Theories of Gold Price Movements: Common Wisdom or Myths?

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Abstract

This paper examines several of the explanations commonly provided regarding gold and its price movements. We consider the safe haven, inflation hedge, and dollar destruction hypotheses. The results are mixed. Our data do not support the theories that gold is a safe haven or an inflation hedge. We find that gold is a zero-beta asset and there is a strong negative correlation between gold and the value of the US dollar in the post Bretton-Woods era. The decomposition of gold prices under a semi-structural model find the aggregate demand shock, monetary policy shock and precautionary demand shock of gold all only have modest influence on the price movement of gold.

Keywords: Gold price; safe haven; inflation hedge; zero-beta asset; dollar destruction; inflation forecast; demand shocks

JEL Classifications: E37, E31, Q31, Q39

THEORIES OF GOLD PRICE MOVEMENTS

1. Introduction

Gold has a unique status in the economic world: a precious medal with wide uses, a store of wealth, and for a long time, the measure of economic power of nations and the cornerstone of international monetary regimes. In recent years, the world witnesses an aggressive growth in gold price. The role of gold in investment has drawn more attention since this transformational economic crisis began to unfold in 2008. This paper is another attempt to disentangle the price movement of gold after the Bretton-Woods system, the last international monetary regime based on gold. To what extents can we understand the price movement of gold? Can we find support for some popular opinions about gold on finance media? For instance: is gold a safe haven, a negative-beta asset, or an inflation hedge? How should we think about gold: a commodity or a currency? This paper provides some thoughts on these questions.

1.1 Gold and the Gold Standard

Returning to gold standard has never been seriously discussed for decades. After waves of gold reserves sales in the last fifteen years or so, gold is more and more seen as a common commodity. But history has a long shade in economic thinking and economic activities; one cannot fully understand the current status of gold and its price fluctuations while totally disregarding its history.

Gold has been used in rituals, decorations and jewelry for thousands of years. Its unusual chemical properties—high density, superb malleability and the imperishable shine—and its genuine rarity all contribute to it being the most coveted commodity in nearly every culture. But it is not until in the late nineteenth century when the gold standard formed that gold went onto the central stage of global economic life. In that half a century, on one hand there were huge supply shocks of gold as a result of the Gold Rushes; on the other hand there was soaring demand for a global monetary medium of high value to finance the rapid industrialization and the emerging international trade and banking. And the fact that Britain, the indisputable super power then, had adopted the gold standard and a series of historical incidents led all major economies save China signed up to gold by 1900.

The gold standard, under which gold coins and fiat money could be converted at banks freely at a pre-set official rate and nations settled balance differences in gold, has intrinsic deflationary pressure: the inelastic supply of gold always made the money supply insufficient in a growing economy with rising productivity (insufficient liquidity). To keep up with demand for money, monetary authorities developed the "gold-exchange standard": bank notes of major economies could also be treated as reserve assets. But the faith in the convertibility of foreign reserves (ultimately the commitment of monetary policy of reserve-currency countries) was always fragile. The huge global deflation after the collapse of foreign reserves under the interwar gold-exchange standard and the "neighbor thy beggar" policies largely caused the Great Depression.

After the Great Depression and WWII, a new international monetary system—Bretton-Woods system was founded. The implemented Bretton-Woods system[2]was a fix-exchange-rate gold-dollar standard regime. Under it, the U.S. monetary authority was immediately put into a dilemma: with the U.S. being the sole de-facto reserve-currency country, whichever policy the Fed implemented—expansionary or tight money, it would lead to either the erosion of confidence on the dollar or a deflationary pressure worldwide. Also, domestic policy goals, such as maintaining economic growth and low employment and the responsibility of reserve-currency

[2] The implemented Bretton-Woods system is pretty different from the designs. See the book "A Retrospective on the Bretton Woods System" for reference.

country—to stabilize the value of the dollar—were often conflicting. These problems worsened in 1960s with the increasing expenditure on social welfare programs and the war in Vietnam. Pressure from foreign governments and speculators on financial markets and U.S. government pushed Bretton-Woods System to an end in 1973.

Since 1973, gold could be publicly traded with little government intervention.[3] It is no longer directly linked to any nation's monetary policy or the value to any currency. The central banks continued to hold considerable amount of gold reserves for strategic or confidence reasons. There have been debates in academia on the better use of the former monetary gold.[4] Since 1990s, Bank of England, Swiss National Bank and central banks of Eastern Bloc countries have sold great amount of their gold reserves.

1.2 Gold Demand

Gold has both private demands and government demands. As previously discussed, in the gold-standard era, government demand is monetary gold. In post Bretton-Woods era, central banks still hold great amount of gold reserves as strategic assets ("war chest") but the government demands are not that active and influential as they were in gold-standard years.[5] Private demands can be further divided using different criteria. One division is investment (ETFs, bullions, bars etc.) and non-investment (jewelry, industrial and dental) demands. Another division is depletive uses (manufacturing and dentistry) and non-depletive uses (bullions, jewelry, ornamentation and hoarding etc.).

[3] This is only the case in the West. In all Communist countries, private possession and trading of gold bars or coins were prohibited. These policies ended in the Eastern Bloc countries and the former Soviet Union countries in early 1990s. But in countries like China or North Korea, the state still holds tight control over gold production and private possession of gold.
[4] For instance, see the paper "The benefits of expediting government gold sales" by Henderson and Salant et al.
[5] Most governments don't increase their holds for gold. Many countries began to their gold reserves. On the whole, government demands have been negative (in other words, net supply) for at least a decade. Only few countries, like Russia and China, are increasing their gold reserves in recent years.

What are the shares of different gold demands? We couldn't find any data for the gold-standard era. But there have been estimates that between half and two-thirds of the annual production went to private uses.[6] One snapshot of recent years' gold demand breakup came from 2007.[7] In that year, the gold reserves of central banks and international institutions (IMF, for instance, is a large holder of gold reserves) decreased by 504.8 tons, which meant a negative demand or a net supply. All newly mined gold went to private sector: More than two thirds of it (2398.7 out of 3558.3 tons) went to jewelry, the industrial and dental demands used up approximately 13% of the production. The remaining fed private investment needs. Geographically, India consumed 773.6 tons of gold, about 20% of the world's production; greater China region consumed 363.3 tons, ranking the second. In terms of "stock", a rough estimate is that the total above-ground stocks of gold are about 161,000 tons[8] now, 51% of which are in terms of jewelry. Official sectors hold nearly 30000 tons (18%), (private) investment 16%, and industrial 12%.

1.3 Gold Supply

Gold supply comes from mining, sales of gold reserves and "old gold scrap" (the recycling of gold). The gold mining went hand in hand with the geographical discovery of the earth by mankind. During the Gold Rushes years (from 1850 to 1900), about twice as much gold was mined as in previous history. The annual production of gold continued to increase dramatically in the twentieth century: from less than 500 tons per year in the 1900s all the way to more than 2000 tons per year in late 1980s. In the last fifteen years though, the annual mining

[6] The discussion is in Barsky and Summers (1988).
[7] The 2007 demand data is from World Gold Council website.
[8] Whether this figure means the amount of gold have been mined in all human history or only those that are available to this generation is unclear.

production fluctuated around 2500 tons,[9] which revealed the increasing difficulty of finding new deposits and mining and extraction in non-rich sites. Most of the gold left to be mined exists as traces buried in marginal areas of the globe, for instance, in the rain forests of Indonesia, the Andes and on the Tibetan plateau of China. Gold mining has been bringing environmental disasters in forms of mercury linkage, deforestation and waste rocks among others to Africa, Latin America and East and Southeast Asia. This have drawn more and more attention worldwide.

