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Gender and age-based investor affinities in a Ponzi scheme

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Utilizing a police dataset of a fundraising Ponzi scheme in China, we establish referrer-investor links and examine how investor affinity in terms of gender and age affects the way the scheme spreads and the way investors suffer losses. We find that female or older investors are more susceptible to investor affinity. Specifically, female or older investors are more likely to be referred into the scheme by female or older investors. Female or older investors tend to occupy lower layers in the investor hierarchy of the scheme and they are more likely to occupy lower layers if they are referred into the scheme by female or older investors. Consequently, female or older investors suffer more losses if they are referred into the scheme by female or older investors. We conclude that gender and age-based investor affinities are especially pronounced among female or older investors in a Ponzi scheme.

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Introduction

Between 1919 and 1920, Charles Ponzi, an Italian immigrant to the U.S., cheated almost 40,000 investors and raised USD 15 million using a fictitious postal coupon investment scheme that promised high returns. Ponzi schemes are named after him. Ponzi schemes rely on paying off earlier investors with funds collected from more recent investors, ultimately running out of cash and collapsing. A recent example was a scheme run by Bernard Madoff, the former Nasdaq chairman, who persuaded investors to inject capital (USD 50 billion) into his firm while merely using newly received funds to pay principals and interests. At the onset of the subprime crisis in 2008, his scheme collapsed due to heightened fund redemptions (Gurun et al., 2018). Both individuals and sophisticated financial institutions (Smith, 2010) have succumbed to this scheme.

Ponzi schemes appear in all stages of development of the modern capital market and permeate cultures and societies. Their persistent emergence even under contemporary well-developed institutions suggests that such fraud exploits particular vulnerabilities in human nature and our social fabrics. Utilizing an investor-level police dataset of a Ponzi scheme in China, we shed light on how certain investor vulnerabilities, as reflected in gender and age-based affinities, are targeted and preyed upon by the Ponzi scheme and how they consequently create investment losses for scheme investors.

During the past decade, thousands of cases of Ponzi schemes emerged in China. They appeared to peak around 2015–2017. In 2015, there were about 6000 cases involving RMB 250 billion (USD 40.15 billion, average USD/RMB = 6.2272 in 2015), in 2016, 5197 cases involving RMB251 billion (USD 37.80 billion, average USD/RMB = 6.6401 in 2016), and in 2017, 5052 cases involving RMB 180 billion (USD 26.65 billion, average USD/RMB = 6.7547 in 2017) (Caixin, 2016; Lieyun, 2017; China Economy, 2018). Investors injected a large amount of wealth into these schemes because the stock market was sluggish and the real estate market started to cool down during that time. Further, social media and mobile technology fueled the propagation of these schemes. A large and well-known case was Ezubao that was established in July 2014. Through promising high returns, it attracted about 900,000 investors and swindled RMB 50 billion (USD 8.14 billion, average USD/RMB = 6.1424 in 2014) in less than two years of its operation (Mount, 2016; Albrecht et al., 2017).

These Ponzi schemes often disguised themselves as project financing schemes backed by manufacturing firms or peer-to-peer (P2P) lending platforms and proliferated with China's rapid development in mobile technology and social media. Wang et al. (2016) provide some interesting patterns, such as more recently founded platforms being at a higher risk of becoming problematic, platforms promising high returns, guaranteeing both principle and interest, and offering daily products being riskier. This wave of Ponzi schemes started to subside after 2017 when many cases collapsed or were exposed. The large number of cases that devastated people's wealth also attracted the government's attention. The 4th plenum of China's 12th National People's Congress in March 2016 pointed out the importance of fighting illegal fundraising schemes. The 1st plenum of the 13th National People's Congress in March 2018 further emphasized fighting illegal fundraising and Internet financing fraud.

Although Ponzi schemes have attracted wide attention from the general public, regulatory authorities, and academics, few investor-level empirical investigations have been carried out due to limited access to detailed Ponzi scheme data. Without a detailed understanding of the referrer-investor relationship network, the architecture of Ponzi schemes is a black box from which few academic or policy implications can be drawn. One exception

in a major finance journal is Rantala (2019) who provides a detailed examination of social interactions at the investor-level in a Finnish Ponzi scheme. However, Rantala (2019) does not establish referrer-investor pairs based on investor affinity. We fill this void. As argued at length below and pointed out by many studies, investor affinity is key to the diffusion and spread of Ponzi schemes (Perri and Brody, 2012; Deason et al., 2015; Gurun et al., 2018).

We obtain a police dataset that includes investor-level information and their banking transaction records on a fundraising Ponzi scheme in China. This enables us to examine how investor affinity in terms of gender and age affects the way a Ponzi scheme spreads and the way investors suffer losses. We find that female or older investors are more likely to be introduced into the scheme by female or older investors. Female or older investors tend to occupy lower layers in the investor hierarchy in the scheme and they are more likely to occupy lower layers if they are introduced into the scheme by female or older investors. Consequently, female or older investors suffer more losses.

While we rely on only one Ponzi scheme and thus the representativeness and external validity of our results and conclusion can be an issue, we do reveal important and interesting patterns at the investor level. We contribute to the finance and financial fraud literature by showing that gender and age-based affinities are especially pronounced among female or older investors in a Ponzi scheme. This result should be valuable to regulators and law enforcement and help them investigate, educate people against, and prevent Ponzi schemes.

Research objectives and hypotheses

Investor affinities in Ponzi schemes. We strive to open the black box of Ponzi schemes from the perspective of investor affinity. Public media and regulators have long alleged that financial fraudsters often rely on investor trust and affinity and the interplay between the two to recruit investors. Financial fraudsters usually target specific groups sharing a common affinity, such as ethnicity, religion, age, gender, education, or profession (Perri and Brody, 2012; Deason et al., 2015). In fact, the US Securities and Exchange Commission (2013) specifically defines affinity fraud as "...investment scams that prey upon members of identifiable groups, such as religious or ethnic communities, the elderly, or professional groups. ...These scams exploit the trust and friendship that exist in groups of people who have something in common."

Ponzi schemes especially prey upon investor trust and affinity to spread "investment ideas" and recruit investors. For example, the Madoff scheme targeted Jewish communities and organizations (Gurun et al., 2018). Modern Ponzi schemes extensively use social networks and interactions (Rantala, 2019). That is, the person who devises the scheme sits at the top but does not interact directly with most of the investors. He/She initially develops a few investors. These investors (referrer investors) individually engage and refer more investors (referred investors) into the scheme through their social networks. The newly recruited investors in turn further refer and recruit more investors. Therefore, Ponzi schemes usually have a pyramidal structure (Zhu et al., 2017) where sham investment ideas quickly spread to a larger number of investors and an investor hierarchy develops in the process.

Referrer investors may or may not know that they are assisting the ultimate fraudsters at the very top. They may or may not know that they can potentially hurt investors below them that they have referred and recruited into the schemes. Further, an

investor is normally both a referrer investor and a referred investor as most members of a scheme participate in the investment, as well as investor recruitment. In this process, the interaction between social networks and investor affinity plays an especially important role. Social networks ensure that investors meet and interact while investor affinity helps with the establishment of referrer-investor relationships.

This assertion suggests that, in the context of Ponzi schemes, cooperation and trust among individuals may not necessarily foster collective efficacy and good outcomes (Securities and Exchange Commission, 2013; Sampson et al., 1997). The key to successfully running a Ponzi scheme, in fact, is the maintenance of investors' trust so that they will not question the scheme's motives and invest their money with confidence. The propensity to invest in a Ponzi scheme is determined by investors' propensity to trust, often derived from being a member of a group that shares common traits, that is, the affinity between referrers and investors. We argue that investor affinity influences how a referrer-investor relationship in a Ponzi scheme is established and that this affinity-induced relationship will in turn affect investment performance in the scheme.

