Strategic Thinking Skills: A Key to Collective Economic Success*

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Abstract

We conduct a large-scale experiment to measure elementary aspects of strategic thinking skills and their linkage to labor market outcomes. Two incentivized measures of higher-order rationality and backward induction are developed. Males' (females') strategic thinking skills are positively (negatively) associated with *individual* labor income. However, among married individuals, strategic thinking skills are significantly and positively associated with their *household* labor income regardless of gender, highlighting the importance of strategic thinking skills for collective economic success. We argue that the intrahousehold channels encompassing collective labor supply with home-to-workplace spillover and marriage assortative matching offer the most plausible explanation for our findings.

Keywords: Strategic Thinking Skills, Higher-Order Rationality, Backward Induction, Labor Income, Collective Labor Supply Model, Online Experiments

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1 Introduction

Humans, as social creatures, engage in numerous interpersonal interactions throughout their lives. The ability to understand motivations, anticipate the behavior of other people, and respond to others is essential to social relationships and economic success. People with higher strategic thinking skills may maintain better interpersonal relations and secure higher economic returns.

In this paper, we argue that strategic thinking is a multi-dimensional skill of significant economic importance, distinct from the traditional collection of cognitive and noncognitive skills. To measure skills of strategic thinking and support our claim, we resort to the experimental methods of detecting the depth of strategic reasoning in situations of simultaneous and sequential interaction. We conduct a large-scale experiment and investigate whether these measures of strategic thinking skills are associated with labor market outcomes.

The canonical approach to understanding interpersonal interaction is based on the concept of Nash equilibrium, which requires no limit in human abilities of strategic reasoning (Aumann and Brandenburger, 1995; Polak, 1999). While the standard equilibrium approach offers a powerful tool for analyzing strategic interactions, it overlooks the possibility that individuals differ in their capability of strategic reasoning, particularly when there is no opportunity to learn from repeated play. In contrast, the experimental economics literature has documented that human reasoning in interpersonal interactions in laboratories and fields is far below the level of sophistication assumed by the standard theory and exhibits a large degree of individual heterogeneity (e.g., Nagel, 1995; Camerer et al., 2004; Crawford et al., 2013).

We consider two elementary aspects of strategic reasoning in interpersonal interaction: (*i*) engaging in introspective reasoning in situations of simultaneous interaction, and (*ii*) exercising anticipatory reasoning or backward induction in situations of sequential interaction. These elements are essential and mutually distinct in the game-theoretic analysis of strategic interaction: the former relates to higher-order rationality or rationalizability (Bernheim, 1984; Pearce, 1984), while the latter is key to sequential rationality serving as a refinement of the Nash equilibrium (Selten, 1965).[1] Although our two measures are

[1] The existing studies (e.g., Nagel, 1995; Crawford et al., 2013; Kneeland, 2015) have focused on identifying individuals' strategic sophistication using a simultaneous-move game. Little attention has been paid to identifying individuals' strategic thinking levels in an environment with sequential moves. Binmore et al.

unlikely to capture the entire spectrum of strategic thinking skills, our attempt is still meaningful as the first step to investigate the relationship between individuals' strategic thinking skills and economic outcomes.

To measure higher-order rationality (HOR), we develop a five-person line-network game, motivated by Kneeland (2015). A series of two-person normal-form games are connected by a network structure of opponents. Participants make a request for money (Arad and Rubinstein, 2012) in each of the five different positions in a random order without any feedback. The choice data from the line-network structure of the opponent enable us to measure different levels of HOR reasoning. Our second measure is developed based on a series of two-player sequential-move games that require different steps of backward-induction (BI) reasoning (Dufwenberg et al., 2010; Gneezy et al., 2010). Each game has a first-mover advantage. Human participants always move first and play against a computer player, programmed to play an optimal strategy. This design allows us to measure BI reasoning at the individual level.[2]

To implement these measures, we recruited participants from the Singapore Life Panel (SLP), a nationally representative sample of people 50–70 years old in Singapore. The final sample consists of 2,146 Singaporeans whose age ranges between 50 and 65. We take advantage of detailed information on their socioeconomic characteristics as well as a rich set of cognitive and noncognitive skill measures available in the large-scale panel data. To

(2002) and Dufwenberg and Van Essen (2018) report experimental evidence that individuals fail to play according to the logic of backward induction. However, neither study is interested in identifying individual-level heterogeneity. In a centipede-game experiment, Palacios-Huerta and Volij (2009) find that the equilibrium play occurred significantly more often when subjects were expert chess players. García-Pola et al. (2020) also use a set of centipede games to identify the nonequilibrium model that explains the observed behavior in the lab.

[2]As noted by Alaoui and Penta (2016) and Jin (2021), an individual's depth of reasoning may depend not only on their ability to conduct rounds of introspection (in the case of our HOR measure) or backward induction (in the case of our BI measure) but also on their beliefs about their opponents. While our goal is not to separately identify these two aspects of strategic sophistication nor claim that our measures can distinguish between them, we address this concern in two different ways. Firstly, for our HOR measure, we define "HOR orders" to capture the number of rounds of best-response an individual can conduct against a fully rational opponent, and "HOR scores" as the average expected payoff against the empirical distribution of the opponent's choices, reflecting how well an individual plays against the real, but not fully rational, population. The second measure accounts for the accuracy of an individual's belief about the opponent's play, while the first measure is belief-free. We demonstrate the robustness of our results to these various definitions of the HOR measure. Secondly, for our BI measure, our experimental design involves human participants playing against a computer player programmed to use an optimal strategy on every path, leaving no room for beliefs about the opponent's strategic thinking skills to influence choices. Section 6.1 presents these alternative measures of strategic thinking skills and discusses the robustness of our main findings.

demonstrate the robustness of the descriptive statistics of our strategic thinking measures to a younger population, we also recruited 786 participants from the Korean Labor and Income Panel Study (KLIPS), a nationally representative sample of urban households and individuals in South Korea.

We view our measures of strategic reasoning as capturing fundamental aspects that all types of real-world strategic interaction commonly share. Those with higher capabilities in exercising strategic reasoning are more likely to better serve their social and economic interests over their life span. To examine this conjecture, we estimate the relationship between strategic thinking skills and labor market outcomes at the individual and household levels. In particular, we examine the associations separately by gender following the literature documenting gender differences in labor supply decisions within the couple (e.g. Altonji and Blank, 1999; Kuziemko et al., 2018).

We find strong gender-dependent associations between individuals' labor income and their strategic thinking skills. Male labor income is *positively* associated with strategic thinking skills. These associations are robust to conditioning on a conventional set of cognitive and noncognitive skills as well as sociodemographic characteristics: a one-level increase in the BI score and a one-standard-deviation (SD) increase in the HOR score are significantly associated with 37 percent and 58 percent *increases* in own labor income, respectively. Regarding female labor income, we find the opposite pattern; female respondents' BI score is *negatively* associated with their individual labor income. This result is robust to conditioning on cognitive and noncognitive skills as well as sociodemographic characteristics: a one-level increase in female respondents' BI score is significantly associated with a 47 percent *decrease* in their labor income.

To gain a deeper understanding of the gender-dependent association between individual labor income and strategic thinking skills, we investigate the *extensive margin of individual labor supply* (i.e., whether one earns positive labor income). We find strong gender-dependent associations between labor supply and strategic thinking skills. Male respondents with higher HOR and BI scores are significantly more likely to work and less likely to be retired or unemployed. In contrast, female respondents with higher BI scores are less likely to work and, in the composition of labor status, more likely to be a homemaker and thus out of the labor force. The observed gender-dependent patterns suggest that strategic thinking skills are associated not only with individual decision making of labor supply but also with intrahousehold interactions. In fact, there is a strong positive linkage between female participants' skills of strategic thinking and their spouses' labor income, suggesting that a variety of intrahousehold interactions, including partner matching, intrahousehold labor supply decision making, and spillover/crossover between home and work, can play a role.

We then explore how *household labor income for married respondents* is associated with their individual strategic thinking skills. We find *gender-independent positive* associations: a one-SD increase in the HOR score is associated with an approximately 35 percent increase for both males and females. Restricting attention to the non-working female married sample, we find that a one-level increase in the BI score and a one-SD increase in the HOR score are significantly associated with 87 percent increase and 63 percent increase in female household labor income, respectively. These gender-independent positive associations with household labor income for married respondents suggest the potential role of strategic thinking skills in collective economic success at the household level.

How can we reconcile the observed household-level, gender-independent, and individual-level, gender-dependent associations between strategic thinking skills and labor market outcomes? To answer this question, we consider several plausible channels. First, we consider the *labor market channels* through which individuals with higher strategic thinking skills contribute better to team production in the workplace (*workplace channel*) or are sorted into professions and industries with higher demand for these skills (*occupation-choice channel*). While the workplace channel can explain the positive association for males' individual labor income, it is difficult to rationalize the opposite pattern found for females' individual labor income, gender-dependent associations for the extensive margin labor supply, and gender-independent associations for household labor income. Regarding the occupation-choice channel, we conduct a regression analysis on whether respondents' occupation choices are associated with strategic thinking skills and find little evidence supporting this explanation.

Given the challenges in rationalizing the empirical findings solely through labor market channels, we direct our focus towards the *intrahousehold interaction channels*. Two plausible channels emerge: 1) collective labor supply with home-to-workplace spillover and 2) assortative matching on strategic thinking skills in marriage. The first channel suggests that when the allocation of household and workplace production tasks between married individuals occurs based on their comparative advantage or gender norms, strategic thinking skills can facilitate coordination and enhance the spillover effect from home to the workplace (e.g., Apps and Rees, 1997; Chiappori, 1997; Benham, 1974; Barnett, 1994). The second channel proposes that individuals tend to marry partners with similar strategic thinking skills.

We contend that these two intrahousehold interaction channels complement each other in explaining our data. While the former channel accounts for the essential empirical patterns of gender-dependent associations with individual labor income and gender-independent associations with household labor income, it does not address the positive correlation of strategic thinking skills between married individuals found in our data. Conversely, the latter channel can explain the positive correlation of strategic thinking skills between spouses and certain patterns of the associations between strategic thinking skills and labor income. However, this channel alone cannot explain why certain couples specialize in household production and workplace production, nor why individual income resulting from this specialization exhibits gender-dependent correlations with strategic thinking skills. Only by combining these two channels can we adequately account for the key empirical findings observed in this study.

One potential concern in the empirical analysis pertains to the measurement errors in eliciting strategic thinking skills and the absence of corrections for any noise in these elicitation methods when establishing the relationship between strategic thinking skills and labor outcomes. To address this concern, we adopt the method of obviously related instrumental variables (ORIV) proposed by Gillen et al. (2019). It is important to note that, in implementing the ORIV approach, we make a compromise by assuming that the BI and HOR measures capture the same underlying trait with errors, departing from our key assumption that strategic thinking is a multi-dimensional construct and our HOR and BI measures capture two distinct facets of strategic thinking skills. Nevertheless, our analysis reveals that the ORIV method generates estimation results consistent with the gender-dependent associations with individual labor income and the gender-independent associations with household labor income. Hence, we argue that our primary findings are unlikely to be compromised by concerns regarding measurement errors.

The existence of a gender gap in labor market outcomes is a well-documented phenomenon, not limited to our dataset, and extensively studied in the literature (Goldin, 1990; International Labour Organisation (ILO), 2018). Various factors, including cultural norms, have been identified as contributors to this observed gender gap (e.g., Attanasio et al., 2008; Albanesi and Olivetti, 2016; Fortin, 2005; Giuliano, 2020). It is important to emphasize that the primary objective of this paper is not to examine or identify the exact sources of the observed gender gap. Instead, we acknowledge the gender gap as a given fact and focus on establishing gender-dependent associations between strategic thinking skills and labor market outcomes. We argue that these associations are driven by intrahousehold interaction channels, including assortative matching based on strategic thinking skills in marriage, as well as the facilitation of intrahousehold task specialization by strategic thinking skills.

The literature on strategic thinking skills has focused on identifying individuals' strategic thinking skills in a controlled laboratory environment with some exceptions, including Bosch-Domenech et al. (2002). To our knowledge, we are the first paper that provides empirical evidence that strategic thinking skills are important components shaping one's individual and collective economic success, even after controlling for a variety of individual characteristics, including educational attainment, family background, cognitive skills, and noncognitive skills. In addition, we propose the intrahousehold interaction channels to account for the empirical findings of these associations.

Recently, researchers have explored the relationship between strategic thinking skills and other cognitive and noncognitive skills. In repeated strategic interactions, Gill and Prowse (2016) find that both cognitive ability and noncognitive skills are correlated with level-k thinking. Using a sample of children aged 5–12 years old, Fe et al. (2022) conduct experiments to investigate how psychometric measures of theory-of-mind and cognitive ability are related to the level-k behavior of children in a variety of incentivized strategic interactions. They find that higher theory-of-mind and cognitive abilities predict a higher degree of strategic thinking skills in competitive games. Our paper also establishes a positive but weak correlation between measures of cognitive ability, including a measure of theory-of-mind capabilities using the Reading the Mind in the Eyes Test (Baron-Cohen et al., 2001), and measures of strategic thinking skills.

We also contribute to the literature on human capital and its importance in the labor market. While human skills are multidimensional in nature (e.g., Heckman et al., 2006b; Cunha and Heckman, 2007), the literature has traditionally focused on cognitive skills (e.g., Herrnstein and Murray, 1994; Hanushek and Woessmann, 2008) and, more recently, on a growing list of noncognitive skills, including personality, grit, and self-efficacy (Bowles et al., 2001; Heckman and Rubinstein, 2001; Borghans et al., 2008; Almlund et al., 2011; Lindqvist and Vestman, 2011; Heckman et al., 2019). A few studies document the importance of social skills in the labor market, related to the theme of this paper. Deming (2017) reports that the U.S. labor market increasingly rewards social skills by providing higher wages for jobs requiring high levels of social interaction. Borghans et al. (2008) document that sociability in youth is a good predictor of later job assignment and that the returns to interpersonal styles vary across jobs depending on the types of interpersonal tasks. Conti et al. (2013) use friendship nomination in high school as a proxy of social skills and show that it is a good predictor of future earnings. Our study uses game-theoretic measures of an individual's strategic thinking skill, uncovers the gender-dependent associations between these measures and individual labor incomes, and develops a model offering a coherent account of the findings.

The remainder of the paper is structured as follows. Section 2 describes how we measure strategic thinking skills and presents the empirical features of these measures. Section 3 discusses how our measures of strategic thinking skills are correlated with each other, and with other standard cognitive and noncognitive measures. In Section 4, we report the estimation results documenting the economic importance of strategic thinking skills. Section 5 considers a few plausible channels to rationalize our key empirical findings. We check the robustness of the baseline findings and discuss the main results in Section 6. Section 7 concludes the paper.

2 Experimental Design and Measurements

2.1 Measuring Strategic Thinking Skills

2.1.1 Line(-Network) Game: Higher-Order Rationality Measure

The HOR measure is built on the *Line-Network Game* (hereafter, the Line Game), developed to identify individual heterogeneity in conducting introspective thinking during the iterative elimination of strictly dominated strategies (i.e., rationalizability, Bernheim (1984) and Pearce (1984)). It is a five-person simultaneous-move, dominance-solvable, network game, à la Kneeland (2015). It consists of a series of two-person games, each of which is adapted from the 11-20 money request game of Arad and Rubinstein (2012), with the opponent structure determined by the line network. Figure A1 in Appendix A presents a sample decision screen for the Line Game.

In the game, there are five positions–A, B, C, D, and E. Each player is assigned to one of the five positions and makes a decision *simultaneously* and independently; the position A player makes a money request of either S$10 (US$7.38) or S$50 (US$36.9); players in any other position make a money request from 5 options: S$10, S$20, S$30, S$40 or S$50.[3] The payoff of the position A player is the amount of money s/he requested. The payoffs of players in any other position consist of two parts: each player receives 1) the amount of money s/he requested and 2) an additional amount of S$100 if and only if the money s/he requested is S$10 lower than the money requested by his/her opponent. The opponent of each player is defined as a player who occupies a position to the left of that player in the line network.[4]

Each individual plays the game five times, in a random order, in each of the five positions. The following set of choices is implied by the full rationality of players: First, the player in position A chooses S$50. Correctly anticipating this choice, the player in position B chooses S$40. This iterative process continues, resulting in the choices of S$30, S$20, and S$10 by the players in positions C, D, and E, respectively.

Our goal is to measure how well each individual in this simultaneous-move environment performs introspective thinking by forming a correct belief about the choices made by others who are not necessarily fully rational.[5] To obtain this measurement, we define "HOR score" as the average expected payoff of an individual, calculated based on his/her choice in each position matched with the empirical distribution of his/her opponent's choices. Specifically, we first obtain the empirical choice distribution for each position from our choice data. We then match an individual's choice in each position with the empirical choice distribution for his/her opponent's position to obtain the expected payoff for each position. Finally, we take the average of the expected payoffs from all five positions to obtain the HOR score of the individual. A standardized version of this measure (having a mean of 0 and a standard deviation of 1 by gender) will be used for our main empirical analyses. In addition, two other variables—discretized HOR score and HOR order measure—are constructed based on individuals' performance in the Line Game and

[3]S$1 is equivalent to 0.74 US$ or 0.66 euro as of January 29, 2022.