1.4 Gold Price Movements

We chose the perspective of testing some commonly-held or heatedly-debated opinions about the price of gold as a means to analyze its price movement. Several common-wisdom "theories" are considered:

Firstly, people claim that as gold remains the eternal symbol of wealth in people's minds, people will switch their investments to gold in ages of turbulence. Gold is the "safe haven" on the financial market. To test this hypothesis, we look into various "fear" measures: volatility in the stock market, consumer expectations of the future, and bond risk premiums (the difference in yield between Aaa and Baa bonds) and check the correlations of those and gold price movements. A somewhat related hypothesis—the negative-beta asset hypothesis ("gold goes up when everything else going down") is also tested.

Secondly, people marketing gold investment products will always describe gold as an "inflation hedge". A straightforward analysis is provided on the real gold price (level), the return of gold and expected and actual inflation to test this claim.

[9] The sources of data for the gold worksheet are the mineral statistics publications of the U.S. Bureau of Mines (USBM) and the U.S.Geological Survey (USGS)—Minerals Yearbook (MYB).

Instead of viewing gold as a special asset, we suggest the data suggest it is more reasonable that we view gold as another currency, whose value is a reflection of the value of U.S. dollar. We investigate extensively on the relationship between gold price and dollar and dollar-valued assets in section 5.

Some other less theoretical sayings are considered too, for example the effect of surging demands in India and China and the central bank gold reserve sales on the gold price.

The remainder of the paper is organized as follows. Section 2 describes the data used in this study. The next three parts discuss three hypotheses one by one: section 3 focuses on safe haven hypothesis and whether gold behaves as a negative beta asset, section 4 is on inflation hedge hypothesis, and section 5 investigates the relationship between gold price and U.S. dollar. Section 6 reports results from multiple linear regressions. A semi-structural VAR model is constructed and analyzed in section 7 before we conclude.

2. Data

Our data includes real gold price, various "fear" indicators, U.S. inflation rate, real long-term interest rate, indicators of real economic activity and the exchange rate. For gold price, we used the closing price on the last trading day for gold each month on the New York Mercantile Exchange. The data series ranges from January 1956 to October 2008 and is available on the Commodity Research Board (CRB) website. The figures are in 2008 dollars. Overall, gold prices appear to have been in a downward trend since the peak in the early 1980s but showed an impressive upward movement in recent five to ten years, as shown in Figure 1. A simple serial correlation test showed the monthly gold price is highly serial correlated. Figure 2 shows the trend of monthly gold returns, or month-to-month gold price changes. It is not serially correlated but quite noisy.

We considered three "fear" indicators for this study. The first one is the stock market volatility; in this case the squared monthly returns of the S&P 500 Index suggested by Cutler, Poterba and Summers (1988). The second is the University of Michigan Index of Consumer Expectations, which represents sentiment of the general public about the economy in the near future. Higher scores represent optimism and lower scores represent pessimism.[10] The index is by construction stable. The last one is a bond premium: the difference in yields between Moody rated Aaa and Baa seasoned corporate bond. This widening of the premium is an indicator of growing uneasiness on the market.

The actual inflation measure is just the monthly change of the Consumer Price Index (urban, all goods). The expected inflation measure comes from the University of Michigan/Reuters Survey of Consumers, in which they reported the median price change the consumers expected over the next twelve months.

We have two measures regarding the value of dollar. The first one is the exchange rate, to be specific, the Trade Weighted Exchange Index provided by St. Louis Fed. The index is de facto the exchange rate of U.S. dollar against a basket of currencies, which includes currencies from the Euro Area, Canada, Japan, United Kingdom, Switzerland, Australia, and Sweden. High values for the index mean a relatively strong dollar, and low values for the index mean a weak dollar. The second one is the value of dollar-backed assets, in this case the real ten-year Treasury bond rate.

We consider three macroeconomic activity measures: monthly return of the S&P 500

[10] This index is based on the relative scores (the percent giving favorable replies minus the percent giving unfavorable replies plus 100) of each of the five survey questions. Higher scores represent optimism and lower scores represent pessimism. The indices are monthly published by Reuters and Survey Research Center of University of Michigan.

Index, U.S. industrial production (detrended) and the cargo freight rate index used in Kilian (2007).

Our sample period is from January 1978 to December 2007. We used monthly data.[11]

3. Safe Haven Hypothesis & Gold as a Negative-Beta Asset

People often associate gold with the notion of a safe haven. We define safe haven assets to be assets that people would like to invest in when uncertainty and fear increases. These assets would preserve their values in times of turmoil or recession. So we investigate the overall relationship between return on gold and various fear measures mentioned above to testify this hypothesis. If this hypothesis is true, if people become more fearful in the markets, the price of gold should rise. The safe haven hypothesis is closely related to the negative-beta-asset hypothesis. We define negative-beta assets to be those whose returns are negatively correlated with macroeconomic performance, measured by monthly return of S&P 500, the dry cargo freight rate index introduced in Kilian (2007) and the U.S. industrial production in our study. First, we look at the “fear premium” side to the safe haven hypothesis.

3.1 Gold & Volatility

We started looking at the effect of volatility on the price of gold to test the safe haven hypothesis. Looking at Figure 3, a graph of the logged real price of gold and the constructed volatility measure, the safe haven effect is not evident. Many of the most salient moves in the graph either provide evidence that is contrary to the idea of gold being a safe haven, or provide no evidence at all. From 1978 to 1980, the price of gold rises from $611 to $1897 (in 2008

[11] The monthly available series include: US Industrial Production Index, U.S. CPI, Kilian Dry Cargo Freight Rate Index and University of Michigan Consumer Expectation Index. The Moody’s BAA and AAA seasoned corporate bond yields, Trade Weighted Exchange Index: Major Currencies, 10-year Treasury bond rate are averages of daily data.

dollars), while volatility falls from 37 to 33. The safe haven hypothesis does not require volatility is the only factor in gold price movements, and there is a lot of noise in the volatility data from month to month, but we would expect the overall mean of volatility to be elevated during a tripling of the gold price. Additionally, elevated levels of volatility such as 1998 to 2003 are accompanied by falling gold prices. One period where the fear premium seems to hold is from 1987-1988 where volatility is at its highest level ever in the sample period and the price of gold rises. The only caveat is the price of gold does not rise by as much as the fear premium hypothesis would lead us to expect.

Regressing monthly real gold price on the constructed volatility measure yields an R-squared of only .0001 and a p-value of the beta coefficient .424. So it is statistically insignificant. The coefficient on the volatility measure at .289 means a one percent rise in volatility leads to a monthly increase in the real gold price by 29 cents, which is economically insignificant. This confirms what the graph shows. Gold price and volatility are uncorrelated and changes in volatility do not seem to have any effect on the price of gold.

One reasonable interpretation of this phenomenon is that market participants do not interpret volatility in the market as risk and thus see no reason to buy gold. Evidence of this is in the technology sector boom in the late 1990s where volatility rose to much higher levels but the gold price declined. The volatility increase in this period was a result of equities rising by large amounts day after day. If investors were afraid of anything, it was that they would wake up late and miss an opportunity for a huge return.

