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SPECIAL ISSUE

Financial capability and investment management of Chinese households: An application of hybrid item response theory

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Abstract

This study estimates Chinese individuals' financial capability and analyzes the association between financial capability and household investment management. By applying a novel hybrid item response theory to data from the China Family Panel Studies, this study finds that more than 70% of Chinese individuals have financial capability around the average level, and less than 12% of individuals have financial capability far below the average. For two of the components of financial capability, desirable behaviors and perceived financial knowledge, however, more than half of Chinese individuals are below the average. The primary finding on whether financial capability predicts investment management is that individuals with higher financial capability are more likely to take control of household investment alone than to share investment decisions with spouses.

KEYWORDS

China family panel studies, financial capability, item response theory

1 | INTRODUCTION

As the Chinese economy transitions from a centralized system to a market-oriented system, the government is employing a series of reforms with strong influence. Compared with the period before the economic reform, when the government or enterprises took care of people's lives,

currently, Chinese people have to take more responsibility for their own well-being. Pension reform has shifted the plan from pay-as-you-go to a defined contribution. In addition, the rising burden of education and health has fallen on individuals, stimulating people to save more (Chamon and Prasad, 2010; Chamon *et al*., 2013). However, people have greater opportunities to promote their own benefits. In addition to a social-pooling pension plan, people can also invest their individual savings in financial markets. The financial market reform provides various choices for individual investors. For example, stock exchanges, mutual funds, and bonds were introduced in the 1990s, and the first index future was launch in 2010. Under dynamic economic development, personal financial competency for the Chinese is more important than ever, allowing them to pursue financial well-being, particularly for individuals in charge of household investment.

The purpose of this study is to evaluate Chinese individuals' financial capability by an index that summarizes a set of individual-level competencies for financial issues. Similar to Jappelli (2010), who showed that people in countries with more generous social security systems are less financially literate, Chinese individuals are expected to develop better financial literacy given the current lack of social security networks. The Organization for Economic Co-operation and Development's Program for International Student Assessment partially confirms that Chinese youth have a good understanding of financial issues.[1] However, such studies as Allgood and Walstad (2016) and Hung *et al*. (2009b) emphasize that taking action is important in making financial decisions. Financial capability is a concept that combines financial knowledge and financial behaviors to describe a person's overall financial competency. In addition to measuring financial capability, this study also evaluates each component of financial capability and identifies the weakness in some components for future improvement. This study contributes to the literature by applying a novel hybrid item response theory (IRT), which is adaptive to various types of survey questions, to estimate financial capability. To the best of our knowledge, this study is the first to estimate Chinese individuals' financial capability. Furthermore, this study connects specialization in household tasks with household financial management. Since specialization can promote household utility (Becker, 1991; Lundberg and Pollak, 2007), this study estimates whether Chinese individuals with better financial capability in married households are more likely to control investment. The primary findings of this study are twofold. First, Chinese individuals perform relatively well in overall financial capability and objective financial knowledge, but more than half of individuals do not exercise desirable financial behaviors. Second, in married households, financially capable individuals tend to manage household investment alone rather than share investment duties with their spouses. This finding shows that Chinese households have a promising chance of achieving financial well-being.

The rest of this paper is divided into five sections. Section 2 reviews the literature on financial capability and household financial management. Section 3 introduces the hybrid IRT and Chinese household data, and presents the estimation results for Chinese individuals' financial capability. Section 4 presents an empirical analysis of the associations between financial capability and individual characteristics and of who manages household investment. Section 5 discusses the findings and concludes.

2 | LITERATURE REVIEW

2.1 | Financial capability and measurement

The term “financial capability” and the approach to measuring it were first proposed by Atkinson *et al*. (2007). Although the authors did not provide a clear definition of financial

capability, they included both desirable financial behaviors and financial knowledge as components of financial capability. Huston (2010) defined financial literacy as the application of financial knowledge to behaviors.[2] Similarly, Xiao *et al*. (2014) defined financial capability as a certain level of financial knowledge and the performance of desirable financial behaviors. In all of these definitions, financial capability should comprise financial knowledge and financial behaviors. Since financial behaviors have a broad range, some authors have divided them into more detailed components. For example, Despard and Chowa (2014) added financial service action and awareness to desirable money management as components of financial capability, Xiao and O'Neill (2016) added perceived financial knowledge as a component of capability, and Potocki and Cierpiat-Wolan (2018) added financial inclusion, which includes the number of financial products and payment methods, as a component of financial capability.

The measures of financial capability differ according to the definition of financial capability and the types of data. Atkinson *et al*. (2007) and Taylor (2011) used factor analysis to measure individuals' financial capability based on a set of desirable financial behaviors and/or financial outcomes. The same approach is used to evaluate financial knowledge by Van Rooij *et al*. (2011). Hung *et al*. (2009a, 2009b) and Xiao *et al*. (2014) emphasized the multiple dimensions of financial capability and financial knowledge and used separate components together in empirical studies. Potocki and Cierpiat-Wolan (2018) and Xiao and O'Neill (2016) used the sum of the *Z*-scores of the components of financial capability. Although financial capability comprises financial knowledge and financial behaviors, which have their own measures, a single measure of financial capability is closer to a definition that summarizes comprehensive financial competency. In this study, a novel measure of financial capability based on hybrid IRT is applied. Similar to factor analysis, which considers the weight of a financial behavior in estimating financial capability, IRT estimates the difficulty of a behavior and assigns a larger weight to the financial capability of an individual who exhibits difficult behavior. Furthermore, although IRT has been used to estimate financial knowledge (Fonseca *et al*., 2012; Hung *et al*., 2009a, 2009b; Knoll and Houts, 2012), hybrid IRT is more adaptive to a questionnaire whose questions are attitudinal or behavioral with no correct answers. Previous studies on Chinese individuals' finance focus on financial literacy (Chu *et al*., 2017; Liao *et al*., 2017), and this study explores the issue further by incorporating financial behaviors to evaluate their individuals' financial capability. More details on hybrid IRT are presented in the next section.

