Bubble Occurrence and Landing[1]

Junmin Wan[2]

Faculty of Economics, Fukuoka University

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Abstract

Firstly, we show the necessary and sufficient conditions of bubble occurrence within one period and multiple periods, and find that bubble premium is necessary and that rational bubble grows faster than the risk-free asset because bubble premium is required by a risk-neutral investor. Secondly, we show that some regimes and tax policies can prevent bubble occurrence by excluding one of the necessary conditions, and that some policies can hard- and soft-land the bubble. Thirdly, bubble tests show that there were bubbles in the stock prices of South Sea during 1718-1722, of the U.S. during 1871-2017 and of Japan during 1952-2018, as well as in daily prices of Bitcoin during April 28, 2013-April 24, 2018, respectively, and bubble premium was identified and significantly raised in the South Sea Bubble which was considered of a natural experiment. Fourthly, dividend yields in the U.S. and Japan were significantly lower than the risk-free interest rates, hence capital gains from stock bubbles could explain the equity premium puzzles in those markets. Finally, due to different colonial rulers in Tsingtao and Shanghai during 1898-1911 and new land law in Zhejiang in 1931, also regarded as social experiments, land prices were significantly decreased by anti-speculation policy such as taxes.

JEL classification: D46, D82, D84, G18

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1 Introduction

Bubble would be a serious issue since it harms economic stability and efficiency (Xiong 2013; Hirano, Inaba &Yanagawa 2015; Miao, Wang & Zhou 2015),[3] thus prevention and landing of bubble is necessary as argued by Wan (2018). Although infinite horizon of the asset usage is the necessary condition on bubble occurrence in Wan (2018), there were land bubbles even though fixed period of land usage in Hong Kong and Mainland China as well as land institution of leasehold in the U.K. were practiced (Huang and Shen 2017). Giglio et al. (2016) report that no evidence of failures of the transversality condition in housing markets in the U.K. and Singapore where residential property ownership takes the form of either leaseholds with finite-maturity or freeholds with infinite-maturity, even sizable bubbles were regularly thought to be present. Hence, we need a theory to give an explanation on a bubble occurrence within limited period.

We will build a model to show the necessary and sufficient conditions of bubble occurrence within one period and multiple periods, and will show some regimes and tax policies can prevent bubble occurrence by excluding one of the necessary conditions, and will show what policy can be used to hard- and soft-land the bubble. We will also examine whether bubble existed, whether bubble premium was significantly raised in the South Sea Bubble, whether dividend yields in the U.S. and that in Japan have been lower than the risk-free interest rates, and whether capital gains from stock bubbles give an explanation on the equity premium puzzle. Finally, by some historical facts in Tsingtao, Shanghai and

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[3] Bubble harms balance sheets of firms, banks (Ogawa 2009; Wan, in press), and households (Ogawa and Wan 2007; Wan 2015, 2016). Bubble is analyzed in overlapping generation model in Tirole (1985).

Zhejiang, we will examine whether land prices have been decreased by anti-speculation policy such as tax.

This paper below is organized as follows: Section 2 presents the basic model of a bubble occurrence, and discusses prevention and landing of the bubble. Section 3 shows that bubble premium was raised by South Sea Bubble, and it can be considered of equity premium. Section 4 shows land prices were decreased by anti-speculation policies by three historical facts. Section 5 presents concluding remarks.

2 The Model

2.1 Bubble Occurrence within One Period

Blanchard and Watson (1982) outlined the basic framework of a rational bubble. Assume that there are two assets in an economy, one safe and the other risky, like land. The market is assumed to have no opportunity for arbitrage, with private ownership of the assets established. The investor or asset owner considers the following risky asset-trading problem:

r : the interest rate of a risk-free asset;

d_t : the dividend of the risky asset at time t;

p_t : the market price of the risky asset at time t.

We further assume that r is consistently positive over the time horizon. Different from a risk averter in Merton (1973), a risk-neutral investor is assumed to freely choose to invest in a risk-free or risky asset following Wan (2018). Furthermore, sufficiently large number of or infinite investors at time t are assumed to be in the market. The source of the risk is from both of the infinite time horizon and infinite investors, and we consider them as a type of "*certain uncertainty*." This risk is uncertain because we do not know the ending point of the infinity of both time horizon and investors, and we say it is "certain" because this type of uncertainty is well known to every investor.

Because of two dimensions of infinity, we first consider of the infinite number of investors for simplicity by assuming zero time span. In this case, the interest rate of a risk-free asset r should be zero, and bubble would not occur in the framework of Blanchard and Watson (1982). Hence, we here introduce bubble premium γ in Wan (2018) to model the bubble. Under the no-arbitrage condition, the following equation should be satisfied in market equilibrium for an investor as a sequential trader,[4]

$$1 = \frac{E_n[p_{n+1}]}{p_n} - \gamma_0 E_n\left[\frac{p_n - f}{p_n}\right] \tag{1}$$

where E_n is the expectation operator of the *n* investor, and $1 \leq \mathrm{n} < \infty$ as well as *f=d/r*, for simplicity, if we assume that, $E_t[d_{t+1}] = E_t[d_{t+j}]$ for any $j \in [1, \infty)$. The forward-looking solution of p_n in the Equation (1) is,

$$p_n = \frac{E_n[p_{n+1}]}{1+\gamma_0} + \frac{\gamma_0}{1+\gamma_0}\mathrm{f} \tag{2}$$

where $1 \leq \mathrm{m} < \infty$, and when $\mathrm{m} \rightarrow \infty$, the result is,

$$p_n = f + lim_{m \to \infty} E_n\left[\frac{p_{n+m}}{(1+\gamma_0)^m}\right]. \tag{3}$$

The first and second terms on the right-hand side of Equation (3) are the fundamental values of income gain and the bubble term of the risky asset, respectively. The bubble term

[4] For a period *t*, the bubble premium would be a function $\gamma_t = f(\gamma_{0,} t)$, then for one period $\gamma_1 = f(\gamma_{0,} 1)$.

