# The Impact of Innovated Mortgage Payment on Labor's Optimal Portfolio

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## ABSTRACT

*Due to the diversification of financial instruments, the labor can adjust the mortgage payment to maximize personal utility function. We derive the optimal asset allocation by the different mortgage payment, and find that the labors who are more risk averse tend to take conservative strategy of investment. Because of the variation of labor income and mortgage payment, the allocation of risky asset will show different. The labor will try to increase the tendency of saving from income and hesitate to hold risky asset, and so become more conservative.*

*We also find when there is positive correlation between the current mortgage payment and stock returns, the labor will increase the risky asset in his portfolio and exhibits more aggressive strategy. In other words, the more mortgage payment and stock returns, the more risky asset the labor will hold in order to diversify the assets. On the other hand, the labor who reduces the mortgage payment and find the stock return drop will re-evaluate the cost of risky assets. Finally, the labor will choose an aggressive strategy to allocate risky asset.*

*Because of the different characteristic in everyone's job situation, some labors can afford mortgage payment persistently and some can not. Some labors may lose job in a harsh environment and are not able to pay the mortgage payment. From the three scenarios we discussed above, the labor will take conservative strategy when facing unemployment or retirement.*

***Keywords:*** *Mortgage Payment, Optimal Asset Allocation, Risk Aversion*

## INTRODUCTION

For many investors, the house is the largest and most important asset in their portfolios. The house is not only a place for living, but is also an investment. However real estate is a risk business, the house sill lose value from disaster, war, and insecurity, and take risk of the inflation of home price and interest rate. Therefore, housing is a risky but important asset for people when they consider their portfolios.

The housing is a high price asset, and can be consume and invested. The labor who has limit income can raise only certain amount for down payment and therefore must get a loan from bank. When the applicants propose loan, the bank will evaluate their personal credit and house value to approve the loan. The terms of a loan includes loan size, down payment, interest rate, payment and criterion of interest rate. The applicants with good credit can get the better loan, lower down payment and interest. The applicants will get qusi-home-occupy after getting mortgage. Whether they rent out the house or then live in, they guarantee to pay back principle and interest regularly in the future. Otherwise, they will fall out of qusi-home-occupy.

The primary factors determining the labor's monthly mortgage payments are the size and the term of the loan. Size refers to the amount of loan and term refers to the length of time within which the loan must be fully paid back. Because of the expectation of income and the instability of interest, the borrowers are very sensitive to the variation of interest rate and the periodic of payments. The periodic mortgage payment will affect the labor's life and his portfolio. No studies have ever tried to find the impact of innovated mortgage payment on labor optimal portfolio. Pursing this question, we shall discuss it in detail.

Housing differs from other financial assets is that housing serves a dual purpose. It is both a durable consumption good from which the owner derives utility and also an investment vehicle that allows the investor to hold home equity. Compared with the other financial assets such as bonds and stocks, the housing investment is often highly leveraged and

relatively illiquid. The Survey of Consumer Finances(SCF), provide the data of average home values, mortgage, and net wealth from 1989 to 2001. The Survey of SCF shows that home value accounts for 55% of household's total assets and home value accounts and the ratio of mortgage to debt is 70% in 2001 report. That means mortgage plays an important role in optimal asset allocation. In 1989, the average labor buys house through mortgage and the balance of mortgage to home value ratio is 25.9%. In 2001, the ratio is up to 34.8. Housing is not only an investment instrument, but is a re-finance tool. Especially, the house is a re-finance tool in the economic recession or short of labor income (Yao and Zhang, 2005).

From the monthly financial statistics, it lists the consumer loans and the loans for construction. The ratio of property purchasing loans, repairing loans and the loans for construction to total consumer loans dropped from 96.77% in 2000 79.32% in 2005. This ratio raises to 94.66% in 2007. That means the high ratio affected consuming and investing activities for the labor. The trend can be seen clearly in figure 1:

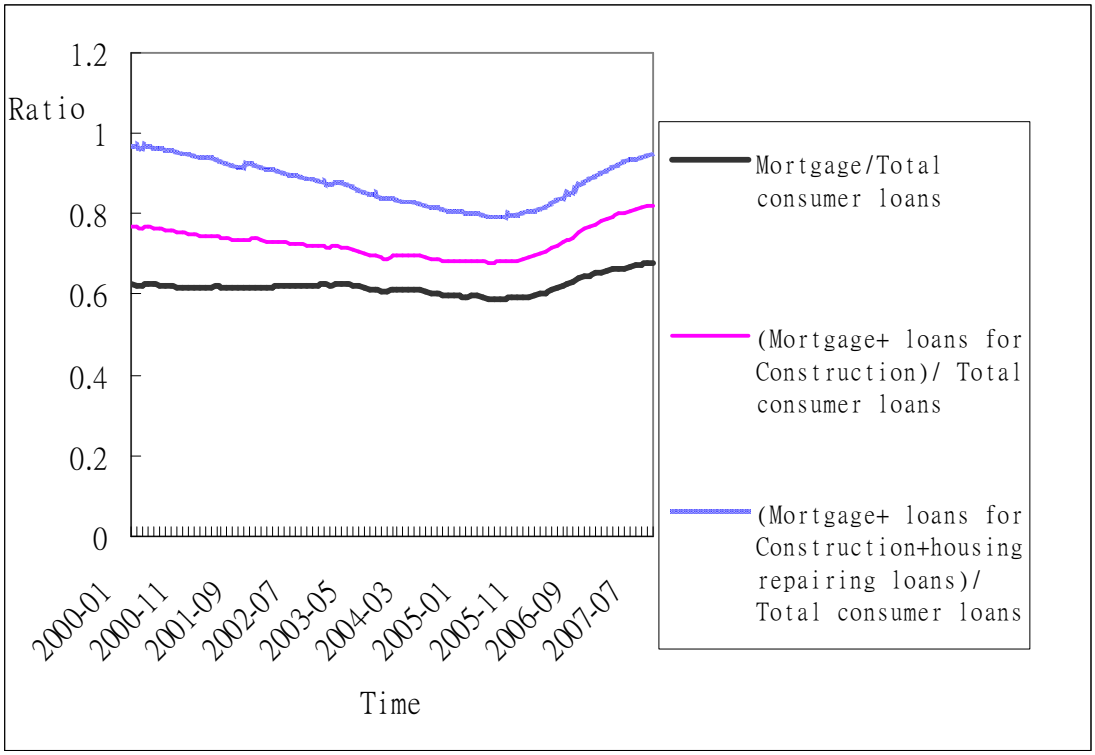


**Figure 1 loans to consumer loans ratio**
Data source：2007 financial statistics monthly of Central Bank in Taiwan

In recent years there has been a rapid growth in origination of financial instruments, such as weekly mortgage payment, mortgage payment even other week and derivations. This provides a lot of hedge way and affects current portfolio and retirement life. With limited labor income, if a labor wants to increase risky asset, he has to reduce other assets including mortgage payment and risk-less asset. Hence, it is important to consider the factors that will influence risky asset allocations.

The choice and management of mortgage is an important issue. The mortgage usually is collateralized by real estate, and a pay back in a schedule. In the choice of interest rate, most mortgages are based on adjusted rate mortgage. The variation of interest rate will add the burden on homeowner. Fabozzi and Modigliani(1992) suggest that the homeowner can take inflated index goods to hedge or other derivatives. Voicu(2007) address that the size of the hedges depends on the probability of moving away, on home the values, and on the labor's income. Shiller and Weiss(1999) discuss how put options on home price indices can be used to insure ownership risk.

Another significant factor is the stability of labor income after fixing the interest rate of mortgage. The basis of mortgage payment periodically is the labor income. When someone is close to retirement age or is suffering in an

unemployment, he is not able to pay mortgage. That will damage his portfolio and homeownership. The more the labor has stable income, the more he can afford the payment. Hence, Hakansson(1970) point out that it is optimal to invest a higher fraction of financial wealth in the risky assets than in the no-income case. In addition, in a change of social structure, demographic shift in its global nature, the demand of investment is more diversified. The competitions between nations are intensified and cause more unemployment. Whenever a labor loses job, his current consumption, portfolio and retirement life will all change.

Many institutions redesign the mortgage to strengthen its liquidity and the mortgage payment to stabilize or accelerate the mortgage. The new design and arrangement are not only attractive to the consumers, but also reduce the default risk. In general, mortgage payment is usually paid monthly to match monthly wage in Taiwan. Some banks propose biweekly payment to build the source of flexible fund and to control the default risk. Further more, the banks can locate potential clients by this way. For the labor who adopts biweekly payment can cut short the period of mortgage and cut down the total interest. But it is also crowd out other opportunities and influence retirement life. To obtain an optimal allocation, the labor should collect the information about finance.