2.2 | Household finance management

Since most individuals live with household members, the household, rather than the individual, could be the most basic economic unit. Rational household members would specialize in tasks to maximize household utility. An observable example is when some members work in the labor market while others choose to perform household work (Becker, 1991). Among various household tasks, household finance is one the most important areas, because the person who manages household finance is responsible for every household member's welfare. A household head's characteristics in financial matters have been proven to be strongly correlated with household financial decisions. For example, financial knowledge determines entrance into financial markets (Van Rooij *et al*., 2011; von Gaudecker, 2015; Grohmann, 2018) and retirement plans (Van Rooij *et al*., 2012; Agnew *et al*., 2013). Previous studies have discussed how decision makers or household heads' characteristics relate to their choices, but little research has discussed who makes decisions in a household. If we consider that a household seeks to

maximize its utility, then a financially capable individual would be expected to specialize in household investment. This prediction leads to the following null hypothesis.

Ho There is a positive association between financial capability and making investment decisions for the whole household.

This hypothesis focuses on married households in which there is specialization in household tasks (Becker, 1991; Lundberg and Pollak, 2007). An empirical example is a household head (mostly a man) who earns a wage premium by marriage because he can specialize in the accumulation of human capital while his partner specializes in domestic tasks (Kenny, 1983; Cornwell and Rupert, 1997; Hersch and Stratton, 2000). This study uses a new measure of financial capability and considers various types of financial management, namely: managing by myself; managing with others, including spouse; and sharing management with spouse. As the literature has found that financial knowledge promotes financial well-being through the effects on financial management (Xiao *et al*., 2008; Antonides *et al*., 2011; Robb and Woodyard, 2011), the empirical results in this study should help to predict Chinese households' financial well-being. Further details of the empirical analysis are presented later.

3 | THE MEASURE OF FINANCIAL CAPABILITY

This section applies a novel approach, namely, a hybrid IRT, to estimate financial capability and its components. Then, this study applies the hybrid IRT to a Chinese individual/household dataset to understand Chinese individuals' overall financial capability and their weaknesses.

3.1 | Hybrid item response theory

IRT has been applied in the recent literature to estimate individuals' objective financial knowledge according to respondents' answers to questions regarding financial issues (Fonseca *et al*., 2012; Hung *et al*., 2009a, 2009b); Knoll and Houts, 2012). IRT assumes that the probability of an individual j giving a correct answer to a question i is

$$\mathrm{P}\left(Y_{ij}=1|\, a_i, b_i, \theta_j\right)=\frac{\exp\left\{a_i\left(\theta_j-b_i\right)\right\}}{1+\exp\left\{a_i\left(\theta_j-b_i\right)\right\}} \tag{1}$$

where Y_{ij} is the outcome for individual j's answer to question i; it equals 1 if his or her answer is correct and 0 if his or her answer is incorrect. a_i represents the discrimination of question i; higher discrimination means that two individuals with distinct financial knowledge have a larger difference in the probability of answering question i correctly. b_i is the difficulty of question i. θ_j is individual j's latent ability or financial knowledge. According to Equation (1), the probability of individual j giving a correct answer to question i depends on his or her financial knowledge and question i's discrimination and difficulty. If financial knowledge equals difficulty, the probability of providing the correct answer is 0.5. The estimated value of financial knowledge, θ_j, is of interest in the related literature.

Being an unobservable ability, the IRT estimation for financial capability is applicable. However, the components of financial capability are more than objective financial knowledge, and the outcome of a question is not exactly binary, that is, correct or incorrect. For example, a respondent's practice for a desirable financial behavior is not absolute. He or she usually follows the desirable behavior but sometimes violates it. The survey questionnaire accommodates this fact by giving respondents ordinal answers that range from the lowest frequency to the highest frequency for choice of frequency that satisfies his or her practice. Researchers may assign points to a behavior, as Potocki and Cierpiat-Wolan (2018) and Xiao and O'Neill (2016) did. If the respondent claims he or she always does not follow a desirable financial behavior, then he or she earns 0 points; if he or she sometimes follows it, then he or she earns 1 point, etc. Alternatively, the respondent can evaluate his or her behavior and report a point by himself or herself (Atkinson *et al.*, 2007; Taylor, 2011). In each way, a researcher can apply *Z*-scores or factor analysis to obtain a numerical measure of financial capability. However, this implies that each frequency of a behavior is equally weighted. For example, a researcher assumes that always exercising a desirable financial behavior is worthy one more point than usually exercising a desirable financial behavior although the former one could be far more difficult for an individual to do. Similar to the estimation of objective financial knowledge, advanced questions are more difficult than basic questions, and fewer respondents can answer advanced questions correctly (Lusardi and Mitchell, 2011); therefore, more weights should be assigned to financial behaviors that are difficult to exercise. When the data have limited information and researchers would like to avoid assigning arbitrary scores, some other approaches to estimate financial capability should be applied. Thus, this study chooses a hybrid IRT that is flexible to accommodate both binary and ordinary outcomes to estimate financial capability. Suppose that there are K ordinal outcomes for question i. The hybrid IRT assumes that the probability of individual j providing outcome k or a higher ordered outcome for question i is

$$\mathrm{P}_{ij} = P\left(Y_{ij} \geq k | a_i, b_{ik}, \theta_j\right) = \frac{\exp\left\{a_i\left(\theta_j - b_{ik}\right)\right\}}{1 + \exp\left\{a_i\left(\theta_j - b_{ik}\right)\right\}}, k = 0, 1, 2, ..., K \tag{2}$$

where b_{ik} is the kth cutoff point for question i, which also represents the difficulty in choosing outcome k or a higher ordered outcome. θ_j now is interpreted as individual j's financial capability, because it is a question that belongs to a component of financial capability. The rest of the notations follow the definition for Equation (1). Equation (2) indicates that if individual j has high financial capability, he or she is more likely to choose a higher ordered outcome or frequency for practicing a desirable financial behavior. In addition, if financial capability equals difficulty, the probability of choosing outcome k or a higher ordered outcome is 0.5. Note that when $K = 1$, Equation (2) becomes a special case and is equivalent to Equation (1).

