

# Empirical Evidence of Hyperbolic Discounting in China

Lin Zhang

## Abstract

This paper investigates the time discounting style and saving/ consumption behavior of Chinese mainland residents with the micro cross-section data “Survey of Living Preferences and Satisfaction” by The Institute of Social and Economic Research of Osaka University GCOE Program in 2009. It is found that the proportion of hyperbolic discounters of Chinese mainland residents is 16.35%. The net financial assets of hyperbolic discounters are significantly lower than other residents and their family expenditure per year is significantly higher. Meanwhile, the discounting style is significantly related to the age, living level and financial education.

**Keywords:** Hyperbolic discounting; Saving; Consumption

**JEL Classification:** D1; D9

## 1. Introduction

Time discounting is one of the foundational conceptions in economics for its characterization of the choice between the current utility and the future utility. It is a reflection of people’s impatience for the future utility and has been widely applied to the research of consumption, saving and investment behavior. For the time being, there are mainly two types of time discounting, the exponential discounting and the hyperbolic discounting. The exponential discounting proposed by Samuelson (1937) has been the standard paradigm, which assumes the time discount rate to be constant over time and dependent on the length between the two time points instead of where it is. The behavior of exponential discounter is time-consistent and hence there is no self-control problem. Therefore, O’Donoghue & Rabin (1999) suggest the behavior under exponential discounting to be the optimal outcome in the long-run. However, it has been found that there are some anomalies which cannot be explained by the exponential discounting according to some experiments in recent years. Meanwhile, the hyperbolic discounting describes the impatience for the future utility – the discount rate in the immediate future is much higher than that in the distant future. Under hyperbolic discounting, the instantaneous time discount rate between two time points does not only depends on the length between them but also where they are. In this context, time discount rate is no more constant but decreasing with time. Therefore, the behavior of hyperbolic discounter is time-inconsistent and there comes

self-control problem. For example, one person plans to reduce consumption every day for the saving in the future. But when time passes by, he does not actually reduce his consumption because of his strong impatience for immediate utility. The time-inconsistency is well explained by hyperbolic discounting. And quasi-hyperbolic discounting is used in the analysis of hyperbolic discounter's behavior, for its sufficient approximation to hyperbolic discounting and the convenience of calculation.

Different discounting styles lead to differences in economic behavior which could affect the economy policies. Laibson (1997) suggests that under liquidity constraints the marginal consumption propensity of quasi-hyperbolic discounter is higher than that of exponential discounter and meanwhile the saving rate is lower. Due to the present bias for current utility, addiction, default and obesity could also turn up. Khwaja et al. (2006) find that smokers are more likely to be hyperbolic discounters. Skiba et al. (2008) find that the payday loan default rate of hyperbolic discounter is significantly higher than that of other ones. Ikeda et al. (2010) show that the BMI Index of respondents is positively related to hyperbolic discounting, and the stronger impatience of future utility leads to a higher possibility of obesity. Therefore, it is of great reasons to empirically investigate the discounting styles of the actual consumers to estimate their economic behavior with micro-data.

There are series of empirical papers which discuss the discounting styles of people in each country. Eisenhauer & Ventura (2006) investigate the discounting styles and discount rate of respondents in Italy and the Netherlands and find that among these respondents the rate of hyperbolic discounters is around one forth. They also show that the discounting styles significantly relate to the residence, occupation, age and education level of the respondents. However, there is no such research on Chinese residents with a large sample for the time being, and in the existing research of this field the respondents are all students in universities which cannot represent the whole outcome.

This paper aims to examine the discounting styles and time discount rate of Chinese residents with a large sample from survey, and to find the internal connections between them and economic, social factors.

## 2. Data

This research employs the Chinese cross-section data from the "Questionnaire on the preferences and satisfaction of living" of GCOE Program by the ISER Osaka University in 2009. And the data includes 2 parts: the urban part and the rural part. In the urban part, there are 6 cities included: Peking, Shanghai, Guangzhou, Chengdu, Wuhan and Shenyang with 963 respondents picked up randomly. In the rural part, there are 12 areas picked up randomly in 4 provinces (Sichuan, Hunan, Hubei and Liaoning) with 1000 random respondents. The questionnaire covers 68 questions about age, occupation, income, preferences and so on. The target age of this survey is between 20 to 69, and the respondent who is younger than 20 or older than 69 is excluded.

## 2.1 Identify hyperbolic discounters

One of the characteristics of hyperbolic discounting is decreasing impatience. The hyperbolic discounting function is

$$f(t) = \frac{1}{1+kt}, \quad k > 0,$$

and the instantaneous discount rate is

$$-\frac{f'(t)}{f(t)} = -\frac{k}{1+kt},$$

which decreases with time  $t$ . This implies higher discount rate in immediate future than in distant future, which is the main feature distinguishing hyperbolic discounters from exponential discounters. This research identifies hyperbolic discounters by using this feature.