## LITERATURE

Krumm and Kelly (1989) find that people will save a greater amount of cash for down payment in order to purchase a house when the house price is increasing. This is because the increasing mortgage payment will add the financial burden to labors. Sometimes, mortgage can be regarded as "forced savings", because it may affect the ownership of the house. The size of this demographic shift and its global nature will affect government's social welfare strategy and may result in the change for demanding different investment products. The optimal portfolio will be affected by the finance and the age. The younger investors are exposed to the new financial instruments and therefore face higher risk. Stock ownership is directly related to the factors of wealth, age, retirement savings. This is advised by Shum and Faig (2006). Cocco(2005) shows that housing can explain the patterns observed in the cross-sectional variation in wealth composition and stock ownership. For younger and poorer households, they buy the house so that is unable to invest in stock. In 2001, studies show that averagely half of seniors' total net assets are invested in their primary residence, with most of the rest assets are in risk-free assets. Gollier and Zeckhauser(2002) attempt to explain changes in the composition of portfolio over the life cycle. They show that if investors' absolute tolerance for risk is convex the young will invest more in risky assets than old one. Gerardi, Rosen, and Willen(2006) verify that homeowners have improved their ability to match their future income with house prices. The reason for this better matching is because of innovations in mortgages. Kullmann and Siegel(2003) suggest that asset allocation models can be improved by considering an individual's exposure to the risk associated assets with homeownership. Flavin and Yamashita (2002) conclude that an increase in the price of the house results in a relatively large shift from equities to bonds in a mean-variance optimal portfolio.

Stanton and Wallace (1998) show that in the presence of transaction costs payable by borrowers on refinancing, it is possible to construct a separating equilibrium in which borrowers with differing mobility select fixed rate mortgages with different combinations of coupon rate and points. Jong, Driessen and Hemert (2007) find that a moderately risk-averse investor always prefers an ARM in order to avoid paying the risk premium on long-term bonds. A very risk-averse investor is relatively more concerned about hedging inflation and interest rate risk, and thus optimally chooses a combination of ARM and FRM (Hemert, Jong, and Driessen, 2005).

Yohannes(1991) find that the frequency of paydays and education had significant influence on mortgage choice. Since the labors receive their wage monthly in Taiwan, they adopt the same frequency to pay mortgage in order to match the same cycle. Recently, some banks purpose biweekly mortgage payment to ease off the total interest, and to speed up mortgage to allocate in the other profitable products. The new design does not only alter the traditional concept of matching income and expenditure, but also shock the optimal portfolio.

In summary, researchers show that the home price risk and the way how to deal with are important, and they explain sufficiently the factors that invest and consume in their model. Besides, it is significance to consider changing preferences, the innovation of labor income, and how consumption and investment will respond to these changes as well

as the availability of new financial instruments. Lock of research in mortgage payment and frequency of payments, we develop an optimal asset allocation model which involves labor income risk, mortgage payment and the period of employment.

It is well-documented in the theoretical asset allocation literature that the inclusion of labor income has dramatic effects on the optimal long-term portfolio choice of individual investors. Some scholars solve an optimal asset allocation problem for a household using a multi-period optimization approach. There are some studies in literature for individual optimal investment strategy. Campbell(1993), Viceira(2001) and Chen et al.(2006) propose an optimization model with the parameters of wage income, consumption expenditure, and both the optimal asset allocation and life insurance.

Since the human capital of long-term investors is often very large compared to financial wealth, labor income has dramatic effects on their optimal portfolios. Duffie, Fleming, Soner, and Zariphopoulou (1997), Koo (1998), and Munk (2000) study the valuation of income and the optimal consumption and investment strategies of an infinite-horizon, liquidity constrained power utility investor with non-spanned income risk. The presence of liquidity constraints and mortgage payment can significantly decrease the individual's implicit valuation of the future income stream and, hence, dampen the quantitative effects of income on portfolio choice. Other recent papers on consumption and portfolio choice with stochastic income include Viceira (2001), Constantinides, Donaldson, and Mehra (2002), and Cocco, Gomes, and Maenhout (2005). Since different risky assets will have different correlations with the labor income of a given labor. We allow a link between mortgage payment and labor income and to observe the impact on optimal portfolio. Guiso et al. (1992) showed that agents with more uncertain labor income hold smaller proportions of their portfolio in risky assets. Jagannathan and Kocherlakota(1996) suggest that the financial management conventional wisdom that equity holdings should decrease over the working life. Benzoni et al. (2007) postulate a long-run co-integration between labor income and stock market dividends and show that such a relation can substantially reduce optimal stock holdings for sufficiently risk-averse long-term investors.◦ Because of idiosyncratic labor income, it will influence the stable and continuous in mortgage payment, and crowd out disposable income. It is valuable to study the mortgage payment issue, and we develop an optimal portfolio model which involves labor income risk, mortgage payment and the period of employment.

