

# Risk Tolerance and Risk Exposure: Evidence from Panel Study of Income Dynamics

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Professor Frank Stafford  
Yang Su  
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## **Abstract**

In this paper, I examined the attitude of U.S. households towards risk as well as its connections with the families' exposure to actual financial risks. I also looked at factors that might affect the risky attitude and the financial position of the families, including age, education, income, the possession of pension, annuities and IRAs as well as the economy status. My result showed that the financial position generally conforms to the risky attitude of the families, given other factors constant, and that age has a negative effect on risk tolerance and risk exposure while income, education and the possession of IRAs have positive effects. The exposure to risk also changes with the changes in the economy.

## I. Introduction

In this project, I am looking at how the financial position of a family and its attitudes towards risk are related to the age of head, the income of head and the wife, the educational levels of the head and the possession of pension, annuities or IRAs of the family. I also look at how the changes in economy affect the exposure to risk of families with different risky attitudes. Most of the data that I used are from Panel Study of Income Dynamics (PSID.) To measure the level of risk that each family is facing, I constructed a variable called Risk Exposure Index where I calculate a weighted average of the portion of each risky asset in the family's wealth. I also utilize the variables measuring risk tolerance of families from PSID to form a contrast with my Risk Exposure Index. I noticed that as the Risk Exposure Index is relatively an objective approach to see degree of risk that a family is exposed to and that the risk tolerance measure shows the subjective attitude of individual towards risk, they may not be consistent with each other all the time. By looking at the five factors – Age of head, Income of Head, Education of Head, the possession of pension, annuities and IRAs and the changes in economy – that may affect the value of Risk Exposure Index and the degree of risk tolerance, I find that the Risk Exposure Index and Risk Tolerance are surprisingly consistent most of the time. It seems that the degree of risk that a family is exposed to does reflect their attitudes towards risk as well as the changes in economy.

### i. The 1996 PSID Risk Tolerance Measure

In 1996, questions about risk tolerance were asked in the PSID. The interviewers started with a question asking if the interviewee (the Head of the family) would accept if given a job that provides the same wage that the interviewee has but also has a fifty-fifty chance to cut their income by one third. If the interviewee's answer was "yes", then circumstances with possibility

of greater loss (fifty percent income cut and seventy five percent income cut) along with possibility of doubling income were provided for him to choose; if the answer was “no”, circumstances with possibility of smaller loss (twenty percent income cut and ten percent income cut) along with possibility of doubling income were provided for him to choose. Based on the Heads’ answers, I divided the families into six groups. As shown in Table 1, people in Group 1 reject even the smallest income cut and people in Group 6 accept the largest income cut.

Assuming that the Head’s attitude towards risks is consistent with that of the Wife and other family members, we can conclude that the higher the group that the family is in, the higher the degree of risk tolerance that the family members have. This is a measure of subjective attitude towards risk – even though the Heads may give answers based on their actual financial status, which should be reflected through the Risk Exposure Index that I constructed in the later part of this paper, other factors that are not directly captured by the Risk Exposure Index such as personalities, education, age and the overall economy status will also affect their answers. An analysis of both of subjective and objective factors would be given in the later parts of this paper.

Chart 1 shows the distribution of families from each group. Not surprisingly, the portion of families gets smaller as the group number gets larger, showing most family do not willing to tolerate the possibility of large income cut. This result indicates not only the families are mostly “risk averse,” but also irrational, because in some of the circumstances with large income cuts, the corresponding expected income is larger than the current income. We can see by the simple calculation shown in the last column of the table, the expected return of five of the provided situations exceed the current income of the head, but most people reject the situation with the highest expected income. It seems that the Heads choose their answers base on the possible degree of income cut, not the overall expected increase in income. This phenomena is consistent,

although somewhat loosely, with the conclusion that Robert Shiller drew from his study on the U.S. stock market since 1920s, that if people bought stocks base solely on the stocks future dividends, the stocks market should be less volatile than it actually were (Shiller, 1981). By the “Equity Premium Puzzle, ” which shows that individuals must be extremely risk averse according to standard economics model as the average yields of stocks are much higher than that of government bonds (Mehra and Prescott, 1985,) we may also interpret the reasons for this result as that the compensation of the income cuts, which is twice of the current income, is not large enough, or the families are very risk averse (even though they make their choice rationally.)

Another variable that is relevant to the risk tolerance measure in 1996 is called RT. To construct this variable, researchers from PSID calculate the parameter  $\theta$  from the following utility function using the answers from the questionnaire and label  $\theta$  as RT:

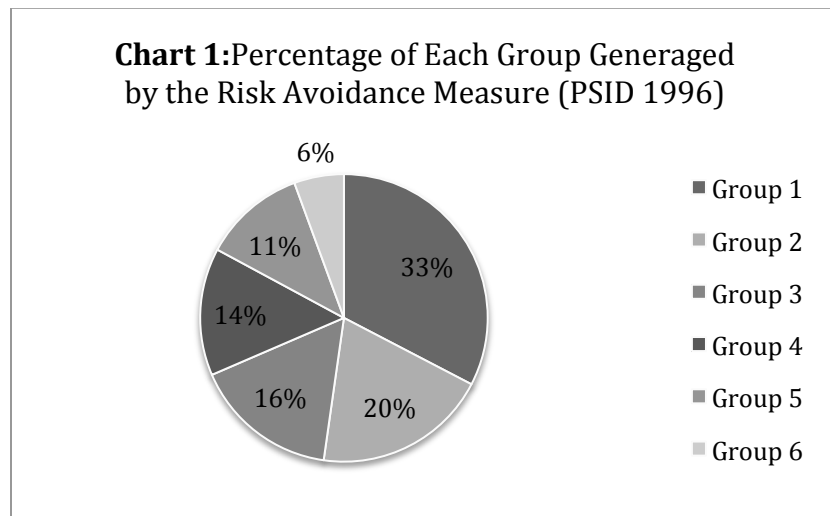
$$U(c)=(1/(1-1/\theta))c^{1-1/\theta}$$

According to the formula, the larger the RT is, the more risk that a family is able to tolerate. RT shows more precisely of the subjective risk tolerance of the Head (and hence the their family, by my assumption,) comparing to merely examining which group they are in. I will utilize this variable as an indication of the risky attitude of families in the following parts of this paper. We should be reminded, however, that RT as well as the group number may not reflect purely the subjective attitude towards risk of the Heads or the Family. As I mentioned above, the answers to the income cut questions that the Heads give are well plausible related to the current financial situation of the family. Thus RT is possible to highly correlated with the Risk Exposure Index that I created later. It would be hard to determine how much of the subjective attitude of the

Heads are included in RT, but I will assume that it contends a considerable portion the could give us information about the instinctive risky attitude of the Heads and the Family.

**Table 1:** The way to divide families according to their risk-tolerance answers

Group	10% Income Cut	20% Income Cut	1/3 Income Cut	50% Income Cut	75% Income Cut	Implication (Assume current income is 1)
Group 1	No	No	No			Reject the situation with an expected income of 1.45
Group 2	Yes	No	No			Reject the situation with an expected income of 1.40
Group 3		Yes	No			Reject the situation with an expected income of 0.67
Group 4			Yes	No		Reject the situation with an expected income of 1.25 while accept the situation with an expected income of 0.67
Group 5			Yes	Yes	No	Reject the situation with an expected income of 1.125 while accept the situation with an expected income of 1.25
Group 6			Yes	Yes	Yes	Accept the situation with an expected income of 1.125 <b>AND</b> accept the situation with an expected income of 0.67



### III. The Risk Exposure Index

In order to compare how each of the family in the data sets is exposed to risk and uncertainty, I constructed an index called “Risk Exposure Index.” The way I construct it is to collect the percentage of the risky asset on the family’s total wealth and then give a weight on it according to its volatility. The weights I assigned are all positive and sum to one, so holding wealth constant, the larger the index, the more risky assets a family owns, and hence they may be facing more uncertainty than the ones with smaller Risk Exposure Index.

The risky assets that I include to my index are as follows: (a) Stocks (b) Home Equity (c) Other/Second Real Estates (d) Farm/ Business (e) Bond/Insurance (f) Money in Checking/Saving Accounts. I choose these assets because once have them in possession, a family would have to face the risk of the depreciation. These are definitely not the only risky assets that exist, but they are the ones whose data is provided in PSID and that compose the main risky assets of a family<sup>1</sup>.

The weights I assigned to each of the assets are ordinal and very simple – they only show that one asset is more risky than the other and they (are supposed to) give no further information. A better way to assign the weights may be finding a way to quantify the exact differences between the risks of owning different kinds of assets, but for now, my Risk Exposure Index is constructed in the following way:

$$\text{R.E.I.} = 0.4(\% \text{Value\_of\_Stocks}) + 0.3(\% \text{Value\_of\_Farm/business}) + 0.2(\% \text{Value\_Real\_Estates}) + 0.099(\% \text{Value\_in\_Bonds/Insurance}) + 0.001(\% \text{MoneyChecking/saving\_accounts})$$

The percentage signs here show that the values of the assets are divided by the value of the total wealth. There are two different wealth summary variables in the PSID, I used the one called Wealth2, which includes the value of home equity (values of home minus the value of the all the

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<sup>1</sup> In the later part of this paper, where I calculated the Risk Exposure Index from the year 1999 to 2009, I also included the value of Annuities and IRAs as risky assets as this variable is available for these years.

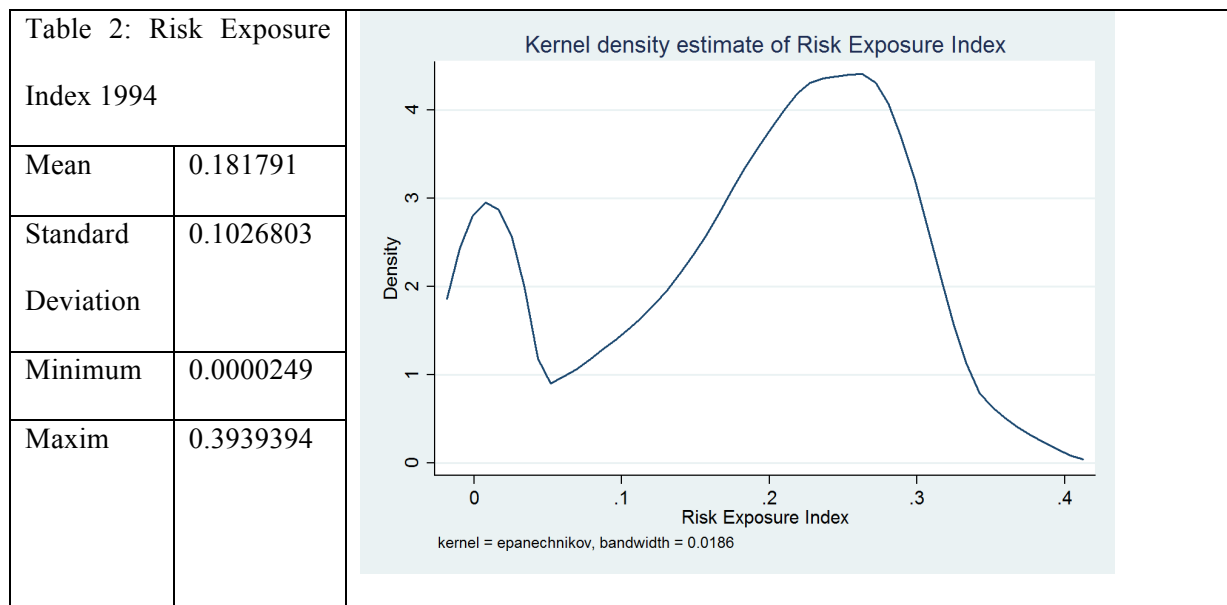
mortgages mentioned in the interviews.) The weights of each assets sum to one as I mentioned ( $0.4+0.3+0.2+0.099+0.001=1.$ )