Nonetheless, there are two spots in Figure 3 where volatility and gold prices move in tandem: 1987 and 2007, two periods of genuine stress in the markets. They suggest we look at alternative measures of fear to further investigate the fear premium hypothesis.

3.2 Gold & Consumer Expectation

Substituting the University of Michigan Index of Consumer Expectations (ICE) for the fear indicator leads to a similar result. For the "safe haven" hypothesis to hold here, gold should rise as the expected index falls. For comparison with the S&P 500 constructed volatility measure, ICE should be high when volatility is low. Graphically, the "safe haven" relationship looks stronger. During the 1990s as the expectations index was rising, the price of gold was falling, and then when ICE began to fall in 2000, gold began to rise. The same relationship held in the 1980 period with the large increase in the price of gold at the same time of a large decline in ICE.

Simple linear regressions showed that one percent increase in the expectations index leads to a decrease in monthly gold return by $23.90. The R-squared from this model is .006; not much of the variation in monthly gold return is explained by consumer expectations. The p-value of .1307 also makes the coefficient statistically insignificant. Nonetheless, the sign is consistent with the theory; if consumers have low expectations of the economy and are thus fearful of the future, the price of gold should rise.

We would expect consumer expectations to give an overall picture of longer term trends in the economy. This characteristic would make ICE less able to inform the return on gold prices for any given month. Using quarterly and bi-annually gold returns yields coefficients of -38.71 and -42.83, respectively. Both coefficients are statistically significant, and the R-squared increases as the frequency decreases. The interpretation is that declines in consumer confidence are more reliably indicative of increasing gold prices in the longer term.

3.3 Gold & Bond Premium

The bond premium we constructed is Moody's Aaa Corporate Yield subtracted from Moody's Baa Corporate Yield. In scarier times, Baa bonds are relatively more risky because lower rated companies become relatively more likely to default, thus investors require a greater premium over the Aaa yield. In 1982 and 1983, the bond premium is rises significantly while the gold price falls. In 1991, there is a spike in the bond premium (perhaps related to the Savings and Loan crisis and or the declaration of the Persian Gulf War) but no similar spike in the gold price. The same thing happens again from 1998 to around 2002 as the bond premium jumps while the price of gold falls or stagnates.

The safe heaven hypothesis fails here again: The regression result of a $7.13 decrease in the monthly gold return for a one percent rise in the bond premium is economically insignificant and the p-value of .35 makes it statistically insignificant. Moreover, the sign contradicts the hypothesis. As the bond premium rises, the gold price should also be rising as should gold returns. The theory of buying gold in hopes of high returns during hard times in the market is defeated. We next turn to gold and its relationship over time to the market in general.

3.4 Gold as a Negative Beta Asset

We then turn to the negative-beta asset hypothesis. First we look into S&P 500. In 1981, gold appears to peak with the S&P 500. In 1983, they appear to bottom out together. In 1984, they again appear to peak together. This co-movement appears roughly throughout the sample period with the exception of 1990-2003. These thirteen years are probably the foundation upon which the hypothesis that gold is a negative beta asset is based. The simple linear regression rejects the negative beta asset hypothesis. Regressing monthly gold return on the difference in the S&P 500 month to month yields a coefficient of .0221 with a p-value of .7382 (using the logarithm of the S&P 500 yields nearly identical results) and an R-squared of .0003. This means, not only does the S&P 500 explain less than 1% of the variation in monthly gold return, but we cannot reject the hypothesis that the coefficient for the S&P 500 is zero. McCown and

Zimmerman (2006) get the same result over a slightly different sample period of 1970 to 2003, stating that, "gold shows the characteristics of a zero-beta asset." Zero-beta in this instance means gold does not follow or counter the S&P 500 at all, instead, it is uncorrelated.

The second macroeconomic condition indicator is the index of U.S. Industrial Production. We regressed monthly gold returns on the difference in industrial production from one month to the next. The coefficient was -3.87 with a p-value of .4766. This is statistically insignificant and tells us the same thing as our analysis of gold and the S&P 500. Gold is not a negative beta asset. If anything, it is a zero-beta asset.

Our last measure of macroeconomic performance is more global. It is the index of dry cargo freight rate" constructed in Kilian (2007). Cargo freight rates are a particularly good indicator of economic activity because the supply of ships is very sticky. If there is a demand surge due to increased economic activity, it takes a long time for new ships to be built to accommodate the new demand. Thus, in the short to medium term, there are large increases in shipping rates. These large increases leave room on the way down for huge plunges. This sensitivity makes shipping rates a good indicator of exactly what is going on in the world markets at a given period in time. Our data comes in the form of percent changes from one month to the next and 1978-1982 do not look promising for the negative-beta hypothesis. The only really convincing negative-beta movement is around 1990 to 2001 where cargo freight rates spike for a little bit and the gold price bottoms. The regression of monthly gold returns on the cargo freight rate change yields a coefficient of .0818 and a p-value of .5533. Negative beta theory fails again. Figure 4 confirms gold is a zero-beta asset as the slope from the regression line for the scatter plot of monthly gold returns and cargo freight rate change is nearly zero.

4. Gold as an Inflation Hedge

Gold is also commonly believed to be a hedge against inflation. We define inflation as the general rise in the price level (rather than an increase in the money supply) and use changes in the Consumer Price Index as the measure of monthly inflation. To be a hedge against inflation as the idea is most commonly understood, gold would not only have to be uncorrelated with inflation, it would have to be negatively correlated.

In 1978, Roy Jastram, a professor of business at Berkeley, wrote a book titled *The Golden Constant* that says since the 1560 gold has held its purchasing power in England and the United States. The theory also claims commodity prices move towards the gold price rather than the other way around. This thinking is in line with inflation hedge theory: an investment in gold should at minimum retain its purchasing power by responding to rising inflation through increased returns. Stated differently, as the general price level is increasing, or the purchasing power of the dollar is decreasing, gold will increase in value thus counteracting an investor's loss in purchasing power. We expect gold prices to respond more to expected inflation rather than actual inflation, because it is the perception of future inflation risk that this hypothesis posits as the reason for fluctuations in the gold price. Our measure of expected inflation comes from the University of Michigan/Reuters Survey of Consumers. The survey reports the median price change expected over the next 12 months. A graph of expected inflation shows it to be somewhat sticky. When actual inflation is rising sharply as it did in the early 1980s, people were expecting it to come back down. When it falls sharply as it did in 1987 and 1998, people were expecting it to rise back to a more normal level.

If the price of gold responded to inflation alone, a graph of the real gold price would be a horizontal line. If gold prices responded to inflation among other things and a graph of the real gold price was an upward sloping line, we would assume its returns outpaced inflation as we would assume its returns trailed inflation if the line sloped downwards. A graph of nominal gold prices should slope upwards at or above the rate of inflation if gold were to be a hedge against inflation. All these examples are assuming the current United States environment of constant targeted inflation of two to three percent each year.

For our Consumer Price Index monthly data, the beginning of a period is the first day of the previous month and the end of the period is the first day of the current month. Because the gold price data is from the last day of the previous month to the last day of the current month, we do not have to use lagged variables to capture effects of inflation on gold.