Why gender and age-based affinities? Prior research suggests that network characteristics shape individual economic and investment behaviors. Stein (2008) and Banerjee and Fudenberg (2004) show that personal communications help the spread of investment information. Shive (2010) shows that social contact, like the transmission of contagious diseases, predicts investors' trading patterns. Zhu et al. (2017) specifically model the diffusion of Ponzi schemes in social networks. They also point out that in social networks, especially with modern Internet-based financing, investors also become "spreaders", or in our case, "referrers" in Ponzi schemes. This suggests that identifying referrer-investor links is key to understanding how Ponzi schemes diffuse and spread. We, empirically, go a step further by accepting that the strength of referrer-investor links is not uniform. Some links are stronger and more persuasive than others. Usually, the referrer-investor pairs with the same affinities, such as race, religion, gender, age, education, profession, and etc., are stronger and more persuasive than others.

While a few studies have examined the victims of Ponzi schemes (Smith, 2010; Deason et al., 2015; Gurun et al., 2018; Rantala, 2019) and have alluded to investor affinities such as race and religion, they do not directly analyze the role played by these forms of investors affinity on Ponzi scheme participation and investment performance. Note that Smith (2010), Deason, Rajgopal, and Waymire (2015) and Gurun et al. (2018) do not have access to detailed investor-level information and have to rely on scheme-level information. These studies thus do not explore the architecture of Ponzi schemes. An analysis of the role of investor affinity requires the matching of an investor with his/her referrer. This requires the data to include referrer-investor links or investor-level information.

We focus on gender and age-based investor affinities to open the black box of a Ponzi scheme in China. The focus on gender and age-based affinities are not just motivated by data availability through the richness of the data does afford us the opportunity to conduct an important piece of research. The data provided by the Public Security Bureau (the police department) of a major Chinese city contains information extracted from investors' national ID cards, as well as information on individual-level bank transactions. Chinese national ID card numbers contain information on investors' gender, age, and place of birth. Therefore, we can exploit gender and age-based investor affinities.

However, the focus on gender and age goes well beyond data availability. First, numerous studies have shown that gender and age affect investment behaviors (Barber and Odean, 2001) and risk-taking and management styles (Sundaram and Yermack, 2007; Yim, 2013; Serfling, 2014; Faccio et al., 2016). Thus, gender and age are salient investor traits to focus on. Second, gender and age are two intuitive sources of investor trust and affinity. They are easily observed and recognized even in casual daily interactions, unlike other forms of affinity, such as race, religion, education, and profession, which need much deeper and more deliberate social contact to discover and establish. Third, there are some significant gender and age patterns in Ponzi schemes in China. The "2017 China Anti-Internet-Fraud Report" by the State Council of China (2017) shows that people between 56 and 60 suffered the most from Internet fraud. Further, the "White Book against Fraud for the Elderly" shows that fraud victims are more likely to be women (58%) than men (42%) (Tencent, 2019). Fourth, gender and age have been considered in research on Ponzi schemes. Deason, Rajgopal, and Waymire (2015) consider investor age as an investor affinity link. However, they rely on the mentioning of this affinity link in SEC documents and not on detailed investor-level data. Fei et al. (2020), examining a fundraising scam between 2006 and 2010 in China, provide some evidence that women are more likely than men and older people are more likely than young people to participate in the scam. This pattern is also found in our study. However, they do not establish referrer-investor links and therefore there is no role for affinity in their study. Rantala (2019), investigating a Finnish Ponzi scheme, shows that investors invest more if their inviters (referrers) have higher age, education, and income. In addition, he finds that gender has no such effect. While Rantala establishes referrer-investor links in his study, he does not establish investor affinity. That is, Rantala does not form referrer-investor pairs based on common personality traits, such as gender, age, education, and income. We argue that links formed based on investor affinity are especially important in helping a Ponzi scheme diffuse and spread and therefore focus our study on investor affinity. More specifically, we show whether female or older investors are more susceptible to gender and age-based investor affinities and how their investment returns are consequently affected.

Hypotheses. Based on the above discussions, we focus our research on how gender and age-based investor affinities assist the diffusion and spread of a Ponzi scheme and its investment performance consequence. We argue that gender and age-based investor affinities quicken the diffusion and spread of the Ponzi scheme and propose the first hypothesis below:

Hypothesis 1: Gender and age-based investor affinities help a Ponzi scheme diffuse and spread.

Empirically, relying on detailed investor-level data, we pair referrers with referred investors to identify investor affinity.

The hierarchy of a Ponzi scheme can reveal how wealth is channeled among investors. A Ponzi scheme relies on paying off earlier investors with funds collected from more recent investors, ultimately running out of cash and collapsing. Therefore, investors who enter the scheme later and thus at lower layers of the investor hierarchy likely lose more while investors at higher layers, if exiting the scheme early enough, may even have a profit. If investor affinities lead female or older investors into more vulnerable positions, we expect that gender and age-based investor affinities are associate with lower layers of investor hierarchy in a Ponzi scheme and consequently lower investment returns. We propose the second and third hypotheses below:

Hypothesis 2: *Gender and age-based investor affinities place investors to lower layers of investor hierarchy in a Ponzi scheme.*

Hypothesis 3: *Gender and age-based investor affinities reduce investment returns from a Ponzi scheme.*

Empirically, we examine how gender or age-linked referrer-investor pairs affect investors' positions in a Ponzi scheme and investment returns.

Data and structure of the Ponzi scheme. The fundraising Ponzi scheme that we examine was established via an investment shell company X in a major city in China. From March 2016 to August 2016, the company illegally attracted personal investments amount to RMB 260 million (USD 39.16 million, average USD/RMB = 6.6401 in 2016) by promising high returns. As with many other Ponzi schemes, the modus operandi of the scheme was simple. The shell company X promised investors the following investment scheme. Investors could invest in a unit or a multiple of RMB 3900 (USD 587.34, average USD/RMB = 6.6401 in 2016). Within a nine-week period, each unit will yield a total of RMB 7400 (USD 1114.44, average USD/RMB = 6.6401 in 2016) with a weekly cash return of RMB 500, 500, 700, 700, 1000, 1000, 1000, 1000, 1000. Both the principal and interest could be reinvested back into the scheme. However, except for collecting and redistributing the invested funds, the shell company did not have any real external investment activities.

This scheme was run by a man Y. Although a few individuals helped him with technical issues associated with establishing and maintaining the company, the police investigation suggested that he was the sole person who had knowledge about the whole operations of the scheme. To encourage participation, the scheme compensated referrers with a significant amount of money. Therefore, the scheme has a pyramid hierarchical structure under which the wealth of lower-layer investors was funneled to higher-layer investors until the very top. In August 2016, the local branch of the Public Security Bureau raided company X and confiscated its trading and bank transaction records. By the end of August 2016, 4843 investors from 29 provinces (autonomous regions or direct administrative cities) across China had participated in the scheme, with a total economic loss as high as RMB 198 million (USD 29.82 million, average USD/RMB = 6.6401 in 2016).

We obtain detailed investor and transaction-level data of this Ponzi scheme from this city's Public Security Bureau. In addition to detailed information on bank transactions by investors, the dataset also includes information extracted from participants' personal national ID cards. Chinese national ID cards contain information on investors' gender, age, and place of birth. This enables us to link investor personal characteristics to investors' investing behaviors and investment returns. This dataset also contains hierarchical referrer-investor relationship information. Our sample period runs from March 2016 to August 2016, covering the entire duration of the scheme.