In the literatures, many researches are focus on the continuous model or discrete model to analyze the optimal problem. The labor can change the mortgage payment in some time, but they do not adjust the mortgage payment frequently. The labor will combine all information and situation and will decide the appropriate payment. Hence, the mortgage payment is not change continuous. Because of transaction cost, discrete model is appropriate to describe the behavior of adjusted payment strategically. Viceira(2001) derived optimal asset allocation for long term investors by discrete model, and obtain an approximation. We can follow Campbell(1993) and Viceira(2001) and derive an similar approximatively solution.

Thus, we address three steps to solute the problem. First, it substitutes objective function with Euler equations in log-linear approximations. Second, it looks for optimal portfolio policies and verifies these log-linear equations. Finally, we identify the sign of the optimal policies. Although we can not drive closed form solutions, but do sufficient to explain phenomenon in optimal portfolio.

## MODEL

We discuss the impact of adjustable mortgage payment on optimal asset allocation. Based on the model of Campbell(1993) and Viceira(2001), we added the consideration of the probability of employment and mortgage payment in dealing with optimal portfolio. The probability of employment and unemployment is denote by ($\pi$) and ($1-\pi$). Assume the retained rate of the current labor income is $K_t$, and the ratio of mortgage payment to current labor income is $(1-K_t)$, where $0 \le K_t \le 1$. Considering to different mortgage payment and employment, the analysis of optimal portfolio is approached through three scenarios:

1、scenario 1： $Y_t = 0, 0 \le K_t \le 1$，a status of unemployment.

2、scenario 2： $Y_t > 0, K_t = 1$，a status of employment, and retain all labor income.

3、scenario 3： $Y_t > 0, 0 \le K_t < 1$，a status of employment, and the labor can adjust retained labor income.

**Assumptions:**

**Assumptions on utility function**

No matter how the mortgage payment, we assume the labor wants to maximize the utility function. The labor will choose financial instruments with risk aversion. Viceira(2001) expressed the utility function as following:

$$U(C_t) = \frac{1}{1-\gamma}(C_t^{1-\gamma}) \quad (1)$$

where $C_t$ represents consumption at time t, and γ represents risk aversion and γ>0.

**Assumptions on Labor Income**

Under a different ratio of retained income, the labor could adjust asset allocation according to the disposable income. It is subjected to both permanent and temporary shocks (eg: the growth of economic, industry version, new technology, and unemployment). Viceira(2001) showed that includes transitory shocks that they have impact on the relationship between retirement horizon and asset allocation. In the employment state, labor income is subjected to a permanent( $g_1$) and multiplicative shocks( $\xi_{t+1}$). The labor income process is as following:

$$Y_{t+1} = Y_t \ \exp\{g_1 + \xi_{t+1}\} \quad (2)$$

$Y_{t+1}$ is the labor's income at time t+1. $\xi_{t+1} \sim NIID(0, \sigma_\xi^2)$. $g_1$ is the permanent component of the wage rate. The second component of the wage rate is $\xi_{t+1}$.

The empirical evidence available suggests that individual labor income is subjected to both the permanent and transitory shocks (MaCurdy, 1982; Abowd and Card, 1989, Carroll, 1992).

**Assumptions on the Financial Instruments**

There are two tradable financial assets for a labor: one is a risky asset, with a period log return $r_{1,t+1}$; the other is risk-less asset $f$, with a constant log return by $r_f$. We refer to risky asset as stocks, and asset $f$ as bonds. The expected excess log return on the risky asset is constant, with

$$E[r_{1,t+1} - r_f] = \mu \quad (3)$$

where，$\mu$ is a constant risk premium.

The unexpected log return on the risky asset, denoted by $u_{t+1}$, is conditionally homoskedastic and serially uncorrelated. I assume shocks to unexpected excess return to be correlated with those in the wage process. Denote these variance and covariance as:

$$Var_t(u_{t+1}) = \sigma_u^2 \quad (4)$$

$$Cov_t(u_{t+1}, \xi_{t+1}) = \sigma_{\xi u} \quad (5)$$

**Assumption on retained rate of the current labor income**

Assume the retained ratio of a labor's income is $K_t$, and the mortgage payment to current labor income ratio is $(1-K_t)$. The retained rate of the current labor income is subject to both permanent retained rate ($l$) and transitory retained rate ($\varphi_t$). Assume $k_t = \log K_t$, and the retained rate of the current labor income and covariance with stock in log are:

$$k_t = l + \varphi_t \quad (6)$$

$$\mathrm{cov}(u_{t+1}, \varphi_t) = \sigma_{u\varphi} \quad (7)$$

**The Problem**

At time t, labor inherits wealth from last period and chooses optimal consumption, labor supply and portfolio allocation in order to maximize his life-time utility, given the prevailing prices:

$$\underset{c_t k_t \alpha_t}{MAX}\ E_0\left[\sum_{t=0}^{\infty}\delta^t U(C_t)\middle|Y_0,u_0,\xi_0\right] \tag{8}$$

