)	(0.4492 0.2246)	(0.4336 0.2402)	(0.4102 0.3242)	(0.3945 0.3398)	(0.4336 0.3008)	(0.4180 0.3164)
CCNC	(0.3555 0.2773)	(0.3086 0.3242)	(0.3555 0.2773)	(0.3086 0.3242)	(0.3438 0.3613)	(0.2969 0.4082)	(0.3438 0.3613)	(0.2969 0.4082)
CCNN	(0.4863 0.2188)	(0.4238 0.2813)	(0.5098 0.1953)	(0.4473 0.2578)	(0.4727 0.2695)	(0.4102 0.3320)	(0.4961 0.2461)	(0.4336 0.3086)
CNCC	(0.2773 0.3184)	(0.2305 0.3652)	(0.2461 0.3496)	(0.1992 0.3965)	(0.2773 0.4023)	(0.2305 0.4492)	(0.2461 0.4336)	(0.1992 0.4805)
CNCN	(0.4082 0.2598)	(0.3457 0.3223)	(0.4004 0.2676)	(0.3379 0.3301)	(0.4063 0.3105)	(0.3438 0.3730)	(0.3984 0.3184)	(0.3359 0.3809)
CNNC	(0.3379 0.2891)	(0.2441 0.3828)	(0.3066 0.3203)	(0.2129 0.4141)	(0.3398 0.3477)	(0.2461 0.4414)	(0.3086 0.3789)	(0.2148 0.4727)
CNNN	(0.4688 0.2305)	(0.3594 0.3398)	(0.4609 0.2383)	(0.3516 0.3477)	(0.4688 0.2559)	(0.3594 0.3652)	(0.4609 0.2637)	(0.3516 0.3730)

(Continue)

(Continuation)

F-strategy (AAAA) \ S-strategy (AAAA, AAAA)	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN	CCNC, CCCC	CCNC, CCCN	CCNC, CCNC	CCNC, CCNN	CCNN, CCCC
CCCC	(0.3047 0.2520)	(0.3047 0.2520)	(0.3047 0.2520)	(0.3047 0.2520)	(0.2910 0.3613)	(0.2910 0.3613)	(0.2910 0.3613)	(0.2910 0.3613)
CCCN	(0.4355 0.2051)	(0.4199 0.2207)	(0.4590 0.1816)	(0.4434 0.1973)	(0.4199 0.2813)	(0.4043 0.2969)	(0.4434 0.2578)	(0.4277 0.2734)
CCNC	(0.3652 0.2305)	(0.3184 0.2773)	(0.3652 0.2305)	(0.3184 0.2773)	(0.3535 0.3145)	(0.3066 0.3613)	(0.3535 0.3145)	(0.3066 0.3613)
CCNN	(0.4961 0.1836)	(0.4336 0.2461)	(0.5195 0.1602)	(0.4570 0.2227)	(0.4824 0.2344)	(0.4199 0.2969)	(0.5059 0.2109)	(0.4434 0.2734)
CNCC	(0.2773 0.2773)	(0.2305 0.3242)	(0.2461 0.3086)	(0.1992 0.3555)	(0.2773 0.3613)	(0.2305 0.4082)	(0.2461 0.3926)	(0.1992 0.4395)
CNCN	(0.4082 0.2305)	(0.3457 0.2930)	(0.4004 0.2383)	(0.3379 0.3008)	(0.4063 0.2813)	(0.3438 0.3438)	(0.3984 0.2891)	(0.3359 0.3516)
CNNC	(0.3379 0.2559)	(0.2441 0.3496)	(0.3066 0.2871)	(0.2129 0.3809)	(0.3398 0.3145)	(0.2461 0.4082)	(0.3086 0.3457)	(0.2148 0.4395)
CNNN	(0.4688 0.2090)	(0.3594 0.3184)	(0.4609 0.2168)	(0.3516 0.3262)	(0.4688 0.2344)	(0.3594 0.3438)	(0.4609 0.2422)	(0.3516 0.3516)

(Continue)

(Continuation)

F-strategy (AAAA) \ S-strategy (AAAA, AAAA)	CCNN, CCCN	CCNN, CCNC	CCNN, CCNN	CCCN, CCCN	CCCN, CCNC	CCCN, CCNN	CCNC, CCCC	CCNC, CCCN
CCCC	(0.3223 0.2813)	(0.3223 0.2813)	(0.3223 0.2813)	(0.3223 0.2813)	(0.3086 0.3906)	(0.3086 0.3906)	(0.3086 0.3906)	(0.3086 0.3906)
CCCN	(0.4512 0.2129)	(0.4355 0.2285)	(0.4746 0.1895)	(0.4590 0.2051)	(0.4355 0.2891)	(0.4199 0.3047)	(0.4590 0.2656)	(0.4434 0.2813)
CCNC	(0.3750 0.2520)	(0.3281 0.2988)	(0.3750 0.2520)	(0.3281 0.2988)	(0.3633 0.3359)	(0.3164 0.3828)	(0.3633 0.3359)	(0.3164 0.3828)
CCNN	(0.5039 0.1836)	(0.4414 0.2461)	(0.5273 0.1602)	(0.4648 0.2227)	(0.4902 0.2344)	(0.4277 0.2969)	(0.5137 0.2109)	(0.4512 0.2734)
CNCC	(0.2871 0.3066)	(0.2402 0.3535)	(0.2559 0.3379)	(0.2090 0.3848)	(0.2871 0.3906)	(0.2402 0.4375)	(0.2559 0.4219)	(0.2090 0.4688)
CNCN	(0.4160 0.2383)	(0.3535 0.3008)	(0.4082 0.2461)	(0.3457 0.3086)	(0.4141 0.2891)	(0.3516 0.3516)	(0.4063 0.2969)	(0.3438 0.3594)
CNNC	(0.3398 0.2773)	(0.2461 0.3711)	(0.3086 0.3086)	(0.2148 0.4023)	(0.3418 0.3359)	(0.2480 0.4297)	(0.3105 0.3672)	(0.2168 0.4609)
CNNN	(0.4688 0.2090)	(0.3594 0.3184)	(0.4609 0.2168)	(0.3516 0.3262)	(0.4688 0.2344)	(0.3594 0.3438)	(0.4609 0.2422)	(0.3516 0.3516)

Appendix 2.3 Analysis on the L1 Player

To get the strategy matrix of the L1 players, we need to compute the wining probability of each action and select the action with the higher wining probability as the strategy of the L1 player in a specific game.

We use $P_k^R(i|I^R)$ to represent type k player's prior probability based on his information set I^R on that the sum of his opponent's 2nd and 3rd cards51 is "i". "k" index types, e.g., L1, L2 or Eq. "R" represents roles of players and if a player is FM/SM, then "R" equals to "F/S". When L1 player is the FM, he predicts that the SM chooses "Call" as 50% possibility. Then the distribution of $P_1^F(i|I^F)$, in which the number on FM's 2nd card is a uniform distribution from 1 to 4, can be drawn in *Table A2.3.1*:

Based on the FM's information set, $I^F = \{FN1, FN2, SN1\}$, the FM can calculate the winning probability of each action:

$$PC_1^F = Prob(win|\ I^F, Call) = \sum_{j=1}^{4} \frac{1}{4} * (\sum_{i=1}^{8} [\mathrm{Prob}(\mathrm{win}|I^F, Call, j, i) * P_1^F(i|I^F)])$$

$$PN_1^F = Prob(win|I^F, No\ Call) = \sum_{i=1}^{8} [\mathrm{Prob}(\mathrm{win}|I^F, No\ Call, i) * P_1^F(i|I^F)]$$

"PC_1^F" represents the probability of winning the game when L1 FM calls a 3rd card and "PN_1^F" represents the probability of winning the game when L1 FM does not call a 3rd card. According to the winning rules (in Section 2.2),

[51] If the opponent player does not call a 3rd card, then we uniform the number on the 3rd card as 0.

Table A2.3.1 *Distribution of the Prior Belief of the L1 FM on his SM's the sum of 2nd card and 3rd card*

i	s	j	$P_1^F(i\|I^F)$	
1	1	0	$P_1^F(1\|\mathrm{I^F}) = Prob(\mathrm{s} = 1) * Prob(j = 0) = 1/4 * 1/2,$ [52]	1/8
2	2 1	0 1	$P_1^F(2\|\mathrm{I^F}) = Prob(\mathrm{s} = 2) * Prob(j = 0) + Prob(\mathrm{s} = 1) * Prob(\mathrm{j} = 1)$ $= 1/4 * 1/2 + 1/4 * 1/4 * 1/2,$ [53]	5/32
3	3 2 1	0 1 2	$P_1^F(3\|\mathrm{I^F}) = Prob(\mathrm{s} = 3) * Prob(j = 0) + Prob(\mathrm{s} = 2) * Prob(\mathrm{j} = 1)$ $+ Prob(\mathrm{s} = 1) * Prob(\mathrm{j} = 2)$ $= 1/4 * 1/2 + 1/4 * 1/4 * 1/2 + 1/4 * 1/4 * 1/2$	3/16
4	4 3 2 1	0 1 2 3	$P_1^F(4\|\mathrm{I^F}) = Prob(\mathrm{s} = 4) * Prob(j = 0) + Prob(\mathrm{s} = 3) * Prob(\mathrm{j} = 1)$ $+ Prob(\mathrm{s} = 2) * Prob(\mathrm{j} = 2) + Prob(\mathrm{s} = 1) * Prob(\mathrm{j} = 3)$ $= 1/4 * 1/2 + 1/4 * 1/4 * 1/2 + 1/4 * 1/4 * 1/2 + 1/4$ $* 1/4 * 1/2$	7/32
5	4 3 2 1	1 2 3 4	$P_1^F(5\|\mathrm{I^F}) = Prob(\mathrm{s} = 4) * Prob(\mathrm{j} = 1) + Prob(\mathrm{s} = 3) * Prob(\mathrm{j} = 2)$ $+ Prob(\mathrm{s} = 2) * Prob(\mathrm{j} = 3) + Prob(\mathrm{s} = 1) * Prob(\mathrm{j} = 4)$ $= 1/4 * 1/4 * 1/2 + 1/4 * 1/4 * 1/2 + 1/4 * 1/4 * 1/2$ $+ 1/4 * 1/4 * 1/2$	1/8
6	4 3 2	2 3 4	$P_1^F(6\|\mathrm{I^F}) = Prob(\mathrm{s} = 4) * Prob(\mathrm{j} = 2) + Prob(\mathrm{s} = 3) * Prob(\mathrm{j} = 3)$ $+ Prob(\mathrm{s} = 2) * Prob(\mathrm{j} = 4)$ $= 1/4 * 1/4 * 1/2 + 1/4 * 1/4 * 1/2 + 1/4 * 1/4 * 1/2$	3/32
7	4 3	3 4	$P_1^F(7\|\mathrm{I^F}) = Prob(\mathrm{s} = 4) * Prob(\mathrm{j} = 3) + Prob(\mathrm{s} = 3) * Prob(\mathrm{j} = 4)$ $= 1/4 * 1/4 * 1/2 + 1/4 * 1/4 * 1/2$	1/16
8	4	4	$P_1^F(8\|\mathrm{I^F}) = Prob(\mathrm{s} = 4) * Prob(\mathrm{j} = 4) = 1/4 * 1/4 * 1/2$	1/32

Note: $i = s\ (number\ on\ the\ 2nd\ card) + j\ (number\ on\ the\ 3rd\ card), i: from\ 1\ to\ 8$

[52] $Prob(\mathrm{s} = 1)$ is the probability that s =1 is equal to the number's random drawn probability, i.e., 25%. The same for s =2, 3, and 4. And the probability that j =0 is 50%, since this probability is equal to the probability of "No Call".

[53] The probability that j =1 is equal to the number's random drawn probability times the 50% probability of "Call". The same for j =2, 3, and 4.

Prob(win$|I^F, Call, j, i)$

$$= \begin{cases} 1, if\ 9 \geq \mathrm{FN1} + \mathrm{FN2} + j > SN1 + i, or\ \mathrm{FN1} + \mathrm{FN2} + j \leq 9 < SN1 + i \\ 0, if\ \mathrm{FN1} + \mathrm{FN2} + j < SN1 + i \leq 9, or\ \mathrm{FN1} + \mathrm{FN2} + j > 9 \\ \frac{1}{2}, if\ \mathrm{FN1} + \mathrm{FN2} + j = SN1 + i \leq 9 \end{cases}$$

$Prob(win|I^F, No\ Call, i)$

$$= \begin{cases} 1, if\ 9 \geq \mathrm{FN1} + \mathrm{FN2} > SN1 + i, or\ \mathrm{FN1} + \mathrm{FN2} + j \leq 9 < SN1 + i \\ 0, if \mathrm{FN1} + \mathrm{FN2} < SN1 + i \leq 9, or\ \mathrm{FN1} + \mathrm{FN2} + j > 9 \\ \frac{1}{2}, if\ \mathrm{FN1} + \mathrm{FN2} = SN1 + i \leq 9 \end{cases}$$

Comparing PC_1^F and PN_1^F, L1 FM chooses the action with a higher winning probability in the scenario of I^F. (Table 2.3 in Section 2.3.2.1 shows the strategy matrix of the L1 FM.)

Since the L1 SM knows or equates with knowing the FM's action, the procedure to get the distribution of $P_1^S(i|I^S)$ is divided into two parts as below Table A2.3.2a and Table A2.3.2b:

Table A2.3.2a *Distribution of the Posterior Belief of the L1 SM on her FM's the sum of 2nd card and 3rd card when the FM does not call a 3rd card (I^S = {SN1, SN2, FN1, FA=N})*

i	s	j	$P_1^S(i|I^S)$	
1	1	0	$P_1^S(1|I^S) = Prob(\mathrm{s} = 1) = 1/4$	1/4
2	2	0	$P_1^S(2|I^S) = Prob(\mathrm{s} = 2) = 1/4$	1/4
3	3	0	$P_1^S(3|I^S) = Prob(\mathrm{s} = 3) = 1/4$	1/4
4	4	0	$P_1^S(4|I^S) = Prob(\mathrm{s} = 3) = 1/4$	1/4

Note: If FM does not call a 3rd card, there is no possible that "i" is equal to 5, 6, 7, or 8. If FM calls for a 3rd card, there is no possible that "i" is equal to 1.

Table A2.3.2b *Distribution of the Posterior Belief of the L1 SM on her FM's the sum of 2nd card and 3rd card when the FM calls a 3rd card (I^S = {SN1, SN2, FN1, FA=C})*

i	s	j	$P_1^F(i\|I^F)$	
2	1	1	$P_1^S(2\|I^S) = Prob(s = 1) * Prob(j = 1) = 1/4 * 1/4$	1/16
3	2 1	1 2	$P_1^S(3\|I^S) = Prob(s = 2) * Prob(j = 1) + Prob(s = 1) * Prob(j = 2)$ $= 1/4 * 1/4 + 1/4 * 1/4$	1/8
4	3 2 1	1 2 3	$P_1^S(4\|I^S) = Prob(s = 3) * Prob(j = 1) + Prob(s = 2) * Prob(j = 2)$ $+ Prob(s = 1) * Prob(j = 3)$ $= 1/4 * 1/4 + 1/4 * 1/4 + 1/4 * 1/4$	3/16
5	4 3 2 1	1 2 3 4	$P_1^S(5\|I^S) = Prob(s = 4) * Prob(j = 1) + Prob(s = 3) * Prob(j = 2)$ $+ Prob(s = 2) * Prob(j = 3) + Prob(s = 1)$ $* Prob(j = 4)$ $= 1/4 * 1/4 + 1/4 * 1/4 + 1/4 * 1/4 + 1/4 * 1/4$	1/4
6	4 3 2	2 3 4	$P_1^S(6\|I^S) = Prob(s = 4) * Prob(j = 2) + Prob(s = 3) * Prob(j = 3)$ $+ Prob(s = 2) * Prob(j = 4)$ $= 1/4 * 1/4 + 1/4 * 1/4 + 1/4 * 1/4$	3/16
7	4 3	3 4	$P_1^S(7\|I^S) = Prob(s = 4) * Prob(j = 3) + Prob(s = 3) * Prob(j = 4)$ $= 1/4 * 1/4 + 1/4 * 1/4$	1/8
8	4	4	$P_1^S(8\|I^S) = Prob(s = 4) * Prob(s = 4) = 1/4 * 1/4$	1/16

Based on the same process[54] as the L1 FM, the SM chooses the action with a higher probability of winning in the scenario of I^S. (Table 2.4 in Section 2.3.2.1 shows the strategy matrix of the L1 SM.)

[54] $PC_1^S = Prob(win|\ I^S, Call) = \sum_{j=1}^{4} \frac{1}{4} * (\sum_{i=1}^{8}[\text{Prob}(\text{win}|I^S, Call, j, i) * P_1^S(i|I^S)])$

$$PN_1^S = Prob(win|\ I^S, No\ Call) = \sum_{i=1}^{8}[\text{Prob}(\text{win}|I^S, No\ Call, i) * P_1^S(i|I^S)]$$

$$\text{Prob}(\text{win}|I^S, Call,\ j, i)\begin{cases} = 1, if\ 9 \geq \text{SN1} + \text{SN2} + j > FN1 + i, or\ \text{SN1} + \text{SN2} + j \leq 9 < FN1 + i \\ = 0, if\ \text{SN1} + \text{SN2} + j < FN1 + i \leq 9, or\ \text{SN1} + \text{SN2} + j > 9 \\ = \frac{1}{2}, if\ \text{SN1} + \text{SN2} + j = FN1 + i \leq 9 \end{cases}$$

Appendix 2.4 Analysis on the L2 Player

The L2 FM chooses an action with a high winning probability between PC_2^F ("Call a 3rd card"), and PN_2^F ("Not call a 3rd card"). To get PC_2^F and PN_2^F, L2 FM needs to deduce $P_2^F(i|I^F)$, which is the prior belief ta the L2 FM on the distribution of "i" of his L1 SM. Since the L1 SM chooses actions based on his FM's action, $P_2^F(i|I^F)$ is updated to $P_2^F(i|I^F, FA = C)$ if L2 FM plans to call a 3rd card, or $P_2^F(i|I^F, FA = N)$ if L2 FM plans not to call a 3rd card.

"i" is composed of "s" (number on the 2nd card) and "j" (number on the 3rd card), and meanwhile "j" depends on the action of the L1 SM, which is affected by the action of the FM. The L2 FM draws a prior probability on the action of the L1 SM according to Table 2.4. For example, in a scenario of {FN1=3, FN2=4, SN1=3, FA=N}, the combinations of the sum of L1 SM's 1st and 2nd cards are from 4 to 7. When the L1 SM faces {SN1=3, FN1=3, FA=N}, there is 75% probability that the L1 SM chooses to call a 3rd card, since when SN2 is equal to 1, 2 or 3, the sum of the L1 SM's 1st and 2nd cards can be 4, 5 or 6. Only in these three cases, the L1 SM's strategy is "Call". Then the sum i can be from 2 to 7. However, when SN2=4, Table 2.4 shows the strategy of the L1 SM is "No Call". The sum i only can be 4 in this case. Table A2.4.1 shows the distribution of i in the scenario of {FN1=3, FN2=4, SN1=3, FA=N}.

$$\text{Prob}(\text{win}|I^S, No\ Call, i)\begin{cases} = 1, if\ 9 \geq \text{SN1} + \text{SN2} > FN1 + i, or\ \text{SN1} + \text{SN2} + j \leq 9 < FN1 + i \\ = 0, if \text{SN1} + \text{SN2} < FN1 + i \leq 9, or\ \text{SN1} + \text{SN2} + j > 9 \\ = \frac{1}{2}, if\ \text{SN1} + \text{SN2} = FN1 + i \leq 9 \end{cases}$$

***Table A2.4.1**. Distribution of $P_2^F(i|FN1=3, FN2=4, SN1=3, FA=N)$*

i	Combination	$P_2^F(i\|\mathrm{FN1}=3, \mathrm{FN2}=4, \mathrm{SN1}=3, \mathrm{FA}=\mathrm{N})$
2	{s=1, j=1}	1/4*1/4=1/16
3	{s=1, j=2; s=2, j=1}	1/4*1/4+1/4*1/4=1/8
4	{s=4, j=0; s=1, j=3, s=2, j=2; s=3, j=1}	1/4+1/4*1/4+1/4*1/4+1/4*1/4=7/16
5	{s=1, j=4; s=2, j=3; s=3, j=2}	1/4*1/4+1/4*1/4+1/4*1/4=3/16
6	{s=2, j=4; s=3, j=3}	1/4*1/4+1/4*1/4=1/8
7	{s=3, j=4}	1/4*1/4=1/16

We generalize that the probability on that the action of the L1 SM is "Call" is $P_1^S(Call|FN1, SN1, SN2=s, FA)$ in the scenario of {FN1, SN1, SN2=s, FA} and the probability on that the action of L1 SM is "No Call" is $P_1^S(No\ Call|FN1, SN1, SN2=s, FA)$ in the scenario of {FN1, SN1, SN2=s, FA} based on L1 SM's strategy matrix. Then the prior[55] distribution of "i" of the L2 FM is shown in each action as below:

[55] As L2 FM actually does not get new information on L1 SM, the belief of L2 FM on L1 SM's action is still a prior estimate. $P_2^F(i|I^F, FA)$ could be expanded as below:

$$P_2^F(i|I^F, FA) = P_2^F(i = SN2 + j|I^F, FA) = \sum_{s=1}^{4} P_1^S(j, SA|I^F, FA, SN2 = s) * P(SN2 = s|I^F, FA)$$

According to Bayes' Rule,

$$P_1^S(j, SA|I^F, FA, SN2 = s) = P_1^S(SA|I^F, FA, SN2 = s) * P(j = i - s|I^F, FA, SN2 = s, SA)$$

Then

$$P_2^F(i|I^F, FA) = \sum_{s=1}^{4} P_1^S(SA|I^F, FA, SN2 = s) * P(j = i - s|I^F, FA, SN2 = s, SA) * P(SN2 = s|I^F, FA)$$

SA denotes SM's action, and $P_1^S(SA|I^F, FA, SN2 = s)$ denotes the probability for the L1 SM's action, either "C" or "N", when $\{I^F, FA, SN2 = s\}$. $P(SN2 = s|I^F, FA)$ which denotes the probability for the number on the SM's 2nd card, i.e., 1, 2, 3, or 4, is always equal to ¼ as s is randomly drawn from 1 to 4. $P(j = i - s|I^F, FA, SN2 = s, SA)$ denotes the probability for the number on the SM's 3rd card in the scenario of $\{I^F, FA, SN2 = s, SA\}$, which is either equal to ¼ when j is from 1 to 4 or equal to 0 when j is nonsexist.

$$P_2^F(i|I^F, FA = C)$$
$$= \sum_{s=1}^{4}[P_1^S(No\ Call|FN1, SN1, SN2 = s, FA = C) * P(i - s = 0) * P(s)]$$
$$+ \sum_{s=1}^{4}[P_1^S(Call|FN1, SN1, SN2 = s, FA = C) * P(j = i - s) * P(s)]$$

$$P_2^F(i|I^F, FA = N)$$
$$= \sum_{s=1}^{4}[P_1^S(No\ Call|FN1, SN1, SN2 = s, FA = N) * P(i - s = 0) * P(s)]$$
$$+ \sum_{s=1}^{4}[P_1^S(Call|FN1, SN1, SN2 = s, FA = N) * P(j = i - s) * P(s)]$$

$P(i - s = 0)$ represents the probability of $i - s = 0$. If $i - s = 0$, the probability is equal to 1. Otherwise, this probability is equal to 0. $P(j = i - s)$ represents the probability of the value j of the 3rd card, which equals to $(i - s)$. If $0 < i - s \leq 4$, the probability is equal to 1/4. Otherwise, this probability is equal to 0. $P(s)$ represents the probability of the value j of the 2nd card equal to s, which is 1/4.

When the L2 FM call a 3rd card, the procedure of inference is similar to the case above. Then L2 FM compares PC_2^F with PN_2^F[56] and picks up the higher one. Table 2.1 shows the strategy matrix of the L2 FM in each scenario after comparison.

In contrast to the L2 FM, the L2 SM chooses an action after she knows her FM's action, which helps L2 SM to update her belief on the distribution of FN2 using Bayes' Rule. For example, in a scenario of {FN1=3, SN1=1, SN2=3, FA=C}, before L2 SM knows her FM's action, the prior distribution of FN2, $P_1^S(i|I^S)$, is a uniform distribution from 1 to 4. However, after

[56] $PC_2^F = Prob(win|\ I^F, Call) = \sum_{j=1}^{4}\frac{1}{4} * (\sum_{i=1}^{8}[\mathrm{Prob}(\mathrm{win}|I^F, Call, \mathrm{j}, \mathrm{i}) * P_2^F(i|I^F, FA = C)])$

$$PN_2^F = Prob(win|I^F, No\ Call) = \sum_{i=1}^{8}[\mathrm{Prob}(\mathrm{win}|I^F, No\ Call, \mathrm{i}) * P_2^F(i|I^F, FA = N)]$$

L2 SM is informed that her FM's action is "Call", the L2 SM updates her belief to the posterior distribution of FN2, $P_2^S(i|I^S)$[57], based on Bayes' Rule following the steps below:

$$P_2^S(FN2|FN1=3,SN1=1,FA=C)$$
$$=P_2^S(\ FA=C|FN1=3,FN2,SN1=1)$$
$$*P(FN2|FN1=3,SN1=1)/P_2^S(\ FA=C|FN1=3,SN1=1)$$

When FN1=3, which means "FN1+FN2" can be chosen randomly from 4 to 7, and SN1=1, according to *Table 3* L2 SM knows the probability of L1 FM calls a 3rd card is 50%, which only occurs when FN2=1 or FN2=2. Then that means $P_2^S(\ FA=C|FN1=3,SN1=1)=50\%$. And the distribution of FN2 is independent of FN1 and SN1, so $P(FN2|FN1=3,SN1=1)=\frac{1}{4}$. Furthermore, Table 3 shows when FN2 is equal to 1 or 2, the strategy of L1 FM is "Call". Then $P_2^S(\ FA=C|FN2,FN1=3,SN1=1)=1$ when FN1=1 or FN1=2. Otherwise, $P_2^S(\ FA=C|FN2,FN1=3,SN1=1)=0$. That is,

$$P_2^S(FN2=1|FN1=3,SN1=1,FA=C)=1/2$$

$$P_2^S(FN2=2|FN1=3,SN1=1,FA=C)=1/2$$

$$P_2^S(FN2=3|FN1=3,SN1=1,FA=C)=0$$

$$P_2^S(FN2=4|FN1=3,SN1=1,FA=C)=0$$

By updating the belief with Bayes' Rule, L2 SM knows FN2 only can be 1 or 2. Next, the range of i could be from 2 to 6, and the distribution could be drawn[58] by $P(i)=P(FN2+j)=P(FN2)*P(j)$. In general, the posterior probability of "i" in scenario of {FN1, SN1, SN2, FA} is drawn as below:

[57] If L2 SM does not use Bayes' Rule to update the prediction on the distribution of the number on FM's 2nd card, the prediction without Bayesian updated is the same as L1 SM's prediction, which is that the numbers on FM's 2nd card is uniformly distributed from 1 to 4.
[58] Since SN2 and j are independent to each other.

$P_2^S(i|I^S)$

$= P_2^S(FN2 + j|I^S)$

$= P_2^S(FN2|I^S) * P_2^S(j|I^S)$[59]

$= [P_2^S(FA|FN2, FN1, SN1) * P(FN2|FN1, SN1)/P_2^S(FA|FN1, SN1)] * P_2^S(j|I^S)$

Similar with other level players, L2 SM gets PC_2^S and PN_2^S by inferring $P_2^S(i|I^S)$ and compares them to pick out the higher one. Table 2.2 shows the strategy matrix of the L2 SM.

Furthermore, based on the deducing above, the L2 SM's beliefs could be represents as following:

a) for the L2 FM, the belief that his opponent calls a 3rd card is

$P(Call|FN1, SN1, FA = C)$

$$= \sum_{i=1}^{8} \sum_{s=1}^{4} [P_1^S(Call|FN1, SN1, SN2 = s, FA = C) * P_1^S(0 < i - s \leq 4) * \frac{1}{4}]$$

$P(Call|FN1, SN1, FA = N)$

$$= \sum_{i=1}^{8} \sum_{s=1}^{4} [P_1^S(Call|FN1, SN1, SN2 = s, FA = N) * P_1^S(0 < i - s \leq 4) * \frac{1}{4}]$$

b) for the L2 SM, the belief that her opponent calls a 3rd card is

$$P(Call|FN1, SN1) = \sum_{i=1}^{8} \sum_{s=1}^{4} [P_1^F(Call|FN1, FN2 = s, SN1) * P_1^F(0 < i - s \leq 4) * \frac{1}{4}]$$

c) for the L2 SM, the beliefs that the number on her opponent's 2nd card is

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59 If FM calls a 3rd card, $P_2^S(j|I^S) = \frac{1}{4}$ when j is from 1 to 4 and $P_2^S(j|I^S) = 0$ for j =0. If FM does not call a 3rd card, $P_2^S(j|I^S) = 0$ when j is from 1 to 4 and $P_2^S(j|I^S) = 1$ for j =0.

$$P_2^S(FN2 = s|FN1, SN1, FA = C)$$
$$= P_2^S(FA = C|FN1, FN2 = s, SN1)$$
$$* P(FN2 = s|FN1, SN1)/P_2^S(FA = C|FN1, SN1)$$

As in each specific game, the equilibrium players (Eq) also respond best to their beliefs, the inferring procedure on Bayes' Rule of building beliefs is the same as the L2 players as described above. Then the equilibrium players' beliefs use the same representations as the L2:

d) for the Eq FM, the belief that his opponent calls a 3rd card is

$$P(Call|FN1, SN1, FA = C)$$
$$= \sum_{i=1}^{8}\sum_{s=1}^{4}\left[P_{Eq}^S(Call|FN1, SN1, SN2 = s, FA = C) * P_{Eq}^S(0 < i - SN2 \leq 4) * \frac{1}{4}\right]$$

$$P(Call|FN1, SN1, FA = N)$$
$$= \sum_{i=1}^{8}\sum_{s=1}^{4}[P_{Eq}^S(Call|FN1, SN1, SN2 = s, FA = N) * P_{Eq}^S(0 < i - SN2 \leq 4) * \frac{1}{4}]$$

e) for the Eq SM, the belief that her opponent calls a 3rd card is

$$P(Call|FN1, SN1)$$
$$= \sum_{i=1}^{8}\sum_{s=1}^{4}[P_{Eq}^F(Call|FN1, FN2 = s, SN1) * P_{Eq}^F(0 < i - FN2 \leq 4) * \frac{1}{4}]$$

f) for Eq SM, the beliefs that the number on her opponent's 2nd card is

$$P_{Eq}^{S}(FN2 = s|FN1, SN1, FA = C)$$

$$= P_{Eq}^{S}(\ FA = C|FN1, FN2 = s, SN1)$$

$$* P_{Eq}(FN2 = s|FN1, SN1)/P_{Eq}^{S}(\ FA = C|FN1, SN1)$$

Appendix 2.5. L1(SA) SM's Strategy

SN1+SN2 \ FN1	1	2	3	4
FA=N:				
2	Call	Call	Call	Call
3	Call	Call	Call	Call
4	Call	Call	Call	Call
5	Call	Call	Call	Call
6	Call	Call	Call	Call
7	No Call	No Call	No Call	No Call
8	No Call	No Call	No Call	No Call
FA=C:				
2	Call	Call	Call	Call
3	Call	Call	Call	Call
4	Call	Call	Call	Call
5	Call	Call	Call	Call
6	Call	Call	Call	Call
7	No Call	No Call	No Call	Call/No Call
8	No Call	No Call	No Call	No Call

Note: The winning probability of "Call" is equal to the winning probability of "No Call", when {SN1+SN2=7, FN1=4, FA=C}.

Appendix 2.6. Subjects' Types

Furthermore, we identify each subject's thinking type and belief type with the given parameters from the models in previous sections and investigate their capabilities to make best responses on their beliefs.

Given e^k and λ which are got from the previous 7-type model or 9-type model, S_i^k evaluates the likelihood value of type k subject i as described in formula (5.8), and then by comparing all S_i^k along with k, a specific k^* is picked, which leads a highest value of S_i^k. This k^* represents the thinking type of subject i.

(5.8)

$$S_i^k = L_i^k\left(e^k \middle| x_i^k\right) \prod_{g=1}^{G=12} L_{i,g}^k\left(\lambda \middle| y_{i,g}, b_g^k\right)$$

Table A2.6.1 presents the numbers of subjects who are identified as a specific type under two models. Table A2.6.1 shows the consistent findings with Table 20 in Section 5.2.3. And the proportions of transferring from L1(Exp) and L1(SA) to Exp-Exp increase to more than 40% except for the SM in DRT.

