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Who Benefits from the Housing Provident Fund System in China? An Analysis of the Internal Rate of Return for Typical Employees with Different Incomes

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Abstract: The Housing Provident Fund System (HPFS) was established in China in the 1990s as a welfare program to offer low-cost loans and encourage the purchasing of houses. However, there has been some controversy over the income redistribution effect of HPFS. Previous studies focused on the effect of low-interest-rate loans but ignored the effects of tax exemptions and low-interest-rate deposits. This paper introduces a lifetime cash flow model which considers the effects of low-interest-rate loans, tax exemptions, and low-interest-rate deposits together. It compares the internal rate of return (IRR) for typical employees with different incomes in four situations: whether or not HPFS participation and whether or not house purchasing. We found that the IRRs of the typical low-income HPFS participants who buy houses with HPFS loans were lower than the IRRs of non-participants who buy houses with commercial mortgages without HPFS participation. For the typical middle-income employees, there is not much difference in IRR between the two situations. Only the typical high-income employees can benefit from HPFS participation, and this is mostly due to the effect of the tax exemptions, rather than the effect of low-interest-rate loans. Increasing the coverage of HPFS and HPFS loans among low-income employees will not improve the income redistribution effect of HPFS.

Keywords: Housing Provident Fund System; low-interest-rate loans; tax exemptions; low-interest-rate deposits; income redistribution; internal rate of return



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1. Introduction

Fairness and efficiency are two eternal themes of social development. Due to disparities in individual endowments, resource structures, and other aspects, market mechanisms tend to lead to unequal outcomes [1,2]. Due to the special nature of real estate, inequality in housing wealth is often greater than income inequality [3–6].

Housing inequality is not only unfair, it is also harmful to stable economic and social development in the long run [7,8]. Therefore, house ownership is the policy choice for housing in many developed and developing countries. Special affordable housing programs have been adopted in many countries to help low-income families buy houses [9,10]. For example, the social housing for socially and economically disadvantaged people in Seoul, the capital of South Korea [11,12], and the economic and comfortable housing policy (ECH) in China [13,14].

However, whether these affordable housing policies actually achieve the goal of fairness has been controversial. For example, rent regulation policies are hard to implement or they reduce the housing supply [15]. The centralized construction of public housing often leads to residential quarantine and social segmentation [11,16]. Due to the difficulty of means-testing, some low-income families are often excluded from affordable housing plans. For those families that have used the affordable housing plan, it can be difficult for

them to exit from indemnificatory apartments after their income has been improved [17]. Therefore, low-interest-rate mortgages have become an alternative. The Central Provident Fund in Singapore [18,19], Housing Provident Fund System (HPFS) in China [20,21], and Assisted Self-help Housing in Mexico are typical examples [22–24].

In the 1990s, China established HPFS as a welfare program to allow participants to get less expensive mortgages to buy houses [25]. According to HPFS rules, the compulsory monthly HPFS contribution from the employer and employee matches the percentage of the employee's monthly salary in the previous year. Both the HPFS contribution ratio for employer and employee are between 5% and 12% as chosen by the employer and employee. The HPFS deposits belong to the employees, and no personal income tax is levied on the HPFS deposits. The HPFS participant may use the HPFS deposits or apply for an HPFS loan to purchase, construct, rebuild, and overhaul the owned house. The interest rate on HPFS deposits is 1.5%, the same as the benchmark rate of a one-year fixed deposit set by the central bank. The central bank also sets the interest rate for HPFS loans lower than the interest rate for commercial mortgages.

HPFS developed rapidly after it was piloted in Shanghai in the early 1990s. According to the "National Housing Provident Fund Annual Report 2019" jointly released by the Ministry of Housing and Urban-Rural Development, the Ministry of Finance, and the People's Bank of China in 2020, there were 3.2240 million employers and 148.8138 million employees making HPFS contributions in 2019. At the end of 2019, the balance of HPFS deposits was 6.5372 trillion yuan and the balance of HPFS loans was 5.5883 trillion yuan. The balance of funds was 946.152 billion yuan.

With the increase in the scale of HPFS funds and the number of HPFS participants, the income redistribution effect of HPFS has attracted increasing attention. As a welfare program, HPFS should enable low-income employees to benefit more, but whether low-income groups actually do benefit from HPFS has been controversial.

HPFS requires the employer and employee to make contributions jointly. As a result, workers who are laid-off, the unemployed, the temporary workers, and individual households cannot participate in HPFS [26]. According to the "Statistical Bulletin on the Development of Human Resources and Social Security in 2019" from the National Bureau of Statistics, there are 442 million urban employees in 2019. HPFS participants accounted for only one-third of urban employees in 2019, and 49.45% of HPFS participants were employees of government, public institutions, and state-owned enterprises. This shows that a considerable number of employees of private enterprises have not yet participated in HPFS.

Many scholars point out that the probability of low-income employees buying houses with HPFS loans is lower than the high-income employees and HPFS is suspected of "robbing the poor to help the rich" [21,26–33]. The policy implications of these studies are not only to increase the coverage of HPFS but also to increase the coverage of HPFS loans among low-income employees.

However, these studies pay too much attention to the effect of low-interest-rate loans and ignore the effects of tax exemptions and low-interest-rate deposits. Although high-income HPFS participants may benefit more from the low-interest-rate loans and tax exemptions, they may suffer more from the compulsory low-interest-rate HPFS deposits. So, their rate of return is not necessarily higher than that of middle- or low-income HPFS participants.

In addition, HPFS involves the cash flow from participation to exiting for decades. It is not comprehensive to evaluate the effect of income redistribution based on cross-sectional data. A thorough analysis of the cash flow from the beginning to the end of participation in HPFS may provide more reliable conclusions on the rate of return for HPFS participation.

In view of the two defects of previous studies, this paper aims to answer the question of who benefits from HPFS participation when the effect of low-interest-rate loans, tax exemptions, and low-interest-rate deposits are considered comprehensively. Using a lifelong cash flow model and cash flow data over the careers of typical employees at

different income levels, the rate of return in four situations, whether participating in HPFS or not, and whether buy houses or not, are calculated. By comparing the internal rate of return (IRR) of typical employees with different incomes in the same situation and the IRRs of the same employee in four different situations, the question of who benefits from HPFS is revisited.