Subject to the period-by-period budget constraint

$$W_{t+1}=(W_t+K_tY_t-C_t)\cdot R_{p,t+1} \tag{9}$$

where $W_{t+1}$ is financial wealth, defined as the value at the beginning of (t+1) of financial assets carried over from period t, and $R_{p,t+1}$ is return of portfolio.

The one-period return on savings is given by:

$$R_{p,t+1}=\alpha_t(R_{1,t+1}-R_f)+R_f \tag{10}$$

where $R_{1,t+1}=\exp\{r_{1,t+1}\}, R_f=\exp\{r_f\}$, and $\alpha_t$ is the proportion of savings invested in the risky asset at time t

Viceira (2001) set current labor income in (9) be 0 or 1. We will not only discuss the case of 0 and 1, but also focus on the case which between 0 and 1. The main objective is to compare the impact on optimal asset allocation with the different mortgage payment.

There are two sets of first order conditions for the optimal asset allocation. The two Euler equations are as following:

In the unemployment or retirement, $\pi=0$ ,and the Euler equation is given by

$$E_t\left[\delta^m\left(\frac{C_{t+1}^m}{C_t^m}\right)^{-\gamma}R_{i,t+1}\right]=1 \tag{11}$$

where $i=1,f$ , and we use the superscripts $m$ to denote the unemployment or retirement state, and $\delta^m$ represents the time discount factor in the unemployment. $R_{1,t+1}$ is the return of risky asset at time t+1, and $R_{f,t+1}$ is the return of risk-less asset at time t+1.

In the unemployment or retirement, $0<\pi\le 1$, the Euler equation is given by

$$E_t\left\{\left[\pi\delta^n\left(\frac{C_{t+1}^n}{C_t^n}\right)^{-\gamma}+(1-\pi)\delta^m\left(\frac{C_{t+1}^m}{C_t^n}\right)^{-\gamma}\right]R_{i,t+1}\right\}=1 \tag{12}$$

where $i=1,f$ , and we use the superscripts $n$ to denote the employment state, and $\delta^n$ represents the time discount factor in the employment state. $R_{1,t+1}$ is the return of risky asset at time t+1, and $R_{f,t+1}$ is the return of risk-less asset at time t+1.

**Log-Linear Approximate Solution Method**

Following Campbell(1993), we can log linearize intertemporal budget constraint, and the Euler equation(11) and (12) as the following sections.

**The Log-linear approximation to the intertemporal budget constraint**

The three scenarios in log-linear form can be write as following

1. scenario 1：$Y_t=0, 0\le K_t\le 1$ Following Campbell(1993) we can write this intertemporal budget constraint in log-linear form as(13)**:**

$$w_{t+1}^m-w_t=\eta^m-\rho_c^m(c_t^m-w_t)+r_{p,t+1}^m \tag{13}$$

$$\eta^m=-(1+\rho_c^m)\log(1+\rho_c^m)+\rho_c^m\log(\rho_c^m)$$

$$\rho_c^m=\exp\{E(c^m-w_t)\}/(1-\exp\{E[c^m-w_t]\})$$

2. scenario 2 $Y_t>0, K_t=1$ Following Viceira(2001) we can write this intertemporal budget constraint in log-linear form as(14):

$$w_{t+1}^n-y_{t+1}\approx\eta^n+\rho_w^n(w_t^n-y_t)-\rho_c^n(c_t^n-y_t)-\Delta y_{t+1}+r_{p,t+1}^n \tag{14}$$

$$\eta^n = -(1-\rho_w^n+\rho_c^n)\log(1-\rho_w^n+\rho_c^n) - \rho_w^n \log(\rho_w^n) + \rho_c^n \log(\rho_c^n)$$

$$\rho_w^n = \frac{\exp\{E[w_t^n - y_t]\}}{1+\exp\{E[w_t^n - y_t]\} - \exp\{E[c_t^n - y_t]\}}$$

$$\rho_c^n = \frac{\exp\{E[c_t^n - y_t]\}}{1+\exp\{E[w_t^n - y_t]\} - \exp\{E[c_t^n - y_t]\}}$$