4.1 Gold & Expected Inflation

At the first sight, there seems to be a close relationship between the gold price and expected inflation. The two variables nearly mirror each other, through the peaks of the early 1980s, to the decline in 1986, to the troughs in 2000. However this relationship is very crude. Looking closer, we can see that in 1983 inflation is dropping dramatically, but the gold price is rising. There are also numerous instances such as 1986, 1988, and 1998-2004 where either expected inflation or the gold price are making large moves but the other remains quite stable or behaves in a way contrary to what inflation hedge theory would suggest. McCown and Zimmerman (2006) find the same result for monthly returns, however, they do find when annual frequency (but not quarterly frequency) is used higher inflation is associated with higher gold returns.Regressing monthly gold returns on the logarithm of expected inflation yields a coefficient of 3.98 with a p-value of .5833. The simple linear model rejects the inflation hedge hypothesis.

4.2 Gold & Actual Inflation

When actual inflation is used as the independent variable, the coefficients are much smaller and are even more statistically insignificant. A graph of expected and actual inflation gives some insight as to why this is true. Actual inflation is much more volatile than expected inflation. People do not wildly change their expectations of future inflation but instead look to see what has happened both in the recent past and further back historically to inform their expectations. As stated earlier, expected inflation is sticky. Actual inflation, on the other hand, fluctuates a lot even when it is in a downward or upward trend. From 1985 to 1992, expected inflation rises a little bit gradually while actual inflation rises sharply, plateaus for a year, rises sharply again, only before dropping dramatically in 1992. These whiplashes are not as present in the expected inflation index and thus that model allows for a stronger relationship with gold returns.

5. Gold and the U.S. dollar: the Dollar Destruction Hypothesis

Connected to the idea of gold and inflation is the theory of gold responding to "dollar destruction." Inflation can also be defined as increases in the money supply. As the money supply increases while productivity and output remain the same, prices increase. This has occurred on numerous occasions as bad governments print large amounts of money and eventually send their countries into hyperinflation. The somewhat analogous story, as purported by defenders of this theory is that when, by decreasing interest rates, or running a budget deficit, the Federal Reserve or the government decreases the value of the dollar. They believe the best defense to the loss of purchasing power that comes about from these government and government-like actions is to buy gold. This is distinct from the inflation hedge theory because it involves not only loss in purchasing power due to the general rise in prices, but also to a loss in purchasing power in a global environment due changes in exchange rates that are unfavorable to dollar holders. We look at the issue from two angles: first, we investigate the relationship between gold and real interest rates, and second, we investigate the relationship between gold and exchange rates.

5.1 Gold & Real Interest Rates

The real interest rate hypothesis suggests that as real interest rates in the United States increase, investors should sell their gold and buy treasuries. There are multiple rationales for this behavior. First, if the return to a risk-free asset, or any asset for that matter increases, the demand for that asset should also increase, thus decreasing the funds available for purchases of gold. Another rationale is related to the value of the dollar. As the U.S. real interest rate increases, the demand for the dollar should increase as investors from around the world should be purchasing dollars to take advantage of treasuries that now carry a higher return. As they purchase dollars the value of the dollar should increase, thus decreasing the relative value of gold. If an ounce of gold is worth $50 today, and tomorrow the dollar is worth twice as much as a result in a surge in demand, that same ounce of gold should only be worth $25. However, following the same analogy, future gold investors should now expect a higher yield from gold as the required rate of return has risen as a result of a rise in the real interest rate. Thus, when real interest rates rise, we would expect a decrease in the gold price and a later rise in the gold return.

The real interest rate used here is the 10-Year Treasury bond rate minus the expected inflation number discussed earlier. The argument for using expected inflation here instead of actual inflation is similar to the earlier argument. According to the real interest rate hypothesis, the price of gold would be affected by future expectations of inflation, not old values. We can see in the early 1980s as gold performs two drops, the real interest rate has two peaks. From 1987 to around 2006, the relationship does not appear to be as strong but it still appears to be there. For our real interest rate monthly data, the beginning of a period is the first day of the previous month and the end of the period is the first day of the current month. Once again, because the gold price data is from the last day of the previous month to the last day of the current month, we do not have to use lagged variables to capture the relevant effect of the real interest rate on gold.

Regressing monthly gold returns on real interest rates yields a coefficient of -3.31 with a t-statistic of -2.89 and an R-squared of .022. This means a one point rise in the real interest rate is associated with a $3 decrease in the price of gold over a month. This is economically insignificant as a one point rise in interest rates is huge. Regressing monthly gold returns on real interest rates for the current period, previous period, two periods past, and three periods past results in two significant coefficients: the contemporaneous coefficient is -9.85 with a t-statistic of -1.92. This is the same sign as before and is what we expect, a drop in gold prices (we can assume a fall in monthly gold return for the current period is the same as an immediate drop in gold prices). The coefficient for three periods (months) in the past is 16.919 with a t-statistic of 3.312. Thus, increases in the real interest rate in the past lead to increases in the monthly gold return. It is worth noting the R-squared value increases to .057 from .022 for this model with three independent variables. A one point rise in real interest rates this month corresponds to a decrease in gold prices this month of $9.85, and an increase in gold prices three months from now of $16.92. This is what we were expecting. Once the real interest rate rises, monthly gold returns should rise as investors are now demanding a higher rate of return since the return on risk-free assets has risen.

5.2 Gold and the Dollar Exchange Rate

Figure 6 shows the logarithm of the real gold price and the value of the dollar. To some degree it resembles the gold and real interest rate graph only it is much smoother. Throughout the entire period (although less so from 1990 to 1997) the gold price and the dollar exhibit an inverse relationship. For example, from 1978 to 1982, the dollar falls and gold rises, from 1982 to 1987, the dollar rises and gold falls. Peaks seem to match up very closely with troughs, and even smaller dollar movements such as those that occurred in 1982-1983 are matched inversely by gold price movements. This graphical analysis suggests gold has a very strong relationship with the value of the dollar.

The simple linear regression confirms this. We used the difference in the dollar value from one month to the next as the independent variable. The coefficient is -7.4. It has a t-statistic of -4.71 and an R-squared of .057. A rise of one unit (because the index oscillates around a base value of 100 this is approximately a one percent rise) in the value of the dollar decreases the real price of gold by $7.40. Put it into the current price level of gold, which is about 800 dollars per Trojan ounce, this amount is approximately one percent, which can be considered economically significant.

A graph of real interest rates and the dollar shows the relationship discussed above. They move pretty well together with real interest rates being a slight lead. However, in 1997, the relationship breaks when the value of the dollar increases significantly. The cause of this decoupling of dollar value to real interest rates was the Asian financial crisis in 1997 after the Thai government could not defend the baht and maintain its peg to the dollar. As Asian currencies crashed, the relative value of the dollar increased thus resulting in the mountain top shown in the graph. As of about 2006, the real interest rate and dollar relationship seems to have been restored.

5.3 Gold as a Currency

To summarize, the dollar destruction hypothesis stands. Gold has unique features in comparison to other commodities. From its physical properties, gold is largely unproductive except in minor mechanical manufacturing and dentistry. One main demand of gold is in jewelry, which largely will be passed down from generation to generation. It is so durable to the point that gold mined each year adds (2,000 to 3,000 tons) very little to the existing stockpile (approximately 150,000 tons). Furthermore, from the little gold demand data available (from the World Gold Council), gold demand, and no sector of gold demand (jewelry, investment & ETF, etc) appear to have any effect on gold prices. Preliminary research shows all coefficients to be statistically insignificant for the short sample period for which data is available, 2001-2008.