By construction, the largest R.E.I. that a family can possibly has is 0.4, in which case all of their wealth are in the form of stocks and they are exposed to the highest degree of risk in my theory. The change of value of Farm or Business is more uncertain than real estates in my opinion because: to maintain a farm or business may involve large flows of cash on a regular basic, these may lead to big loss once revenues are not able to make up for the costs, and the revenues from a farm or business are sensitive to the market that they are aimed for as well as the general economical environment. On the other hand, although the value of a real estates are also affected by the outside market, they are still considered a good way to make long-term (and thus with stable returns) investments except in extreme circumstances like in the year of 2007. Therefore the portion of value in Farm and Business receives higher weight that that of value in Real Estate. Cash is generally considered very safe but holding cash a person still face the risk of inflation, so I assign a very small weight to them.

I first construct the Risk Exposure Index using data from 1994. I have dropped the cases when there is no wealth data or when the value of wealth or any of the assets are negative. Negative values of assets or wealth show that the family is already “in danger”, which is not the object that I am studying at – I am studying the “potential danger” that a family is facing. I also drop the small amount of cases where R.E.I. exceeds 0.4. As Wealth2 are the summary of assets that are net of debts, it is possible that R.E.I exceeds 0.4 with the given data. By dropping the cases when R.E.I is larger than 0.4, I am only considering the cases where there is no debt or the amount of debt is relatively small. However, we should still note that for cases with high Risk Exposure Index, they may not be hold a large portion of risky assets but face a large amount of

debts. In this sense, the Risk Exposure Index should still reflect their financial status well, although holding risky assets and facing debts may be affected by different factors. As I am going to compare the risk tolerance measure data in 1996, I also drop the cases that are not in presented in the year of 1996 in order to form a panel data. The total case count of my sample is 3018.

As seen in Table 2, the Risk Exposure Index that I constructed for the year 1994 has a mean of 0.181791. Looking at the Kernel density estimate of the Risk Exposure Index, we can see that although a large portion of the sample has a very small Risk Exposure Index (less than 0.05), a larger portion of them has a Risk Exposure Index around 0.3.



To look further in to the Risk Exposure Index, I estimated a multivariable regression on factors that are possible to affect the value of the index and the result is shown in the following table. For the next part of this paper, I will analyze the results generated from this regression.



<b>Table 3: Multiple Regression of the Logarithm of Risk Exposure Index 1994 on Possible Factors that May affect Risk Exposure</b>		
<b>Variable</b>	<b>Coefficient</b>	<b>Standard Deviation</b>
Age of Head	0.2880395	0.0219318
Squared Age of Head	-0.0025374	0.0002478
Head Wage Rate - 94	0.0041683	0.0022127
Wife Wage Rate - 94	0.0231734	0.0037107
Education - High School	-0.2269935	0.2663759
Education - College	-0.0730851	0.2693544
Education has Graduate	0.015926	0.2888333
Whether Head has Private Annuity	0.2324303	0.15321
Whether Head has Pension	-0.0340338	0.2413704
Whether has Other Pension	-0.4530821	1.004375
Whether Wife has Pension	0.1268458	0.5411738
Whether Head Annuity or IRA	0.2619747	0.4974352
Whether Cashed -In Pension	0.3865828	0.1912156
Money in Stocks (Adjusted)	0.008238	0.0035555
Risk Tolerance (RT)	0.0275419	0.0218785
Constance	-10.05082	0.5079408

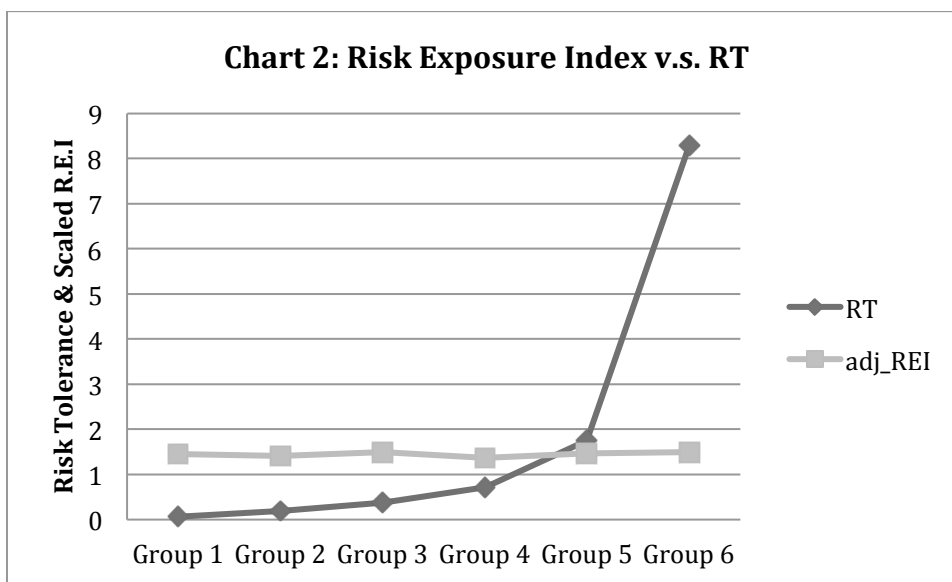
#### IV. Panel Study Results and Analysis 1994 – 1996