If there are I questions in total and each question is independent, then the likelihood for individual j is computed by integrating financial capability from the joint density:

$$L_j = \int_{-\infty}^{\infty} \prod_{i=1}^{I} P_{ij} \cdot \emptyset\left(\theta_j\right) d\theta_j \tag{3}$$

where $\prod_{i=1}^{I} P_{ij}$ is the joint density conditional on θ_j, which is commonly assumed to follow a standard normal distribution. Therefore, $\emptyset(\theta_j)$ is the density function of the standard normal

distribution. This assumption gives a convenient criterion for the scales of financial capability and difficulty: an individual with financial capability larger (smaller) than 0 is defined as being better (worse) than the average, and an outcome with a difficulty larger (smaller) than 0 is defined as being relatively difficult (easy). Note that if any individual j skips some questions, we can still write Equation (3) and continue to the next step. Suppose that there are J independent individuals in the sample; then, the log likelihood for the sample is the sum of Equation (3) from $j = 1, 2, ..., J$,

$$\log L = \sum_{j=1}^{N} logL_j \tag{4}$$

The solution is the set of a_i and b_{ik} for $k = 0, 1, ..., K$ and $i = 1, 2, ..., I$ that maximizes the log likelihood. After a_i and b_{ik} are estimated, θ_j can be measured. Since Equation (4) is not tractable due to the complication of the integral, numerical approaches are needed to solve the maximization problem. For the numerical approaches applied in IRT, see Chalmers (2012), for example. The next subsection introduces the data applied in the hybrid IRT to estimate Chinese individuals' financial capability.

3.2 | Data

The collection of detailed socio-demographic data for Chinese consumers and households is still developing, particularly data on household finance and subjective opinions about public and private matters. One of the available Chinese individual/household datasets is the China Family Panel Studies (CFPS). The CFPS is a biennial survey starting in 2010 that aims to record nationally representative Chinese households' changes in economic and social status. Although the CFPS does not focus on household finance, the CFPS conducted a special survey for household finance in 2014 that provides detailed data about objective financial status and subjective opinions.[3] The same survey was used to study the association between financial literacy and financial risk tolerance (Chu *et al*., 2017; Liao *et al*., 2017 and the relationship between attitudinal and actual financial behaviors (Xiao and Porto, 2019). In addition, in each household, a member, although not always the household head, was asked to answer questions about financial knowledge and financial behaviors. There were 3,696 respondents who completed or partially completed the household finance survey. With these answers on financial knowledge and financial behaviors and the data of the ownership of financial assets, we can estimate each respondent's financial capability. According to the data availability, three components are used to compose financial capability: perceived financial knowledge, objective financial knowledge, and desirable financial behaviors. The details of these three components and the frequencies of the respondents' choices for each component are reported in Table 1.

The first component is objective financial knowledge, which contains 13 true-or-false and multiple-choice questions (see Appendix), which are mostly covered in, for example, Hung *et al*. (2009a, 2009b) and Lusardi and Mitchell (2011). These questions contain basic financial concepts, such as compound interest rates and inflation, and investment knowledge, such as the function of the stock market and risk of financial assets. More than half of the respondents answered Questions 1, 4, 5, 6, and 9 correctly, while Questions 10 and 11 were difficult for most respondents. The second component is perceived financial knowledge, which shows financial

TABLE 1 Frequencies and IRT estimation results for the components of financial capability

Components of financial capability	Frequency	Discrimination	Difficulty
I. Objective financial knowledge (binary outcomes)			
(1) Answering question 1 correctly	2,096	1.2222*** (.0629)	−0.2791** (0.0365)
(2) Answering question 2 correctly	1,742	0.8304***(0.0502)	0.1626*** (0.0463)
(3) Answering question 3 correctly	1,964	1.0789*** (0.0556)	−0.1387***(0.0382)
(4) Answering question 4 correctly	2,239	1.5662***(0.0808)	−0.3857***(0.0330)
(5) Answering question 5 correctly	2,623	1.2939***(0.0706)	−0.9016***(0.0478)
(6) Answering question 6 correctly	3,278	0.9992***(0.0736)	−2.4164***(0.1439)
(7) Answering question 7 correctly	1,353	1.0960***(0.0608)	0.6257***(0.0444)
(8) Answering question 8 correctly	1,184	1.0118***(0.0580)	0.9000***(0.0553)
(9) Answering question 9 correctly	2,608	1.3609***(0.0685)	−0.8555***(0.0440)
(10) Answering question 10 correctly	641	1.1570***(0.0701)	1.6706***(0.0818)
(11) Answering question 11 correctly	489	1.5631***(0.0982)	1.6593***(0.0710)
(12) Answering question 12 correctly	1,158	1.5430***(0.0793)	0.7263***(0.0377)
(13) Answering question 13 correctly	1,100	1.4083***(0.0731)	0.8324***(0.0425)
II. Perceived financial knowledge (ordinal outcomes)		0.7701***(0.0493)	
Way below the average	345		
Below the average	1,325		−2.9139***(0.1867)
About average	1,356		0.2081**(0.0513)
Above the average	184		3.8689*(0.2321)
Way above the average	26		6.7169***(0.4681)
III. Desirable financial behaviors (ordinal outcomes)			
(1) Considering capacity when shopping		0.2506***(0.0545)	
Totally inapplicable	62		
Somewhat inapplicable	101		−15.6965***(3.6227)
Generally applicable	708		−11.7017***(2.5549)
Somewhat applicable	976		−3.8989***(0.8785)
Totally applicable	1,380		1.3044***(0.2859)
(2) Paying bills on time		0.4115***(0.0621)	
Totally inapplicable	60		
Somewhat inapplicable	74		−9.7051***(1.4690)
Generally applicable	344		−7.6819***(1.1614)
Somewhat applicable	696		−4.2487***(0.6474)
Totally applicable	2,044		−1.2720***(0.2200)
(3) Paying close attention to my financial situation		0.3814***(0.0537)	
Totally inapplicable	148		
Somewhat inapplicable	280		−7.9556***(1.1394)
Generally applicable	733		−4.8718***(0.6985)

(Continues)

TABLE 1 (Continued)

Components of financial capability	Frequency	Discrimination	Difficulty
Somewhat applicable	860		−1.3571***(0.2261)
Totally applicable	1,167		1.6257***(0.2222)
(4) Making long-term financial plans		0.3244***(0.0509)	
Totally inapplicable	488		
Somewhat inapplicable	672		−5.1912***(0.8451)
Generally applicable	937		−1.5589***(0.2920)
Somewhat applicable	638		2.2736***(0.3377)
Totally applicable	433		5.9274***(0.8887)
(5) Making ends meet and consuming according to my income daily		0.2373***(0.0572)	
Totally inapplicable	33		
Somewhat inapplicable	79		−19.2642***(4.7300)
Generally applicable	569		−14.0001***(3.3969)
Somewhat applicable	1,047		−5.4846***(1.3542)
Totally applicable	1,496		0.7467***(0.2065)
(6) Collecting product information and comparing various products when choosing financial products		0.5484***(0.0537)	
Totally inapplicable	344		
Somewhat inapplicable	242		−3.4571***(0.3562)
Generally applicable	675		−2.2498***(0.2418)
Somewhat applicable	811		−0.0508***(0.0786)
Totally applicable	652		2.4578***(0.2188)
(7) Not maintaining financial balance by using loans		0.0350(0.0460)	
Totally inapplicable	153		
Somewhat inapplicable	252		−84.8714 (111.7853)
Generally applicable	341		−54.5507 (71.9043)
Somewhat applicable	544		−33.3013*(44.0249)
Totally applicable	1,860		−10.3171*(13.8025)
(8) Having the habit of bookkeeping		0.2208***(0.0446)	
Totally inapplicable	1,187		
Somewhat inapplicable	676		−2.3194***(5,220)
Generally applicable	638		1.6082***(0.3284)
Somewhat applicable	359		5.8690***(1.1478)
Totally applicable	354		9.6621***(1.9095)
Sample size		3,696	