Table A2.6.1. *Summary on Identifications on Action & Stated Belief Data for Individual Subject (All games)*

	7-type model				9-type model			
	DRT		SMT		DRT		SMT	
Type	FM	SM	FM	SM	FM	SM	FM	SM
SA-No belief	0	-	0	-	0	-	0	-
Exp- No belief	2	4	0	3	2	4	0	4
SA-SA Play	-	-	-	-	0	-	1	-
Exp- Exp Play	-	-	-	-	9	5	11	11
L1	0	0	0	0	0	0	0	0
*C1**	*2*	*4*	*0*	*3*	*11*	*9*	*12*	*15*
L1(SA)	9	13	10	15	6	9	7	4
L1(Exp)	8	9	15	7	1	8	6	7
L2	2	0	1	0	2	0	1	0
Eq	6	1	1	2	7	1	1	1

The result by identifying each subject's type is corresponding to the previous finding that strategy method impedes strategy thinking. Details for each subject's type shown as the table below:

***Table A2.6.2**. Type of Each Subject*

Treatment	Session	Subject	Role	Action	Belief	Action & Belief 7 Type	Action & Belief 9 Type
DRT	1	1	FM	L1(SA)/Exp	Exp play	L1(Exp)	Exp-Exp play
DRT	1	2	FM	L1(SA)/Exp	SA Play	L1(Exp)	Exp-Exp play
DRT	1	3	FM	L1(SA)/Exp	SA Play	L1(Exp)	Exp-Exp play
DRT	1	4	FM	L1(SA)/Exp	Exp play	L1(SA)	L1(SA)
DRT	1	5	FM	L1(SA)/Exp	Exp play	L1(Exp)	Exp-Exp play
DRT	1	6	FM	L1(SA)/Exp	Exp play	L1(SA)	Exp-Exp play
DRT	1	7	FM	L1(SA)/Exp	no belief	L1(Exp)	Exp-Exp play
DRT	1	8	FM	L1(SA)/Exp	Exp play	L1(SA)	L1(SA)
DRT	1	9	FM	L1(SA)/Exp	Eq	L1(SA)	L1(SA)
DRT	2	1	FM	SA	SA Play	Exp-No belief	Exp-No belief
DRT	2	2	FM	L1(SA)/Exp	Exp play	Exp-No belief	Exp-No belief
DRT	2	3	FM	L1(SA)/Exp	Exp play	L1(SA)	Exp-Exp play
DRT	2	4	FM	L1(SA)/Exp	Exp play	L1(SA)	L1(SA)
DRT	2	5	FM	SA	Exp play	Eq	Eq
DRT	2	6	FM	Eq	SA Play	L1(Exp)	L1(Exp)
DRT	2	7	FM	SA	Exp play	L1(SA)	L1(SA)
DRT	2	8	FM	Eq	Eq	L2	L2
DRT	3	1	FM	SA	L1	Eq	Eq
DRT	3	2	FM	Eq	Exp play	Eq	Eq
DRT	3	3	FM	L1(SA)/Exp	SA Play	L1(SA)	Exp-Exp play
DRT	3	4	FM	Eq	Exp play	Eq	Eq
DRT	3	5	FM	Eq	Exp play	Eq	Eq
DRT	3	6	FM	Eq	no belief	Eq	Eq
DRT	3	7	FM	Eq	no belief	L1(Exp)	Eq
DRT	3	8	FM	L1(SA)/Exp	no belief	L1(Exp)	Exp-Exp play
DRT	3	9	FM	L1(SA)/Exp	Exp play	L1(SA)	L1(SA)
DRT	3	10	FM	Eq	no belief	L2	L2
SMT	1	1	FM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	1	2	FM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	1	3	FM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	1	4	FM	L1(SA)/Exp	no belief	Exp-No belief	Exp-No belief
SMT	1	5	FM	L1(SA)/Exp	Exp play	L1(SA)	L1(SA)
SMT	1	6	FM	Eq	Exp play	L1(Exp)	L1(Exp)
SMT	1	7	FM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)

(continue)

(Continuation)

SMT	1	8	FM	L1(SA)/Exp	no belief	Exp-No belief	Exp-No belief
SMT	1	9	FM	L1(SA)/Exp	Exp play	L1(SA)	L1(SA)
SMT	2	1	FM	L1(SA)/Exp	Exp play	L1(Exp)	L1(Exp)
SMT	2	2	FM	L1(SA)/Exp	no belief	Exp-No belief	Exp-No belief
SMT	2	3	FM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	2	4	FM	L1(SA)/Exp	Eq	Eq	Exp-Exp play
SMT	2	5	FM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	2	6	FM	L1(SA)/Exp	Exp play	L1(Exp)	L1(Exp)
SMT	2	7	FM	Eq	Exp play	L1(Exp)	L1(Exp)
SMT	2	8	FM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	2	9	FM	Eq	Exp play	L1(Exp)	L1(Exp)
SMT	3	1	FM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	3	2	FM	L1(SA)/Exp	no belief	Exp-No belief	Exp-No belief
SMT	3	3	FM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	3	4	FM	L1(SA)/Exp	Exp play	L1(Exp)	Exp-Exp play
SMT	3	5	FM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	3	6	FM	L1(SA)/Exp	Eq	Eq	Eq
SMT	3	7	FM	Eq	Exp play	L1(Exp)	L1(Exp)
SMT	3	8	FM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	3	9	FM	Eq	Exp play	L1(Exp)	L1(Exp)
DRT	1	10	SM	L1(SA)/Exp	Exp play	L1(Exp)	Exp-Exp play
DRT	1	11	SM	Eq	Eq	Eq	Eq
DRT	1	12	SM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
DRT	1	13	SM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
DRT	1	14	SM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
DRT	1	15	SM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
DRT	1	16	SM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
DRT	1	17	SM	L1(SA)/Exp	Exp play	L1(Exp)	Exp-Exp play
DRT	1	18	SM	L1(SA)/Exp	L2	L2	L2
DRT	2	9	SM	L1(SA)/Exp	Exp play	L1(Exp)	Exp-Exp play
DRT	2	10	SM	L1(SA)/Exp	Exp play	L1(SA)	Exp-Exp play
DRT	2	11	SM	L1(SA)/Exp	Exp play	L1(Exp)	Exp-Exp play
DRT	2	12	SM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
DRT	2	13	SM	L1(SA)/Exp	Exp play	L1(SA)	Exp-Exp play
DRT	2	14	SM	L1(SA)/Exp	Exp play	L1(Exp)	Exp-Exp play
DRT	2	15	SM	Eq	L2	L1(Exp)	L1(Exp)
DRT	2	16	SM	Eq	Eq	L1(Exp)	L1(Exp)
DRT	3	11	SM	Eq	Eq	L1(Exp)	L1(Exp)
DRT	3	12	SM	L1(SA)/Exp	Exp play	L1(Exp)	Exp-Exp play
DRT	3	13	SM	Eq	no belief	L1(Exp)	L1(Exp)
DRT	3	14	SM	SA	SA Play	L1(SA)	SA-SA play
DRT	3	15	SM	L1(SA)/Exp	Exp play	L1(Exp)	Exp-Exp play
DRT	3	16	SM	L1(SA)/Exp	Exp play	L1(Exp)	Exp-Exp play
DRT	3	17	SM	Eq	Eq	L1(Exp)	L1(Exp)

(continue)

(Continuation)

DRT	3	18	SM	L1(SA)/Exp	Exp play	L1(Exp)	Exp-Exp play
DRT	3	19	SM	Eq	Eq	L1(Exp)	L1(Exp)
DRT	3	20	SM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	1	10	SM	L1	Exp play	L1(SA)	Exp-Exp play
SMT	1	11	SM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	1	12	SM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	1	13	SM	L1(SA)/Exp	Exp play	Eq	Exp-Exp play
SMT	1	14	SM	L1(SA)/Exp	Exp play	L1(SA)	Exp-Exp play
SMT	1	15	SM	L1(SA)/Exp	Exp play	L1(SA)	Exp-Exp play
SMT	1	16	SM	L1(SA)/Exp	no belief	Exp-No belief	Exp-No belief
SMT	1	17	SM	L1(SA)/Exp	Exp play	L1(Exp)	L1(Exp)
SMT	1	18	SM	Eq	Eq	L1(Exp)	L1(Exp)
SMT	2	10	SM	Eq	SA Play	L1(Exp)	L1(Exp)
SMT	2	11	SM	L1(SA)/Exp	Exp play	L1(SA)	Exp-Exp play
SMT	2	12	SM	L1(SA)/Exp	Exp play	L1(SA)	L1(SA)
SMT	2	13	SM	L1(SA)/Exp	Exp play	L1(Exp)	L1(Exp)
SMT	2	14	SM	L1(SA)/Exp	Exp play	L1(Exp)	L1(Exp)
SMT	2	15	SM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	2	16	SM	L1(SA)/Exp	Exp play	L1(SA)	Exp-Exp play
SMT	2	17	SM	L1(SA)/Exp	Eq	Eq	Eq
SMT	2	18	SM	L1(SA)/Exp	L1	L1(SA)	L1(SA)
SMT	3	10	SM	L1(SA)/Exp	Exp play	L1(SA)	Exp-Exp play
SMT	3	11	SM	L1(SA)/Exp	SA Play	L1(SA)	L1(SA)
SMT	3	12	SM	L1(SA)/Exp	Exp play	L1(SA)	Exp-Exp play
SMT	3	13	SM	Eq	Exp play	L1(Exp)	L1(Exp)
SMT	3	14	SM	L1	no belief	Exp-No belief	Exp-No belief
SMT	3	15	SM	L1(SA)/Exp	no belief	L1(SA)	L1(SA)
SMT	3	16	SM	L1(SA)/Exp	no belief	L1(SA)	L1(SA)
SMT	3	17	SM	Eq	Exp play	L1(Exp)	L1(Exp)
SMT	3	18	SM	L1	no belief	Exp-No belief	Exp-No belief

Appendix Instructions

Instruction of DRT

WELCOME!

PLEASE WAIT UNTIL THE EXPERIMENTER TELLS YOU TO START

You are about to participate in an experiment in interdependent decision making. If you follow the instructions and pass the Understanding Test, you will be allowed to continue in the experiment. By continuing in the experiment, you will then be able to earn a considerable amount of money. The amount that you earn will be determined by your decisions, the decisions of other participants in the experiment, and chance. All that you earn is yours to keep, and will be paid to you in private, in cash, after today's session.

It is important to us that you remain silent and do not look at other people's work. If you have any questions or need assistance of any kind, please raise your hand, and an experimenter will come to you. If you talk, exclaim out loudly, etc., you will be asked to leave, and you will forfeit your earnings. Thank you.

The experiment consists of two parts, Part I and Part II.

In Part I, you and all the other participants will first be randomly assigned to one of two roles: “First Mover” and “Second Mover”. You will have the same role throughout all of Part I.

In Part I, you and everybody else will then be presented with 12 interdependent decision situations, one in each round. In each round of Part I, you will be anonymously matched with one of the other participants assigned to the other role, a new one in each round. Both of you will face the same interdependent decision situation in that round.

You will not know which of the other participants you are matched with, and your identity and the identities of the other participants will never be revealed. We will refer to the other participant as "S/He."

In the interdependent decision situation of each round you and "S/He" make decisions, as explained below. Your decisions in a round will neither influence the matching of participants nor the assignment of interdependent decision situations in later rounds.

Once a round is over, you will not be able to change your decisions in that round. In each round of Part I, you will have to wait until everyone is done with his/her own decisions, before proceeding to the next round.

In Part II, neither you nor anyone else will interact with anyone else. You will first face a decision situation and next answer the questions of a quiz. In this part, your earnings will depend on your decision and chance in the decision situation and on your answers to the quiz's questions. Your Part I decisions will not influence what you will be asked to do in Part II.

You will receive the instructions that correspond to each part immediately before that part begins.

PART I INSTRUCTIONS

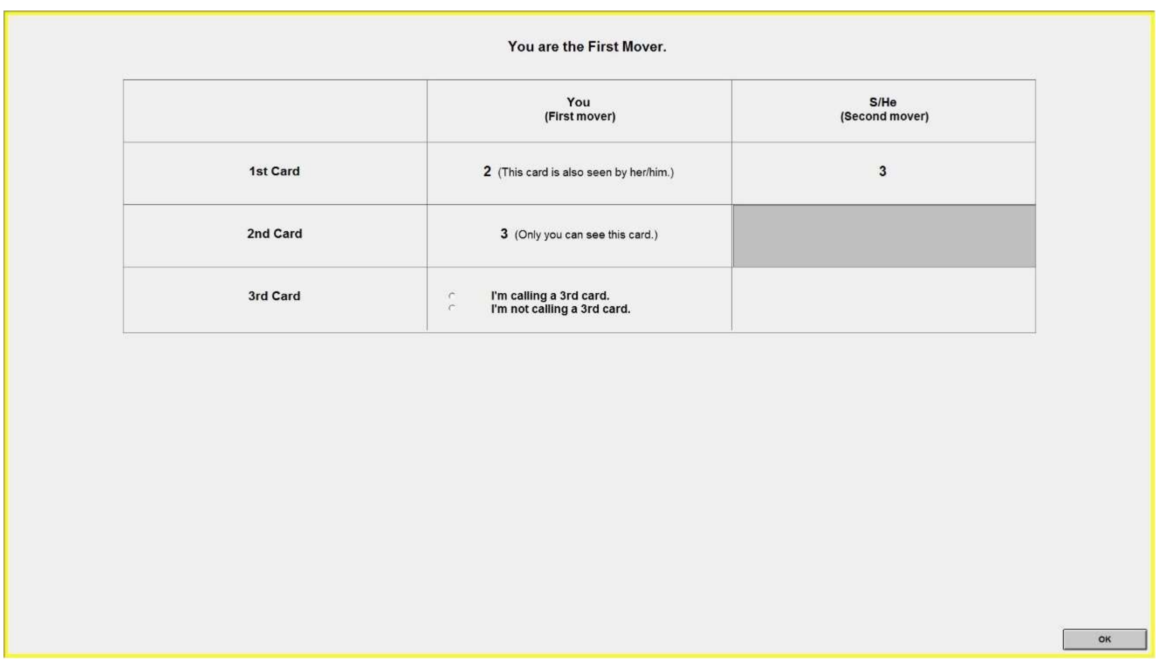
Each interdependent decision situation you will face in Part I is as follows:

The First Mover will be given two cards, a 1st card and a 2nd card. Each of the First Mover's two cards has a number on it, 1, 2, 3 or 4. The Second Mover will also be given two cards, a 1st card and a 2nd card. Each of the Second Mover's cards has a number on it, 1, 2, 3 or 4.

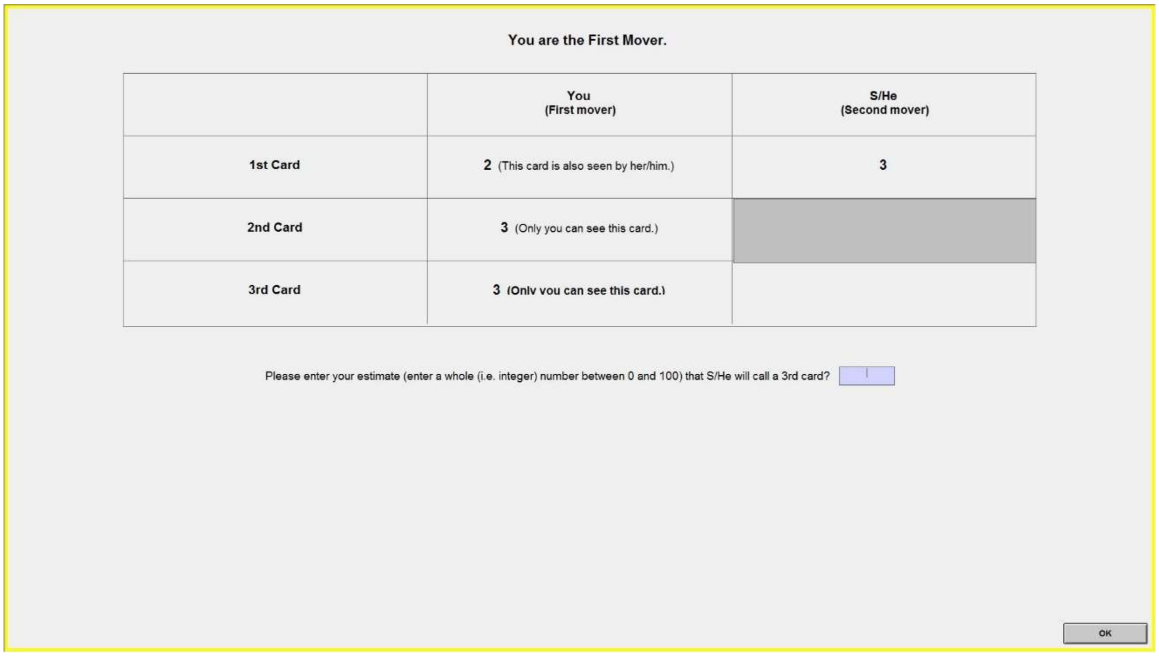
The First Mover will see the numbers on her/his 1st and 2nd cards, but will only see the number on the Second Mover's 1st card, not the number on the Second Mover's 2nd card. The Second Mover will see the numbers on her/his 1st and 2nd cards, but only the number on the First Mover's 1st card, not the number on the First Mover's 2nd card.

In this interdependent decision situation, the First Mover, is the first to make a choice: to call or not call the 3rd card. The First Mover's choice is then revealed to the Second Mover, who then chooses whether or not to call the 3rd card. The First and Second Mover 3rd cards each have a number on them, that is drawn independently, that can be 1, 2, 3 or 4.

The next screens display an illustrative example (IT IS ONLY AN ILLUSTRATION): The first screen displays the example from the point of view of the participant assigned to the role of First Mover (refers to the First Mover as "You," while the Second Mover is "S/He"). It shows the choice that the First Mover has to make. (The dark grey rectangle indicates that there is a number on the Second Mover's 2nd card that cannot be seen by "You", the First Mover.)

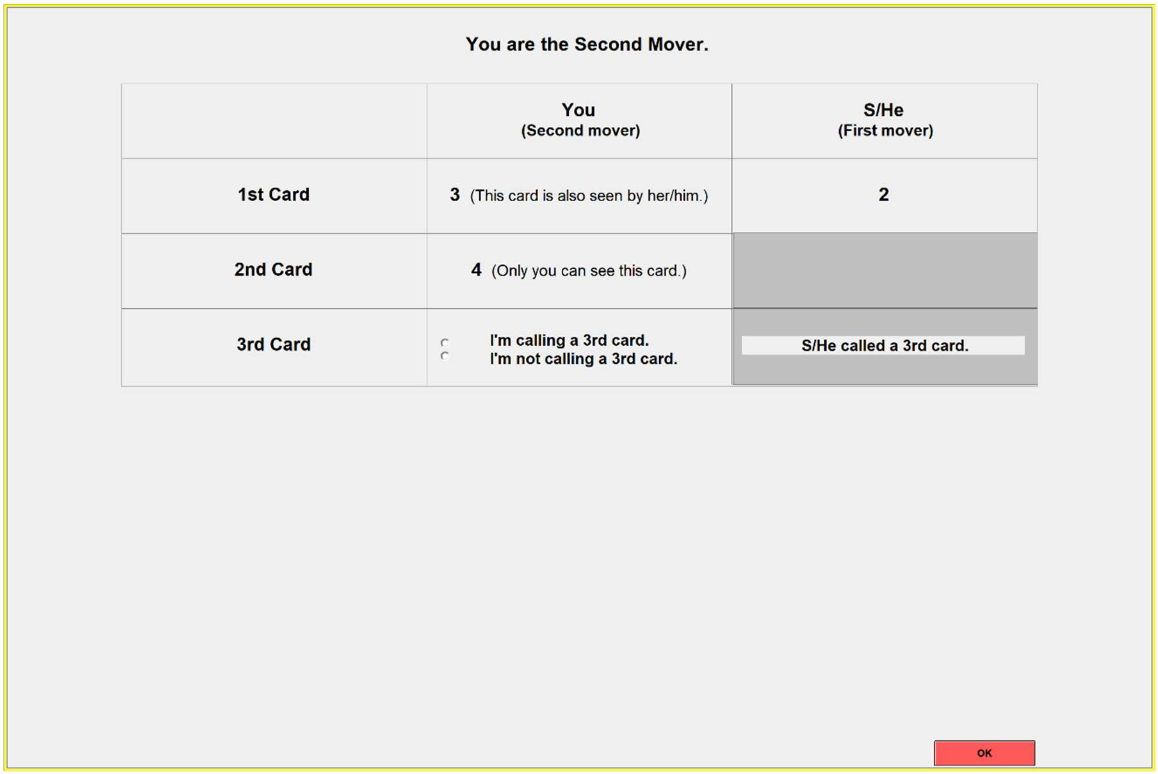


Suppose the First Mover calls the 3rd card. Then, in the example, the First Mover would then see the next screen:

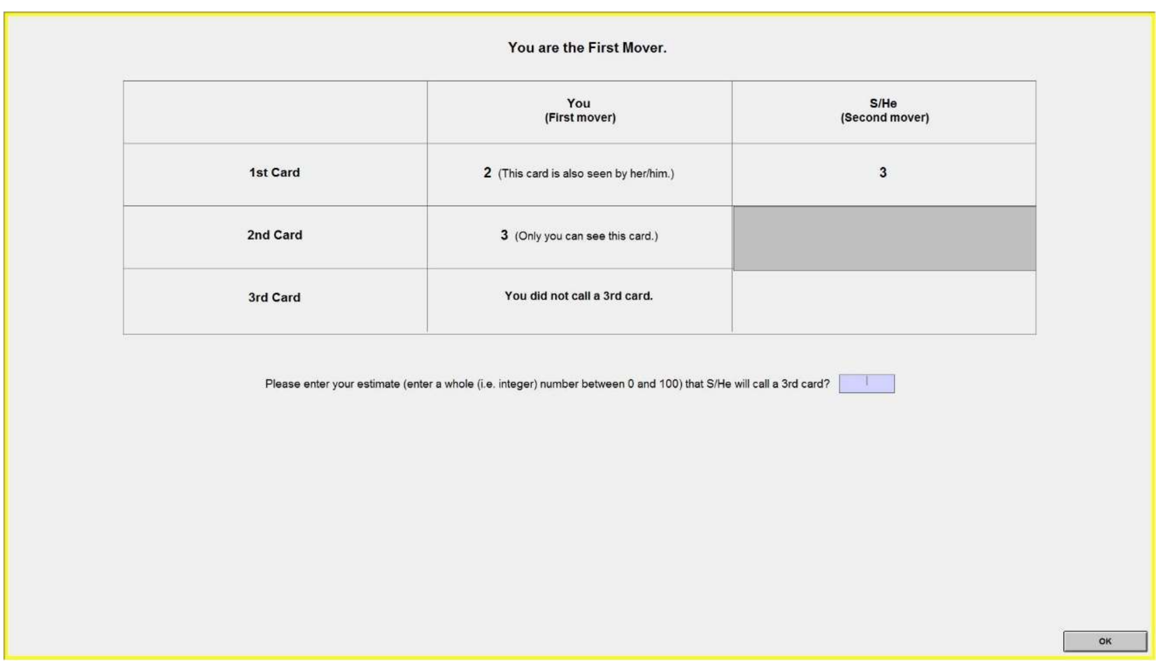


(At this stage please ignore the sentence at the bottom of the screen "Please enter your estimate (enter a whole (i.e. integer) number between 0 and 100) that S/He will call the 3rd card?" We will explain this later.)

In the case the First Mover calls the 3rd card, the next screen displays this interdependent decision situation example from the point of view of the participant assigned to the role of Second Mover (and therefore, refers to the Second Mover as "You", while the First Mover is "S/He"). (The dark grey rectangle shows that there is a number on the First Mover's 2nd card that cannot be seen by "You", the Second Mover.) The screen shows that the Second Mover has to choose whether to call the 3rd card.

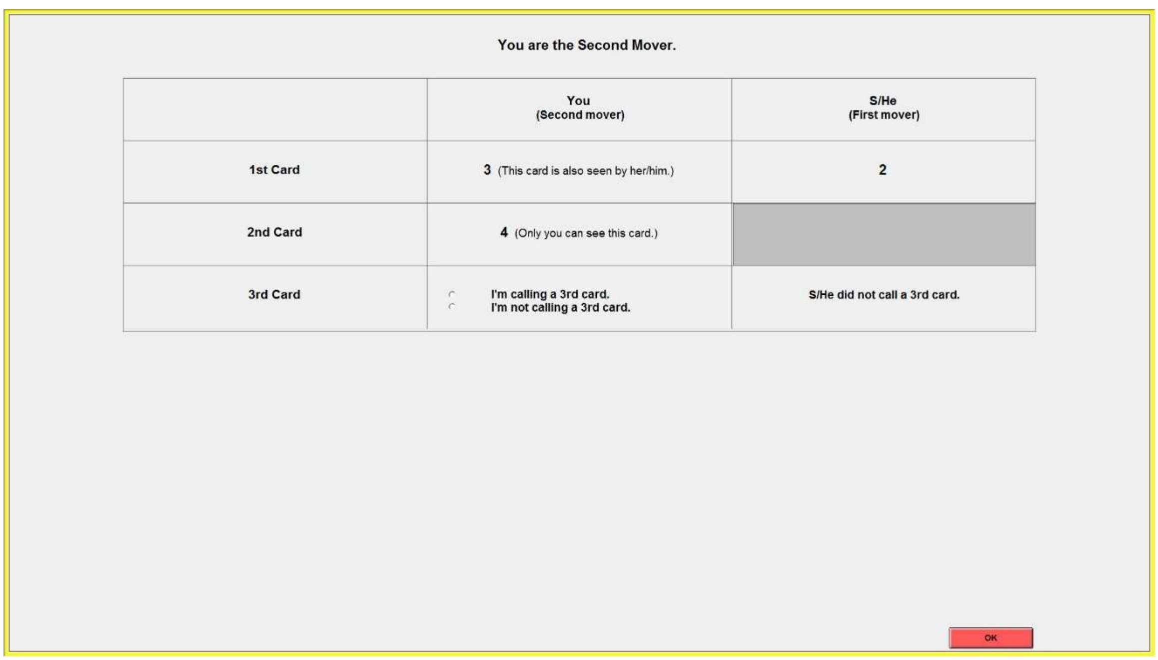


Instead suppose the First Mover does not call the 3rd card. Then, in this interdependent decision situation example, the First Mover would then see the next screen:



(At this stage please ignore the sentence at the bottom of the screen "Please enter your estimate (enter a whole (i.e. integer) number between 0 and 100) that S/He will call the 3rd card?" We will explain this later.)

In the case the First Mover does not call the 3rd card, the next screen displays the interdependent decision situation example from the point of view of the participant assigned to the role of Second Mover (and therefore, refers to the Second Mover as "You", while the First Mover is "S/He"). (The dark grey rectangle shows that there is a number on the First Mover's 2nd card that cannot be seen by "You", the Second Mover.) The screen shows that the Second Mover has to choose whether to call a 3rd card.



After the Second Mover makes her/his choice on whether to call the 3rd card, the sum of the numbers on the First Mover's cards (either the sum of the numbers on the two initial cards, or the sum of the numbers on all three cards if the First Mover called the 3rd card) is compared to the sum of the numbers on the Second Mover's cards (either the sum of the numbers on the two initial cards, or the sum of the numbers on all three cards if the Second Mover called the 3rd card), and the **WINNER** of the interdependent decision situation is selected as follows:

- If both sums are larger than 9, no one wins;
- If both sums are smaller than 9, the participant in the role with the largest sum wins;
- If one of the sums is equal to 9, and the other sum is either smaller or larger than 9, then the participant in the role whose numbers on the cards sum to 9 wins.
- If one of the sums is smaller than 9, and the other sum is larger than 9, then the participant in the role whose numbers on the cards sum to less than 9 wins.
- If both sums are equal and also smaller than or equal to 9, then they tie, and the winner is determined randomly by the computer. In this case both participants have the same chance of winning, one in two.

Neither you nor the other participants will learn the WINNER in any round before Part II.

How are the numbers on the 2nd cards selected?

In the 12 decision situations both the First Mover's 2nd card and the Second Mover's 2nd card will have the number 1, 2, 3 or 4 on it an equal number of times. In other words, the First Mover's 2nd card will have the number 1 on it 3 times, number 2 also 3 times, number 3 also 3 times and number 4 also 3 times. The same is true for the Second Mover. Since neither the First Mover nor the Second Mover will find out the number on the 2nd card of the participant in the other role until they have completed all 12 rounds, i.e., the end of Part I, they should think of the number on the other role's 2nd card as having an equal chance of being 1, 2, 3 or 4 in each interdependent decision situation. In other words, in each of the 12 interdependent decision situations it is as if the other role's 2nd card has one in four chances of being each of the numbers, 1, 2, 3 or 4.

How are the numbers on the 3rd cards selected?

Every time the First or the Second Mover calls the 3rd card, a number from 1, 2, 3, or 4 is drawn by the computer. Each number has one in four chances of being drawn every time the 3rd card is called. This means that across all 12 interdependent decision situations the four different numbers might appear a different number of times, even if the four different numbers have the same chance of being drawn every time the 3rd card is called.

How will you be paid for your decisions?

Your payment will be determined as follows:

Three of the 12 rounds will be selected at random by the computer to determine your earnings for your choices on whether or not to call a third card. For each of the three rounds that you won you will earn £4.

If you have questions about the instructions so far please raise your hand.

Next, you will take an Understanding Test, to demonstrate that you understand all the instructions so far. You need to pass the test in order to continue in the experiment. After that you will be assigned your role for Part I, First or Second Mover.

Appendix Instructions: Instruction of ST

WELCOME!

PLEASE WAIT UNTIL THE EXPERIMENTER TELLS YOU TO START

You are about to participate in an experiment in interdependent decision making. If you follow the instructions and pass the Understanding Test, you will be allowed to continue in the experiment. By continuing in the experiment, you will then be able to earn a considerable amount of money. The amount that you earn will be determined by your decisions, the decisions of other participants in the experiment, and chance. All that you earn is yours to keep, and will be paid to you in private, in cash, after today's session.

It is important to us that you remain silent and do not look at other people's work. If you have any questions or need assistance of any kind, please raise your hand, and an experimenter will come to you. If you talk, exclaim out loudly, etc., <u>you will be asked to leave</u>, and you will forfeit your earnings. Thank you.

The experiment consists of two parts, Part I and Part II.

In Part I, you and all the other participants will first be randomly assigned to one of two roles: “First Mover” and “Second Mover”. You will have the same role throughout all of Part I.

In Part I, you and everybody else will then be presented with 12 interdependent decision situations, one in each round. In each round of Part I, you will be anonymously matched with one of the other participants assigned to the other role, a new one in each round. Both of you will face the same interdependent decision situation in that round.

You will not know which of the other participants you are matched with, and your identity and the identities of the other participants will never be revealed. We will refer to the other participant as "S/He."

In the interdependent decision situation of each round you and “S/He” make decisions, as explained below. Your decisions in a round will neither influence the matching of participants nor the assignment of interdependent decision situations in later rounds.

Once a round is over, you will not be able to change your decisions in that round. In each round of Part I, you will have to wait until everyone is done with his/her own decisions, before proceeding to the next round.

In Part II, neither you nor anyone else will interact with anyone else. You will first face a decision situation and next answer the questions of a quiz. In this part, your earnings will depend on your decision and chance in the decision situation and on your answers to the quiz's questions. Your Part I decisions will not influence what you will be asked to do in Part II.

You will receive the instructions that correspond to each part immediately before that part begins.

PART I INSTRUCTIONS

Each decision situation you will face in Part I is as follows:

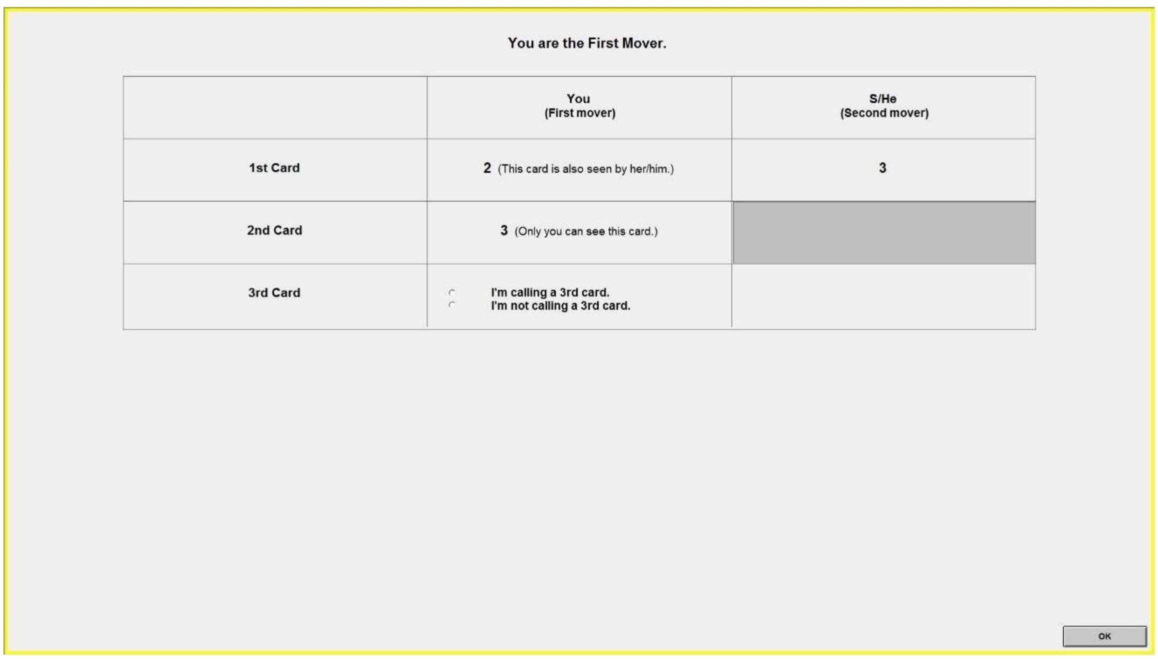
The First Mover will be given two cards, a 1st card and a 2nd card. Each of the First Mover's two cards has a number on it, 1, 2, 3 or 4. The Second Mover will also be given two cards, a 1st card and a 2nd card. Each of the Second Mover's cards has a number on it, 1, 2, 3 or 4.

The First Mover will see the numbers on her/his 1st and 2nd cards, but will only see the number on the Second Mover's 1st card, not the number on the Second Mover's 2nd card. The Second Mover will see the numbers on her/his 1st and 2nd cards, but only the number on the First Mover's 1st card, not the number on the First Mover's 2nd card.