In this part, I will first compare the Risk Exposure Index that I constructed for 1994 and the risk tolerance measurement from 1996. I will then look into details of the factors that might affect the value of Risk Exposure Index as well as the group number and RT that each family have.

### 1. Risk Exposure Index and Risk Tolerance Measure

The result of the multiple regression shows that there is a positive relationship between Risk Exposure Index and Risk Tolerance. As Risk Exposure Index measures the objective risky position of a family while the Risk Tolerance reflex their attitude, it would be interesting to see the links between subjective opinions and objective positions. In order to do so, Chart 3 shows the relationship between RT and Risk Exposure Index of each group.

**Chart 3:** Risk Exposure Index v.s. RT



For RT, the result corresponds with the way I divided the groups – people in Group I have the smallest degree of risk tolerance while for people in Group 6, their Risk Tolerance value is very high. However, the change of Risk Exposure Index is not obvious across groups. So I then estimate a multiple regression of Risk Exposure Index on dummy variables indicating which group that the family is in. From the result we can see that, being in the groups with smaller group numbers has a negative effect on the mean Risk Exposure Index while being in the groups with larger group numbers has positive effect on the mean Risk Exposure index. The negative effect gets stronger as the group number gets smaller and the positive effect gets stronger as the

group numbers gets higher. This result is consistent with the relationship between Risk Exposure Index and Risk Tolerance as well as the relationship between Risk Tolerance and group number. This result shows that families with high tolerance with risk do expose themselves to more risk than families with lower risk tolerance.

**Table 4:** SLR of Risk Exposure Index on risk tolerance groups

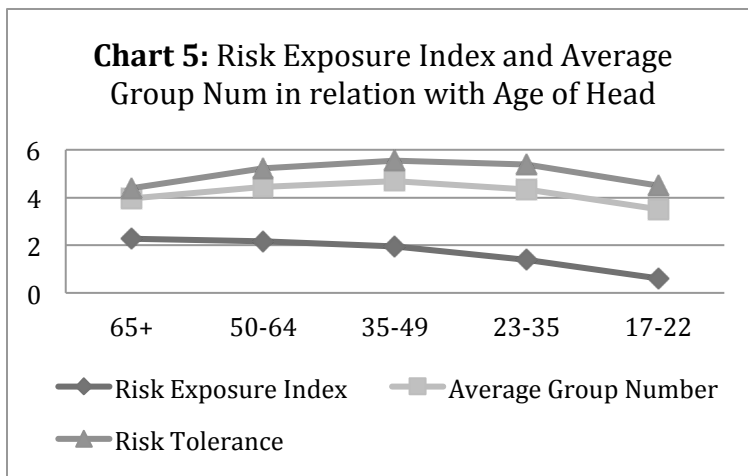
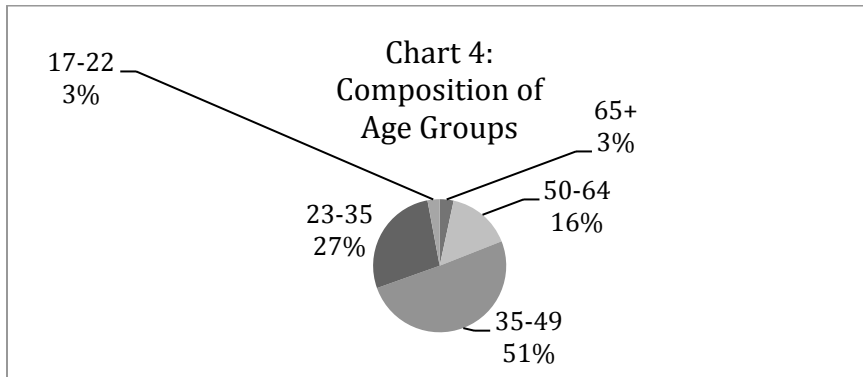
<b>Independent Variable</b>	<b>Coefficient</b>	<b>Standard Deviation</b>
Group2	-0.0053611	0.0053931
Group3	0.0049756	0.0057291
Group4	-0.0103106	0.0059797
Group5	0.0023661	0.0064671
Group6	0.0061238	0.0086346
Constance	0.1813633	0.0033043

## 2. Age of Head

I divided the data set into different groups according to the age of Heads of each family. The composition of each group is shown in the following pie chart. I divide the age groups in this way because – (1) the usual way of retirement is 65 years old in the United States. Sorting this group out would give us the chance to see how retirement impacts the risk exposure as well as risk tolerance of families. (2) The youngest head of the data set is 18 years old. People between 18 to 22 may either still at school or just enter the job markets, they should be representing a group with little wealth and income.