Note: Values in square brackets are robust standard errors.
*$p < .1$.
**$p < .05$.
***$p < .01$.

confidence. There is only one question that belongs to this component. Among five ordinal levels of perceived financial knowledge, most respondents consider their financial knowledge to be average or below average, while only 210 respondents consider their financial knowledge to be above average.

The third component is desirable financial behaviors. The survey asked questions on various types of financial behaviors, but there are eight financial behaviors that can be defined as desirable. Desirable financial behaviors include such practices as keeping a short-term budget balance to having long-term financial plans. Some of the behaviors, such as (1), (3), (5), and (6), are identical to the measure that Atkinson *et al*. (2007) used to evaluate financial capability. The respondents chose one out of the five following ordinal levels that satisfies their situation: totally inapplicable, somewhat inapplicable, generally applicable, somewhat applicable, and totally applicable. When the level is higher, the behavior is more desirable. Desirable financial behaviors, such as (2) paying bills on time and (7) not maintaining a financial balance by using loans, are applicable to most respondents, but half of the respondents claimed that (8) having the habit of bookkeeping is not applicable.

Given the respondents' answers to the questions regarding the three components, the hybrid IRT is applied to estimate the discrimination and difficulty of each element.[4] The estimated results are reported in the last two columns of Table 1. Note that each question in a component has one level of discrimination, each ordinal question has $K - 1$ levels of difficulty, and each binary variable has one level of difficulty. For an ordinal question, the estimated difficulty for level k represents this difficulty value, and the probability of choosing k or a higher order is 50%. The difficulty generally decreases in frequency; when the respondents choose an outcome more (less) often, the outcome is less (more) difficult. For example, the estimated difficulty for "below the average," an outcome that belongs to perceived financial knowledge, is as easy as when financial capability is only −2.91, because more than one-third of the respondents chose it. An opposite example is when the estimated difficulty is larger than 9 for the choice of "totally applicable" in variable (8) of desirable financial behaviors, because only a few respondents have the habit of bookkeeping, and it is considered very difficult to always maintain this habit. The variables that belong to objective financial knowledge have higher discrimination, which indicates that the probability of two respondents with distinct financial capability answering a question correctly would be more different.

3.3 | Financial capability of Chinese individuals

After the discrimination and difficulty are estimated, we can measure financial capability.[5] Each component of financial capability is measured separately using the same procedure by the hybrid IRT to obtain a better understanding of Chinese individuals' performance regarding financial knowledge, and behaviors.[6] In other words, for example, only questions about objective financial knowledge are used to measure individuals' objective financial knowledge. The descriptive statistics and distributions of financial capability and its components are presented in Panel A of Table 2 and Figure 1, respectively; the distributions of components of financial capability are presented in Figure 2. In both Figures 1 and 2, the horizontal axis describes the estimated financial capability or components of financial capability, and the vertical axis describes the density. The means of the estimated values for financial capability and its components are close to 0, like the assumption for the mean value of the latent ability in the hybrid IRT. Figure 1 shows that the distribution of financial capability has a smooth bell shape with a

TABLE 2 Descriptive statistics and correlation coefficients for the measures of financial capability and components

Panel A descriptive statistics

	Statistics				
Variable	**Mean**	**Median**	***SD***	**Minimum**	**Maximum**
Financial capability	0.00001	0.02016	0.88026	−2.50419	2.82903
Objective financial knowledge	0.00002	0.01585	0.87259	−1.98529	2.17921
Perceived financial knowledge	2.45025	2	0.78922	1	5
Desirable financial behaviors	−0.00019	−0.05352	0.85175	−3.11464	1.68053
Sample size	3,696				

Panel B correlation coefficients

	Financial capability	**Objective financial knowledge**	**Perceived financial knowledge**	**Desirable financial behaviors**
Financial capability	1			
Objective financial knowledge	0.7733	1		
Perceived financial knowledge	0.4067	0.2957	1	
Desirable financial behaviors	0.2882	0.1210	0.0575	1

Note: Descriptive statistics and correlation for perceived financial knowledge are from the original survey data, not the IRT estimation. Perceived financial knowledge equals 1 if it is way below the average, 2 if it is below the average, 3 if it is about average, 4 if it is above the average, and 5 if it is way above the average.

peak slightly larger than 0. More than 70% of individuals have financial capability within one standard deviation (theoretical value of standard deviation) around 0 (theoretical value of mean); and less than 12% of individuals' financial capability is below 0 minus one standard deviation. Figure 2 shows that the distribution of objective financial knowledge is similar to that of financial capability. The symmetric distributions indicate that most Chinese individuals have average financial capability and objective financial knowledge and there is only a small number of individuals who are far below the average. The distribution of desirable financial behaviors is more irregular. Desirable financial behaviors are the only variable with a negative mean and median, which indicates that more than half of respondents do not practice proper financial behaviors. This is reflected in Figure 1 in that the peak of distribution is smaller than 0. As the descriptive statistics indicate, the distribution of normalized perceived financial knowledge is skewed to the right, showing that most Chinese individuals lack confident in their own financial knowledge. Therefore, we conclude that Chinese individuals better understand financial matters and have better overall financial capability, but their financial behaviors and financial confidence need improvement.