The 2 questions by which hyperbolic discounting can be identified are as follows.

### AQ3

Let's assume you have **two options** to receive some money. You may choose Option "A", to receive 200 CNY **today**; or Option "B", to receive a different amount in **7 days**. Compare the **amounts** and **timing** in Option "A" with Option "B" and indicate which amount you would prefer to receive for all 9 choices.

**Table 1**

<b>Option A</b>	<b>Option B</b>	<i>Annual Interest Rate</i>	<b>Which option do you prefer?</b>	
<b>Receiving Today (CNY)</b>	<b>Receiving in 7 days (CNY)</b>			
200	199.62	-10%	A	B
200	200.00	0%	A	B
200	200.38	10%	A	B
200	201.53	40%	A	B
200	203.84	100%	A	B
200	207.67	200%	A	B
200	211.51	300%	A	B
200	238.36	1000%	A	B
200	391.78	5000%	A	B

### AQ4

Let's assume you have **two options** to receive some money. You may choose Option "A", to receive 200 CNY **in 90 days**; or Option "B", to receive a different amount in **97 days**. Compare the **amounts** and **timing** in Option "A" with Option "B" and indicate which amount you would prefer to receive for all 9 choices.

Table 2

Option A	Option B	Annual Interest Rate	Which option do you prefer?	
Receiving in 90days (CNY)	Receiving in 7 days (CNY)			
200	199.62	- 10%	A	B
200	200.00	0%	A	B
200	200.38	10%	A	B
200	201.53	40%	A	B
200	203.84	100%	A	B
200	207.67	200%	A	B
200	211.51	300%	A	B
200	238.36	1000%	A	B
200	391.78	5000%	A	B

(200 CNY=2674. JPY on 2009.12.15)

The Figures above show the time discount rate between now (90 days) and 7 days (97days) later as annual interest rate in each row. The respondents value the amounts of option A and B and make the choice. The option in AQ3 chosen by the respondent reveals that the 200 CNY today is equivalent with m CNY in 7 days for him/her, while in by AQ4 200 CNY in 90 days is equivalent with n CNY in 97 days. Therefore, the time discount rate of each respondent can be estimated by the options chosen. At a certain annual interest rate, the chosen option will switch from A to B. In this research, the average value of the annual interest rate which is corresponding to the first chosen option B and the annual interest rate in last row is defined as the discount rate between now (90 days later) and 7 days later (97 days later).<sup>1</sup> Here the discount rate between now and 7 days later is denoted as p and the discount rate between 90 days later and 97 days later is denoted as q. According to the feature of hyperbolic discounting, if  $p > q$  the respondent is defined as hyperbolic discounter, and in other cases he/she is defined as exponential discounter. And the binary indicator Hyper is employed to mark hyperbolic discounters off from exponential discounters for the empirical study.

By the method above-mentioned, it is found that among the 1963 respondents there are 321 hyperbolic discounters which are 16.35% of the whole sample. The ratio of hyperbolic discounters is 15.78% in the urban sample and 16.90% in the rural sample. And there is no significant difference between urban and rural area in discounting style by chi-square test.

## 2.2 Time discount rate

Time discount rate can be measured by the method foregoing. By taking average values of each respondent's discount rate, the average discount rate between today and 7 days later is 3.84% in the form of annual interest rate

<sup>1</sup> In the case that all options A are chosen, the time discount rate (annual interest rate) is -15%; and in the case that all options B are chosen, the time discount rate (annual interest rate) is 7000%.

and the average discount rate between 90 days later and 97 days later is 3.62%. In the general level, the respondents exhibit the feature of hyperbolic discounting with decreasing impatience.

### 2.3 Variables and data processing

In this research, the original data has been processed. The target age of this survey is from 20 to 69 and the ones who are younger than 20 or older than 69 are excluded.

Net family financial assets are defined as the difference between total family financial assets and debts other than housing loans, and measured as 1000 CNY.

Family expenditure per year is defined as the expense of whole family except durable goods per year and summed up from the amounts obtained in the survey shown as below.

*How much was the average food expense of your entire family per month in 2009? How much are the average expenditures of your entire family per month in 2004? Exclude durable consumer goods purchased such as housing, cars, expensive electronic products, taxes, insurance premiums, and mortgage interest. Include costs of public utilities and energy bills.*

Net family housing properties are defined as the difference between total family housing properties and housing loans, and measured as 1000 CNY.

Risk aversion is obtained from the survey shown as below.