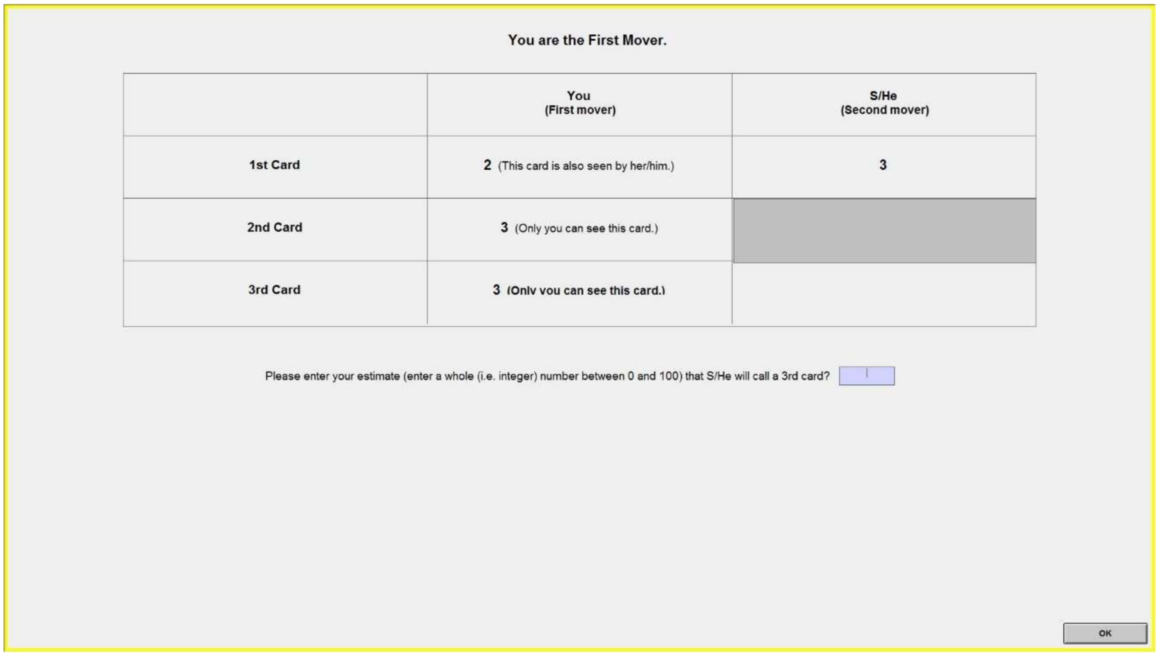
In this interdependent decision situation, the First Mover, is the first to make a choice: to call or not call a 3rd card. Next, the Second mover has to make a choice: to call or not to call a 3rd card. The Second Mover makes this choice without knowing the First

Mover’s choice. However, Second Mover can condition her/his choice on the First Mover’s choice. The First and Second Mover 3rd cards each have a number on them, that is drawn independently, and that can be 1, 2, 3 or 4.

The next screens display an illustrative example (IT IS ONLY AN ILLUSTRATION): The first screen displays the example from the point of view of the participant assigned to the role of First Mover (refers to the First Mover as “You,” while the Second Mover is “S/He”). It shows the choice that the First Mover has to make. (The dark grey rectangle indicates that there is a number on the Second Mover’s 2nd card that cannot be seen by “You”, the First Mover.)

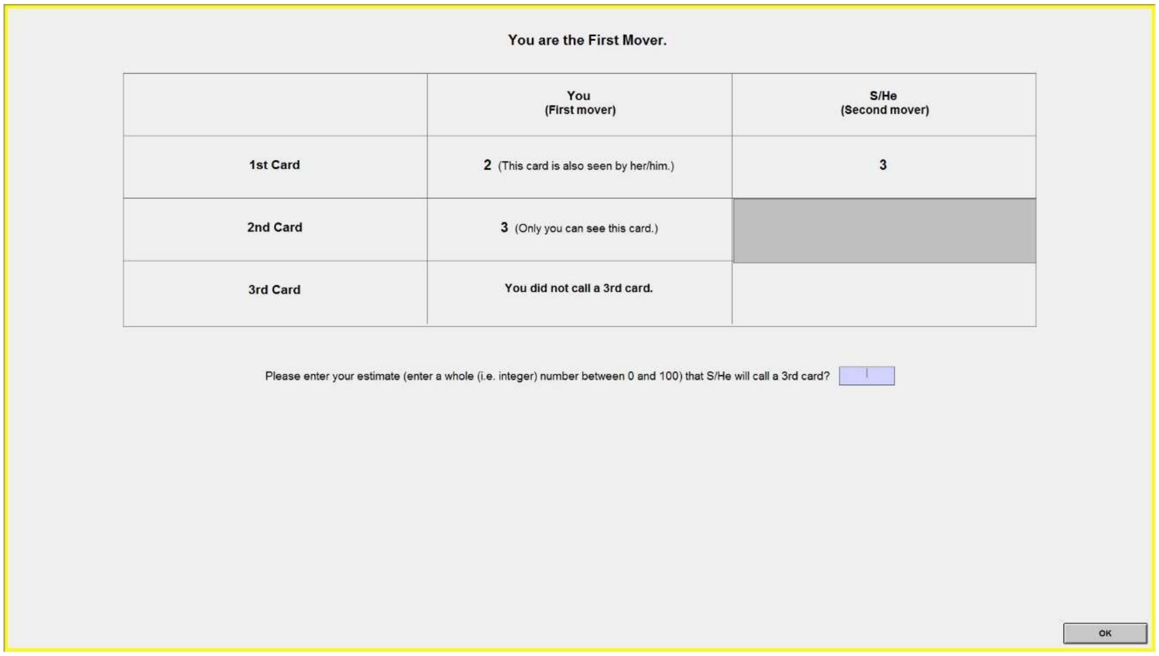


Suppose the First Mover calls the 3rd card. Then, in the example, the First Mover would then see the next screen:



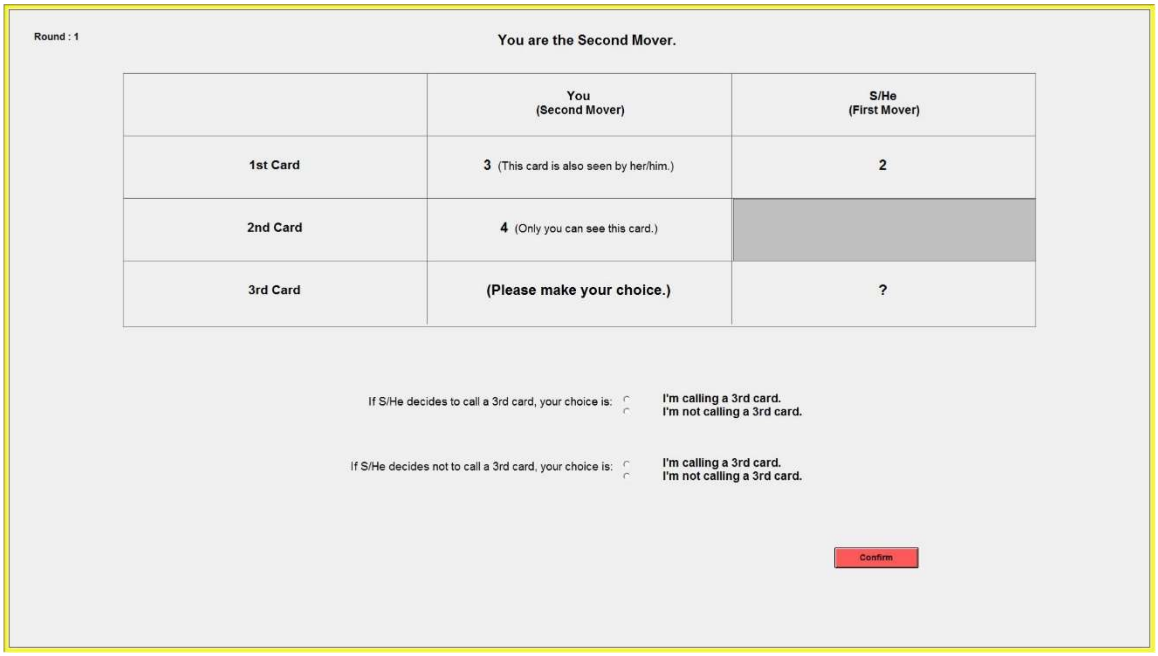
(At this stage please ignore the sentence at the bottom of the screen "Please enter your estimate (enter a whole (i.e. integer) number between 0 and 100) that S/He will call the 3rd card?" We will explain this later.)

Instead suppose the First Mover does not call the 3rd card. Then, in the example, the First Mover would then see the next screen:



(At this stage please ignore the sentence at the bottom of the screen "Please enter your estimate (enter a whole (i.e. integer) number between 0 and 100) that S/He will call the 3rd card?" We will explain this later.)

After the First Mover makes her/his choice of whether to call the 3rd card, the next screen displays this interdependent decision situation example from the point of view of the participant assigned to the role of Second Mover (and therefore, refers to the Second Mover as "You", while the First Mover is "S/He"). (The dark grey rectangle shows that there is a number on the First Mover's 2nd card that cannot be seen by "You", the Second Mover.) The Second Mover is not told the First Mover's choice (the question mark "?" in the First Mover's 3rd card indicates that). Therefore, the Second Mover sees the same screen independently of the First Mover's choice. The Second Mover then decides what her/his choice for the two possible choices the First Mover could have made, i.e., in the case the First Mover called the 3rd card, and in the case the First Mover did not call the 3rd card.



After the Second Mover makes her/his choice on whether to call the 3rd card, the sum of the numbers on the First Mover's cards (either the sum of the numbers on the two initial cards, or the sum of the numbers on all three cards if the First Mover called the 3rd card) is compared to the sum of the numbers on the Second Mover's cards (either the sum of the numbers on the two initial cards, or the sum of the numbers on all three cards if the Second Mover called the 3rd card), and the **WINNER** of the interdependent decision situation is selected as follows:

- If both sums are larger than 9, no one wins;
- If both sums are smaller than 9, the participant in the role with the largest sum wins;
- If one of the sums is equal to 9, and the other sum is either smaller or larger than 9, then the participant in the role whose numbers on the cards sum to 9 wins.
- If one of the sums is smaller than 9, and the other sum is larger than 9, then the participant in the role whose numbers on the cards sum to less than 9 wins.
- If both sums are equal and also smaller than or equal to 9, then they tie, and the winner is determined randomly by the computer. In this case both participants have

the same chance of winning, one in two.

Neither you nor the other participants will learn the WINNER in any round before Part II.

How are the numbers on the 2nd cards selected?

In the 12 decision situations both the First Mover's 2nd card and the Second Mover's 2nd card will have the number 1, 2, 3 or 4 on it an equal number of times. In other words, the First Mover's 2nd card will have the number 1 on it 3 times, number 2 also 3 times, number 3 also 3 times and number 4 also 3 times. The same is true for the Second Mover. Since neither the First Mover nor the Second Mover will find out the number on the 2nd card of the participant in the other role until they have completed all 12 rounds, i.e., the end of Part I, they should think of the number on the other role's 2nd card as having an equal chance of being 1, 2, 3 or 4 in each interdependent decision situation. In other words, in each of the 12 interdependent decision situations it is as if the other role's 2nd card has one in four chances of being each of the numbers, 1, 2, 3 or 4.

How are the numbers on the 3rd cards selected?

Every time the First or the Second Mover calls the 3rd card, a number from 1, 2, 3, or 4 is drawn by the computer. Each number has one in four chances of being drawn every time the 3rd card is called. This means that across all 12 interdependent decision situations the four different numbers might appear a different number of times, even if the four different numbers have the same chance of being drawn every time a 3rd card is called.

How will you be paid for your decisions?

Your payment will be determined as follows:

Three of the 12 rounds will be selected at random by the computer to determine your earnings for your choices on whether or not to call the 3rd card. For each of the three rounds that you won you will earn £4.

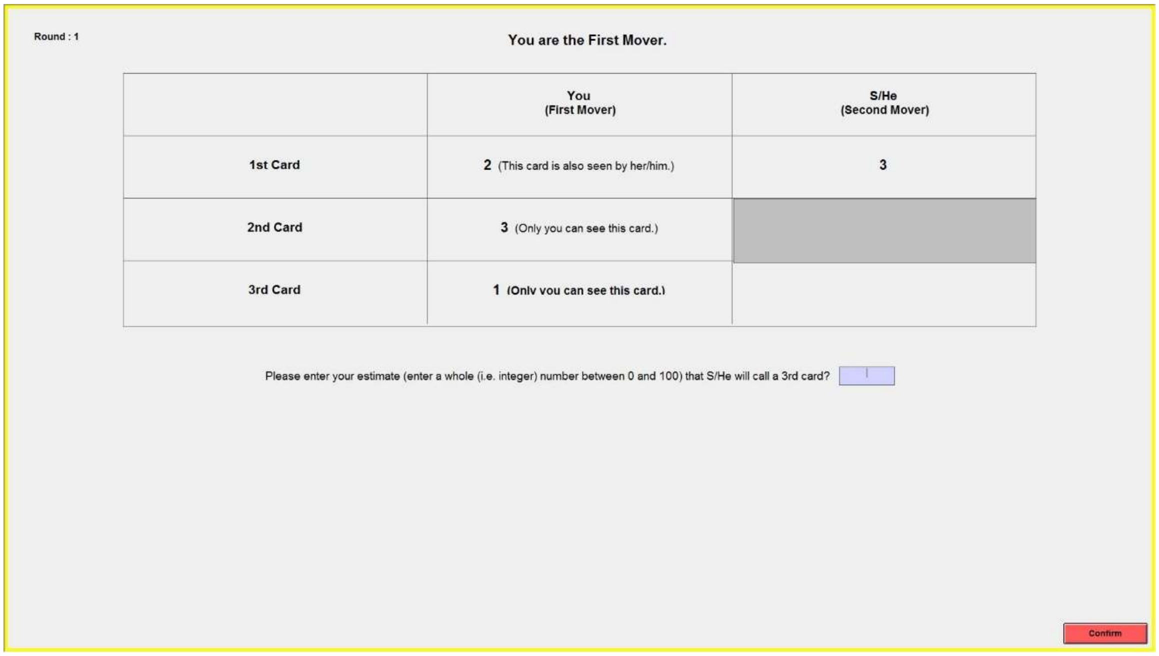
If you have questions about the instructions so far please raise your hand.

Next, you will take an Understanding Test, to demonstrate that you understand all the instructions so far. You need to pass the test in order to continue in the experiment. After that you will be assigned your role for Part I, First or Second Mover.

Appendix Instructions: Instruction of FM

You have now been assigned the role of First Mover.

In each round, after you make your choice of whether to call a 3rd card you will be asked to provide an **estimate of how likely it is that the Second Mover will call a 3rd card**, after the S/He knows whether you call a 3rd card. That is, we ask you to think about the chance in percentage terms (i.e., out of 100%) that the Second Mover will call a 3rd card, once S/He knows your choice. The next screens display an illustrative example (IT IS ONLY AN ILLUSTRATION):



If you are absolutely sure that the Second Mover will call a 3rd card, then you would want to enter 100%. If you are absolutely sure that the Second Mover will not call the 3rd card, you want to enter 0%. If you are less sure about the Second Mover's choice, you would want to respond with an intermediate percentage number, reflecting what you think. A higher number would indicate a stronger tendency towards the Second Mover calling the 3rd card, and a lower number would indicate a stronger tendency towards the Second Mover not calling the 3rd card.

In each round you will be rewarded for the accuracy of your estimate, as follows. You receive 400 points, minus a number "L" (short for "loss") that indicates how well your estimate indicates the Second Mover's choice. This number L is determined in several simple steps.

The computer first looks up the Second Mover's choice. If the Second Mover called a 3rd card, we take the difference between your answer, which we call "ESTIMATE", and the number 100. If the Second Mover did not call a 3rd card, we take the difference between your answer, which we call "ESTIMATE", and the number 0. Then, this difference is multiplied by itself, and then multiplied by 0.04, yielding the number L.

Expressed as a formula, your earnings from the estimate are therefore given by

400 – L, where

If the Second Mover called a 3rd card*:*

L = 0.04 x (ESTIMATE -100) x (ESTIMATE -100).

If the Second Mover did not call a 3rd card*:*

L = 0.04 x ESTIMATE x ESTIMATE.

You can convince yourself that with this formula, you will earn a number of points of at least 0 and at most 400, and that you will earn more points if your ESTIMATE is closer to indicating correctly the Second Mover's choice. It will therefore pay off for you to report a good guess. In fact, your expected earnings are maximal if you report truthfully what you think is the average likelihood of the Second Mover calling a 3rd card. (We skip a more mathematical version of this property, and you can trust us on this. But fairly obviously, it has to do with the fact that L is a positive number, and that the better your estimate, the smaller L will be.)

Example: Suppose that the Second Mover's choice is to call a 3rd card. Your task is to estimate this choice – you earn more points if your estimate better reflects the Second Mover's choice. With the above formula, you can verify that for this choice of the Second Mover, you would receive

- 400-0.04×(100-100) × (100-100)=400-0=400 points if your estimate of the Second Mover calling a 3rd card is 100%, or

- 400-0.04× (30-100) × (30-100)=400-196=204 points if your estimate of the Second Mover calling a 3rd card is 30%, or
- 400-0.04× (10-100) × (10-100)=400-364=36 points if your estimate of the Second Mover calling a 3rd card is 10%.

How will you be paid for your estimates?

After you have submitted your estimates for all 12 rounds, your earnings will be determined as follows:

One of the 9 rounds not selected to determine your earnings from your choice of whether you called a 3rd card will be selected at random by the computer. You will earn 1 pence for each point you received for your estimate in that round.

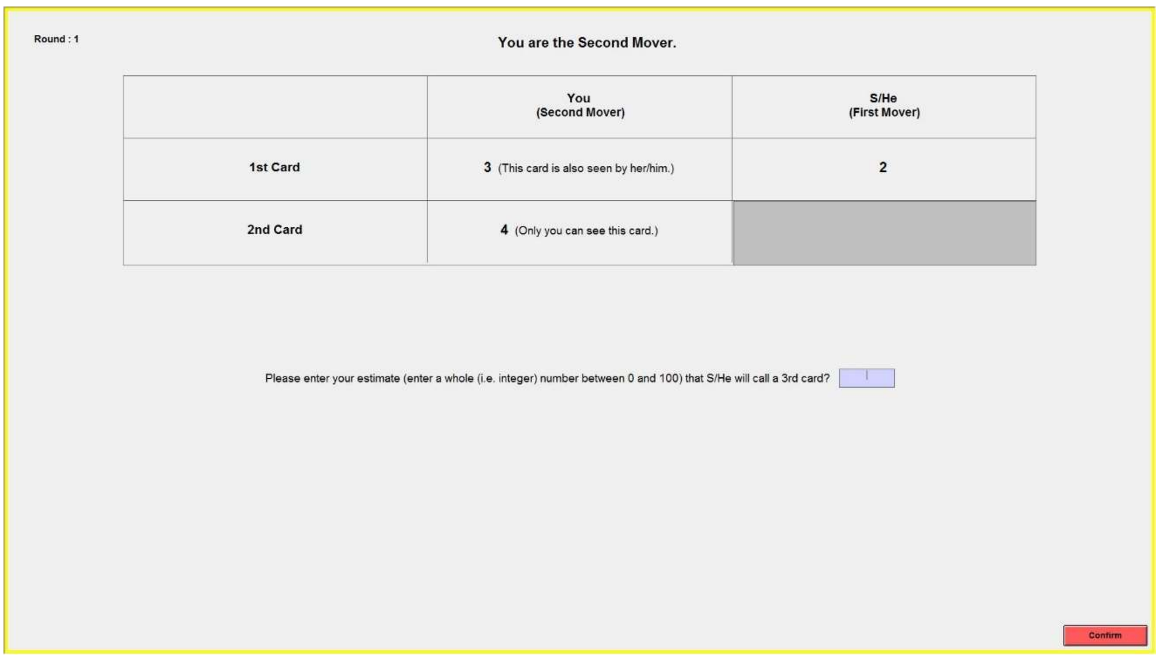
If you have questions about this part of the instructions so far please raise your hand.

Next, you will take an Understanding Test, to demonstrate that you understand how your estimate earns you points. You need to pass the test in order to continue in the experiment. After that we will start Part I.

Appendix Instructions: Instruction of FM

You have now been assigned the role of Second Mover.

In each round, before you make your choice of whether to call the 3rd card you will be asked to provide an **estimate of how likely it is that the First Mover will call the 3rd card**. That is, we ask you to think about the chance in percentage terms (i.e., out of 100%) that the First Mover will call the 3rd card. The next screens display an illustrative example (IT IS ONLY AN ILLUSTRATION):



If you are absolutely sure that the First Mover will call the 3rd card, then you would want to enter 100%. If you are absolutely sure that the First Mover will not call the 3rd card, you want to enter 0%. If you are less sure about the First Mover's choice, you would want to respond with an intermediate percentage number, reflecting what you think. A higher number would indicate a stronger tendency towards the First Mover calling the 3rd card, and a lower number would indicate a stronger tendency towards the First Mover not calling the 3rd card.

In each round you will be rewarded for the accuracy of your estimate, as follows. You receive 400 points, minus a number "L" (short for "loss") that indicates how well your estimate indicates the First Mover's choice. This number L is determined in several simple steps.

If the First Mover called the 3rd card, we take the difference between your answer, which we call "ESTIMATE", and the number 100. If the First Mover did not call the 3rd card, we take the difference between your answer, which we call "ESTIMATE", and the number 0. Then, this difference is multiplied by itself, and then multiplied by 0.04, yielding the number L.

Expressed as a formula, your earnings from the estimate are therefore given by

400 – L, where

If the First Mover calls the 3rd card*:*

L = 0.04 x (ESTIMATE-100) x (ESTIMATE-100).

If the First Mover does not call the 3rd card*:*

L = 0.04 x ESTIMATE x ESTIMATE.

You can convince yourself that with this formula, you will earn a number of points of at least 0 and at most 400, and that you will earn more points if your ESTIMATE is closer to indicating correctly the First Mover's choice. It will therefore pay off for you to report a good guess. In fact, your expected earnings are maximal if you report truthfully what you think is the average likelihood of the First Mover calling a 3rd card. (We skip a more mathematical version of this property, and you can trust us on this. But fairly obviously, it has to do with the fact that L is a positive number, and that it is smaller the better is your estimate.)

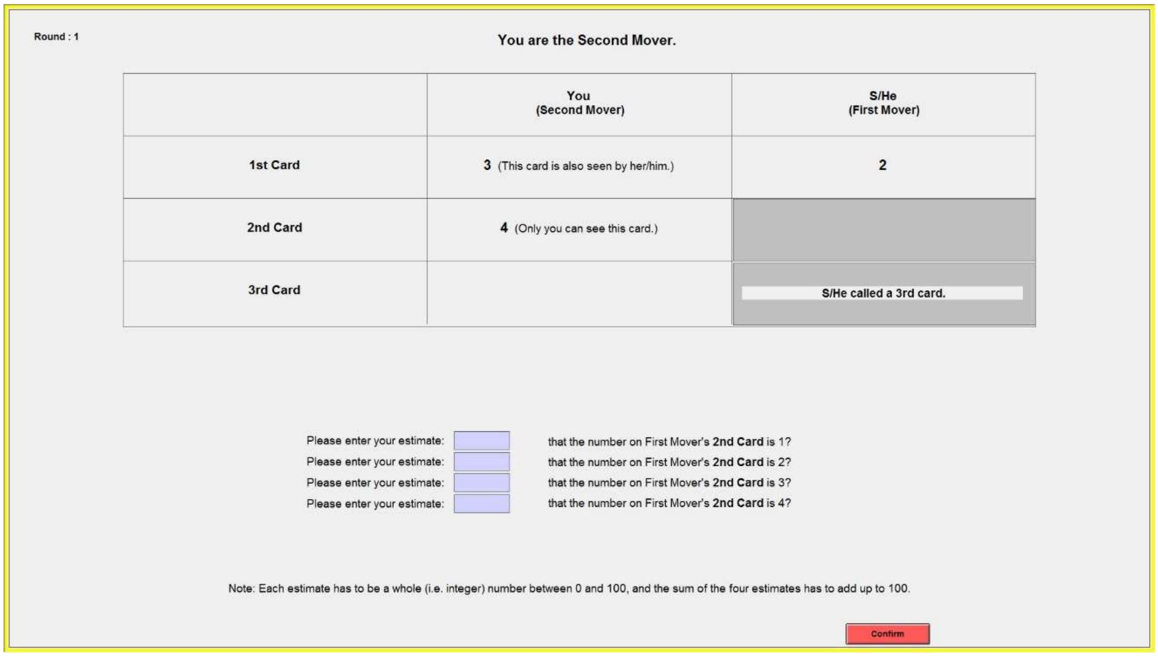
Example: Suppose that the First Mover's choice is to call a 3rd card. Your task is to estimate this choice – you earn more points if your estimate better reflects the First Mover's choice. With the above formula, you can verify that for this choice of the First Mover, you would receive

- 400-0.04×(100-100) × (100-100)=400-0=400 points if your estimate of the Second Mover calling a 3rd card is 100%, or
- 400-0.04× (30-100) × (30-100)=400-196=204 points if your estimate of the Second Mover calling a 3rd card is 30%, or
- 400-0.04× (10-100) × (10-100)=400-364=36 points if your estimate of the Second Mover calling a 3rd card is 10%.

If you have questions about this part of the instructions above please raise your hand.

Next, you will take an Understanding Test, to demonstrate that you understand how your estimate earns you points. You need to pass the test in order to continue in the experiment.

In addition to providing the above estimate we will also ask you to estimate the number on the First Mover's 2nd card. You will be asked to provide this estimate after you make your choice of whether to call the 3rd card. That is, we ask you to think about the chance in percentage terms (i.e., out of 100%) that the number on the First Mover's 2nd card is a 1, 2, 3 or 4. Your estimate has four percentage entries, one percentage entry for each of the feasible numbers. The sum of the four entries has to be 100%. The next screens display an illustrative example (IT IS ONLY AN ILLUSTRATION):



If you are absolutely sure that the number on the First Mover's 2nd card is 1, you would enter 100%, 0%, 0% and 0%. On the other hand, if you are absolutely sure that the number on the First Mover's 2nd card is 3 then you would want to enter 0%, 0%, 100% and 0%. If you are less certain about the number on the First Mover's 2nd card, your percentage entries would be intermediate percentages, i.e. neither 0% nor 100% (but would sum to 100%), reflecting what you think. A higher percentage entry for any of the four numbers would indicate a stronger tendency towards the First Mover's 2nd card being that number, while a lower percentage entry would indicate a weaker tendency towards the First Mover's 2nd card being that number. For example, if after seeing the First Mover's 1st card and being told whether S/He called the 3rd card, you still think that the number on the First Mover's 2nd card is equally likely to be 1, 2, 3, or 4, you would enter 25%, 25%, 25% and 25%.

Caution: The numbers used in these examples were selected arbitrarily. They are NOT intended to suggest how anyone might respond in any situation.

In each round you will be rewarded for the accuracy of your estimate, as follows. You receive 400 points, minus a number "L" (short for "loss") that indicates how well your estimate indicates the number on the First Mover's 2nd card. This number L is determined in several steps.

For each of the possible four numbers on the card (i.e., 1, 2, 3 or 4), we will calculate a number which reflects how well you estimated whether or not that was the number on the card. We use these four calculated numbers to determine the points you earn from your estimate.

In the first step, the computer looks up the number on the First Mover's 2nd card. For example, suppose it is 3. The computer then compares your estimate that the number would be 3 (i.e., your percentage entry for the number 3) with the number 100, and calculates the difference between the two. This difference will then be squared (multiplied by itself). The resulting number is then multiplied by a factor of 0.02. Hence, if your estimate that the number is 3 was high, the resulting number will be smaller (because the difference between your estimate and 100 is small), as compared to the case in which your estimate that the number is 3 was low.

In a second step, the computer determines how well you predicted that the remaining three numbers would not be on the First Mover's 2nd card. For example, still assuming that 3 is the number on the First Mover's 2nd card that means that neither of the remaining three numbers, 1, 2 and 4, were on the First Mover's 2nd card. For each of these three numbers (e.g., 4) , the computer compares your estimate that the number on the First Mover's 2nd card would be that number (i.e., your percentage entry for the number 4) with the number 0, and calculates the difference between the two. This difference will then be squared (multiplied by itself). The resulting number is then multiplied by a factor of 0.02.

In a third step, the computer sums up the four numbers computed above, and calls it L.

Finally, L is subtracted from 400, and the result is the number of points that you earn from your estimate of the number on the First Mover's 2nd card.

(Don't worry about the exact numbers too much at this point, below you will see examples which illustrate the range of points you can earn.)

Example: Suppose that the number on the First Mover's 2nd card is 2. Suppose that your estimates that the number on the First Mover's 2nd card is 1,2, 3 and 4, respectively, were:

- 0, 100, 0 and 0. Hence, your estimate was completely accurate. Thus, you earn $400 - (0.02 \times (0) \times (0) + 0.02 \times (100 - 100) \times (100 - 100) + 0.02 \times (0) \times (0) + 0.02 \times (0) \times (0)) = 400$
- 15, 55, 10 and 20. You estimated that the number 2 had a 55% chance of being the number on the First Mover's 2nd card, but the other three numbers had some small chance of being the number on the First Mover's 2nd card. Since the number on the First Mover's 2nd card is 2, you earn $400 - (0.02 \times (15 - 0) \times (15 - 0) + 0.02 \times (55 - 100) \times (55 - 100) + 0.02 \times (10 - 0) \times (10 - 0) + 0.02 \times (20 - 0) \times (20 - 0)) = 345$
- 100, 0, 0 and 0. You estimated that the number 1 was the number on the First Mover's 2nd card, but in fact the number on the First Mover's 2nd card was 2. Thus, you earn $400 - (0.02 \times (100 - 0) \times (100 - 0) + 0.02 \times (0 - 100) \times (0 - 100) + 0.02 \times (0) \times (0) + 0.02 \times (0) \times (0)) = 0$

How will you be paid for your estimates?

After you have submitted your estimates on whether the First Mover called the 3rd card for all 12 rounds and your estimates of the number on the First Mover's 2nd card for all 12 rounds, your earnings from your estimates will be determined as follows:

One of the 9 rounds not selected to determine your earnings from your choice of whether you called the 3rd Card will be selected at random by the computer.

Next, the computer will select at the random the estimate you will be paid for that round: either your estimate on whether the First Mover called the 3rd card in the interdependent decision of that selected round or the estimate of the number on the First Mover's 2nd card in the interdependent decision of that selected round.

You will earn 1 pence for each point you received for the randomly selected estimate.

If you have questions about the instructions above please raise your hand.

Next, you will take an Understanding Test, to demonstrate that you understand the points that your earn from estimating the number on the First Mover's 2nd card. You need to pass the test in order to continue in the experiment. After that we will start Part I.

Appendix Understanding Test

<u>Test for DRT:</u>

UNDERSTANDING TEST

ID NUMBER: ____________

Please write your code number just above.

You will now take an UNDERSTANDING TEST. You will see a series of questions in each screen. Before you move to the next screen you have to answer all questions correctly. In order to the next part of instruction, you have to ANSWER ALL THE QUESTIONS CORRECTLY. If you cannot finish the test you will be asked to leave, and you will receive your show-up fee at the exit.

Q1: In a round, will you see the number on Her/His 2nd card? Yes/No

Q2: In a round, can S/He see the number on your 2nd card? Yes/No

Q3: Will you be told whether you won or lost at the end of every round? Yes/No

Q4: Will S/He be told whether S/He won or lost at the end of every round? Yes/No

Q5: Will S/He see the number on your 3rd card (if you called a 3rd card in this round) at the end of every round? Yes/No

(The following questions are shown in the pictures, the numbers on the cards in which vary from subjects to subjects.)

Suppose the Second Mover is the computer, which chooses whether or not to call a 3rd card randomly.
You are the First Mover. Please make your choice.

You are the First Mover.

	You (First Mover)	S/He (Second Mover)
1st Card	2 (This card is also seen by her/him.)	4
2nd Card	4 (Only you can see this card.)	
3rd Card	○ I'm calling a 3rd card. ○ I'm not calling a 3rd card.	

OK

Suppose the Second Mover is the computer, which chooses whether or not to call a 3rd card randomly.

You are the First Mover.

	You (First Mover)	S/He (Second Mover)
1st Card	2 (This card is also seen by her/him.)	4
2nd Card	4 (Only you can see this card.)	
3rd Card	1 (Only you can see this card.)	

The number on the computer's 2nd card is 2; the computer did not call a 3rd card.

Who won this round?
- ○ First mover
- ○ Second mover
- ○ First mover and Second mover tied.
- ○ Neither.

Submit

Suppose the First Mover is the computer, which chose whether or not to call a 3rd card randomly.
You are the Second Mover. Please make your choice.

You are the Second Mover.

	You (Second Mover)	S/He (First Mover)
1st Card	1 (This card is also seen by her/him.)	4
2nd Card	3 (Only you can see this card.)	
3rd Card	○ I'm calling a 3rd card. ○ I'm not calling a 3rd card.	S/He called a 3rd card.

OK

Suppose the First Mover is the computer, which chose whether or not to call a 3rd card randomly.

You are the Second Mover.

	You (Second Mover)	S/He (First Mover)
1st Card	1 (This card is also seen by her/him.)	4
2nd Card	3 (Only you can see this card.)	
3rd Card	2 (Only you can see this card.)	S/He called a 3rd card.

The number on the computer's 2nd card is 1; the computer called a 3rd card, and the number on that card is 4.

Who won this round?
- ○ First mover
- ○ Second mover
- ○ First mover and Second mover tied.
- ○ Neither.

Submit

Test for ST:

UNDERSTANDING TEST

ID NUMBER: ____________

Please write your code number just above.

You will now take an UNDERSTANDING TEST. You will see a series of questions in each screen. Before you move to the next screen you have to answer all questions correctly. In order to the next part of instruction, you have to ANSWER ALL THE QUESTIONS CORRECTLY. If you cannot finish the test you will be asked to leave, and you will receive your show-up fee at the exit.

Q1: In a round, will you see the number on Her/His 2nd card? Yes/No

Q2: In a round, can S/He see the number on your 2nd card? Yes/No

Q3: Will you be told whether you won or lost at the end of every round? Yes/No

Q4: Will S/He be told whether S/He won or lost at the end of every round? Yes/No

Q5: Will S/He see the number on your 3rd card (if you called a 3rd card in this round) at the end of every round? Yes/No

(The following questions are shown in the pictures, the numbers on the cards in which vary from subjects to subjects.)

Suppose the Second Mover is the computer, which chooses whether or not to call a 3rd card randomly.
You are the First Mover. Please make your choice.

You are the First Mover.

	You (First Mover)	S/He (Second Mover)
1st Card	2 (This card is also seen by her/him.)	4
2nd Card	4 (Only you can see this card.)	
3rd Card	○ I'm calling a 3rd card. ○ I'm not calling a 3rd card.	

OK

Suppose the Second Mover is the computer, which chooses whether or not to call a 3rd card randomly.

You are the First Mover.

	You (First Mover)	S/He (Second Mover)
1st Card	2 (This card is also seen by her/him.)	4
2nd Card	4 (Only you can see this card.)	
3rd Card	1 (Only you can see this card.)	

The number on the computer's 2nd card is 2; the computer did not call a 3rd card.

Who won this round?
- ○ First mover
- ○ Second mover
- ○ First mover and Second mover tied.
- ○ Neither.