The rest of this paper is organized as follows. The second part is a review of literature on the effects of income redistribution of HPFS. Based on the HPFS policy in City A, the third part introduces a lifelong cash flow model to examine the IRRs of typical employees with different incomes. The fourth part is a sensitivity analysis on IRRs from different assumptions about the growth of wages and changes in house prices as well as changes in HPFS policy such as reducing the interest rate on HPFS loans, increasing the interest rate on deposits, raising the ceiling for HPFS loans, and eliminating tax exemptions. The fifth part presents conclusions and discussions.

2. Literature Review

There are two ways for the government to encourage housing consumption through the housing finance system. One is to integrate housing finance into the market-based financial system, and the other is to establish a special self-financing system [30]. The general problems for emerging markets are high inflation and underdeveloped capital markets, which limit any activity that relies on long-term funding. So, in many emerging markets, the solution is to establish housing provident funds [27].

Some studies focus on the impact of HPFS participation on housing consumption and the effect of negative redistribution that results from a low HPFS coverage rate among low-income employees. Using household survey data from China, HPFS participation is proved to have a significant positive impact on house ownership [33]. Since HPFS began in 1998, the rate of house ownership of families whose member participates in HPFS increased faster [34]. The policy implication of these studies is that increasing the HPFS coverage rate among low-income groups can improve the fairness of HPFS.

However, other scholars point out that the probability of low-income HPFS participants buying houses with HPFS loans is low, and HPFS is suspected of “robbing the poor to help the rich.” Analysis on microdata from the Changzhou HPFS Center in Jiangsu Province shows that with the increase of income, the probability of using HPFS funds and HPFS loans also increases [29]. The employees of government, public institutions, and state-owned enterprises, highly educated and high-income participants are found more likely to use HPFS funds [31]. Some evidence shows that the support provided by HPFS reduced the financial pressure on families by an average of 14%. However, HPFS did not provide enough financial support for low-income employees and lead to a negative redistribution effect [35]. Analysis based on a computable general equilibrium model shows that HPFS increased the Gini coefficients for income and consumption by 2.06% and 2.15% respectively [32]. The policy implication of these studies is not only to increase the coverage of HPFS but also to increase the coverage of HPFS loans among low-income employees.

As many researchers have pointed out, the financial balance of HPFS requires that only a small percentage of HPFS participants may make HPFS loans. Most HPFS participants do not make HPFS loans, but they are forced to make deposits at low-interest rates and subsidize participants who buy houses with HPFS loans [21,26–28,30].

Those studies have pointed out very important HPFS issues, however, the focus is mainly on the effect of low-interest-rate loans without considering the effects of tax exemptions and low-interest-rate deposits as well. Analysis based on the China Household Income Survey data in 2013 (CHIP, 2013) found that except for the effect of low-interest-rate deposits, the effects of employer deposits, tax exemptions, and low-interest-rate loans all widened the income gap [36].

However, all the above studies are based on cross-sectional data, which makes it difficult to reflect the overall rate of return for HPFS participants.

Based on a simulation model, the net present value of the wealth of HPFS participation between buying a house and renting a house for HPFS participants were compared. When housing prices rise fast, buying is better than renting a house. When housing prices grow slower than a specific level, the net present value of the wealth of HPFS participation may be negative. However, the study did not compare the rate of return for participating in HPFS to no HPFS participation and the effect of tax exemptions was not considered in the simulation model either [25].

From a longitudinal perspective, this paper considers the effects of low-interest-rate loans, tax exemptions, low-interest-rate deposits, and the appreciation of house values in a lifetime cash flow model. The model is used to calculate the IRRs of employees with different incomes in four situations: whether employees participate in HPFS or not combined with buying houses or not. The paper focuses on whether the IRRs of employees who buy houses with HPFS loans are higher than the IRRs of non-participants who buy houses with commercial mortgages.

3. The Lifetime Cash Flow Model

3.1. Model Settings

In this paper, by constructing a lifetime cash flow model, we compare the IRRs of typical HPFS participants with different incomes in four situations. To examine the redistribution effect of HPFS, we analyze the cash flow of employees from the time they begin to participate in HPFS at 23 years old until they retire.

We assume that when they receive their monthly income, employees make the following allocations in sequence: HPFS contribution (or not), payment of personal income tax, payment of necessary living costs, and bank savings. Since the HPFS contribution is part of the cost of labor, we assume that if the employee does not participate in HPFS, the employer will pay the corresponding employer and employee contributions to the employees as part of the salary. The employee's income after taxation will pay for all necessary living costs first. In the initial state of the model, the employees do not own a house and they have no savings or liabilities. They must pay rent before buying a house.

After participating in HPFS and before buying a house, the funds the employee puts into bank savings are intended for the down payment of a house. As soon as the bank savings are enough for the down payment, the employee will use the highest available HPFS loan amount to buy a house. If the amount of the HPFS loan is not enough, the employee will take out a commercial mortgage. Thereafter, the monthly HPFS contribution is used to repay the HPFS loan, if the contribution is not enough, the remainder is drawn from the monthly income.

For those who do not participate in HPFS, before buying a house, the employee's monthly income is used to pay personal income tax, rent, and necessary living costs, and the rest is put into a bank saving account. The employee will buy a house as soon as the bank savings are enough for the down payment, and the employee will take out the highest commercial mortgage available. Thereafter, the monthly payment of the mortgage is drawn from the monthly income.

3.2. The Internal Rate of Return

The net present value is the difference between the present value of the investment and the present value of the benefit at a certain artificially set interest rate. The internal rate of return (IRR) is the discount rate that makes the net present value of the investment project cash flow equal to zero. Compared with the net present value, the IRR is considered to be a more reliable measurement of the return rate of investment projects. If the typical employee is regarded as an investment project, the monthly cash flow received by the investment project is the employee's income, and the cash flow is allocated to HPFS contribution, the income tax, cost of living, rent, bank savings, and repayment of loans.

Among them, the cost of living, rent, and personal income tax do not generate any profit. HPFS contributions and bank savings generate interest at a fixed rate, and mortgages

may generate profit or loss according to the house price. When the typical employee exits HPFS, the HPFS account balance, the bank savings balance, and the market price of their house are the total profit from HPFS.