[4]The position A player is the opponent of the position B player. The position B player is the opponent of the position C player. The position C player is the opponent of the position D player. The position D player is the opponent of the position E player. However, the opponent relationship is asymmetric. For example, the position B player is *not* the opponent of the position A player.

[5]The full-rationality benchmark is also considered, and our results do not depend on which measure we adopt. For more details, see Section 6.1.

used to demonstrate the robustness of our results. These two variables will be defined and discussed in Section 6.1.

Table 1 below presents the empirical distributions of the HOR scores obtained from the SLP and KLIPS data. The two distributions share the same qualitative features, although the distribution from the SLP data first-order stochastically dominates that from the KLIPS data slightly.[6]

Table 1: Distribution of the HOR scores

Data	Min	10th	25th	50th	75th	90th	Max
SLP	23.9	37.9	41.3	49.4	65.6	68.6	72.6
KLIPS	21.5	36.4	40.3	48.1	54.8	64.1	67.6

2.1.2 Lift Game: Backward Induction Measure

The BI measure is built upon the *Lift Game*, a two-person sequential-move game that has been considered in the literature, e.g., the Race Game (Gneezy et al., 2010) and the Game of 21 (Dufwenberg et al., 2010). The game is developed to identify individual heterogeneity in conducting BI reasoning (Selten, 1965).

To describe the game, imagine that two players–player 1 (she) and player 2 (he)–get on the same lift on the ground floor (floor 0). Player 1 first decides how many floors to go up. She has three choices: one, two, or three floors up. Then, the lift moves up to the floor chosen by the first mover. Player 2 next decides how many floors to go up while facing the same three choices. There is a predetermined and publicly known target floor, denoted by $k > 1$. The two players take turns moving until the lift arrives at the target floor. The player who presses the target floor button k in the lift wins the game.

There are four rounds of the Lift Game with different target numbers. Human participants, always being the first mover, play the four rounds of the Lift Game in a random order against a computer player. The computer player is programmed to choose an optimal move in every information set while uniformly randomizing whenever indifferent. This experimental design ensures that the human player does not face any strategic uncertainty about what the opponent will do. Thus, the design faithfully implements an environment where rationality is common knowledge. The target numbers we chose are 5, 11, 14, and

[6]The distribution of the HOR scores by gender is reported in Appendix B.

17. Game G_k denotes the Lift Game with target number k in which $k \in \{5, 11, 14, 17\}$. Figure A2 in Appendix A presents sample decision screens for G_{14}.

Each game G_k has a winning strategy for the first mover. For example, the winning strategy for the first mover in G_5 is to go up to the 1st floor in her first turn and then to the 5th floor in her second turn. The winning strategy for each game is presented in the last column of Table 2. The existence of a winning strategy for the first mover implies that an individual who can perform two steps of backward inductive reasoning should win game G_5. Similarly, an individual who can perform three, four, and five steps of backward inductive reasoning should win games G_{11}, G_{14}, and G_{17}, respectively. Hence, we assign the BI score of 1 to an individual who did not win game G_5, the BI score of 2 to an individual who won G_5 but not G_{11}, and so on. Table 2 below illustrates the classification criterion we used for the BI score.[7] The last two rows present the empirical distribution of the BI scores. For example, in the SLP sample (our baseline Singapore data), 41.7% and 34.9% of participants won the game only once and twice out of the five rounds, respectively. Those who won each of the five rounds account for only 1.8% of the participants. We also find the similar pattern in the Korean sample (KLIPS data) showing that 40.1% and 36.8% of the participants won only once and twice out of the five rounds, respectively. Despite the population difference, it is notable that the distribution of the BI score is fairly consistent between the two countries. As a robustness check, we consider alternative measures—categorical BI score and BI counting score—in Section 6.1.

Table 2: Classification and distribution of the BI score

Score	1	2	3	4	5	Winning Strategy
G_5	Lose	Win	Win	Win	Win	1-5
G_{11}	-	Lose	Win	Win	Win	3-7-11
G_{14}	-	-	Lose	Win	Win	2-6-10-14
G_{17}	-	-	-	Lose	Win	1-5-9-13-17
SLP	41.7%	34.9%	19.6%	2.1%	1.8%	-
KLIPS	40.1%	36.8%	17.6%	1.7%	3.9%	-

[7] Our identification method only captures the *upper bound* of the BI reasoning steps an individual could perform. For example, a person who can perform only two steps of BI reasoning could randomly make a first move that coincidently matches the winning strategy in G_{11}.

2.2 Data and Procedures

2.2.1 Data

For the main empirical analysis, we recruited our study participants from the Singapore Life Panel (SLP), a nationally representative internet-based panel survey in Singapore. Most respondents were 50–70 years old when it was launched in July 2015, and participate in the survey every month. The SLP has been collecting a rich array of individual and household characteristics, such as family structure, labor market outcomes, and health. The online nature of the survey allows researchers to flexibly ask various types of questions in an interactive manner.

In the August 2017 wave, we invited 3,595 respondents between 50 and 65 years old to participate in our study. We deliberately decided to not invite those aged over 65 years to focus on the working-age population. At the time of the survey, the Retirement and Re-employment Act in Singapore mandated most employers offer continued employment until 65. In addition, the official pension claiming age in Singapore called the Payout Eligibility Age, is 65. Participants were informed that they would receive S$5 upon completing the tasks in our study and up to S$150 based on their performance in each task. A total of 2,787 (78%) accepted our offer, and 2,146 completed all tasks in our study.

In addition to the data collection in the SLP, we also recruited 786 participants from the Korean Labor and Income Study (KLIPS), a nationally representative sample of urban households and individuals in South Korea. Because the KLIPS sample covers younger ages below 50, it can demonstrate the robustness of the descriptive statistics of strategic thinking measures with respect to age despite the small sample size.

As measures of cognitive ability, we use educational attainment and two internationally popular and well-validated tests of fluid intelligence and social cognition. The Intelligence Structure Test (IST) is our measure of fluid intelligence (Cattell, 1963). It is an internationally used and popular *nonverbal* cognitive ability test first developed in 1953 (Beauducel et al., 2010). The validity and reliability of the IST as a measure of cognitive ability have been established over more than 1800 samples. The figural matrix part of the IST consists of 20 questions and is very similar to the Raven's Matrices test. Figure A3 shows a sample question.[8]

[8]The full-length test includes other dimensions of intelligence such as verbal memory and numerical knowledge, but we could not implement those components due to the survey time constraints. According to

The Reading the Mind in the Eyes Test (hereafter, Eyes Test), developed by Baron-Cohen et al. (2001), is our measure of an individual's theory of mind or social cognition, i.e., an individual's ability to recognize another individual's mental state (Astington et al., 1988). It concerns reading cues in face-to-face human interaction, ignored in mathematical descriptions of strategic interaction but found to play an important role (e.g., Scharlemann et al., 2001; Stirrat and Perrett, 2010). The Eyes Test contains 28 questions, each of which shows a photo of the human eye area, and asks the respondent to choose a word that best describes the person's mental state. Figure A4 shows a sample question. The validity and reliability of the Eyes Test are also well established across many countries (Olderbak et al., 2015).

As measures of noncognitive traits and economic preferences, we use financial planning horizon, risk tolerance, self-efficacy, and personal optimism. The definitions of the cognitive and noncognitive trait variables are included in Appendix D.

Column (1) of Table A3 in the Appendix D reports sample characteristics of the study participants who completed all tasks. Participants are, on average, 58.5 years old, and almost half of them are male; 91 percent are ethnic Chinese, and 82 percent are married with almost 3 children. Of the participants, 45 percent received at least postsecondary education, and the average cognitive ability, in terms of the IST score, is 10.8 (out of 20), which is more than 1 point higher than 9.6, the score corresponding to an IQ score of 100 according to the test's manual (Beauducel et al., 2010). Of the participants, 70 percent reported positive annual labor income, earning approximately S$50,283 on average. We do not have information on hourly wages due to a lack of data on specific work hours.

Column (2) of Table A3 reports the sample characteristics of study dropouts, i.e., those who accepted our invitation but did not complete the survey module. Column (3) of Table A3 presents the sample characteristics of nonparticipants, i.e., those who did not accept our invitation. In general, participants, dropouts, and nonparticipants are similar in terms of individual characteristics. Table A5 in Appendix E shows the descriptive statistics of the KLIPS sample. For the regression analysis, we focus on the SLP sample and do not use the KLIPS sample due to the small sample size.

the publisher, the time length of the full test components ranges from 77–130 minutes.

2.2.2 Procedures

Our study comprised two tasks that correspond to the strategic thinking measures discussed in Section 2.1. In Task I, each participant played four rounds of the Lift Game. In Task II, each participant was randomly matched with four other participants and played five rounds of the Line Game.[9]

The cash payment consisted of three parts. First, upon completing the experiment, every participant received the show-up fee of S$5. Second, for each participant, one game (out of 4 games) in Task I was chosen randomly; the winning participant received S$5, and the others received S$0. Third, the dollar amount each participant earned in one randomly chosen round (out of 5 rounds) in Task II was paid to the participant depending on the outcome of a lucky draw in which each participant had a 10 percent chance of winning. Given the uncertainty of the lucky draw for actual earnings in Task II, we increased the money stake in Task II so that the expected earnings from Task II are similar to those from Task I. Participants received a minimum amount of S$5 (US$3.7) and a maximum amount of S$150 (US$110.6) by participating in the experiment, which lasted approximately twenty minutes on average.[10]

3 Correlations Among Our Measures

Table 3 provides the Pearson correlation coefficients and statistical significance levels between the strategic thinking measures obtained from the SLP and KLIPS datasets. It also presents the correlation coefficients between our strategic thinking measures and other cognitive/noncognitive skills.

Upon examination, several observations become evident. Firstly, our strategic thinking measures exhibit positive correlations with conventional measures of cognitive and noncognitive skills. Specifically, both the HOR and BI measures show correlations with the Eyes test score and IST score. However, it is important to note that the degree of correlation is not excessively large, comparable to some correlations between different elici-

[9]In Tasks I and II, after reading the instructions, participants were asked to answer a few comprehension quiz questions and to play a practice round. The scripts for the experimental instructions are available in Appendix A. The Eyes Test was conducted after these two tasks.

[10]Due to an administrative restriction, the payment was delivered in the following month in the form of a cash voucher for the largest grocery store chain in Singapore.

tation methods of common economic preferences reported in Chapman et al. (2023). This positive correlation aligns with the conceptual connection of our strategic thinking measures to the theory of mind (in the case of the Eyes test) and intellectual/cognitive ability (in the case of the IST). Nevertheless, we emphasize that our strategic thinking measures are fundamentally distinct from the theory of mind and cognitive skills for two reasons. Firstly, none of the known cognitive skill measures involve interactive decision-making. Secondly, the theory of mind, as measured by the Eyes test, primarily captures an individual's ability to perceive and interpret facial cues in interpersonal interactions but not any kind of higher-order reasoning.

Table 3: Correlations among strategic thinking skill measures and other skills

SLP

	BI Score	HOR Score
HOR Score	0.317***	
Eyes Test Score	0.115***	0.164***
Postsecondary education	0.013	0.062***
IST Score	0.230***	0.213***
Financial planning horizon	0.029	0.037*
Risk Tolerance	0.005	0.025
Self-efficacy	0.040*	0.055***
Personal Optimism	0.077***	0.123***

KLIPS

	BI Score	HOR Score
HOR Measure	0.125***	
Eyes Test Score	0.183***	0.050
Postsecondary education	0.032	0.010
Risk Tolerance	-0.011	-0.054
Patience	-0.008	0.027
Openness	0.061*	0.025
Conscientiousness	-0.0004	0.074**
Extraversion	0.074**	0.085**
Agreeableness	0.029	0.059
Neuroticism	0.065*	0.017

Note: * denotes statistical significance at 0.10; ** at 0.05; *** at 0.01.

Secondly, it is evident that our two strategic thinking measures exhibit a correlation with each other. The correlation coefficients are 0.317 in the SLP data and 0.125 in the KLIPS data. This positive correlation is expected due to their conceptual relationship. However, we assert that strategic thinking skills are multi-dimensional, and our measures of HOR and BI capture distinct aspects of strategic thinking skills. The HOR measure, derived from the money request game, assesses introspective thinking ability by evaluating an individual's capacity to think strategically on behalf of others, empathetically placing oneself in their position. Conversely, the BI measure, derived from the lift game, focuses on anticipatory thinking ability, requiring individuals to consider various potential future scenarios to inform decision-making in the present moment. In summary, the BI measure necessitates a comprehensive evaluation of multiple future contingencies to arrive at a present decision, while the HOR measure involves placing oneself in the positions of up to four different players. Consequently, the HOR measure and the BI measure aim to capture two distinct aspects of strategic thinking skills.[11]

The utilization of separate measures to capture different dimensions of a particular skill or ability is well-accepted in the existing literature. For instance, the Wechsler Adult Intelligence Scale, one of the most widely-used measures of intelligence quotient, consists of several performance subtests that assess distinct dimensions of cognitive ability.

To investigate the possibility of assortative matching on strategic thinking skills in marriage, we examine the correlations of strategic thinking skills within married couples who both participated in our study. We find substantial correlations for strategic thinking skills, with a coefficient of 0.44 for the BI score and 0.45 for the HOR score. However, it is worth noting that we also observe similarly high correlations for traditional cognitive and non-cognitive skills within the couples. Specifically, the correlations are 0.46 for education, 0.73 for the IST score, 0.53 for the Eyes test score, 0.53 for subjective risk preference, and 0.50 for self-efficacy.

4 Strategic Thinking and Labor Market Outcomes

To establish that strategic thinking skills are strong predictors of an individual's economic outcomes, we consider the individual and household labor incomes of participants as the real-world outcomes of interest. Identifying the determinants of individual- and household-level labor income is a key area of research in labor economics (e.g., Mincer, 1958; Pencavel, 1986; Chiappori, 1988; Miles, 1997; Blundell and Macurdy, 1999; Heckman et al., 2006a). The literature has shown that various skills contribute to inequality in labor market outcomes (Heckman, 1995; Katz and Autor, 1999; Heckman and Kautz, 2012). Therefore, it is natural for us to investigate whether our measures of strategic thinking skills can independently explain variations in labor income.

We use annual labor income data collected in January 2015 (i.e., annual labor income earned during the calendar year 2014) for the main empirical analysis.[12] The participants

[11]We do not claim that these two elementary aspects encompass the entirety of strategic thinking skills. There are additional strategic thinking skills that are not captured by our measures, including (but not limited to) 1) learning ability, which refers to how quickly individuals can acquire knowledge about others' strategies, and 2) belief updating, as described in the concept of cursed equilibrium by Eyster and Rabin (2005). Our intent is to contribute to the understanding of strategic thinking by focusing on elementary aspects captured by the HOR and BI measures, recognizing that there are broader and more nuanced facets of strategic thinking that warrant further investigation.

[12]We extend the analysis by pooling multiyear income data in Section 6.2. The results remain robust.

in our study are aged 50–65 years; thus, 30% of participants report zero annual labor income. Hence, it is also important to study the association between strategic thinking skills and the extensive margin of labor supply. We define the extensive margin as a binary indicator that takes the value of 1 if a participant has a positive labor income and 0 otherwise. The extensive margin analysis refers to the analysis of labor income using this binary indicator as a dependent variable, while the intensive margin analysis refers to the analysis omitting zero-income earners.[13]

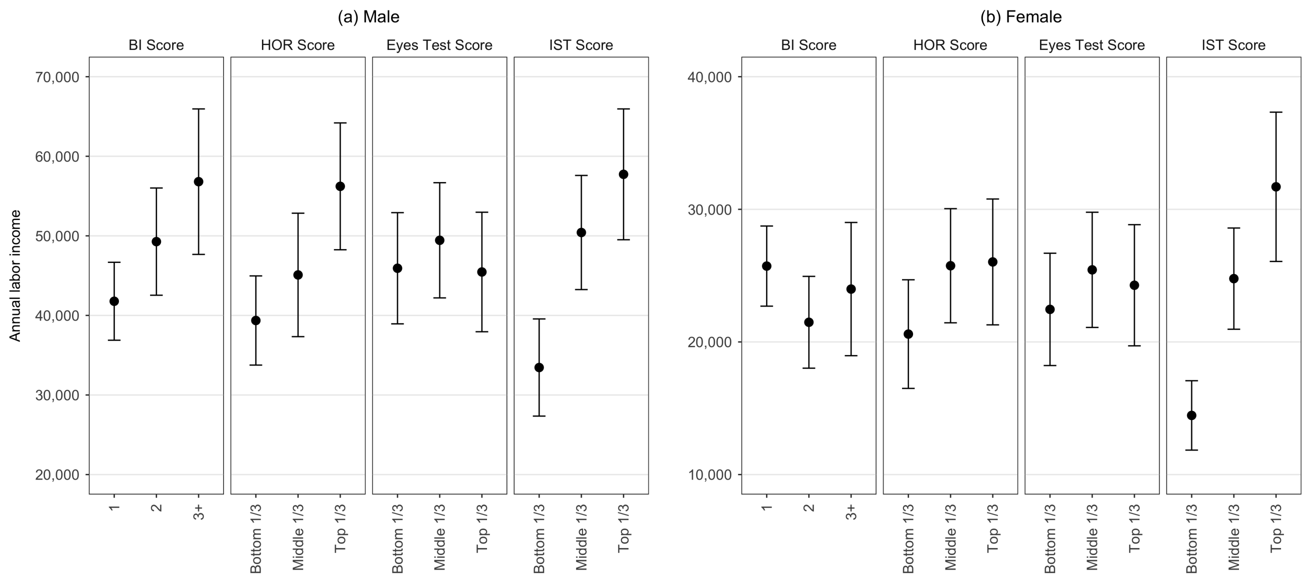
We conduct the empirical analysis separately by gender. The gender gap in labor income and labor market participation has historically been substantial and persistent, although it has decreased to some extent over recent decades (Altonji and Blank, 1999; Kuziemko et al., 2018). This gap depends on the degree of gender discrimination in hiring and workplace relations as well as on differences in gender roles in intrahousehold labor supply (Chiappori, 1992; Fernandez and Fogli, 2009; Bertrand et al., 2015; Charles et al., 2018). Unless such gender differences in the labor market are orthogonal to strategic thinking skills, establishing their association with labor outcomes would be biased if we pool the data over gender.