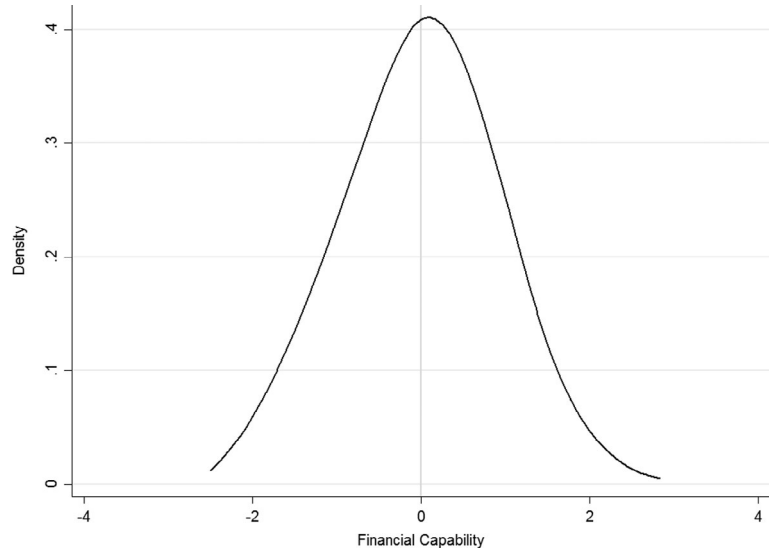

FIGURE 1 Distribution of financial capability

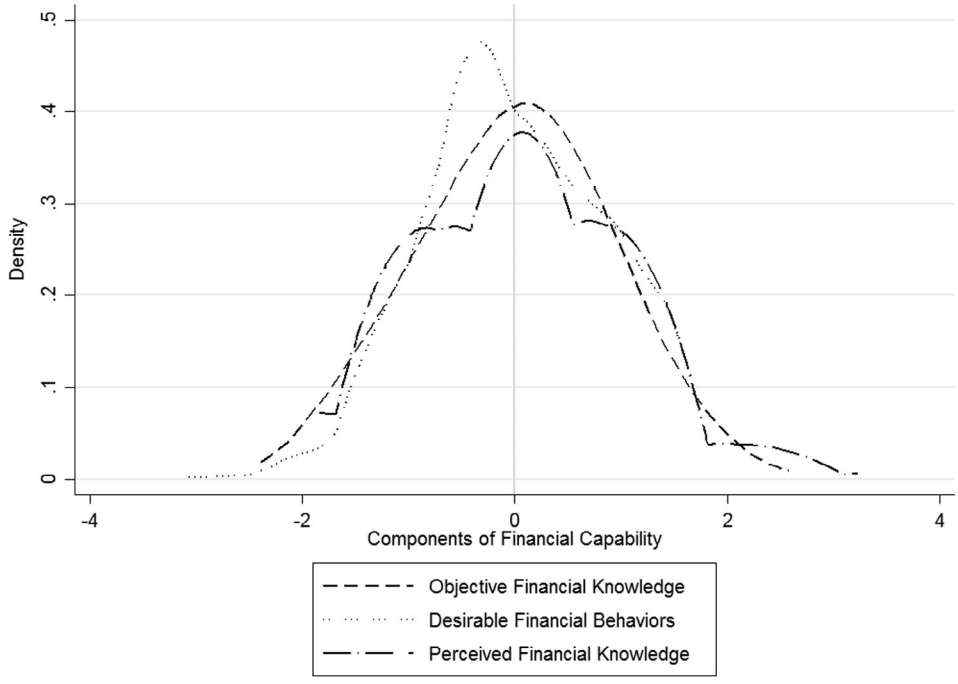

FIGURE 2 Distribution of components of financial capability. *Note:* For consistency with the assumption that the population's financial capability or other components follow standard normal distribution, perceived financial knowledge is normalized to have mean of 0 and *SD* equal to 1

According to Hung *et al.* (2009b), objective financial knowledge, perceived financial knowledge, and financial behaviors interact. Therefore, we further calculate the correlation coefficients of each pair of components reported in Panel B of Table 2. Our calculation shows that all components are positively and moderately correlated. Perceived financial knowledge and

objective financial knowledge have a relatively strong correlation. Works in the literature that support this strong correlation include Guiso and Jappelli (2008) and Hung. Panel B of Table 2 also shows the linear correlations between financial capability and its components. Financial capability and both types of financial knowledge are highly correlated; the coefficients are 0.77 and 0.41 for objective financial knowledge and perceived financial knowledge, respectively.

4 | EMPIRICAL ANALYSIS

4.1 | Variables

After estimating each respondent's financial capability, the next step is to examine the null hypothesis based on the theory of specialization, which predicts that an individual with better financial capability is more likely to control household investments. In addition to the primary variable, financial capability, other respondents' individual and household characteristics are controlled. The descriptive statistics of the explanatory variables extracted from CFPS 2014 are presented in Panel A of Table 3.

The controlled characteristics include respondents' gender, education, marital status, location of residence, industry, and age, and the household characteristics considered are the previous year's total labor income and net worth (household's wealth minus debt). Respondents with any missing values in these characteristics are excluded. The size of this sub-sample reduces to 2,450. For respondents in this sub-sample, the average financial capability and other components, which are measured in the previous section, are slightly larger than for the full sample average, which are close to 0. The respondents in the sub-sample are mostly women, have at least a high school diploma, are married, and live in urban areas. Less than 2.5% of the respondents work in an industry related to finance and banking. Their average age is approximately 47 years.

The descriptive statistics for who makes investment decisions are reported in Panel B of Table 3. The CFPS 2014 asked individual respondents who manages investments in their household. The respondent could choose one of the following answers: (i) I manage the investment; (ii) other family members or my spouse manages the investment; (iii) my spouse and I manage her/his
and I manage
my investment separately; (iv) my spouse and I manage our investments together; and (v) there is no investment. Among all answers, a respondent who chooses (i) has the highest decision power in the household. However, (ii) implies that the respondent has the lowest decision power. For (iii) and (iv), the respondent shares decision power with his or her spouse, and we cannot clearly distinguish in which case the respondent has the larger power. Meanwhile, (v) implies that decision making on investments does not exist in the household. Because this question focuses on the decision making between a respondent and spouse, this study retains only married households in the sample. The size of the second sub-sample is 2,018. Most respondents claimed that they share power of investment decisions with their spouse by choosing (iii) and (iv), while 15.85% of the respondents claimed that they made these decisions for the entire family. Around one-third of married households did not have investments.