Research design

Investor participation. To determine whether female or older investors join the Ponzi scheme earlier or later than male or young investors, we adopt a hazard/survival analysis and estimate the following Cox hazard model:

$$h(t_i) = h_0(t_i) \exp \left[\begin{array}{l} \alpha_1 \text{Female}_{\text{investor}_i} + \alpha_2 \text{Age}_{\text{investor}_i} \\ + \alpha_3 \text{Poverty}_{\text{investor}_i} + \alpha_4 \text{Famine}_{\text{investor}_i} \end{array} \right], \quad (1)$$

where $h_0(t)$ is the baseline hazard rate; t ($\text{Interval}_{\text{investor}}$) represents the number of days from the establishment of the Ponzi scheme (March 5, 2016) to the date when a particular investor joined the platform. Equation (1) uses investor-date panel data

for the analysis and we focus on $\text{Female}_{\text{investor}}$ and $\text{Age}_{\text{investor}}$. $\text{Female}_{\text{investor}}$ indicates the gender of an investor. It equals 1 when an investor is a female and 0 when an investor is a male. $\text{Age}_{\text{investor}}$ is the age of an investor in 2016. If female (older) investors join the Ponzi scheme earlier than male investors, then the coefficient on $\text{Female}_{\text{investor}}$ ($\text{Age}_{\text{investor}}$) should be positive.

Existing research shows that early life experience can significantly impact people's behavior and decision-making (Bernile et al., 2017). Therefore, we add variables to capture the potential impact of the investors' early life experience. We control for an investor's potential experience of poverty $\text{Poverty}_{\text{investor}}$ is an indicator that equals 1 when an investor was born in a poor county, and 0 otherwise. This information comes from the Poverty Alleviation Office of the State Council of China (2012). This office lists counties that are targets of China's poverty alleviation program. The classification criterion is mainly based on a county's per capita income. When an investor's birth county is listed as a target for poverty alleviation, it is treated as a poor county. We also control for the Great Famine (1959–1961) experience ($\text{Famine}_{\text{investor}}$). $\text{Famine}_{\text{investor}}$ is an indicator that equals 1 when an investor has experienced China's Great Famine in his/her youth (born in 1947–1961), and 0 otherwise. The inclusion of the above two variables is based on the assumption, in the spirit of Bernile et al. (2017), that when a person was born in a poor county or has experienced a famine in youth, he/she likely has memories of poverty and hardship which can, in turn, affect his/her investment behaviors or management styles. We want to emphasize here that the purpose of our using *Poverty* as a control is not to indicate whether an investor is poor or not, but rather to capture the likelihood of poverty/hardship memories of his/her early childhood or youth. In a China setting, Xu and Li (2016) show that firms with CEOs born in poor counties or having the Great Famine experience make more charitable contributions.

To determine whether female or older investors are more or less active in the Ponzi scheme than male or young investors, we estimate the following regression:

$$\text{Invest_Freq}_{\text{investor}_i} = \beta_0 + \beta_1 \text{Female}_{\text{investor}_i} + \beta_2 \text{Age}_{\text{investor}_i} + \beta_3 \text{Poverty}_{\text{investor}_i} + \beta_4 \text{Famine}_{\text{investor}_i} + \varepsilon_i, \quad (2)$$

where $\text{Invest_Freq}_{\text{investor}}$ is investment frequency for an investor. It equals the number of investments made during the operating period of the Ponzi scheme. Equation (2) is estimated in an OLS, as well as a Poisson regression. We focus on $\text{Female}_{\text{investor}}$ and $\text{Age}_{\text{investor}}$. If female (older) investors are more active in investing than male investors, then the coefficient on $\text{Female}_{\text{investor}}$ ($\text{Age}_{\text{investor}}$) should be positive. We also include $\text{Poverty}_{\text{investor}}$ and $\text{Famine}_{\text{investor}}$ to control for the potential impact of investors' early life experience.

The spread of the Ponzi scheme. Zhu et al. (2017) argue that in social networks, Ponzi scheme investors are often also spreaders (referrers) in the schemes. This means, identifying referrer-investor links and classifying them based on certain identifiable investor affinities can assist us in understanding how Ponzi schemes diffuse and spread.

Referrer-investor relationships recorded in the dataset allow us to examine how the Ponzi scheme spreads through gender and age-based investor affinities. We examine this issue separately for female and older investors. If a female or older investors are more susceptible to gender and age-based investor affinities, then female or older investors are more likely to be referred and persuaded into the scheme by female or older investors.

We estimate the following regression equations:

$$\text{prob}(\text{Female}_{\text{investor}i} = 1) = \beta_0 + \beta_1 \text{Female}_{\text{referrer}i} + \beta_2 \text{Age}_{\text{referrer}i} + \beta_3 \text{Poverty}_{\text{referrer}i} + \beta_4 \text{Famine}_{\text{referrer}i} + \varepsilon_i, \quad (3)$$

$$\text{Age}_{\text{investor}i} = \beta_0 + \beta_1 \text{Female}_{\text{referrer}i} + \beta_2 \text{Age}_{\text{referrer}i} + \beta_3 \text{Poverty}_{\text{referrer}i} + \beta_4 \text{Famine}_{\text{referrer}i} + \varepsilon_i, \quad (4)$$

where Eq. (3) is estimated in a logit regression while Eq. (4) is estimated in an OLS, as well as a Poisson regression. $\text{Female}_{\text{referrer}}$ indicates the gender of a referrer. It equals 1 when a referrer is a female, and 0 when a referrer is a male. $\text{Age}_{\text{referrer}}$ is the age (in 2016) of a referrer. $\text{Poverty}_{\text{referrer}}$ is an indicator that equals 1 when a referrer was born in a poor county, and 0 otherwise. $\text{Famine}_{\text{referrer}}$ is an indicator that equals 1 when a referrer has experienced China's Great Famine in his/her youth (born in 1947–1961), and 0 otherwise. Equations (3) and (4) are designed to test Hypothesis 1 that gender and age-based investor affinities help a Ponzi scheme diffuse and spread.

Formation of investor hierarchy in the Ponzi scheme. To determine how gender and age-based investor affinities affect investors' hierarchical positions in the Ponzi scheme, we estimate the following two equations:

$$\text{Layer}_{\text{investor}i} = \beta_0 + \beta_1 \text{Female}_{\text{investor}i} + \beta_2 \text{Age}_{\text{investor}i} + \beta_3 \text{Poverty}_{\text{investor}i} + \beta_4 \text{Famine}_{\text{investor}i} + \varepsilon_i, \quad (5)$$

$$\begin{aligned} \text{Layer}_{\text{investor}i} = & \beta_0 + \beta_1 \text{Male-to-Female}_i + \beta_2 \text{Female-to-Male}_i + \beta_3 \text{Female-to-Female}_i \\ & + \beta_4 \text{Young-to-Old}_i + \beta_5 \text{Old-to-Young}_i + \beta_6 \text{Old-to-Old}_i \\ & + \beta_7 \text{Female}_{\text{investor}i} + \beta_8 \text{Age}_{\text{investor}i} + \beta_9 \text{Poverty}_{\text{investor}i} + \beta_{10} \text{Famine}_{\text{investor}i} \\ & + \beta_{11} \text{Female}_{\text{referrer}i} + \beta_{12} \text{Age}_{\text{referrer}i} + \beta_{13} \text{Poverty}_{\text{referrer}i} \\ & + \beta_{14} \text{Famine}_{\text{referrer}i} + \varepsilon_i, \end{aligned} \quad (6)$$

where $\text{Layer}_{\text{investor}}$ is the layer an investor occupies in the scheme. Its value ranges from 0 to 22 with a higher value indicating a lower layer. Male-to-Female is an indicator that equals 1 when the referrer is a male while the investor is a female, and 0 otherwise. Female-to-Male is an indicator that equals 1 when the referrer is a female while the investor is a male, and 0 otherwise. Female-to-Female is an indicator that equals 1 when both the referrer and the investor are female, and 0 otherwise. Young-to-Old is an indicator that equals 1 when the referrer is young (below or equal to the median of Age) while the investor is old (above the median of Age), and 0 otherwise. Old-to-Young is an indicator that equals 1 when the referrer is old (above the median of Age) while the investor is young (below or equal to the median of Age), and 0 otherwise. Old-to-Old is an indicator that equals 1 when both the referrer and the investor are old (above the median of Age), and 0 otherwise. All other variables are as defined earlier. Both Eqs. (5) and (6) are estimated in an OLS, as well as a Poisson regression. Equation (6) is designed to test Hypothesis 2 that gender and age-based investor affinities place investors to lower layers of investor hierarchy in a Ponzi scheme.