Before proceeding to the regression analysis, we present Figures 1 and 2 showing the mean and 95 percent confidence intervals of annual labor income (including zero income) and the likelihood of working (i.e., reporting a positive annual labor income). Each figure is drawn by partitioning the sample according to the ranking of each measure of strategic thinking skills and cognitive ability.[14] There are notable differences between male and female participants in terms of the unconditional association between strategic thinking skills and labor outcomes. On the one hand, male participants with higher scores for BI and HOR earn a higher annual labor income and are more likely to participate in the labor market. On the other hand, female participants with higher BI scores are less likely to supply their labor in the market and consequently earn lower annual labor income. These patterns reveal the gender-specific relationship between strategic thinking skills and labor outcomes. It is also noteworthy that the IST score measuring cognitive ability is strongly correlated with labor income for both male and female participants, while the Eyes Test score measuring social cognition is not clearly correlated with labor income.

[13] Powell (2020) adopted the same interpretation when studying the impacts of tax rebates on earnings.

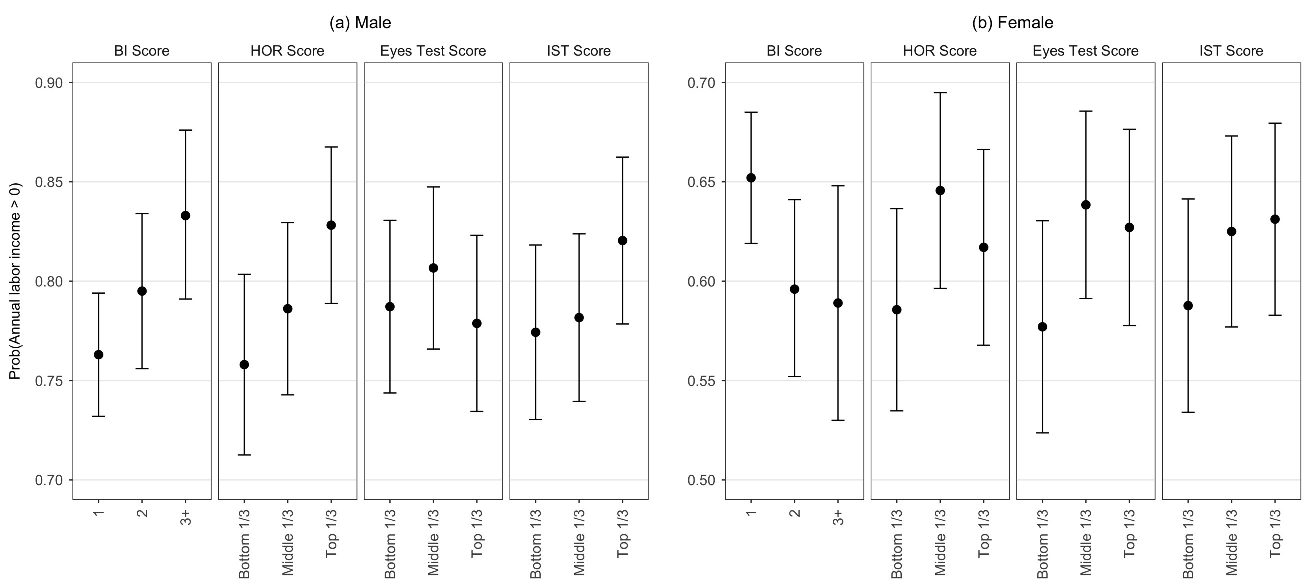
[14] Figure A6 in Appendix I presents the mean and the 95 percent confidence intervals of annual labor income by gender conditional on positive labor income (i.e., intensive margin anlaysis). The general patterns for this restricted sample are qualitatively similar to those shown in Figure 1.

Figure 1: Annual labor income by strategic thinking skills



Notes: Dots represent the average annual labor income of the SLP sample respondents. Caps represent upper and lower bounds of the 95 percent confidence intervals.

Figure 2: Extensive margin labor supply by strategic thinking skills



Notes: Dots represent the average probability of positive annual labor income for the SLP sample respondents. Caps represent upper and lower bounds of the 95 percent confidence intervals.

We transform the annual labor income variable with the inverse hyperbolic sine (IHS) function (Burbidge et al., 1988) and use it as the primary dependent variable in the regression analysis. The IHS transformation has the same interpretation of the log transformation (i.e., percent change) but provides the advantage that it is defined at zero. Thus, we do not need to drop zero-income earners from the sample. This transformation method has been widely used in the literature analyzing medical spending, wealth, and savings (Carroll et al., 2003; Pence, 2006; Gelber, 2011) as well as earnings (Powell, 2020), in which the variable of interest frequently takes the value of zero.

4.1 Strategic Thinking and Individual Labor Outcomes

Our analysis proceeds in three steps. First, we run a baseline regression of the IHS transformation of an individual's labor income on a measure of strategic thinking skills while controlling for sociodemographic variables. These controls include age group dummies, gender, ethnicity, marital status, number of children, spouse's age, and a dummy for a missing observation of spouse's age (mostly for unmarried respondents).

Second, we additionally control for educational attainment and cognitive abilities measured by the IST score and the Eyes Test score. Educational attainment and cognitive abilities are traditionally considered major determinants of labor income (Becker, 1964; Mincer, 1975; Heckman et al., 2006b). Thus, we control for them in assessing the robustness of the association between strategic thinking skills and labor income.[15]

Third, we further control for noncognitive skills and economic preferences available in the SLP data—risk tolerance, financial planning, self-efficacy, and personal optimism—following the literature documenting the role of noncognitive skills and preferences in economic outcomes (Heckman et al., 2006b; Almlund et al., 2011; Falk et al., 2018; Heckman et al., 2019). In addition, we include a response time taken to complete a corresponding experiment and the random order of tasks in the experiment as experimental controls.

[15] We also investigate how much of the variation in labor market outcomes is explained by our measures of strategic thinking skills and the cognitive ability measures (IST score and Eyes Test Score). The findings are reported in Appendix H.

4.1.1 Individual Labor Income

Table 4 reports the regression results for the IHS-transformed annual individual labor income of male respondents (Panel A) and female respondents (Panel B) on their own strategic thinking skills, following the three steps we outlined above. To save space, we do not report the coefficient estimates of the control variables here, but the full results are presented in Tables A6 and A7 in Appendix F.

We begin with male respondents. Columns (1) and (2) of Panel A report the baseline regression results for each measure of strategic thinking skills, controlling for sociodemographic variables. We find that a one-level increase in the BI score and a one-SD increase in the HOR score are associated with respective 42.9 percent and 68.1 percent increases in male respondents' annual labor income. The coefficient estimates are statistically significant at the 1 percent level.

The findings from the baseline regression might be partially driven by educational attainment, and cognitive ability, which can be correlated with both strategic thinking skills and labor income. Hence, in columns (3) and (4), we additionally control for educational attainment, IST score, and Eyes Test score. The coefficient estimates on the BI score and the HOR score—0.375 and 0.612, respectively—remain significant at the 5 percent level, although the magnitudes drop slightly by about 0.05 for the BI score and 0.07 for the HOR score.

Columns (5) and (6) show the regression results, further controlling for noncognitive traits and experimental variables. We find that a one-level increase in a male respondent's BI score is associated with a 37 percent increase in his annual income and a one-SD increase in his HOR score is associated with a 58 percent higher annual labor income. The magnitudes for the BI score and the HOR score decrease by only 13–15 percent compared with those from the baseline specification reported in columns (1) and (2).

We turn to female respondents. In the baseline specification, columns (1) and (2) of Panel B, we find that a one-level increase in a female respondent's BI score is associated with a 36.7 percent lower annual labor income. The coefficient estimate is statistically significant at the 5 percent level. The coefficient estimate of the HOR score is positive but imprecisely estimated.

In columns (3) and (4), the negative association between the BI score and annual labor income for female respondents becomes even greater in its magnitude and significance

Table 4: Regression of individual labor income on strategic thinking skills

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Dep. Var: IHS transformation of own annual labor income					
Panel A: Male						
BI score	0.429***		0.375**		0.372**	
	(0.144)		(0.149)		(0.151)	
HOR score (standardized)		0.681***		0.612**		0.580**
		(0.240)		(0.248)		(0.249)
Observations	1,044	1,044	1,044	1,044	1,044	1,044
R-squared	0.037	0.037	0.041	0.041	0.053	0.052
Panel B: Female						
BI score	-0.367**		-0.462***		-0.473***	
	(0.179)		(0.176)		(0.182)	
HOR score (standardized)		0.257		-0.031		-0.006
		(0.285)		(0.289)		(0.289)
Observations	1,102	1,102	1,102	1,102	1,102	1,102
R-squared	0.052	0.049	0.088	0.082	0.103	0.100
Demographics	Yes	Yes	Yes	Yes	Yes	Yes
Education and cognitive skills	No	No	Yes	Yes	Yes	Yes
Noncognitive and preference traits	No	No	No	No	Yes	Yes

Notes: Standard errors are corrected for heteroskedasticity. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively. Columns (1)–(2) include only demographic variables: age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, and the dummy variable reflecting a missing observation for spouse's age for single individuals. Columns (3)–(4) additionally control for educational attainment, IST score, and Eyes Test score. Columns (5)–(6) additionally control for noncognitive traits such as financial planning time horizon, subjective risk tolerance, self-efficacy, personal optimism, and time taken to complete a corresponding task. Odd-numbered and even-numbered columns include dummy variables for the random orders of the Lift Game and the Line Game, respectively.

after additionally controlling for educational attainment, the IST score, and the Eyes Test score. The association with the HOR level is close to zero and statistically insignificant.

In columns (5) and (6), with further controls for noncognitive and preference traits and experimental variables, the association of the BI score with female labor income remains statistically significant at the 1 percent level: a one-level increase in a female respondent's BI score is associated with a 47 percent decrease in her annual labor income. The association with the HOR level becomes close to zero and statistically insignificant.

As we discussed before, the depth of reasoning exhibited by individuals in our line game may not solely rely on their ability to engage in introspection but also on their beliefs about the behavior of their opponents. Thus, our HOR measure may capture some measurement error due to such beliefs. However, in the case of our BI measure, the experimental design mitigates this concern as subjects play against a computer player programmed to employ an optimal strategy in all scenarios. In this sense, the HOR measure could be more likely subject to measurement error compared to the BI measure, which attenuates the relation between female labor income and the HOR measure in Table 4.

In the spirit of Altonji et al. (2005), the fact that the estimates are robust to a large extent to additional sets of controls (except for female respondents' BI score) supports the causal interpretation of the gender-dependent roles of strategic thinking skills in labor income. The negative association between the BI score and labor income for female respondents appears puzzling. However, Subsection 4.1.2 below shows that the gender-specific association between labor income and the BI score seems to be driven by the difference in extensive-margin labor supply decisions. In addition, we discuss potential channels to accommodate these findings in Section 5.

Due to the nontrivial share of the participants reporting zero labor income, small changes at the low end of the income distribution may lead to disproportionate weights in the mean regression analysis. To address this concern, we report quantile regression analyses of the IHS-transformed labor income at different parts of the distribution in Tables A9 and A10 in Appendix G. We find that the large magnitude reported in the mean regression analysis is indeed driven by disproportionately large effects at the low end of the income distribution, suggesting the role of strategic thinking skills in explaining the extensive margin of labor supply. Nevertheless, we also find that strategic thinking skills are related to labor income at the high end of the distribution as well. For male participants, a one-SD increase in the HOR score is associated with an increase of 15 percentage points and 12 percentage points at the 80th and 90th percentiles of the distribution, respectively. For female participants, a one-level increase of her BI score is associated with a decrease of 12 percentage points and 11 percentage points at the 80th and 90th percentiles of the distributions.

4.1.2 Extensive Margin of Labor Supply

The preceding analysis of labor income does not distinguish the extensive and intensive margins of labor supply because the IHS-transformed annual labor income contains observations with zero income. In this subsection, we examine the relationship between strategic thinking skills and the extensive margin of labor supply by gender.[16]

Columns (1)–(4) of Table 5 present the regression results for both male and female respondents' labor supply along the extensive margin on their strategic thinking skills, including the full set of controls. The dependent variable takes the value of 1 if a respondent has a positive annual labor income and 0 otherwise. This measure includes both working for pay and self-employment.

Columns (1)–(2) report that male respondents with higher values of the BI and HOR scores are more likely to earn positive labor income. A one-level increase in a male respondent's BI score is associated with an increase of 3 percentage points in the probability of his employment, and a one-SD increase in his HOR score is associated with an increase of 4.7 percentage points. Both estimates are statistically significant at the 5 percent level.

Columns (3)–(4) show that, in contrast to the case of male respondents, a female respondent's BI score is negatively correlated with the likelihood of earning a positive annual labor income. A one-level increase in a female respondent's BI score is associated with a decrease of 4.2 percentage points in the probability of a positive annual labor income at the 5 percent significance level.

Table 5: Regression results for the extensive margin of labor supply by gender

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	I (Annual labor income > 0)				Retired or Unemployed		Homemaker	
	Male		Female		Male		Female	
BI score	0.030**		-0.042**		-0.035**		0.053***	
	(0.013)		(0.017)		(0.014)		(0.018)	
HOR score (standardized)		0.047**		0.002		-0.035		0.037
		(0.022)		(0.027)		(0.022)		(0.031)
Observations	1,044	1,044	1,102	1,102	1,044	1,044	821	821
R-squared	0.044	0.042	0.082	0.079	0.108	0.097	0.064	0.059

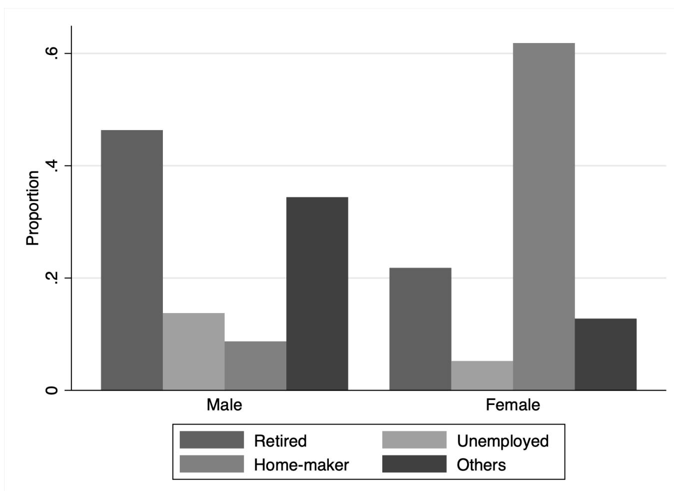
Notes: Standard errors corrected for heteroskedasticity are reported in parentheses. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, and the dummy variable reflecting a missing observation for spouse's age for single individuals, educational attainment, IST score, Eyes Test score, financial planning time horizon, subjective risk tolerance, self-efficacy, personal optimism, and the time taken to complete each task. Odd-numbered and even-numbered columns include dummy variables for the random orders of the Lift Game and the Line Game, respectively. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively.

[16]The literature has documented that male and female labor supply has differential responsiveness to various factors, including the gender pay gap, marriage matching, cultural norms, and intrahousehold bargaining, compared with male labor supply (Chiappori, 1992; Pencavel, 1998; Blundell et al., 2007; Chiappori and Mazzocco, 2017)

These results suggest that the gender-dependent associations between labor income and strategic thinking skills documented in Subsection 4.1 are driven at least partly by gender differences in the association between the extensive margin decision of labor supply and strategic thinking skills.[17]

Where does the gender difference in the associations between strategic thinking skills and the extensive margin of labor supply come from? To answer this question, we examine the composition of self-reported labor status among the respondents who reported zero annual labor income. Figure 3 shows a stark gender difference in terms of the labor status composition for zero-income earners. Among male respondents, retirees and the unemployed account for the majority of zero-income earners, while among female respondents, the majority of zero-income earners report themselves as homemakers.[18]

Figure 3: Labor status composition of participants with zero labor income



To further examine whether the gender differences in the composition of labor status contribute to the gender differences in the association between strategic thinking skills and the extensive margin of labor supply, we conduct regression analyses of either being retired or unemployed for males and the homemaker status for females on the strategic thinking skill measures while including the full set of controls.