Therefore, the IRR for HPFS participants is the discount rate that enables the participants to make the present value of their monthly income equal to the current value of their assets in the last year.

$$\sum_{t=0}^n \frac{I_t}{(1 + \text{IRR})^t} = \frac{B_n}{(1 + \text{IRR})^n} \quad (1)$$

In this IRR formula, n is the number of months of contributing to HPFS, that is, the total number of months from the first to the last contribution to HPFS. I_t refers to the income in t -month. B_n refers to the total value of assets in the n -th month when the employee exits HPFS.

3.3. The Assumed Parameters

Although the basic rules of HPFS are the same throughout the country, the specific operating rules are different. The relevant parameters for the model, such as the upper limit of an HPFS loan, must be determined in simulation. City A is set as the example for the analysis, and sensitivity analyses for different rules and parameters will be made in a later part of this paper.

City A is a county-level city in Zhejiang Province. At the end of 2019, the resident population was 516,000 and the GDP in 2019 was 64.525 billion yuan. City A established HPFS in 1994. There were 28,543 HPFS participants at the end of 2015, of which 9113 participants had borrowed HPFS loans, accounting for 31.93% of all HPFS participants.

Contribution Base: According to the “City A Housing Provident Fund Annual Report 2018,” the upper limit of the HPFS contribution base in 2018 was 3 times the average monthly salary of employees in 2017 in City A, which was 24,420 yuan. The lower limit was the minimum wage for urban employees in 2017 in City A, which was 2010 yuan. We define the employees whose contribution base reaches the upper and lower limits as “high-income employees” and “low-income employees” respectively, and we define the employees whose contribution base is City A’s average monthly salary in 2017, which was 8140 yuan, as “middle-income employees.”

Paying Period: The age at which typical HPFS participants start to make HPFS contributions is set at 23 according to the highest frequency of age for HPFS participation in City A. By law, the retirement age is 60 for males and 50 for females.

Wage Growth Rate (g): According to a previous study, the average annual GDP growth rate for 2015–2040 is set at 6.5% [37]. Considering the inflation rate of 3%, this paper assumes that the average nominal annual GDP growth rate is 9.5%, and the wage growth rate is equal to the average nominal annual GDP growth rate. As China’s economy is facing downward pressure, the wage growth rate is set at 8.5% in the following sensitivity analyses.

Marginal Tax Rate of Personal Income Tax (t): Since the tax threshold increases as wages increase, using the current threshold and the progressive tax formula to calculate the monthly tax amount would create a large deviation. We assume that the monthly marginal tax rate of different income levels is consistent. For a typical HPFS participant, we calculate the taxable amount of the first month using the current progressive tax formula and then divide it by the salary of the first month to get the marginal tax rate. The result is 0 for low-income employees, 0.03 for middle-income employees, and 0.13 for high-income employees.

HPFS Contribution Ratio (a): The individual contribution rate of low-income employees is the lower limit, which is 5%. The individual contribution rate of the high-income employees is the upper limit, which is 12%. The individual contribution ratio is the midpoint of the personal deposit ratio interval, which is 8.5%, for middle-income employees. The employer contribution ratio is the same as the employee contribution ratio for all HPFS participants.

Cost of Living (L): We set the basic cost of living standard as the minimum living security line of City A, which was 745 yuan in 2018. The growth rate of the cost of living is assumed to be the same as the consumer price index (CPI), which is 3%.

Cost of Renting (R): According to “A Brief Analysis of the Living Consumption of City A Residents in 2018” released by the National Bureau of Statistics in City A, the per capita housing area of City A residents reached 48.98 m² in 2018. According to the China Housing Price Web hosted by the China Real Estate Association, the average rent in City A is 23 yuan per month per m². So, the average cost of rent is the product of the per capita housing area and the average rent, which is 1126.54 yuan. The ratio of the cost of rent to the average cost of rent for different typical employees is assumed to equal the ratio of their wages to the average social wage. So, the rental cost of high-income employees is 3 times that of middle-income employees and the rental cost of low-income employees is 0.247 times the cost of middle-income employees (Wage ratio of low-income employees to middle-income employees = 2010/8140 = 0.247). The growth rate of rent is assumed to equal the growth rate of house prices.

Deposit Interest Rate (i): HPFS deposit interest rate i_g is implemented according to the 2018 one-year fixed deposit benchmark interest rate of 1.5%, and bank savings deposit interest rate i_s is set according to the 2018 “Five Major Banks” one-year fixed deposit interest rate of 1.75%. The annual interest settlement date is June 30.

Loan Interest Rate (d): The annual interest rate d_g of an HPFS loan for the first house over 5 years (excluding 5 years) is 3.25%. The annual benchmark interest rate d_s of commercial mortgages, over 5 years (excluding 5 years) is 4.9%.

House Price Growth Rate (h): We find that the growth rate of house prices in City A from 2003 to 2018 (13.63%) is very close to the growth rate of GDP (13.21%) in City A. Therefore, the estimated GDP growth rate after 2020 is used to approximately replace the growth rate of house prices. It is assumed that the growth rate of house prices is equal to the nominal GDP growth rate of 9.5%. The sensitivity analyses will be done by setting the nominal GDP growth rate at 8.5%.

The Initial House Purchase Price (H_0): The model must set different target areas for different typical HPFS participants. The target area for low, middle, and high-income employees is assumed to be 60, 90, and 144 m² (The (2007) 24 document “Several Opinions of the State Council on Solving the Housing Difficulties of Urban Low-income Families” issued by the State Council states: “Affordable housing standard is based on the level of economic development and people’s living standards, and the construction area is controlled at about 60 m². Generally, a 90 m² house is called a medium-sized apartment in China and a 144+ m² is called a large apartment”).

According to The National Housing Provident Fund Annual Report 2019, 58.59% of employees with HPFS loans in 2019 were dual-participant families. Since most of the purchases are made by families, it is assumed the husband and wife share the housing expenses. So, only half of the target area for purchases is assumed, namely 30, 45, and 72 m² for low-, middle-, and high-income employees. The initial house price is set at the average house price of RMB 10,090 per m² in City A in 2018 which was released by China House Price Market Web. Table 1 shows the target area of houses for typical employees with different incomes.

Table 1. The Purchase Targets of Typical Employees with Different Incomes.