Submit

Suppose the First Mover is the computer, which chose whether or not to call a 3rd card randomly.
You are the Second Mover. Please make your choice.

You are the Second Mover.

	You (Second Mover)	**S/He** (First Mover)
1st Card	**4** (This card is also seen by her/him.)	**3**
2nd Card	**2** (Only you can see this card.)	
3rd Card	**(Please make your choice.)**	**?**

If S/He decides to call a 3rd card, my choice is:
- **I'm calling a 3rd card.**
- **I'm not calling a 3rd card.**

If S/He decides not to call a 3rd card, my choice is:
- **I'm calling a 3rd card.**
- **I'm not calling a 3rd card.**

OK

Suppose the First Mover is the computer, which chose whether or not to call a 3rd card randomly.

You are the Second Mover.

	You (Second Mover)	**S/He** (First Mover)
1st Card	**4** (This card is also seen by her/him.)	**3**
2nd Card	**2** (Only you can see this card.)	
3rd Card	**You did not call a 3rd card.**	**S/He called a 3rd card.**

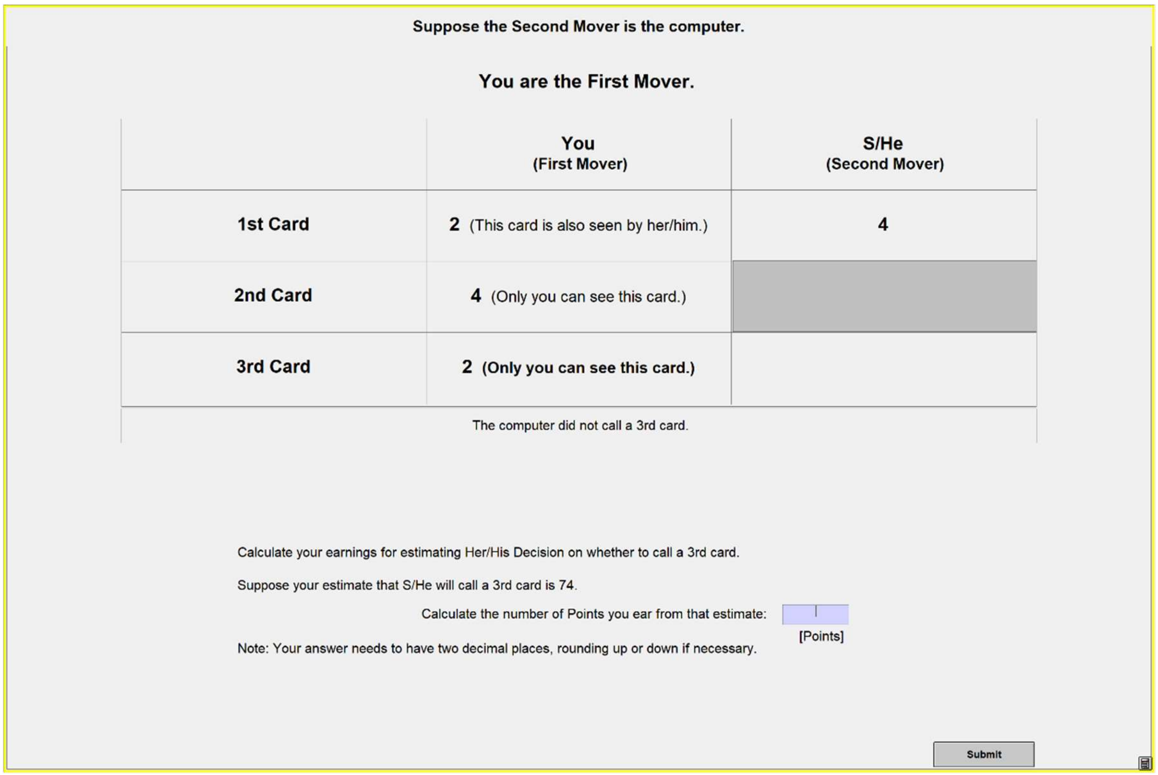
The number on the computer's 2nd card is 2; the computer called a 3rd card, and the number on that card is 1.

Who won this round?
- First mover
- Second mover
- First mover and Second mover tied.
- Neither.

Submit

Test for FM:

(The question is shown in the picture, the numbers on the cards in which vary from subjects to subjects.)



Suppose the Second Mover is the computer.

You are the First Mover.

	You (First Mover)	**S/He** (Second Mover)
1st Card	**2** (This card is also seen by her/him.)	**4**
2nd Card	**4** (Only you can see this card.)	
3rd Card	**2** **(Only you can see this card.)**	

The computer did not call a 3rd card.

Calculate your earnings for estimating Her/His Decision on whether to call a 3rd card.

Suppose your estimate that S/He will call a 3rd card is 74.

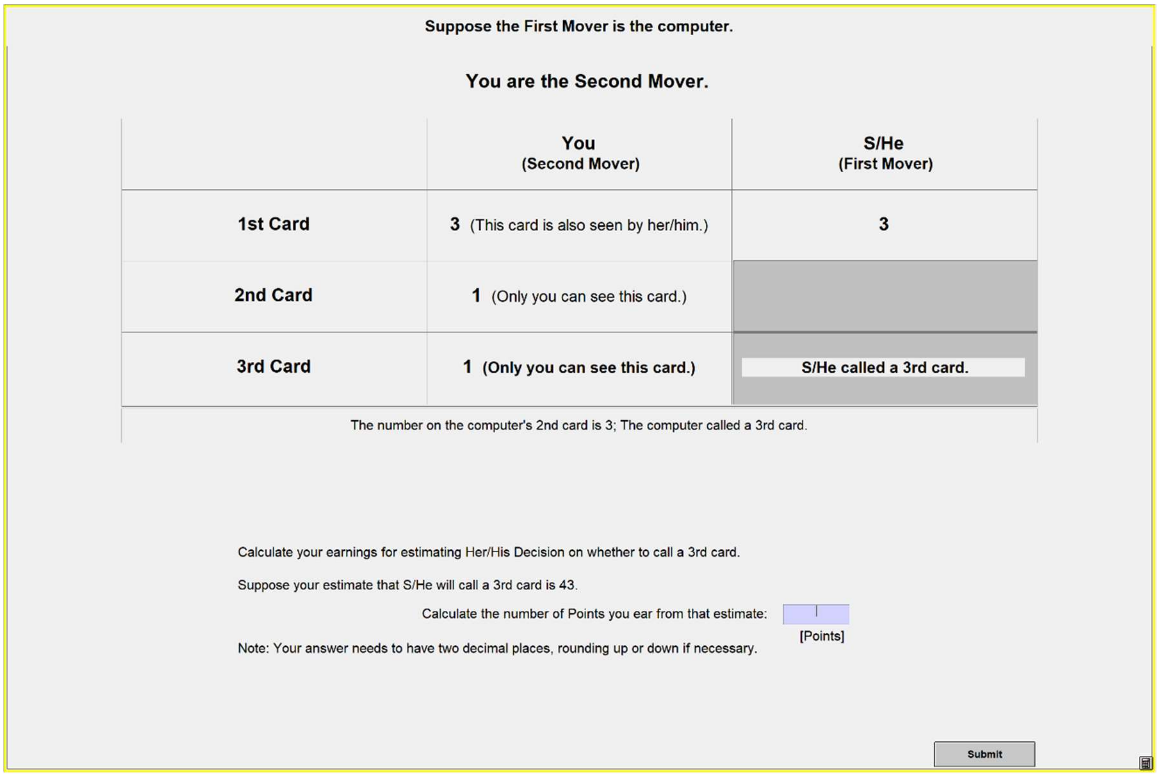
Calculate the number of Points you ear from that estimate: [Points]

Note: Your answer needs to have two decimal places, rounding up or down if necessary.

Submit

Test for SM:

(The questions are shown in the pictures, the numbers on the cards in which vary from subjects to subjects.)



Suppose the First Mover is the computer.

You are the Second Mover.

	You (Second Mover)	**S/He** (First Mover)
1st Card	**3** (This card is also seen by her/him.)	**3**
2nd Card	**1** (Only you can see this card.)	
3rd Card	**1** (Only you can see this card.)	**S/He called a 3rd card.**

The number on the computer's 2nd card is 3; The computer called a 3rd card.

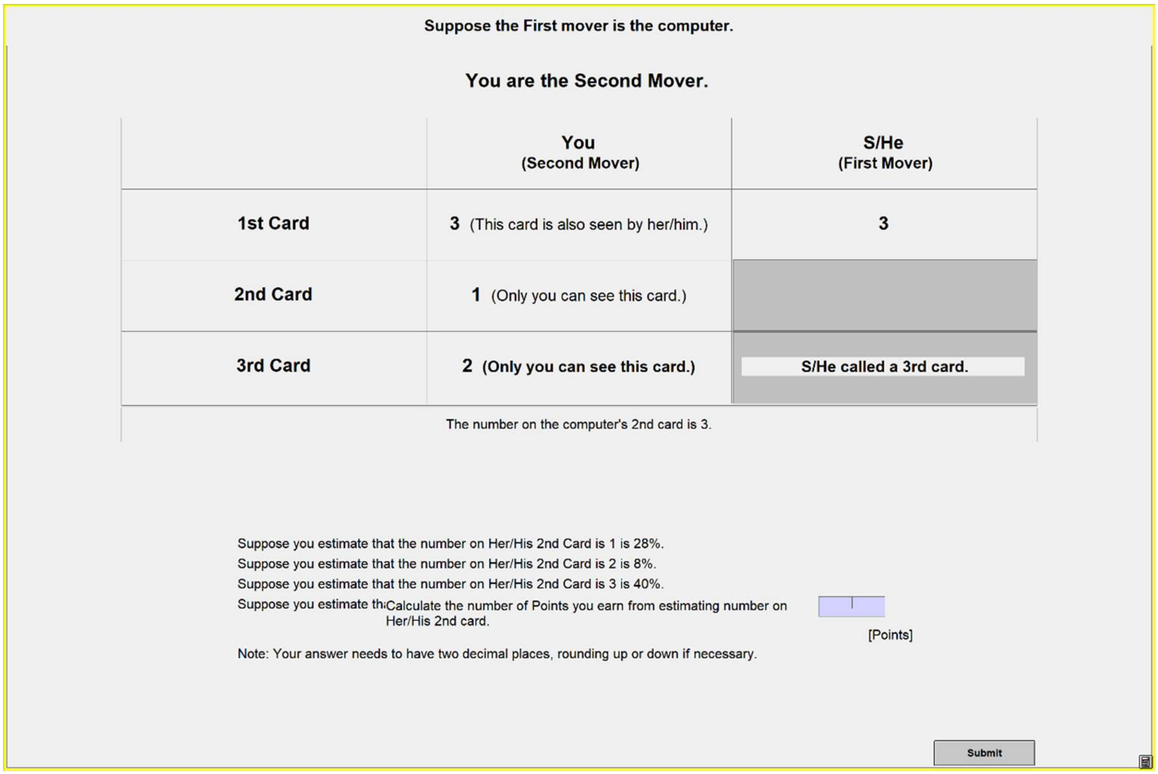
Calculate your earnings for estimating Her/His Decision on whether to call a 3rd card.

Suppose your estimate that S/He will call a 3rd card is 43.

Calculate the number of Points you ear from that estimate: [Points]

Note: Your answer needs to have two decimal places, rounding up or down if necessary.

Submit



Suppose the First mover is the computer.

You are the Second Mover.

	You (Second Mover)	S/He (First Mover)
1st Card	3 (This card is also seen by her/him.)	3
2nd Card	1 (Only you can see this card.)	
3rd Card	2 (Only you can see this card.)	S/He called a 3rd card.

The number on the computer's 2nd card is 3.

Suppose you estimate that the number on Her/His 2nd Card is 1 is 28%.
Suppose you estimate that the number on Her/His 2nd Card is 2 is 8%.
Suppose you estimate that the number on Her/His 2nd Card is 3 is 40%.
Suppose you estimate th: Calculate the number of Points you earn from estimating number on Her/His 2nd card.

[Points]

Note: Your answer needs to have two decimal places, rounding up or down if necessary.

Submit

Appendix Instruction on Bomb Task & CRT

PART II INSTRUCTIONS

In this part you will first face a single decision situation. Next, you will be asked to answer three questions of a quiz.

DECISION SITUATION:

On the screen in front of you there is a display of 100 boxes. Your task is to decide how many boxes you want to collect. For every box that you collect you provisionally earn 4 pence.

Your earnings per box collected are provisional, because behind one of these boxes there is a time bomb that destroys all the boxes that you have collected so far. You do not know where the time bomb lies. You only know that the time bomb can be in any box with equal probability.

Moreover, even if you collect the time bomb, you will only be told that at the end of the experiment.

Every second a box is collected, starting from the top-left corner. Once collected, the box disappears from the screen and your earnings are updated accordingly. At any moment you can see the amount earned up to that point. Your task is to choose when to stop the collecting process. To stop the collection of boxes you have to click the “Stop” button.

At the end of the experiment we will randomly determine the number of the box containing the time bomb by means of a bag containing 100 numbered tokens.

If you happen to have collected the box where the time bomb is located, you will earn zero. If the time bomb is located in a box that you did not collect you will earn the amount of money that you had earned up to moment you clicked the “Stop” button.

We will start with a practice round. After that, you will play one round for real money.

QUIZ: Please answer the following three questions. You will earn £1 for each correct answer, and earn nothing if answer is incorrect. You have 5 minutes to answer all questions, after which the computer will move to the next question.

PLEASE WAIT UNTIL THE EXPERIMENTER TELLS YOU TO START

Appendix CRT

Q1: In a water reservoir, there is a patch of nenuphar water lilies. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire water reservoir, how long (in days) would it take for the patch to cover half of the water reservoir? (Ans: 47)

Q2: A pen and an ink recharge cost £0.10. The pen costs £1 more than the ink recharge. How much (in £) does the ink recharge cost? (Ans: £0.05)

Q3: If it takes 5 printers 5 minutes to print 5 large pictures, how long (in minutes) would it take 100 printers to print 100 large pictures? (Ans: 5)

Chapter 3: An Experimental Study on the Intertemporal Trade-Offs between Saving and Consumption Decisions[60]

3.1 Introduction

The intertemporal consumption behaviour in the endowment economy is a popular topic in the empirical and theoretical macroeconomics studies. However, rare experimental studies pay attention to it. In this chapter, an experimental study is presented to investigate that how players manage their intertemporal consumption paths over the finite life cycle with an anticipated taxation scheme. This experimental study is based on the finite life cycle of the endowment economy analysed in the "Anticipated fiscal policy and adaptive learning" (EHM2009) (Evans et al., 2009).

There are some experimental studies to explore the intertemporal consumption behaviours in different scenarios with various features. However, these existing experimental studies only focused on the scenarios in which there is no interaction within players. In the study on Ricardian Equivalence (Meissner and Rostam-Afschar, 2017), players determined their consumption paths facing the stochastic income process and various tax schemes. Moreover, the similar study of Meissner (2016) either only allow debt or only allow saving in the design. Furthermore, the experimental study of Feltovich and Ejebu (2014) forbids borrowing behaviours. Moreover, Carbone and Duffy (2014) introduce a constant interest rate into their design, but borrowing is not allowed.

The interaction within individuals is ubiquity. Thus, it is necessary to include this feature in the experimental study. Our study is the first experimental study on the consumption behaviours in an endowment economy, in which players determine their consumption paths by trading with each other, i.e., borrowing or lending from other players. In our economy, the market interest factor (MIF) is fully determined by all the players' interaction. The MIF is based on the uniform price double auction to get the

[60] This chapter is joint work with Prof. Miguel Costa-Gomes, Prof. George Evans and Prof. Kaushik Mitra.

market clearing, and meanwhile, it also has effects on players' trading results. Furthermore, the uncertainty in the previous experimental studies is from either the stochastic endowment or the tax scheme, but the uncertainty in our experiment is only from the unpredictable MIF.

To predict the theoretical market of the economy in the experiment, we firstly introduce two popular analyses into our analysis. Rational expectation (RE) is a widespread model in the macroeconomic analysis. RE replies on complete information and assumes that the whole structure and all parameters in the economy are fully known. Moreover, in EHM2009's study, adaptive learning (AL) is introduced to compensate the analysis on the scenario with imprecise information on MIF, in which it is not necessary for players to have complete knowledge on the economy. Generally, the theoretical analysis of RE and AL imply far-sight and smoothing consumption. However, some empirical studies using actual policy changes in the US work on householder-level consumption with predictable income fluctuations and provide evidence on the behaviours deviated from these predictions. The evidence in Parker (1999) with data from Consumer Expenditure Survey (from 1980) points out that households do adjust their consumption when there is predictable fluctuated income caused by the Social Security tax system, which is against consumption-smoothing prediction. Moreover, another empirical study (Poterba, 1988) mentions that households are myopic, which investigates the monthly consumption data on two temporary federal income tax policies in 1968 and 1975 and suggests that households tend to respond to the policies but not the announcements of the policies. Therefore, we secondly add a series of myopic models and simple consumption-smoothing models to compensate for the far-sight models of RE and AL for identifying individual player's behaviour in the economy.

The study in this chapter discovers that most of the subjects' behaviours can be explained by myopic models. Meanwhile, some subjects do have far sight and manage their intertemporal consumption paths over their life cycles by reacting to the announcement of the policy. A small number of subjects even use RE thinking models, which seems that they could predict all the future markets accurately.

The remaining of the chapter is structured as follows. The following section (Section 3.2) describes the economy used in the experiments and Section 3.3 represents a series of theoretical models to predict subjects' behaviours. Section 3.4 explains our experimental design. Section 3.5 demonstrates the Macro-view and Micro-view data analysis on the experimental data. Section 3.6 is the conclusion.

3.2 The economy

In this section, we present the endowment economy designed to investigate life-cycle consumption behaviours. N households with finite T-period lifetime live in this endowment economy and all households receive the constant nondurable endowment (perishable goods) at the beginning of each life period, which cannot be reserved across periods and are converted into utilities as consumption at the end of each period. Furthermore, there is a government in the economy, whose spending is financed by the equal lump-sum tax. Households are informed their anticipated tax schemes of T-period lifetime at the beginning of the whole T-period lifetime. The tax scheme is either constant across all periods or equal to τ_h in the first T_{p-1} periods and decreases to τ_l from period T_p until the end of the whole life. The households then determine their consumptions in each life period by buying one-period debt (borrowing) and/or selling one-period saving (lending) in order to manage their whole life wealth (utilities). All borrowings and lendings will repay or be repaid in the next period based on the market interest factor in the current period, which is determined by all households' borrowing and lending wills in the current period. The household i 's CARA utility function[61] in period t is given by

$$u_t^i = \alpha\left(1 - e^{-\beta c_t^i}\right)$$

The "flow" budget constraint for the household i in period t is

$$c_t^i = y - \tau_t - r_{t-1} b_{t-1}^i + b_t^i$$

The debt constraint for the household i in period t is

[61] CARA refers to a utility function with constant absolute risk-aversion. HEY (1980) explained how CARA worked in the scenario with income uncertainty. This utility function is also used by other experimental studies on life cycle consumption/saving, i.e., Carbone and Hey (2004), Meissner (2016), and Meissner and Rostam-Afschar (2017).

$$r_t b_t^i \leq y - \tau_{t+1}$$

Let t=1, …, T index life period and i =1, …, N index household. y represents constant endowment and τ_t represents lump-sum tax in period t. r_t represents market interest factor (MIF) of period t determined at period t. b_t^i represents the amount of one-period net debt (net difference between borrowing and lending) by subject i at period t (b_t^i<0 is interpreted as lending larger than borrowing; $b_0^i = 0$.). Then $r_{t-1}b_{t-1}^i$ represents the repayment in period t. If household i has net borrowing in period $t-1$, which means $b_{t-1}^i > 0$, he will repay $r_{t-1}b_{t-1}^i$ at the beginning of period t before he starts his borrowing or lending in period t. If household i has net lending in period $t-1$, which means $b_{t-1}^i < 0$, he will be repaid $r_{t-1}b_{t-1}^i$ at the beginning of period t before he starts his borrowing or lending in period t. We define $y - \tau_t - r_{t-1}b_{t-1}^i$ as subject i's net income in period t (NI_t^i). $c_t^i (\geq 0)$ represents the amount of consumption by subject i at period t. Consumption in each period is converted to utilities based on the utility function automatically at the end of the current period. By determining the paths of b_t^i from $t = 1$ to $t = T$, the households achieve their target consumption paths.

3.3 Theoretical prediction on the economy

Then in this section, the theoretical analyses of RE and AL are conducted to draw the possible MIF paths in the economy. In general, RE and AL assume that all households in the economy are homogenous. That is, the behaviours of all households in the economy follow the same rules, so there is no trading in the market.

3.3.1 Rational expectation (RE) analysis

RE is the classical Macroeconomics theory, which models households who maximise the expected total utility. As RE is a general equilibrium model, all the households in the model are identical. In the market level, RE predicts what the path of the MIFs is in equilibrium, which is used to adjust households' incentives in order to reach the market clearing in the economy in each period. That is, all traded borrowing amount in the market equals to the traded lending amount in the market. Meanwhile, in the individual level, RE predicts households' consumption paths in the RE equilibrium with the MIF path in equilibrium.

As all households are identical in RE, then households follow the same decision process. A representative household maximises his whole life utility by deciding his life consumption path at the beginning of his life. Then all households' consumption paths determine the MIF path, which leads market clearing in each period of the economy. The individual optimisation problem of household i is described as following:

$$\max_{\{c_t^i\}_1^T} E^{i^*}\left\{\sum_{t=1}^{T} \alpha\left(1-e^{-\beta c_t^i}\right)\right\}$$

$$subject\ to \begin{cases} c_t^i = y - \tau_t - r_{t-1}b_{t-1}^i + b_t^i \\ r_t b_t^i \leq y - \tau_{t+1} \\ c_t^i \geq 0 \\ b_0^i = 0 \\ b_T^i = 0 \\ t < T_p, \qquad \tau_t = \tau_h \\ t \geq T_p, \qquad \tau_t = \tau_l \end{cases}$$

"r_t" is the market interest factor determined in period t by all households' borrowing amount in period t. As in the first period, there is no previous borrowing or lending, b_{t-1}^i at $t = 0$ is 0. Similarly, in the last period, households are not allowed to borrow or lend as there is no more period for them to repay or be repaid. That is $b_T^i = 0$.

Then, the cumulated market budget constraint is shown as below:

$$\sum_{i=1}^{N} c_t^i = \sum_{i=1}^{N} b_t^i + \sum_{i=1}^{N} (\mathrm{y} - \tau_t) - r_{t-1}\sum_{i=1}^{N} b_{t-1}^i$$

Market clearing condition in each period implies $\sum_{i=1}^{N} b_t^i = 0$ and $\sum_{i=1}^{N} b_{t-1}^i = 0$. Then the equation above could be rewritten as below:

$$\sum_{i=1}^{N} c_t^i = \sum_{i=1}^{N} (\mathrm{y} - \tau\ \ ) = N(\mathrm{y} - \tau_t)$$

As all households are identical, we can use c_t as the representative household's consumption in period t instead of c_t^i:

$$\sum_{i=1}^{N} c_t \ = Nc_t \ = N(\mathrm{y} - \tau_t)$$

Then, $c_t^{i\,*REE} = c_t{}^{*REE} = \mathrm{y} - \tau_t$ for the representative household in equilibrium. That is, each individual household borrows nothing and lends nothing in the equilibrium of rational expectation analysis (REE), $\{c_t^{i\,*REE} = 0\}_1^T$. Furthermore, Euler equation of the representative household is given as following:

$$e^{-\beta c_t{}^{*REE}} = r_t * e^{-\beta c_{t+1}{}^{*REE}}$$

Then,

$$r_t^{*REE} = e^{-\beta(c_t{}^{*REE} - c_{t+1}{}^{*REE})} = e^{-\beta(\mathrm{y} - \tau_t - \mathrm{y} + \tau_{t+1})} = e^{\beta(\tau_t - \tau_{t+1})}$$

That is, if the tax scheme is a constant tax over all periods, the equilibrium MIF path[62], $\{r_t^{*REE}\}_1^{T-1}$, has a constant value which equals to 1 as $\tau_t = \tau_{t+1}$. If the tax scheme has a tax decreasing after period T_p, $\{r_t^{*REE}\}_1^{T-1}$ has a peak value in period T_{p-1} as $\tau_t > \tau_{t+1}$. Figure 3.1 represents $\{r_t^{*REE}\}_1^T$ under the scenario with tax decreasing, when $T = 22$, $T_p = 12$, $\tau_h = 70$, and $\tau \quad = 10$.

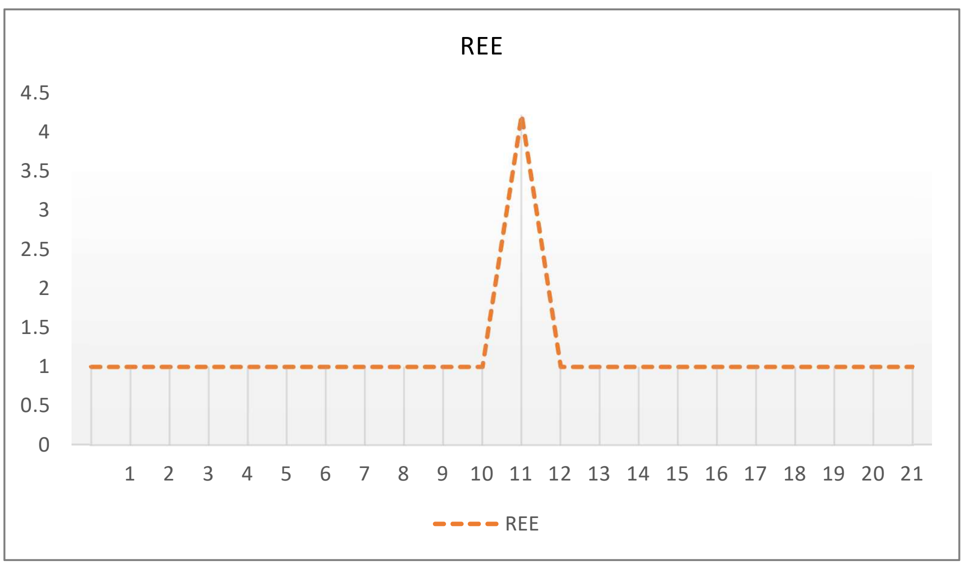


Figure 3.1

3.3.2 Adaptive Learning (AL) analysis

AL model (EHM2009) used in this section[63] is generalised from Evans et al., 2009. In EHM2009's study, adaptive learning (AL) is introduced to compensate the analysis on

[62] There is no r_T, as there is no borrowing or lending allowed in the last period.
[63] Utility function in this chapter is different with the utility function used in EHM 2009.

the scenario with imprecise information on future MIF, in which it is not necessary for households to have complete knowledge on the economy. In other words, AL does not assume that households know the future accurately, but it allows households to have their expectations on the future MIFs and to update their expectations based on the current history.

Households modelled by AL build their expectations on the future's MIF based on an adaptive learning rule. AL assumes that the market is in the steady state when the information on tax change is announced. The overreaction of the representative agent on the anticipated change pushes MIF far away from 1 from the beginning of the whole life, and then MIF goes back to approximately 1 among with periods. When the timeline is close to the conducted tax change, the representative household tends to react strongly again, which pushes MIF far away from 1 again. One period before conducting time, MIF reaches the highest value (if tax change is decreased, otherwise MIF reaches the lowest value). In the conducting period, MIF falls below 1, and converges to 1 along with periods.

We start from the general equilibrium model (ALE) (similar to Evans's study), in which households are identical to follow the same forecasting and decision rules (for a specified γ). In the market level, ALE also predicts the path of MIF in equilibrium, which is driven by market clearing in the economy in each period. Meanwhile, in the individual level, ALE predicts the representative household's optimal consumption path in equilibrium given the MIF path in equilibrium. Then the representative household solves the similar optimization problem as in RE described as following:

$$\max_{\{c_s^i\}_{s=t}^T} E_t^{i^*}\left\{\sum_{s=t}^{T} \alpha\left(1-e^{-\beta c_s^i}\right)\right\}$$

$$subject\ to \begin{cases} c_s^i = y - \tau_s - \tilde{r}_{s-1} b_{s-1}^i + b_s^i \\ \tilde{r}_s b_s^i \leq y - \tau_{s+1} \\ c_s^i \geq 0 \\ b_0^i = 0 \\ b_T^i = 0 \\ s < T_p, \qquad \tau_s = \tau_h \\ s \geq T_p, \qquad \tau_s = \tau_l \end{cases}$$

$\tilde{r}_s$ represents the prediction on MIF in period s. Then Euler equation is shown below:

$$E_t^{i^*} c_{s+1}^i = \frac{ln(\tilde{r}_s)}{b} + c_s^i, s = t, \dots, T$$

Furthermore,

$$E_t^{i^*} c_{t+j}^i = \frac{ln\left(\tilde{r}_t \prod_{h=2}^{j} \tilde{r}_{t+h-1}\right)}{b} + c_t^i, j \geq 2$$

In ALE, the representative household does not know all the following future MIFs, $\{\tilde{r}_{t+h-1}\}_{h=2}^{T-t}$, but he predicts all following future MIFs starting from period t as $\{\tilde{r}_{t+h-1}^e\}_{h=2}^{T-t}$. $\tilde{r}_{t+h-1}^e(t) = r^e(t)$ for all $h \geq 2$, and $\tilde{r}_t = \hat{r}_t$ (as $\hat{r}_t$ is seen by households in period t). $\tilde{r}_{t+h-1}^e(t)$ refers to the expectation on the MIF $\tilde{r}_{t+h-1}$ formed at period t. The expectation $r^e(t)$ consists of the previous expectation and the current period's MIF, and "gain" parameter γ $(1 < \gamma < 1)$ is introduced to discount on the distance from current period's MIF to the previous expectation. The following equation shows how to get the expectation with past information:

$$r^e(t) = r^e(t-1) + \gamma(\hat{r}_t - r^e(t-1))$$

Then,

$$E_t^{i^*} c_{t+j}^i = \frac{ln\left(\hat{r}_t \prod_{h=2}^{j} r^e(t)\right)}{b} + c_t^i, j \geq 2$$

As $\prod_{h=2}^{j} r^e(t) = r^e(t)^{j-1}$, then

$$E_t^{i^*} c_{t+j}^i = \frac{ln\left(\hat{r}_t * r^e(t)^{j-1},\right)}{b} + c_t^i$$

We use $D_{t,t+j-1}^e(t)$ to represent $\hat{r}_t * r^e(t)^{j-1}$ $(j \geq 2)$ and $\hat{r}_t$ $(j = 1)$. As households in ALE are identical, then let $c_t^i = c_t$ and $c_{t+j}^e(t) = E_t^{i^*} c_{t+j}^i$. Then the representative household's life-time budget constraint at period t is described as below:

$$c_t + \sum_{j=1}^{T-t} \frac{c_{t+j}^e(t)}{D_{t,t+j-1}^e(t)} = y - \tau_t - \hat{r}_t b_{t-1} + \sum_{j=1}^{T-t} \frac{y - \tau_{t+j}^e(t)}{D_{t,t+j-1}^e(t)}, t \leq T-1$$

$\sum_{j=1}^{T-t}\frac{c_{t+j}^e(t)}{D_{t,t+j-1}^e(t)}$ represents the discount of all future consumptions at period t and $\sum_{j=1}^{T-t}\frac{y-\tau_{t+j}^e(t)}{D_{t,t+j-1}^e(t)}$ represents the discount of all future wealth at period t. According to EHM 2009, when $t=1$, $r^e(0)=1$. It assumes that when the anticipated tax scheme is announced, the economy is in the steady state. Similar to REE, market clearing implies zero debt, which means $c_t = y-\tau_t$. Then MIF in equilibrium, $\tilde{r}_t^{*ALE}$, is described as below (details see *Appendix 3.II*):

$$\tilde{r}_t^{*ALE} = exp\wedge \left[\frac{(\tau_h-\tau_l)(r^e(t-1)^{T-T_{P-1}}-1)b}{(r^e(t-1)^{T-t}-1)} - \frac{(r^e(t-1)^{T-t}-(T-t)r^e(t-1)+T-t-1)lnr^e(t-1)}{(r^e(t-1)^{T-t}-1)(r^e(t-1)-1)}\right]$$

for $1 \le t \le T_{p-1}$, and for $t > T_{p-1}$,

$$\tilde{r}_t^{*ALE} = \exp\wedge\left[\frac{(r^e(t-1)^{T-t}-(T-t)r^e(t-1)+T-t-1)lnr^e(t-1)}{(r^e(t-1)-1)(1-r^e(t-1)^{T-t})}\right]$$

And as all households are identical, the optimal consumption path is $\{c_t^{i*ALE}=0\}_1^T$ given $\{\tilde{r}_t^{*\mathrm{ALE}}\}_1^{T-1}$ .When $r^e(0)=1$, $T=22$, $T_p=12$, $\tau_h=70$ and $\tau_l=10$, $\{\tilde{r}_t^{*ALE}\}_1^{T-1}$ is drawn in Figure 3.2:

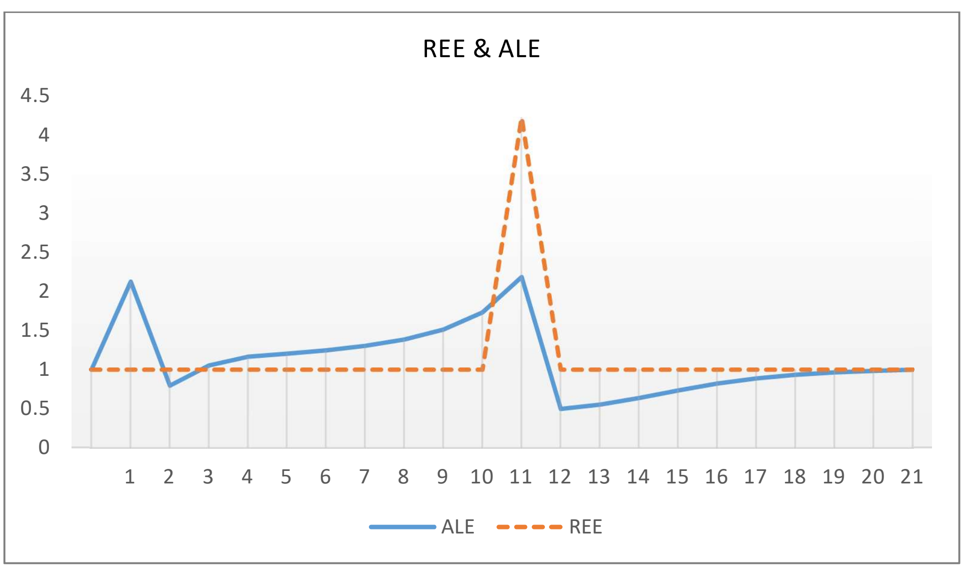


Figure 3.2

3.4. Experimental design

In this section, the experiment is designed to investigate how households determine their whole life consumption paths facing an anticipated tax scheme. Following the models described in the previous section, the parameters are set up as follows. The length of life T equals to 22 periods and the number of players in an economy N equals to 10. At the beginning of each period, endowment y equals to 120. In the treatment with constant tax scheme (FT), τ_t is always 40 in each period, and in the treatment with the tax-decreasing scheme (DT), τ_h is 70 and τ_l is 10. In DT, T_p equals to 12. That is, players pay 70 taxes at the first 11 periods and 10 taxes at the latter 11 periods. Then the total tax income is 880 for both treatments.