[17]In Appendix I, we conduct an analysis of intensive margin labor supply decisions by shutting down the extensive margin channel (i.e., by excluding zero-income earners). The regression results reported in Table A11 indicate that the associations between strategic thinking skills and individual labor incomes are in the same direction but are imprecisely estimated when we exclude those who report zero labor income.

[18]The "others" category includes studying, disability, sick leave, etc.

Columns (5)–(6) of Table 5 report the regression results for male respondents' labor status of being either retired or unemployed on strategic thinking skills with the full set of controls. The dependent variable takes the value of 1 if a male respondent declares himself to be retired or unemployed and 0 otherwise. The results show that male respondents with higher values of the BI and HOR scores are less likely to be retired or unemployed. Overall, the negative associations between strategic thinking skills and zero income due to retirement and unemployment are consistent with the earlier findings, reported in Panel A of Table 4 and Columns (1)–(2) of Table 5.

Columns (7)–(8) of Table 5 report the regression results for female respondents. The dependent variable takes the value of 1 if a female respondent declares herself to be a homemaker and 0 otherwise. We restrict the sample of female respondents in this analysis to those who were married at the time of the survey. In column (7), a one-level increase in the married female respondent's BI score is associated with a 5.3 percent increase in the likelihood of being a homemaker. This evidence is consistent with the earlier findings that a female respondent's BI score is negatively correlated with the likelihood of working and, as a result, with her annual labor income. In column (8), we find a positive association between a married female respondent's HOR score and her homemaker status, but the estimate is not statistically significant.

4.2 Strategic Thinking and Household Labor Income

The gender-dependent relationship with individual labor outcomes raises a question about whether strategic thinking skills play a role beyond the scope of individual outcomes. We address this question by examining the association between household labor income and married respondents' strategic thinking skills. Table 6 reports the regression results for the IHS-transformed household annual labor income for male married respondents (columns (1) and (2)), for female married respondents (columns (3) and (4)) and for female married respondents whose individual labor income is zero (columns (5) and (6)). All reported results include the full set of controls.

Regardless of gender, we find significantly positive associations between household labor income and individual-level strategic thinking skills. A one-SD increase in the HOR score is associated with a 35.2 percent increase in household labor income for male married respondents and a 34.4 percent increase for female married respondents. The estimates are significant at the one percent level for males and at the 5 percent level for females. Similarly, a one-level increase in the BI score is associated with a 6.4 percent increase in household labor income for male respondents and a 14.4 percent increase for female married respondents, although the estimates are imprecisely estimated.

Since females are less likely to be working in our data, we further examine the association for married females whose individual labor income is zero. The results reported in columns (5) and (6) indicate that a one-level increase in the BI score and a one-SD increase in the HOR score are associated with an 87.3 percent increase at the one percent significance level and a 63 percent increase in household labor income at the five percent significance level, respectively.

We find that, unlike the gender-dependent associations with individual labor income, strategic thinking skills are positively associated with household labor income independently of gender. This finding suggests the potential importance of strategic thinking skills for collective economic success at the household level.

Table 6: Regression of household labor income on married respondents' strategic thinking skills

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Male		Female		Non-working Female	
BI score	0.064		0.144		0.873***	
	(0.125)		(0.135)		(0.315)	
HOR score (standardized)		0.352***		0.344**		0.630**
		(0.123)		(0.145)		(0.281)
Observations	938	938	822	822	338	338
R-squared	0.047	0.055	0.148	0.150	0.209	0.200

Notes: Standard errors corrected for heteroskedasticity are reported in parentheses. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, the dummy variable reflecting a missing observation for spouse's age for single individuals, educational attainment, IST score, Eyes Test score, financial planning time horizon, subjective risk tolerance, self-efficacy, personal optimism, and the time taken to complete each task. Odd-numbered and even-numbered columns include dummy variables for the random orders of the Lift Game and the Line Game, respectively. ***, **, and * denote p<0.01, p<0.05, and p<0.1, respectively.

5 Discussion on Potential Channels

What drives the observed household-level, gender-independent, and individual-level, gender-dependent associations between strategic thinking skills and labor market outcomes? We consider broadly two potential channels: *labor market channels* and *household interaction channels*.

5.1 Labor Market Channels

We first explore whether the labor market channel through which individuals' strategic thinking skills affect their labor and household incomes can provide a coherent account of the empirical findings in this paper. Two potential channels are worth considering: a workplace channel and an occupation-choice channel. The former suggests that individuals with higher strategic thinking skills may contribute more effectively to team production in the workplace and hence earn higher wages. This idea has been studied by Deming (2017), who proposes that social skills distinct from cognitive skills can enhance labor productivity by facilitating task specialization. While this channel can explain the positive association between strategic thinking skills and labor income among male respondents, it does not account for the opposite pattern found among female respondents, nor does it explain gender-dependent patterns regarding the extensive margin of labor supply. Therefore, this channel may have limited explanatory power for our main empirical findings.

We turn to the occupation-choice channel whereby individuals with higher strategic thinking skills are sorted into professions and industries with higher demand for these skills. The SLP collected information about the respondent's occupation as a special module of the July 2017 wave and thus we examine whether their past career choices are associated with strategic thinking skills. It asked the respondent's longest-held, last (if not working), and current (if working) occupation using the Singapore Standard Occupation Classification code. To analyze the association between strategic thinking skills and respondents' past occupation choice, we constructed the following two dependent variables: (i) whether a respondent's longest-held job was a senior manager, professional, and sales and service worker and (ii) the social skill score of the longest-held job. We assume that the occupation categories of the first variable are likely to require a higher level of strategic thinking skills. The latter variable is computed using the U.S. Department of Labor's O*NET database, which provides the skill requirements associated with each occupation following Deming (2017).[19]

[19] We first cross-walked the U.S. Standard Occupation Classification code and that of Singapore and merged O*NET's occupation. A higher value indicates that the occupation requires more social skills. See Deming (2017) for details.

Table A18 reports the regression results of each dependent variable by gender. We find that our strategic thinking skill measures are not significantly associated with the level of social skills required by respondents' longest-held jobs. The results remain robust when using the information on current or last occupation. With the caution that the sample size in this analysis is smaller than the baseline sample because the occupation information was collected as part of a special module, we interpret that these results provide little evidence supporting the occupation-choice channel for our data.

In summary, we conclude that the labor market channels alone cannot provide a coherent account of both the household-level gender-independent associations and individual-level gender-dependent associations between strategic thinking skills and labor market outcomes.

5.2 Intrahousehold Interaction Channels

Next, we investigate whether the intrahousehold interaction channel through which individuals' strategic thinking skills play a role in intrahousehold decision making which further affects their labor and household incomes can provide a coherent account of our main empirical findings. There are two plausible such channels: i) an intrahousehold decision-making of labor supply with home-to-workplace spillover, and ii) an assortative matching on strategic thinking skills in marriage. The former suggests that when the division of labor for domestic and marketable good production occurs between a wife and her husband based on their comparative advantage or gender norms, strategic thinking skills can facilitate better coordination and improve the spillover from home to the workplace. The positive spillover from home to the workplace is well documented in the psychology literature (Barnett, 1994; Barnett and Marshall, 1992a,b; Kirchmeyer, 1992) as well as in the economics literature (Benham, 1974; Lefgren and McIntyre, 2006; Huang et al., 2009). It is plausible that factors such as higher quality meals, better care for children, social status, leisure activities, companionship, love, and improved health can enhance an individual's productivity in the labor market.

In Appendix K, we propose a model of household labor supply built upon the literature on collective labor supply with household production and workplace production (e.g., Apps and Rees, 1997; Chiappori, 1997). Following the literature, a household consisting of two individuals achieves a Pareto-efficient resource allocation between market labor supply and time spent in domestic production under the condition that the domestic good increases the productivity of the marketable good production. Individuals who are heterogeneous with respect to their productivity in producing domestic goods and marketable goods need to coordinate intrahousehold specialization between these two production tasks. Strategic thinking skills are assumed to facilitate coordination between them and create a larger degree of home-to-workplace spillover. It is a natural adoption of the production function introduced in the literature on task allocation in the workplace (e.g., Autor et al., 2003; Acemoglu and Autor, 2011; Autor and Handel, 2013; Deming, 2017).

This model of collective labor supply offers a set of predictions consistent with the following empirical findings in our data, while it is silent about the high correlation of strategic thinking skills within the married couple. First, both married males' and females' strategic thinking skills are positively associated with their household labor income. Second, males' strategic thinking skills are positively associated with their individual labor income and negatively associated with the likelihood of being retired; females' strategic thinking skills are negatively associated with their individual labor income and positively associated with the likelihood of being homemakers. Third, as reported in Table 6, we also found that married, non-market-participating females' strategic thinking skills are positively associated with household labor income. Fourth, as reported in Appendix N, females' strategic thinking skills are positively associated with their spouses' individual labor income.

An alternative possibility in the household interaction channels is assortative matching in marriage, whereby individuals marry someone with similar strategic thinking skills. This channel assumes that strategic thinking is socially valuable, and therefore, individuals seek partners who possess these skills. This channel offers a couple of insights. First, strategic thinking skills between the couple members are positively correlated as we reported in Section 3. Second, if individual strategic thinking skills are positively associated with the traditional sources of determining labor outcomes such as education and cognitive ability (as we found in Table 3), this channel may generate the positive relation between strategic thinking skills and individual and household labor incomes. However, this channel alone is unable to explain why some couples specialize between household production and workplace production nor why individual income resulting from this specialization is correlated with strategic thinking skills in a gender-dependent manner.[20]

[20]The marriage assortative matching channel suggests that a non-working household member's higher

Therefore, we conclude that the intrahousehold interaction channels combining the collective model of labor supply and the assortative marriage matching channel can accommodate the key empirical findings of this paper.

6 Robustness Checks and External Validity

6.1 Alternative Measures of Strategic Thinking Skills

We examine the robustness of the main results reported in Section 4 to alternative measures of HOR and BI. In our first alternative measure, we address the nonlinear effects of the HOR score by splitting the sample into equal-sized terciles. The average expected payoffs of the first, second, and third terciles are S$39.0, S$50, and S$67.4, respectively, for male participants and S$192, S$245, and S$333, respectively, for female participants.

Our second alternative measure is the HOR orders, defined based on the dominance solvability of the Line Game.[21] This alternative measure provides a full-rationality benchmark when identifying individuals' HOR. We classify an individual who did not choose S$50 in position A as HOR order 0, an individual who chose S$50 in position A but not S$40 in position B as HOR order 1, etc.[22] Table 7 illustrates the classification criterion we used for the HOR orders. The last two rows of Table 7 present the empirical distributions of the HOR orders. Approximately two-thirds of the respondents are HOR order 0 or 1 in both the SLP and KLIPS samples.

Regarding the BI measure, we first consider the categorical variables of BI reasoning

strategic thinking skill contributes to increased household income solely because they selected a partner with higher strategic thinking skills. To investigate this, we conducted a regression analysis, additionally controlling for the strategic thinking skill of the working spouse, using a sample of 138 married couples where only one household member is active in the labor market (see Table A19 in Appendix O). Despite the caveat regarding the limited sample size and the generalizability of these findings, we observed that the non-working spouse's strategic thinking skill remained statistically significant at a 10% level, with a substantial effect size for the HOR measure.

[21] A respondent who is one-order rational must choose S$50 in position A. A respondent who is two-order rational must choose S$40 in position B. A respondent who is three-order rational must choose S$30 in position C. A respondent who is four-order rational must choose S$20 in position D. A respondent who is five-order rational must choose S$10 in position E.

[22] This identification method only captures the upper bound of an individual's higher-order rationality because, for instance, it is possible that a person who is able to perform only one round of iterative elimination of strictly dominated strategies randomly chose S$30 in position C. This identification strategy is standard in the literature (e.g., Brandenburger et al., 2017). Kneeland (2015) presented an experimental design that resolves the identification problem of the upper bound approach.

Table 7: HOR order classifications and empirical distributions

	Order 0	Order 1	Order 2	Order 3	Order 4	Order 5
A	$\neq 50$	50	50	50	50	50
B	-	$\neq 40$	40	40	40	40
C	-	-	$\neq 30$	30	30	30
D	-	-	-	$\neq 20$	20	20
E	-	-	-	-	$\neq 10$	10
SLP	22.0%	44.4%	9.9%	5.7%	2.7%	15.3%
KLIPS	31.2%	46.2%	10.7%	5.5%	1.8%	4.7%

by assigning respondents into 3 group dummies–those with a BI score of 1, those with a BI score of 2, and those with a BI score of 3 or higher. These BI categories allow us to detect the nonlinear effects of the BI scores on an individual's labor income. As a second alternative BI measure, we consider the number of rounds each individual won in the Lift Game, referred to as the BI counting score. The empirical distributions of the BI counting score in the SLP and KLIPS samples are reported in Table 8.

Table 8: Distribution of the BI counting scores

Data	0	1	2	3	4
SLP	31.9%	40.9%	22.5%	2.8%	1.8%
KLIPS	29.6%	42.9%	20.7%	2.6%	4.2%

Table 9 reports the regression results for respondents' annual labor income using the alternative definitions discussed above and with the full set of control variables. Column (1) indicates that male respondents, whose BI score is 2, earn 31.9 percent more than males whose BI score is 1 (not statistically significant), and males whose BI level is 3 or higher earn 89.4 percent more than those whose BI level is 1 (statistically significant at the 5 percent level). Column (5) suggests that female respondents whose BI score is 2 (resp., 3 or higher) earn 90.6 percent (resp., 114.9 percent) less than those whose BI score is 1. These coefficient estimates are statistically significant at the 5 percent level. These nonlinear effects are overall consistent with the findings reported in Table 4, in which linear relations are imposed. This finding is also consistent with the results using the BI counting scores reported in columns (2) and (6) of Table 9. The BI counting score is associated positively with the male respondents' labor income but negatively with the female respondents' labor income at the 5 percent significance level.

Table 9: Regression of labor income on alternative strategic thinking skills

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Male				Female			
BI score = 1	0.319				-0.906***			
	(0.357)				(0.347)			
BI score = 2+	0.894**				-1.149***			
	(0.371)				(0.421)			
BI counting score		0.344**				-0.466**		
		(0.156)				(0.185)		
HOR score: mid 1/3			0.184				0.562	
			(0.363)				(0.376)	
HOR score: top 1/3			0.728**				-0.027	
			(0.356)				(0.389)	
HOR order				0.152*				-0.103
				(0.087)				(0.095)
Observations	1,044	1,044	1,044	1,044	1,102	1,102	1,102	1,102
R-squared	0.054	0.053	0.052	0.050	0.105	0.102	0.101	0.102

Notes: Standard errors corrected for heteroskedasticity are reported in parentheses. The dependent variable is a respondent's own annual labor income transformed with the IHS function. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, the dummy variable reflecting a missing observation for spouse's age for single individuals, educational attainment, IST score, Eyes Test score, financial planning, risk tolerance, self-efficacy, personal optimism, and time taken to complete each task. Columns (1), (2), (5), and (6) include dummy variables for the random order of the Lift Game. Columns (3), (4), (7), and (8) include dummy variables for the random order of the Line Game. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively.

Columns (3) and (7) of Table 9 report the regression results using the HOR score terciles. For male respondents, we find that those with HOR scores above the top one-third of the distribution have, on average, a 72.8 percent higher labor income than those with HOR scores at the bottom one-third. The coefficient estimate is statistically significant at the 5 percent level. For female respondents, we do not find statistically significant relations between the HOR score terciles and their labor income. Column (4) shows that the association between male respondents' labor income and their HOR order is substantial in magnitude: a one-order increase in the HOR order measure is associated with a 15.2 percent increase in male participants' annual labor income. It is, however, statistically significant only at the 10 percent level. We do not find a significant association between the HOR orders and female respondents' labor income in column (8). In sum, these findings are qualitatively consistent with the baseline findings reported in Table 4.[23]

[23]The corresponding results using the household annual income variable are reported in Table A12. The results remain robust.

6.2 Pooled Regression of Multiyear Annual Labor Income

Contemporaneous labor income in 2014 (or any given year) could have a measurement error. To address this concern, we utilize multiple observations of a respondent's annual labor income data for 2014–2016 and conduct the pooled regression analysis of annual labor income on strategic thinking skills, including the full set of controls.

Table 10: Pooled regression of individual labor income on strategic thinking skills

	(1)	(2)	(3)	(4)
	Male		Female	
BI score	0.346**		-0.418**	
	(0.136)		(0.164)	
HOR score (standardized)		0.504**		-0.011
		(0.223)		(0.263)
Observations	3,089	3,089	3,278	3,278
R-squared	0.055	0.054	0.092	0.091

Notes: Standard errors clustered at the respondent level are reported in parentheses. The dependent variable is a respondent's own annual labor income transformed with the IHS function. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, the dummy variable reflecting a missing observation for spouse's age for single individuals, educational attainment, IST score, the Eyes Test score, financial planning time horizon, subjective risk tolerance, self-efficacy, personal optimism, and time taken to complete each task. Columns (1) and (3) include dummy variables for the random order of the Lift Game. Columns (2) and (4) include dummy variables for the random order of the Line Game. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively.