The theories about life cycle asset allocation argue that when people approach the age of retirement, they invest less in risky assets, although age is also strongly correlated with factors such as the time (older investors have less time to get the perceived returns from investment) and

cohort influences (the birth year of people may affect their earning or investing profiles) that may lead to these to this final result (Campbell and Viceira, 2002). To verify this explanation, I take the Age of Head as well as its squared term into the multiple linear regression that I conducted in part III. As the coefficient of the squared term is negative, indicating that the Risk Exposure Index would decrease after certain age. The result of my calculation shows that the age is about 113.52 ( $0.880395/0.0025374$ ), this is an odd number, but the result is at least consistent with the theory. Chart 5 shows the corresponding Risk Exposure Index and average group number of each age group. We can see a clear trend of decline in the average Risk Exposure Index, Risk Tolerance as well as the group number after the in groups after the age of 35-49. It seems that the life cycle asset allocation theory is shown through the changes in Risk Exposure Index and Risk Tolerance even without regressing through the square of age.



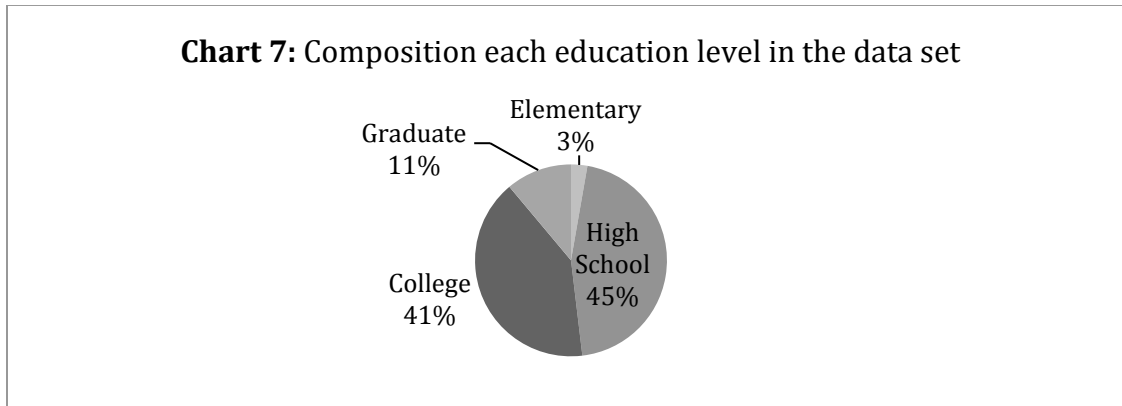
### 3. Income

The variables that I use to measure the income of Head and Wife are called “Head Wage Rate 1994” and “Wife Wage Rate 1994.” Both variables calculate the values of the total labor income of head or wife divided by the total working hours of the head or wife. Without the distraction of the differences in working hours, we are able to compare the income level of the head and wife of each family. As shown in the regression in part III, both the wage rate of the Head and the Wife as a positive effect on Risk Exposure Index, indicating that having more income may increase the possession of risky assets. One possible understanding for this result is to consider labor income as the value of human resources which is a non-tradable asset that can be considered to be part of the families’ portfolio, which, if not strongly correlated to the change in stocks market, is mostly riskless (Campbell and Viceira, 2002.) Hence, it is natural for families with higher labor income to invest more in risky assets. This also gives a preview of the result in the later part, in which I examine the relationship between education and risk exposure, that families with Heads that have higher education have higher Risk Exposure Index. The coefficient of the wage rate of Wife is much larger than that of the Head’s, an explanation to this is that there are 1249 out of 3018 cases in my data set where the Wife does not have income, so the effects of a one-dollar increase in Wife’s wage rate on Risk Exposure Index is more than that of the Head’s. This could be understood as that as the cases that wife has an income is relatively rare, their income, as a riskless asset to the family, provides more protection if asset return falls.

### 4. Education of Head

The variable that I used to evaluate the education of head is called “Completed Education – Head.” This variable records the highest grade that the head has completed, valued from 0

(representing taking no year in school) to 17 (representing “at least some gradate work.”) I drop the cases where the Head has no education at all (Variable value=0) and divide the data set into four sub groups – (a) Elementary (Variable value=1-8), (c) High School (9-12), (d) College (13-16) (e) Graduate Level (17) according to the years of education completed by the Head. Chart 7 shows the information of the composition of the subgroups.



The result of the multiple linear regression in part III shows that having higher education will increase Risk Exposure Index. This result is confirmed in chart 8, where I compare the Risk Exposure Index, Risk Tolerance and average group number across different educational groups. It is not difficult to understand that people with higher education may tolerance risk better. First, higher education often means higher value in human resources, and thus higher labor income. Secondly, people with higher education may have more cognitive skills in dealing with available information as well as uncertainties in the markets. They may also have more available funds to do the investment for the reason that they may have more income. I compared the average wage rate of head and average money in stocks for groups with different educational level and the results is shown in Chart 9. Money In Stock is the variable asking the amount of money invested in stocks during the past five years, I have rescaled this variable to only show the differences between groups to make it fit with the mean wage rate. As we may see from the chart, there is an

upward trend of wage rate of head with the increase of educational levels. Also, the difference in the amount of money invested in stocks is very significant across groups – the average amount invested by families with the Head who have post graduate studies is about 40 times higher than families with Heads who have only elementary education.