Investor performance in the Ponzi scheme. We now determine how gender and age-based investor affinities affect investment performance in the Ponzi scheme. We estimate the following two equations:

$$\text{Return}_{\text{investor}i} = \beta_0 + \beta_1 \text{Female}_{\text{investor}i} + \beta_2 \text{Age}_{\text{investor}i} + \beta_3 \text{Poverty}_{\text{investor}i} + \beta_4 \text{Famine}_{\text{investor}i} + \varepsilon_i, \quad (7)$$

$$\begin{aligned} \text{Return}_{\text{investor}i} = & \beta_0 + \beta_1 \text{Male-to-Female}_i + \beta_2 \text{Female-to-Male}_i \\ & + \beta_3 \text{Female-to-Female}_i + \beta_4 \text{Young-to-Old}_i + \beta_5 \text{Old-to-Young}_i + \beta_6 \text{Old-to-Old}_i \\ & + \beta_7 \text{Female}_{\text{investor}i} + \beta_8 \text{Age}_{\text{investor}i} + \beta_9 \text{Poverty}_{\text{investor}i} + \beta_{10} \text{Famine}_{\text{investor}i} \\ & + \beta_{11} \text{Female}_{\text{referrer}i} + \beta_{12} \text{Age}_{\text{referrer}i} + \beta_{13} \text{Poverty}_{\text{referrer}i} \\ & + \beta_{14} \text{Famine}_{\text{referrer}i} + \varepsilon_i, \end{aligned} \quad (8)$$

where Return is (withdrawals–investments)/investments for an investor. All other variables are as defined earlier. Both equations are estimated in an OLS regression. Equation (8) is designed to test Hypothesis 3 that gender and age-based investor affinities reduce investment returns from a Ponzi scheme.

Empirical results

Descriptive statistics. Panel A, Table 1 reports descriptive statistics for main variables. The mean value of Female is 0.6089 and the median is 1, indicating that female investors, unconditionally, are more likely than male investors to participate in the scheme. The mean value of Age is 43.38 and the median is 44 with a 1st quartile value of 35 and a 4th quartile value of 52. The average value of Layer, which reflects investor's hierarchical layer in the scheme, is 5.9461, the median is 5 with a 1st quartile value of 4 and a 4th quartile value of 7. The mean value of Invest_Freq is 23.3795, the median is 10, with a 1st quartile value of 5, and a 4th quartile value of 23. The mean value of Interval, which is the number of days from the inception of the platform to the date an investor joined the scheme, is 107.9135, the median is 115, with a 1st quartile value of 89 and a 4th quartile value of 138, indicating that investors joined the scheme mainly during the first three months of its operation. Investors are scattered across 29 provinces (autonomous regions or direct administrative cities) throughout China, meaning that the scheme has a wide geographic impact.

Panel B, Table 1 reports the correlation coefficients between variables. The correlation between Female and Invest_Freq is positive and significant (0.0315, $p = 0.03$ for Pearson and 0.0357, $p = 0.01$ for Spearman), suggesting that female investors invest more frequently than male investors. The correlation between Age and Invest_Freq is positive and significant (0.0780, $p = 0.00$ for Pearson and 0.1377, $p = 0.00$ for Spearman), suggesting the older investors invest more frequently than young investors. These associations indicate that female or older investors are more active in investing in the Ponzi scheme. The correlation between Female and Return is negative and significant (−0.0327, $p = 0.02$) for Pearson and is negative but insignificant (−0.0169, $p = 0.24$) for Spearman. The correlation between Age and Return is negative and significant (−0.0552, $p = 0.00$ for Pearson and −0.0515, $p = 0.00$ for Spearman). These associations provide preliminary evidence that investment returns for female or older investors are low.

Investor participation. Column (1) of Table 2 presents regression results for estimating the duration model Eq. (1). The coefficients on $\text{Female}_{\text{investor}}$ (0.0352, $z = 1.14$) and $\text{Age}_{\text{investor}}$ (0.0007, $z = 0.41$) are insignificant, suggesting that investor gender and age do not appear to affect the timing of joining the Ponzi scheme. In addition, the coefficients on Poverty and Famine are insignificant.

Columns (2) and (3) of Table 2 presents regression results for estimating Eq. (2). The coefficient on $\text{Female}_{\text{investor}}$ is positive and significant (2.4890, $t = 1.74$ for OLS; 0.1097, $z = 1.75$ for Poisson), indicating that female investors are more active in investing than male investors in the Ponzi scheme. This result is somewhat different from the finance and accounting literature concerning the trading pattern and risk preference of female

Table 1 Descriptive statistics and correlations.

Panel A: descriptive statistics						
Variable	Sample size	Mean	Standard deviation	Median	1st Quartile	4th Quartile
Female	4843	0.6089	0.4880	1.0000	0.0000	1.0000
Age	4843	43.3814	11.2881	44.0000	35.0000	52.0000
Poverty	4843	0.0343	0.1820	0.0000	0.0000	0.0000
Famine	4843	0.1714	0.3769	0.0000	0.0000	0.0000
Layer	4843	5.9461	3.0213	5.0000	4.0000	7.0000
Invest_Freq	4843	23.3795	50.9452	10.0000	5.0000	23.0000
Interval	4843	107.9135	37.8426	115.0000	89.0000	138.0000
Return	4843	-0.4906	0.5072	-0.5860	-0.8782	-0.2142

Panel B: Pearson/Spearman correlation coefficients								
	Female	Age	Poverty	Famine	Layer	Invest_Freq	Interval	Return
Female	1							
Age	0.1010 (0.00)***	1						
Poverty	0.0021 (0.88)	-0.1012 (0.00)***	1					
Famine	0.0591 (0.00)***	0.6275 (0.00)***	-0.0315 (0.03)**	1				
Layer	0.0560 (0.00)***	0.0808 (0.00)***	-0.0515 (0.03)**	0.0475 (0.00)***	1			
Invest_Freq	0.0315 (0.03)**	0.0780 (0.00)***	0.0029 (0.84)	0.0674 (0.00)***	0.1000 (0.00)***	1		
Interval	-0.0089 (0.54)	-0.0205 (0.15)	-0.0082 (0.57)	-0.0383 (0.00)***	0.3610 (0.00)***	-0.3621 (0.00)***	1	
Return	-0.0327 (0.02)**	-0.0552 (0.00)***	0.0028 (0.84)	-0.0464 (0.00)***	-0.1214 (0.00)***	-0.0522 (0.00)***	-0.3945 (0.00)***	1

***, **, and * indicate significance levels at 1, 5, and 10%, respectively. As all variables here pertain to investors of the Ponzi scheme, we, therefore, omit typing out the suffix "investor".

investors. For example, Barber and Odean (2001) find that women trade less frequently than men, which significantly increases women’s investment returns. Faccio et al. (2016) show that female CEOs have a lower propensity for risk-taking. Hodge et al. (2009) and Ge et al. (2011) use females to proxy for risk aversion. The coefficient on Age_{investor} is positive and significant (0.2603, $t = 3.82$ for OLS; 0.0118, $z = 4.02$ for Poisson), indicating that older investors are more active in investing than young investors in the Ponzi scheme. This result again is not consistent with older people being more conservative and risk-averse (Sundaram and Yermack, 2007; Yim, 2013; Serfling, 2014). The coefficients on Poverty_{investor} and Famine_{investor} are both insignificant. Overall, female or older investors appear to be more active in investing in the Ponzi scheme.