is also called a transversality condition, and a rational bubble occurs if and only if

$$lim_{m\to\infty}E_n\left[\frac{p_{n+m}}{(1+\gamma_0)^m}\right]>0 \tag{4}$$

In the literature, such as Miller and Modigliani (1961) or Montrucchio (2004), the above condition was assumed to be satisfied to exclude the rational bubble,

$$lim_{m\to\infty}E_n\left[\frac{p_{n+m}}{(1+\gamma_0)^m}\right]=0. \tag{5}$$

Some cases satisfy or violate Equation (5). We assume the growth rate of expectation for p_{n+m} is g_0, where g_0 expresses speculative aspects of an investor, which are independent from dividend d. The speculative investor believes that the asset will be bought by a new speculator, even though the bubble term is common knowledge for all investors. Phillips, Shi and Yu (2015) developed an empirical method of detecting an explosive bubble, and serious housing bubbles in large cities in China were determined via a similar method in Wan (2015, in press, mimeo). This empirical method would theoretically be expected to measure the size of g_0. We then have,

$$p_{n+m}=(1+g_0)^m, \tag{6}$$

where,

$$lim_{m\to\infty}E_n\left[\frac{p_{n+m}}{(1+\gamma_0)^m}\right]\to 0, for\ g_0<\gamma_0\ , \tag{7}$$

$$lim_{m\to\infty}E_n\left[\frac{p_{n+m}}{(1+\gamma_0)^m}\right]\to 1, for\ g_0=\gamma_0\ , \tag{8}$$

$$lim_{m\to\infty}E_n\left[\frac{p_{n+m}}{(1+\gamma_0)^m}\right]\to \infty, for\ g_0>\gamma_0\ , \tag{9}$$

and Equations (7), (8), and (9) show conditions of no bubble, concurrent or coexisting bubbles, and explosive bubble, respectively. For the explosive bubble expressed by

Equation (9), this situation rules out the no-arbitrage condition from Equation (1). We obtain the following proposition.

Proposition 1:

Bubble occurs if and only if the positive bubble premium is levied under the non-arbitrage condition is satisfied.

Proof:

See Equations (7), (8) and (9). Q.E.D.

Even with leaseholds with finite-maturity of residential property ownership in U.K, Singapore and Hong Kong, and Mainland China, we show that rational bubble may occur. This result would give an explanation on why there are not significant difference between leaseholds and freeholds in Giglio et al. (2016), because there are bubbles in the prices of these two type of properties.

2.2 Bubble Occurrence within Multiple Periods

Assume that m ($1 \leqq m \ll \infty$) times of turn over occur within one period, the bubble would be,

$$b_m = (1 + g_0)^m. \tag{10}$$

Further assume that the above bubble satisfies the following intertemporal non-arbitrage condition following Wan (2018),

$$1+r=\frac{E_t[p_{t+1}+d_{t+1}]}{p_t}-\gamma E_t\left[\frac{p_t-d_{t+1}/r}{p_t}\right], \tag{11}$$

where $\gamma = f(\gamma_{0,}1)$. If $E_t[d_{t+1}]=E_t[d_{t+j}]$ for any $j\in[1,\infty)$, then the forward-looking solution of the Equation (11) becomes,

$$p_t = E_t\left[\frac{d_{t+1}}{r}\right]+\underset{T\to\infty}{E_t}\left[\frac{p_{t+T}}{(1+r+\gamma)^T}\right], \tag{12}$$

and the condition of no bubble in Equation (11) becomes,

$$\underset{T\to\infty}{E_t}\left[\frac{p_{t+T}}{(1+r+\gamma)^T}\right]=0\,. \tag{13}$$

The premium parameter γ has impact on the bubble term, but not the fundamental term. Further assume that the bubble grows at,

$$p_{t+T}=(1+g_b)^T, \tag{14}$$

where $1+g_b=b_m=(1+g_0)^m$, and $g_b=b_m-1$. Then we have,

$$\underset{T\to\infty}{E_t}\left[\frac{p_{t+T}}{(1+r+\gamma)^T}\right]\to 0\text{, for } g_b<r+\gamma, \tag{15}$$

$$\underset{T\to\infty}{E_t}\left[\frac{p_{t+T}}{(1+r+\gamma)^T}\right]=1\text{, for } g_b=r+\gamma, \tag{16}$$

$$\underset{T\to\infty}{E_t}\left[\frac{p_{t+T}}{(1+r+\gamma)^T}\right]\to \infty\text{, for } g_b>r+\gamma. \tag{17}$$

Equations (15), (16), and (17) show new conditions of no bubble, concurrent or coexisting bubbles (Kamihigashi, 2010), and explosive bubble, respectively. Noticeably, the growth rate of bubble term is higher than that of risk-free asset, and the ratio of the former to the latter increases with time. Thus, the portion of bubble term increases with time when bubble occurs, while in the standard bubble model or in the model with a risk-averter who asks for risk premium (Wan 2011), this portion is unchanged. This setting would give a plausible explanation of why bubble grows obviously faster than interest rate at the country and city level in Wan (in press). Equation (17) violates the intertemporal no-arbitrage condition (11). We obtain the following bubble which simultaneously satisfies the intra-temporal and intertemporal non-arbitrage conditions, as well as the following property.

Proposition 2:

The bubble grows with the rate $(1+\gamma_0)^m$, and at the time T the bubble would be $(1+\gamma_0)^{mT}$, and $\gamma = (1+\gamma_0)^m - (1+r)$.

Proof:

By Equations (16) and (14), we obtain the bubble at time T. Q.E.D.

The times *m* of asset turn over would be an indicator of degree of speculation. If the bubble premium γ is not sufficiently high, the no-bubble condition (15) would be easily violated, then a bubble occurs. For preventing this type of bubble, five policy and tax tools shown in Wan (2018) would be effective.

2.3 Bubble Prevention within One Period

Within one period, we should know what regime and tax cannot prevent bubble, then clarify how we can prevent the bubble. First, we obtain the following proposition.

Proposition 3:

Asset holding tax cannot prevent the bubble, and fixed period of land usage also cannot exclude the bubble. By contrast, Tobin tax, capital gain tax, and the rebate option can prevent the bubble.

Proof:

See appendix, arbitrage equations with taxes.

The former part of this proposition is obvious because time span of holding the asset is zero. Asset holding tax such as property tax in Wan (2018) would not be effective to prevent the bubble occurrence. Furthermore, fixed period of land usage in Wan (2018) could also not prevent the bubble. By contrast, the rebate option, Tobin tax, and capital gain tax shown in Wan (2018) would be effective tool to exclude the bubble. These results are in line with those in Tobin (1974) and Stiglitz (1989).

2.4 Bubble Prevention within Multiple Periods

Within multiple periods, we find similar properties to Wan (2018)

Proposition 4:

Asset holding tax, Tobin tax, capital gain tax, the rebate option, and fixed period of land usage can prevent the bubble.

Proof:

See appendix, arbitrage equations with taxes.

2.5 Hard- and Soft Landing within One Period and Multiple Periods

For a bubble within one period, to hard land the bubble, tax tools such as Tobin tax and capital gain tax in Wan (2018) would be effective. For a bubble within multiple periods, the hard and soft landing policies would be different from those in Wan (2018). For soft landing within one period, it would be different from Wan (2018), while for soft landing within multiple periods, it would be similar to Wan (2018).