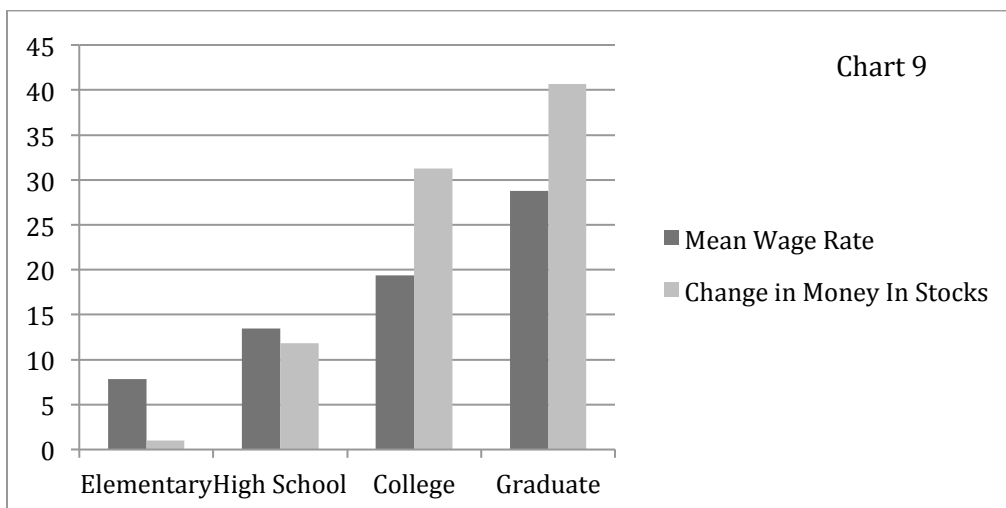
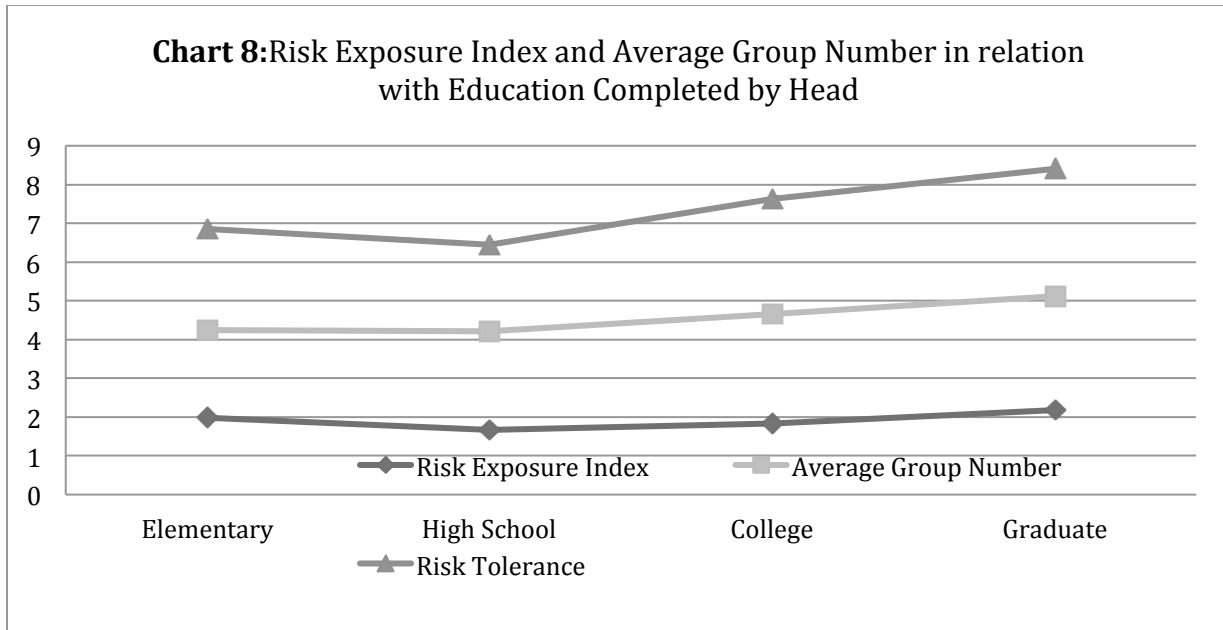


Table 5

<b>Head has Pension</b>	<b>Wife Has Pension</b>	<b>Obs.</b>	<b>REI</b>	<b>RT</b>	<b>Avg. Group Number</b>	<b>Avg. Money In Stocks</b>	<b>Age of Head</b>	<b>Age of Wife</b>
√	√	7	0.211	1.282	2.00	9358.611	59.4	38.6
√		102	0.221	0.368	1.97	8117.873	57.9	36.5
	√	18	0.202	1.403	3.18	20863.64	58.8	57.8
Otherwise		2898	0.179	0.903	2.72	1993.618	40.1	25.8

Table 6

<b>Case</b>	<b>Obs.</b>	<b>REI</b>	<b>RT</b>	<b>Avg. Group Number</b>	<b>Avg. Money In Stocks</b>	<b>Age of Head</b>	<b>Age of Wife</b>	<b>Edu catio n</b>	<b>Wage Rate</b>
Have Private Annuity, Annuity or IRA.	265	0.21	0.668	2.59	5577	45.0	30.4	14.6	21.40
Otherwise	2753	0.18	0.908	2.70	1960	40.4	26.0	13.2	17.08



## 5. Pension, Annuities and IRAs

PSID contains a series of data indicating whether or not the Head or Wife of the family have income from Pension, Annuities or IRAs. It also provides a detail distinction in which in of Pension, Annuities or IRAs that the Head or Wife holds. I have included some of these variables as independent variables for the multiple linear regression in part III as I consider Pension, Annuities and IRAs are ways to avoid risk and thus holding them may affect the Risk Exposure Index.