3. scenario 3 $Y_t > 0, 0 \le K_t < 1$ we can write this intertemporal budget constraint in log-linear form as(15):

$$w_{t+1}^n - y_{t+1} \approx \eta^z + \rho_w^z (w_t^n - y_t) - \rho_c^z (c_t^n - y_t) - \rho_k^z k_t - \Delta y_{t+1} + r_{p,t+1}^n \qquad (15)$$

$\eta^z$、$\rho_w^z$、$\rho_c^z$、$\rho_k^z$ are log-linearization constants, and do not influence the final results.

**The Log-linear approximation for the log return on financial wealth**

Viceira(2001) drives an approximation expression for the log return on financial wealth that holds exactly in continuous time:

$$r_{p,t+1} = \alpha_t (r_{1,t+1} - r_f) + r_f + \frac{1}{2}\alpha_t (1-\alpha_t)\sigma_u^2 \qquad (16)$$

**The Log-linear approximation to the problem**

The Euler equations (11) and (12) are highly non-linear. We can find log-linear approximations for them. The Euler equation in the retirement (or unemployment) state takes the following log-linear form:

$$0 = \log \delta^m - \gamma E_t[c_{t+1}^m - c_t^m] + E_t[r_{i,t+1}] + \frac{1}{2} Var_t[r_{i,t+1} - \gamma(\Delta c_{t+1}^m)] \qquad (17)$$

The log-linear approximation to the Euler equation in the employment state takes the following form: $0 < \pi \le 1$

$$0 = \sum_{s=m,n} \pi \left\{ \log \delta^s - \gamma E_t(c_{t+1}^s - c_t^n) + E_t(r_{i,t+1}) + \frac{1}{2} Var_t(r_{i,t+1} - \gamma(c_{t+1}^s - c_t^n) \right\} \qquad (18)$$

## OPTIMAL PORTFOLIO

We can derive three optimal portfolio solutions with the different mortgage payment scenarios.

**Scenario 1**

$Y_t = 0, 0 \le K_t \le 1$，the optimal allocation to stock $\alpha_t^m$ is：

$$\alpha_t^m = \frac{u + \frac{\sigma_u^2}{2}}{\gamma \sigma_u^2} \qquad (19)$$

When the retirement state occurs, labor income is set to zero, $Y_t = 0$, the labors must live off his financial wealth under constant investment opportunities. They could not afford the monthly mortgage payment. From equation (20), it is easy to find important factors that affect the optimal asset allocation: the degree of risk aversion( $\gamma$ ), and the degree of volatility of stock return ( $\sigma_u^2$ ). We can see $\frac{\partial \alpha_t^m}{\partial \gamma} < 0$, and $\frac{\partial \alpha_t^m}{\partial \sigma_u^2} < 0$ ,and that means inversely related to the optimal allocation to stock $\alpha_t^m$ .This imply that when the labor is more(less) risk aversion, he will decrease(increase) risky asset on his portfolio.

**Scenario 2**

$Y_t > 0, K_t = 1$，the optimal allocation to stock $\alpha_t^n$ is：

$$\alpha_t^n = \frac{u + \frac{1}{2}\sigma_u^2}{\gamma \bar{b}_1 \sigma_u^2} - \frac{\pi(1-b_1^n)}{\bar{b}_1} \cdot \frac{\sigma_{\xi u}}{\sigma_u^2} \qquad (20)$$

where $\overline{b_1} = \pi b_1^m + (1-\pi) \cdot b_1^n$ (21)

$$-\frac{\pi\left(1-b_1^n\right)}{\overline{b}_1} \cdot \frac{\sigma_{\xi u}}{\sigma_u^2} \quad (22)$$

This component of the optimal allocation to risky asset is opposite to the sign of optimal portfolio. If labor income shock are correlated with unexpected returns on a risky asset, a rational labor will modify his optimal portfolio to take advantage of the hedging properties of the risky asset. $\frac{\partial \alpha_t^n}{\partial \sigma_{\xi u}} < 0$, if this correlation is positive, it will be optimal for an employed investor to have a negative hedging for risky asset, since shorting the risky asset.