Perhaps more important, gold has played a role as universal means of exchange through most of human history. Thus, it makes sense to think of gold as another currency. Along this line of thinking, gold value is simply relative to other currencies, and thus the gold price in real dollars should have an inverse relationship to the value of the dollar. Because high real interest rates increase the value of a currency, high interest rates should also in the shortest term have an inverse relationship with gold (and in the longer term increase gold monthly returns) and this is what we find.

To further examine the idea of gold being more of a currency than a commodity, we regressed gold returns on the CRB index (differenced) and stored the residuals. We then regressed these residuals on the one-period lagged residual (to correct for serial correlation) and also the same factors mentioned earlier in the paper to see if the effects of interest rates, industrial production, inflation, and so on, were influencing commodities in general or were specific to gold prices. If coefficients showed up with significant relationships to the residuals, then we could conclude there is some component of gold price movement that cannot be captured by the general movement of commodities. The results are reported in Table 2 below. The first column of numbers shows the coefficients for many simple linear regressions, and the next column shows the coefficients for a single multiple linear regression.

The coefficients do not mean much, but the significance for the multiple linear regression is close to our previous results. The dollar appears to have an effect on gold prices that is outside its effect on commodities in general. This would suggest gold is more of a currency than other commodities. In multiple linear models, consumer expectation is also significant. In our previous results, it was nearly significant, so this is not a real clash. The only real change is that real interest rates no longer show up as significant and the p-value of .34 is quite large. It is possible inflation expectations are taking away from some of this relationship as discussed before, or it may just be that real interest rates affects gold in the same way as they do other commodities. They are all assets after all which must earn some rate of return.

The simple linear regressions in Table 2 all show up with statistically significant coefficients (with the exception of volatility), so there is not much to infer here other than individually, the relationship between these factors and gold prices is not fully accounted for in general commodity price movement.

6. Multiple Linear Regression Models

We now do several multiple linear regressions to see the *ceteris paribus* effects of the above-mentioned factors. Model 1 incorporates all the independent variables from the simple linear regressions earlier. The results are shown in Table 1. The coefficients of independent variables in Model 1 are similar to those in the simple linear regressions, showing the correlations between independent variables are not large. Model 3 is slightly more restrictive, limiting the regression to only the best fear indicator, inflation indicator, and market indicator as defined by highest significance from the simple linear regression. All of the independent variables from the dollar destruction section are included. The results once again remain unchanged except for slight changes in the magnitudes of the coefficients. None of these multiple linear regression models are particularly interesting however, prompted by McCown and Zimmerman's (2006) finding that inflation is not a factor in the short term but in the long term, we applied our same models to annual frequency. The results shown in Table 1 are different. Tables 1 also compares Model 2 for monthly and annual frequencies, along with Model 3 for monthly and annual frequencies.

Previous research says inflation becomes significant over longer periods of time. To explain this, we can consider how we think about gold. When gold demand is broken down, only 15% is investment demand, the rest is jewelry consumption, industrial and dental[12] . If we think about gold as a good or production input, rather than money, it is not far fetched to assume its price over time should rise along with the general rise in prices. The Consumer Price Index is derived the change in prices of a basket of goods, maybe computers, refrigerators, bread. If you throw gold into that list, it should rise along with everything else over longer frequencies. Nonetheless, in shorter time frames, the 15% of gold demand that is investment is moving the price all over the place as it considers factors such as the value of the dollar and real interest rates.

To explain the insignificance of expected inflation (which is counter-intuitive by earlier analysis), we need to think about inflation, real interest rates, and the value of the dollar together.

[12] More on http://www.research.gold.org/supply_demand/.

As we have said earlier, they are intertwined. Regressing the difference in the dollar value on real interest rates yields a coefficient of 1.06 with a p-value of .0571 and an R-squared of .12. Regressing the difference in real interest rates from one period to the next on the logarithm on inflation yields a coefficient of 1.22 with a p-value of .008 and R-squared on .224. If inflation is perceived to be increasing, people can reasonably understand interest rates will rise. If real interest rates rise, it can be believed the value of the dollar will increase. Both increases in real interest rates and increases in the value of the dollar lead to drops in the gold price. Although a higher interest rate may lead to higher gold returns in the future, this multiple linear regression is contemporaneous and thus does not capture this effect. Instead, we probably get a lower coefficient on expected inflation due to people anticipating the effects such inflation will have on real interest rates and eventually the dollar.

7. A Semi-Structural VAR Model

In the previous section, we showed very roughly the correlation between macroeconomic factors of interest. The above-mentioned multiple linear regression models are not proper for investigating the responses of gold price to changes in those macroeconomic aggregates and vice versa as there is consensus among economists that the price of gold is endogenous. Nevertheless, we are interested in which factors drove up the real price of gold and their relative contribution in different times of history. In order to do so, we perform impulse response functions, variance decomposition (VDC) and historical decomposition (HDC) of the real price of gold using a semi-structural vector auto-regression (VAR) model.

7.1. Methodology

VAR allows us to examine the dynamics between variables in the models with the presence of movements of other variables. The power of a structural VAR is that it can give us mutually independent shocks (structural shocks) which enable us to track how the cumulative effect of one given shock alone on the price of gold. Also, we can identify the contribution of one shock in the price movement of gold at given points in history. We first estimate the reduced form VAR using the least squares method. Then, we orthogonalize the reduced-form errors in VAR using Cholesky decomposition to get the structural errors. By orthogonalization we actually assume a particular recursive relationship, which must be an economically sensible framework. We will defend the structure and assumptions of the model below. For the purpose of this study, we use a semi-structural VAR model because we cannot specify all the structural shocks under the recursive structure. For instance, it is impossible to set apart the influence of real exchange rate *per se* on real price of gold as we know the real exchange rate is endogenous, therefore, any thought of "exchange market shock" cannot be structural.

Given the fitted structural VAR model, we can readily obtain the impulse responses of the return of gold to the specified structural shocks. Furthermore, we can compare the contributions of different structural shocks to variability of return of gold, as measured by the prediction mean squared error. It is meaningful to point out that this kind of forecasting variance decomposition (VDC) is retrospective conclusion; it can only depict the average of a certain sample period. Alternatively, based on impulse response functions, we could put ourselves into certain points in history and computer the cumulative influence of certain structural shocks on return of gold until that time. This is historical decomposition (VDC).

7.2. A semi-structural VAR model

My semi-structural VAR model consists of five monthly series: $y_t = (rea_t, \pi_t, r_t^{ante}, e_t^r, P_t^{rg})$, where rea_t is the dry cargo freight rate index mentioned earlier, π_t refers to U.S. inflation measured by percentage change of CPI from 12 months ago, r_t^{ante} denotes the expected (ex ante) real long-term interest rate we discussed earlier, e_t^r defers to the real exchange rate between U.S. dollar and a basket of major currencies, for which we use "Price-adjusted Trade Weighted Exchange Index" constructed by Federal Reserve Board, and lastly, P_t^{rg} is the real price of gold (logged). The sample period is January 1973 to December 2007. In estimating the model, I allow lags of up to two years (24 lags, as our data is monthly).

7.3. Identifying Assumptions

The reduced-form VAR is:

$$y_t = \alpha + \sum_{i=1}^{24} A_i y_{t-i} + \varepsilon_t$$

The structural VAR model is:

$$B_0 y_t = \alpha' + \sum_{i=1}^{24} B_i y_{t-i} + u_t \ ,$$

where u_t is mutually uncorrelated.