The regression results in Tables 10 and A13 reinforce the baseline findings reported in Table 4 for individual labor income and Table 6 for household labor income. The magnitudes and statistical significance generally remain similar.[24]

6.3 ORIV approach regarding measurement errors

One potential concern regarding the analysis of the paper is potential measurement error in eliciting strategic thinking skills and the lack of corrections of any noise in these elicitations in establishing the relation between strategic thinking skills and labor outcomes. One form of this concern can be expressed as that our HOR and BI measures are just two experimental proxies of a common trait of strategic thinking and are measured

[24]We also check the robustness of the regression results for the extensive and intensive margin analyses of individual labor income using multiyear observations. The results shown in Table A14 remain robust.

with errors. We take this concern for granted and attempt to remove the attenuation bias caused by potential measurement error by following Gillen et al. (2019)'s obviously related instrumental variables (ORIV) method. It is worth emphasizing that the ORIV approach assumes that BI and HOR measures capture the same underlying trait (strategic thinking skill) with idiosyncratic errors. In contrast, as we addressed in Section 3, we argue that the nature of strategic thinking is multi-dimensional and our HOR and BI measures capture two distinct features of strategic thinking.

Table 11 reports the ORIV estimation results on the relation between strategic thinking skills and individual and household labor income for male and female participants, respectively. To make the scale consistent, we standardized the BI score using a normal distribution as in the HOR score. Then we assume that the measurement errors in BI and HOR scores are uncorrelated with one another. Banking on this assumption, we use BI as an instrument for HOR and vice versa to remove measurement error and estimated the two-stage least squares regression where strategic thinking skill is the endogenous variable with measurement error in the second stage.[25]

The ORIV estimation results are consistent with the gender-dependent associations with individual labor income and the gender-independent associations with household labor income in the previous analysis assuming that our measures of HOR and BI capture two distinct features of strategic thinking skills. For male participants, the strategic thinking skill is positively associated with their individual income at the 1% significant level. However, it is negatively correlated with females' individual income, although it is imprecisely estimated at the 10% significant level. In addition, we find consistent evidence that the strategic thinking skill can increase household labor income regardless of gender, as shown in Table 6. The estimates are both statistically significant at 5% level. Hence, we conclude that the key findings with individual and household labor incomes are immune from the concerns of measurement errors.

6.4 Discussion of External Validity

One might be concerned that our findings are confined to the context of Singapore due to the large cultural and economic differences between Singapore and the rest of the world.

[25]Following Gillen et al. (2019), we stacked the duplicated data to further improve statistical precision. The assumption of this approach is that the underlying strategic thinking skill (measured with error) is BI (HOR) score and the IV is HOR (BI) score in the original (duplicated) dataset.

Table 11: ORIV estimation of labor income on strategic thinking skills

	(1)	(2)	(3)	(4)
	IHS of own laobr income		IHS of household labor income	
	Male	Female	Male	Female
Strategic thinking skill	1.215***	-0.907*	0.712**	1.093**
	(0.367)	(0.509)	(0.297)	(0.425)
Observations	2,088	2,204	1,876	1,644
R-squared	0.028	0.088	0.042	0.120

Notes: Standard errors clustered at the respondent level are reported in parentheses. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, the dummy variable reflecting a missing observation for spouse's age for single individuals, educational attainment, IST score, the Eyes Test score, financial planning time horizon, subjective risk tolerance, self-efficacy, personal optimism, random orders of the Lift Game and Line Game, and time taken to complete each task. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively.

To assess this concern, we examine whether the gender norms of Singapore are significantly different from those of Western and other Asian countries. We use Wave 6 data from the World Values Survey (and the corresponding wave of the European Values Survey) and compare the proportion of respondents who agree or strongly agree with the following two statements among seven countries (Australia, Germany, Japan, Singapore, South Korea, Sweden, and the U.S.): i) having a job is the best way for a woman to be an independent person, and ii) being a housewife is just as fulfilling as working for pay.[26] Figure A8 indicates that Singaporeans do not exhibit skewed perceptions about gender roles compared with people in other Asian countries or Western countries. The proportion of participants who agree or strongly agree with the first statement is 0.67 for Singapore, which is fairly high and comparable to those for other countries. Regarding the second statement, the response of Singaporeans is also similar to those from the U.S., Australia, Japan, and South Korea, while Germany and Sweden record slightly higher figures.

We also compare the female labor market participation rate and GDP per capita across countries between 2000 and 2020, which are presented in Figure A9. During this period, Singapore's GDP per capita and female labor market participation rate were as high as those of most of the comparison countries. This descriptive evidence suggests that the gender norms and female labor market activities in Singapore are not particularly different from those of other developed countries. Thus, we argue that the findings of this study

[26]To be comparable with the age range of the SLP sample, we restrict the age of the World and European Values survey samples to be 50–65 years old. The UK and France are not included because these questions were not asked during the same survey period in these countries.

can be applicable to other countries.

In addition, as we use a sample of individuals aged 50–65, we only examine the associations between strategic thinking skills and labor market outcomes in the later part of the life cycle. As such, there could be a concern about whether these associations remain robust in the earlier part of the life cycle. Although we cannot directly address this concern using the SLP data, we find that the distributions of our HOR and BI measures and their correlations with other cognitive and non-cognitive traits are consistent between SLP and KLIPS. Since the KLIPS consists of a nationally representative sample of Korean individuals aged 15 and above, the similarity between SLP and KLIPS suggests that the use of older study participants is unlikely to change the interpretation of our main results. Nonetheless, we acknowledge that it would be fruitful to explore the relationship between strategic thinking skills and marriage matching/occupational choice using a sample of younger individuals.

7 Concluding Remarks

In our large-scale experiment, we measured strategic thinking skills, specifically focusing on fundamental aspects of strategic reasoning in interpersonal interaction. These measures, capturing higher-order rationality and backward induction, were found to be distinct from the conventional collection of cognitive and noncognitive skills. Notably, both married males and married females exhibited significant and positive associations between their strategic thinking skills and their household labor income, emphasizing the importance of strategic thinking skills for collective economic success within a household. However, we also observed contrasting roles of strategic thinking skills across genders in their individual labor market outcomes. Males' strategic thinking skills were positively associated with both individual labor income and labor market participation, while females' strategic thinking skills showed a negative association with these outcomes. Consequently, our findings strongly support the notion that strategic thinking is a skill of economic significance. We propose intrahousehold interaction channels as a potential explanation for the patterns observed in our study.

As acknowledged earlier, the two strategic thinking measures developed in our paper only cover elementary aspects of strategic thinking skills, and there are likely several other aspects that are relevant to real-life decision-making. One such aspect is related to subjects' learning rules and the speed at which they learn, as our game-theoretic measures of strategic thinking skills focus on subjects' initial play, without considering learning opportunities. The experimental literature on learning in games has demonstrated heterogeneity among human subjects in their sophistication when it comes to learning rules (e.g., Camerer and Ho, 1999). The capacity to effectively learn in strategic environments may be associated with individuals' economic and social success. Future research could explore the development of a measure for learning capabilities and investigate its relationship with economic performance. Additionally, there is a need for further exploration of scientific interventions aimed at enhancing strategic thinking skills and ultimately improving economic outcomes.

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Appendices: For Online Publication

A Experimental Instructions and Sample Screen Shots

Full Instructions

- English Version: https://www.dropbox.com/s/0i14kps23rrgqtp/Instructions_Screens_ENGLISH.pdf?dl=0
- Chinese Version: https://www.dropbox.com/s/9bfzle8sgn54xey/Instructions_Screens_CHINESE.pdf?dl=0

Selected Screen Shots

Figure A1: Line game - position B

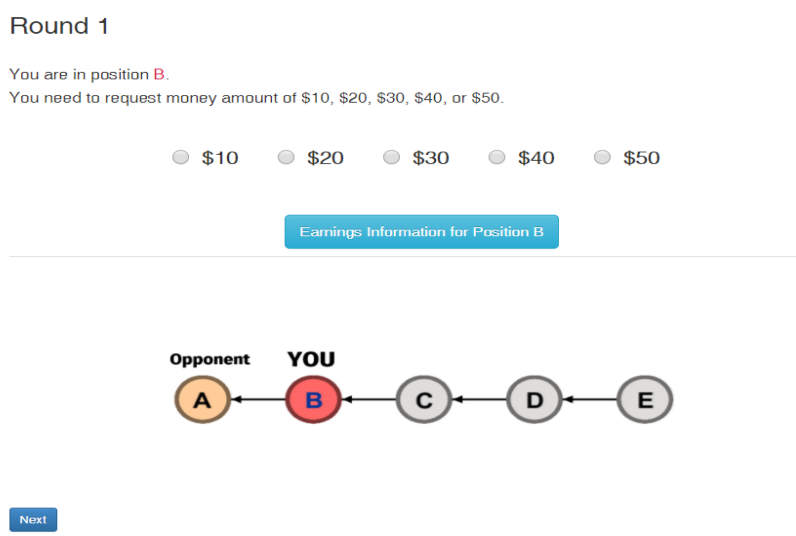
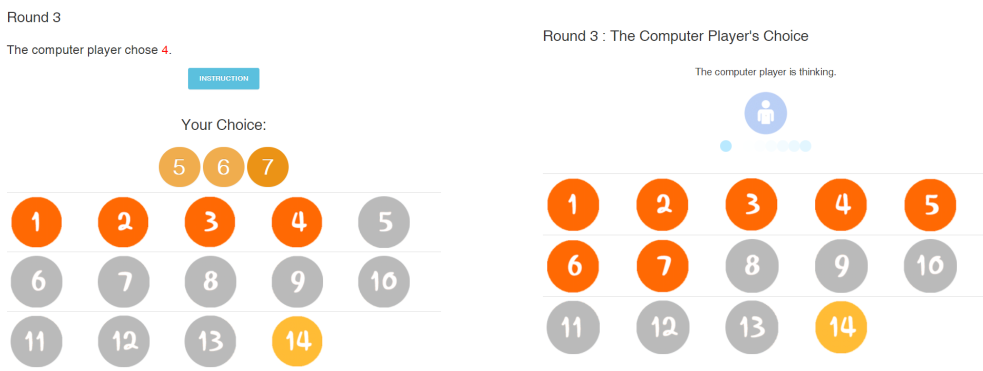


Figure A2: Lift game with target number 14



B The Distributions of Strategic Thinking Skills by Gender

Table A1: Distribution of the HOR scores by gender

Panel A: Male							
Data	Min	10th	25th	50th	75th	90th	Max
SLP	26.1	37.5	41.2	49.0	65.4	68.6	72.6
KLIPS	21.5	37.2	40.3	48.3	56.5	64.5	66.7
Panel B: Female							
Data	Min	10th	25th	50th	75th	90th	Max
SLP	23.9	38.1	41.6	50.0	66.1	68.6	72.6
KLIPS	21.5	35.7	39.7	46.9	53.1	65.3	67.6

Table A2: Distribution of the BI score by gender

Score	1	2	3	4	5
Panel A: Male					
SLP	40.7%	33.9%	21.5%	2.0%	1.9%
KLIPS	38.9%	36.5%	18.0%	2.8%	3.9%
Panel B: Female					
SLP	42.7%	35.9%	17.6%	2.1%	1.7%
KLIPS	41.0%	37.0%	17.2%	0.7%	4.0%

C SLP Summary Statistics

Table A3: SLP sample characteristics by participation status

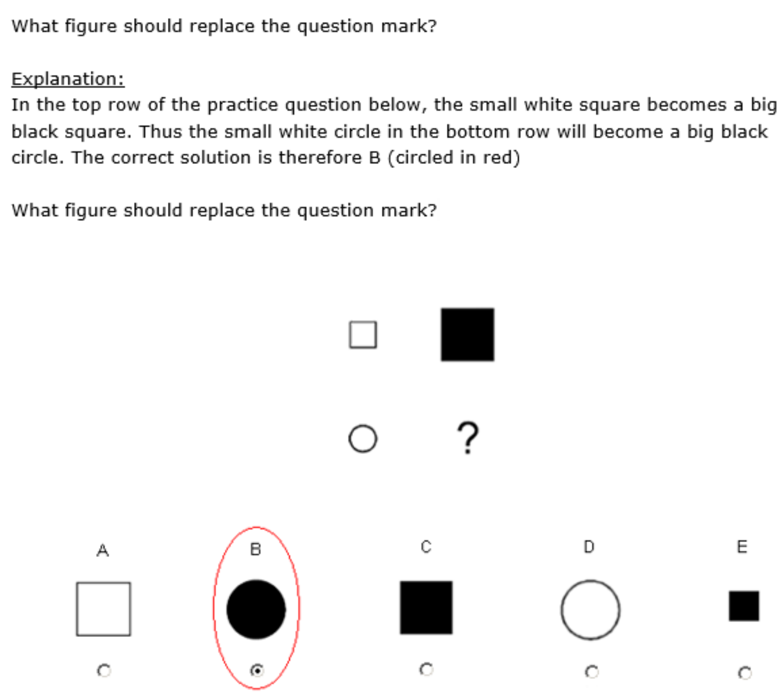
	(1) Participants Mean (SD)	(2) Dropouts Mean (SD)	(3) Nonparticipants Mean (SD)
Age	58.5	58.5	58.3
	(3.62)	(3.54)	(3.63)
Male	0.49	0.46	0.48
	(0.50)	(0.50)	(0.50)
Chinese	0.91	0.86	0.87
	(0.29)	(0.35)	(0.34)
Married	0.82	0.76	0.83
	(0.38)	(0.43)	(0.37)
Number of children	2.86	2.76	2.90
	(1.09)	(1.16)	(1.12)
Postsecondary education	0.45	0.45	0.36
	(0.50)	(0.50)	(0.48)
IST Score	10.8	9.23	9.47
	(4.08)	(4.15)	(4.14)
Financial planning horizon longer than the next 5 years	0.50	0.45	0.43
	(0.50)	(0.50)	(0.50)
Risk tolerance	3.72	3.73	3.35
	(2.47)	(2.43)	(2.42)
Self-efficacy	14.7	14.5	14.3
	(2.52)	(2.78)	(2.45)
Personal optimism	13.2	13.1	12.9
	(2.59)	(2.57)	(2.37)
Proportion (own annual labor income > 0)	0.70	0.70	0.70
	(0.46)	(0.46)	(0.46)
Own annual labor income (excl. zero's)	50,283	51,359	41,863
	(63824)	(70355)	(50680)
Own annual labor income (incl. zero's)	35,263	36,032	29,122
	(58,190)	(63,431)	(46,447)
Proportion (spouse's annual labor income > 0)	0.52	0.47	0.51
	(0.50)	(0.50)	(0.50)
Spouse's annual labor income (excl. zero's)	47,199	40,126	44,516
	(56,946)	(47,329)	(55,524)
Spouse's annual labor income (incl. zero's)	29,982	24,789	26,869
	(50,752)	(42,989)	(48,309)
Observations	2146	641	808

Notes: This table presents statistics based on cross-sectional data of different waves but mainly on the August 2017 survey. Monetary variables are in 2016 Singapore dollars.

D Data Appendix

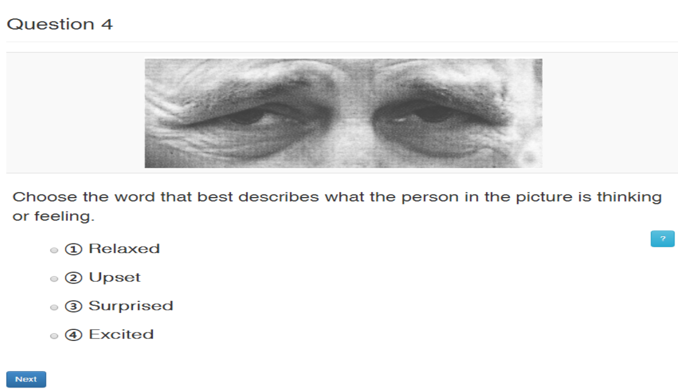
- Intelligence Structure Test
  - We use the Intelligence Structure Test (IST) as a measure of IQ. The IST is an internationally used, popular cognitive ability test originally developed by Beauducel et al. (2010). It is similar to the Raven's Matrices test in the sense that both tests use figural matrices to assess an individual's cognitive ability without requiring verbal intelligence.
  - There are 20 figural questions, each of which contains a matrix of abstract figures with a missing part. A participant needs to choose one of five figures presented to guess the missing part. A sample question is presented below in Figure A3.
  - The first version of the IST was developed in 1953 and has been regularly updated. The current English version we use is updated in 2000. We define the IST score as the number of correct answers to 20 questions. In our study, the experiment participants in Singapore scored 10.8 on average, with male respondents scoring 11.0 and female respondents scoring 10.6. According to the authors of the IST, the German sample participants scored 9.6 on average (Beauducel et al., 2010).

Figure A3: IST sample question



- Reading the Mind in the Eyes Test (Eyes Test)
  - This test was originally developed by Simon Baron-Cohen and his research team as "a test of how well the participant can put themselves into the mind of the other person, and tune in to their mental state" (Baron-Cohen et al., 2001). They find that individuals with autism or Asperger syndrome perform significantly worse than others in this test. Figure A4 presents a sample question. In the original version of the Eyes Test, there are 36 questions. Each question shows a picture of human eyes area and asks the respondent to choose the word that best describes what the person in the picture is thinking or feeling. We use a simpler version of the test, often used for children in the literature, that has 28 questions only and uses easier vocabulary for the descriptions of possible mental states in each picture following the recommendation of Olderbak et al. (2015).