Type of Employees	Home Purchase Goals (m ²)	Individual Purchase Goals (m ²)	Purchase Target Initial Price (Yuan)
Low Income	60	30	302,700
Middle Income	90	45	454,050
High Income	144	72	726,480

3.4. Model Construction

First, we calculate the monthly income of a typical HPFS participant. The monthly HPFS contribution is equal to the sum of the employer contribution ratio and employee contribution ratio multiplied by the payment base. The payment base is the employee's average monthly income in the previous year, that is, the t -month HPFS contribution $C_t = W_{t-12} \times (a + a)$. Moreover, because the total monthly income of employees in the model is determined by the employee's monthly pre-tax salary and the HPFS monthly deposit, the income in month t is:

$$I_t = W_t + W_{t-12} \times (a + a) \quad (2)$$

W_t is the pre-tax salary after deducting the HPFS contribution in the t -th month.

As noted earlier, the monthly salary increases at 6.5%, the rental cost increases with house prices, and the cost of living increases with the consumer price index. The calculation formula is as follows:

$$W_t = W_{t-12} \times (1 + g) \quad (3)$$

$$R_t = R_{t-12} \times (1 + h) \quad (4)$$

$$L_t = L_{t-12} \times (1 + \text{CPI}) \quad (5)$$

Starting from the taxable amount, HPFS participants and non-HPFS employees should be discussed separately. For HPFS participants, the tax base Y_t in the t -th month is the salary of month W_t because the HPFS deposit enjoys tax exemption. For employees who do not participate in HPFS, there is no tax exemption and tax base Y_t in the t -th month is the monthly income I_t . Since the marginal tax rate is assumed to be constant, the formula for the tax payable is:

$$T_t = Y_t \times t \quad (6)$$

We will calculate the rate of return of typical HPFS participants and non-participant employees in four situations in the flowing part.

3.4.1. HPFS Participant Who Does Not Buy a House

The amount put into bank savings is what remains after deducting HPFS contributions, personal income tax, the cost of living, and rent, so the formula for bank savings is:

$$S_t = I_t - C_t - T_t - L_t - R_t \quad (7)$$

The accumulated balance of HPFS deposits and bank savings generates interest at a fixed rate each month, and the interest is settled once a year. The formula is given below.

Before the interest settlement date, the formulas for HPFS deposits and bank savings accumulated balance are Formulas (8) and (9):

$$TC_t = TC_{t-1} + C_t \quad (8)$$

$$TS_t = TS_{t-1} + S_t \quad (9)$$

When the annual settlement date is reached, the formulas for the accumulation of HPFS deposits and accumulated bank savings are Formulas (10) and (11):

$$TC_t = TC_{t-1} + C_t + \sum_{k=t-11}^t TC_k \times i_g \quad (10)$$

$$TS_t = TS_{t-1} + S_t + \sum_{k=t-12}^t TS_k \times i_s \quad (11)$$

When the employee retires at the n -th month, the accumulated assets owned by the typical HPFS participant comprise the accumulated HPFS contributions and the accumulated savings. The formula is:

$$B_n = TC_n + TS_n \quad (12)$$

3.4.2. Non-Participant Employee Who Does Not Buy a House

For such employees, there is no need to consider HPFS deposits. After deducting income tax, necessary living costs, and rental costs, the remainder is bank savings. The formula for the bank savings in month t is:

$$S_t = I_t - T_t - L_t - R_t \quad (13)$$

When the employee retires in the n -th month, the accumulated assets owned by a typical employee are only their accumulated savings. The formula is as follows.

$$B_n = TS_n \quad (14)$$

Next, we will discuss the case of buying a house with a loan.

The price of a typical employee's target house is assumed to increase monthly at the growth rate of house prices.

$$H_t = H_{t-1} \times (1 + h)^{\frac{t}{12}} \quad (15)$$

When buying a house, the minimum down payment $DP = H_t \times dp$, where dp is the minimum down payment ratio.

3.4.3. HPFS Participant Who Buys a House with an HPFS Loan

Before buying a house, the formulas for the accumulation of HPFS deposits and bank savings is the same as Formulas (8)–(11).

According to "Notice of the State Council on Resolutely Restraining Excessive House Price Increases in Certain Cities" issued by the State Council in 2010 and "Notice of the City A Housing Provident Fund Management Committee on Adjusting the Relevant Policies of the City A Housing Provident Fund Loan" issued by Housing Provident Fund Management Committee in City A in 2017, the following conditions must be met when applying for HPFS loans in City A.

- (1) Continuous HPFS contributions for at least two years before the first HPFS loan.
- (2) The amount of the HPFS loan = the balance of the deposit of the borrower and the joint borrower on the loan application date $\times 12$. The maximum loan amount is 400,000 yuan for the first HPFS loan and 200,000 yuan for the second HPFS loan. The minimum loan amount is 150,000 yuan per household.
- (3) To purchase the first self-occupied house or second improved self-occupied house after an HPFS loan or commercial loan has been repaid, the down payment is at least 30% of the total price of the house (for a price-limited house) and 20% for an affordable house (Quoted from "Common Problems of Housing Provident Fund Loans" issued by the Housing Provident Fund Management Center of City A. According to the "State Council's Notice on Resolutely Restraining the Excessive Rise of House Prices in Some Cities" issued by the State Council in 2010 for the purchase of the first self-occupied house with a built-up area over 90 m², the loan down payment ratio should not be less than 30%).

We assume that as soon as the savings are enough for the down payment and the conditions above are satisfied, the typical HPFS participant will immediately purchase a house and successfully receive the maximum HPFS loan amount under the policies.

To calculate the monthly repayment amount, that amount is usually applied equally to principal and interest:

$$D_t = \frac{P_g \times d_g \times (1 + d_g)^m}{(1 + d_g)^m - 1} + \frac{P_s \times d_s \times (1 + d_s)^m}{(1 + d_s)^m - 1} \quad (16)$$

where $\frac{P_g \times d_g \times (1 + d_g)^m}{(1 + d_g)^m - 1}$ is the monthly repayment amount of the HPFS loan, $\frac{P_s \times d_s \times (1 + d_s)^m}{(1 + d_s)^m - 1}$ is the monthly repayment amount of the commercial mortgage, and m is the number of loan repayment periods.

The balance in the HPFS account can be used to repay the loan. If the HPFS balance is not sufficient, bank savings are used for the remainder. In other words, $D'_t = D_t - TC_t$. The calculation process is shown in Table 2.