**Scenario 3**

$Y_t > 0, 0 \le K_t < 1$，the optimal allocation to stock $\alpha_t^n$ is：：

$$\alpha_t^n = \frac{u + \frac{1}{2}\sigma_u^2}{\gamma \overline{b}_1 \sigma_u^2} - \frac{\pi\left(1-b_1^n\right)}{\overline{b}_1} \cdot \frac{\sigma_{\xi u}}{\sigma_u^2} - \frac{\rho_k^z \sigma_{\varphi u}}{\sigma_u^2} \quad (23)$$

where $\overline{b_1} = \pi b_1^m + (1-\pi) \cdot b_1^n$

$$-\frac{\rho_k^n \sigma_{\varphi u}}{\sigma_u^2} \quad (24)$$

which is proportional to the hedge ratio for mortgage payment. Because of adjustable labor income flexible, the labor can increase the mortgage payment or raise the frequency in order to gain lighter interest or shorten the terms. $\frac{\partial \alpha_t^n}{\partial \sigma_{\varphi u}} < 0$ which implies the opposition of $\sigma_{\varphi u}$ and $\alpha_t^n$. The more(less) -$\sigma_{\varphi u}$, and $\sigma_{\varphi u}$ is small (larger), and result $\alpha_t^n$ increase (decrease). We can say that when the labor can adjust mortgage payment ratio(1-$K_t$) flexibly, if innovations to current mortgage payment are positively correlated with innovations to stock returns, stock are desirable.

## DISCUSSION

From the diversification of financial instruments, the labor can adjust the mortgage payment to maximize personal utility function. We drived the optimal asset allocations with the different mortgage payments, and found that the labors who are more risk aversion tend to take conservative strategy of investment. Because of verities of labor income and mortgage payment, the allocation of risky asset will be different. It showed that the optimal portfolio rule has four components: the degree of risky aversion($\gamma$), the probability of employment, the correlation between shocks to labor income and unexpected returns on the risky asset($\sigma_{\xi u}$) and the correlation between shocks to monthly mortgage payment and unexpected returns on the risky asset($-\sigma_{\varphi u}$). The other parameters of the model can affect the magnitude of risky asset, but do not change the direction of risky asset allocation. The labors who are more risk averse save more and reduce the risky asset in the portfolio. The labors with higher probability of unemployment will reduce risky asset. This implies the uncertainty of income make labors to take more conservative strategy.

The positive correlation between Shocks to labor income and unexpected returns on risky asset will enforce the labor to decrease the risky asset, and cause the labor to be conservative. The labor will choose investment more on the saving rather than the stock. On the other hand, The negative correlation between Shocks to labor income and unexpected returns on risky asset will enforce the labor to increase the risky asset holding, and make the labor invest more on risky asset. The positive correlation between Shocks to mortgage payment and unexpected returns on risky asset will enforce the labor to increase the risky asset, and cause the labor to be active. This imply that the labor will not only increase mortgage payment but also increase risky asset to diversify the risk.

Risk-aversive labors by nature prefer to invest a smaller fraction of their wealth in stocks. The risk aversive investors have a weak incentives to hold risky asset. They have stronger incentives to save for retirement (Viceira, 2001; Vigna and Haberman, 2001); Cairns, Blake, and Dowd, 2006).

## CONCLUSION

This paper is intended as an investigation of optimal portfolio for the labor with different mortgage payment. We find when there is positive correlation between the current mortgage payment and stock returns, the labor will increase the risky asset in his portfolio and exhibits more aggressive strategy. Because of the different characteristic in everyone's job situation, some labors can afford mortgage payment persistently and some can not. Some labors may lose job in a harsh environment and are not able to pay the mortgage payment. From the three scenarios we discussed above, the labor will take conservative strategy when facing unemployment or retirement.

## REFERENCES


Abowd, J. M. and Card, D. (1989). On the covariance structure of earnings and hours changes. Econometrica, 57, 411-445.

Benzoni, L., Dufresne, P. C. and Goldstein, R. S. (2007), Portfolio choice over the life-cycle when the stock and labor markets are cointegrated. Journal of Finance, forthcoming.

Cairns, A. J. G., Blake, D. and Dowd, K. (2006). Stochastic Lifestyling: Optimal Dynamic Asset Allocation for Defined Contribution Pension Plans. Journal of Economic Dynamics and Control, 30(5), 843-877.

Campbell, J. Y. (1993). Intertemporal asset pricing without consumption data. American Economic Review. 83, 487-512.

Carroll, C. D. (1992). The butter-stock theory of saving : Some macroeconomic evidence. Brookings papers on Economic Activity. 61-156.