2.6 Bubble Growth Violating Non-arbitrage Condition

Equations (9) and (17) violate the intra- and inter- temporal no-arbitrage condition, respectively, and bubble grows faster than $\mathrm{r} + \gamma$. The economic implication would be that a risk neutral investor borrows the maximum of volume which bank tends to lend. Hence, the lending volume would determine the asset price. The relationship between bubble and lending policy could be easily analyzed. Consequently, financial policies such as control of lending interest rate $(r + \gamma)$ or the limit of lending volume could prevent and land the bubble.

Proposition 5:

The realized bubble growth may be higher than $r + \gamma$, and soft landing can be possible via control of lending volume or bubble premium.

Proof:

See appendix.

3 Bubble Premium and Equity Premium Puzzle

3.1 Bubble Premium in the South Sea Bubble in 1720

We obtained the data on lending against South Sea stock at Hoare's Bank from Temin and Voth (2004, Table 7, and description in p.1665). The lending rate, loan value, market price, and discount rate were reported. We also obtained data on composition of Hoare's Bank asset from Temin and Voth (2006, Figure 2). It is reported that the bank invested the highest value of 14% of its assets in South Sea stock on June 24, 1720, while the ratios in other years were much lower. Rate of government bond was 5%, and the average interest rate of Hoare's Bank during 1702-1713 was about 6%, then dropped to about 5% during 1714-1722 (Temin and Voth, 2006). We plotted the data on stock price in Figure 1, lending rate against South Sea and average interest rate in the Figure 2. It is obvious that the bubble premium commoves with the bubble.

By a bubble test following Phillips, Shi and Yu (2015) and Wan (2015), empirical results in Table 1a show that there was bubble in the monthly stock prices of the South Sea. The South Sea bubble and the different lending rate by Hoare's bank provide us a natural experiment to identify the bubble premium. Following the results in the above section and Wan (2018), we calculate the bubble premium by Hoare's Bank. The size of bubble of South Sea stock is equal to the stock price subtracted the fundamental value where the fundamental value should be just 100 pounds. Form Figure *3*, positive relationship between bubble premium and size of bubble would be easily observed.

Next, we perform a formal test on the hypothesis of bubble premium. The null hypothesis is that the bubble premium should be raised by the size of bubble. Table 1b summarizes the statistics of the related variables. The linear estimation by Ordinary Least Squares (OLS) with standard errors was used to identify the impact of South Sea bubble on bubble premium. In Table 2c, the coefficient of bubble is significantly positive, hence the null hypothesis is supported. The estimated parameter of the bubble premium here would also be γ ／stock price in the structural model of Wan (2018). It implies that bubble premium would have non-linear relationship with the loss given default.

3.2 Bubble Premium as Equity Premium

Following Equation (12), we can rewrite it as,

$$r = E_t\left[\frac{d_{t+1}}{p_t}\right] + \lim_{T\to\infty} E_t\left[\frac{rp_{t+T}}{p_t\,(1+r+\gamma)^T}\right], \tag{18}$$

the first and second term of the right hand of Equation (18) means the yield curve and gain from bubble term, while the *r* means the risk-free interest rate. We will use the related information from U.S. and Japan to test the condition by Equation (18).

The yearly dividend yield in the stock market and the yearly interest rate in the U.S. and Japan are shown in Figures 4 and 5, and their basic statistics are summarized in Table 2a, and b, respectively. For the U.S., the null hypothesis (dividend yield is equal to interest rate) is rejected at p-value=0.003. For Japan, the same null hypothesis is also rejected at p-value=0.000. For both the U.S. and Japan cases, the alternative hypotheses are accepted. It implies that dividend yield is significantly lower that the interest rate. Also by bubble tests following Phillips, Shi and Yu (2015) and Wan

(2015), empirical results in Table 2c, and d show that there was bubble in the stock prices of both the U.S. and Japan. The empirical results on bubble in U.S. stock market is also consistent with those in White and Rappoport (1993, 1994).

For the bubble by Equation (3) which does not depend on time, the risk-free interest rate should be sufficiently small to be Negligible, then we rewrite Equation (3) as

$$1 = E_n\left[\frac{f}{p_n}\right] + \lim_{m\to\infty} E_t\left[\frac{p_{n+m}}{p_n\,(1+\gamma_0)^m}\right], \tag{19}$$

and the Equation (19) shows the condition on rational bubble. We can test it using daily data of Bitcoin. Figure 8 shows the daily price of Bitcoin during April 28, 2013 to April 24, 2018, and Table 2e shows there was bubble in the daily price. Because the dividend of Bitcoin is always zero, the price increase should be all from the bubble.

Considering of that the stock prices have increased more than one hundred times during the sample periods in the U.S. and Japan, the summation of dividend yield and the ratio of yearly capital gain to stock price becomes higher than the interest rate. The capital gain would be from stock bubble, hence it would be obvious that the higher return of stock (dividend plus capital gain) includes bubble premium. Presume that there is an extreme case in the Miller and Modigliani (1961) economy where dividends of corporate firms will not be distributed forever, then returns of corporate shares should totally be from the capital gain of stock price just like Bitcoin bubble also argued by Cheah and Fry (2015). The price of share may include bubble also as argued by Shiller (1981), and the bubble causes bubble premium. This bubble premium could also be explained as equity premium for a risk neutral investor, then the equity premium puzzle argued by Mehra and Prescott (1985) could be understood.

3.2 Speculation and Land Prices in Tsingtao and Shanghai, 1898-1911

Tsingtao had been German colony for some years. Before institution of counter-speculation, serious speculation on land purchase at Tsingtao occurred. It was reported that sharp jump with over 1,000% of land price increase took place (Yang, 2012). After German colony government made new institution of counter-speculation based on Tsingtao tradition, for example, introduced some new policies such as Land Value Tax （6%）, Capital Gains Tax (33.3%), priority of governmental purchase, etc. on March 6, 1898, the land price became stable even the new railway to Jinan and new port was started up. By contrast, Shanghai was colony of UK, France, etc., hence land speculation was permitted. Consequently, the land price in Tsingtao shown different change compared with Tsingtao in Figure 6.

Table 3a shows the summary statistics of land prices in Tsingtao and Shanghai, where land prices in Shanghai are estimated based on Du (2012). We pool the data of these two cities, and make city dummies, *Tsingtao=1* and *Shanghai=0*. We also make *after1904* dummy which equals *1* after 1904 but *0* otherwise. The coefficient of the interterm of *Tsingtao* and *after1904* is the difference in difference (DID) estimator. We perform OLS with robust standard errors and obtain the empirical results in Table *3b*. The coefficient of *Tsingtao*after1904* is significantly negative. It implies that anti-speculation policy significantly decreased the land price in Tsingtao.