By some algebra, we can show that $\alpha = B_0^{-1}\alpha', A_i = B_0^{-1}B_i$ and $\varepsilon_t = B_0^{-1}u_t$. It follows that we can use Cholesky decomposition to transform the variance-covariance matrix of the reduced-form errors $\sum \varepsilon_t$ into that of structural error $\sum u_t$. Specifically,

$$\varepsilon_t = \begin{bmatrix} \varepsilon_t^{rea} \\ \varepsilon_t^{\pi} \\ \varepsilon_t^{r(ante)} \\ \varepsilon_t^{exchange} \\ \varepsilon_t^{rgp} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 \\ a_{41} & a_{42} & a_{52} & a_{44} & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} \bullet \begin{bmatrix} u_t^1 \\ u_t^2 \\ u_t^3 \\ u_t^4 \\ u_t^5 \end{bmatrix}$$

We can name a few of the orthogonalized shocks, namely, u_t^1, u_t^3 and u_t^5. u_t^1, which is only related to the change of US industrial production, is referred to as the aggregate demand shock for industrial commodities (aggregate demand shock for short). As commonly postulated, the Federal Reserve bases their targeted interest rate on real economic activity and inflation. u_t^3 is likely represents monetary policy shocks that affect the *ex ante* real long-term interest rate (10-year Treasury bond in this case). u_t^5 reflects innovations other than aggregate demand shocks, monetary policy shocks and some other unspecified shocks underlying inflation and exchange rate that can affect the real gold returns. Presumably it could contain many components. But as I will argue below, the behavior and timing of the estimated shocks were consistent with what the safe haven hypothesis would have predicted. So we name this to be “gold-specific demand shock”. By the above specification, we impose the following assumptions:

First, we assume that fluctuations in real economic activity, for which the cargo freight rate index is a proxy, can affect inflation, exchange rate, ex ante real interest rate and the return of gold in the same month, but not vice versa. This is very reasonable as manufacturing production tends to behave sticky or sluggish.

Second, we hypothesize that the monetary policy shock and the “residual” structural shock influencing the exchange rate and the gold-specific demand shock will not affect inflation, at least not in the same month. The empirical evidence for this is vague, so we believe that it is acceptable to add this assumption in constructing the model.

Third, we impose the restriction that the gold-specific demand shock and the underlying but unspecified structural shock on exchange rate won't affect the ex ante real interest rate at least in the same month. How the exchange rate and the Fed-monitored T-bond rate interact empirically is an intriguing issue. So this assumption is debatable, but nevertheless, one can hardly rule out this assumption as being one reasonable alternative. Also, we exclude the possibility that gold-specific demand shock can affect exchange rate of US dollar against major currencies, which is not a big matter to our topic.

Lastly, we implicitly postulate that there is no gold supply shock in our model. The rationale for this is that gold is an extremely durable asset. The amount of newly-extracted gold each year is negligible comparing to the stock of gold worldwide, and therefore will hardly affect the price. But we fully understand that this assumption is somewhat presumptuous in the sense that the price of gold is determined mainly by the amount of gold on open market. The change in central bank gold reserves is potentially a huge influence on gold price. But to get an accurate measure and timing of these actions is not easy. There is little research looking into this field, we will try to take this factor into account in our future drafts of this paper.

7.4.1. How Gold Returns Respond to the Specified Shocks

Figure 7 plots the impulse responses of real price of gold to unit structural shocks. Figure 8 plots the cumulative impulse responses of real price of gold to unit structural shocks.

An unexpected aggregate demand expansion of industrial commodities, which often associates with global economic expansion, will cause gold returns to fluctuate in the first twenty months; mostly it will drag it downwards. After twenty months, the expansion will lift gold returns, but very modestly. From the cumulative graph, we can see an aggregate demand shock will lower gold returns. This pattern seems to verify the story of negative beta asset, which claims the movement of gold price is in the opposite direction to most other commodities. But notice the magnitude of the effect is not very noticeable, even in the starting months. Without the bootstrap confidence intervals, we can not judge whether it contradicts the zero-beta asset conclusion stated earlier.

An unanticipated monetary expansion will have a similar effect on gold returns as the aggregate demand shock does: it will modestly disturb gold returns. The effect will diminish after about twenty months. Cumulatively, a positive monetary policy shock (loosening the money supply) will lower gold returns, which is consistent with the economic theory such as Capital Asset Pricing Model: the monetary expansion will lower the return of Treasury securities. In equilibrium, gold should also have lower returns, but in the short-term, there is an expected substitution effect, driving gold returns up and down. Again, the monetary policy shocks are of a very modest magnitude.

The gold-specific demand shock will have an immediate significant positive effect on gold returns, but that effect diminishes very quickly, within two or three months. This resembles the sensitive and ever-changing sentiment in the financial market and its effect on gold returns. The historical decomposition will give additional evidence that this shock is likely to be the precautionary demand shock.

7.4.2. Contribution of Each Shock to the Variability of Return of Gold

As shown in Table 3, the variability of return of gold is overwhelmingly determined by the unspecified shock relating to exchange rate. In the first ten phases, that unspecified shock accounts for over 90% of the variation. The aggregate demand shock, monetary policy shock and gold-specific demand shock each contribute 3% or so. As forecasting steps increase, the aggregate demand shock plays a bigger role. If we use 200 as a proxy for infinity, u_4^t still contributes over 62% of the variation. The share of the aggregate demand shock is nearly 21%, the monetary policy shock, 3.5%, the gold-specific demand shock, 4%. This variance decomposition (VDC) table (Table 3) verifies the concurrent correlations we observed in the in simple linear regressions: the fear premium and aggregate demand can explain little of the movement of real gold price.

7.4.3. The Cumulative Effect of the Specified Shocks on the Return of Gold

Figure 9 is the historical decomposition of return of real gold. The figure shows that the specified structural shocks could not explain the average movement of real gold price at monthly level that well. There is some evidence that the spikes of real gold price in 1980 are only related to gold-specific demand shock, raising the possibility that the gold-specific demand shock is the “fear” precautionary demand shock. The spike in 1983 can be tracked to both gold-specific demand shock and aggregate demand shock. The downward trending real gold price in 1990s is mostly related to aggregate demand shocks among the three. And the recent boom in gold price since 2005 until the outbreak of the recent recession is related to both aggregate demand and gold-specific demand.

8. Conclusion

This paper reexamines several commonly-held opinions about gold price movements. We consider safe haven, inflation hedge, and dollar destruction hypotheses. The safe haven hypothesis claims that gold returns will increase as fear increases. We use three alternative measures of fear: volatility in the S&P 500 Index, the consumer expectation in Michigan Survey of Consumers and Moody’s Baa and Aaa bond premium. Gold returns do not have significant correlation with any of these measures. Related to safe haven hypothesis is the idea of gold being a negative-beta asset. We tested this hypothesis with S&P 500 returns, U.S. Industrial Production and Kilian's Dry Cargo Index and rejected it in favor of the zero-beta asset alternative. The inflation hedge hypothesis postulates the negative correlation between expected inflation and the return of gold. Our analysis disproves that hypothesis for shorter term frequencies. We find a very significant relationship between the price movement of gold, real interest rates and the exchange rate, suggesting a close relationship between gold and the value of U.S. dollar. The multiple linear regressions verify these findings.

The decomposition of gold price under a semi-structural VAR model shows that aggregate demand shocks, monetary demand shocks, and precautionary demand shocks have only a modest influence on the price of gold. The unspecified structural shock underlying exchange rates is the driving force of the gold price.