Figure A4: Reading the mind in the Eyes Test – sample question



  - We implemented the Eyes Test in both the SLP and the KLIPS. We obtained a well-shaped empirical distribution presented in Table A4, with a mean score of 19.8 and a standard deviation of 3.46 in the SLP sample and a mean score of 19.3 and a standard deviation of 4.01 in the KLIPS sample. The mean Eyes Test scores of the SLP and KLIPS samples are similar to that of the adult sample in the original study (Baron-Cohen et al., 2001) after adjusting for the number of questions. Most studies of the Eyes Test in psychology were conducted on a small number of nonrepresentative samples with sample sizes smaller than 100 individuals. To our knowledge, this study is the first to implement the Eyes Test in a large-scale survey of a nationally representative population of over 2,000 individuals. We find little gender differences in the average Eyes test score.

Table A4: Distribution of the Eyes Test score

Data	Min	10th	25th	50th	75th	90th	Max
SLP	3	15	18	20	22	24	28
KLIPS	3	14	17	20	22	24	27

- Time Horizon for Financial Planning
  - We measure the time horizon for financial planning using a response to the following question.
    - * *In planning your (family's) saving and spending, which of the following time periods is most important to [you / you and your spouse]?*
      1. the next few months
      2. the next year
      3. the next few years
      4. the next 5-10 years
      5. longer than 10 years
- Risk Tolerance
  - We use a subjective response to the following question as a measure of risk tolerance.
    - * *Are you generally a person who tries to avoid taking risks or one who is fully prepared to take risks? Please rate yourself from 0 to 10, where 0 means 'not at all willing to take risks' and 10 means 'very willing to take risks'.*
- Personal Optimism and Self-efficacy
  - Personal optimism is defined as a person's expectation that outcomes will be positive regardless of what caused a problem or a situation. Self-efficacy is a positive belief that a person is able to solve the problem (Gavrilov-jerkovic et al., 2014). To measure personal optimism and self-efficacy, we use the abridged version of *the Questionnaire for the Assessment of Personal Optimism and Social Optimism - Extended* (POSO-E). The POSO-E is originally developed by Schweizer and Koch (2001). We use a shortened version of the POSO-E scales by Gavrilov-jerkovic et al. (2014). The scales are based on subjective responses to the following 8 items. A respondent can rate how agreeable s/he is on a scale of 1 to 5, where 1 indicates strongly disagree and 5 indicates strongly agree.

1. For each problem I will find a solution.
2. In difficult situations I will find a way.
3. I am facing my future in an optimistic way.
4. I can hardly think of something positive in the future.*
5. I can master difficulties.
6. I worry about my future.*
7. I always find a solution to a problem.
8. It often seems to me that everything is gloomy.*

- Items 1, 2, 5, and 7 reflect self-efficacy. Items 3, 4, 6, and 8 reflect personal optimism. * indicates reverse-coded items.

E Summary Statistics of the KLIPS Sample

Our baseline sample is 50–65 years old Singaporeans. Hence, it would be useful to check whether our findings on the strategic thinking skill measures can be externally validated in other countries and other age groups. We implemented the same survey experiments on a randomly chosen small sample of the Korea Labor Income Panel Study (KLIPS), which surveys a nationally representative sample of urban Korean households.[27] Thus, it provides an opportunity to test whether the observed patterns of strategic thinking skills from the SLP sample are similar in other countries and other age groups. Table A5 reports the summary statistics of the KLIPS sample.

Table A5: Summary statistics of the KLIPS sample

Variable	Mean (SD)
Ages 30-39	0.24 (0.43)
Ages 40-49	0.33 (0.47)
Ages 50-59	0.19 (0.39)
Ages 60-69	0.10 (0.30)
Ages 70-79	0.03 (0.18)
Male	0.46 (0.50)
Married	0.88 (0.32)
Number of children	1.02 (0.99)
Postsecondary education	0.49 (0.50)
Risk Tolerance	4.03 (1.39)
Impulsivity	3.65 (1.44)
Big 5 Personality: Openness	12.49 (3.22)
Big 5 Personality: Conscientiousness	6.62 (2.81)
Big 5 Personality: Extraversion	6.37 (3.02)
Big 5 Personality: Agreeableness	6.31 (2.63)
Big 5 Personality: Neuroticism	12.07 (2.67)
Individual annual labor income	3752 (10358)
Spouse's annual labor income	3872 (14671)
Weekly hours of wage workers (weekly)	40.81 (9.08)
Hourly wages of wage workers	1.50 (1.29)
Observations	786

Notes: This table presents statistics based on cross-sectional data of different waves but mainly on Wave 25 (2017). Monetary variables are in 2015 10,000 Korean Won.

[27]The KLIPS can be roughly considered as the Korean version of the U.S. Panel Study of Income Dynamics (PSID). The details of the KLIPS can be found at https://www.kli.re.kr.

F Full Results of Annual Labor Income Regression

Tables A6 and A7 report the regression results reported in Table 4 with the coefficient estimates of all covariates, except for the experimental controls to save space. We acknowledge that the coefficient estimates of the education and cognitive ability variables reported are not statistically significantly estimated (except for the education dummy for females). However, as in the literature, we observe a large education-income gradient in the SLP data before controlling for individual characteristics. In addition, the magnitudes of the coefficient estimates are likely to be smaller than those estimated among prime-aged workers in other developed countries because our sample individuals are relatively older and thus the incremental impacts of additional education could have been dampened.

Table A6: Regression of male labor income (full results)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Inverse hyperbolic sine transformation of own annual labor income					
BI score	0.429***		0.375**		0.372**	
	(0.144)		(0.149)		(0.151)	
HOR Score (standardized)		0.681***		0.612**		0.580**
		(0.240)		(0.248)		(0.249)
Age 55-59	-0.195	-0.173	-0.152	-0.134	-0.164	-0.169
	(0.382)	(0.383)	(0.383)	(0.383)	(0.385)	(0.385)
Age 60-65	-1.261***	-1.252***	-1.198**	-1.196**	-1.104**	-1.195**
	(0.468)	(0.468)	(0.471)	(0.471)	(0.473)	(0.475)
Chinese	0.129	0.236	0.077	0.159	0.143	0.238
	(0.504)	(0.497)	(0.501)	(0.495)	(0.502)	(0.510)
Married	-1.216*	-1.228*	-1.258*	-1.279*	-1.132	-1.132
	(0.697)	(0.740)	(0.714)	(0.754)	(0.715)	(0.810)
Number of Children	-0.123	-0.100	-0.124	-0.104	-0.131	-0.086
	(0.145)	(0.146)	(0.146)	(0.146)	(0.146)	(0.147)
Spouse's age	-0.033	-0.035	-0.035	-0.037	-0.045	-0.041
	(0.032)	(0.032)	(0.031)	(0.032)	(0.031)	(0.032)
Missing spouse's age or nonmarried	-1.218	-1.122	-1.117	-1.035	-0.512	-0.611
	(1.646)	(1.670)	(1.635)	(1.659)	(1.626)	(1.705)
Tertiary education			0.264	0.232	0.152	0.136
			(0.299)	(0.297)	(0.303)	(0.303)
IST score			0.053	0.058	0.041	0.045
			(0.038)	(0.037)	(0.038)	(0.038)
Eyes Test Score (standardized)			-0.102	-0.172	-0.266	-0.176
			(0.367)	(0.371)	(0.368)	(0.375)
Financial planning horizon longer than the next 5 years					-0.142	-0.233
					(0.286)	(0.287)
Risk tolerance					0.059	0.058
					(0.063)	(0.063)
Self-efficacy					0.039	0.048
					(0.065)	(0.065)
Personal Optimism					0.056	0.051
					(0.065)	(0.065)
Constant	12.25***	12.36***	11.82***	11.92***	10.68***	11.21***
	(1.842)	(1.866)	(1.890)	(1.917)	(2.127)	(2.234)
Observations	1,044	1,044	1,044	1,044	1,044	1,044
R-squared	0.037	0.037	0.041	0.041	0.053	0.052

Notes: Standard errors are corrected for heteroskedasticity. ***, **, * denote $p<0.01$, $p<0.05$, $p<0.1$, respectively.

Table A7: Regression of female labor income (full results)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Inverse hyperbolic sine transformation of own annual labor income					
BI score	-0.367**		-0.462***		-0.473***	
	(0.179)		(0.176)		(0.182)	
HOR Score		0.257		-0.031		-0.006
		(0.285)		(0.289)		(0.289)
Age 55-59	-0.113	-0.078	-0.129	-0.106	-0.056	-0.012
	(0.399)	(0.398)	(0.392)	(0.392)	(0.393)	(0.393)
Age 60-65	-2.277***	-2.258***	-2.173***	-2.153***	-2.165***	-2.098***
	(0.473)	(0.473)	(0.463)	(0.463)	(0.465)	(0.464)
Chinese	1.720***	1.612***	1.893***	1.828***	1.906***	1.832***
	(0.592)	(0.600)	(0.559)	(0.570)	(0.562)	(0.580)
Married	-0.980	-1.045	-1.339	-1.405	-1.152	-1.227
	(0.859)	(0.860)	(0.863)	(0.868)	(0.843)	(0.837)
Number of Children	-0.056	-0.074	0.098	0.076	0.123	0.075
	(0.149)	(0.149)	(0.149)	(0.149)	(0.152)	(0.151)
Spouse's age	0.027	0.032	0.036	0.040	0.039	0.046
	(0.039)	(0.040)	(0.038)	(0.038)	(0.038)	(0.038)
Missing spouse's age or nonmarried	-0.912	-1.103	-1.523	-1.676	-1.515	-1.863
	(1.708)	(1.721)	(1.651)	(1.670)	(1.641)	(1.653)
Tertiary education			1.810***	1.841***	1.480***	1.535***
			(0.331)	(0.333)	(0.348)	(0.347)
IST score			0.060	0.042	0.044	0.028
			(0.039)	(0.039)	(0.039)	(0.039)
Eyes Test Score (standardized)			0.733*	0.652*	0.716*	0.599
			(0.377)	(0.380)	(0.378)	(0.383)
Financial planning horizon longer than the next 5 years					-0.084	-0.087
					(0.309)	(0.311)
Risk tolerance					0.151**	0.161**
					(0.065)	(0.065)
Self-efficacy					0.110	0.120*
					(0.071)	(0.072)
Personal Optimism					0.086	0.080
					(0.070)	(0.071)
Constant	5.231**	4.705*	2.810	2.526	-1.127	-1.649
	(2.566)	(2.578)	(2.527)	(2.539)	(2.793)	(2.804)
Observations	1,102	1,102	1,102	1,102	1,102	1,102
R-squared	0.052	0.049	0.088	0.082	0.103	0.100

Notes: Standard errors are corrected for heteroskedasticity. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively.

Table A8: Regression of individual labor income on both BI and HOR measures of strategic thinking skills

Variables	(1)	(2)	(3)
	IHS-transformed own annual labor income		
Panel A: Male			
BI score	0.372**		0.261*
	(0.151)		(0.158)
HOR score (standardized)		0.580**	0.486*
		(0.249)	(0.261)
Observations	1,044	1,044	1,044
R-squared	0.053	0.052	0.064
Panel B: Female			
BI score	-0.473***		-0.510***
	(0.182)		(0.189)
HOR score (standardized)		-0.006	0.226
		(0.289)	(0.297)
Observations	1,102	1,102	1,102
R-squared	0.103	0.100	0.110
Demographics	Yes	Yes	Yes
Education and cognitive skills	Yes	Yes	Yes
Noncognitive and preference traits	Yes	Yes	Yes

Notes: Standard errors are corrected for heteroskedasticity. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively. All columns demographic variables (age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, and the dummy variable reflecting a missing observation for spouse's age for single individuals), educational attainment, IST score, and Eyes Test score, noncognitive traits (financial planning time horizon, subjective risk tolerance, self-efficacy, personal optimism), time taken to complete corresponding tasks, the random order of the Line and Lift games.

G Quantile Regression Analysis of Annual Labor Income

Tables A9 and A10 report the coefficient estimates of respective male and female labor incomes across different quantiles of the distribution. The full set of control variables are included as in the mean regression analysis. Due to the significant sample size of zero labor income earners, we conduct the quantile regression analysis from the 20th percentile for male participants and from the 30th percentile for female participants.

Table A9: Quantile regression results of male labor income

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Percentile	10th	20th	30th	40th	50th	60th	70th	80th	90th
					Panel A				
BI score		0.696	0.243	0.185	0.128**	0.077*	0.037	0.046	0.028
		(0.543)	(0.218)	(0.113)	(0.050)	(0.043)	(0.032)	(0.039)	(0.034)
Observations		1,044	1,044	1,044	1,044	1,044	1,044	1,044	1,044
Pseudo R-squared		0.092	0.037	0.030	0.036	0.044	0.055	0.070	0.087
					Panel B				
HOR score (standardized)		1.175	0.940**	0.283*	0.141	0.155**	0.137**	0.149***	0.119**
		(0.928)	(0.390)	(0.170)	(0.089)	(0.064)	(0.062)	(0.052)	(0.050)
Observations		1,044	1,044	1,044	1,044	1,044	1,044	1,044	1,044
Pseudo R-squared		0.102	0.038	0.029	0.034	0.043	0.053	0.068	0.087

Notes: Heteroskedasticity-robust standard errors are reported in parentheses. The dependent variable is a respondent's own annual labor income transformed with the IHS function. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, the dummy variable reflecting a missing observation for spouse's age for single individuals, educational attainment, IST score, the Eyes Test score, financial planning time horizon, subjective risk tolerance, self-efficacy, personal optimism, and time taken to complete each task. Panels A and B include dummy variables for the random order of the Lift Game and the Line Game, respectively. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively. The coefficient estimates on the 10th percentile are missing due to the lack of variations in the dependent variable.

Table A10: Quantile regression results of female labor income

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Percentile	10th	20th	30th	40th	50th	60th	70th	80th	90th
					Panel A				
BI score			-0.826**	-0.758**	-0.371	-0.145	-0.112	-0.118**	-0.107*
			(0.407)	(0.297)	(0.259)	(0.109)	(0.075)	(0.050)	(0.058)
Observations			1,102	1,102	1,102	1,102	1,102	1,102	1,102
Pseudo R-squared			0.095	0.141	0.068	0.048	0.048	0.051	0.061
					Panel B				
HOR score (standardized)			0.027	0.085	0.062	0.039	-0.036	-0.248***	-0.082
			(0.443)	(0.365)	(0.331)	(0.173)	(0.130)	(0.088)	(0.063)
Observations			1,102	1,102	1,102	1,102	1,102	1,102	1,102
Pseudo R-squared			0.068	0.138	0.067	0.048	0.048	0.049	0.060

Notes: Heteroskedasticity-robust standard errors are reported in parentheses. The dependent variable is a respondent's own annual labor income transformed with the IHS function. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, the dummy variable reflecting a missing observation for spouse's age for single individuals, educational attainment, IST score, the Eyes Test score, financial planning time horizon, risk tolerance, self-efficacy, personal optimism, and time taken to complete each task. Panels A and B include dummy variables for the random order of the Lift Game and the Line Game, respectively. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively. The coefficient estimates on the 10th and 20th percentiles are missing due to the lack of variation in the dependent variable.

H Evaluating Explanatory Power

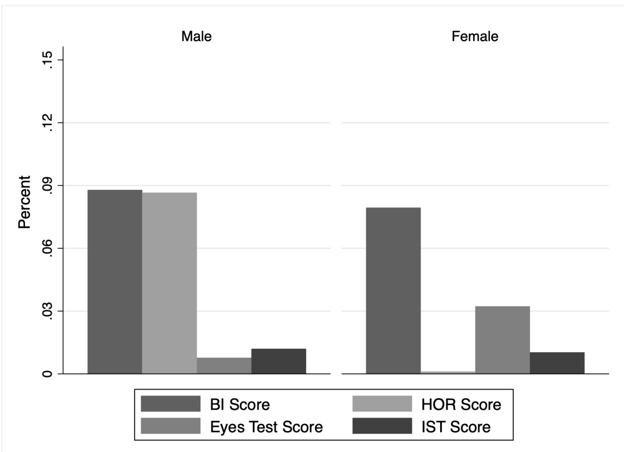
We investigate how much of the variation in labor market outcomes is explained by our measures of strategic thinking skills. First, we compute a partial R^2 of labor outcomes on our strategic thinking skill measures with the full set of control variables. We then normalize the variation in labor market outcome explained by each variable of interest by the total variation explained by the entire set of variables in this exercise. We also consider the cognitive ability measures (IST score and Eyes Test score) to compare with the explanatory power of the strategic thinking skill measures.

Figure A5 presents a graphical summary of the explanatory powers of the variables of interest for (a) individual labor income including zero-income earners, (b) individual labor income excluding zero-income earners, and (c) the proportion of individuals with a positive annual labor income.