The spread of the Ponzi scheme. Results are reported in Table 3. Column (1) shows how female investors are referred into the Ponzi scheme conditional on referrers’ personal characteristics. The coefficient on Female_{referrer} is positive and significant (0.2355, $z = 3.81$), suggesting that female investors are more likely to be referred by female referrers into the Ponzi scheme. The corresponding odds ratio of 1.2656 (Column (2)) suggests that the odds that a female investor being referred by a female referrer into the scheme is 1.2656 higher than that (0.7497) if her referrer is a male (Fig. 1). The coefficient on Age_{referrer} is also positive and significant (0.0127, $z = 3.44$), suggesting that female investors are also more likely to be referred by older referrers into the Ponzi scheme.

Columns (3) and (4) of Table 3 show how older investors are referred into the Ponzi scheme conditional on referrers’ characteristics. The coefficient on Age_{referrer} is positive and significant (0.3219, $t = 15.06$ for OLS; 0.0076, $z = 14.99$ for Poisson), suggesting that older investors are more likely to be referred by older referrers into the Ponzi scheme. In fact, investors referred into the Ponzi scheme by older referrers (based on the median of age and OLS coefficient) are on average 5.47 years older than those referred into the scheme by young referrers (based on the median of age) (Fig. 1, based on OLS results). The coefficient on Female_{referrer} is positive and significant (1.1616, $t = 3.67$ for OLS; 0.0270, $z = 3.66$ for Poisson), suggesting that older investors are also more likely to be referred by female referrers into the Ponzi scheme.

The results that female (older) investors are more likely to be referred by female (older) investors into the Ponzi scheme point to the presence of gender and age-based investors affinities, among many, such as ethnicity, religion, age, gender, education, or profession, discussed in the literature (Perri and Brody, 2012; Deason et al., 2015; Gurun et al., 2018), as well as defined by the US Securities and Exchange Commission (2013). While prior studies argue for the importance of investor affinity in Ponzi schemes or other forms of financial fraud, or they consider investors’ age or gender in their analysis (Rantala, 2019), they do not directly empirically establish affinity. With our investor-level data, we identify gender and age-based investor affinities through matching investors and referrers and show that Ponzi schemes (based on our example) especially prey upon investor trust and affinity associated with gender or age to spread “investment ideas” and recruit investors.

Further, we also discover some form of cross-affinity, that is, female (older) investors are more likely to be referred by older (female) investors into the Ponzi scheme. This pattern is new in the literature. It appears that female and older investors have things in common. *Ex post* based on our results, there can be several reasons. First, the psychology literature shows that females (Richter and Kunzmann, 2011; Sze et al., 2012), as well as older people (Auyeung et al., 2012; Yan and Su, 2018), are more likely to have empathy towards others and they can thus easily connect and herd.

Second, financial literacy appears to be relatively low for females and older people (Lusardi and Mitchell, 2008, 2014; Lusardi et al., 2014). Third, traditionally females are more likely than males in China (or Asia in general) to be in charge of household financing. Older people are also more likely to have the extra financial resources or idle cash to invest than younger people.

Overall, results in Table 3 show that female or older investors are especially susceptible to gender and age-based investor affinities. They support Hypothesis 1 that gender and age-based investor affinities help a Ponzi scheme diffuse and spread. Further, the cross-affinity between gender and age is an interesting and important finding of our research.

Formation of investor hierarchy in the Ponzi scheme. In the process of implementing the fundraising Ponzi scheme, the scamming firm adopted a hierarchical reference system for its membership development. Specifically, starting from the initial layer, all members are developed into an interrelated hierarchical structure through referrals from the preceding layer. Each investor falls into one tier out of 0 to 22. Figure 2 draws the links among investors. The red lines in Fig. 3 highlight female-to-female referrer-investor relationships and the red lines in Fig. 4 highlight old-to-old referrer-investor relationships.

From the quick (between March and August of 2016) and widespread development (Figs. 3 and 4) of this Ponzi scheme, we can see that it is different from older schemes that did not rely on mobile technology-based social media. The Madoff scheme was spread through his firm or “feeder” funds. Further, Madoff victims tend to concentrate in specific pockets of geographic areas (Gurun et al., 2018). Neither was Rantala’s (2019) Finnish case likely

mobile technology social media-based and it operated for a relatively long period of time (2003–2008) though equally widespread as the Ponzi scheme examined by us. The case examined in our research was likely fueled by mobile technology-based social media that reinforces a tight social network and overcomes physical and geographic barriers. Mobile technology-based social media ensures that a scheme can quickly diffuse and cause widespread damage.

Equation (5) examines how investors of different gender and age are positioned in the investor hierarchy of the Ponzi scheme. Panel A, Table 4 provides results. The coefficients on $Female_{investor}$ (0.3027, $t = 3.41$ for OLS; 0.0514, $z = 3.40$ for Poisson) and $Age_{investor}$ (0.0196, $t = 3.97$ for OLS; 0.0033, $z = 3.98$ for Poisson) are positive and significant, suggesting that female or older investors occupy lower layers in the investor hierarchy of the Ponzi scheme.

Equation (6) introduces pairs of gender and age-based investor affinities and examines how gender and age-based investor affinities affect investor hierarchy in the Ponzi scheme. Panel B, Table 4 provides the results. In Columns (1) and (4) where only gender-based affinity is included, while the coefficients on Male-to-Female and Female-to-Male are insignificant, the coefficient on Female-to-Female is positive and significant (0.4138, $t = 3.28$ for OLS; 0.0689, $z = 3.21$ for Poisson). In Columns (2) and (5) where only age-based affinity is included, while the coefficients on Young-to-Old and Old-to-Young are insignificant, the coefficient on Old-to-Old is positive and significant (0.4538, $t = 3.44$ for OLS; 0.0750, $z = 3.48$ for Poisson). In Columns (3) and (6) where both gender and age-based investor affinities are included, the coefficients on Male-to-Female, Female-to-Male, Young-to-Old, and Old-to-Young are all insignificant. However, the coefficients on Female-to-Female (0.3931, $t = 3.08$ for OLS; 0.0658, $z = 3.04$ for Poisson) and Old-to-Old (0.4498, $t = 3.41$ for OLS; 0.0744, $z = 3.45$ for Poisson) are both positive and significant. OLS coefficients are depicted in Fig. 5. These results suggest that gender and age-based investor affinities are especially pronounced in female or older investors and that gender and age-based investor affinities place female or older investors in lower layers of investor hierarchy in the Ponzi scheme, supporting Hypothesis 2.

Investor performance in the Ponzi scheme. Equation (7) examines how investors of different gender and age are associated with investment returns in the Ponzi scheme. Panel A, Table 5 provides results. The coefficients on $Female_{investor}$ (−0.0285, $t = -1.82$) and $Age_{investor}$ (−0.0018, $t = -2.01$) are negative and significant, suggesting that female or older investors have lower investment returns in the Ponzi scheme.