The central message of the paper is that gold's relationships with fear and inflation are not what most people believe. We should not regard gold as a mysterious asset that is immune to fluctuations and behaves uniquely on the market. Rather, we should regard it as another currency, whose value is a reflection of the value of the U.S. dollar and U.S. monetary policy.

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Figures and tables:

Figure 1: Real Gold Price 1978-2008

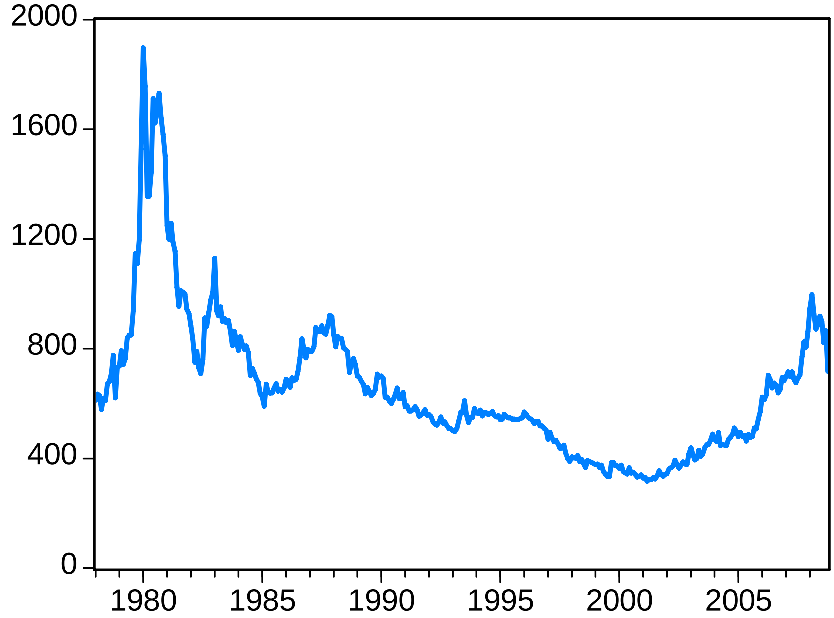