Table 2. Accumulated HPFS Contribution and Bank Savings of Typical HPFS Participants Who Buy houses with HPFS Loans.

	Accumulated HPFS Deposit	Monthly Bank Savings	Accumulated Bank Savings
Before Loan	$TC_t = TC_{t-1} + C_t$	$S_t = I_t - C_t - T_t - L_t - R_t$	$TS_t = TS_{t-1} + S_t$
Borrowing a Loan	$TC_t = TC_{t-1} + C_t - D_t$	$S_t = I_t - C_t - T_t - L_t - D'_t$	$TS_t = TS_{t-1} + S_t - DP$
During Loan Repayment	$TC_t = TC_{t-1} + C_t - D_t$	$S_t = I_t - C_t - T_t - L_t - D'_t$	$TS_t = TS_{t-1} + S_t$
After Loan Repaid	$TC_t = TC_{t-1} + C_t$	$S_t = I_t - C_t - T_t - L_t$	$TS_t = TS_{t-1} + S_t$

The calculation is divided into four stages: before loan, borrowing a loan, during loan repayment and after loan repaid. Before loan, a monthly deposit is needed to pay rent. When borrowing a loan, the down payment is paid by bank savings. In repaying the loan, the monthly repayment amount should be deducted from the HPFS deposit and bank saving account until the loan is repaid.

The total value of assets when the employee exits HPFS $B_n = TC_n + TS_n + H_n$.

3.4.4. Non-Participant Employee Who Buys a House

Before buying a house, the formulas for accumulating bank savings are the same as Formulas (9) and (11).

Once the savings are enough for the down payment, the non-HPFS employee will buy a house with a commercial mortgage and repay the mortgage thereafter. The monthly repayment for a commercial mortgage $D_t = \frac{P_s \times d_s \times (1 + d_s)^m}{(1 + d_s)^m - 1}$. The formula for the repayment process is shown in Table 3.

Table 3. Bank Deposit Balance of Typical Non-participant Employees Who Buy houses with Commercial Mortgages.

	Monthly Bank Savings	Accumulated Bank Savings
Before loan	$S_t = I_t - C_t - T_t - L_t - R_t$	$TS_t = TS_{t-1} + S_t$
Borrowing a Loan	$S_t = I_t - C_t - T_t - L_t - D_t$	$TS_t = TS_{t-1} + S_t - DP$
During Loan Repayment	$S_t = I_t - C_t - T_t - L_t - D_t$	$TS_t = TS_{t-1} + S_t$
After loan repaid	$S_t = I_t - C_t - T_t - L_t$	$TS_t = TS_{t-1} + S_t$

The total value of assets when exiting HPFS at retirement: $B_n = TS_n + H_n$.

4. IRRs of Typical HPFS Participants Compared

4.1. IRRs under the Basic Model

Under the assumptions of the basic model, the loan portfolios of typical male and female HPFS participants and non-participants who purchase a house are shown in Tables 4 and 5.

Table 4. The Housing Loan Portfolio of Typical Male Employees with Different Incomes.

Income Type	Participation or Not	House Order	Loan Starting Time (mon)	Down Payment (Yuan)	Down Payment Ratio (%)	HPFS Loan Amount (Yuan)	HPFS Loans Proportion (%)	Commercial Loan Amount (Yuan)	Commercial Loans Proportion (%)
Low-Income	Yes	1th	95th	184,875	30	335,980	54.52	95,394.41	15.48
		2nd	—	—	—	—	—	—	—
	No	1th	80th	165,047	30	0	0	385,112	70
		2nd	411th	2,531,151	30	0	0	5,906,019	70
Middle-Income	Yes	1th	25th	163,325	30	381,092	70.00	0	0.00
		2nd	386th	2,504,732	30	400,000	4.79	5,444,375	65.21
	No	1th	19th	156,080	30	0	0	364,186	70.00
		2nd	380th	2,393,614	30	0	0	5,585,100	70.00
High-Income	Yes	1th	25th	261,320	30	400,000	45.92	209,747	24.08
		2nd	386th	4,007,571	30	400,000	2.99	8,950,999	67.01
	No	1th	10th	233,295	30	0	0	544,355	70.00
		2nd	371th	3,577,780	30	0	0	8,348,153	70.00

Table 5. The Housing Loan Portfolio of Typical Female Employees with Different Incomes.

Income Type	Participation or Not	House Order	Loan Starting Time (mon)	Down Payment (Yuan)	Down Payment Ratio (%)	HPFS Loan Amount (Yuan)	HPFS Loans Proportion	Commercial Loan Amount (Yuan)	Commercial Loans Proportion (%)
Low-Income	Yes	1th	95th	184,875	30	335,980	54.52	95,394	15.48%
		2nd	—	—	—	—	—	—	—
	No	1th	80th	165,048	30	0	0	385,112	70.00
		2nd	—	—	—	—	—	—	—
Middle-Income	Yes	1th	25th	163,325	30	381,092	70.00	0	0.00
		2nd	—	—	—	—	—	—	—
	No	1th	19th	156,080	30	0	0	364,186	70.00
		2nd	—	—	—	—	—	—	—
High-Income	Yes	1th	25th	261,320	30	400,000	45.92	209,747	24.08
		2nd	—	—	—	—	—	—	—
	No	1th	10th	233,295	30	0	0	544,355	70.00
		2nd	—	—	—	—	—	—	—

Since low-income employees need more time to save enough money for the down payment, both the low-income males and females buy a house later than middle and high-income employees. Since HPFS participants must deposit part of their income into the HPFS account monthly, the bank savings accumulation is less than those for non-participant employees.

So, the HPFS participant buys a house later than a non-participant employee. In addition, female employees retire earlier than males, and they have no opportunity to purchase a second house. Compared with the IRR for a male employee with the same income and loan portfolio, the IRR of a female employee is relatively low.

Table 6 shows the IRRs of typical employees with different incomes under the same situations. The results show: (1) For the typical employee who buys a house, the IRR rankings are all “low-income employees > middle-income employees > high-income employees.” (2) For employees who do not buy a house, except for the female HPFS participants, the IRR rankings in the other three situations are all “middle-income employees > high-income employees > low-income employees”.