*When you usually go out, how high does the probability of rain have to be **before** you take an umbrella?*

## 3. Main results

### 3.1 Discounting styles and basic characteristics

Based on the previous theoretical and empirical studies, time discounting styles are associated with some economic, social and demographic characteristics. However, because the basic conditions in each countries or regions are different, these basic characteristics influence discounting styles in different ways. This sub-section investigates how time discounting styles are related to these basic characteristics in China with Chi-squared test in order to find the connection between them.

Table 3

	Sample	Hyperbolic discounting (%)	Chi-squared (p-value)
<i>Gender</i>			
Male	976	17.42	1.611
Female	987	15.30	(0.204)
<i>Age</i>			
20-29	406	14.78	15.246
30-39	428	15.65	(0.004)***
40-49	422	18.96	
50-59	421	12.11	
60-69	286	22.03	
<i>Marriage</i>			
Married	1,615	16.28	5.545
Divorced	98	15.31	(0.136)
Widowed	50	28.00	
Single	200	14.50	
<i>Education</i>			
Illiteracy	60	11.67	6.072
Literacy but never in school	66	24.24	(0.531)
Elementary school	341	17.60	
Middle school	842	16.86	
High school	437	14.65	
University students	23	13.04	
Bachelor degree	193	15.03	
MA or PHD degree	1	0.00	
<i>Occupation</i>			
Office worker	426	17.37	6.363
Government employee	10	0.00	(0.272)
Managerial post	9	33.33	
Individual owner	649	16.33	
Self-employed	173	12.72	
State-owned enterprise worker	202	18.32	
<i>Industry</i>			
Agriculture and forestry	450	17.33	9.514
Mining	12	0.00	(0.575)
Construction	125	15.20	
Manufacturing	125	15.20	
Wholesale/Retail	275	16.00	
Financial/Insurance	42	14.29	

	Real estate	20	10.00	
	Transport /Correspondence	100	14.00	
	Electric/Gas/Water/Heat supply	26	30.77	
	Service	254	18.50	
	Education	21	9.52	
	Others	19	15.79	
<i>House type</i>				
	Own house	1,072	16.79	25.076
	Own condominium	669	16.74	(0.001)***
	Private rented house	44	11.36	
	Supplied house	36	5.56	
	Government-owned housing	76	5.26	
	Share flat	9	0.00	
	Dormitory	34	38.24	
	Others	23	21.74	
<i>Holding life insurance</i>				
	No	1,683	17.23	6.659.
	Yes	280	11.07	(0.010)**
<i>Holding futures/options</i>				
	No	1,944	16.15	5.589
	Yes	19	36.84	(0.015)**
<i>Private pension</i>				
	Not join	1,809	15.59	9.835
	Join	154	25.32	(0.002)***
<i>Living level</i>				
	1	18	38.89	24.464
	2	39	5.13	(0.004)***
	3	94	15.96	
	4	197	17.26	
	5	555	12.07	
	6	435	20.00	
	7	403	18.61	
	8	186	16.13	
	9	30	10.00	
	10	6	16.67	
<i>Received financial education</i>				
	Yes	195	10.26	5.715
	No	1,505	16.94	(0.057)*
	Don't know	137	16.79	

Table 3 shows different results from Eisenhauer & Ventura (2006) in that discounting styles are not significantly associated with gender, marriage, education, occupation or industry. It is usually considered that these differences are caused by different conditions in each country. And it is of great interest to do further research on it.

However, it can be found that discounting styles do significantly associate with some characteristics, such as age, house type, financial assets, living level and financial education. Only significant results are shown in Table 3 even though many more variables have been tested.

Among the respondents who are 60-69 years old, the proportion of hyperbolic discounters is significantly higher than other age groups, which means that older respondents are much strongly with diminishing impatience. This is consistent with theoretical prediction in that they are more reluctant to wait for future utilities.

It is of interest to notice that the house types that respondents are living in are significantly associated with discounting styles. The proportions of hyperbolic discounters who are living in supplied house, government-owned house, or share flat are significantly lower than those who are living in owned houses. In the usual case, house types are related to income, which is an essential factor influencing discounting style. Therefore, it is consistent with theoretical prediction that house types are associated with discounting styles.

Among the results of financial assets, it could be found that hyperbolic discounters are more likely to hold life insurances, futures/options, and pensions, while the inclination to hold other financial assets such as stocks and national bonds is not found. According to O'Donoghue & Rabin (1999), these hyperbolic discounters who hold life insurances or pensions are sophisticated, because they realize the self-control problems of their own and try to mitigate these issues by commit their future behavior.

Living levels are also significantly related to discounting styles. The living level of a respondent is evaluated by his/her subjective answer, from 0 to 10. A higher number represents a higher living level. Among the whole sample, there is no "0" that has been chosen, while most of the respondents chose "1" (38.89%).