Table 2 Investor gender/age and the timing of joining the scheme and investment activeness.

	Time of participating (Interval _{investor})	Investment frequency (Invest_Freq _{investor})	
	Cox hazard (1)	OLS (2)	Poisson (3)
$Female_{investor}$	0.0352 (1.14)	2.4890 (1.74)*	0.1097 (1.75)*
$Age_{investor}$	0.0007 (0.41)	0.2603 (3.82)***	0.0118 (4.02)***
$Poverty_{investor}$	−0.1556 (−1.59)	2.6959 (0.62)	0.1168 (0.64)
$Famine_{investor}$	0.0340 (0.61)	4.0639 (1.56)	0.1266 (1.34)
Constant		9.7835 (3.81)***	2.5311 (21.40)***
Observations	522,625	4843	4843
Wald χ^2 /R-squared	5.36	0.0073	0.0181

OLS regression t-statistics are computed using heteroscedasticity-consistent standard errors. ***, ** and * indicate significance levels at 1, 5, and 10%, respectively.

Table 3 Investor gender/age and referrer-investor relationships.

Investor gender and referrer-investor relationships			Investor age and referrer-investor relationships		
Dependent variable = prob($Female_{investor}$)			Dependent variable = $Age_{investor}$		
	Logit (1)	Odds ratio (2)		OLS (3)	Poisson (4)
$Female_{referrer}$	0.2355 (3.81)***	1.2656	$Female_{referrer}$	1.1616 (3.67)***	0.0270 (3.66)***
$Agerereferrer$	0.0127 (3.44)***	1.0127	$Agerereferrer$	0.3219 (15.06)***	0.0076 (14.99)***
$Poverty_{referrer}$	−0.0039 (−0.03)	0.9961	$Poverty_{referrer}$	−0.4381 (−0.68)	−0.0098 (−0.63)
$Faminerereferrer$	0.2093 (1.99)**	1.2328	$Faminerereferrer$	0.6366 (1.12)	0.0072 (0.59)
Constant	−0.2881 (−1.83)*	0.7497	Constant	28.3097 (30.81)***	3.4120 (153.01)***
Observations	4689		Observations	4689	4689
R-squared	0.0095		R-squared	0.1042	0.0356

OLS regression t-statistics are computed using heteroscedasticity-consistent standard errors. ***, ** and * indicate significance levels at 1, 5, and 10%, respectively.

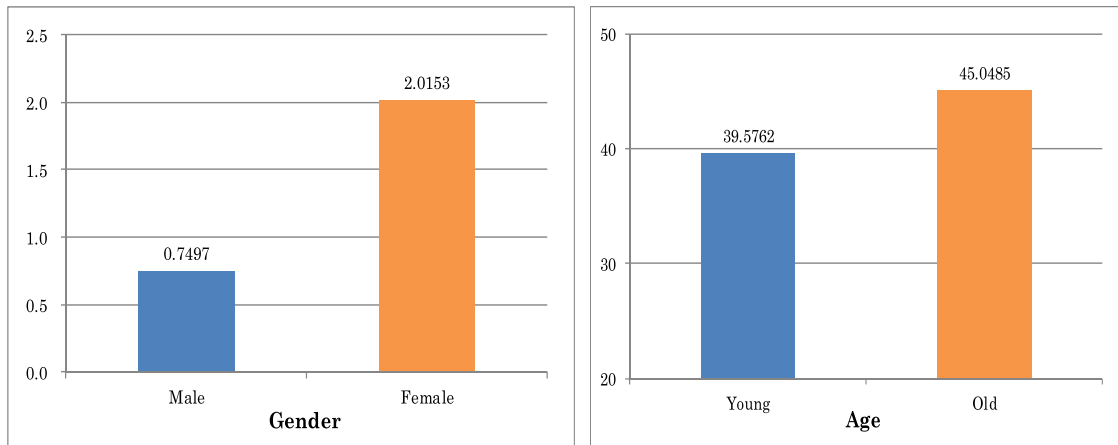


Fig. 1 Investor gender/age and referrer-investor relationships. The left-hand graph illustrates how referrers' gender affects investors' gender (the odds of being a female) and the right-hand graph illustrates how referrers' age affects investors' age. The left-hand graph is based on odds ratios and the right-hand graph is based on OLS results.

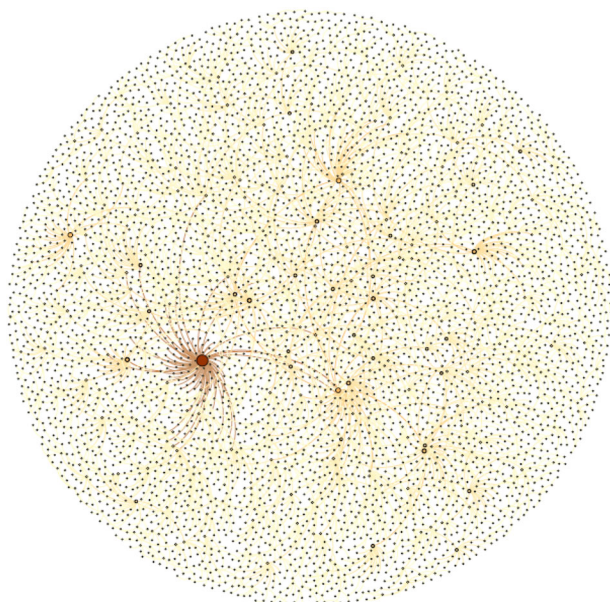


Fig. 2 Referrer-investor relationships as a social network. This graph illustrates the Ponzi scheme as a social network. The nodes are individual investors and the lines connecting them represent referrer-investor relationships. The largest node (in red) in the middle is the originator of the scheme. The graph includes all investors who can be linked to the originator through a chain of referrers.

Equation (8) introduces pairs of gender or age-based investor affinities and examines how gender and age-based investor affinities affect investment performance in the Ponzi scheme. Panel B, Table 5 provides the results. In Column (1) where only gender-based affinity is included, while the coefficients on Male-to-Female and Female-to-Male are both insignificant, the coefficient on Female-to-Female is negative and significant ($-0.0505, t = -2.14$). In Column (2) where only age-based affinity is included, while the coefficients on Young-to-Old and Old-to-Young are both insignificant, the coefficient on *Old-to-Old* is positive and significant ($-0.0573, t = -2.71$). Therefore, the female-to-female or old-to-old referrer-investor relationship lowers investment return by 5.05 or 5.73% (Fig. 6). In Column (3) where both gender and age-based investor affinities are included, the

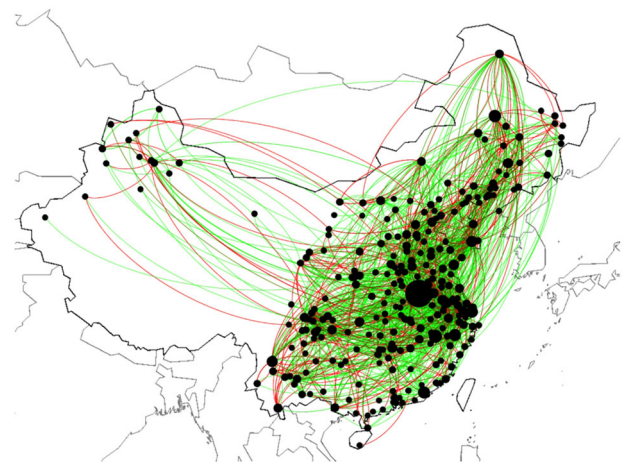


Fig. 3 Geographic locations of investors and female-to-female referrer-investor relationships. This map shows investors' geographic locations and referrer-investor relationships. Each line connects a referrer and an investor. The red lines highlight female-to-female referrer-investor relationships.

coefficients on Male-to-Female, Female-to-Male, Young-to-Old, and Old-to-Young are all insignificant. However, the coefficients on Female-to-Female ($-0.0502, t = -2.15$) and Old-to-Old ($-0.0571, t = -2.71$) are both negative and significant. In sum, these results suggest that female or older investors suffer more losses when they are referred and persuaded into participating in the Ponzi scheme by female or older investors, supporting Hypothesis 3 that gender and age-based investor affinities reduce investment returns from a Ponzi scheme.