3.3 Land Prices and Land Value Tax in 1930

President Sun, Yat Sen visited Tsingtao and highly appreciated land institution and construction of Tsingtao (Sun 1922; Trescott, 1994). Then President Sun invited Wilhelm Ludwig Schrameier who made Land Law of Tsingtao to make the land law for the whole country (Zhang, 2014), and eventually they jointly started to make the Land Law of Republic of China. The first purpose of this law is to prevent the land speculation (Zhang, 2014).

Land law of Republic of China was made on June 30 in 1930. A land tax was based on the market value of land. A land owner had to self-report the land value to the government, and *1.5%-5.5%* of the self-reported value should be paid as the land tax. The land owner had incentive to underreport the value, but if the difference between self-reported value and governmental assessment was higher than *20%*, the government had option to buy the land via the self-reported value. Figure *6* shows plotted value of the self-reported and the governmental assessment values.

Summary statistics of land values are shown in Table *4a*. Estimated results by OLS with robust standard errors are reported in Table *4b*. The coefficient of government assessment value is significantly positive, and the figure *0.497* (marginal effect) means that self-reported value is about half of the governmental assessment one. The aggregate data on the whole value of self-reported and government assessment in whole Zhejiang province was, *1,583,265,837* Yuan, *2,226,002,582* Yuan in 1931, respectively, and the ratio of the former to later was 0.711 (average effect). One explanation of this result would be that land value tax was capitalized, and that the land owner reported the land value after tax while the government assessed the land value without tax. If it was true without bubble occurrence, the implied interest rate would be as follows.

Land value before tax without bubble would be, $p=d/r$, while the value with tax rate τ, $p_{\tau}= d/(r+\tau)$, where d is the dividend. We obtain $p_{\tau}/p=r/(r+\tau)=0.711$. By solving the equation of interest rate, r would be *5.359% - 19.651%* for the land value tax rate *1.5%-5.5%*. The average interest rate would be *12.505%*. This implied yearly interest rate was close to the yearly deposit rate *10.800%* in Nanking in 1931 (vol.12, p.32, interest rate in major cities). An alternative explanation would be that the government also assessed the land value with tax, and that the land owner underreported *29.9% (=1-0.711)* of the land value after tax. Even the difference between self-reported one and governmental assessment was higher than *20%*, the government was presumably predicted to hardly practice the option or to have to incur some transaction cost as large as about *0.45% (=5%*9%)* of land value. If one of the above two explanations captured that situation, the behaviors of land owners and the government were rational based on the theory of land value with tax.

5 Conclusions

We have built a model to show the necessary and sufficient conditions of bubble occurrence within one period and multiple periods, and have found that bubble premium is necessary. Next, we have also shown that some regimes and tax policies can prevent bubble occurrence by excluding one of the necessary conditions, and have found that some policies can be used to hard- and soft-land the bubble. Thirdly, we have found that bubble premium was significantly raised in the South Sea Bubble. Fourthly, dividend yields in the U.S. and Japan as well as Bitcoin have been shown significantly lower than the risk-free interest rates, it implies that capital gains from stock bubbles would give an explanation on the equity premium puzzle. Finally, by some historical facts in Tsingtao, Shanghai and Zhejiang, it was found that land prices have been significantly decreased by anti-speculation policy such as tax.

The theoretical and empirical findings here imply that bubble would easily occur, however, it could be excluded by some policies and taxes. As of research left in the future, bubble premium and bubble occurrence should be analyzed in a general equilibrium framework.