The results of the regression shows that if the Head has a pension, the family's Risk Exposure Index decreases, which is reasonable as having pension as another source of income will reduce that financial risk that the family is facing. The coefficient of the dummy variable of whether the Head has cashed in pension shows that there is a large percentage point increase in Risk Exposure Index if the Head has had done so. This is also explainable as most people usually do not cashed in their pension early unless they are facing financial hardships, which can be shown by the Risk Exposure Index. Having more than one kind of pension, on the other hand, will decrease the Risk Exposure Index significantly. Having a pension seems to also increase the investment activities of families. As shown in table 5, the average amount of money in stocks if any of the Head or Wife has pension is much larger than that of the rest of the cases. The average amount in stocks if only the Wife has a pension is especially large, which in my opinion, is the reason that the coefficient of whether the Wife has pension is positive. This seems consistent with the result that the coefficient of Wife's income is larger than the coefficient of the Head's income and it could be better understood if we take pension as an increase in income after retirement. As there are only 18 such cases in my sample, we may need more information to draw the conclusion of the effect of only the Wife has pension.

A possible explanation for why both the coefficients of whether have Private Annuity and whether have Annuity or IRAs are positive is shown in table 6. We can see that the Risk Tolerance of families that have any kind of Annuity or IRAs is lower than those who do not, this explains, in part, why they choose to hold Annuity or IRAs at the first place. We can also see that the average wage rate, education as well as money in stocks are higher in these cases. As the wage rate, education and money in stocks are all positively related to the Risk Exposure Index, for families that own Annuities or IRAs, even though they may be more risk averse than other families, they still expose themselves to more risk because of their more diversified sources of income, investment behavior and their education level.

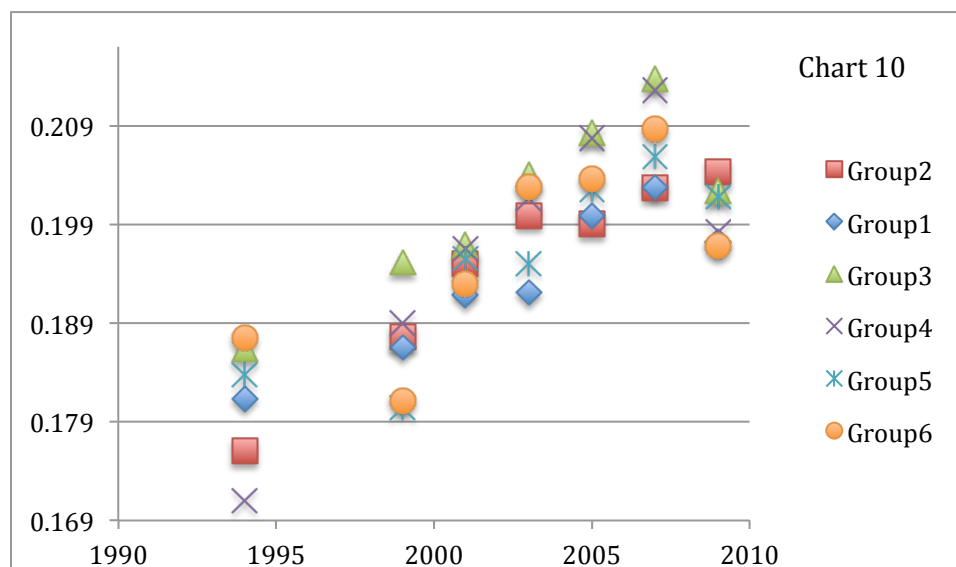
## 6. External Markets

The change of Risk Exposure Index is, to a large degree, subject to the change in stock market and the overall economic status. In this part, I look at the changes of Risk Exposure Index of each group through the year of 1994 to 2009. For each year included in this part (1994, 1999, 2001, 2003, 2005, 2007), which is also the year that has wealth summary data in PSID, I created a panel dataset with the year 1996 so that we can see how the Risk Exposure Index changes. As for these years, there are variables showing the value of Annuities and IRAs in the wealth summary data series, I also include the portion of Annuities and IRAs to the Risk Exposure Index and give them the same weight as bond and insurance. The results are shown in Chart 10. As a reference of the changes in stock market, I use the S&P 500 index of the corresponding years. I also use the GDP of the United States of the corresponding years as the reference of the overall economic status.

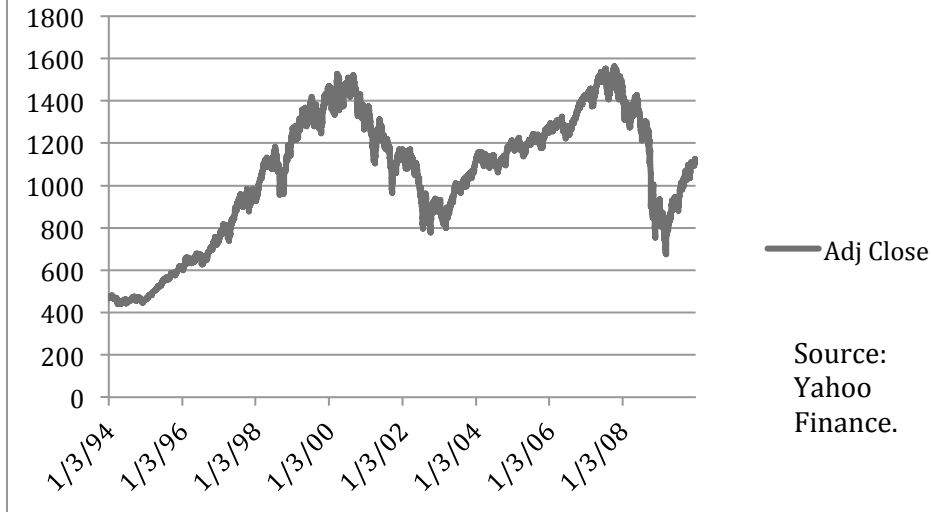
Holding other factors constant, if the value of the stocks that a family is increasing, its Risk Exposure Index should also increase. Comparing the peak of Risk Exposure Index at 2007