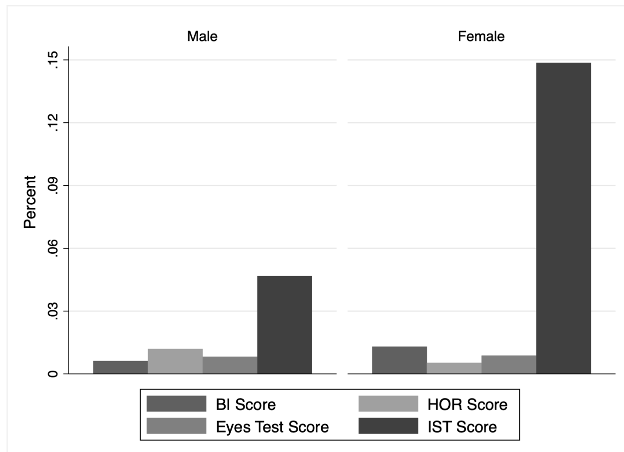
For male respondents, each of the BI and HOR scores contributes approximately 9 percent of the total explained variation in their own labor income (including the sample of zero-income earners), whereas the Eyes Test score and IST score contribute only marginally (Figure A5a). When we distinguish between the extensive margin and the intensive margin of labor supply for male respondents, we find that the relative explanatory power of the BI and HOR scores is mainly driven by their power to explain the variations in the extensive margin of labor supply (Figure A5c). Both the Eyes Test score and IST score have little explanatory power for the extensive margin. When we focus only on the sample of respondents who earned positive labor income, however, strategic thinking skills contribute less than cognitive ability measured by the IST score (Figure A5b).

Figure A5: Comparing explanatory power for individual labor market outcomes

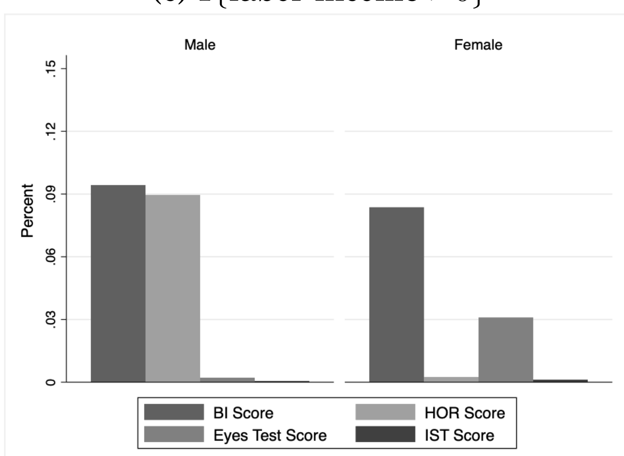
(a) Annual labor income (incl. 0s)



(b) Annual labor income (excl. 0s)



(c) $1\{\text{labor income} > 0\}$

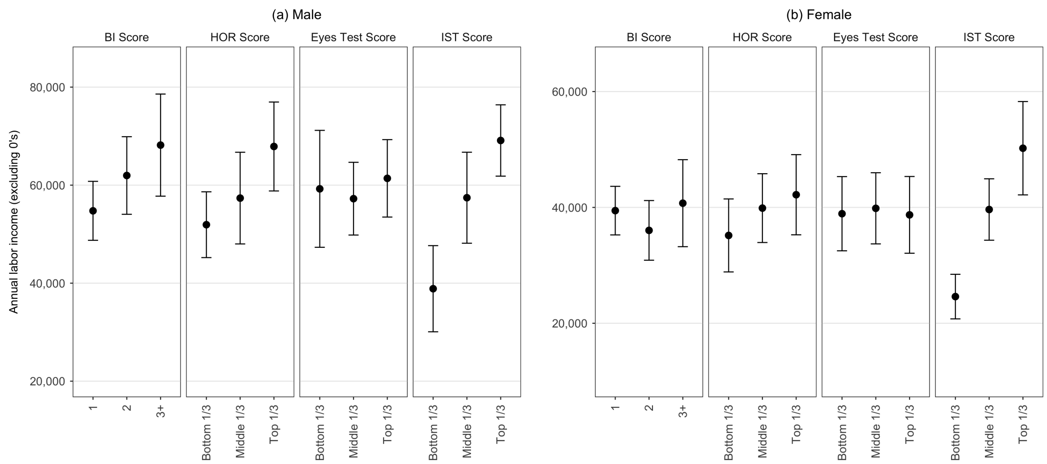


For female respondents, the BI score contributes the most, approximately 8 percent, to the total explained variation in their own labor income (including the sample of zero-income earners), while the Eyes Test score contributes approximately 3 percent (Figure A5a). The explanatory power of these two measures originates mostly from their ability to explain the extensive margin of the female labor supply (Figure A5c). The IST score has substantial explanatory power in explaining the variation in labor income when the sample of zero-income earners is excluded (Figure A5b).

I Intensive Margin Analysis of Annual Labor Income

Figure A6 presents the mean and the 95 percent confidence intervals of annual labor income by gender conditional on positive labor income.

Figure A6: Labor income (excluding 0s) by strategic thinking skill measures



Notes: Dots represent the average annual labor income of the SLP sample respondents conditional on positive incomes. Caps represent upper and lower bounds of the 95 percent confidence intervals.

Table A11 presents the regression results that estimate the relationship between strategic thinking skills and annual labor income conditional on positive income.

Table A11: Regression of annual labor income (excl. 0s)

	(1)	(2)	(3)	(4)
	Male		Female	
BI score	0.057		-0.075	
	(0.046)		(0.057)	
HOR score (standardized)		0.094		-0.065
		(0.077)		(0.103)
Observations	826	826	679	679
R-squared	0.169	0.172	0.172	0.166

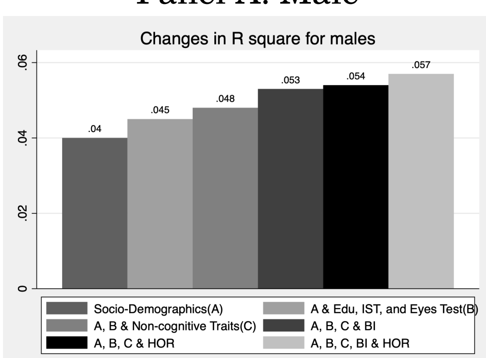
Notes: Standard errors corrected for heteroskedasticity are reported in parentheses. The dependent variable is a respondent's own annual labor income transformed with the IHS function excluding 0s. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, and the dummy variable reflecting a missing observation for spouse's age for single individuals, education attainment, IST score, and Eyes Test score, financial planning, risk tolerance, self-efficacy, and personal optimism, and time taken to complete each task. Odd-numbered and even-numbered columns include dummy variables for the random orders of the Lift Game and the Line Game, respectively. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively.

J Comparing Explanatory Power

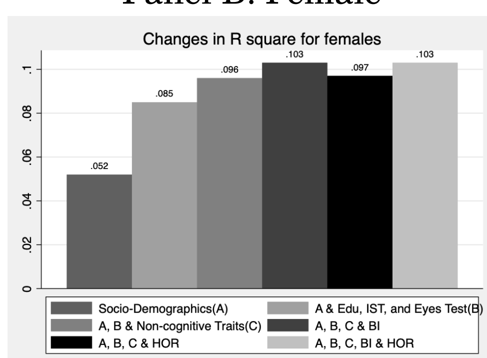
Figure A7 shows how R^2 changes for the regression of individual annual labor income when we use different sets of regressors.

Figure A7: Changes in R^2 by the choice of regressors

Panel A: Male



Panel B: Female



K Model

We propose a model of household labor supply to account for the key empirical findings found in this paper, built upon the literature on collective labor supply with household production and workplace production (e.g., Apps and Rees, 1997; Chiappori, 1997). Our main innovation is to introduce two additional features to standard models in the literature as follows. First, we add individual heterogeneity in productivity over two tasks of production to consider the possibility of intrahousehold task specialization according to comparative advantage. Second, we assume positive home-to-workplace spillover and introduce strategic thinking skills as the means of facilitating better coordination for home-to-workplace spillover.

A household consists of two individuals, $i = 1, 2$, who achieve a Pareto-efficient resource allocation. We define three goods as follows: a composite market consumption good, x, with the price set to be 1; a nonmarketable domestically produced good or simply a domestic good, y; a marketable good g, the source of the labor income with the market wage w.[28]

We assume that individuals are heterogenous with respect to their productivity in producing domestic goods and marketable goods and to the way they generate the home-to-workplace spillover. Precisely, each individual i is characterized by three skill parameters: $s_i \in (0, 1)$ refers to the strategic thinking skill; $\alpha_i > 0$ refers to the productivity parameter for the domestic good production; and $\beta_i > 0$ refers to the productivity parameter for the marketable good production. Let t_i denote time spent in domestic production and l_i denote market labor supply.[29] The household domestic production function is

$$y_i(t_i) = \alpha_i t_i. \tag{K.1}$$

The domestic good increases the productivity of the marketable good production.[30] It is not difficult to imagine that better quality of meals, of children, prestige, recreation, companionship, love, and health status would create positive home-to-workplace spillover (see, e.g., Barnett, 1994; Barnett and Marshall, 1992a,b; Kirchmeyer, 1992). More precisely, the marketable good production

[28]The domestic good essentially captures an aggregation of numerous household-produced commodities such as "the quality of meals, the quality and quantity of children, prestige, recreation, companionship, love, and health status" (pp. 816, Becker, 1973).

[29]To focus on the household decision problem of allocating their time resource to domestic good production and marketable good production, we exclude pure leisure.

[30]It may be more realistic to assume that a domestic good may not only be a source of the positive home-to-workplace spillover but also directly increase utilities of the household members who consume it. We simplify our model by focusing on the role of domestic good production in a positive home-to-workplace spillover and do not pay attention to its role in generating consumption utility. However, incorporating the consumption utility of a domestic good neither 1) affects the qualitative conclusion of the model that intrahousehold task specialization is more likely to take place when the household members have higher strategic thinking skills nor 2) provides any new insight on intrahousehold task specialization and collective labor supply decision.

function is

$$g_i(t_i, t_j; s_i, s_j) = [y_i(t_i) + s(s_i, s_j)y_j(t_j)]\beta_i l_i, \quad \text{for } i \neq j. \tag{K.2}$$

The production function (K.2) captures two important aspects of intrahousehold production with positive home-to-workplace spillover. The first term of (K.2), $y_i(t_i)\beta_i l_i$, reflects the complementary nature of one's own nonmarketable domestic good production in producing the marketable good. The second term, $sy_j(t_j)\beta_i l_i$, reveals that such complementarity still exists between member j's nonmarketable good production in member i's marketable good production, but achieving the complementarity gain requires coordination between the two household members. $s(s_1, s_2) \geq 0$ is a multiplier that is applied proportionately, where $s(\cdot,\cdot)$ is increasing in both components. Thus, it captures that strategic thinking skills facilitate coordination between the household members and create a larger degree of home-to-workplace spillover. It is a natural adoption of the production function introduced in the literature on task allocation in the workplace (e.g., Autor et al., 2003; Acemoglu and Autor, 2011; Autor and Handel, 2013; Deming, 2017).

Individuals have strictly quasi-concave, increasing, and twice-differentiable utilities $u^i(x_i)$, $i = 1, 2$. For simplicity, we consider the competitive labor market in which identical firms each hire a worker and pay market wages that are equal to output g_i times an exogenous output price normalized to be 1, i.e., $w_i = g_i/l_i$. Then, the problem for the household is

$$\begin{aligned}
\max_{t_1, t_2} u^1 \quad \text{subject to} \quad & u^2 \geq u_0^2, \\
& \sum x_i \leq \sum (w_i l_i + m_i), \\
& y_i = \alpha_i t_i, i = 1, 2 \\
& g_i = (y_i + sy_j)\beta_i l_i, i \neq j \text{ and } i = 1, 2 \\
& l_i + t_i = 1, i = 1, 2 \\
& l_i \geq 0, t_i \geq 0, i = 1, 2 \\
& w_i = g_i/l_i, i = 1, 2.
\end{aligned}$$

where m_i refers to the exogenously given nonlabor income.

The individual heterogeneity we introduced, together with the assumption that individuals pursue the Pareto-efficient resource allocation, implies that the above household optimization problem may have a corner solution; i.e., household members want to specialize in the production of goods in which they have a comparative advantage. To visualize this, assume without loss of generality that individual 1 has a comparative advantage in producing the marketable good, i.e., $\beta_1/\beta_2 > \alpha_1/\alpha_2$. The utility benefit of specialization comes from relaxing the budget constraint achieved by higher total household income. Thus, the above optimization problem boils down to maximizing the total household labor income. It is easy to verify that the total household labor income

$$\sum_{i=1,2} g_i = (\alpha_1 t_1 + s\alpha_2 t_2)\beta_1(1-t_1) + (\alpha_2 t_2 + s\alpha_1 t_1)\beta_2(1-t_2) \tag{K.3}$$

is strictly concave in both t_1 and t_2. Then, the perfect specialization with $(t_1 = 0, t_2 = 1)$ is optimal if and only if $\frac{\partial \sum g_i}{\partial t_1}|_{t_1=0,t_2=1} \leq 0$ and $\frac{\partial \sum g_i}{\partial t_2}|_{t_1=0,t_2=1} \geq 0$ or, equivalently,

$$s \geq \max(\frac{\alpha_1}{\alpha_2}, \frac{\beta_2}{\beta_1}) := s^*. \tag{K.4}$$

The following proposition summarizes this finding.[31]

Proposition 1 (Extensive Margin of Labor Supply). *Perfect specialization is optimal for any household with $s > s^*$. In this case, only one member of the household who has a comparative advantage on the marketable good production participates in the labor market.*

From equation (K.3), it is straightforward to show that the household member i's labor income strictly increases in both s_i and s_j, and it is still true even when the perfect specialization takes place. Thus, we have our next proposition as follows.

Proposition 2 (Household-level, Gender-independent Positive Associations). *Conditional on intrahousehold task specialization, the labor income of the household member who has comparative advantage on the marketable good production, or equivalently household labor income, increases not only in his own but also in his spouse's strategic thinking skills.*

It is noteworthy that the predictions presented in Propositions 1 and 2 are derived without making any assumption on the distributions of the primitives. We now introduce an assumption on a joint distribution of the individual productivity parameters to obtain our next result about the gender-specific association between strategic thinking skills and labor supply. Let $C_d := \frac{\alpha_2\beta_1}{\alpha_1\beta_2}$ denote a household d's comparative advantage schedule. If $C_d > 1$, member 1 in the household d has a comparative advantage on the marketable good production. Assume that C_d is distributed over $[0, \infty)$ where its *median*, denoted by $M(C_d)$, is larger than 1. This assumption ensures that the majority of households engaging in task specialization have a member 1 specializing in marketable good production and a member 2 specializing in nonmarketable good production.

While the model is silent on which gender specializes in marketable and nonmarketable goods productions, our data show that the male labor supply is the primary source of labor income in

[31] $s^* \leq 1$ iff $\frac{\beta_1}{\beta_2} \geq 1 \geq \frac{\alpha_1}{\alpha_2}$, i.e., when no household member has absolute advantage on both marketable good production and domestic good production.

many households. This pattern is consistent with the literature reporting that the gender gap in labor market participation remains globally persistent (Goldin, 1990; International Labour Organisation (ILO), 2018). The literature identified various factors including cultural norms as a main contributor to the observed gender gap (e.g., Attanasio et al., 2008; Albanesi and Olivetti, 2016; Fortin, 2005; Giuliano, 2020). We would like to emphasize that it is not the main objective of the current paper to examine and/or identify the exact sources of the observed gender gap. Instead, taking the gender gap as given, we are interested in establishing gender-dependent associations between strategic thinking skills and labor market outcomes and argue that these associations are the outcomes of intrahousehold task specialization pursuing efficient allocation.[32]

To link the model with the data, it is natural to interpret each member's role in the model as representing each gender. First, member 1 is more likely to participate in the labor market if s_1 is higher and member 2 is less likely to participate if s_2 is higher. This is because as s_1 increases, the household is more likely to have task specialization in which case member 1 is more likely to specialize in marketable good production. Second, a positive association between member 1's own strategic thinking skill and his labor income is predicted. The positive association is stronger when his own or spouse's strategic thinking skill is higher. However, a negative association between member 2's own strategic thinking skill and her labor income is predicted. The negative association is stronger when her own or spouse's strategic thinking skill is higher. These results are summarized in the following proposition whose proof is straightforward and thus omitted.

Proposition 3 (Individual-level, Gender-dependent Associations). *Suppose* $M(C_d) > 1$. *Then*

(a) Member 1 *is more likely to participate in the labor market if* s_1 *is higher and member 2 is less likely to participate if* s_2 *is higher.*

(b) A positive association between member 1*'s own strategic thinking skill and his labor income is predicted. The positive association becomes stronger as his own strategic thinking skill is higher and his spouse's strategic thinking skill is higher.*

(c) A negative association between member 2*'s own strategic thinking skill and her labor income is predicted. The negative association becomes stronger as her own strategic thinking skill is higher and her spouse's strategic thinking skill is higher.*

Our collective model of labor supply presents the first systematic channel in the literature

[32] We do not explicitly model various sources of gender gaps including gender norms found in the literature. However, all qualitative predictions of our model are robust to introducing such sources as gender norms to affect household labor supply decisions because 1) the results presented in Propositions 1 and 2 hold irrespective of the distributions of the primitives and 2) the results in Proposition 3 still hold when one takes the labor supply decisions as given.

through which a non-market-participating household member contributes to household labor income. The degree of positive home-to-workplace spillover is the key determinant of the household labor supply decision, which is substantially affected by both household members' strategic thinking skills. Our experimental result provides strong supporting evidence for this channel. First, in line with Proposition 2, both married males' and females' strategic thinking skills are positively associated with their household labor income. Second, consistent with Proposition 3, males' strategic thinking skills are positively associated with their individual labor income and negatively associated with the likelihood of being retired; females' strategic thinking skills are negatively associated with their individual labor income and positively associated with the likelihood of being homemakers. Third, as reported in Table 6, we also found that married, non-market-participating females' strategic thinking skills are positively associated with household labor income. Fourth, as reported in Appendix N, females' strategic thinking skills are positively associated with their spouses' individual labor income. This finding suggests that a higher labor income that a market-participating household member receives is driven not only by his/her own human capital facilitating workplace performance but also by positive home-to-household spillover induced by greater strategic thinking skills of both household members.