Because the five choices do not reveal clear ordinal levels of a respondent's power in investment decisions, it is natural to treat the five choices as categorical variables and to apply a multinomial probit regression. In this study, category (iv) is selected as the base category; therefore,

TABLE 3 Descriptive statistics of the variables

Panel A				
Variables	**Average**	***SD***	**Minimum**	**Maximum**
Financial capability	0.1489	0.8524	−2.4751	2.8290
Perceived financial knowledge	2.4604	0.8019	1	5
Objective financial knowledge	0.1468	0.8406	−1.9853	2.1792
Desirable financial behaviors	0.0176	0.8505	−3.1146	1.6805
Gender				
Male (base)	0.4751	0.4995	0	1
Female	0.5249	0.4995	0	1
Education				
No formal education	0.0584	0.2345	0	1
Elementary/junior high school	0.4004	0.4901	0	1
High school (base)	0.2722	0.4452	0	1
College/undergraduate	0.2551	0.4360	0	1
Postgraduate	0.0139	0.1170	0	1
Marital status				
Never married (base)	0.0890	0.2848	0	1
Married	0.8237	0.3812	0	1
Divorced	0.0433	0.2035	0	1
Widowed	0.0441	0.2053	0	1
Location				
Rural (base)	0.0706	0.2562	0	1
Urban	0.9294	0.2562	0	1
Industry				
Finance industry	0.0249	0.1558	0	1
Other industries (base)	0.9751	0.1558	0	1
Log(labor income)	10.8473	1.0635	2.3026	15.1020
Log(net worth)	12.1830	2.9922	0	20.2134
Age	46.9780	14.2752	17	90
Sample size	2,450			

Panel B		
Who makes investment decisions in the household?	**Frequency**	**Percentage (%)**
(i) I manage the investment	320	15.86
(ii) Other members manage the investment	141	6.99
(iii) My spouse and I manage her/his and I manage my investment separately	165	8.18
(iv) My spouse and I manage our investment together (base)	735	36.42
(v) No investment	657	32.56
Sample size	2,018	

Note: Descriptive statistics for perceived financial knowledge are from the original survey data, not the IRT estimation. Perceived financial knowledge equals 1 if it is way below the average, 2 if it is below the average, 3 if it is about average, 4 if it is above the average, and 5 if it is way above the average.

the estimated coefficients for financial capability in (i) and (ii) indicate that compared with (iv), a respondent with higher financial capability is more or less likely to have the power to make investment decisions. However, the estimation for the coefficient of financial capability in (v) indicates that compared with (iv), a respondent with higher financial capability is more or less likely to enter the financial markets to invest.

4.2 | Associations between financial capability and characteristics

The literature has found that individuals with certain characteristics are more likely to possess some financial ability and behaviors. For example, Almenberg and Dreber (2015) and Fonseca *et al.* (2012) found that women have lower financial knowledge than men. Allgood and Walstad (2016) found that lower educated individuals are more likely to spend over their credit limit. Perry and Morris (2005) found that income is strongly and positively correlated with responsible financial behavior. Since financial knowledge and financial behaviors are all included within financial capability, the first part of the empirical analysis examines whether individual characteristics are correlated with financial capability and its components by using the first sub-sample of 2,450 respondents. Table 4 presents the estimation coefficients and robust standard errors, which use a linear regression and ordered probit.

When the dependent variable is financial capability, it is significantly correlated with most characteristics. The characteristics that strongly explain financial capability are a college degree, the finance industry, income and net worth, while for women, individuals without a high school degree and individuals who divorced have lower financial capability. Because financial capability comprises several components, it would be informative to observe the associations between each component and characteristic to understand which part of the associations contributes to the correlation associated with financial capability. The associations of objective financial knowledge and perceived financial knowledge are similar. Women, lower educated respondents, or those who divorced tend to have lower perceived and objective financial knowledge. On the contrary, respondents who work in the finance industry, earn a higher income, or have high net worth are more likely to have both higher perceived financial knowledge and higher objective financial knowledge.

Only a few characteristics can explain desirable financial behaviors. Women and the respondents with a higher income have better financial behaviors. Net worth is weakly positively correlated with desirable financial behaviors. Education, marital status, and age have no significant association. By comparing the estimated coefficients of each variable between financial capability and the other components of financial capability, the estimated coefficients of objective financial knowledge are closest to the estimated coefficients of financial capability. This finding may indicate that objective financial knowledge is a good proxy for financial capability.

4.3 | Associations between financial capability and investment decisions within a married household[7]

The second part of the empirical analysis examines whether respondents with better financial capability have more decision power in investments within a married household. This study assigns category (iv), the respondent and the spouse who manage investments together, as the

TABLE 4 Estimation results for the associations between financial capability and household characteristics

	Dependent Var			
Explanatory Var.	**Financial capability**	**Objective financial knowledge**	**Perceived financial knowledge**	**Desirable financial behaviors**
Female	−0.1719***(0.0292)	−0.1892***(0.0287)	−0.1687***(0.0450)	0.1160***(0.0348)
No formal education	−0.6284***(0.0693)	−0.6243***(0.0674)	−0.2202**(0.1063)	−0.0979 (0.0840)
Elementary/junior high school	−0.2674***(0.0366)	−0.2799***(0.0360)	−0.0819 (0.0555)	−0.0371 (0.0430)
College/undergraduate	0.3728***(0.0405)	0.3843***(0.0396)	0.1381**(0.0623)	0.0628 (0.0481)
Postgraduate	0.3204*(0.1700)	0.3405**(0.1528)	0.3737 (0.2422)	−0.1212 (0.1847)
Married	−0.1106*(0.0649)	−0.1115*(0.0621)	−0.2137** (0.1007)	0.0513 (0.0781)
Divorced	−0.2082**(0.0973)	−0.2171**(0.0932)	−0.3806** (0.1640)	0.0973 (0.1113)
Widowed	−0.1209 (0.0962)	−0.1387(0.0941)	−0.1004 (0.1527)	0.0994 (0.1092)
Urban	0.1349** (0.0600)	0.1446**(0.0595)	0.0351 (0.0938)	0.0186 (0.0742)
Finance industry	0.5160*** (0.0760)	0.4587***(0.0723)	0.7811***(0.1638)	0.0502 (0.1032)
Log(labor income)	0.1013*** (0.0148)	0.0916***(0.0146)	0.0697***(0.0214)	0.0576***(0.0194)
Log(net worth)	0.0400*** (0.0054)	0.0358***(0.0054)	0.0448***(0.0081)	0.0111*(0.0063)
Age	0.0003 (0.0072)	0.0026 (0.0070)	−0.0141 (0.0113)	−0.0053 (0.0083)
Age square	−0.0001 (0.0001)	−0.0001*(<0.0001)	0.0001(0.0001)	0.0001(0.0001)
F/Wald statistics [*p*-value]	83.65 [<.0001]	89.73 [<.0001]	165.66 [<.0001]	3.18 [.0001]
R^2/pseudo R^2	0.3060	0.3154	0.0315	0.0186
Sample size	2,450			

Note: Values in square brackets are robust standard errors. For the case of perceived financial knowledge, an ordered probit regression is adopted, and the associated Wald statistics and pseudo R^2 are reported. For the rest, linear regression approaches are adopted, and *F* statistics and R^2 are reported.