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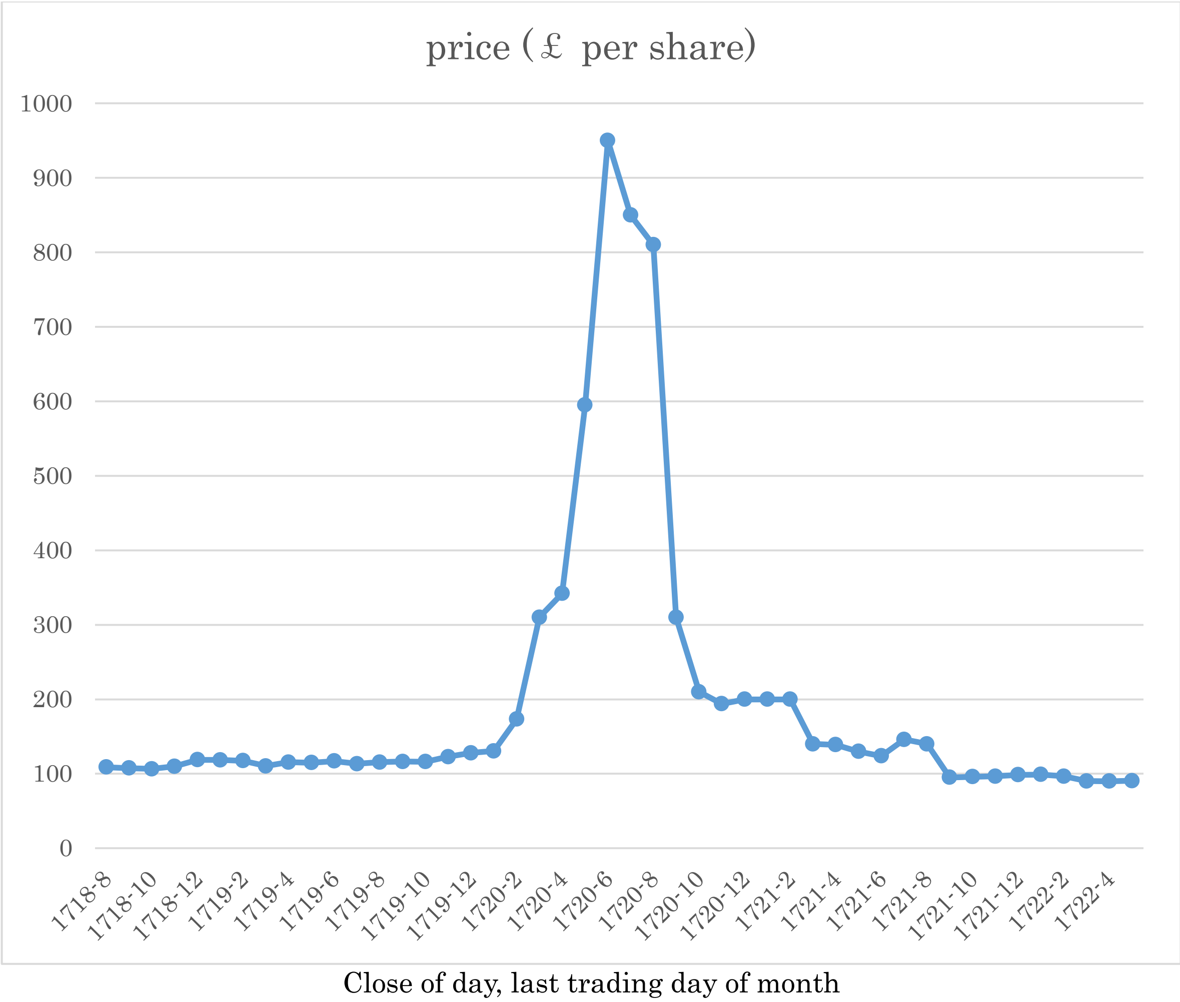
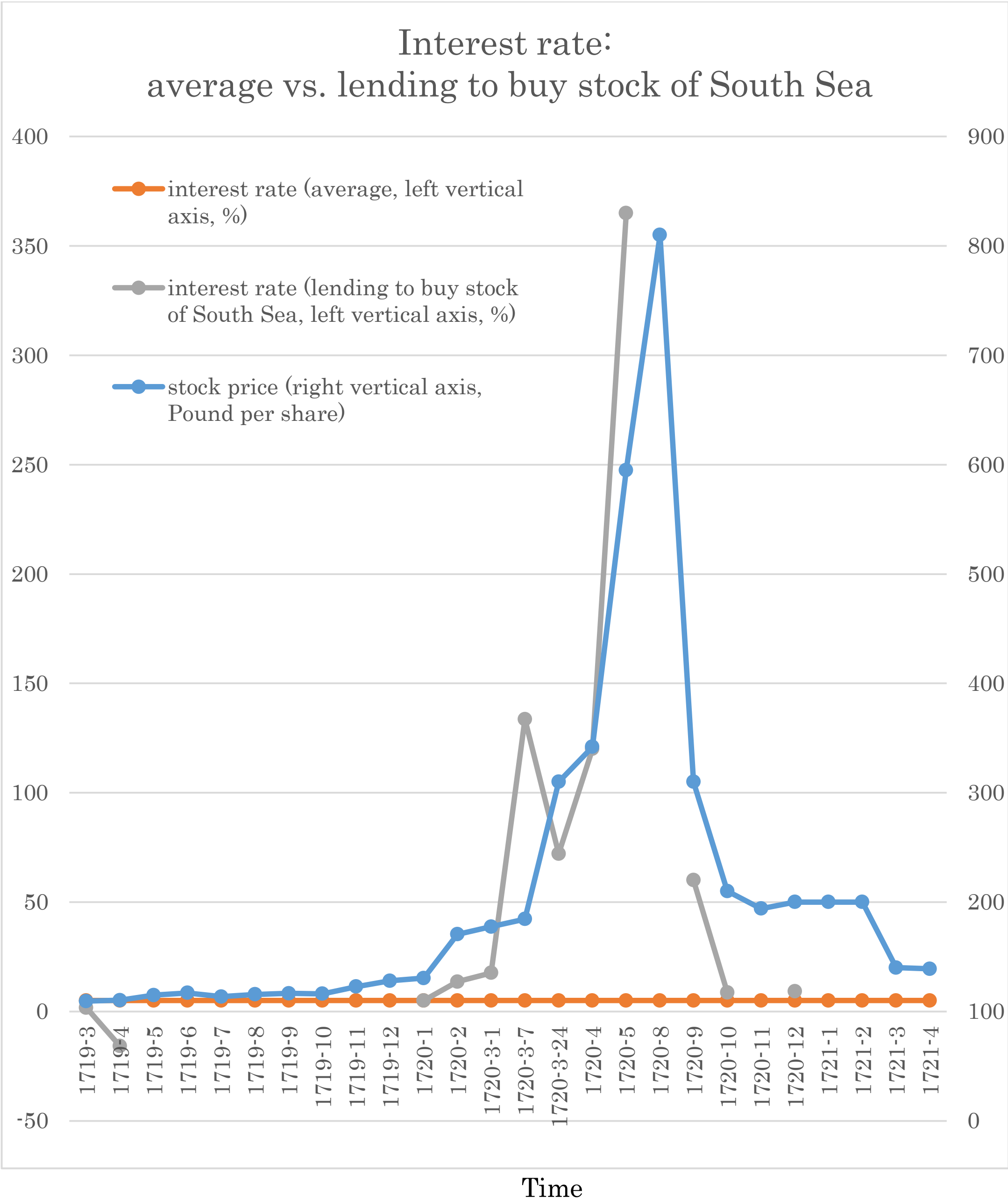
Figure 1: Monthly stock price of South Sea Company, 1718-1722.



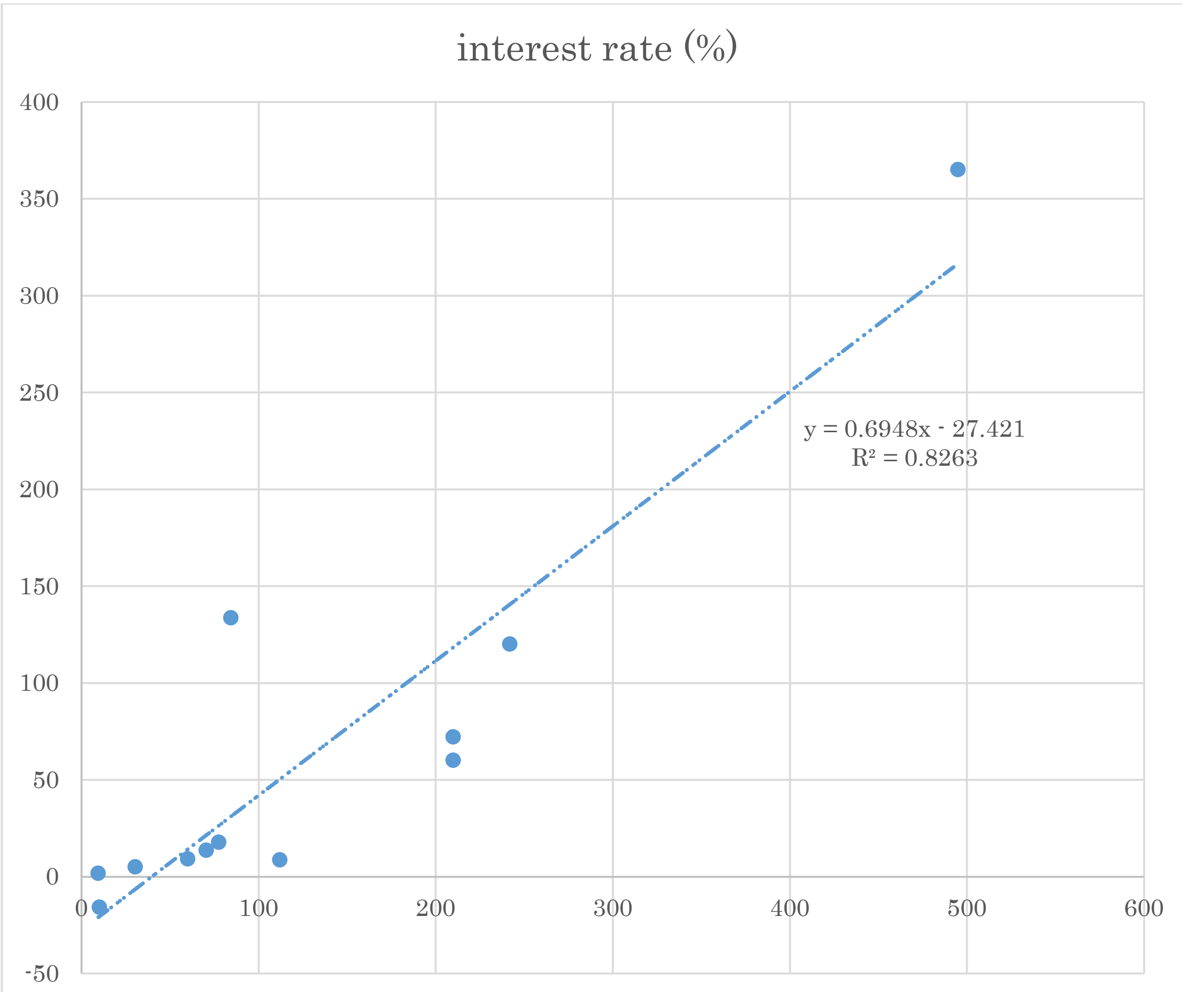
Source: Author's drawing based on Neal (1990, pp.234-235).