Finally, we establish a link between investor hierarchy and investment performance by regressing $Return_{investor}$ directly on $Layer_{investor}$. The coefficient on $Layer_{investor}$ is negative and significant ($-0.0204, t = -9.05$; untabulated). Therefore, when an investor occupies a lower layer in the investor hierarchy of the Ponzi scheme, she/he suffers more losses. This result triangulates with earlier results that female or older investors, being more likely to be referred into the Ponzi scheme by female or older investors, occupy lower investor layers in the scheme, and consequently suffer more losses.

To summarize, with our investor-level analysis and combining results in Tables 3, 4, and 5, we go beyond Deason et al. (2015),

Gurun et al. (2018), and Rantala (2019) by empirically establishing investor-level affinity in sustaining a Ponzi scheme. Further, we show that affinity (gender and age) tends to place investors in a disadvantaged position, leading them to lose money. A central theme here is that while participating in a Ponzi scheme is generally harmful, it is especially harmful when participation is induced through investor affinities such as gender and age.

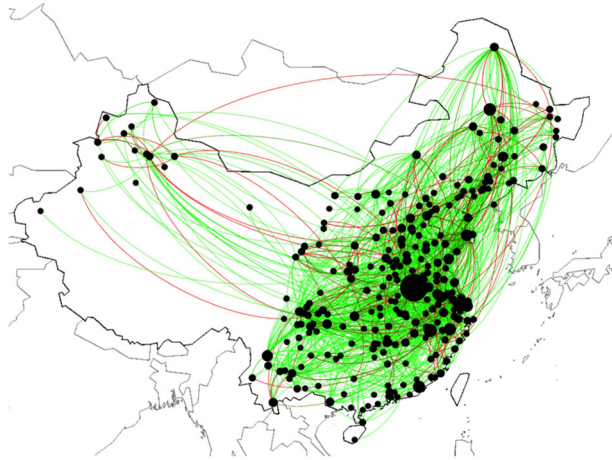


Fig. 4 Geographic locations of investors and old-to-old referrer-investor relationships. This map shows investors' geographic locations and referrer-investor relationships. Each line connects a referrer and an investor. The red lines highlight old-to-old referrer-investor relationships.

Summary and conclusion

Utilizing a police dataset that includes investor-level information and individual bank transaction records on a Ponzi scheme in China, we examine how investor affinity in terms of gender and age affects the way a Ponzi scheme spreads and the way investors suffer losses. We find that female or older investors are more susceptible to investor affinity. Specifically, female or older investors are more likely to be introduced into the scheme by female or older investors. Female or older investors tend to occupy lower layers in the investor hierarchy in the scheme and they are more likely to occupy lower layers if they are introduced into the scheme by female or older investors. Consequently, female or older investors suffer more losses if they are introduced into the scheme by female or older investors. Overall, our results suggest that gender and age-based affinity effects are especially pronounced among female or older investors in a Ponzi scheme.

Our research is important to the academic community and regulatory authorities. Attempts to examine Ponzi schemes are often hampered by a lack of detailed information on investor characteristics and transaction details. Our dataset enables us to study a Ponzi scheme at the investor level and contribute to the understanding of Ponzi schemes. We show that Ponzi schemes prey upon members of vulnerable groups and exploit the trust that exists in the groups. Specifically, gender and age-based investor affinity effects are especially pronounced in female or older investors in a Ponzi scheme. Consequently, female or older investors suffer more losses. Governments and regulatory authorities should raise awareness of the Ponzi scheme, especially among female or older citizens.

Table 4 Investor gender/age, referrer-investor relationships, and investor hierarchy.

Panel A: investor gender/age and investor hierarchy

	OLS (1)	Poisson (2)
Female _{investor}	0.3027 (3.41)***	0.0514 (3.40)***
Age _{investor}	0.0196 (3.97)***	0.0033 (3.98)***
Poverty _{investor}	-0.7343 (-3.97)***	-0.1340 (-3.75)***
Famine _{investor}	-0.0212 (-0.15)	-0.0049 (-0.21)
Constant	4.9424 (24.05)***	1.6114 (45.56)***
Observations	4843	4843
R-squared	0.0108	0.0034

Panel B: referrer-investor relationships and investor hierarchy

	OLS			Poisson		
	(1)	(2)	(3)	(4)	(5)	(6)
Male-to-Female	0.0701 (0.50)	-	0.0924 (0.66)	0.0124 (0.51)	-	0.0163 (0.67)
Female-to-Male	0.0207 (0.15)	-	0.0204 (0.15)	0.0042 (0.18)	-	0.0042 (0.18)
Female-to-Female	0.4138 (3.28)***	-	0.3931 (3.08)***	0.0689 (3.21)***	-	0.0658 (3.04)***
Young-to-Old	-	0.1099 (0.82)	0.1140 (0.85)	-	0.0195 (0.84)	0.0202 (0.87)
Old-to-Young	-	0.1054 (0.80)	0.1040 (0.79)	-	0.0191 (0.86)	0.0189 (0.85)
Old-to-Old	-	0.4538 (3.44)***	0.4498 (3.41)***	-	0.0750 (3.48)***	0.0744 (3.45)***
Female _{investor}	-	0.2548 (2.85)***	-	-	0.0431 (2.85)***	-
Age _{investor}	0.0198 (3.81)***	-	-	0.0033 (3.83)***	-	-
Poverty _{investor}	0.1075 (0.52)	0.0582 (0.28)	0.0570 (0.28)	0.0233 (0.60)	0.0156 (0.40)	0.0156 (0.40)
Famine _{investor}	-0.0850 (-0.58)	0.0835 (0.64)	0.0799 (0.62)	-0.0152 (-0.64)	0.0134 (0.64)	0.0129 (0.62)
Female _{referrer}	-	0.1866 (2.02)**	-	-	0.0316 (2.02)**	-
Age _{referrer}	-0.0102 (-1.78)*	-	-	-0.0017 (-1.77)*	-	-
Poverty _{referrer}	-2.1786 (-14.42)***	-2.1132 (-14.03)***	-2.1133 (-14.02)***	-0.4454 (-12.04)***	-0.4346 (-11.79)***	-0.4347 (-11.78)***
Famine _{referrer}	0.4205 (2.80)***	0.1394 (1.04)	0.1394 (1.04)	0.0686 (2.82)***	0.0223 (1.04)	0.0223 (1.05)
Constant	5.4793 (19.72)***	5.6388 (57.50)***	5.7318 (50.42)***	1.7015 (36.19)***	1.7293 (101.24)***	1.7448 (87.69)***
Observations	4689	4689	4689	4689	4689	4689
R-squared	0.0438	0.0427	0.0432	0.0149	0.0145	0.0146

OLS regression t-statistics are computed using heteroscedasticity-consistent standard errors. ***, ** and * indicate significance levels at 1, 5, and 10%, respectively. The bold values indicates the pairing results.