Furthermore, the person who has not received financial education is more like to be a hyperbolic discounter than who has received.

Notice that there are many groups according to different economic, social, and population factors, but in each group, the percentage of hyperbolic discounter is around 20% ~ 25%. This is close the result of Eisenhauer & Ventura (2006), and it shows that hyperbolic discounting is not as common as non-hyperbolic discounting.

### **3.2 Saving and consumption behavior**

According to Laibson (1997), the saving of a hyperbolic discounter is lower than that of an exponential discounter, and the consumption of a hyperbolic discounter is higher. In other words, hyperbolic discounting leads to under-saving and over-consumption. The following section will discuss whether these theoretical conclusions are consistent with the empirical results from the Survey in China.

Because of the absence of saving amount questions, this paper employs the net financial assets amount (NET\_FINANCIAL\_ASSETS) as the dependent variable. Independent variables include hyperbolic discounting binary

indicator (HYPER) and family income per year (INCOME\_YEAR). Control variables include family size (FAMILY\_SIZE), risk preference (RISK), holding loan dummy (HAVE\_LOAN) and normalized time discounting rate (DISCOUNT\_RATE\_AVE).

After deleting 13 respondents with un-completed answers, the whole sample include 1950 respondents. To control the heteroscedasticity problem, this paper uses WLS regression and the results are shown in Table 4.

One of the important features shown in Table 4 is that after controlling family size, risk preference, holding loan and discounting rate, the net amounts financial assets of China mainland families are negatively associated with hyperbolic discounting, which is consistent with the previous studies. The phenomenon that the net financial assets amounts of hyperbolic discounters are significantly lower than those of other families can be explained by the impatience toward future consumption.

**Table 4**

<b>NET_FINANCIAL_ASSETS</b>	<b>Coef.</b>	<b>Std. Err.</b>	<b>t</b>	<b>P-value</b>
<b>HYPER</b>	-10.495	1.812	-5.79	0.000***
<b>FAMILY_SIZE</b>	-6.808	0.772	-8.82	0.000***
<b>INCOME_YEAR</b>	1.454	0.664	2.19	0.029***
<b>RISK</b>	0.154	0.033	4.71	0.000***
<b>HAVE_LOAN</b>	-18.819	2.834	-6.64	0.000***
<b>DISCOUNT_RATE_AVE</b>	-7.184	0.852	-8.43	0.000***
<b>_cons</b>	10.362	24.442	0.42	0.672

In order to investigate the consumption behavior, the family expenditure per year (EXPENDITURE\_YEAR) is used as the dependent variable. Independent variables are hyperbolic discounting binary indicator (HYPER) and family income per year (INCOME\_YEAR). Control variables include family size (FAMILY\_SIZE), risk preference (RISK), holding loan dummy (HAVE\_LOAN), normalized time discounting rate (DISCOUNT\_RATE\_AVE) and family net real assets (NET\_HOUSE\_PRO). The regression results of WLS are shown in Table 5.

**Table 5**

<b>EXPENDITURE_YEAR</b>	<b>Coef.</b>	<b>Std. Err.</b>	<b>t</b>	<b>P-value</b>
<b>HYPER</b>	5.819	0.609	9.56	0.000***
<b>FAMILY_SIZE</b>	-1.025	0.234	-4.39	0.000***
<b>INCOME_YEAR</b>	1.371	0.167	8.23	0.000***
<b>RISK</b>	-0.064	0.012	-5.24	0.000***
<b>HAVE_LOAN</b>	-5.471	1.972	-2.77	0.006***
<b>DISCOUNT_RATE_AVE</b>	-0.193	0.271	-0.71	0.476
<b>OLD</b>	2.872	0.712	4.04	0.000***
<b>NET_HOUSE_PRO</b>	-0.301	0.048	-6.23	0.000***
<b>_cons</b>	-8.695	5.428	-1.60	0.109

The results in Table 5 also confirm the theoretical prediction that the marginal propensity to consume of hyperbolic discounters is higher than that of exponential discounter. The family expenditure per year has significantly positive association with hyperbolic discounting indicator.

#### 4. Conclusions

This paper investigates the time discounting style and saving/ consumption behavior of Chinese mainland residents with the micro cross-section data “Survey of Living Preferences and Satisfaction” by The Institute of Social and Economic Research of Osaka University GCOE Program in 2009. It is found that the proportion of hyperbolic discounters of Chinese mainland residents is 16.35%. The net financial assets of hyperbolic discounters are significantly lower than other residents and the family expenditure per year of them is significantly higher. Meanwhile, the discounting style is significantly related to the age, living level and financial education, but does not significantly relates to gender, occupation and other characteristics.

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