Figure 2: Average lending rate and lending rate to buy stock of South Sea, 1719-1720



Source: See the text.

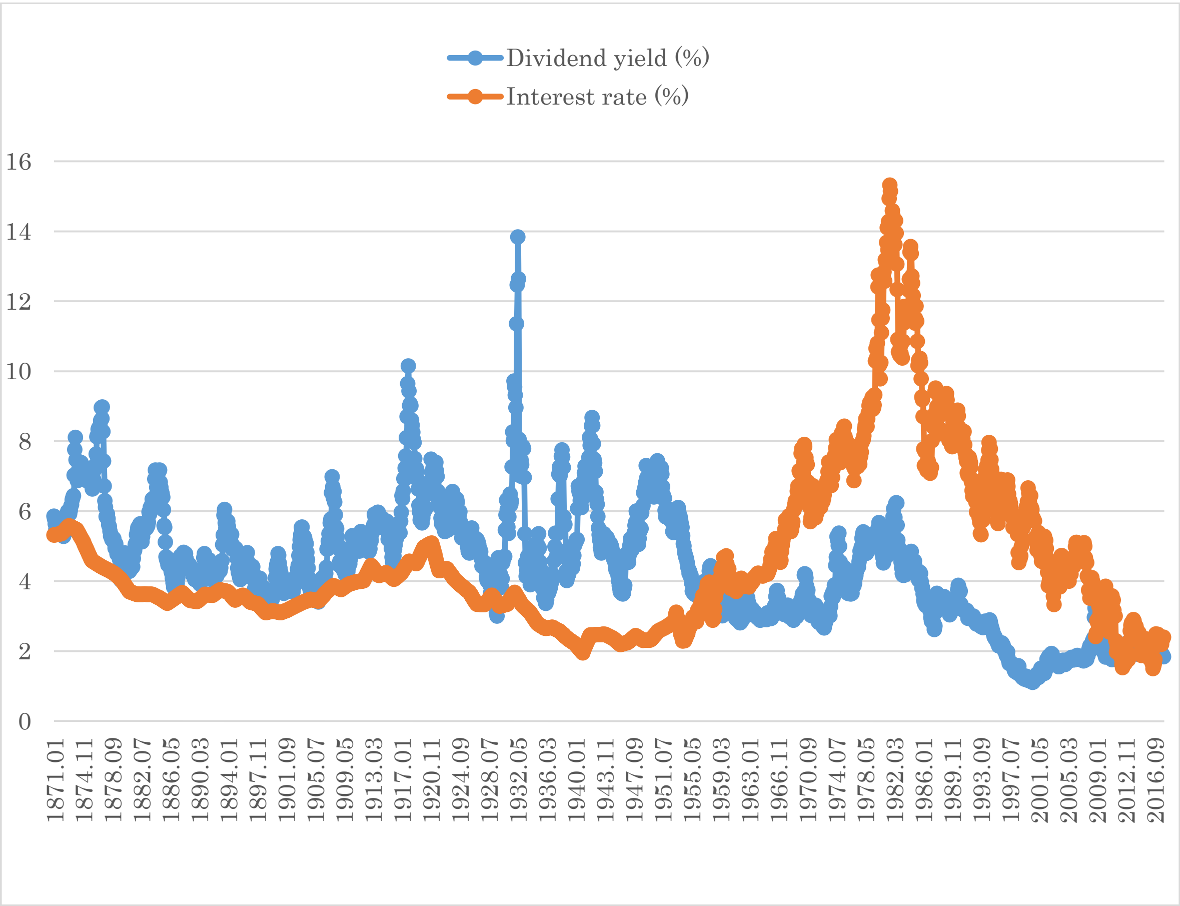
Figure 3: Bubble premium and bubble, 1719-1720



Size of Bubble = stock price – fundamental (unit: £)