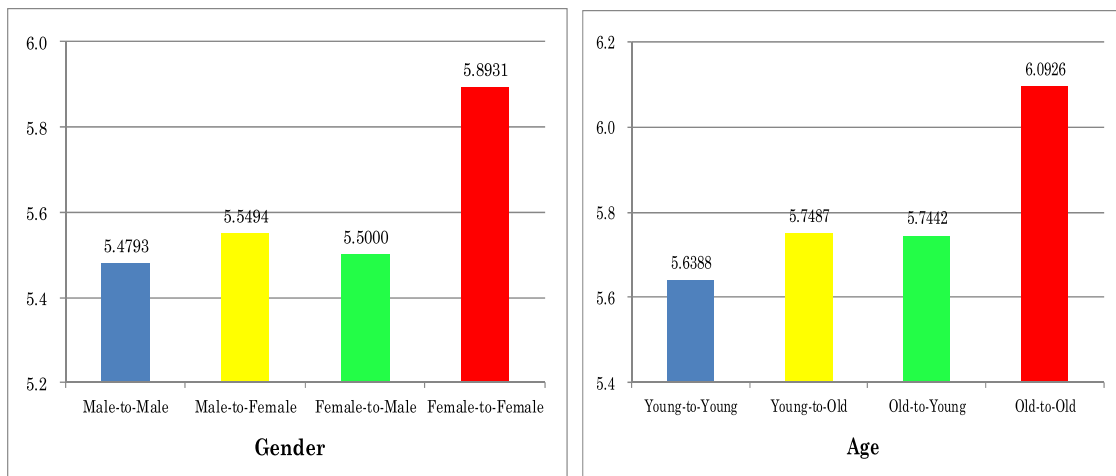


Fig. 5 Referrer-investor relationships and investor hierarchy. The left-hand graph illustrates how the gender-to-gender referrer-investor relationship affects layers in the investor hierarchy and the right-hand graph illustrates how the age-to-age referrer-investor relationship affects layers in the investor hierarchy. They are based on OLS results.

Table 5 Investor gender/age, referrer-investor relationships, and investment returns.

Panel A: investor gender/age and investment returns

Female _{investor}	-0.0285 (-1.82)*
Age _{investor}	-0.0018 (-2.01)**
Poverty _{investor}	-0.0051 (-0.12)
Famine _{investor}	-0.0261 (-1.07)
Constant	-0.3896 (-10.58)***
Observations	4843
R-squared	0.0040

Panel B: referrer-investor relationships and investment returns

	(1)	(2)	(3)
Male-to-Female	-0.0079 (-0.29)	-	-0.0092 (-0.34)
Female-to-Male	-0.0267 (-1.03)	-	-0.0260 (-1.01)
Female-to-Female	-0.0505 (-2.14)**	-	-0.0502 (-2.15)**
Young-to-Old	-	0.0016 (0.06)	0.0014 (0.05)
Old-to-Young	-	0.0148 (0.68)	0.0149 (0.68)
Old-to-Old	-	-0.0573 (-2.71)***	-0.0571 (-2.71)***
Female _{investor}	-	-0.0179 (-1.15)	-
Age _{investor}	-0.0010 (-1.10)	-	-
Poverty _{investor}	-0.0711 (-1.60)	-0.0673 (-1.51)	-0.0672 (-1.51)
Famine _{investor}	-0.0191 (-0.76)	-0.0170 (-0.80)	-0.0168 (-0.79)
Female _{referrer}	-	-0.0349 (-2.30)**	-
Age _{referrer}	-0.0023 (-2.53)**	-	-
Poverty _{referrer}	0.1597 (3.28)***	0.1588 (3.30)***	0.1588 (3.30)***
Famine _{referrer}	-0.0228 (-0.98)	-0.0463 (-2.27)**	-0.0463 (-2.27)**
Constant	-0.3191 (-6.37)***	-0.4450 (-25.11)***	-0.4500 (-21.14)***
Observations	4689	4689	4689
R-squared	0.0155	0.0159	0.0159

OLS regression t-statistics are computed using heteroscedasticity-consistent standard errors. ***, ** and * indicate significance levels at 1, 5, and 10%, respectively. The bold values indicates the pairing results.

Limitations and future research

There are limitations associated with our research. First, during the 2015–2017 peak years alone, there were thousands of cases of Ponzi schemes involving hundreds of billions RMB worth of wealth in China. We only have access to investor-level information on one of them. Data on Ponzi schemes are normally not made public or released to researchers by regulatory authorities or the police. The Ponzi scheme that we examine is certainly not among the largest or has wreaked the greatest havoc on investors

and, considering its size, is literally a drop in the bucket. Therefore, the representativeness of this Ponzi scheme and the external validity of our conclusion can be an issue. Second, a very important research question is in fact how the probability of participating in a Ponzi scheme, or more generally, being financially deceived, is affected by gender and age and the investor affinity associated with them. With information only on investors who are already participants of a Ponzi scheme, we cannot answer this question. While our descriptive statistics (Table 1) do show

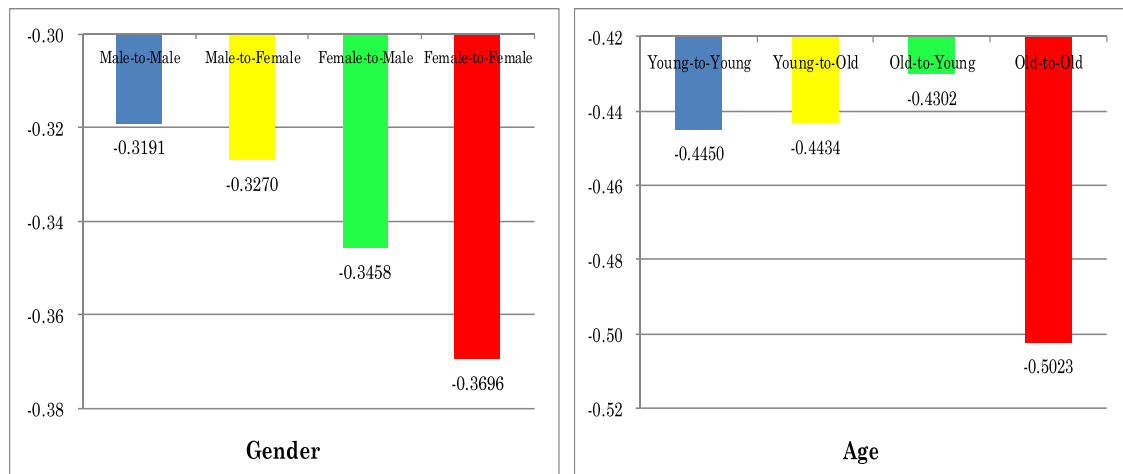


Fig. 6 Referrer-investor relationships and investment returns. The left-hand graph illustrates how the gender-to-gender referrer-investor relationship affects investment performance and the right-hand graph illustrates how the age-to-age referrer-investor relationship affects investment performance.

that female and people above a certain age are more likely to participate in the Ponzi scheme and consequently suffer more losses, we cannot show if gender, age, and their associated affinities contribute to enticing investors into participating in the scheme in the first place as we do not have information on people who are accosted but refuse to participate. In our study, participation is given and we can only show how a referrer's gender and age are associated with the next investor's gender and age and how these gender and age-based investor affinities affect investor hierarchy and investment returns (losses).

Future research on this topic would benefit from more released data (if possible) to incorporate information on investors, as well as characteristics of schemes in an expanded analysis. This would help resolve the external validity issue associated with our study and potentially answer the question of whether gender, age, and the affinity associated with them also affect Ponzi scheme participation. Further, with richer data, researchers can also examine the interplay between Ponzi schemes and investments in other areas, such as the stock and real estate markets.

Data availability

This research relies on proprietary police data on a Ponzi scheme in China. The data are not available to third parties.

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Competing interests

The authors declare no competing interests.

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