As a proper concavity is needed in the experiment so that deviations from optimal path could lead enough loss, and a moderate growth proportion (around 20%) from high tax to low tax is also needed, β is set at 0.024. The payoff function used in the experiment is shown as following:

$$u = 388(1 - e^{-0.024c})$$

The endowment, tax, consumption and all other trading players used in each period are measured as POINTS, which is converted to ECU (Experiment Currency Unit) at the end of each period according to the payoff function. The duration of each period is 105s, in which players submit borrowing or lending proposals to reach the target consumption they preferred.

The rules to submit proposals are described as follows. A lending proposal consists of the lowest interest factor that the player would like to lend and the largest amount that the player would like to lend on the interest factor which is not lower than the one he proposed. A borrowing proposal consists of the highest interest factor that the player would like to borrow and the largest amount that the player would like to borrow on the interest factor which is not higher than the one he proposed. Each play's borrowing amount cannot exceed his borrowing limit, which equals to $\frac{(y-\tau_{t+1})}{r_t}$. That is, the difference between player's next period's endowments and next period's tax is divided by the current MIF. As players can update their borrowing or lending proposals within

105s, players' borrowing limit keep updated by new proposals submitted or current proposals cancelled. And lending limit equals to the net income of the current period. Players can neither borrow more than they can repay in the future nor lend more than they have now. Players can submit as many proposals as they would like to but only the last borrowing or lending proposal is defined as the current valid (or active) borrowing or lending proposal. Each player can have no more than one valid borrowing proposal and no more than one valid lending proposal at the same time.

The market interest factor (MIF) is determined by all players' valid lending and borrowing proposals in the market based on discrete demand and supply rules. (The trading mechanism is the uniform price double auction updated every time when a new proposal is made or cancelled.) Then some players' borrowing proposals or lending proposals can be fully satisfied, and some players' proposals cannot be fully satisfied or even cannot be chosen to trade. Players are told about their proposals' states, i.e., fulfilled, partially fulfilled or unfulfilled, so that that player can update their proposals.

After 105s, the market is closed, and players can no longer borrow or lend. At this time, all valid proposals in the market are defined as players' final borrowing or lending proposal, and MIF in this period is then determined by all these final proposals. MIF is used to determine the amount that players will repay or be repaid in the next period. Moreover, the left POINTS, which are not used to borrow or lend, are converted to ECU. After 22 periods, the cumulated ECUs across all 22 periods are converted to cash as 400 ECU equal to £1.

At the beginning of each session, subjects read an instruction (see Appendix 3.IV Instruction) on the experiment and have to pass an understanding test related to the instruction. Failure to pass the test leads to dismissal. Afterwards, the subjects left play five practice periods before they start the real experiment. All the parameters in the practice periods are never used in the real experiment. Before subjects enter to the first period, players are informed on the tax they need to pay in each period. And after each period, players are also informed on their performance in this period (Details see Appendix 3.IV Instruction). After 22 periods, subjects take the bomb task (Crosetto & Filippin, 2013) on risk aversion (see Appendix III), the payment of which is up to £5. The fix payoff show-up fee is £5.

The experiment was conducted from May 2017 to April 2019. All subjects were students and staffs from the University of St Andrews. Each treatment included 9 sessions. And the average payoff of all players was £22.24.

3.5 Data analysis

In this section, the data analysis is presented on the market-level and individual-level views. Firstly, the market-level analysis focuses on the comparisons on the market interest rate (MIF) and aggregated borrowing behaviours between two treatments. Secondly, the individual-level analysis concentrates on the identification of each player based on a series of decision models. Then a risk analysis (Bomb Task) is added to assist the analysis on the performance of the models.

3.5.1 Market-level comparison

This section presents a series of figures to demonstrate a series of market-level differences on the MIF and the consumption (borrowing) behaviours caused by different anticipated tax schemes.

Firstly, we compare the paths of MIFs in two treatments. Figure 3.3 shows the comparisons of the MIF's paths between two treatments. "X-axis" represents periods and "Y-axis" represents the value of MIFs. All MIFs from the same periods across nine sessions in the same treatment are pooled together to get the average value of MIF in each period, and the path of average MIF along periods for DT (blue line) is significantly higher than the one for FT. Testing on the two paths with Two-sample Kolmogorov-Smirnov test gave the P-value as 0.009. It means that an anticipated tax decrease does lead to a higher MIF path. There is a peak just before tax decrease happens and meanwhile, the path of MIF in FT is flatter and closes to 1. This implies that borrowing will in DT is stronger than in FT so that MIF is pushed to a higher level to balance the market demand and supply in DT. Due to a high-level MIF, the incentive of lending is also higher in DT than in FT.

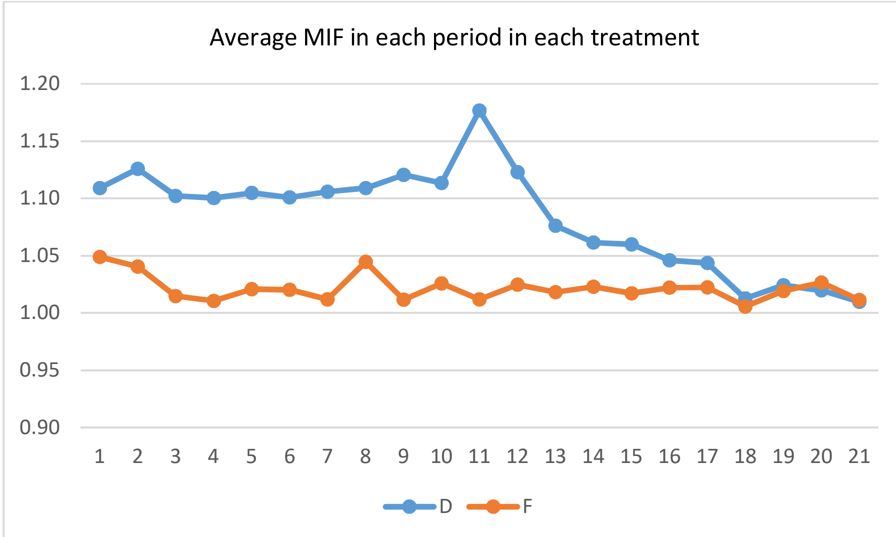


Figure 3.3

Figure 3.4 shows the standard deviation of each session (ordered as the values). The p-value of Two-sample Kolmogorov-Smirnov test 0.124 and the p-value of Two-sample Wilcoxon rank-sum (Mann-Whitney) test is 0.047. This emphasises the significant difference between the two treatments. (Appendix 3.I presents the path of MIF of each session along with periods.)

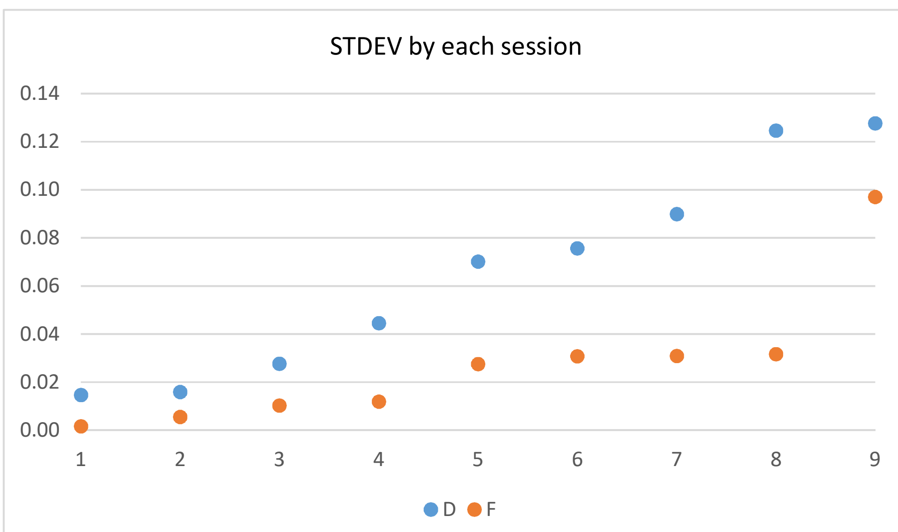


Figure 3.4

Next, a series of box-whisker plot figures (Figure 3.5, Figure 3,6, Figure 3.7, and Figure 3.8) demonstrate the within-period fluctuations of individual consumption and individual net borrowing (which is from that borrowing amount minus lending amount in the same period) along with periods. All subjects' consumption ratios or net borrowing ratios in the same periods (90 observations in each period) across all sessions in the same treatment are pooled together. "X-axis" represents periods and "Y-axis" represents consumption ratio (consumption in the current period is divided by the difference between endowment and tax in the current period) or net borrowing ratio (borrowing in the current period is divided by the difference between endowment and tax in the next period).

Figure 3.5 shows a converged trend along with periods. The within-period fluctuation of consumption ratios in the earlier periods are larger than the ones on the latter periods, and finally, the consumption ratios are close to 1, which implies that subjects borrow or lend less, and consume what they have, i.e., endowment minuses tax. In contrast, Figure 3.6 shows a stable path of the within-period fluctuation of consumption ratios along with periods. There is no obviously converged trend, which is corresponding to the MIF path demonstrated in Figure 3.3 that implies the trading incentive in FT is less than in DT.

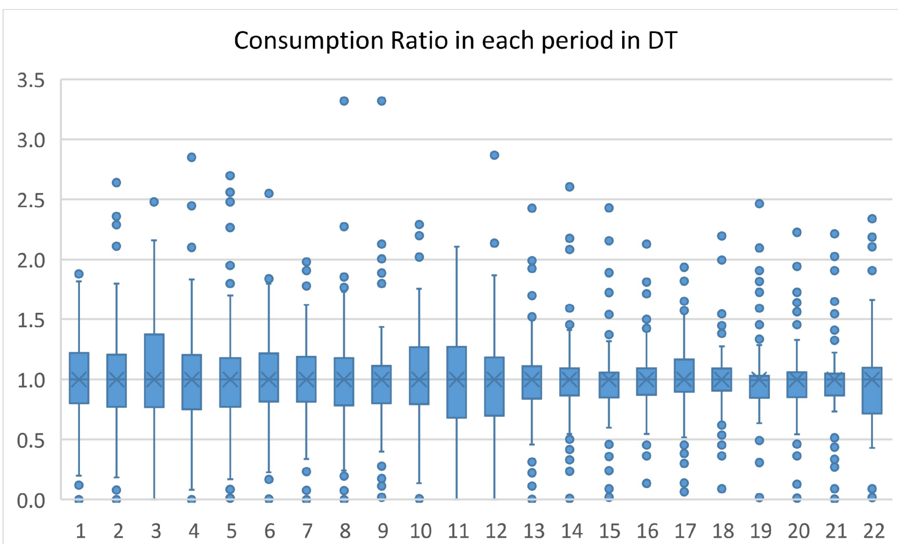


Figure 3.5[64]

[64] The dots in the figures are the outliers which are larger/smaller than the values of the upper bounds of the boxes plus the 1.5 times lengths of the boxes/the values of the lower bounds of the boxes minus the 1.5 times lengths of the boxes.

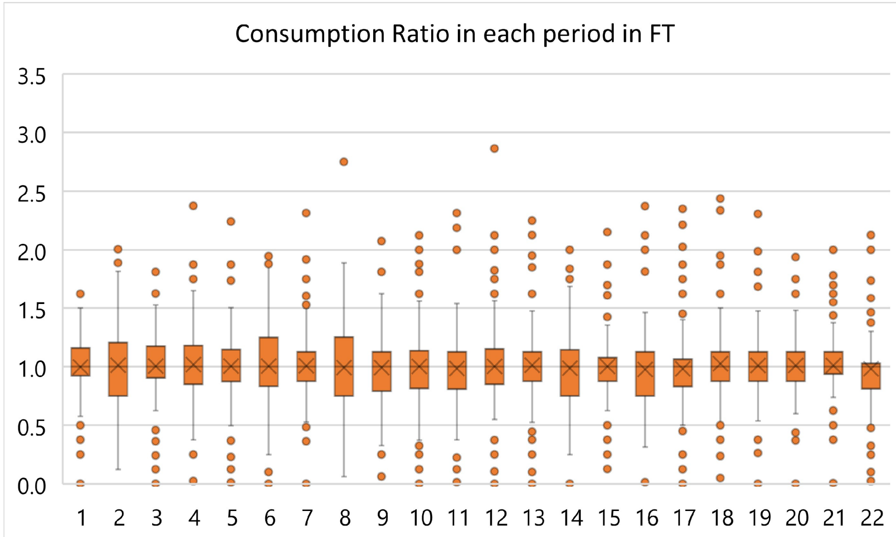


Figure 3.6

Figure 3.7 and Figure 3.8 is the supplements of Figure 3.5 and Figure 3.6, which provide consistent trends from the view of borrowing behaviours. Figure 3.7 shows an obvious contrast to the within-period fluctuation of net borrowing ratios between the first 11 periods and the latter 11 periods. On the contrast, the within-period fluctuation in FT is relatively stable, and the range of fluctuation in FT is smaller than in DT. The large fluctuations of net borrowing ratios in the first 11 periods in DT, which is caused by higher MIFs, lead to large fluctuations of consumption ratios.

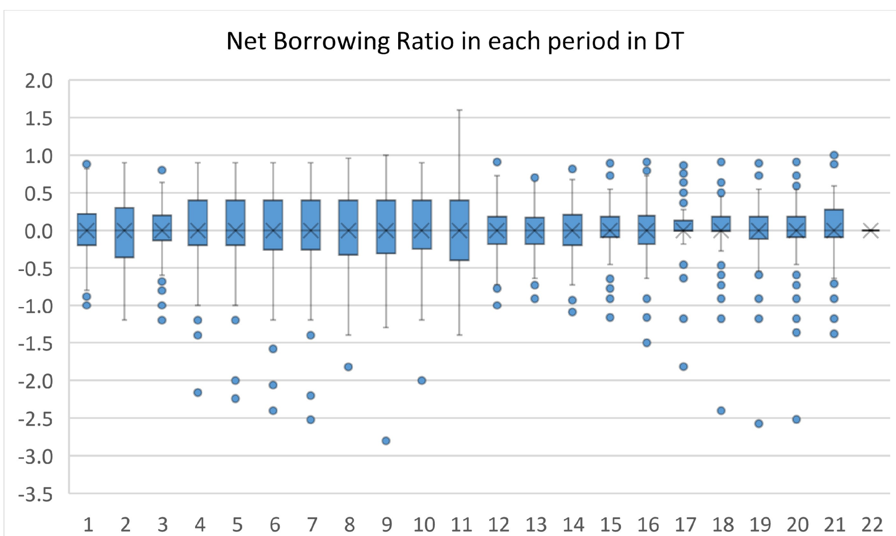


Figure 3.7

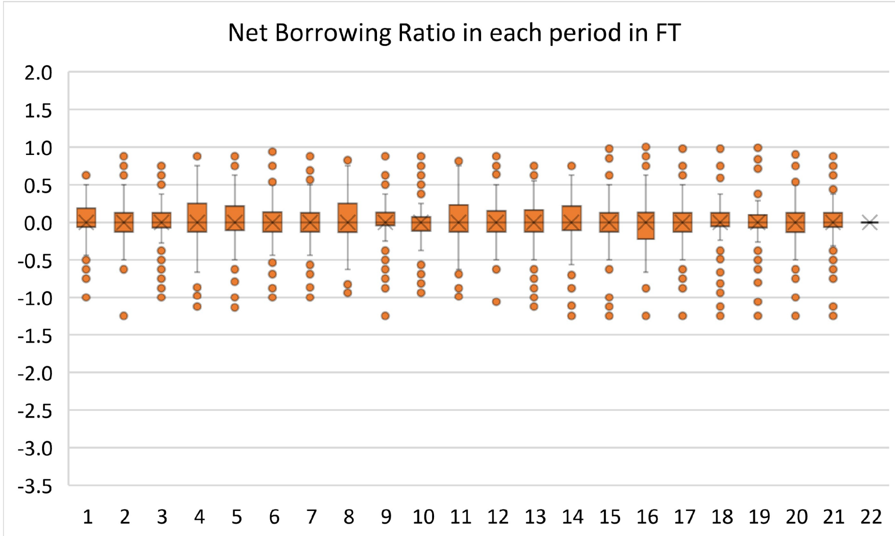


Figure 3.8

The following series of Figures show the comparisons of distributions of total net borrowing ratio of each period [65]. Figure 3.9 shows the comparison of the distributions of the total net borrowing ratios between treatments. "X-axis" represents the scale of intervals on total net borrowing ratios, and "Y-axis" represents the number of total net borrowing ratios in each interval. The behaviour of borrowing between treatments shows a significant difference. (P-value of Two-sample Kolmogorov-Smirnov test is 0.) In DT, subjects tend to borrow more, while subjects tend to borrow less in FT. The distribution of total net borrowing ratios tends to concentrate more in FT than in DT.

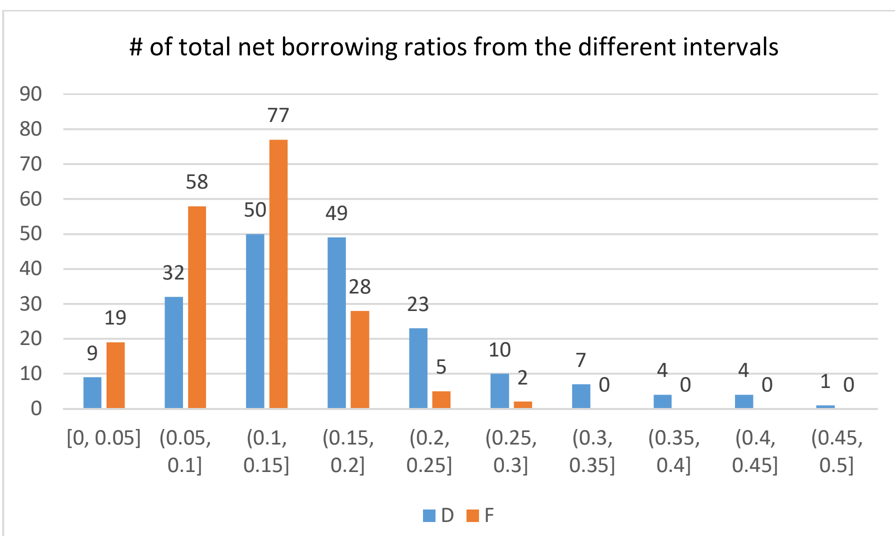


Figure 3.9

[65] That is the sum of all positive net borrowing /(total endowment – total tax).

Figure 3.10 and Figure 3.11 compare the distributions of total net borrowing ratios between two treatments in the first 11 periods and the latter 10 periods.

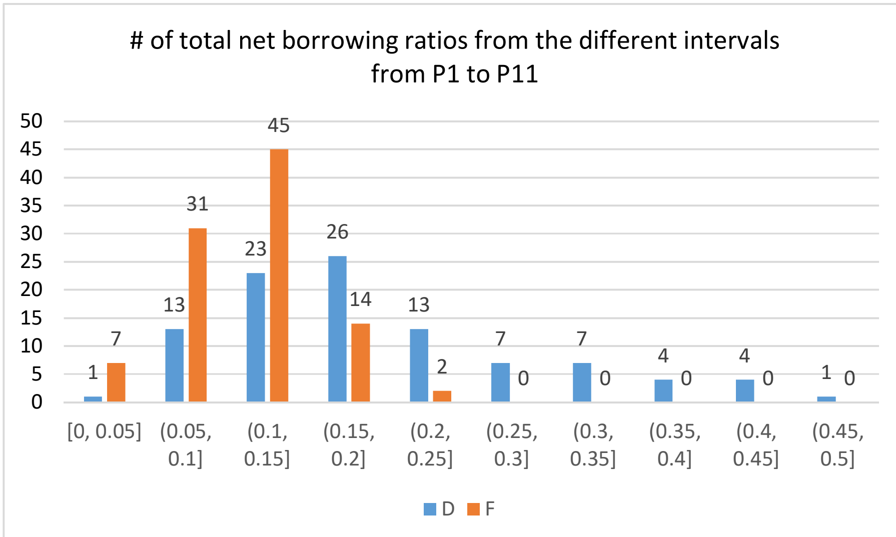


Figure 3.10

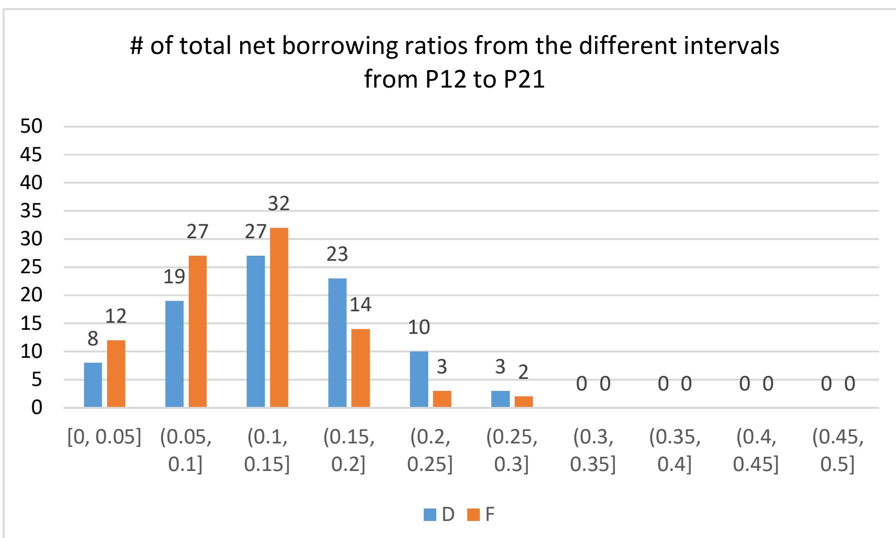


Figure 3.11

Figure 3.10 shows the comparison from period 1 to period 11 between treatments. The behaviour of borrowing between treatments shows a significant difference for the first 11 periods. (P-value of Two-sample Kolmogorov-Smirnov test is 0.) The distribution in DT shows flatter than in FT comparing with the distribution in Figure 3.10. Figure 3.11 shows the comparison from period 12 to period 21 between treatments. The behaviour of borrowing between treatments shows no significant difference for the latter 10 periods. (P-value of Two-sample Kolmogorov-Smirnov test is 0.226.) The difference between Figure 3.10 and Figure 3.11 imply that the anticipated tax decrease has an effect on households' behaviours before the decrease happens, and after the decrease, the behaviours of households converge to the lower trading level.

Figure 3.12 shows the comparison of the distributions of total net borrowing ratios between the first 11 periods and the latter 10 periods within DT. The behaviour of borrowing within DT shows a significant difference. (P-value of Two-sample Kolmogorov-Smirnov test is 0.003). Figure 3.13 shows the comparison of the distributions of total net borrowing ratio between the first 11 periods and the latter 10 periods within FT. The behaviour of borrowing within FT shows no significant difference. (P-value of Two-sample Kolmogorov-Smirnov test is 0.878.)

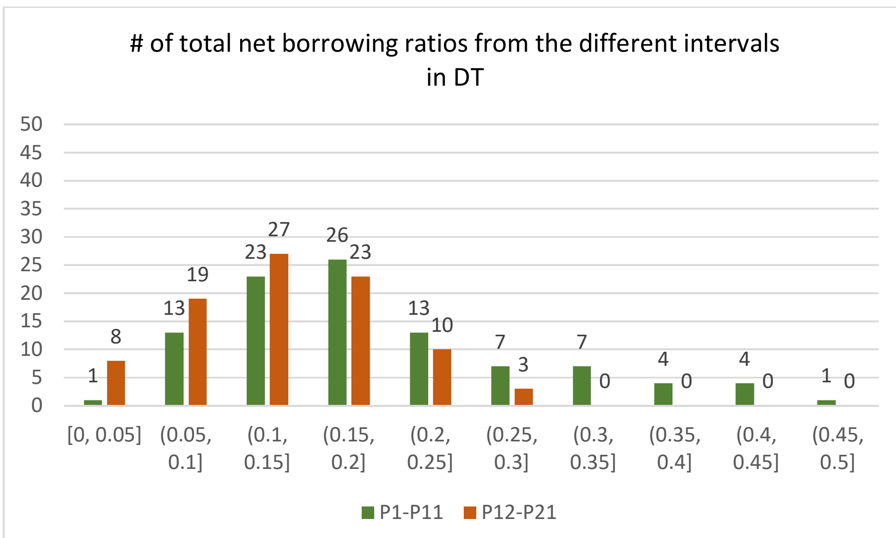


Figure 3.12

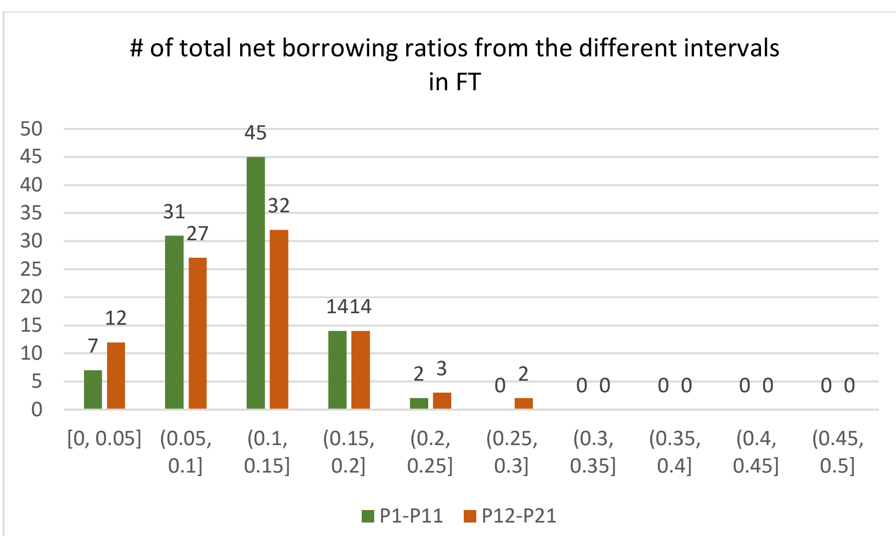


Figure 3.13

The results shown in Figure 3.12 and Figure 3.13 are consistent with the results shown in Figure 3.10 and Figure 3.11. That is, the borrowing behaviours in the first 11 periods in DT show the highest borrowing tend, and after the decrease, the behaviours in the latter periods in DT are similar to the ones in FT.

Figure 3.14 and Figure 3.15 compare the distributions of total net borrowing ratios between the two treatments in period 11. P-value of Two-sample Kolmogorov-Smirnov test is 0.002 for Figure 3.14, and 0.081 for Figure 3.15. That implies that subjects do react to the tax decrease in the period T_{p-1}.

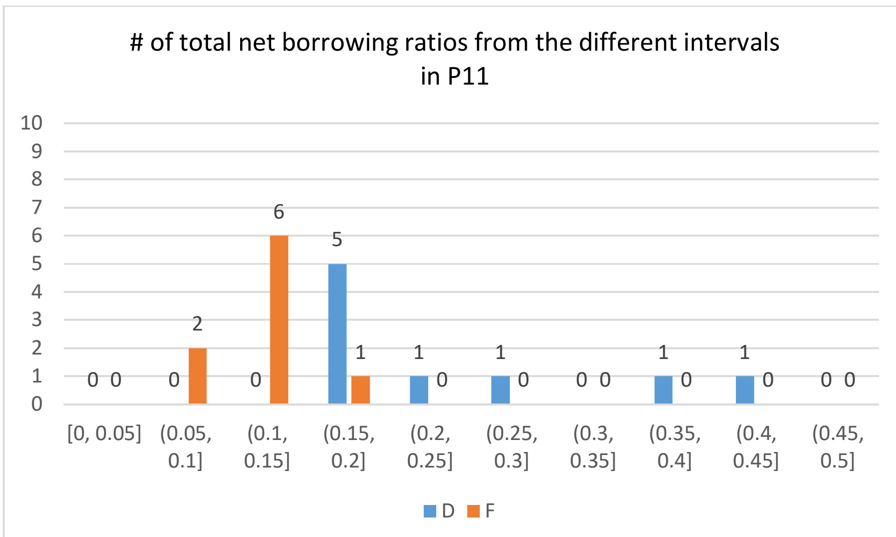


Figure 3.14

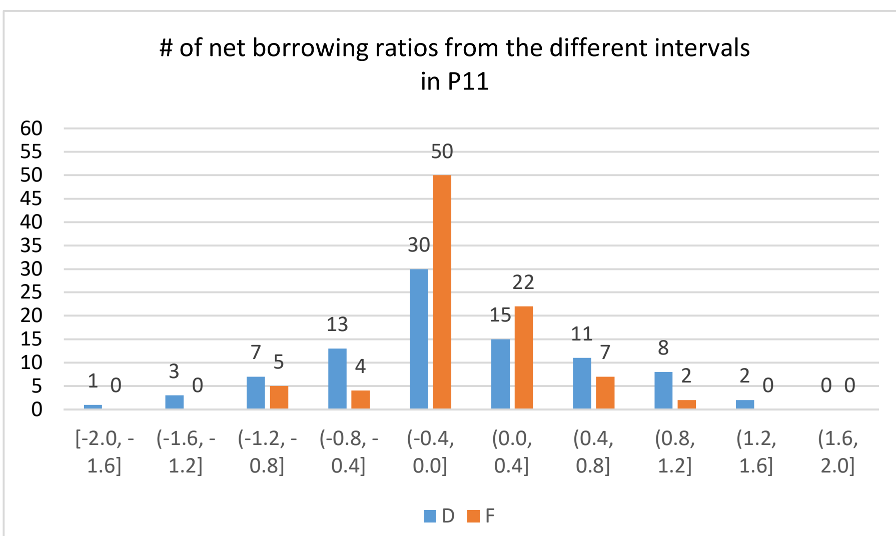


Figure 3.15

The comparisons from Figure 3.5 to Figure 3.15 imply that an anticipated tax decrease affects households' consumption behaviours. This is consistent with the theoretical prediction that players have more incentive to borrow before tax decreases than after tax decreases. This behaviour preference brings stronger incentive to lend for households in DT than in FT and leads to higher MIFs in DT than in FT.

3.5.2 Identification in DT

In this section, we identify subjects' borrowing behaviours in DT based on a series of models in order to explain how individual-level motivations drive market-level manifestations as described in the previous section (Section 3.5.1). As the results show in the previous section, most of the MIF paths appear to deviate from the prediction of RE and AL (shown as Appendix 3.I). Based on the studies of Parker (1999) and Poterba (1988), a series of myopic models are added. Then, the models of identification contain two categories of models, far-sighted models and myopic models. Far-sight models are generalised from 3 main theories, RE, AL and consumption smoothing. Myopic models consist of two-period consumption smoothing models and borrowing adverse models.

In the experiment, y always equals to 120. Life period t is from 1 to 22 and T=22. Then $t+1$ means the next period of the current period. τ_{t+1} means tax in the next period, which equals 70 from period 1 to period 10 and equals to 10 from period 11 to period 21 in DT. Subjects were informed their NI_t^i in each period. β equals to 0.024. r_t is the MIF in period t, which was determined after 105s trading finished. The following sections detail each model with the parameters used in the experiment.

3.5.2.1 Far-sight Models

3.5.2.1.a) RE models

As REE is a market equilibrium model, which predicts both MIF path and individual consumption path in equilibrium, and all households predict themselves and others are identical. Meanwhile, $\{r_t^{*REE}\}_1^{T-1}$ is endogenous determined by all households' consumption paths, and all households should trade nothing in $\{r_t^{*REE}\}_1^{T-1}$. In other words, as everyone is identical, if someone has incentive to borrow, then all others also have the same incentive. As a result, no trading could exist. However, it is reasonable that households are not identical. Outside of REE, some households do not follow RE, but other households conceivably do. Thus, it is necessary to improve REE to an individual-level model, Perfect-Foresight Model (PFM), in which the MIF is considered as exogenous. Then the group of households who follow rational expectation still solve the similar optimization problem with a given specific $\{\hat{r}_t\}_1^{T-1}$. PFM only predicts individual-level consumption path in the group of households who follow RE. The group of households modelling by PFM are assumed to know the specific $\{\hat{r}_t\}_1^{T-1}$ at the beginning of the life, and the optimization problem in PFM is shown below:

$$\max_{\{c_t^i\}_1^T} E^{i^*}\left\{\sum_{t=1}^{T} \alpha\left(1-e^{-\beta c_t^i}\right)\right\}$$

$$subject\ to \begin{cases} c_t^i = y - \tau_t - \hat{r}_{t-1} b_{t-1}^i + b_t^i \\ \hat{r}_t b_t^i \le y - \tau_{t+1} \\ c_t^i \ge 0 \\ b_0^i = 0 \\ b_T^i = 0 \\ t < T_p, \qquad \tau_t = \tau_h \\ t \ge T_p, \qquad \tau_t = \tau_l \end{cases}$$

Using Euler equation,

$$e^{-\beta c_t^i} = \hat{r}_t * e^{-\beta c_{t+1}^i}$$

Then,

$$c_{t+1}^i = \frac{\ln(\hat{r}_t)}{\beta} + c_t^i$$

The optimal consumption path $\{c_t^{i^{*PFM}}\}_1^T$ is determined by $\{\hat{r}\}_1^{T-1}$ in PFM at the beginning of the life. The group of households modelled by PFM with the same $\{\hat{r}\}_1^{T-1}$share the same consumption path $\{c_t^{i^{*PFM}}\}_1^T$. As PFM determines $\{c_t^{i^{*PFM}}\}_1^T$ for households at the beginning of the life, $\{c_t^{i^{*PFM}}\}_1^T$ is time consistent, which does not change over time.