Chen, P., Ibbotson, R., Milevsky, M. and Zhu, K. (2006). Human Capital, Asset Allocation, and Life Insurance. Financial Analysts Journal, 62, 1-13.

Cocco, J. F. (2005). Portfolio choice in the presence of housing. Review of Financial Studies 18, 535–567.

Cocco, J. F., Gomes, F. J. and Maenhout, P. J. (2005). Consumption and Portfolio Choice over the Life Cycle. The Review of Financial Studies 18 (2), 491–533.

Constantinides, G. M., Donaldson, J. B. and Mehra, R. (2002). Junior Can't Borrow: A New Perspective on the Equity Premium Puzzle. Quarterly Journal of Economics 117, 269–296.

Duffie, Fleming, Soner and Zariphopoulou. (1997). Hedging in Incomplete Markets with HARA Utility. Journal of Economic Dynamics and Control, 21, 753-782

Fabozzi, F. and Modigliani, F. (1992). Mortgage and Mortgage-Backed Securities Markets. Harvard Business School Press.

Flavin, M. and Yamashita, T. (2002). Owner-Occupied Housing and the Composition of the Household Portfolio", American Economic Review. American Economic Association, 92(1), 345-362.

Gerardi, C., Rosen, H. and Willen, P.(2006). Do Innovations on Wall Street Help People on Main Street? The Case of the Mortgage Market. Federal Reserve Bank of Boston working paper.

Gollier, C. and Zeckhauser, R. J. (2002). Horizon length and portfolio risk. Journal of Risk and Uncertainty, 24, 195–212.

Guiso, L., Jappelli, T. and Terlizzese, D. (1992). Earnings Uncertainty and Precautionary Saving. Journal of Monetary Economics, 30, 307–338.

Hakansson, Nils H. (1970). Optimal Investment and Consumption Strategies Under Risk for a Class of Utility Functions. Econometrica, Econometric Society.

Hemert, V., Jong, D. and Driessen (2005). Dynamic portfolio and mortgage choice for homeowners. Working Paper.

Hsueh, L. M. and Chen, H. L. (1998). A Comparison of Household Expenditure by Tenure Choice (in Chinesse). Journal of Housing Studies, **7**, 21-40.

Jagannathan, R. and Kocherlakota, N. R. (1996). Why Should Older People Invest Less in Stocks Than Younger People?. Federal Reserve Bank of Minneapolis Quarterly Review, 20, 11-23.

Jong, F. D., Driessen, J. and Hemert, O. V. (2007). Hedging House Price Risk: Portfolio Choice with Housing Futures. Working paper, University Van Amsterdam.

Koo, H. K. (1998). Consumption and Portfolio Selection with Labor Income: A Continuous Time Approach. Mathematical Finance, 8 (1), 49–65.

Krumm, R. K., and Kelly, A. (1989). Effects of homeownership on household Savings. Journal of Urban Economics, 6 ,281-294.

Kullmann, C. and Siegel, S. (2003). Real estate and its role in household portfolio choice. Manuscript. Faculty of Commerce and Business Administration, University of British Columbia, Vancouver, BC, Canada.

MaCurdy, T. E. (1982). The use of time series processes to model the error structure of earnings in a longitudinal data analysis. Journal of Econometrics, 18, 83-134.

Munk, C. (2000). Optimal Consumption-Investment Policies with Un-diversifiable Income Risk and Liquidity Constraints. Journal of Economic Dynamics and Control, 24 (9), 1315–1343.

Shiller, Robert J., and Weiss, A. N. (1999). Home Equity Insurance. Journal of Real Estate Finance and Economics, 19(1), 21–48.

Shum, P. and Faig, M. (2006). What explains household stock holdings?. Journal of Banking & Finance, 30, 9, 2579-2597.

Stanton, R. and Wallace, N. (1998). Mortgage Choice: What Is the Point?. Real Estate Economics, 26, 173-205.

Viceira, L. M. (2001). Optimal portfolio choice for long-horizon investors with nontradable labor income. The Journal of Finance, 56, 433-470.

Vigna, E. and Haberman, S.(2001). Optimal investment strategy for defined contribution pension schemes. Insurance: Mathematics and Economics, 28, 233-262.

Voicu, C. (2007). Optimal portfolio with housing derivatives. Working paper.

Yao, R. and Zhang, H. H. (2005). Optimal consumption and portfolio choices with risky housing and borrowing constraints. The Review of Financial Studies, 18, 197-239.

Yohannes, A. G. (1991-1992). Comparing mortgages with different payment frequencies. Financial Services Review, 1, 2, 131-142.