*$p < .1$.

**$p < .05$.

***$p < .01$.

TABLE 5 Multinomial probit estimation of the associations between financial capability and the role of investment decisions

	Category				
Explanatory Var.	**(i) I manage the investment**	**(ii) Other members manage the investment**	**(iii) My spouse and I manage her/his and I manage my investment separately**	**(iv) My spouse and I manage our investment together (base)**	**(v) No investment**
Financial capability	0.1916*** (0.0736)	−0.3257*** (0.0747)	0.0668 (0.0774)	–	−0.4428*** (0.0638)
Female	−0.0326 (0.0994)	0.0857 (0.1184)	−0.0070 (0.1139)	–	0.0626 (0.0884)
No formal education	0.1754 (0.2716)	−0.0656 (0.3351)	0.5201* (0.2888)	–	0.5706*** (0.2194)
Elementary/junior high school	−0.1888 (0.1232)	−0.1136 (0.1495)	−0.1125 (0.1443)	–	−0.0284 (0.1090)
College/undergraduate	−0.1131 (0.1369)	0.1628 (0.1638)	.1058 (0.1585)	–	−0.0704 (0.1288)
Postgraduate	0.2366 (0.4057)	0.9726** (0.4063)	0.2728 (0.4688)	–	0.0452 (0.4125)
Urban	0.1133 (0.1944)	0.0007 (0.2203)	−0.0024 (0.2111)	–	0.4345**(0.1775)
Finance industry	0.3836 (0.3009)	−0.5288 (0.5289)	0.5635* (0.3173)	–	−0.2882 (0.3587)
Log(labor income)	0.0495 (0.0571)	0.1574* (0.0823)	−0.0327 (0.0537)	–	−0.0458 (0.0427)
Log(net worth)	0.0076 (0.0238)	0.0533 (0.0372)	0.0028 (0.0243)	–	−0.0585*** (0.0167)
Age	0.0647** (0.0269)	0.0258 (0.0300)	−0.0070 (0.0264)	–	0.0415* (0.0224)
Age square	−0.0005* (0.0003)	−0.0002 (0.0003)	0.0001 (0.0003)	–	−0.0003 (0.0002)
Wald statistics [*p*-value]	302.99 [<.0001]				
Sample size	2,018				

Note: Values in square brackets are robust standard errors.
*$p < .1$.
**$p < .05$.
***$p < .01$.

base category and applies a multinomial probit analysis. The estimation results are reported in Table 5.

Table 5 shows that financial capability has better explanatory power than the other variables regarding who manages household investment. The positive and significant coefficient of financial capability for category (i) indicates that a respondent with higher financial capability is more likely to be the person who manages investment for the entire household. By contrast, the negative and significant coefficient of financial capability for category (ii) shows that a financially capable respondent is less likely to leave investment decisions to his spouse or other household members. For category (iii), financial capability is positive but not significant. This could be because there is little distinction between categories (iii) and (iv), and both represent a respondent and spouse who share decision power. These results confirm the null hypothesis that when a respondent's financial capability is higher, he or she is more likely to control investment decisions.

Categories (i)–(iv) distinguish who manages investments under the condition that the household had previously invested, but category (v) indicates that the household has not entered financial markets. Therefore, the negative and significant coefficient of financial capability means that compared with a respondent who shares power with a spouse in investment decisions, a respondent with better financial capability is less likely to choose no investment. If category (ii) is assigned as the base, the coefficient of financial capability for category (v) becomes negative but not significant (not shown in Table 5). In other words, if a respondent has low financial capability, he or she would either choose to let other household members make investment decisions or choose not to invest. The other variables with important explanatory power are no formal education and net worth. The respondents without a formal education

TABLE 6 Multinomial probit estimation of the associations between objective financial knowledge and the role of investment decisions

	Category				
Explanatory Var.	**(i) I manage the investment**	**(ii) Other members manage the investment**	**(iii) My spouse and I manage her/his and I manage my investment separately**	**(iv) My spouse and I manage our investment together (base)**	**(v) No investment**
Objective financial knowledge	0.1716** (0.0738)	−0.2362*** (0.0769)	0.0552 (0.0797)	–	−0.3933*** (0.0642)
Control variables	Included				
Wald statistics [*p*-value]	275.93 [<.0001]				
Sample size	2,018				

Note: Values in square brackets are robust standard errors.
**$p < .05$.
***$p < .01$.

or with a low net worth are more likely to choose not to invest. Given that 80% of Chinese individuals has financial capability around or higher than 0 (theoretical mean) and household investment is conducted by individuals with better financial capability, there is promising potential for the financial well-being of Chinese households.

Since objective financial knowledge is highly correlated with financial capability, the next part of the empirical analysis replaces financial capability with objective financial knowledge to estimate whether objective financial knowledge can interpret the investment decision. The main results are reported in Table 6. Compared with Table 5, the signs of the coefficients for objective financial knowledge do not change. However, the lower absolute values of coefficients and t-statistics indicate that there is lower prediction power of objective financial knowledge for the investment decision. Thus, objective financial knowledge might serve as an imperfect proxy of financial capability if other components of financial capability are not available in the data.

5 | DISCUSSION AND CONCLUSION

China is experiencing a transition from a centralized system to a market-oriented system. Accordingly, individuals need to take more responsibility for their own household finance than in the past. Competency in financial issues is essential for a household's well-being. Financial capability is an indicator that comprises both objective and perceived financial knowledge, and financial behavior, and it summarizes an individual's competency in financial issues. By using household and individual data from the CFPS 2014, this study applies a novel hybrid IRT to estimate individuals' financial capability. The distributions of each component of financial capability show that more than 80% of Chinese individuals have average financial capability and objective financial knowledge or higher than average, but more than half of individuals do not exercise desirable financial behaviors and perceive their own financial knowledge below the average.