PFM assumes households do not make deviations from the optimal path, but it is conceivable that some households do deviate from the optimal path at least once. An updated sequential model, Sequential Perfect-Foresight Model (SPFM), evolves from

PFM by conducting PFM at the beginning of each period. SPFM is also an individual-level model and only predicts individual-level consumption path with a given specific $\{\hat{r}_t\}_1^{T-1}$. SPFM solves the individual optimization problem but does not predict MIF.

As households in the group modelled by SPFM can have different deviation levels in each period, then different households in the group have different NI_t^i. This means different "flow" budget constraints in each period. The households i's optimization problem is given as following:

$$\max_{\{c_s^i\}_{s=t}^T} E_t^{i^*}\left\{\sum_{s=t}^{T} \alpha\left(1-e^{-\beta c_s^i}\right)\right\}$$

$$subject\ to \begin{cases} c_s^i = y - \tau_s - r_{s-1}b_{s-1}^i + b_s^i \\ r_s b_s^i \leq y - \tau_{s+1} \\ c_s^i \geq 0 \\ b_0^i = 0 \\ b_T^i = 0 \\ s < T_p, \qquad \tau_s = \tau_h \\ s \geq T_p, \qquad \tau_s = \tau_l \end{cases}$$

Then, there are T series of optimal consumption path $\{c_s^{i^{*SPFM}}\}_{s=t}^T$ from $t = 1$ to $t = T$ determined by $\{\hat{r}\}_1^{T-1}$ and pick up the first item of each series, i.e., $c_s^{i^{*SPFM}}$ at $s = t$ from $t = 1$ to $t = T$. The new $\{c_t^{i^{*SPFM}}\}_{t=1}^T$ becomes to the optimal consumption path of SPFM.

In a particular scenario, in which a household makes no deviation from the beginning of the life to the end, his $\{c_t^{i^{*SPFM}}\}_{t=1}^T$ reduces to his $\{c_t^{i^{*PFM}}\}_1^T$ given the same $\{\hat{r}\}_1^{T-1}$. Otherwise, when the household makes at least one deviation, his $\{c_t^{i^{*SPFM}}\}_{t=1}^T$ becomes time inconsistent, as his optimal path $\{c_t^{i^{*SPFM}}\}_{t=1}^T$ is updated along with time at least once.

PFM and SPFM are both individual-level models and non-equilibrium models. That is, MIF, $\{\hat{r}\}_1^{T-1}$, is exogenous, which is not only determined by either of two groups of households' consumptions and which is assumed to be fully known by households in these two groups. However, households modelled by PFM with the same $\{\hat{r}\}_1^{T-1}$ are homogenous, who share the same optimal path, $\{c_t^{i^{*PFM}}\}_1^T = \{c_t^{\ *PFM}\}_1^T$. However, households modelled by SPFM with the same $\{\hat{r}\}_1^{T-1}$are heterogenous, who could have different optimal paths, $\{c_t^{i*PFM}\}_1^T$. As different households in SPFM can have different deviation levels, this implies that SPFM allows households to correct their previous mistakes by repeatedly conducting the optimal procedure at the beginning of each period.

As we need to identify subjects according to their borrowing behaviours, the optimisation problem of PFM is transformed to find the optimal borrowing path. PFM assumes that subjects plausibly know $\{MIF\}_1^{21}$ at the beginning of each session. Then we use Mathematica to solve the maximal problem below:

$$\max_{\{b_t^i\}_1^{21}} E^{i^*}\left\{\sum_{t=1}^{22} 388\left(1-e^{-0.024c_t^i}\right)\right\}$$

$$subject\ to \begin{cases} c_t^i = 120 - \tau_t - MIF_{t-1} * b_{t-1}^i + b_t^i \\ MIF_t * b_t^i \leq 120 - \tau_{t+1} \\ c_t^i \geq 0 \\ b_0^i = 0 \\ b_{22}^i = 0 \\ t < 12, \qquad \tau_t = 70 \\ t \geq 12, \qquad \tau_t = 10 \end{cases}$$

As $\{MIF\}_1^{21}$ is known after each session, then $\{b_t^i\}_1^{21}$ is the path of optimal net borrowing $b_t^{i*}(PFM)$ of each session in DT. Subjects in the same session share the same $b_t^*(PFM)$.

Also, to get the optimal net borrowing of SPFM of each session in DT, the procedure of PFM is conducted in each period. Subjects solve the maximisation problem in period t below with the given $MIF_{t-1} * b_{t-1}^i$ determined at period $t-1$:

$$\max_{\{b_s^i\}_{s=t}^{21}} E_t^{i^*}\left\{\sum_{s=t}^{22} 388\left(1-e^{-0.024c_s^i}\right)\right\}$$

$$
subject\ to \begin{cases} c_s^i = 120 - \tau_s - MIF_{s-1} * b_{s-1}^i + b_s^i \\ MIF_s * b_s^i \leq 120 - \tau_{s+1} \\ c_s^i \geq 0 \\ b_0^i = 0 \\ b_{22}^i = 0 \\ s < 12, \qquad \tau_s = 70 \\ s \geq 12, \qquad \tau_s = 10 \end{cases}
$$

Then the optimal net borrowing of SPFM consists of the series of $\{b_s^i\}_{s=t}^{21}$ in period t. The first item of the solution series of each period of each subject is the optimal net borrowing in that period, $b_t^{i*}(SPFM) = b_{s=t}^i$.

3.5.2.1.b) AL models

Households modelled by AL also may have different "gain" parameter, γ. Then, Al evolves to a series of individual-level AL(γ) models with different "gain" parameter γ_i. Similar to SPFM, MIFs of individual-level AL(γ) models are exogenous, and households correct their consumption paths in each period. The individual optimization problem is described as below:

$$
\max_{\{c_s^i\}_{s=t}^T} E_t^{i^*} \left\{ \sum_{s=t}^{T} \alpha \left(1 - e^{-\beta c_s^i}\right) \right\}
$$

$$
subject\ to \begin{cases} c_s^i = y - \tau_s - \tilde{r}_{i,s-1} b_{s-1}^i + b_s^i \\ \tilde{r}_{i,s} b_s^i \leq y - \tau_{s+1} \\ c_s^i \geq 0 \\ b_0^i = 0 \\ b_T^i = 0 \\ s < T_p, \qquad \tau_s = \tau_h \\ s \geq T_p, \qquad \tau_s = \tau_l \end{cases}
$$

$\tilde{r}_{i,s}$ represents household i's prediction on MIF in period s. And start from household i's expectation MIF, $r_i^e(0) = 1$, for all i and use $r_i^e(t)$ instead of all future MIFs from $t + 1$ to T. Following $r_i^e(t) = r_i^e(t-1) + \gamma_i(\hat{r}_t - r_i^e(t-1))$, $\{\tilde{r}_{i,s}\}_{s=t}^{T-1}$ can be calculated. Then, solving the optimization problem above, there are T series of $\{c_s^i\}_{=t}^T$ from $t = 1$ to $t = T$ and pick up the first item of all series, i.e., c_s^i at $s = t$ from $t = 1$ to $t = T$. The new $\{c_t^{i^{*AL}}\}_{t=1}^T$ becomes to household i's optimal consumption path of AL(γ).

Individual-level models AL(γ) are time inconsistent models. That is, as the deviation level across households may be different, different households modelled by AL(γ) with the same γ may have different consumption paths.

Likewise, the optimisation problem of AL(γ) is needed to transform to find the optimal borrowing path. AL suggests different optimal net borrowing paths with different "gain" parameter γ. Subjects solve the maximization problem in each period along with t:

$$\max_{\{b_s^i\}_{s=t}^{21}} E_t^{i*}\left\{\sum_{s=t}^{22} 388\left(1-e^{-0.024c_s^i}\right)\right\}$$

$$subject\ to \begin{cases} c_s^i = 120 - \tau_s - r_{s-1}b_{s-1}^i + b_s^i \\ r_s b_s^i \leq 120 - \tau_{s+1} \\ r_t^e = r_{t-1}^e + \gamma(MIF_t - r_{t-1}^e) \\ r^e(0) = 1 \\ r_s = MIF_t, \qquad s = t \\ r_{s-1} = MIF_{t-1}, \qquad s = t \\ r_s = r_t^e, \qquad s > t \\ c_s^i \geq 0 \\ b_0^i = 0 \\ b_{22}^i = 0 \\ s < 12, \qquad \tau_s = 70 \\ s \geq 12, \qquad \tau_s = 10 \end{cases}$$

given $r_t^e = r_{t-1}^e + \gamma(MIF_t - r_{t-1}^e)$ and $r^e(0) = 1$.

Then the optimal net borrowing of AL(γ) consist of the series of $\{b_s^i\}_{s=t}^{21}$ when $s = t$. The first item of the solution series of each period of each subject is the optimal net borrowing in that period, $b_t^{i*}(\mathrm{AL}\gamma\ ) = b_{s=t}^i$. In AL($\gamma$), each subject has his own optimal net borrowing path, which is different to others'. To investigate how the performance of AL(γ) varies along with gain parameter, we choose three values of the gain parameter, $\gamma = 1$, $\gamma = 0.5$, and $\gamma = 0.1$ Corresponding to the three models AL10, Al05 and AL01.

3.5.2.1.c) Consumption Smoothing (CS) models

RE and AL models ask households to solve a maximising problem. This requires that households are high intelligence. However, it is scarce that an economy is all composed of high intelligent householders. Then, we introduce a series of individual-level bounded rational models (CS), which allows households not to solve the maximise problem. Households in CS react the anticipated tax scheme when they are informed, but households cannot maximise their total utilities of life accurately, so they try to smooth their consumption over the life. As the utility function is concavity, smoothing whole life consumption is intuitively reasonable.

Firstly, we start from a CS model without sequentially updated target (CSHO), in which households determine the consumption strategy at the beginning of life. He will choose the actual consumption level in each period. To smooth consumption in each period, households sum all T-period incomes $\sum_{t=1}^{T}(y-\tau_t)$ and divide it by T to get their target consumption in each period. Then in each period, households try to reach the target consumption as close as possible by borrowing and lending when $t < T_{P-1}$. And when $t = T_{P-1}$, households reset their target consumptions as the same smoothing procedure. After that, households try to reach the target consumptions as close as possible by borrowing and lending. Then households get the consumption paths $\{c_t^{i*CSHO}\}_{t=1}^{T}$ in CSHO model. CSHO is a time inconsistent model, as different households have different deviations. The procedure is described as below:

$$c_t^{i*CSHO} = \min[NI_t^i + \frac{y-\tau_{\mathrm{t+1}}}{\hat{r}_t}, \frac{\sum_{t=1}^{T}(y-\tau_t)}{T}], t < T_{P-1}$$

$$c_t^{i*CSHO} = \min\left[NI_t^i + \frac{y-\tau_{\mathrm{t+1}}}{\hat{r}_t}, \frac{\sum_{t=T_P}^{T}(y-\tau_t)}{T-T_{P-1}+1}\right], t \geq T_{P-1}$$

Secondly, we updated CSHO models to a model (CSHE) with a sequentially updated target, in which households update their target consumptions at the beginning of each period by dividing $NI_t^i + \sum_{s=t+1}^{T}(y-\tau_s)$ by $(T-t+1)$. As different households may make deviations from their previous target consumptions, different households have different NI_t^i in period t. Thus, CSHE is also time inconsistent. The procedure is described as below:

$$c_t^{i*CSHE} = \min[NI_t^i + \frac{y-\tau_{\mathrm{t+1}}}{\hat{r}_t}, \frac{NI_t^i + \sum_{s=t+1}^{T}(y-\tau_s)}{T-t+1}]$$

Furthermore, CSHO and CSHE both do not include wealth discount by MIF. Then another updated model (CSR) with sequentially updated target and future wealth discount, is introduced. Households modelled by CSR first discount all future incomes $\sum_{s=t}^{T}(y-\tau_s)$ into current period t by the MIF $\hat{r}_t$ in period t and divide it by $(T-t+1)$. This model also allows households to correct their previous deviations by resetting their target consumptions in each period. Similarity, CHR is also time inconsistent. The consumption in CSR is described as below:

$$c_t^{i*CSR} = \min[NI_t^i + \frac{y-\tau_{t+1}}{\hat{r}_t}, \frac{NI_t^i + \sum_{s=t+1}^{T}\frac{(y-\tau_s)}{\hat{r}_t^{\,s-t}}}{T-t+1}]$$

Finally, transforming the problem to find the optimal borrowing path, CSHO suggests the optimal net borrowing path is described as below:

$$b_t^{i*}(\text{CSHO}) = \min[\frac{120-\tau_{t+1}}{MIF_t}, 80 - NI_t^i], t < 11$$

$$b_t^{i*}(\text{CSHO}) = \min\left[\frac{120-\tau_{t+1}}{MIF_t}, 110 \times \frac{11}{12} - NI_t^i\right], t \geq 11$$

As all subjects in the same session face the same MIF path, $b_t^{i*}(\text{CSHO})$ is the same for all subjects in the same sessions.

The optimal net borrowing of CSHE and CSR are described as shown below:

$$b_t^{i*}(\text{CSHE}) = \min[\frac{120-\tau_{t+1}}{MIF_t}, \frac{NI_t^i + \sum_{s=t+1}^{22}(120-\tau_s)}{22-t+1} - NI_t^i]$$

$$b_t^{i*}(\text{CSR}) = \min[\frac{120-\tau_{t+1}}{MIF_t}, \frac{NI_t^i + \sum_{s=t+1}^{22}\frac{(120-\tau_s)}{MIF_t^{\,s-1}}}{22-t+1} - NI_t^i]$$

Both CSHE's and CSR's optimal bet borrowing paths vary with different subjects.

3.5.2.2 Myopic models

To align with the empirical evidence, we introduce a series of time-inconsistent myopic models in this section, which only allow households to manage their consumptions on two successive periods. The series of myopic models consist of two kinds of models, consumption smoothing between two periods and borrowing aversion.

3.5.2.2 a) Two-Period Consumption Smoothing models

As households following myopic models cannot manage whole life consumption plans, they could only manage their tomorrow's plans. Then households try to smooth their 2-period consumptions or maximise their total utilities in the current period and the next period.

Firstly, we introduce a 2-period consumption smoothing (2PCS) model. Assuming zero debt in next period, households try to make the current period's utilities equal to the next period's utilities by borrowing and lending. That is,

$$u_t^i = u_{t+1}^i$$

$$\alpha\left(1 - e^{-\beta(NI_t^i + b_t^i)}\right) = \alpha\left(1 - e^{-\beta(y - \tau_{t+1} - r_t b_t^i)}\right)$$

Then,

$$b_t^{i*} = \frac{y - \tau_{t+1} - NI_t^i}{1 + \hat{r}_t}$$

And $c_t^{i*2PCS} = NI_t^i + b_t^{i*}$.

The next model is a 2-period Euler Equation (2PEU) model, in which households try to maximise the sum of the current period's utilities and the next period's utilities by borrowing and lending with zero debt in next period. That is,

$$\max_{c_t^i, c_{t+1}^i} E_t^{i^*}\left\{\alpha\left(1 - e^{-\beta c_t^i}\right) + \alpha\left(1 - e^{-\beta c_{t+1}^i}\right)\right\}$$

$$Subject\ to \begin{cases} c_t^i = y - \tau_t - \hat{r}_{t-1} b_{t-1}^i + b_t^i \\ \hat{r}_t b_t^i \le y - \tau_{t+1} \\ b_{t+1}^i = 0 \\ c_t^i \ge 0 \\ b_0^i = 0 \\ b_T^i = 0 \\ t < T_p, \qquad \tau_t = \tau_h \\ t \ge T_p, \qquad \tau_t = \tau_l \end{cases}$$

given$\hat{r}_{t-1} b_{t-1}^i$ known. Then the first order condition implies:

$$\frac{du_t^i}{db_t^i} = -\frac{du_{t+1}^i}{db_t^i}$$

$$e^{-\beta(NI_t^i+b_t^i)} = r_t * e^{-\beta(y-\tau_{t+1}-\hat{r}_t b_t^i)}$$

Then,

$$b_t^{i*} = \frac{y - \tau_{t+1} - NI_t^i - \frac{lnr_t}{\beta}}{1 + \hat{r}_t}$$

And $c_t^{i*2PEU} = NI_t^i + b_t^i$.

Then the optimal borrowing paths are described as below:

$$b_t^{i*}(2PCS) = \frac{120 - \tau_{t+1} - NI_t^i}{1 + MIF_t}$$

$$b_t^{i*}(2PEU) = \frac{120 - \tau_{t+1} - NI_t^i - \frac{lnMIF_t}{0.024}}{1 + MIF_t}$$

3.5.2.2 b) Two-Period Borrowing-Averse Model

As mentioned by Meissner's study (2016), some people do not like borrowing from others. Then we describe this kind of behaviour with borrowing-averse models, which are updated from the 2PCS and 2PEU. 2-Period Borrowing Averse (2PCSBA) model from 2PCS is drawn as follows:

$$c_t^{i*2PCSBA} = \min\left\{NI_t^i, \frac{y - \tau_{t+1} + \hat{r}_t * NI_t^i}{1 + \hat{r}_t}\right\}$$

Moreover, 2-Period Euler Equation Borrowing Averse (2PEUBA) model from 2PEU is drawn as follows:

$$c_t^{i*2PEUB} = \min\left\{NI_t^i, \frac{y - \tau_{t+1} + \hat{r}_t * NI_t^i - \frac{lnr_t}{\beta}}{1 + \hat{r}_t}\right\}$$

As $b_t^i < 0$ means lending, then the two functions above imply that b_t^{i*} will never be positive. Therefore, no borrowing will be realised as any borrowing plan will be reduce to 0 in 2PCSBA and 2PEUBA. Then the optimal borrowing paths are described as below:

$$b_t^{i*}(2PCSBA) = \min\left\{0, \frac{120 - \tau_{t+1} - NI_t^i}{1 + MIF_t}\right\}$$

$$b_t^{i*}(2PEUBA) = \min\left\{0, \frac{120 - \tau_{t+1} - NI_t^i - \frac{lnMIF_t}{0.024}}{1 + MIF_t}\right\}$$

When $b_t^{i*}(2PCS)$ or $b_t^{i*}(2PEU)$ is non-positive, $b_t^{i*}(2PCS)$ or $b_t^{i*}(2PEU)$ equals to $b_t^{i*}(2PCSBA)$ or $b_t^{i*}(2PEUBA)$. Otherwise, $b_t^{i*}(2PCSBA)$ or $b_t^{i*}(2PEUBA)$ always equals to 0.

3.5.2.3 Identification

According to the series of optimal net borrowing paths provided previously (Section 3.5.2.2), we conduct a series of regressions for each subject in DT and test if the subject follows at least one optimal path suggested by these 12 models. The regress is described as below:

$$bl_t^i = b0(k) + b1(k) * b_t^{i*}(k) + e$$

$$blp_t^i = b0(k) + b1(k) * b_t^{i*}(k) + e$$

$b_t^{i*}(k)$ represents subject i's optimal net borrowing in period t suggested by model k. k indexes, 2PCS, 2PEU, 2PCSBA, 2PEUBA, PFM, SPFM, AL10, AL05, AL01, CSHO, CSHE and CSR. bl_t^i represents subject i's net borrowing in period t, which is the subject's actual traded net borrowing after 105s, and blp_t^i represents subject i's proposal net borrowing in period t, which is determined by the subject's last valid fulfilled or partially fulfilled borrowing and/or lending proposal(s) within 105s. That is, blp_t^i reflects subject's will to borrow and/or lend, but due to the market size, the willing may not be fully satisfied.

If a subject follows an optimal path provided by model k, then theoretically $b0(k)$ should be 0 and $b1(k)$ should equal to 1. To identify the subject's decision path, we conduct a series of joint tests on the 12 regressions of each subject:

$$Hypothesis\ 3.I\ 0: b0(k) = 0\ and\ b1(k) = 1$$

If the p-value of a joint test on model k of a subject is larger than 0.1, the subject is labelled as strictly following model k. The same subject could be labelled as more than one model type. Another weak test is:

$$Hypothesis\ 3.II\ 0: b1(k) \geq 0.5$$

If the p-value of a joint test on model k of a subject is larger than 0.1, the subject is labelled as weakly following model k.

Table 3.2 presents the summary of groups of subjects labelled into each model in DT. “Proposal” column means $b0(k)$ and $b1(k)$ get from the regressions using blp_t^i and “Actual” column means $b0(k)$ and $b1(k)$ get from the regressions using bl_t^i. “b0=0 & b1=1” column presents the results on $Hypothesis\ 3.I$ and “b1>=0.5” column presents the results on $Hypothesis\ 3.II$.

***Table 3.2**. Summary of the Performance of Models*

	b0=0 & b1=1		b1>=0.5	
Model	Actual	Proposal	Actual	Proposal
Myopic				
2PCS	31	50	46	31
2PEU	34	48	46	33
2PCSBA	35	56	51	41
2PEUBA	35	70	62	53
Far-sight				
PFM	0	4	2	3
SPFM	11	16	22	13
CSHO	5	5	12	6
CSHE	5	7	15	7
CSR	9	17	14	10
AL10	11	18	21	11
AL05	11	18	22	11
AL01	12	19	22	14
Random (15) (Chi-square test)	+5	+5	+6	+12
total (90)	57	75	68	67

Numbers in the table show the number of subjects who follow a specific borrowing path. Obviously, four myopic models dominate the most labelled subjects’ behaviours (out of 90 observations in DT). This is consistent with the results found by Poterba (1988). Within far-sight models, AL shows relatively better performance than other models. The results using actual net borrowing data are consistent with the ones using proposal net borrowing data, and the number of subjects explained by models with actual net borrowing data is obviously less than the one with proposal net borrowing data in the strict models. This better performance of proposal data may be explained by that the proposal data reflect players' true wills.

However, there are still around 1/3 ~1/6 subjects whose borrowing paths cannot be explained by any models used in the experiment. Furthermore, the Chi-square test is conducted to check if subjects' behaviours follow randomisation. We define subject i's valid choosing interval as below:

$$[-NI_t^i, \frac{120-\tau_{t+1}}{MIF_t}]$$

We divide the interval into four subintervals equally, which are named from 1 to 4. Check which subinterval subject i's net borrowing belongs to and sign the subinterval's name to the subject. Then each subject has a series of numbers from 1 to 4 along with periods, which is tested by Chi-square test. "Random (Chi-square test)" row in Table Models reports the adding number of subjects whose borrowing behaviours are classified as randomization.

Table 3.3 represents the summary of overlapping among models for "Actual" columns of $Hypothesis\ 3.I$. In general, AL models show non-sensitive to the "gain" parameter, as subjects who are explained by both AL10 and AL05 are also explained by AL01. Moreover, subjects who are explained by other far-sight models are highly possibly explained by AL models.

3.5.2.4 Rule of Thumb

As there are still some subjects left whose borrowing paths cannot be explained by any of 12 models, we run $bl_t^i = b0(j) + b1(j) * bl_t^j + e, j \neq i$ among all subjects within each session to check if there are some rules of thumb used by subjects. There is only one pair of subjects (Subject 3 and Subject 5) out of 405 pairs[66] within the same session (Session 8) whose borrowing series in the 21 periods have been explained by each other at 90% significant level (passing $Hypothesis\ 3.I$). (Details on test results in *Appendix 3.III*.) In general, there is no obvious rules of thumb following by players.

[66] 1 * 9 (each subject has 9 pairs with the other 9 subjects in the same treatment) * 10 (total subjects in each treatment) /2 (excluding repeated pairs) * 9 (sessions) = 405 (pairs).

Table 3.3. *Summary on Overlapping among Models*

	2PCS	2PEU	2PCSBA	2PEUBA	PFM	SPFM	CSHO	CSHE	CSR	AL10	AL05	AL01
2PCS	31											
2PEU	30	34										
2PCSBA	23	24	36									
2PEUBA	22	25	31	35								
PFM	0	0	0	0	0							
SPFM	6	7	4	5	0	11						
CSHO	1	1	0	0	0	3	5					
CSHE	2	2	0	0	0	2	4	5				
CSR	3	4	2	2	0	6	4	3	9			
AL10	5	7	4	5	0	10	3	2	7	11		
AL05	5	7	4	5	0	10	3	2	7	11	11	
AL01	6	8	4	5	0	10	3	2	7	11	11	12

Table 3.4. *Summary of Coefficient r*

	2PCS	2PEU	2PCSBA	2PEUBA	PFM	SPFM	CSHO	CSHE	CSR	AL10	AL05	AL01
Binary Value	-0.18	-0.16	-0.15	-0.12	-	0.04	-0.06	0.01	-0.06	0.02	0.02	0.01
P-value	-0.15	-0.15	-0.16	-0.16	-0.10	0.06	0.05	0.05	0.04	0.03	0.03	0.03
Mean of Boxes	35.39	36.32	37.81	37.74	-	42.91	35.40	41.40	36.67	41.55	41.55	41.42
Mean of "r"[67]	0.56	0.60	0.56	0.68	-	1.03	0.98	1.14	0.87	0.99	0.99	0.96

[67] "Mean of r" excludes an observation with 100 boxes collected.

3.4.3 Risk Analysis

In this section, we introduce the risk attitude of subjects into the analysis with models. Following the study of Crosetto and Filippin (2013), we used a dynamic visual version to elicit subjects' risk attitudes. Then the coefficient of risk aversion, "r", is determined by the number (k) of boxed collected. That is,

$$k = \frac{100r}{1+r}$$

Then,

$$r = \frac{k}{100-k}$$

Subjects who collected no more than 49 boxes are signed as risk aversion. Subjects who collected 50 boxes are signed as risk neutral. Subjects who collected more than 50 boxes are signed as risk seeker. Figure 3.16 shows the distribution of 90 subjects' numbers of boxes collected. "X-axis" represents the scale of intervals on the numbers of boxes collected, and "Y-axis" represents the number of observations in each interval.

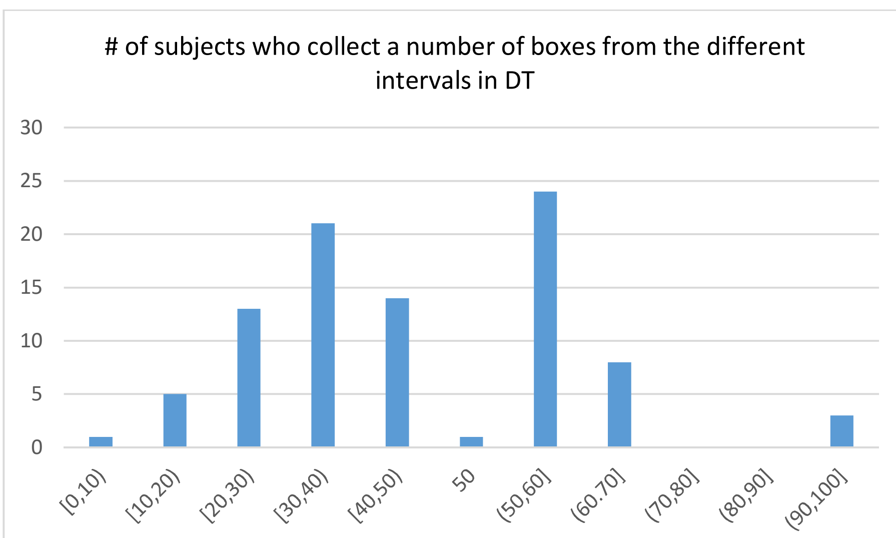


Figure 3.16

Figure 3.17 represents the distribution of 90 subjects' coefficient of risk aversion, "r". "X-axis" represents the scale of intervals on "r" and "Y-axis" represents the number of observations in each interval.

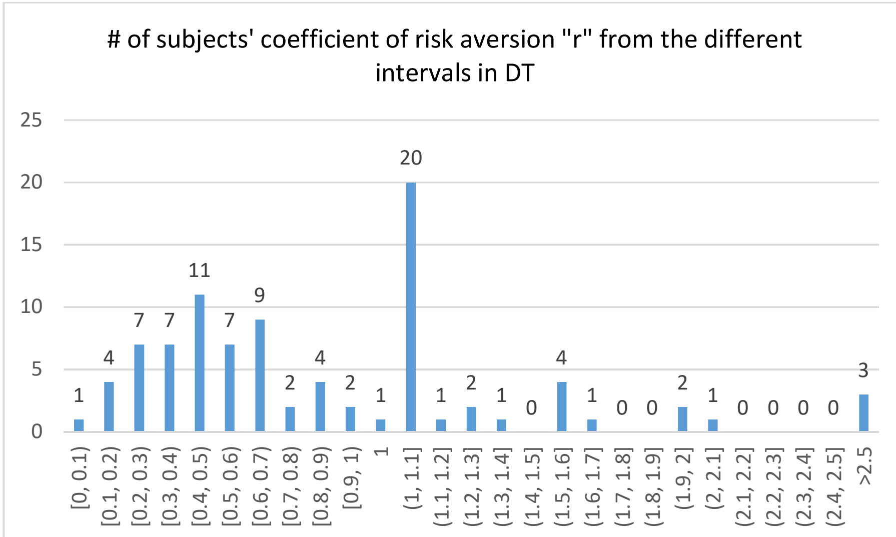


Figure 3.17

Figure 3.16 and Figure 3.17 both show that more subjects are risk averse. Table 3.4 represents a series of correlation analysis on 12 models and risk attitude. “Binary Value” row shows the correlation coefficient between the numbers of collected boxes by subjects and whether the subjects pass $Hypothesis\ I$ on a specific model with their actual data on 90% level (if pass, then valued as 1; if not, then valued as 0). “P-Value” row shows the correlation coefficient between the numbers of collected boxes of subjects and the P-value of the subjects on $Hypothesis\ I$ testing on a specific model with their actual data. “Mean of Boxes” row represent the average boxes collected of subjects whose borrowing paths are explained by a specific model. “Mean of r” represents the average of “r” of subjects whose borrowing paths are explained by a specific model.

“Binary Value” and “P-Value” show negative in 4 myopic models, and “Mean of Boxes” and “Mean of r” consistently indicate risk averse for subjects who follow 4 myopic models. This implies that subjects who follow myopic models are risk averse, and in contrast, subjects who follow far-sight models are more likely to be risk seeker. As most of the far-sight models predict the future’s MIFs, which includes uncertainty, risk seekers could bear more risk so that they could manage fthe uture’s plans.

3.5. Conclusion

In this chapter, we design an experiment to study how players determine their life consumption plans by reacting to an anticipated tax decrease and explore the factors which affect subjects' whole life consumption paths.

We compare the MIF paths and borrowing behaviours between the treatment with constant tax and the treatment with tax decrease, and the differences between two treatments are significant on both MIF paths and borrowing behaviours. We generalise four myopic models and eight far-sight models to explain subjects' borrowing behaviours. Myopic models show a better performance, which are followed by around 2/3 subjects explained by at least one models. This result is similar to previous studies. Meanwhile, the other 1/3 far-sight subjects do react to the tax decrease and have the incentive to borrow before the tax decrease happens. Myopic subjects are driven by a higher MIF level, which is caused by far-sight subjects' borrowing needs, to lend their wealth. Lending brings a temporary wealth rise to myopic subjects. The active trading in DT maintains the MIF on a higher level than in FT, but in FT there is no strong incentive for far-sight subjects to borrow. Moreover, within far-sight models, a small number of subjects behave as sequential RE paths, in which subjects are assumed to have the full knowledge on the future MIFS, but adaptive learning shows a relatively better performance comparing with other far-sight models. In general, most of the subjects whose behaviours can be explained by one far-sight model also can be explained by AL models.

In the next step, risk attitude is introduced to compensate the analysis on the factor which drives subjects to play as myopic or far-sight players. The analysis shows that there is a plausible correlation between myopic playing and risk aversion. Subjects who follow myopic models are more risk-averse. However, there is no evidence or studies on that either risk aversion or intelligence limit can lead the subject to follow myopic models. In our study, only the correlation between behaviours and risk is investigated. More studies are needed to be conducted to study the correlation between behaviours and intelligence.