and the peak of S&P 500 index at 2007, the previous theory can be observed. S&P 500 index declined sharply after the year 2007 so did the Risk Exposure Index. Within the same year, we can also see that the Risk Exposure Index of groups with higher risk tolerance in 1996 (Group4, Group5 and Group6) is generally higher than the other groups. One mystery is that at the year 2001, when there is another peak in S&P 500 and the index decline thereafter, the overall trend in Risk Exposure Index is not as obvious except for Group5 and Group1. An explanation to this is that there must be other factors that affect the change in Risk Exposure Index over the years. Another explanation is that, as I am simply comparing the mean Risk Exposure Index of each group, some other changes over the years may be overlooked.

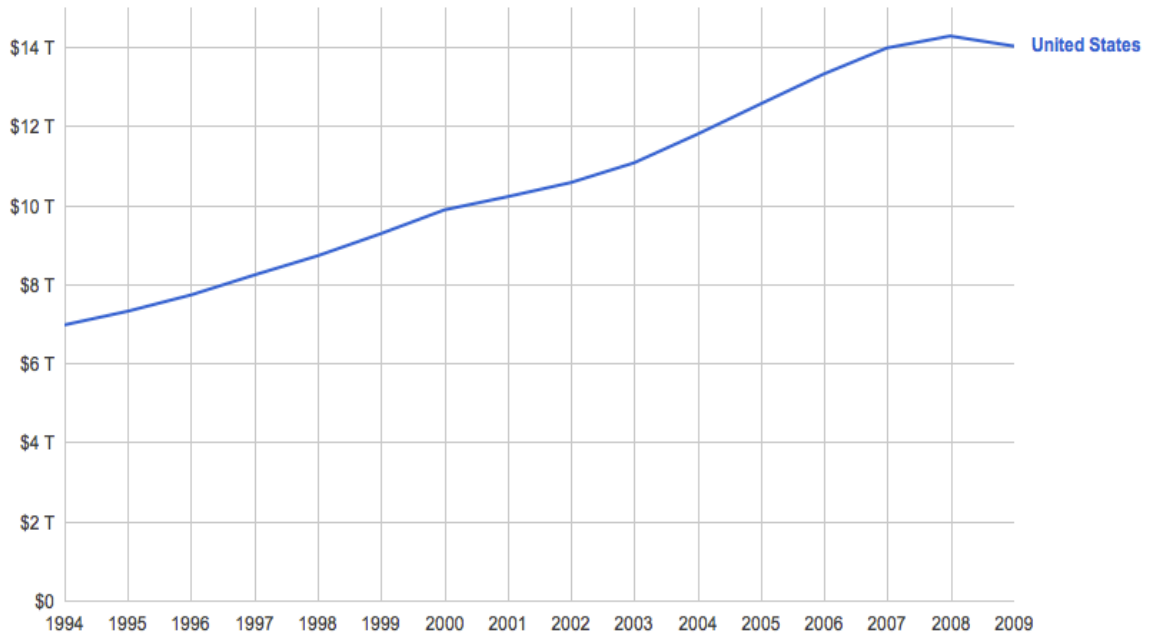
Another external factor that may affect the Risk Exposure Index is the overall economic status. If the economy is improving, people may have the confidence to invest more in risky assets, correspondingly, their Risk Exposure Index will rise. Comparing the GDP of the United States from 1994 to 2004 and the Risk Exposure Index of the same years, we can see very similar trends in these two variables – both the GDP and the Risk Exposure Index have been rising since 1994 and the increase stopped after the year 2007. It would be safe to say that the change in Risk Exposure Index reflects the change in GDP.



## S&P 500 1994-2009



GDP of the United States from 1994-2009  
Source - World Bank  
Table generated by Google  
Public data



### III. Conclusion

Age, income, education and investment behaviors such as having a pension, annuities or IRAs, affect the risk exposure index in different ways. My study here shows that having higher income and higher education will expose a family to a larger degree of risk, and families with higher income and higher education can tolerate risk subjectively as they may have more cognitive skills be better at using financial information and at facing uncertainties than other families. Having a pension will decrease the family's exposure to risk in a large magnitude, while the effect of holding annuities and IRAs are not as obvious. The changes in stock market as well as GDP seem also have positive effect on the changes in Risk Exposure Index, indicating that, to some degree, the exposure to risk is not entirely controlled by the subject, it may also be affected by the external economy status. My study also confirms the lifecycle asset allocation theory, showing that the exposure to risk and risk tolerance of a family all decrease after a certain age. Another surprising finding from my study is that, Risk Exposure Index and Risk Tolerance acts uniformly most of the time. If Risk Tolerance do carry the information about the Head's attitude towards risk that is instinctive, it seems that, at least in terms of facing risk, the behavior of the family conforms to their attitude.

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