Table 6. IRRs of Typical Employees with Different Incomes under the Lifetime Cash Flow Model.

Four Situations	IRR of Male Employee				IRR of Female Employee			
	No HPFS & Not Buy	HPFS & Not Buy	No HPFS & Buy	HPFS & Buy	No HPFS & Not Buy	HPFS & Not Buy	No HPFS & Buy	HPFS & Buy
Low-income	−0.32%	−0.35%	5.91%	5.67%	−1.28%	−1.32%	5.89%	5.88%
Middle-income	0.06%	0.07%	4.04%	4.03%	−0.34%	−0.33%	3.60%	3.65%
High-income	−1.04%	−0.77%	2.23%	2.32%	−1.52%	−1.20%	1.69%	1.88%

Comparing the IRR of the same typical employee in different four situations, we have the following findings. (1) For employees who do not buy a house, both HPFS participants and non-participating employees, most of their IRRs are negative and lower than the IRRs for employees who buy houses with HPFS loans or commercial mortgage. (2) Both the male or female low-income HPFS employees who buy a house with combined loans (Combined loans are loans issued by the housing funds management department to the same borrower using policy housing funds and commercial banks credit funds, and are a general term for a combination of policy loans and commercial loans) have lower IRRs than if they do not participate in HPFS and buy the house with commercial mortgages. (3) Both the male or female high-income HPFS participants who buy houses with combined loans have higher IRRs than if they do not participate in HPFS and buy houses with commercial loans. (4) There is little difference in the IRRs of middle-income HPFS participants who buy houses with HPFS loans and non-participants who buy houses with commercial mortgages.

To sum up, if the effect of low-interest-rate loans, tax exemptions, and low-interest-rate deposits are considered together, we find that high-income HPFS participants who buy houses with HPFS loans have lower IRRs than those of low-income HPFS participants. However, this does not mean that the income redistribution from HPFS is positive. Low-income HPFS participants who buy houses with HPFS loans have lower IRRs than those of non-participants who buy houses with commercial mortgages. The high-income HPFS participants who buy houses with HPFS loans have higher IRRs than non-participants who buy houses with commercial mortgages. In other words, the high-income HPFS participants rather than middle- or low-income HPFS participants are the beneficiaries of HPFS.

4.2. IRRs under Different Growth Rates of Wages and House Prices

In this part, we conduct sensitivity analyses with different combinations of parameters with the growth of wages of 8.5% and 9.5% and the rise in house prices of 8.5% and 9.5%.

As shown in Table 7, the IRR of a low-income male employee is higher than that of a high-income employee. However, low-income HPFS participants who buy houses with HPFS loans have lower IRRs than non-participants who buy houses with commercial mortgages. The IRRs for high-income male HPFS participants who buy houses with HPFS loans increased. These conclusions are all valid under all four situations of the growth of wage and the rise of house prices.

Table 7. IRRs of Typical Male Employees with Different Incomes under Different Growth Rates of Wages and House Prices.

Wage Growth Rate	House Price Growth Rate	Different Situations	IRR of Low-Income Employees	IRR of Middle-Income Employees	IRR of High-Income Employees
9.50%	9.5%	No HPFS and Not buy	−0.32%	0.06%	−1.04%
		HPFS and Not buy	−0.35%	0.07%	−0.77%
		No HPFS and buy	5.91%	4.04%	2.23%
		HPFS and buy	5.67%	4.03%	2.32%
9.50%	8.5%	No HPFS and Not buy	−0.32%	0.06%	−1.04%
		HPFS and Not buy	−0.35%	0.07%	−0.77%
		No HPFS and buy	4.82%	3.27%	1.67%
		HPFS and buy	4.68%	3.28%	1.79%
8.5%	9.5%	No HPFS and Not buy	−0.86%	−0.25%	−1.28%
		HPFS and Not buy	−0.89%	−0.25%	−1.01%
		No HPFS and buy	6.21%	4.39%	2.58%
		HPFS and buy	6.08%	4.39%	2.64%
8.5%	8.5%	No HPFS and Not buy	−0.43%	0.12%	−0.86%
		HPFS and Not buy	−0.46%	0.12%	−0.61%
		No HPFS and buy	5.14%	3.55%	1.95%
		HPFS and buy	4.95%	3.56%	2.05%

As shown in Table 8, low-income females have higher IRRs than middle- or high-income female employees regardless of whether they buy houses with HPFS loans or commercial mortgages. However, for low-income female employees, the difference between using an HPFS loan or a commercial loan is small. To sum up, when the effects of low-interest-rate loans effect, tax exemptions, and low-interest-rate deposits are all considered, the following conclusions remain robust in the sensitivity analyses. (1) For both HPFS participants and non-participants, buying a house can significantly increase their IRRs. (2) Whether the houses are bought with HPFS loans or with commercial mortgages, the IRRs of high-income employees are lower than those of low-income employees. (3) Compared with buying houses with commercial mortgages without HPFS participation, buying houses with HPFS loans will not increase the IRRs of low-income female HPFS participants and will even decrease the IRRs of low-income male HPFS participants. (4) High-income HPFS participants who buy houses with HPFS loans have higher IRRs than high-income non-participants who buy houses with commercial loans.

4.3. IRRs under Different HPFS Reform Plans

If we raise the interest rate for HPFS deposits and the quota limits for HPFS loans or lower the interest rate for HPFS loans, will the above conclusions still be valid?

According to the “National Housing Provident Fund Annual Report 2019,” the value-added income of HPFS in China was 97.615 billion yuan in 2019. This income comes mainly from the 1.75% interest spread between HPFS deposits and HPFS loans. The value-added income is divided into three parts: 27.363 billion yuan for the HPFS loan risk reserve, 11.578 billion yuan for management costs, and 58.87 billion yuan for supplementary funds to build urban public rental housing (low-rent housing).

If we return the value-added income for building urban public rental housing to HPFS participants, then there may be a spread of about 1 percentage point (Calculation process: (low-rent housing construction funds/value-added gains) * provident fund deposit and loan spreads = $(58.87/97.615) * 1.75\% = 1.06\%$) which can be shared by HPFS participants. We can consider raising the interest rate on HPFS deposits by one percentage point, lowering the interest rate on HPFS loans by one percentage point, or increasing the upper limit of the amount of HPFS loans from 0.4 million to 1 million yuan. To test the impact of such reform plans on the HPFS redistribution effect, the following part measured the IRRs of typical employees with different incomes in the above reform plans.