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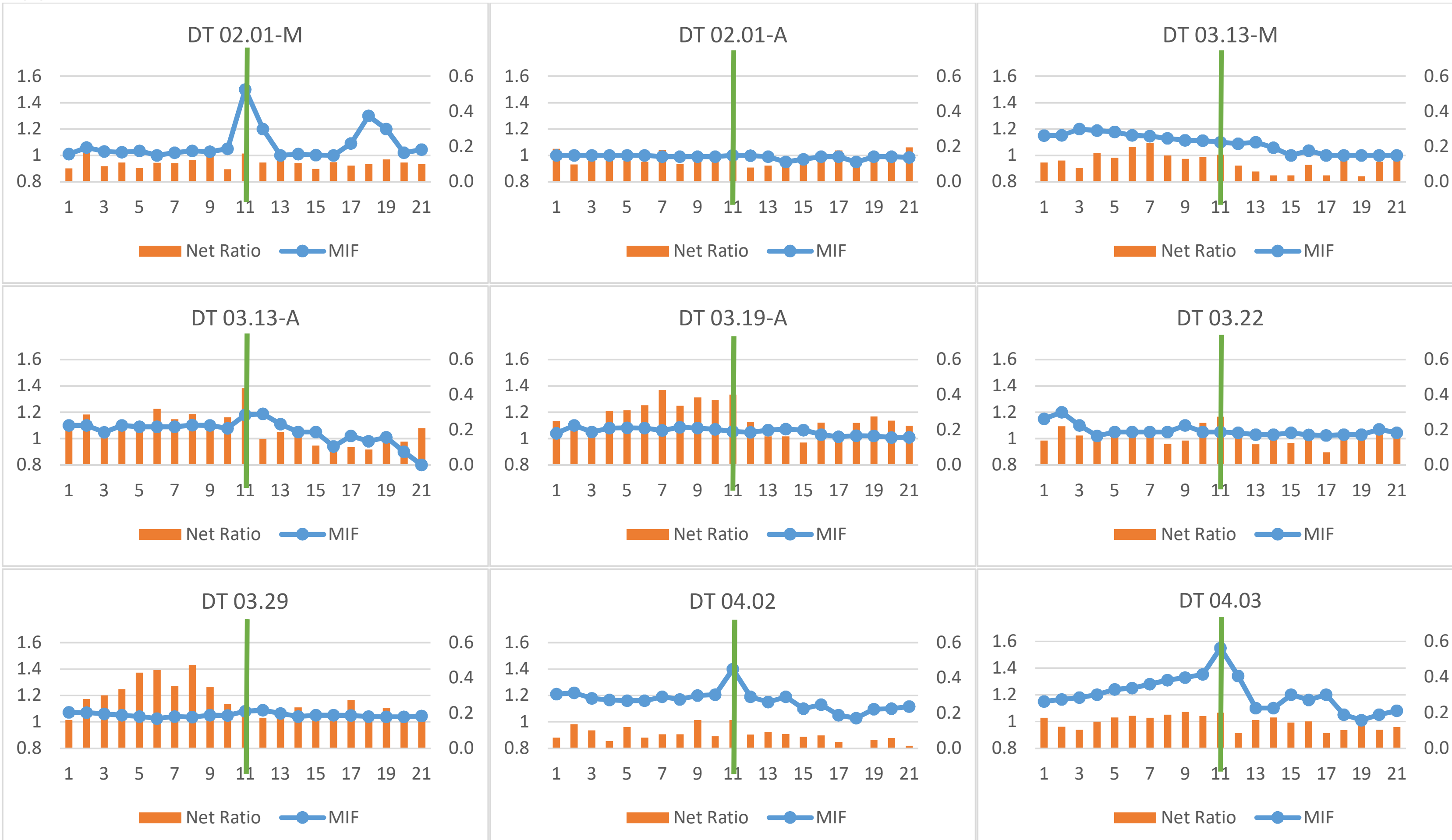
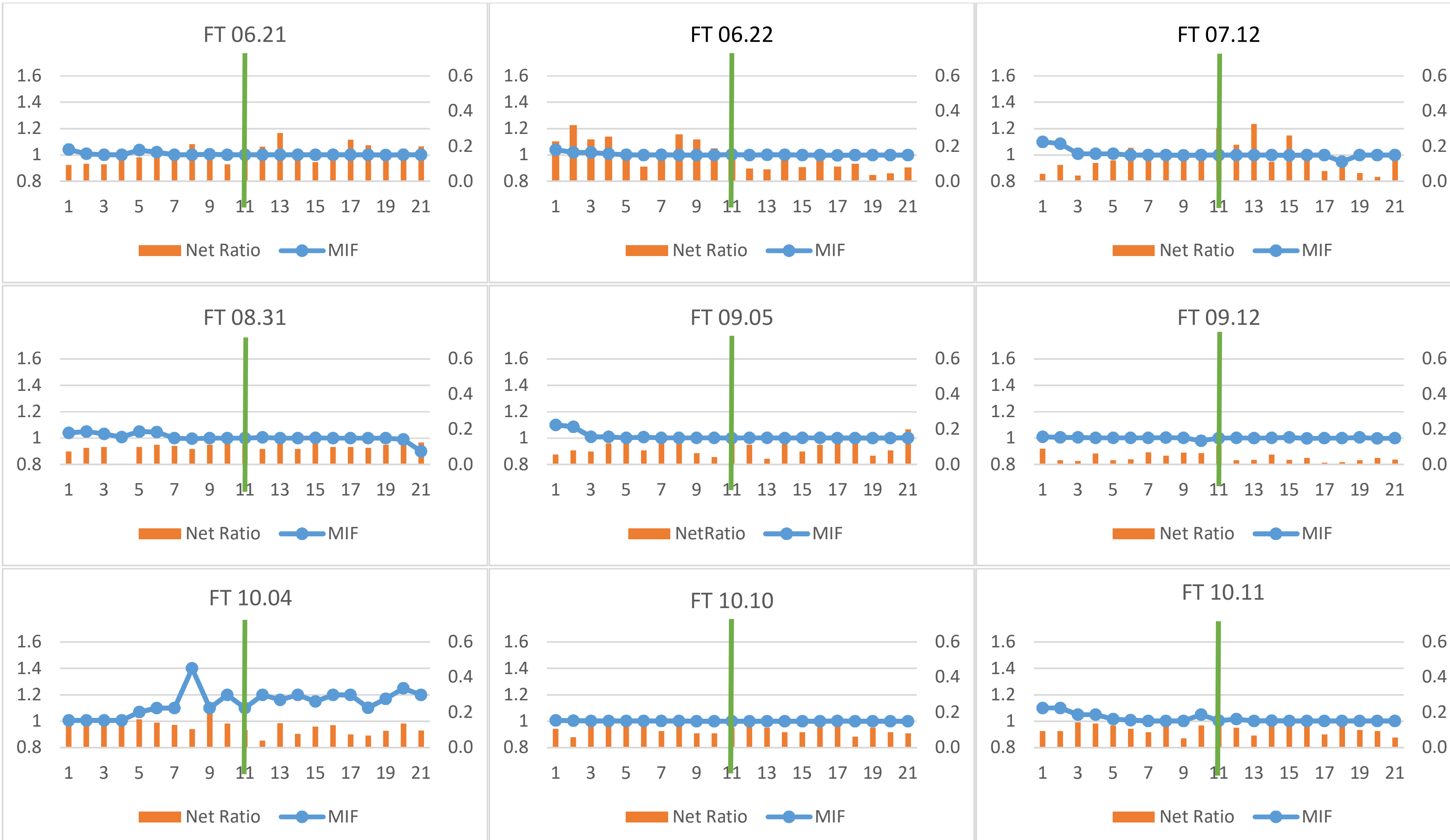
Appendix 3.I



Note: The left axis represents the value of MIFs and the right axis represents the value of Net Ratios.



Note: The left axis represents the value of MIFs and the right axis represents the value of Net Ratios.

Appendix 3.II

Following Section 3.1.2, ALE used in this chapter is the maximising problem as following

$$\max_{\{c_s^i\}_{s=t}^{T}} E_t^{i^*}\left\{\sum_{s=t}^{T} \alpha\left(1 - e^{-\beta c_s^i}\right)\right\}$$

$$subject\ to \begin{cases} c_s^i = y - \tau_s - \tilde{r}_{s-1} b_{s-1}^i + b_s^i \\ \tilde{r}_s b_s^i \le y - \tau_{s+1} \\ c_s^i \ge 0 \\ b_0^i = 0 \\ b_T^i = 0 \\ s < T_p, \qquad \tau_s = \tau_h \\ s \ge T_p, \qquad \tau_s = \tau_l \end{cases}$$

$\tilde{r}_s$ represents the prediction on MIF in period s. Then Euler equation shows:

$$E_t^{i^*} c_{s+1}^i = \frac{ln(\tilde{r}_s)}{b} + c_s^i, s = t, \dots, T$$

Furthermore,

$$E_t^{i^*} c_{s+j}^i = \frac{ln\left(r_s \prod_{h=2}^{j} \tilde{r}_{s+h-1}\right)}{b} + c_t^i, j \ge 2, s = t, \dots, T$$

As $r_{t+h-1}^e(t) = r^e(t)$ for all $h \ge 2$, and

$$r^e(t) = r^e(t-1) + \gamma(\hat{r}_t - r^e(t-1))$$

Then,

$$E_t^{i^*} c_{t+j}^i = \frac{ln\left(\hat{r}_t \prod_{h=2}^{j} r^e(t)\right)}{b} + c_t^i, j \ge 2, s = t, \dots, T$$

As $\prod_{h=2}^{j} r^e(t) = r^e(t)^{j-1}$, then

$$E_t^{i^*} c_{t+j}^i = \frac{ln\left(\hat{r}_t * r^e(t)^{j-1},\right)}{b} + c_t^i$$

We use $D_{t,t+j-1}^e(t)$ to represent $\hat{r}_t * r^e(t)^{j-1}$ ($j \ge 2$) and $\hat{r}_t$ ($j = 1$). As households in ALE are identical, then let $c_t^i = c_t$ and $c_{t+j}^e(t) = E_t^{i^*} c_{t+j}^i$. Then the representative household's life-time budget constraint at period t is described as below:

$$c_t + \sum_{j=1}^{T-t} \frac{c_{t+j}^e(t)}{D_{t,t+j-1}^e(t)} = y - \tau_t - \hat{r}_t b_{t-1} + \sum_{j=1}^{T-t} \frac{y - \tau_{t+j}^e(t)}{D_{t,t+j-1}^e(t)}, t \leq T-1$$

Then re-write the life balance function:

$$c_t + \sum_{j=1}^{T-t} \frac{\frac{ln\left(D_{t,t+j-1}^e(t)\right)}{b} + c_t^i}{D_{t,t+j-1}^e(t)} = y - \tau_t - \hat{r}_t b_{t-1} + \sum_{j=1}^{T-t} \frac{y}{D_{t,t+j-1}^e(t)} - \sum_{j=1}^{T-t} \frac{\tau_{t+j}^e(t)}{D_{t,t+j-1}^e(t)}$$

$$c_t\left(1 + \sum_{j=1}^{T-t} \frac{1}{D_{t,t+j-1}^e(t)}\right) + \sum_{j=1}^{T-t} \frac{ln\left(D_{t,t+j-1}^e(t)\right)}{b * D_{t,t+j-1}^e(t)}$$

$$= y - \tau_t - \hat{r}_t b_{t-1} + \sum_{j=1}^{T-t} \frac{y}{D_{t,t+j-1}^e(t)} - \sum_{j=1}^{T-t} \frac{\tau_{t+j}^e(t)}{D_{t,t+j-1}^e(t)}$$

Market clearing implies zero debt, which means $c_t = y - \tau_t$. Then,

$$(y - \tau_t)\left(\sum_{j=1}^{T-t} \frac{1}{D_{t,t+j-1}^e(t)}\right) + \sum_{j=1}^{T-t} \frac{ln\left(D_{t,t+j-1}^e(t)\right)}{b * D_{t,t+j-1}^e(t)}$$

$$= y\sum_{j=1}^{T-t} \frac{1}{D_{t,t+j-1}^e(t)} - \sum_{j=1}^{T-t} \frac{\tau_{t+j}^e(t)}{D_{t,t+j-1}^e(t)}$$

Then,

$$\sum_{j=1}^{T-t} \frac{ln\left(D_{t,t+j-1}^e(t)\right)}{b * D_{t,t+j-1}^e(t)} = \sum_{j=1}^{T-t} \frac{\tau_t - \tau_{t+j}^e(t)}{D_{t,t+j-1}^e(t)}$$

As $D_{t,t+j-1}^e(t) = \hat{r}_t * r^e(t)^{j-1}$, then

$$\sum_{j=1}^{T-t} \frac{1}{D_{t,t+j-1}^e(t)} = \sum_{j=1}^{T-t} \frac{1}{\hat{r}_t * r^e(t)^{j-1}} = r_t \sum_{j=1}^{T-t} \frac{1}{r^e(t)^{j-1}} = \frac{1}{\hat{r}_t} \frac{r^e(t)^{T-t} - 1}{(r^e(t) - 1) r^e()^{T-t-1}}$$

Then,

$$\sum_{j=1}^{T-t}\frac{ln\left(D^e_{t,t+j-1}(t)\right)}{b*D^e_{t,t+j-1}(t)}=\frac{\ln(\hat{r}_t)}{b*\hat{r}_t}\sum_{j=1}^{T-t}\frac{1}{r^e(t)^{j-1}}+\frac{\ln r^e(t)}{b*\hat{r}_t}\sum_{j=1}^{T-t}\frac{j-1}{r^e(t)^{j-1}}$$

$$=\frac{\ln(\hat{r}_t)}{b*\hat{r}_t}\frac{r^e(t)^{T-t}-1}{(r^e(t)-1)r^e(t)^{T-t-1}}+\frac{\ln r^e(t)}{b*\hat{r}_t}\sum_{j=1}^{T-t}\frac{j-1}{r^e(t)^{j-1}}$$

$$=\frac{\ln(\hat{r}_t)}{b*\hat{r}_t}\frac{r^e(t)^{T-t}-1}{(r^e(t)-1)r^e(t)^{T-t-1}}$$

$$+\frac{\ln r^e(t)}{b*\hat{r}_t}\frac{r^e(t)^{T-t}-(T-t)r^e(t)+T-t-1}{r^e(t)^{T-t-1}(r^e(t)-1)^2}$$

When $t \leq T_{P-1}$,

$$\sum_{j=1}^{T-t}\frac{\tau_t-\tau^e_{t+j}(t)}{D^e_{t,t+j-1}(t)}=\sum_{j=T_P-t}^{T-t}\frac{\tau_h-\tau_l}{D^e_{t,t+j-1}(t)}=\frac{\tau_h-\tau_l}{\hat{r}_t}\frac{r^e(t)^{T-T_{P-1}}-1}{r^e(t)^{T-t-1}(r^e(t)-1)}$$

When $t > T_{P-1}$,

$$\sum_{j=1}^{T-t}\frac{\tau_t-\tau^e_{t+j}(t)}{D^e_{t,t+j-1}(t)}=\sum_{J=1}^{T-t}\frac{\tau_l-\tau_l}{D^e_{t,t+j-1}(t)}=0$$

Then, when $t \leq T_{P-1}$,

$$\frac{\ln(r_t)}{b*\hat{r}_t}\frac{r^e(t)^{T-t}-1}{(r^e(t)-1)r^e(t)^{T-t-1}}+\frac{\ln r^e(t)}{b*\hat{r}_t}\frac{r^e(t)^{T-t}-(T-t)r^e(t)+T-t-1}{r^e(t)^{T-t-1}(r^e(t)-1)^2}$$

$$=\frac{\tau_h-\tau_l}{\hat{r}_t}\frac{r^e(t)^{T-T_{P-1}}-1}{r^e(t)^{T-t-1}(r^e(t)-1)}$$

So,

$$\tilde{r}_t^{*ALE}$$

$$=\exp\hat{}\ \frac{(\tau_h-\tau_l)(r^e(t)^{T-T_{P-1}}-1)b-\frac{(r^e(t)^{T-t}-(T-t)r^e(t)+T-t-1)lnr^e(t)}{r^e(t)-1}}{(r^e(t)^{T-t}-1)}$$

And when $t > T_{P-1}$,

$$\frac{\ln(\hat{r}_t)}{b*\hat{r}_t}\frac{r^e(t)^{T-t}-1}{(r^e(t)-1)r^e(t)^{T-t-1}}+\frac{\ln r^e(t)}{b*\hat{r}_t}\frac{r^e(t)^{T-t}-(T-t)r^e(t)+T-t-1}{r^e(t)^{T-t-1}(r^e(t)-1)^2}=0$$

So,

$$\tilde{r}_t^{*ALE} = \exp \wedge \frac{(r^e(t)^{T-t} - (T-t)r^e(t) + T - t - 1)\ln r^e(t)}{(r^e(t) - 1)(1 - r^e(t)^{T-t})}$$

Appendix 3.III

The series of following tables represent the p-value of the test on *Hypothesis 3.I* for regressions between subjects in each session. "Subject i" in the first row represents the dependent variable and the "Subject j" in the first column represent the independent variable.

Table I. *P-value of Test on Hypothesis 3.I in Session 1*

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10
Subject 1	.	0.000	0.000	0.061	0.000	0.000	0.000	0.000	0.000	0.000
Subject 2	0.232	.	0.001	0.089	0.003	0.010	0.032	0.000	0.006	0.000
Subject 3	0.000	0.000	.	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Subject 4	0.000	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000	0.000
Subject 5	0.049	0.000	0.001	0.001	.	0.100	0.194	0.000	0.008	0.001
Subject 6	0.000	0.000	0.000	0.000	0.000	.	0.000	0.000	0.000	0.000
Subject 7	0.000	0.000	0.000	0.000	0.000	0.000	.	0.000	0.000	0.000
Subject 8	0.003	0.000	0.000	0.016	0.000	0.039	0.000	.	0.000	0.024
Subject 9	0.000	0.000	0.000	0.058	0.000	0.019	0.002	0.000	.	0.000
Subject 10	0.000	0.000	0.000	0.010	0.000	0.004	0.000	0.000	0.000	.

Table II. *P-value of Test on Hypothesis 3.I in Session 2*

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10
Subject 1	.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000
Subject 2	0.000	.	0.000	0.000	0.000	0.000	0.000	0.000	0.982	0.000
Subject 3	0.003	0.001	.	0.000	0.000	0.000	0.000	0.000	0.634	0.000
Subject 4	0.337	0.008	0.004	.	0.000	0.041	0.000	0.449	0.419	0.000
Subject 5	0.182	0.199	0.021	0.000	.	0.001	0.000	0.005	0.822	0.046
Subject 6	0.001	0.000	0.000	0.000	0.000	.	0.001	0.000	0.001	0.000
Subject 7	0.000	0.000	0.000	0.000	0.000	0.000	.	0.000	0.000	0.000
Subject 8	0.285	0.014	0.000	0.027	0.000	0.038	0.000	.	0.281	0.000
Subject 9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.	0.000
Subject 10	0.153	0.023	0.003	0.000	0.000	0.002	0.000	0.000	0.001	.

Table III. *P-value of Test on Hypothesis 3.I in Session 3*

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10
Subject 1	.	0.006	0.001	0.000	0.053	0.000	0.117	0.000	0.000	0.000
Subject 2	0.000	.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subject 3	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subject 4	0.000	0.000	0.272	.	0.209	0.000	0.015	0.036	0.000	0.000
Subject 5	0.000	0.000	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000
Subject 6	0.393	0.008	0.011	0.000	0.534	.	0.080	0.000	0.000	0.002
Subject 7	0.000	0.000	0.000	0.000	0.000	0.000	.	0.000	0.000	0.000
Subject 8	0.001	0.000	0.142	0.000	0.019	0.000	0.027	.	0.000	0.000
Subject 9	0.001	0.001	0.001	0.000	0.980	0.000	0.090	0.001	.	0.011
Subject 10	0.010	0.000	0.014	0.000	0.723	0.000	0.079	0.002	0.000	.

***Table IV**. P-value of Test on Hypothesis 3.I in Session 4*

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10
Subject 1	.	0.000	0.000	0.000	0.000	0.000	0.000	0.039	0.000	0.000
Subject 2	0.000	.	0.234	0.030	0.000	0.034	0.000	0.000	0.000	0.002
Subject 3	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subject 4	0.000	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000	0.000
Subject 5	0.000	0.000	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000
Subject 6	0.000	0.000	0.049	0.071	0.000	.	0.000	0.001	0.000	0.000
Subject 7	0.000	0.027	0.571	0.502	0.002	0.840	.	0.024	0.003	0.000
Subject 8	0.002	0.000	0.000	0.000	0.000	0.000	0.000	.	0.000	0.000
Subject 9	0.001	0.027	0.006	0.595	0.001	0.012	0.000	0.000	.	0.002
Subject 10	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	.

***Table V**. P-value of Test on Hypothesis 3.I in Session 5*

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10
Subject 1	.	0.000	0.108	0.000	0.000	0.000	0.000	0.001	0.000	0.000
Subject 2	0.000	.	0.000	0.137	0.000	0.000	0.000	0.000	0.030	0.000
Subject 3	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subject 4	0.000	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000	0.000
Subject 5	0.000	0.004	0.086	0.023	.	0.012	0.005	0.311	0.002	0.055
Subject 6	0.002	0.000	0.000	0.000	0.000	.	0.000	0.011	0.000	0.000
Subject 7	0.000	0.001	0.001	0.031	0.000	0.000	.	0.002	0.138	0.032
Subject 8	0.000	0.000	0.006	0.001	0.000	0.000	0.000	.	0.007	0.008
Subject 9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.	0.000
Subject 10	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.077	.

Table VI*. P-value of Test on Hypothesis 3.I in Session 6*

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10
Subject 1	.	0.000	0.001	0.000	0.000	0.000	0.000	0.172	0.000	0.000
Subject 2	0.000	.	0.000	0.000	0.040	0.000	0.000	0.000	0.000	0.000
Subject 3	0.000	0.000	.	0.000	0.001	0.000	0.000	0.114	0.000	0.000
Subject 4	0.000	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000	0.000
Subject 5	0.000	0.000	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000
Subject 6	0.000	0.022	0.004	0.152	0.307	.	0.000	0.003	0.000	0.062
Subject 7	0.000	0.022	0.000	0.000	0.071	0.000	.	0.000	0.000	0.000
Subject 8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.	0.000	0.000
Subject 9	0.000	0.004	0.000	0.337	0.020	0.000	0.000	0.001	.	0.003
Subject 10	0.000	0.012	0.000	0.004	0.006	0.000	0.000	0.002	0.000	.

Table VII*. P-value of Test on Hypothesis 3.I in Session 7*

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10
Subject 1	.	0.004	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.001
Subject 2	0.000	.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subject 3	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subject 4	0.000	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000	0.000
Subject 5	0.001	0.000	0.000	0.060	.	0.000	0.003	0.000	0.481	0.000
Subject 6	0.000	0.002	0.001	0.001	0.000	.	0.000	0.014	0.000	0.000
Subject 7	0.000	0.000	0.000	0.000	0.000	0.000	.	0.000	0.000	0.000
Subject 8	0.000	0.000	0.026	0.000	0.000	0.001	0.000	.	0.000	0.000
Subject 9	0.000	0.000	0.000	0.107	0.000	0.000	0.007	0.000	.	0.000
Subject 10	0.000	0.292	0.000	0.001	0.000	0.000	0.001	0.000	0.000	.

***Table VIII**. P-value of Test on Hypothesis 3.I in Session 8*

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10
Subject 1	.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subject 2	0.017	.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subject 3	0.007	0.015	.	0.001	0.101	0.009	0.000	0.000	0.159	0.000
Subject 4	0.038	0.052	0.564	.	0.436	0.079	0.000	0.000	0.038	0.008
Subject 5	0.025	0.036	0.337	0.003	.	0.014	0.000	0.000	0.024	0.004
Subject 6	0.000	0.003	0.000	0.000	0.000	.	0.000	0.000	0.005	0.000
Subject 7	0.000	0.000	0.000	0.000	0.000	0.000	.	0.000	0.000	0.000
Subject 8	0.018	0.446	0.201	0.503	0.507	0.264	0.000	.	0.113	0.415
Subject 9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.	0.000
Subject 10	0.001	0.056	0.000	0.000	0.000	0.232	0.000	0.000	0.110	.

***Table IX**. P-value of Test on Hypothesis 3.I in Session 9*

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10
Subject 1	.	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000
Subject 2	0.000	.	0.000	0.137	0.000	0.000	0.000	0.000	0.000	0.015
Subject 3	0.627	0.000	.	0.000	0.233	0.000	0.000	0.000	0.000	0.010
Subject 4	0.000	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000	0.000
Subject 5	0.036	0.000	0.000	0.000	.	0.000	0.000	0.000	0.000	0.000
Subject 6	0.000	0.000	0.000	0.000	0.000	.	0.018	0.000	0.000	0.000
Subject 7	0.000	0.000	0.000	0.001	0.000	0.000	.	0.000	0.000	0.000
Subject 8	0.057	0.000	0.000	0.000	0.001	0.000	0.000	.	0.000	0.002
Subject 9	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	.	0.022
Subject 10	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	.

Appendix 3.IV Instructions

INSTRUCTIONS

WELCOME!

You are about to participate in an experiment in decision making.

First, you will read instructions that explain the decision scenarios that you will face in the experiment. Next, you will answer questions that test your understanding of the instructions. If you answer the questions correctly, you will earn £3. You must answer the questions correctly in order to participate in the experiment.

In the actual experiment, you will make decisions that will allow you to earn money. Your decisions and the decisions of other participants in the experiment will determine your monetary earnings in the experiment. All that you earn is yours to keep, and will be paid to you in private, in cash, after today's session.

It is important to us that you remain silent and do not look at other people's work. If you have any questions or need assistance of any kind, please raise your hand, and an experimenter will come to you. If you talk, exclaim out loudly, etc., you will be asked to leave, and you will forfeit your earnings. Thank you.

In the experiment, you will interact anonymously in a group of **10** people who are currently in the room. *We will assign an ID to you and all the other participants, so that you interact with the other participants in your group anonymously*. Your ID, and the IDs of the other participants in your group, will not be revealed to any of the participants, either during or after the experiment.

DESCRIPTION OF THE EXPERIMENT

The experiment has **22 decision PERIODS.** At the start of each period, you will receive an **ENDOWMENT** of ''experimental currency units,'' (**ECUs** for short). In each period, you will pay a certain amount of ECUs in **TAX**. This **TAX** will be automatically deducted from your **ENDOWMENT** for that period. Your **ENDOWMENT** and **TAX** for all periods will be announced before period 1 starts.

In each period, you will be making **decisions** that **determine the amount of ECUs you CONSUME** that period. You may think of each period as a consumption period. The amount of ECUs you consume in a period determines the **NUMBER OF POINTS you earn that period** according to the formula described below. The **number of points that you earn in the experiment** is the **SUM of the POINTS you earn in the 22 decision PERIODS**.

In each period, except in the last period, you can increase or decrease the amount of ECUs you consume that period by **BORROWING** or **LENDING** an amount of ECUs (under some conditions described below).

To **BORROW** you need to submit:

A BORROWING PROPOSAL: the **AMOUNT of ECUs** you want to **BORROW** and **the INTEREST FACTOR, which is the MAXIMUM AMOUNT of ECUs you would be willing to pay back next period for each ECU you borrow in the current period**;

To **LEND** you need to submit:

A LENDING PROPOSAL: the **AMOUNT of ECUs** you want to **LEND** and **the INTEREST FACTOR, which is the MINIMUM AMOUNT of ECUs you would want to be paid back next period for each ECU you lend in the current period.**

In a period, the decisions that you and all the other participants in the group make on the amount of ECUs to borrow and/or lend and the interest factors that all participants indicate for their borrowing and lending proposals jointly determine **that period's MARKET INTEREST FACTOR** (as explained in the Appendix).

A period's **MARKET INTEREST FACTOR** is the <u>amount of ECUs every participant will repay next period for every ECU s/he borrows in the current period</u>, as well as <u>the amount of ECUs every participant will be repaid next period for every ECU s/he lends in the current period</u>.

Examples:

- Suppose the market interest factor is 1.05. In this case if you were to borrow 1 ECU this period you would repay 1.05 ECUs next period. Likewise, if you were to lend 1 ECU this period you would be repaid 1.05 ECUs next period.

- Suppose the market interest factor is 0.78. In this case if you were to borrow 1 ECU this period you would repay 0.78 ECUs next period. Likewise, if you were to lend 1 ECU this period you would be repaid 0.78 ECUs next period.

In every period after the first period, you might receive or pay a certain amount of ECUs, because you have to repay what you borrowed in the previous period, and you are repaid what you lent in the previous period. This amount is the **NET REPAYMENT in the current period**, and is equal to:

$$\boldsymbol{NET\ REPAYMENT} =$$

$$= (\boldsymbol{Previous\ LENDING} - \boldsymbol{Previous\ BORROWING}) \times \boldsymbol{Previous\ MARKET\ INTEREST\ FACTOR}$$

<u>where Previous LENDING, Previous BORROWING, and the Previous MARKET INTEREST FACTOR refer to your lending, borrowing and the market interest factor in the previous period</u>.

From this expression you can conclude that:

a) If in the previous period you borrowed fewer ECUs than you lent, or if you only lent but did not borrow, your **NET REPAYMENT** this period will be **positive**.

b) If in the previous period you borrowed more ECUs than you lent, or if you borrowed but did not lend, your **NET REPAYMENT** this period will be **negative**;

c) **NET REPAYMENT** will be equal to **zero** if in the previous period you lent and borrowed the same amount of ECUs, or if you neither lent nor borrowed

Your **ENDOWMENT**, **TAX** and **NET REPAYMENT** determine your **NET INCOME (in ECUS)** in a period as follows:

$$\boldsymbol{NET\ INCOME = ENDOWMENT - TAX + NET\ REPAYMENT}$$

Your **CONSUMPTION** in a period is equal to your net income minus the amount of ECUs you lend plus the amount of ECUs you borrow:

$$\boldsymbol{CONSUMPTION = NET\ INCOME - LENDING + BORROWING}$$

So, your consumption would be larger than your **NET INCOME** if you borrow more than you lend, and vice-versa. If you neither borrow nor lend your consumption will be equal to your **NET INCOME**.

In all periods, except the last period, the lending and borrowing proposals have to satisfy the following conditions:

i) You cannot propose to lend an amount of ECUs larger than your **NET INCOME**.

ii) Your borrowing proposal has to be such that you can repay it in entirety next period. Therefore, the proposal cannot require that you pay back more than an amount of ECUs equal to your ENDOWNMENT minus TAX next period. **This means the interest factor and the borrowing amount (in ECUs) in your borrowing proposal** has to satisfy the following condition:

$$\boldsymbol{INTEREST\ FACTOR \times BORROWING \leq Next\ ENDOWMENT - Next\ TAX}$$

In other words, it follows that the borrowing amount (in ECUs) in your borrowing proposal has to be less than or equal to your (next-period) ENDOWMENT minus (next-period) TAX divided by the interest factor:

$$BORROWING \leq \frac{(Next\ ENDOWMENT - Next\ TAX)}{INTEREST\ FACTOR}$$

Examples:

a) Suppose that next period your ENDOWMENT is 60, and the TAX you will pay is 20, if you propose an interest factor of 1.05, then you cannot propose to borrow more than 38.

b) Suppose that next period your ENDOWMENT is 60, and the TAX you will pay is 20, if you propose an interest factor of 0.78, then you cannot propose to borrow more than 51.

Please note in the last period you cannot either lend or borrow, since there is no next period. In the last period your CONSUMPTION will simply be equal to your NET INCOME that period.

In each period, you will earn a number of **POINTS** calculated by converting your **CONSUMPTION** (in ECUs) in that period, according to the formula below.

$$\boldsymbol{POINTS = 388 \times (1 - EXP\,(-0.024 \times CONSUMPTION))}$$

where EXP is a NUMBER approximately equal to 2.718.

A numerical and graphical representation of the formula are provided in the Table and Graph in the Appendix of the instructions. Please see the Table and Graph now.

It is not necessary to fully understand the formula. What is important to understand, and which you can see from the Table and Graph is that: 1) The larger your **CONSUMPTION** (in ECUS) in a period the larger the number of **POINTS** you earn that period; 2) The NUMBER OF ADDITIONAL POINTS you earn in a period when you increase your consumption by ONE ECU decreases as your CONSUMPTION (in ECUs) that period increases.

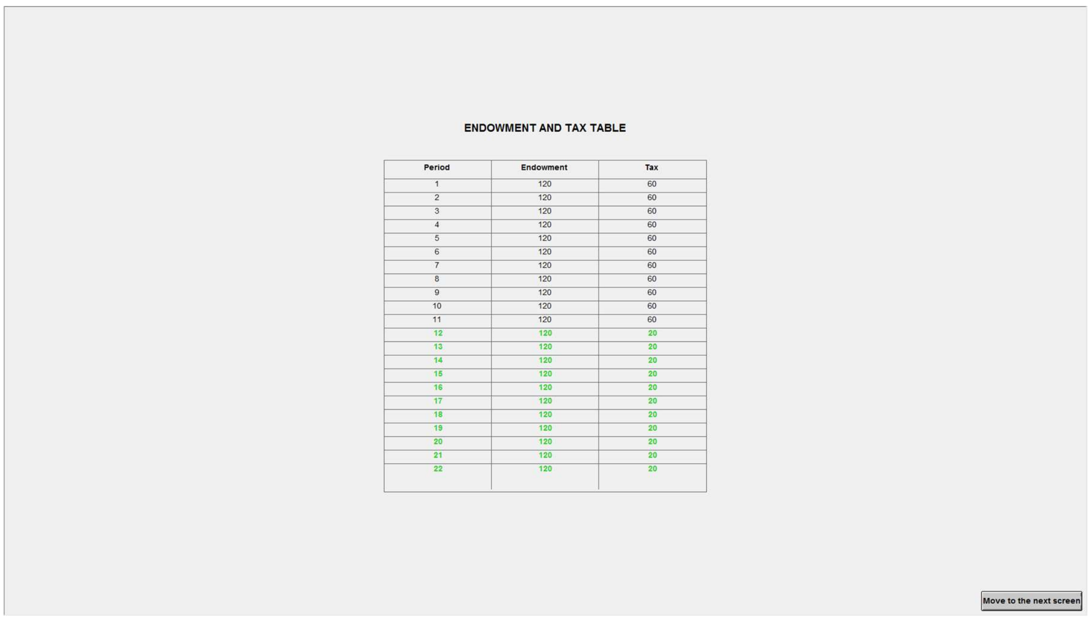
At the end of the experiment **POINTS** will be converted into cash according to the following exchange rate: Each 400 POINTS are worth £1, i.e. every 4 points is worth 1 pence.

THE COMPUTER INTERFACE

We now describe the different screens of the computer interface that you will use to enter your decisions, see the decisions of the other participants, and receive feedback throughout the 22 periods of the experiment.

THE ENDOWMENT AND TAX TABLE SCREEN

At the start of the experiment you will see the **ENDOWMENT AND TAX TABLE**. This screen tells you your endowment and the tax you will pay in each of the periods of the experiment. Every time the tax and/or endowment changes from one period to the next the numbers in the table are displayed in a different color. See the example in the screen below.