L Alternative Measures of Strategic Thinking Skills

Table A12: Regression of household labor income on alternative strategic thinking skills

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	Male				Female				Non-working Female			
BI score = 1	-0.195				-0.615*				0.082			
	(0.316)				(0.346)				(0.675)			
BI score = 2+	0.000				0.295				1.927**			
	(0.327)				(0.354)				(0.807)			
BI counting score		0.068				0.138				0.720**		
		(0.129)				(0.137)				(0.318)		
HOR score: mid 1/3			0.161				0.769**				0.890	
			(0.333)				(0.380)				(0.701)	
HOR score: top 1/3			0.779**				0.900**				1.803***	
			(0.307)				(0.364)				(0.689)	
HOR order				0.207***				0.154*				0.410**
				(0.067)				(0.084)				(0.172)
Observations	938	938	938	938	822	822	822	822	338	338	338	338
R-squared	0.048	0.047	0.054	0.055	0.154	0.148	0.152	0.147	0.211	0.203	0.205	0.203

Notes: Standard errors corrected for heteroskedasticity are reported in parentheses. The dependent variable is a respondent's own annual labor income transformed with the IHS function. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, the dummy variable reflecting a missing observation for spouse's age for single individuals, education attainment, IST score, Eyes Test score, financial planning, risk tolerance, self-efficacy, personal optimism, and time taken to complete each task. Columns (1), (2), (5), and (6) include dummy variables for the random order of the Lift Game. Columns (3), (4), (7), and (8) include dummy variables for the random order of the Line Game. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively.

M Additional Results for the Pooled Regression of Multiyear Annual Labor Income

Table A13: Pooled Regression of Household Labor Income on married respondents' Strategic Thinking Skills

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Male		Female		Non-working Female	
BI score	0.156		0.028		0.617**	
	(0.102)		(0.118)		(0.256)	
HOR score (standardized)		0.375***		0.290**		0.485**
		(0.106)		(0.120)		(0.230)
Observations	2782	2782	2461	2461	1011	1011
R-squared	0.051	0.058	0.148	0.148	0.191	0.192

Notes: Standard errors clustered at the respondent level are reported in parentheses. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, and the dummy variable reflecting a missing observation for spouse's age for single individuals, education attainment, IST score, Eyes Test score, financial planning time horizon, subjective risk tolerance, self-efficacy, personal optimism, and the time taken to complete each task. Odd-numbered and even-numbered columns include dummy variables for the random orders of the Lift Game and the Line Game, respectively. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively.

Table A14: Pooled regression results for multiyear annual labor income

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep. Var: Annual labor incomes (excl. 0s)				Dep. Var: I (Annual labor income > 0)			
	Male		Female		Male		Female	
BI score	0.056		-0.071		0.028**		-0.038**	
	(0.037)		(0.048)		(0.012)		(0.015)	
HOR score (standardized)		0.058		-0.148*		0.043**		0.006
		(0.061)		(0.079)		0.020)		(0.024)
Observations	2,414	2,414	2,414	2,414	3,089	3,089	3,278	3,278
R-squared	0.192	0.194	0.172	0.170	0.040	0.039	0.071	0.070

Notes: Standard errors clustered at the respondent level are reported in parentheses. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, and the dummy variable reflecting a missing observation for spouse's age for single individuals, education attainment, IST score, Eyes Test score, financial planning, risk tolerance, self-efficacy, and personal optimism, and time taken to complete each task. Odd-numbered and even-numbered columns include dummy variables for the random orders of the Lift Game and the Line Game, respectively. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively.

N Spouse's Labor Income

We first investigate whether there is any linkage between male labor income and their wives' strategic thinking skills. While identifying the exact channels for this relationship goes beyond the scope of this paper, a variety of interpersonal interactions can contribute to this potential linkage, including partner matching, intrahousehold labor supply decisions, and spillover/crossover between home and work (e.g., Bolger, DeLongis, Kessler, and Wethington, 1989; Barnett and Marshall, 1992a; Barnett, Marshall, and Sayer, 1992). For female participants, we find that a one-level increase in their BI score and a one-SD increase in their HOR score are robustly associated with respective 39 percent and 75 percent *increases* in their husbands' labor income.

Wife's strategic thinking skills. We next evaluate the relationship between male labor income and the wife's strategic thinking skills. This relationship can be shaped through a variety of channels, including marriage matching and spillover/crossover between home and workplace (e.g., Bolger, DeLongis, Kessler, and Wethington, 1989; Barnett and Marshall, 1992a; Barnett, Marshall, and Sayer, 1992). We cannot disentangle those underlying channels due to the lack of data. However, we aim to establish robust associations between an individual's strategic thinking skills and the spouse's labor outcome.

Table A15 reports the regression results of the IHS-transformed annual labor income of female respondents' husbands on female respondents' strategic thinking skill measures. The sample size decreased to 822 after excluding 208 female respondents who were not married at the time of our study due to never marrying, divorce, or bereavement.

In columns (1)–(2), our measures of the strategic thinking skills of female respondents are all positively correlated with their husbands' annual labor income. We find that a one-level increase in a female respondent's BI score is associated with a 49.9 percent higher annual labor income for her husband. Similarly, a one-SD increase in a female respondent's HOR score is associated with a 90.5 percent increase in her husband's annual labor income. The coefficient estimates are statistically significant at the 1 percent level.

The positive correlation between each of a female respondent's strategic thinking skills and her husband's labor income is robust to the inclusion of additional controls for educational attainment, IST score, Eyes Test score, and noncognitive and preference traits. In columns (5) and (6) with the full set of controls, the point estimates indicate that a one-level increase in a female respondent's BI score is related to a 36.2 percent higher annual labor income for her husband, and a one-SD increase in her HOR score is associated with a 70.6 percent increase in her husband's annual labor income. Both estimates are statistically significant at the 1 percent level.

Table A15: Regression of male labor income based on their wife's strategic thinking skills

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Dep. Var: IHS transformation of annual labor income					
BI score	0.499***		0.380**		0.362**	
	(0.173)		(0.176)		(0.180)	
HOR score (standardized)		0.905***		0.685**		0.706**
		(0.303)		(0.307)		(0.311)
Demographics	Yes	Yes	Yes	Yes	Yes	Yes
Education and cognitive ability	No	No	Yes	Yes	Yes	Yes
Noncognitive and preference traits	No	No	No	No	Yes	Yes
Observations	822	822	822	822	822	822
R-squared	0.116	0.118	0.127	0.128	0.145	0.143

Notes: Standard errors are corrected for heteroskedasticity. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively. Columns (1)–(2) include only demographic variables: age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, and the dummy variable reflecting a missing observation for spouse's age for single individuals. Columns (3)–(4) additionally control for educational attainment, IST score, Eyes Test score. Columns (5)–(6) additionally control for noncognitive traits such as financial planning, risk tolerance, self-efficacy, personal optimism, and time taken to complete a corresponding task. Odd-numbered and even-numbered columns include dummy variables for the random orders of the Lift Game and the Line Game, respectively.

Husband's strategic thinking skills. Table A16 reports the regression results for IHS-transformed female labor income on their husbands' strategic thinking skills. In this analysis, we excluded 106 male respondents who were not married. Columns (1)–(2) show that the coefficient estimates on the BI score and the HOR score are not statistically significant and remain so after controlling for additional characteristics in columns (3)–(6).

Spouse's labor supply. Table A17 reports the regression results of spouse's labor supply status

Table A16: Regression of female labor income based on their husband's strategic thinking skills

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Dep. Var: IHS transformation of annual labor income					
BI score	-0.019		-0.123		-0.122	
	(0.186)		(0.193)		(0.196)	
HOR score (standardized)		0.460		0.300		0.231
		(0.300)		(0.312)		(0.314)
Demographics	Yes	Yes	Yes	Yes	Yes	Yes
Education and cognitive ability	No	No	Yes	Yes	Yes	Yes
Noncognitive and preference traits	No	No	No	No	Yes	Yes
Observations	938	938	938	938	938	938
R-squared	0.021	0.023	0.028	0.029	0.039	0.045

Notes: Standard errors are corrected for heteroskedasticity. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively. Columns (1)–(2) include only demographic variables: age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, and the dummy variable reflecting a missing observation for spouse's age for single individuals. Columns (3)–(4) additionally control for educational attainment, IST score, Eyes Test score. Columns (5)–(6) additionally control for noncognitive traits such as financial planning, risk tolerance, self-efficacy, personal optimism, and time taken to complete a corresponding task. Odd-numbered and even-numbered columns include dummy variables for the random orders of the Lift Game and the Line Game, respectively.

on respondents' strategic thinking skills by gender. The dependent variable takes the value of 1 if the spouse's annual labor income is positive and 0 otherwise.

Table A17: Regression results for the spouse's labor supply by gender

Variables	(1)	(2)	(3)	(4)
	Dep. Var: I (Annual spouse labor income > 0)			
	Male		Female	
BI score	-0.013		0.031*	
	(0.018)		(0.016)	
HOR score (standardized)		0.012		0.062**
		(0.029)		(0.028)
Observations	938	938	822	822
R-squared	0.041	0.045	0.112	0.109

Notes: Standard errors corrected for heteroskedasticity are reported in parentheses. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, the dummy variable reflecting a missing observation for spouse's age for single individuals, education attainment, IST score, Eyes Test score, financial planning, risk tolerance, self-efficacy, personal optimism, and time taken to complete each task. Odd-numbered and even-numbered columns include dummy variables for the random orders of the Lift Game and the Line Game, respectively. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively.

For male respondents, the measures of strategic thinking skills reported in columns (1) and (2) are not significantly associated with a wife's extensive margin labor supply decision. In contrast, for female respondents, columns (3)–(4) report that female respondents with higher values for the BI and HOR scores are associated with higher probabilities of having a husband who earns a positive annual labor income. The results reported in this subsection are consistent with the findings in Tables A15 and A16.

O Potential Channels

Table A18: Regression results for the occupation choice and social skill requirement

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Manager, professional, service or sales				Score of social skill requirements			
	Male		Female		Male		Female	
BI score	-0.017		-0.030		-0.029		-0.029	
	(0.024)		(0.026)		(0.020)		(0.024)	
HOR score (standardized)		-0.003		-0.030		0.039		-0.009
		(0.037)		(0.045)		(0.033)		(0.039)
Observations	616	616	553	553	630	630	583	583
R-squared	0.153	0.152	0.192	0.191	0.153	0.152	0.052	0.050

Notes: Standard errors clustered at the respondent level are reported in parentheses. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, and the dummy variable reflecting a missing observation for spouse's age for single individuals, education attainment, IST score, Eyes Test score, financial planning, risk tolerance, self-efficacy, and personal optimism, and time taken to complete each task. Odd-numbered and even-numbered columns include dummy variables for the random orders of the Lift Game and the Line Game, respectively. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively.

For male respondents, the measures of strategic thinking skills reported in columns (1) and (2) are not significantly associated with a wife's extensive margin labor supply decision. In contrast, for female respondents, columns (3)–(4) report that female respondents with higher values for the BI and HOR scores are associated with higher probabilities of having a husband who earns a positive annual labor income. The results reported in this subsection are consistent with the findings in Tables A15 and A16.

Table A19: Regression results for household income on the couple's strategic thinking skills

Variables	(1)	(2)
	Dep. Var: IHS transformation of annual household labor income	
Wife's BI score	0.033	
	(0.128)	
Wife's HOR score (standardized)		0.215*
		(0.127)
Observations	138	138
R-squared	0.301	0.306

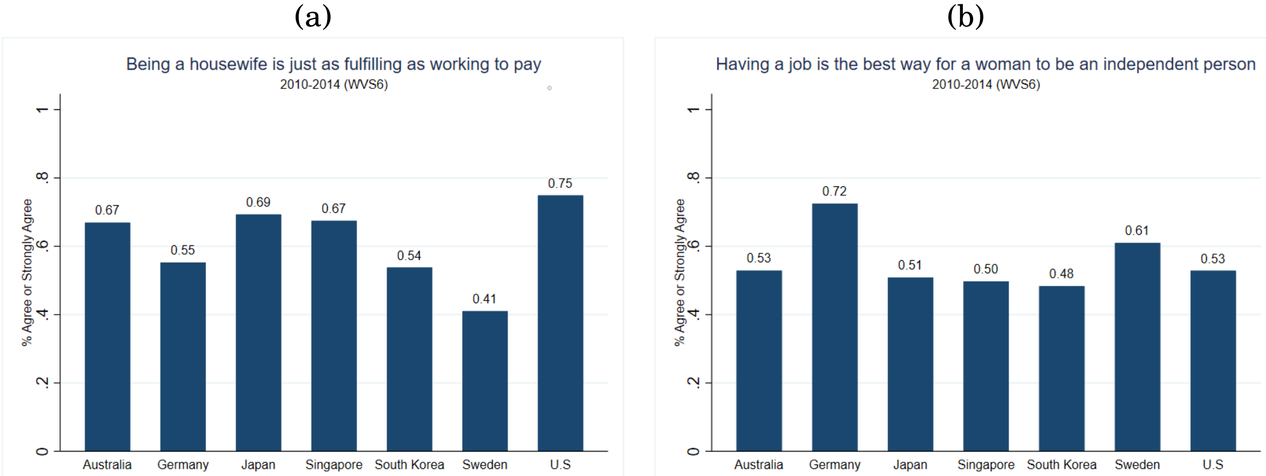
Notes: Standard errors corrected for heteroskedasticity are reported in parentheses. All columns include age group dummies, the ethnic Chinese dummy, marital status, number of children, spouse's age, the dummy variable reflecting a missing observation for spouse's age for single individuals, education attainment, IST score, Eyes Test score, financial planning, risk tolerance, self-efficacy, personal optimism, and time taken to complete each task. Columns (1) and (2) include dummy variables for the random orders of the Lift Game and the Line Game as well as the spouse's BI score and HOR score, respectively. ***, **, * denote p<0.01, p<0.05, p<0.1, respectively.

P Cross-country Comparison of Gender Norms and Female Labor Market Participation

We use Wave 6 data from the World Values Survey (WVS) including the European Values Survey that was surveyed in 2010–2014 to show suggestive evidence regarding gender norms. To make data comparable to the SLP, we restrict the WVS sample to be 50–65 years old.

Figure A8: Gender norms

(a) (b)

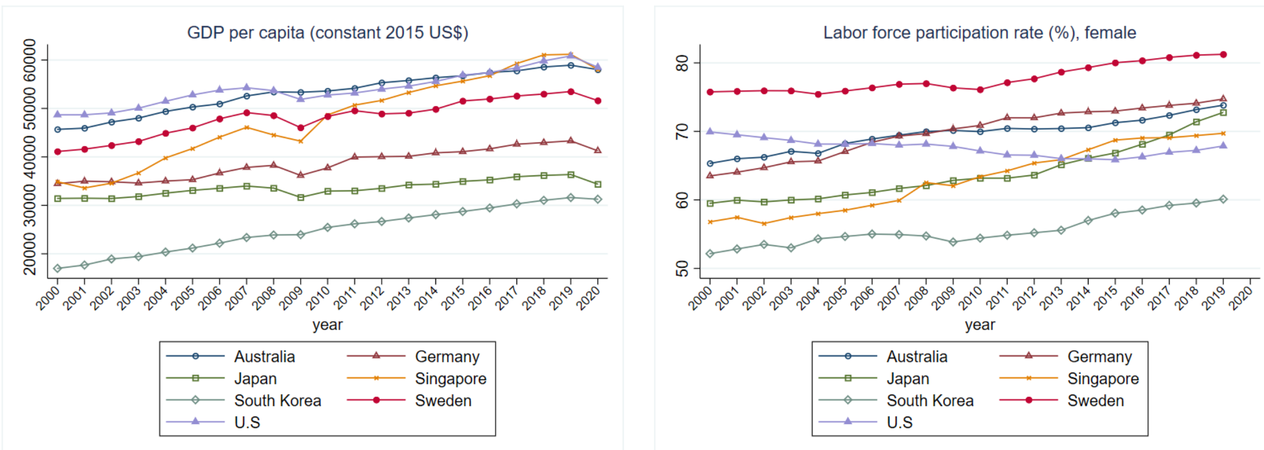


Source: Authors' calculation based on data from the World Values Survey and the European Value Survey.

Then we present the trends of per capita GDP and the female labor market participation rate of the same countries analyzed in Figure A8 using data from the World Bank.

Figure A9: Per capita GDP and female labor market participation

(a) (b)



Source: World Bank (2022).

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