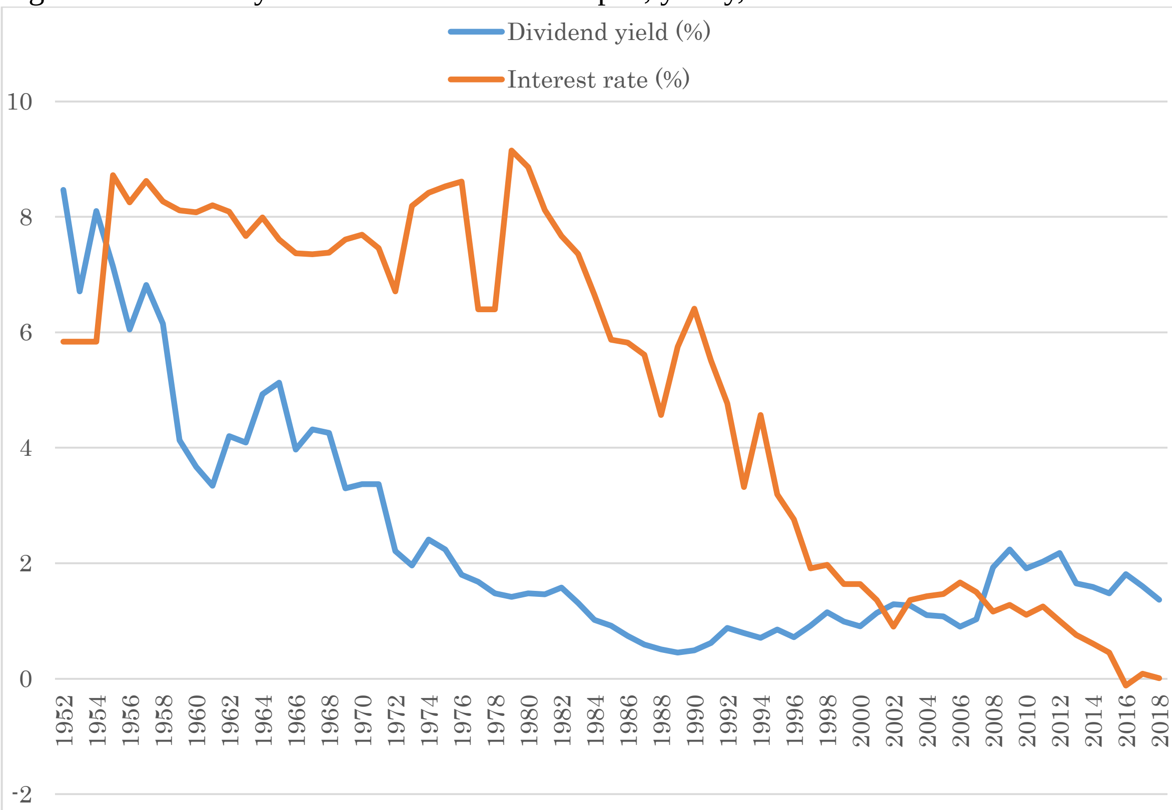
Source: See the text.

Figure 4: Dividend yield and interest rate in the U.S., yearly, 1871-2017.



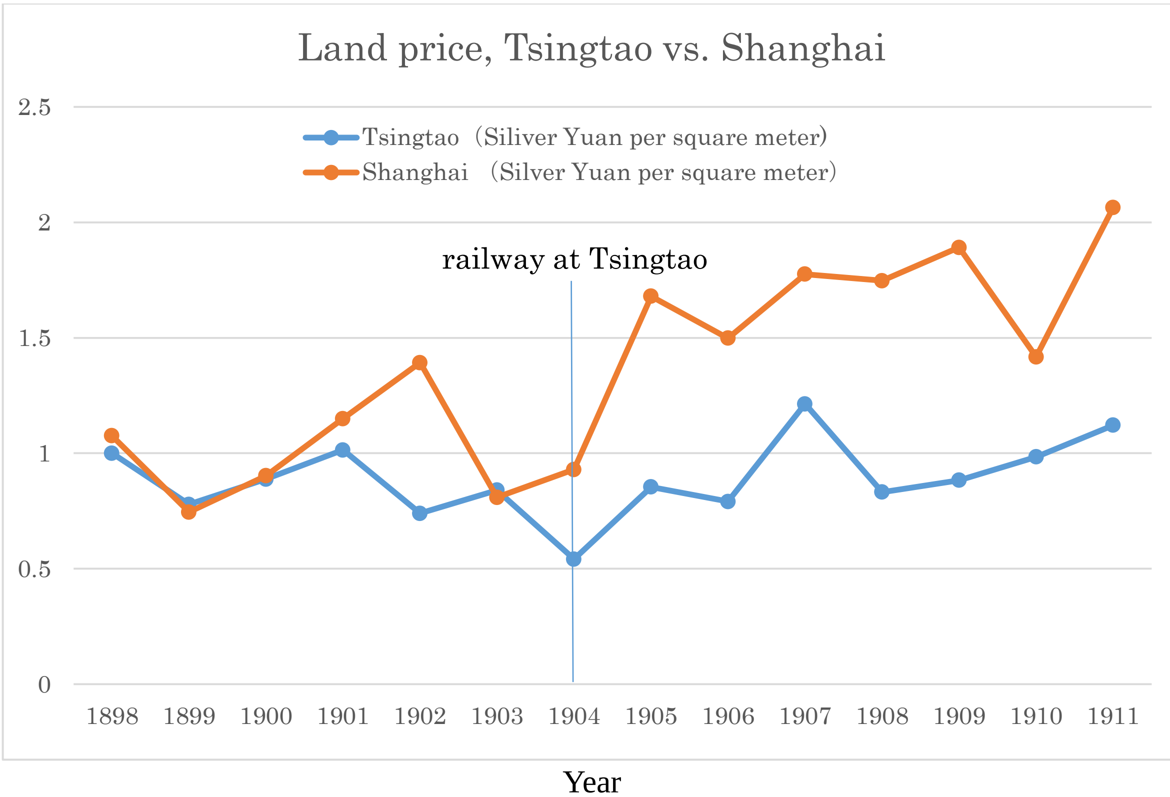
Source: Drawn by the author based on data from website of Robert J. Shiller.
(http://www.econ.yale.edu/~shiller/data.htm).

Figure 5: Dividend yield and interest rate in Japan, yearly, 1952-2018.



Source: Drawn by the author based on data of Financial Statistics in Japan.
Note: Data on dividend yield in 2018 is estimated by Japan Exchange Group.

Figure 6: Land prices at Tsingtao and Shanghai, 1989-1911



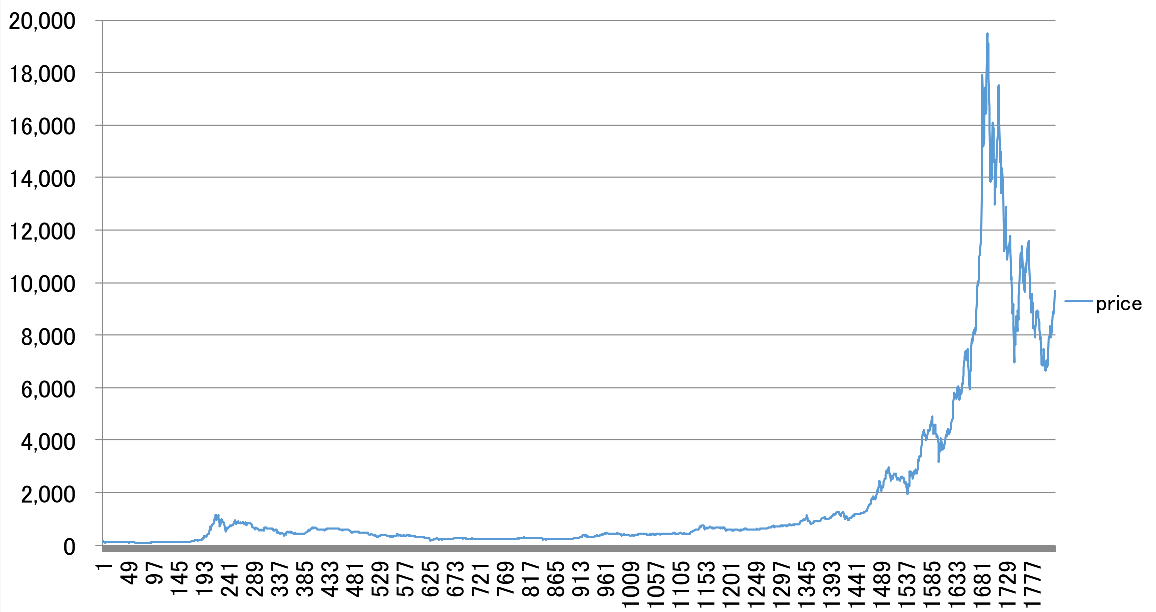
Source: See the text.