The empirical analysis examines the association between financial capability and individual characteristics and that between financial capability and who manages investments within a married household. The estimation results show that male, higher educated, never married, and rich individuals tend to have better financial capability. Furthermore, an individual with higher financial capability is more likely to manage investments for the entire family instead of sharing management with his spouse. On the contrary, an individual with low financial capability leaves investment management to other household members or does not invest. This study concludes that there is promising potential for Chinese households to achieve financial well-being owing to the existence individuals with better financial capability who specialize in managing investments.

Although this study finds that individuals with better financial capability are more likely to take control of the investment within a household, it does not prove that financial capability is the cause of deciding who manages this investment. It is possible that an individual develops financial capability by managing investments. Since financial capability has many components and each component is correlated with other components, there is no clear instrumental variable to conduct a test of causality. Another way to test causality is to use panel data to regress investment management on lagged financial capability. Chinese household data are still developing, and this solution may be feasible in the near future.

Another limitation of this study is that in the CFPS, only one respondent per household answered the special survey for household finance; thus, we cannot compare a couple's

financial capability or further understand the distribution of power with regard to financial management within a household. For example, we cannot currently answer the question of whether a husband shares management power with his wife who has a similar level of financial capability. Different datasets, such as the Health and Retirement Study, which provide both a husband and wife's cognitive skills, may overcome this limitation. To the best of our knowledge, there has been no similar survey of China's nationally representative population. Nonetheless, we consider that this study sheds light on the role that financial capability plays in Chinese households' financial decisions. Finally, the tradeoff in flexibility of using the hybrid IRT to estimate financial capability is that it is subject to time-consuming numerical approaches and could fail to estimate the parameters of interest. In that case, using another numerical approach or excluding some items could help to overcome the problems. However, this remains for future research.

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ENDNOTES

[1] Based on the 2015 results of students' financial literacy, Chinese students sampled from two provinces and two municipal cities had the highest financial literacy among 16 participating countries. See www.oecd.org/pisa/ for details.

[2] Objective financial knowledge and financial literacy are used interchangeably in the literature. This study defines objective financial knowledge as an individual's understanding of financial issues without considering his or her behaviors and attitudes.

[3] These data are available upon request at http://opendata.pku.edu.cn/dataverse/CFPS.

[4] The procedure for estimating discrimination and difficulty is as follows. Given the data of individuals' choices, that is, Y_{ij}, we have Equation (2). Assuming that financial capability follows standard normal distribution, Equation (3) and then (4) can be obtained. The estimated values of discrimination and difficulty are those that maximize the log-likelihood in Equation (4). Since Equation (4) contains integrals and analytical solutions are not feasible, a numerical approach, for example, Gauss–Hermite quadrature, should be applied. Modern software packages, such as Stata, SAS, and R, can perform the procedure automatically and provide the estimated values.

[5] The approach used to measure financial capability in this study is empirical Bayes means.

[6] Note that because there is only one question on perceived financial knowledge, no additional measure for perceived financial knowledge can be estimated.

[7] Adding single households in the sample does not significantly alter the estimation results but reduces the predictive power of financial capability.

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APPENDIX A.

The 13 true-or-false and multiple-choice questions used to estimate Chinese individuals' objective financial knowledge.

1. According to your estimation, what is the annual interest rate of one-year fixed deposit in the bank? (1) lower than 1%; (2) 1–5%; (3) 5–10%; (4) 10% and higher; (5) do not know.
2. Suppose you have a one-year fixed deposit of 10,000 yuan and the annual interest rate is 3%. If you do not withdraw within this period, how much money will you get on the due date? (1) 10300 yuan; (2) more than 10,300 yuan; (3) less than 10,300 yuan; (4) do not know.
3. After the due date of deposit in the above question, if you continue to save the money as one-year fixed deposit and the annual interest rate is 3%, how much money will you have in this account after 1 year, including the principal and interests? (1) 10600 yuan; (2) more than 10,600 yuan; (3) less than 10,600 yuan; (4) do not know.
4. If the annual interest rate of your savings account is 3%, and the inflation rate is 5%, how many goods you can buy using your savings in this account after 1 year? (1) more than today; (2) the same as today; (3) less than today; (4) do not know.
5. Suppose Zhang San inherits 100,000 yuan today, and Li Si will inherit 100,000 yuan 3 years later. Who has a higher value of inheritance? (1) Zhang San has a higher value of inheritance. (2) Li Si has a higher value of inheritance. (3) they have the same value of inheritance. (4) do not know.
6. In general, investments with high returns have high risks. (1) Right; (2) wrong; (3) do not know.
7. In general, the risk of investing in one-share stock is smaller than that of investing in stock fund. (1) Right; (2) wrong; (3) do not know.
8. Which of the following bank is responsible for making and carrying out monetary policies? (1) Bank of China. (2) industrial and commercial Bank of China. (3) People's Bank of China. (4) China construction Bank. (5) do not know.

(Continues)

9. Generally speaking, which of the following investment has the highest risk? (1) bank savings; (2) national debts; (3) stocks; (4) capital funds; (5) do not know.
10. If you purchase stocks of some companies, that means: (1) No matter you hold these stocks for a short term or long term, you lend the money to the company anyway. (2) No matter you hold these stocks for a short term or long term, you are the stockholder of the company anyway. (3) You are the stockholder of the company when you hold these stocks for long term; and you lend the money to the company when you hold these stocks for short term. (4) None of the above is correct. (5) Do not know.
11. Which one of the following is correct in terms of describing capital fund: (1) Low-price (low unit value) capital fund has a better future performance. (2) In general, the same capital fund could be invested in several assets; for example, one capital fund can be invested into both stocks and bonds. (3) In general, capital fund can provide a guaranteed rate of return based on past performance. (4) None of the above is correct. (5) Do not know.
12. Which of the following statement is correct about a bank's financial products? (1) Same as with other risky investments, a bank's financial products are also possible to suffer from loss. (2) As safe as savings, bank financial products at least will not lose. (3) The expected profits of bank financial products are actual profits. (4) None of the above is correct. (5) Do not know.
13. Which of the following statements correctly describes the core function of stock market? (1) Stock market is helpful in predicting the profits of stocks. (2) Stock market increases the prices of stocks. (3) Stock market helps to make matches between stock buyers and sellers. (4) None of the above is correct. (5) Do not know.