ENDOWMENT AND TAX TABLE

Period	Endowment	Tax
1	120	60
2	120	60
3	120	60
4	120	60
5	120	60
6	120	60
7	120	60
8	120	60
9	120	60
10	120	60
11	120	60
12	120	20
13	120	20
14	120	20
15	120	20
16	120	20
17	120	20
18	120	20
19	120	20
20	120	20
21	120	20
22	120	20

THE ACTIVITY SCREEN

At the start of every period you will see the **ACTIVITY SCREEN**, an example of which is below. In this screen you can:

i) See the number of the current period and the time remaining in the current period. **Note that each period has a duration of 105 seconds** (please see the box at the top of the screen; in the example screen below the current period is 1 and the remaining time is 49 secs.);

ii) See your endowment, tax, net repayment received, and your net income at the start of the current period (please see box on the top left side of the screen labeled "Current Period Information");

iii) See the market interest factor, the amount of ECUs you lent, the amount of ECUs you borrowed, and your consumption (in ECUs) in the previous period (please see the second box from the top on the left side of the screen labeled “Previous Period Information”);

iv) See the maximum amount of ECUs you can lend, which is equal to your net income this period, as well your current provisional level of consumption, i.e., the amount of ECUs you will consume given your current borrowing and lending proposals and how the current period’s provisional market outcome determines the amount of ECUs that you borrow and/or lend, which we explain below in detail (please see the third box from the top on the left side of the screen labeled “Further Current Period Information”);

v) Enter your borrowing and lending proposals for the current period and see the list of all the proposals you have entered so far this period (please see box in the middle of the screen labeled “CURRENT PERIOD PROPOSAL BOX”). If you want to enter a borrowing or lending proposal you will first enter the interest factor (a number that can have up to three decimal places, i.e., a number such as 1.005) and the amount of ECUs you want to borrow or lend (which has to be a whole a number). You will next click the red “Borrowing Proposal” or the red “Lending Proposal” button to submit the proposal. In a period, you can always replace the most recent borrowing/lending proposal by entering a new one. You may enter as many borrowing/lending proposals you want in a period. However, among your entered borrowing proposals only the most recent is active. Similarly, among your entered lending proposals only the most recent is active.

Your lending proposal will be permitted if the amount of ECUs you wish to lend is smaller than or equal to the maximum amount of ECUs you can lend (this appears in the “Further current period information” box). Your borrowing proposal will be permitted as long as your income after taxes next period is sufficient to repay it (as explained above).

You can click the calculator icon in order to use a pop-up calculator for any calculations you might find useful. For example, the amount of ECUs you would be repaid next period given the interest factor and the amount of ECUs of your lending proposal, or the amount of ECUs you will have to repay given the interest factor and the amount of ECUs of your borrowing proposal.

In the "CURRENT PERIOD PROPOSAL BOX" you can also find the list of all the borrowing and lending proposals you have made so far in the current period. The proposals are ordered according to the decision time, i.e., how many seconds into the period you submitted them, with the most recent proposal at the top. The most recent borrowing proposal and lending proposal appears in blue (even if you have cancelled it). If you have cancelled a proposal, then it will disappear from the relevant ALL PARTICIPANTS' PROPOSALS list.

vi) In the "CURRENT PERIOD'S PROVISIONAL MARKET OUTCOME" (please see the box on the top right hand side of the screen), see the list of the current period's provisional market interest factor and the market amount borrowed. The market amount (in ECUs) borrowed is the sum of the amounts (in ECUs) borrowed by you and all the other participants. Note that this amount (in ECUs) is also equal to the sum of the amounts (in ECUs) lent by you and the other participants, since any amount of ECUs that is borrowed by one participant has to be lent to him/her by the other participants. The list of the current period's provisional market interest factor and the market amount (in ECUs) borrowed is numbered from the most recent (at the top and highlighted in red) to the earlier ones at the bottom. The most recent market interest factor and the market amount (in ECUs) borrowed/lent determines the amount of ECUs that you lend and/or borrow, as explained below. Every time any of the participants enters a new borrowing and lending proposal the current period's provisional market outcome is updated. Below we explain in more detail how the market interest factor and the market amount (in ECUs) borrowed/lent are determined.

A detailed and extended explanation on how to find the CURRENT PERIOD'S PROVISIONAL MARKET OUTCOME is provided in the print out named Appendix that is on your desk. Nevertheless, here is a brief explanation on how it is found: all participants' active borrowing and lending proposals are taken together and the computer software searches for the particular interest factor (X) such that the sum of the amounts of the borrowing proposals with interest factors greater than or equal to this particular interest factor (X) is equal to the sum of the amounts of the lending proposals with interest factors smaller than or equal to this particular interest factor. We call this particular interest factor (X), the **Market Interest Factor**, at which all borrowing and lending outcomes in the market take place.

In some cases, there is no **Market Interest Factor (and thus there is no borrowing or lending)**, in other cases several values work as the **Market Interest Factor (the average of those vales is chosen as the Market Interest Factor)**, while in other cases **no value works as the Market Interest Factor to fulfil *all* borrowing proposals with equal or smaller interest factors and *all* lending proposals with equal or larger interest factors** (in this case the borrowing and lending proposals that specify the same interest factors will be fulfilled, partially fulfilled or be unfulfilled **according to a time priority rule: proposals submitted earlier will be fulfilled before proposals that were submitted later.**

vii) See the list of the borrowing proposals currently submitted to the market by all the participants (please see the box on the bottom left hand side of the screen labeled "PARTICIPANTS' BORROWING PROPOSALS"). The borrowing proposals are ordered according to the interest factor with the largest at the top and the smallest at the bottom. Your most recent borrowing proposal is highlighted in blue. In case you want to cancel your borrowing proposal you first click on it and next click the "Cancel your Borrowing Proposal" button, which appears below the list.

The status of a borrowing proposal is displayed in the "Provisional outcome" column: It appears as fulfilled if in the provisional market outcome, the participant will borrow the amount of ECUs she wishes (in which case the number in the "Provisional amount" column equals the number in the "Amount" column); It appears as part-fulfilled if in the provisional market outcome, the participant will borrow an amount of ECUs smaller (but larger than zero) than the amount of ECUs she wishes (in which case the number in the "Provisional amount" column is smaller than the number in the "Amount" column); Finally, it appears as unfulfilled if in the provisional market outcome, the participant will not borrow anything.

viii) See the list of the lending proposals currently submitted to the market by all the participants (please see the box on the bottom right hand side of the screen labeled "PARTICIPANTS' LENDING PROPOSALS"). The lending proposals are ordered according to the interest factor with the smallest at the top and the largest at the bottom. Your most recent lending proposal is highlighted in blue. In case you want to cancel your lending proposal you first click on it and next click the “Cancel your Lending Proposal” button, which appears below the list.

The status of a lending proposal is displayed in the “Provisional outcome” column: The interpretation of fulfilled, part-fulfilled and unfulfilled is the same as in the borrowing proposals explained above in (vi).

ix) Calculate how many points consumption of a certain amount of ECUs will earn you in the current period. By entering an amount of ECUs in front of the box “Consumption”, followed by clicking the “calculate” button at the bottom left hand side of the screen, will show you the points you earn.

x) Vote to end the current period, by ticking the box in front of “Vote to end current period”, followed by clicking the red “Vote” button at the bottom right hand side of the screen. If all the participants vote to end the current period, the period will end before its default duration, i.e., 120 seconds. However, the period cannot end during the first 90 seconds, even if all participants have voted to end the period. If a period ends before its default duration, i.e., 120 seconds, at the moment of ending, the current period’s provisional outcome becomes final.

When the current period ends you have 10 seconds to review the activity screen. However, no participant can submit or cancel a proposal. You can still use the calculator to learn how many points you will earn from the ECUs you CONSUMED in the current period.

Please note that you will not see an activity screen for the last period. In the last period your CONSUMPTION will simply be equal to your NET INCOME, as explained above.

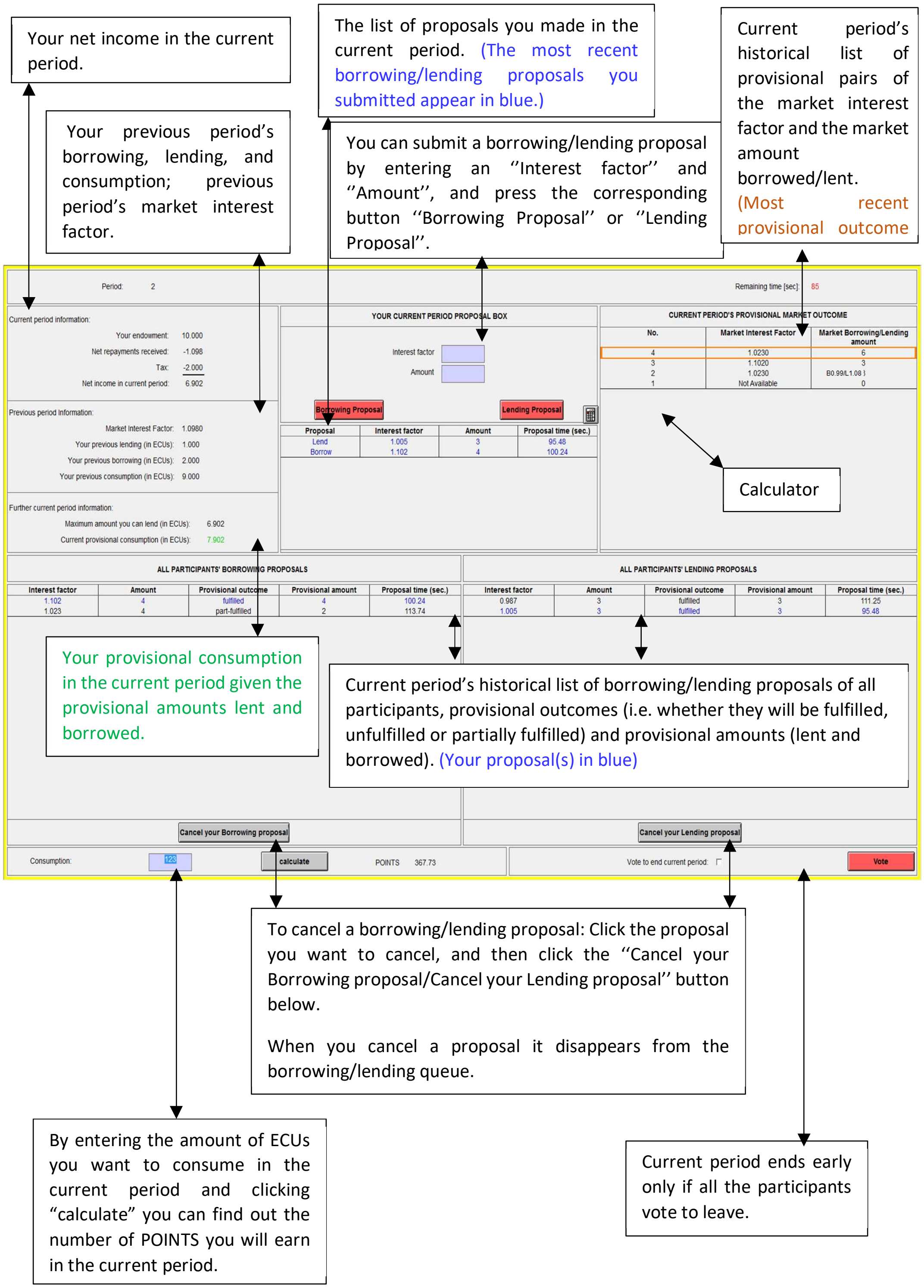

Your net income in the current period.
Your previous period's borrowing, lending, and consumption; previous period's market interest factor.
The list of proposals you made in the current period. (The most recent borrowing/lending proposals you submitted appear in blue.)
You can submit a borrowing/lending proposal by entering an ''Interest factor'' and ''Amount'', and press the corresponding button ''Borrowing Proposal'' or ''Lending Proposal''.
Current period's historical list of provisional pairs of the market interest factor and the market amount borrowed/lent. (Most recent provisional outcome
Period: 2
Remaining time [sec]: 85
Current period information:
Your endowment: 10.000
Net repayments received: -1.098
Tax: -2.000
Net income in current period: 6.902
YOUR CURRENT PERIOD PROPOSAL BOX
Interest factor
Amount
Borrowing Proposal
Lending Proposal
CURRENT PERIOD'S PROVISIONAL MARKET OUTCOME
No.
Market Interest Factor
Market Borrowing/Lending amount
Previous period Information:
Market Interest Factor: 1.0980
Your previous lending (in ECUs): 1.000
Your previous borrowing (in ECUs): 2.000
Your previous consumption (in ECUs): 9.000
Proposal
Interest factor
Amount
Proposal time (sec.)
Calculator
Further current period information:
Maximum amount you can lend (in ECUs): 6.902
Current provisional consumption (in ECUs): 7.902
ALL PARTICIPANTS' BORROWING PROPOSALS
ALL PARTICIPANTS' LENDING PROPOSALS
Interest factor
Amount
Provisional outcome
Provisional amount
Proposal time (sec.)
Your provisional consumption in the current period given the provisional amounts lent and borrowed.
Current period's historical list of borrowing/lending proposals of all participants, provisional outcomes (i.e. whether they will be fulfilled, unfulfilled or partially fulfilled) and provisional amounts (lent and borrowed). (Your proposal(s) in blue)
Cancel your Borrowing proposal
Cancel your Lending proposal
Consumption:
calculate
POINTS 367.73
Vote to end current period:
Vote
To cancel a borrowing/lending proposal: Click the proposal you want to cancel, and then click the ''Cancel your Borrowing proposal/Cancel your Lending proposal'' button below.
When you cancel a proposal it disappears from the borrowing/lending queue.
By entering the amount of ECUs you want to consume in the current period and clicking "calculate" you can find out the number of POINTS you will earn in the current period.
Current period ends early only if all the participants vote to leave.

Figure 1

THE FEEDBACK SCREEN

In each period after the activity screen you will see the feedback screen (an example of which appears in Figure 2) for 25 seconds. A countdown clock is displayed at the top right hand side of the screen.

The left hand side of this screen displays from top to bottom, your endowment, tax, and the market interest factor for the current period; your borrowing/lending outcome (the amount of ECUs you lent, the amount of ECUs you will be repaid next period, the amount of ECUs you borrowed, the amount of ECUs you will repay next period), your consumption (in ECUs) and the POINTS you earned in the period just ended, and your cumulative POINTS (i.e. the POINTS you have earned up to and including the period just ended).

The top part of the right hand side of the screen displays your consumption and net repayment for all the periods up to the period just ended.

The bottom part of the right hand side of the screen displays the endowment and tax table for the remaining periods.

When the 25 seconds end, you move to the next period automatically, and you will see the new period's activity screen (like the one in Figure 1).

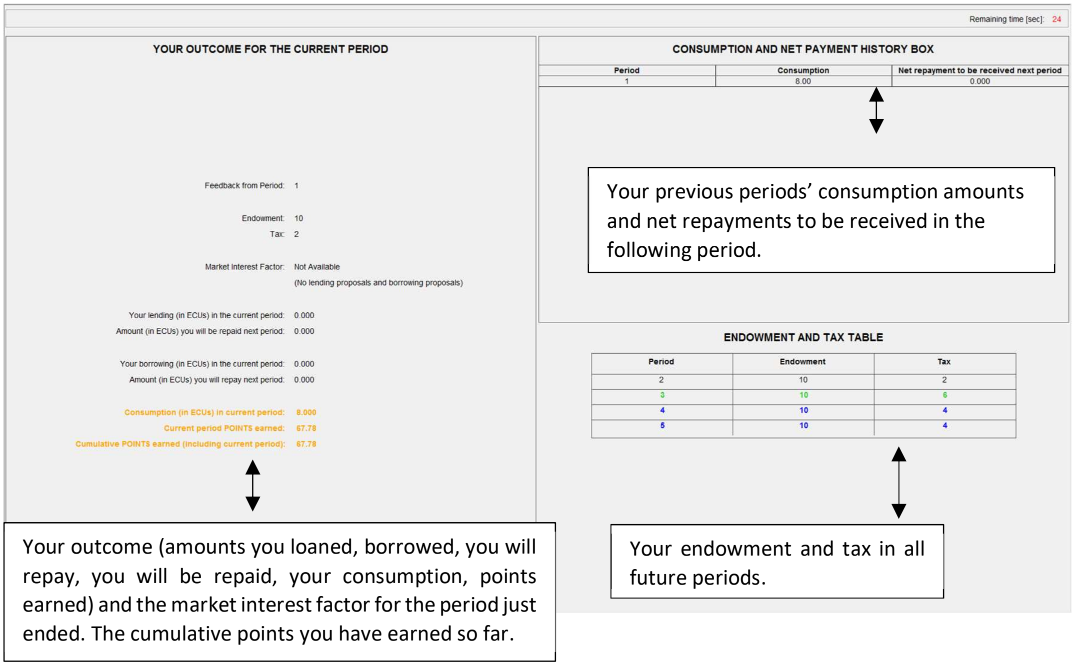


Figure 2

APPENDIX: FINDING THE CURRENT PERIOD'S PROVISIONAL MARKET OUTCOME

We now explain in more detail how the CURRENT PERIOD'S PROVISIONAL MARKET OUTCOME is determined, i.e., how the **market interest factor** and the **market amount borrowed/lent** are determined.

After any participant submits a new proposal or cancels an existing proposal, a new provisional outcome is determined, as follows:

A) All participants' active borrowing proposals (which appear in the "ALL PARTICIPANTS' BORROWING PROPOSALS" box) are ordered according to the interest factor, with the largest number at the top and the smallest number at the bottom.

B) All participants' active lending proposals (which appear in the "ALL PARTICIPANTS' LENDING PROPOSALS" box) are ordered according to the interest factor, with the smallest number at the top and the largest number at the bottom.

C) The computer searches for the particular interest factor (X) such that the sum of the amounts of the borrowing proposals with interest factors greater than or equal to this particular interest factor (X) is equal to the sum of the amounts of the lending proposals with interest factors smaller than or equal to this particular interest factor (X). We call this particular interest factor (X), the **Market Interest Factor**, at which all borrowing and lending outcomes in the market take place. Below we provide some concrete examples.

If the Market Interest Factor is below your borrowing proposal interest factor, then your order will be fulfilled at the Market Interest Factor. If the Market Interest Factor is above your lending proposal interest factor, then your order will be fulfilled at the Market Interest Factor.

(It is also possible that several values work as the Market Interest Factor. In that case, the Market Interest Factor is defined as the average of the largest and smallest of these values. Example 3 below illustrates this possibility.)

Note that if the interest factors of all the borrowing proposals are smaller than all the interest factors of all the lending proposals, then there does not exist a market interest factor. In this instance, the "Market Interest Factor Column" will display two interest factors side by side: the largest of the interest factors among all the borrowing proposals preceded by the letter B; the smallest of the interest factors among all the lending proposals preceded by the letter L. For example, B0.99/L1.08 as in the activity screen above.

It is also possible that no value works as the Market Interest Factor to fulfil *all* borrowing proposals with equal or smaller interest factors and *all* lending proposals with equal or larger interest factors, but that there are borrowing proposals with interest factors larger than the interest factors of some lending proposals. In this case, we define a Market Interest Factor at which some orders are *partially* fulfilled. Specifically, the Market Interest Factor is defined as the particular value (Y) such that the difference between the sum of the amounts of the borrowing proposals with interest factors greater than or equal to this particular value (Y) and the sum of the amounts of the lending proposals with interest factors smaller than or equal to this particular value (Y) is as small as possible. In this case some proposals will be fulfilled, while others will be part-fulfilled. Example 4 below illustrates this possibility.

D) Borrowing proposals with an interest factor greater than the market interest factor are fulfilled; Lending proposals with an interest factor smaller than the market interest factor are fulfilled; Borrowing proposals with an interest factor smaller than the market interest factor are unfulfilled; Lending proposals with an interest factor greater than the market interest factor are unfulfilled; Borrowing and lending proposals with an interest factor equal to the market interest factor are either fulfilled or part-fulfilled, as explained in the examples below.

The provisional market outcome at the end of the period becomes the actual outcome of that period, which determines your outcome (mainly your borrowing and lending and your consumption) in that period.

EXAMPLES: Determining the Market Interest Factor and Market Amount Borrowed/Lent:

Example 1: Illustration when **the Market Interest Factor** does not exist. Suppose the borrowing and lending proposals are as follows:

Borrowing proposals	Lending proposals
Interest factor: 1.09; Amount: 12	Interest factor: 1.11; Amount: 20
Interest factor: 0.69; Amount: 8	Interest factor: 1.51; Amount: 12

In this example, there is no Market Interest Factor (which we called X) because the interest factor of the borrowing proposal with the largest interest factor is smaller than the interest factor of the lending proposal with the lowest interest factor. All proposals are unfulfilled.

Example 2: Illustration of **Fulfilled** and **Unfulfilled** proposals. Suppose the borrowing and lending proposals are as follows:

Borrowing proposals	Lending proposals
Interest factor: 1.29; Amount: 12	Interest factor: 1.17; Amount: 20
Interest factor: 1.17; Amount: 8	Interest factor: 1.31; Amount: 12
Interest factor: 1.01; Amount: 10	Interest factor: 1.44; Amount: 8
Interest factor: 0.87; Amount: 20	Interest factor: 1.55; Amount: 22

In this example, 1.17 is the Market Interest Factor (which we called X). In particular, for X=1.17, the sum of the amounts of the borrowing proposals with interest factors greater than or equal to 1.17 (the borrowing proposal of 12 in the first row plus the borrowing proposal of 8 in the second row) is equal to the sum of the amounts of the lending proposals with interest factors smaller than or equal to 1.17 (the lending proposal of 20 in the first row). These proposals are fulfilled. The other proposals are left unfulfilled.

The participant who submitted the borrowing proposal in the first row will repay 12x1.17=14.04 next period. The participant who submitted the borrowing proposal in the second row will repay 8x1.17=9.36 next period. The participant who submitted the lending proposal in the first row will be repaid 20x1.17=23.40 next period.

Example 3: Illustration of the **Market Interest Factor** when several values work as the Market Interest Factor. Suppose the borrowing and lending proposals are as follows:

Borrowing proposals	Lending proposals
Interest factor: 1.19; Amount: 12	Interest factor: 0.80; Amount: 20
Interest factor: 0.99; Amount: 18	Interest factor: 0.95; Amount: 10
Interest factor: 0.85; Amount: 10	Interest factor: 1.08; Amount: 8
Interest factor: 0.60; Amount: 20	Interest factor: 1.23; Amount: 22

In this example, any number from 0.95 to 0.99 may qualify as the Market Interest Factor (which we called X). In particular, for X from 0.95 to 0.99, the sum of the amounts of the borrowing proposals with interest factors greater than or equal to X (the borrowing proposal of 12 in the first row plus the borrowing proposal of 18 in the second row) is equal to the sum of the amounts of the lending proposals with interest factors smaller than or equal to X (the lending proposal of 20 in the first row plus the lending proposal of 10 in the second row). In this case, we select the average of 0.95 and 0.99, i.e. 0.97 as the Market Interest Factor. The lending and borrowing proposals in the first and second rows are fulfilled. The remaining borrowing and lending proposals will be unfulfilled.

The participant who submitted the borrowing proposal in the first row will repay 12x0.97=11.64 next period. The participant who submitted the borrowing proposal in the second row will repay 18x0.97=17.46 next period. The participant who submitted the lending proposal in the first row will be repaid 20x0.97=19.40 next period. The participant who submitted the lending proposal in the second row will be repaid 10x0.97=9.70 next period.

Example 4: Illustration of **Part-fulfilled** proposals. Suppose the borrowing and lending proposals are as follows:

Borrowing proposals	Lending proposals
Interest factor: 1.02; Amount: 12	Interest factor: 1.00; Amount: 20
Interest factor: 1.00; Amount: 10	Interest factor: 1.01; Amount: 12
Interest factor: 0.98; Amount: 10	Interest factor: 1.02; Amount: 8
Interest factor: 0.96; Amount: 20	Interest factor: 1.03; Amount: 22

In this example, 1.00 is the Market Interest Factor (which we called X). In particular, X=1.00, makes the difference between the sum of the amounts of the borrowing proposals with interest factors greater than or equal to X (for X=1.00 this sum is equal to 22, 12 plus 10 from the borrowing proposals in the first and second rows, respectively) and the sum of the amounts of the lending proposals with interest factors smaller than or equal to X (for X=1.00 this sum is equal to 20 from the lending proposal in the first row) as small as possible (for X=1.00, this difference is 22-20=2), (You can check that any value different from X=1.00 leads to a larger difference than 2). In this case, the lending and borrowing proposals in the first row are fulfilled. However, the borrowing proposal in the second row is part-fulfilled, because the amount of the lending proposal in the first row that remains after fulfilling the borrowing proposal in the first row, (i.e., 8 = 20 - 12) is smaller than the amount of the borrowing proposal in the second row (i.e. 10). All the other borrowing proposals and lending proposals will be unfulfilled.

The participant who submitted the borrowing proposal in the first row will repay 12x1.00=12 next period. The participant who submitted the borrowing proposal in the second row will repay 8x1.00=8 next period. The participant who submitted the lending proposal in the first row will be repaid 20x1.00=20 next period.

Note: When the interest factor of different borrowing proposals or of different lending proposals is the same, the proposals entered first will be fulfilled. This might result in some proposals with the same interest factor being fulfilled, while others are part-fulfilled or unfulfilled.

Please be sure you understand all above. Raise your hand if you would like further explanation. Otherwise, if you feel that you understand with how to play the experiment, please wait until the other participants have finished reading these instructions. After everyone in the room has read the instructions, we will proceed to the understanding test, in which you will be asked several questions about some decision situation. These decision situations will be different from the one described above.

Consumption	POINTS	Additional POINTS
0	0.00	
1	9.20	9.20
2	18.18	8.98
3	26.95	8.77
4	35.52	8.56
5	43.87	8.36
6	52.04	8.16
7	60.00	7.97
8	67.78	7.78
9	75.37	7.59
10	82.79	7.41
11	90.03	7.24
12	97.09	7.07
13	103.99	6.90
14	110.73	6.74
15	117.30	6.58
16	123.72	6.42
17	129.99	6.27
18	136.11	6.12
19	142.08	5.97
20	147.91	5.83
21	153.61	5.69
22	159.16	5.56
23	164.59	5.43
24	169.89	5.30
25	175.06	5.17
26	180.11	5.05
27	185.04	4.93
28	189.85	4.81
29	194.55	4.70
30	199.14	4.59
31	203.62	4.48
32	207.99	4.37
33	212.26	4.27
34	216.43	4.17
35	220.50	4.07

Consumption	POINTS	Additional POINTS
36	224.47	3.97
37	228.35	3.88
38	232.13	3.79
39	235.83	3.70
40	239.44	3.61
41	242.96	3.52
42	246.40	3.44
43	249.76	3.36
44	253.04	3.28
45	256.24	3.20
46	259.36	3.12
47	262.41	3.05
48	265.39	2.98
49	268.30	2.91
50	271.14	2.84
51	273.91	2.77
52	276.61	2.71
53	279.26	2.64
54	281.83	2.58
55	284.35	2.52
56	286.81	2.46
57	289.21	2.40
58	291.55	2.34
59	293.84	2.29
60	296.07	2.23
61	298.25	2.18
62	300.38	2.13
63	302.46	2.08
64	304.49	2.03
65	306.47	1.98
66	308.40	1.93
67	310.29	1.89
68	312.13	1.84
69	313.93	1.80
70	315.69	1.76

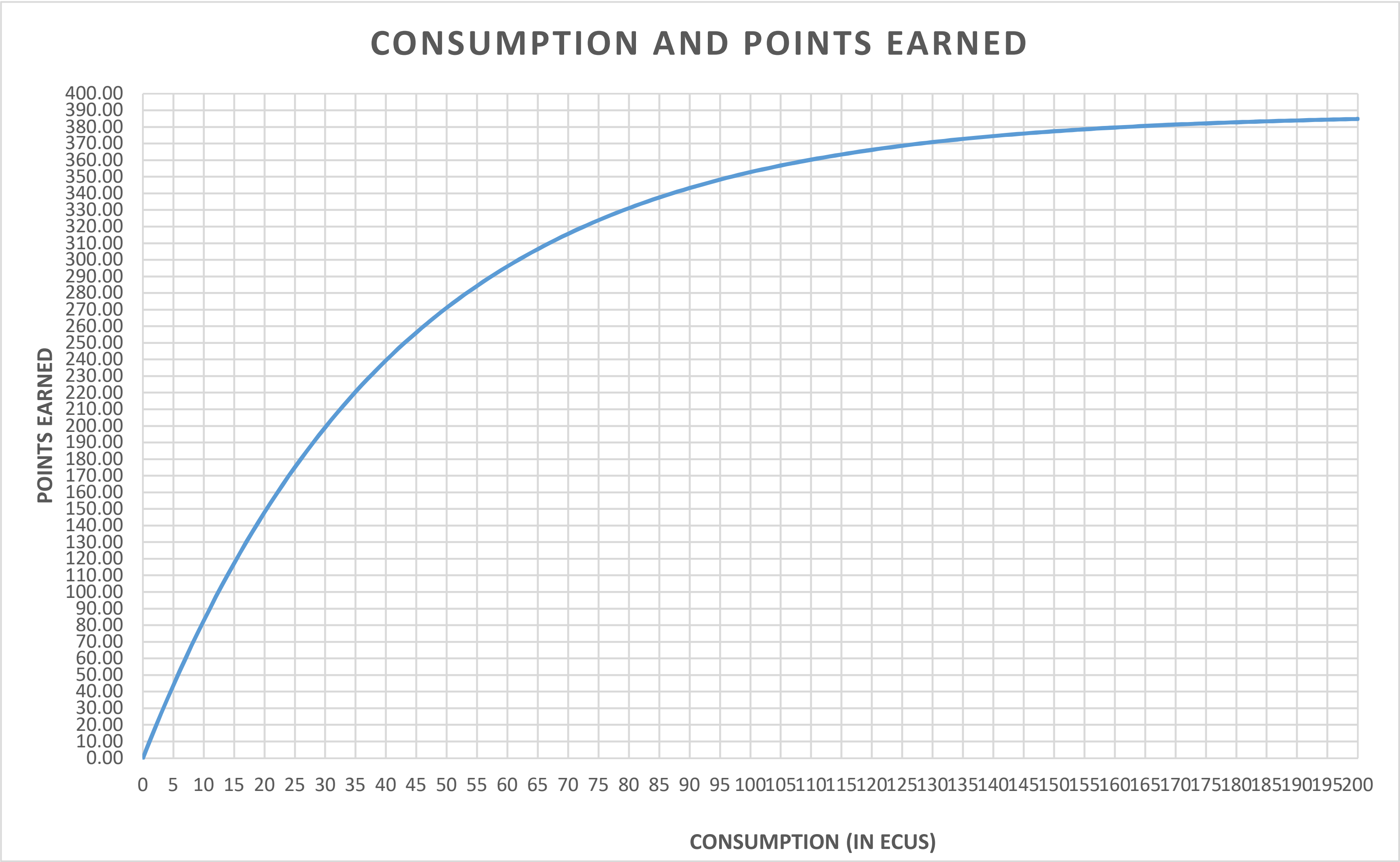
Consumption	POINTS	Additional POINTS
71	317.40	1.71
72	319.08	1.67
73	320.71	1.63
74	322.31	1.60
75	323.86	1.56
76	325.38	1.52
77	326.87	1.48
78	328.32	1.45
79	329.73	1.42
80	331.12	1.38
81	332.47	1.35
82	333.78	1.32
83	335.07	1.29
84	336.32	1.26
85	337.55	1.23
86	338.75	1.20
87	339.91	1.17
88	341.05	1.14
89	342.17	1.11
90	343.25	1.09
91	344.31	1.06
92	345.35	1.04
93	346.36	1.01
94	347.35	0.99
95	348.31	0.96
96	349.25	0.94
97	350.17	0.92
98	351.07	0.90
99	351.95	0.88
100	352.80	0.85
101	353.64	0.83
102	354.45	0.81
103	355.25	0.80
104	356.02	0.78
105	356.78	0.76

Consumption	POINTS	Additional POINTS
106	357.52	0.74
107	358.24	0.72
108	358.95	0.71
109	359.64	0.69
110	360.31	0.67
111	360.97	0.66
112	361.61	0.64
113	362.24	0.63
114	362.85	0.61
115	363.44	0.60
116	364.03	0.58
117	364.59	0.57
118	365.15	0.56
119	365.69	0.54
120	366.22	0.53
121	366.74	0.52
122	367.24	0.50
123	367.73	0.49
124	368.21	0.48
125	368.68	0.47
126	369.14	0.46
127	369.59	0.45
128	370.02	0.44
129	370.45	0.43
130	370.87	0.42
131	371.27	0.41
132	371.67	0.40
133	372.06	0.39
134	372.44	0.38
135	372.80	0.37
136	373.16	0.36
137	373.52	0.35
138	373.86	0.34
139	374.20	0.34
140	374.52	0.33

Consumption	POINTS	Additional POINTS
141	374.84	0.32
142	375.15	0.31
143	375.46	0.30
144	375.76	0.30
145	376.05	0.29
146	376.33	0.28
147	376.61	0.28
148	376.88	0.27
149	377.14	0.26
150	377.40	0.26
151	377.65	0.25
152	377.90	0.25
153	378.13	0.24
154	378.37	0.23
155	378.60	0.23
156	378.82	0.22
157	379.04	0.22
158	379.25	0.21
159	379.46	0.21
160	379.66	0.20
161	379.86	0.20
162	380.05	0.19
163	380.24	0.19
164	380.42	0.18
165	380.60	0.18
166	380.78	0.18
167	380.95	0.17
168	381.12	0.17
169	381.28	0.16
170	381.44	0.16
171	381.60	0.16
172	381.75	0.15
173	381.90	0.15
174	382.04	0.14
175	382.18	0.14

Consumption	POINTS	Additional POINTS
176	382.32	0.14
177	382.45	0.13
178	382.59	0.13
179	382.71	0.13
180	382.84	0.13
181	382.96	0.12
182	383.08	0.12
183	383.20	0.12
184	383.31	0.11
185	383.42	0.11
186	383.53	0.11
187	383.64	0.11
188	383.74	0.10
189	383.84	0.10
190	383.94	0.10
191	384.04	0.10
192	384.13	0.09
193	384.22	0.09
194	384.31	0.09
195	384.40	0.09
196	384.49	0.09
197	384.57	0.08
198	384.65	0.08
199	384.73	0.08
200	384.81	0.08
201	384.88	0.08
202	384.96	0.07
203	385.03	0.07
204	385.10	0.07
205	385.17	0.07
206	385.24	0.07
207	385.30	0.07
208	385.36	0.06
209	385.43	0.06
210	385.49	0.06

Notes: i) The more ECUs you CONSUME in a period the more POINTS you earn that period (see middle column); ii) The number of ADDITIONAL POINTS that you earn in a period when you increase the ECUs CONSUMED by ONE ECU decreases as the amount of ECUs you CONSUME that period increases (see right column).



CONSUMPTION AND POINTS EARNED
POINTS EARNED
CONSUMPTION (IN ECUS)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00
190.00
200.00
210.00
220.00
230.00
240.00
250.00
260.00
270.00
280.00
290.00
300.00
310.00
320.00
330.00
340.00
350.00
360.00
370.00
380.00
390.00
400.00
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200