Table 8. IRRs of Typical Female Employees with Different Incomes under Different Growth Rates of Wages and House Prices.

Wage Growth Rate	House Price Growth Rate	Different Situations	IRR of Low-Income Employees	IRR of Middle-Income Employees	IRR of High-Income Employees
9.50%	9.5%	No HPFS and Not buy	−1.28%	−0.34%	−1.52%
		HPFS and Not buy	−1.32%	−0.33%	−1.20%
		No HPFS and buy	5.89%	3.60%	1.69%
		HPFS and buy	5.88%	3.65%	1.88%
9.50%	8.5%	No HPFS and Not buy	−1.00%	−0.10%	−1.24%
		HPFS and Not buy	−1.03%	−0.09%	−0.94%
		No HPFS and buy	4.78%	3.00%	1.29%
		HPFS and buy	4.80%	3.07%	1.50%
8.5%	9.5%	No HPFS and Not buy	−1.82%	−0.60%	−1.69%
		HPFS and Not buy	−1.85%	−0.59%	−1.38%
		No HPFS and buy	6.17%	3.83%	1.92%
		HPFS and buy	6.14%	3.89%	2.09%
8.5%	8.5%	No HPFS and Not buy	−1.46%	−0.31%	−1.37%
		HPFS and Not buy	−1.50%	−0.30%	−1.07%
		No HPFS and buy	5.02%	3.18%	1.48%
		HPFS and buy	5.03%	3.25%	1.67%

As shown in Tables 9 and 10, if the annual interest rate for HPFS deposit is set at 2.5%, one percentage point higher than the current rate, ceteris paribus, then all the IRRs are improved. The higher the income of HPFS participants, the more the IRR improved. Nonetheless, raising the interest rate on HPFS deposits by one percentage point does not change the conclusion that low-income employees cannot benefit from HPFS, and high-income employees are beneficiaries of HPFS.

Table 9. IRRs of Typical Male Employees with Different Incomes under Different HPFS Reform Plans.

HPFS Deposit Interest Rate	HPFS Loan Interest Rate	Tax Exemption	Loan Ceiling	Income Type of Employee	No HPFS & Not Buy	HPFS & Not Buy	No HPFS & Buy	HPFS & Buy
1.50%	3.25%	Yes	400,000	Low	−0.32%	−0.35%	5.91%	5.67%
				Middle	0.06%	0.07%	4.04%	4.03%
				High	−1.04%	−0.77%	2.23%	2.32%
2.50%	3.25%	Yes	400,000	Low	−0.32%	−0.23%	5.91%	5.68%
				Middle	0.06%	0.25%	4.04%	4.07%
				High	−1.04%	−0.49%	2.23%	2.45%
1.50%	2.25%	Yes	400,000	Low	−0.32%	−0.35%	5.91%	5.70%
				Middle	0.06%	0.07%	4.04%	4.05%
				High	−1.04%	−0.77%	2.23%	2.32%
1.50%	3.25%	Yes	1,000,000	Low	−0.32%	−0.35%	5.91%	5.67%
				Middle	0.06%	0.07%	4.04%	4.04%
				High	−1.04%	−0.77%	2.23%	2.32%
1.50%	3.25%	No	400,000	Low	−0.32%	−0.35%	5.91%	5.67%
				Middle	0.06%	0.02%	4.04%	4.01%
				High	−1.04%	−1.11%	2.23%	2.13%

Table 10. IRRs of Typical Female Employees with Different Incomes under Different HPFS Reform Plans.

HPFS Deposit Interest Rate	HPFS Loan Interest Rate	Tax Exemption	Loan Ceiling	Income Type of Employee	No HPFS & Not Buy	HPFS & Not Buy	No HPFS & Buy	HPFS & Buy
1.50%	3.25%	Yes	400,000	Low	−1.28%	−1.32%	5.89%	5.88%
				Middle	−0.34%	−0.33%	3.60%	3.65%
				High	−1.52%	−1.20%	1.69%	1.88%
2.50%	3.25%	Yes	400,000	Low	−1.28%	−1.18%	5.89%	5.88%
				Middle	−0.34%	−0.15%	3.60%	3.71%
				High	−1.52%	−0.92%	1.69%	2.03%
1.50%	2.25%	Yes	400,000	Low	−1.28%	−1.32%	5.89%	5.94%
				Middle	−0.34%	−0.33%	3.60%	3.69%
				High	−1.52%	−1.20%	1.69%	1.89%
1.50%	3.25%	Yes	1,000,000	Low	−1.28%	−1.32%	5.89%	5.88%
				Middle	−0.34%	−0.33%	3.60%	3.65%
				High	−1.52%	−1.20%	1.69%	1.89%
1.50%	3.25%	No	400,000	Low	−1.28%	−1.32%	5.89%	5.88%
				Middle	−0.34%	−0.39%	3.60%	3.62%
				High	−1.52%	−1.59%	1.69%	1.63%

If the annual interest rate for HPFS loans is set at 2.25%, one percentage point lower than the current HPFS loan rate, *ceteris paribus*, the IRRs of all the HPFS participants who purchase houses increase and the IRRs of low-income HPFS participants increase more. However, the conclusion that low-income employees cannot benefit from HPFS and the high-income HPFS participants are the beneficiaries of HPFS does not change.

If the maximum amount of HPFS loans is increased from 0.4 million yuan to 1 million yuan, the IRRs of typical HPFS participants almost do not change, regardless of income. Low-income employees can apply only for HPFS loans of 336,000 yuan (see Tables 4 and 5). So, raising the upper limit of HPFS loans to 1 million yuan does not change the conclusion that low-income employees cannot benefit from HPFS and high-income employees are the beneficiaries of HPFS.

In the last parts of Tables 9 and 10, we examine the effect of tax exemptions on IRR. If the tax exemption for HPFS contributions is canceled, we find that there is no impact on the IRRs of low-income employees, but the IRRs of middle and high-income HPFS participants are greatly affected and the IRRs of high-income HPFS participants is lower than that of non-participants who buy houses with commercial mortgages. These findings show that the higher the HPFS participant's income, the greater benefits from tax exemption policies. The main reason for those benefits to high-income HPFS participants is tax exemptions rather than low-interest-rate loans.