Figure 7: Self-reported value vs. governmental assessment value in Zhejiang in 1930

Governmental assessment value

Source：Drawn by the Author, based on Summary Statistics of Republic of China in 1935.

Figure 8 : Daily price of Bitcoin ($, April 28, 2013–April 24, 2018)



Source: Coinmarketcap.com.
https://coinmarketcap.com/ja/currencies/bitcoin/historical-data/?start=20100326&end=20180425.

Table 1a: Bubble test for the monthly stock price of South Sea, 1718-1722.

A: Unit root test
Monthly price (Sept. 1718 – May 1722, 45 observations)

Null Hypothesis: The series has a unit root

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.759	0.396

*MacKinnon (1996) one-sided p-values.

B: The SADF test and the GSADF test of the price
Null hypothesis: The series has a unit root

Monthly price (Aug. 1718 – May 1722, 46 observations)

	SADF	GSADF
Test statistics	8.919	8.919
p-value	0.000	0.000

Right-tailed test.

Note: Critical values of tests are obtained by Monte Carlo simulation with 1,000 replications. The smallest window has 20 observations. The author's calculations.

Table 1b: Summary statistics of bubble premium and size of bubble

Variable	Obs	Mean	Std. Dev.	Min	Median	Max
interest rate	12	65.901	105.790	−15.825	15.642	365.000
bubble	12	134.313	138.399	9.500	81.000	495.000

Table 1c: Bubble premium by bubble, OLS estimation with robust standard errors.

	Bubble premium
Bubble	0.695
	(0.101)***
Constant	−27.421
	(16.690)
R^2	0.83
N	12

Robust standard errors in parentheses.

* p<0.1; ** p<0.05; *** p<0.01.

Table 2a: Summary statistics for the U.S.

Variable	Obs	Mean	Std. Dev.	Min	Median	Max
Dividend yield	1,764	4.360	0.040	1.109	4.289	13.836
Interest rate	1,764	4.573	0.055	1.500	3.860	15.320

Table 2b: Summary Statistics for Japan.

Variable	Obs	Mean	Std. Dev.	Min	Median	Max
Dividend yield	67	2.439	2.000	0.450	1.600	8.470
Interest rate	67	5.100	3.058	−0.117	5.840	9.150

Table 2c: Unit root and bubble test for U.S. stock market

A: Unit root test
Price-dividend ratio (Nov. 1872 – Dec. 2017, 1,742 observations)

Null Hypothesis: The series has a unit root

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.625	0.269

*MacKinnon (1996) one-sided p-values.

B: The SADF test and the GSADF test of the price-renting ratio
Null hypothesis: The series has a unit root

Price-dividend ratio (Jan. 1871 – Dec. 2017, 1,764 observations)

	SADF	GSADF
Test statistics	2.430	2.771
p-value	0.000	0.000

Right-tailed test.
Note: Critical values of tests are obtained by Monte Carlo simulation with 1,000 replications. The smallest window has 93 observations. The author’s calculations.

Table 2d: Unit root and bubble test for Japan stock market.

A: Unit root test
Price-dividend ratio (1955 – 2018, 64 observations)

Null Hypothesis: The series has a unit root

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.590	0.786

*MacKinnon (1996) one-sided p-values.

B: The SADF test and the GSADF test of the price-renting ratio
Null hypothesis: The series has a unit root

Price-dividend ratio (1952 – 2018, 67 observations)

	SADF	GSADF
Test statistics	3.642	3.642
p-value	0.000	0.000

Right-tailed test.
Note: Critical values of tests are obtained by Monte Carlo simulation with 1,000 replications. The smallest window has 20 observations. The author's calculations.

Table 2e: Unit root and bubble test for Bitcoin.

A: Unit root test
Price-dividend ratio (2013 – 2018, 1,800 observations after adjustments)

Null Hypothesis: The series has a unit root

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.474	0.341

*MacKinnon (1996) one-sided p-values.

B: The SADF test and the GSADF test of the price-renting ratio
Null hypothesis: The series has a unit root

Price-dividend ratio (2013 – 2018, 1,823 observations after adjustments)

	SADF	GSADF
Test statistics	5.689	16.720
p-value	0.000	0.000

Right-tailed test.
Note: Critical values of tests are obtained by Monte Carlo simulation with 1,000 replications. The smallest window has 20 observations. The author’s calculations.

Table 3a: Summary statistics of land prices in Tsingtao and Shanghai.

Variable	Obs	Mean	Std. Dev.	Min	Median	Max
land price of Tsingtao	14	0.892	0.168	0.542	0.869	1.214
land price of Shanghai	14	1.363	0.432	0.745	1.405	2.064
year	14	1904.500	4.183	1898.000	1904.500	1911.000

Table 3b: Land prices in Tsingtao and Shanghai, pooled OLS estimation with robust standard errors.

	land price
Tsingtao	−0.136
	(0.123)
after1904	0.247
	(0.258)
Tsingtao*after1904	−0.587
	(0.170)***
year	0.052
	(0.025)*
constant	−98.412
	(48.143)*
R^2	0.73
N	28

Robust standard errors in parentheses.

* p<0.1; ** p<0.05; *** p<0.01.

Table 4a: Summary statistics of county land value with and without tax

Variable	Obs	Mean	Std. Dev.	Min	Median	Max
self-reported value	59	15,100,000	12,800,000	358,749	10,600,000	58,000,000
government assessment value	59	27,000,000	18,300,000	3,548,970	23,800,000	69,600,000

Table 4b: Land values with and without land value tax, OLS estimation with robust standard errors.

	self-reported value
government assessment value	0.497
	(0.075)***
Constant	1,733,681.618
	(2,260,870.619)
R^2	0.504
N	59

Robust standard errors in parentheses.

* p<0.1; ** p<0.05; *** p<0.01.