5. Conclusions and Discussion

As we all know, HPFS participants can enjoy tax exemption and low-interest HPFS loans, but they also have to bear the opportunity cost of low-interest-rate HPFS deposits. Previous studies on the income redistribution effect of HPFS paid more attention to the effect of low-interest-rate loans and believed that HPFS is “robbing the poor to help the rich” because the low-income employee is less likely to participate in HPFS and use HPFS loans. Previous studies have emphasized that participating in HPFS is good for low- and middle-income employees and isolation from HPFS leads to a reverse income redistribution effect.

However, those studies ignored the effects of tax exemptions and low-interest-rate HPFS deposits. Although high-income HPFS participants may benefit more from low-interest-rate loans, their monthly deposits are much higher than those of low-income HPFS participants, and they also benefit more from tax exemptions. Therefore, compared with

buying houses with a commercial mortgage without participating in the HPFS, whether buying houses with HPFS loans may increase the rate of return is still a question to be discussed.

To answer this question, this paper introduces a longitudinal perspective that focuses on the cash flow from the beginning of their careers to the retirement of typical employees with different incomes in four situations. This perspective considers the effects of low-interest-rate loans, tax exemptions, and low-interest-rate deposits comprehensively. By comparing the IRRs of typical employees with different incomes under four situations, we have the following five findings.

- (1) Considering the effect of low-interest-rate loans, tax exemptions, and low-interest-rate deposits, the IRRs of high-income HPFS participants and non-participants employees who buy houses with HPFS loans or commercial loans are lower than those of low-income employees in the same situations. Compared with low-income employees, high-income employees are more affected by the effect of low-interest-rate deposits.
- (2) Compared to non-participants who buy houses with commercial mortgages, buying houses with HPFS loans increases the IRRs of high-income employees, and it has little effect on middle-income employees. However, it reduces the IRRs of low-income employees.
- (3) The tax exemption policy does not affect low-income employees much, while the benefit of low-interest-rate loans is completely offset by the effects of low-interest-rate deposits. This is why the IRR of low-income employees is reduced from HPFS participation. However, tax exemptions, rather than low-interest-rate loans, are the main reason that the high-income participants can benefit from HPFS.
- (4) Increasing the interest rate on HPFS deposits by one percentage point, reducing the interest rate of HPFS loans by one percentage point, or raising the maximum amount of HPFS loans to 1 million yuan does not change the above conclusions.

As previous studies have discovered, low-income employees have a lower probability of using HPFS loans and enjoying low-interest-rate HPFS loans. However, this paper further points out that even if low-income employees buy houses with HPFS loans, their IRRs are still lower than those of non-participants who use commercial mortgages to buy houses. This finding proves that low-income employees not only do not benefit from HPFS, rather they suffer from HPFS participation. High-income employees are the beneficiaries of HPFS, and tax exemptions are the main reason for their higher IRRs.

In other words, the benefits from the low-interest-rate loan are very limited. The low-interest rate on deposits reduces the IRRs of all employees, and high-income employees have more HPFS deposits, so they are more affected in that regard. However, high-income HPFS participants still benefit more, based on tax exemptions. Low-income employees can benefit only a little from tax exemptions, and the effect of low-interest-rate deposits decreases their IRRs.

It should be pointed out here in particular that the conclusions from the analysis on IRRs in this paper look the same as the outcomes of many previous studies. However, the policy implications of this paper are completely contrary to the previous studies. Previous research believes that various measures should be taken to help more low and middle-income employees participate in HPFS and use HPFS loans to buy houses. However, the findings in this article indicate that there is no need to include more low and middle-income employees in HPFS.

In fact, there is an endogenous contradiction between increasing the coverage rate of HPFS loans and allowing HPFS borrowers to have sufficient financial leverage. According to the current regulations, HPFS participants only need to contribute for a very short time (usually two years) to meet the conditions to apply for HPFS loans. If many participants apply for HPFS loans when housing prices are rising, this will inevitably lead to a shortage of HPFS funds, longer waiting periods for an HPFS loan, and reduced upper limits of HPFS loan amounts.

In the context of rising house prices, the ratio of the ceiling of HPFS loans amounts to house prices declines. This reduces the role of HPFS in helping participants to buy houses. Commercial mortgages can provide a higher loan quota than the ceiling for HPFS loans without compulsory future deposits. Although the interest rate for a commercial mortgage is higher, this study finds that if we consider the effect of compulsory low-interest-rate deposits, low-income employees still do not benefit from HPFS loans.

So, what we should consider is not to increase the coverage of HPFS and HPFS loans among middle- and low-income employees, but to thoroughly reflect on the basic orientation and design of the HPFS.

It should be pointed out here that the lifetime cash flow model and the IRR analysis in this study may have certain enlightening significance for evaluating similar public housing finance programs in other countries, as far as such programs involve deposits, loans, and loan repayment operations during a certain period of time. The cross-sectional data and Gini coefficient analysis cannot reflect the income redistribution effect as well as the lifetime cash flow model and the IRR analysis.

For example, Singapore's Central Provident Fund (CPF) is also a fund that is jointly contributed by employers and employees and managed by the Central Provident Fund Board (CPF Board). Part of the fund can be used to buy a cheaper flat which is built by the Housing and Development Board (HDB) and repay loans provided by HDB [38,39]. The interest rate of the HDB loan is 2.6%, 0.1% higher than the minimum interest rate of CPF deposits. The HDB flat and HDB loan is only available for the middle- and low-income groups. Singapore's PFS pays special attention to low-income groups, which is worth learning about for China.

So, when we exam the income redistribution effect of CPF in Singapore with the lifetime cash flow model and the IRR analysis, the basic principle is the same while the specific formulas will be different.

Of course, the IRR analysis is an analysis of a typical employee under certain parameter assumptions. During the span of nearly 40 years, with the macroeconomic situation change, parameters such as interest rate, house price growth rate, wage growth rate, and other parameters will change accordingly. Although sensitivity analysis has been done, there still may be deviations between the analysis result and the real world.

In future research, if the micro-enrollment data of HPFS and macroscopic parameters are available, the IRRs of specific HPFS participants, rather than the IRRs of the typical HPFS participants, can be calculated and the income redistribution effects between different HPFS groups can be further analyzed.

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