Figure 2: Monthly Gold Returns 1978-2008

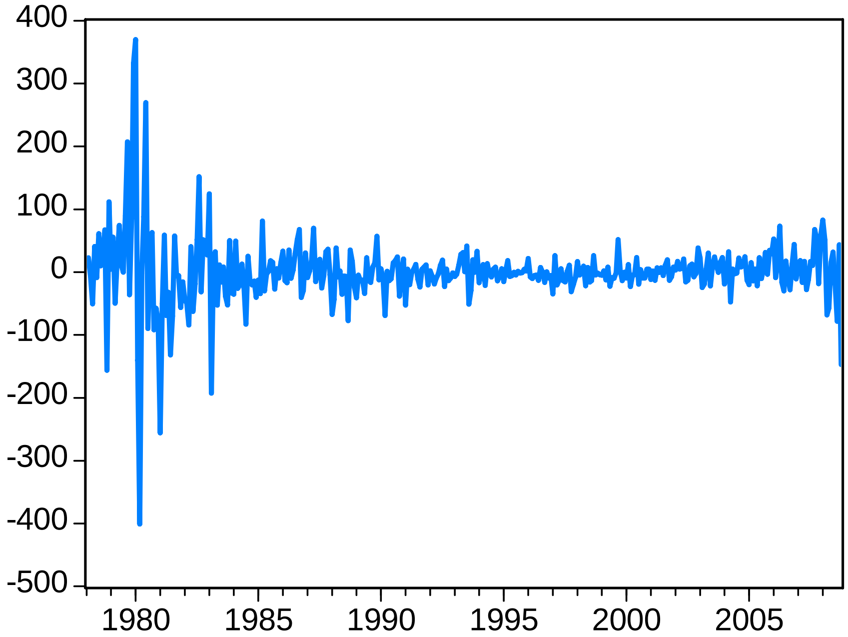

Figure 3: Gold & Volatility

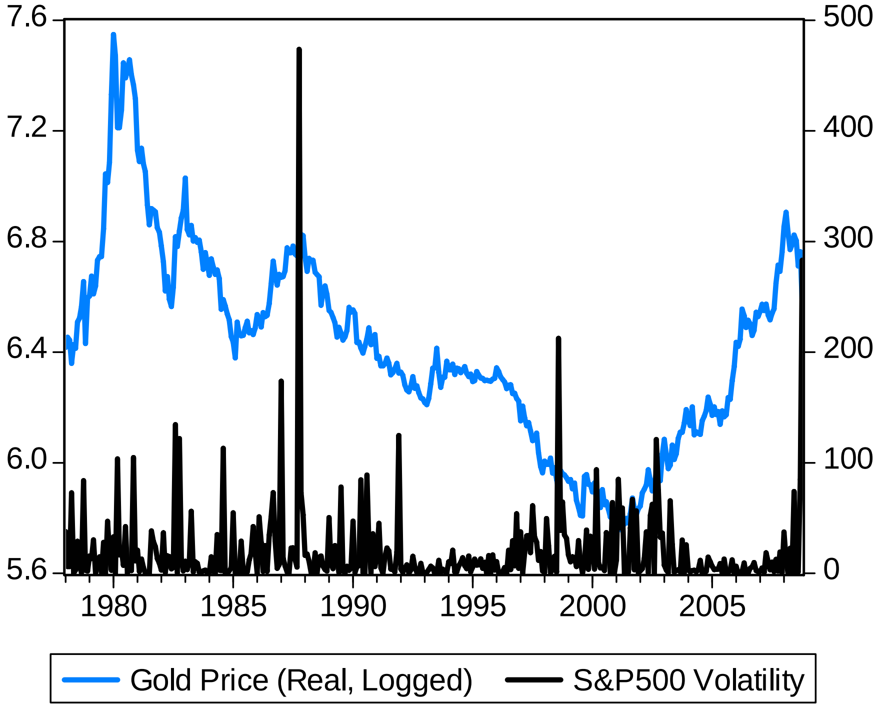

Figure 4: Zero-Beta Asset

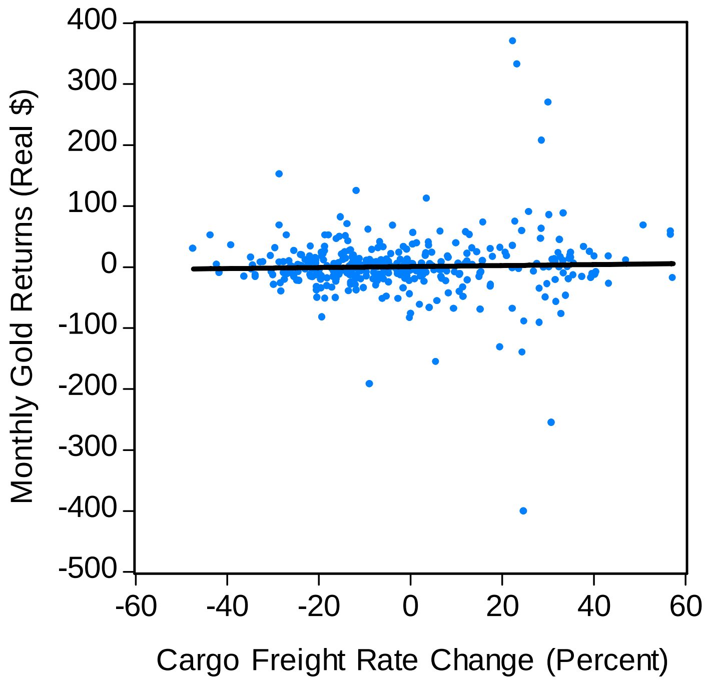

Figure 5: Gold & Real Interest Rates

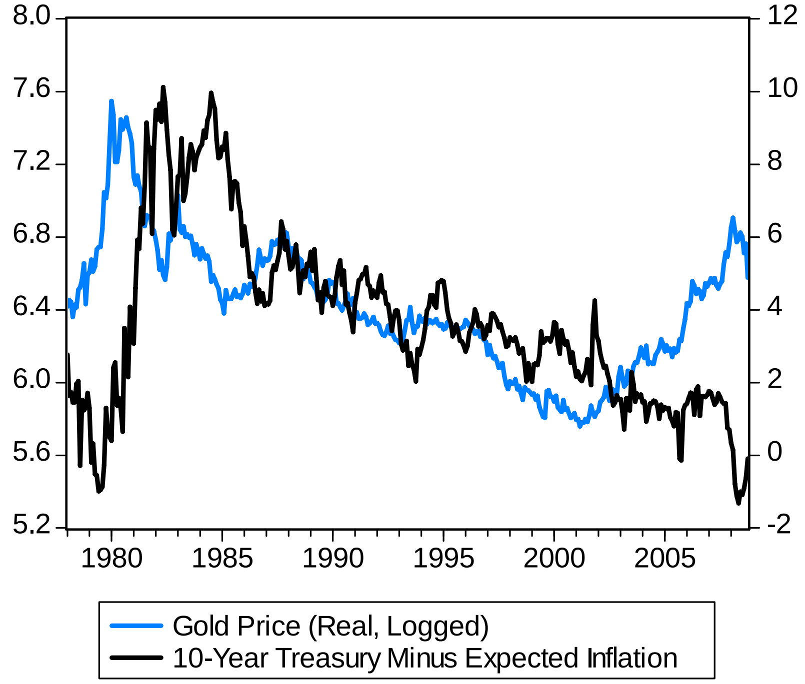

Figure 6: Gold & The Dollar

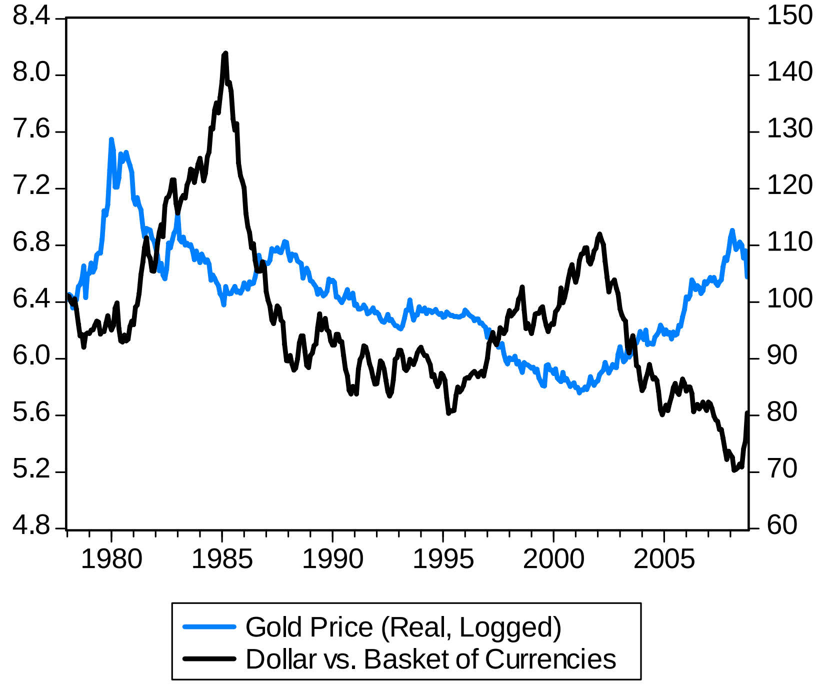

Figure 7

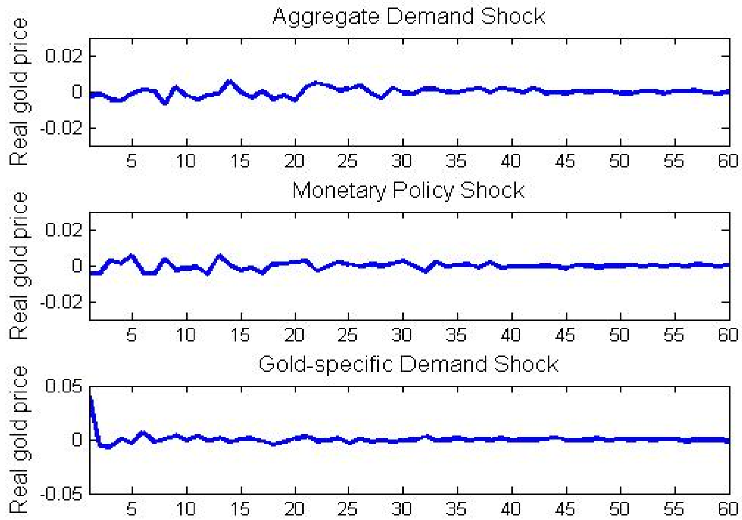

Figure 8

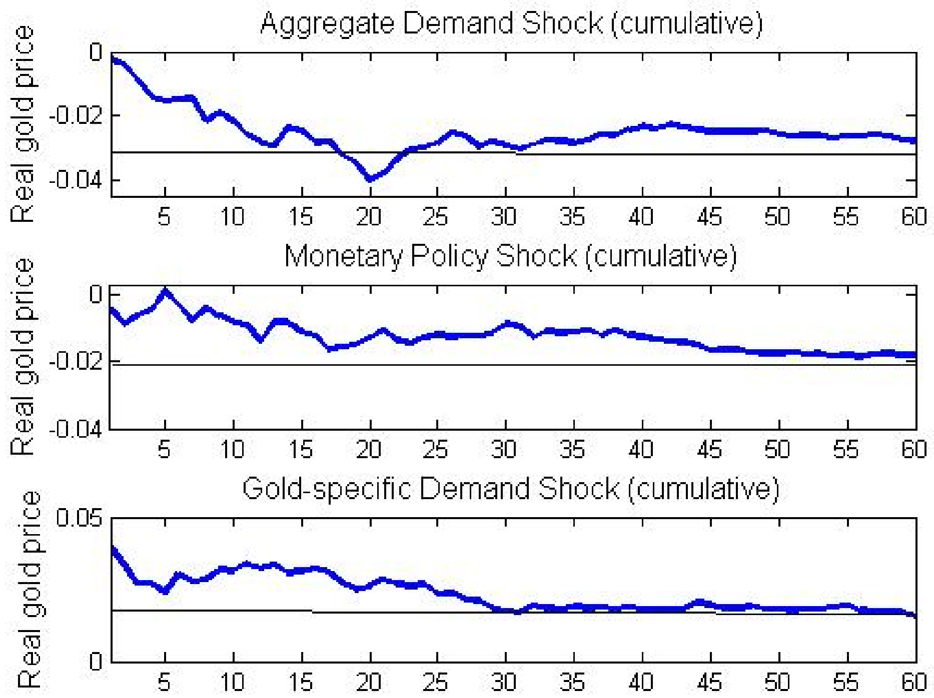

Figure 9

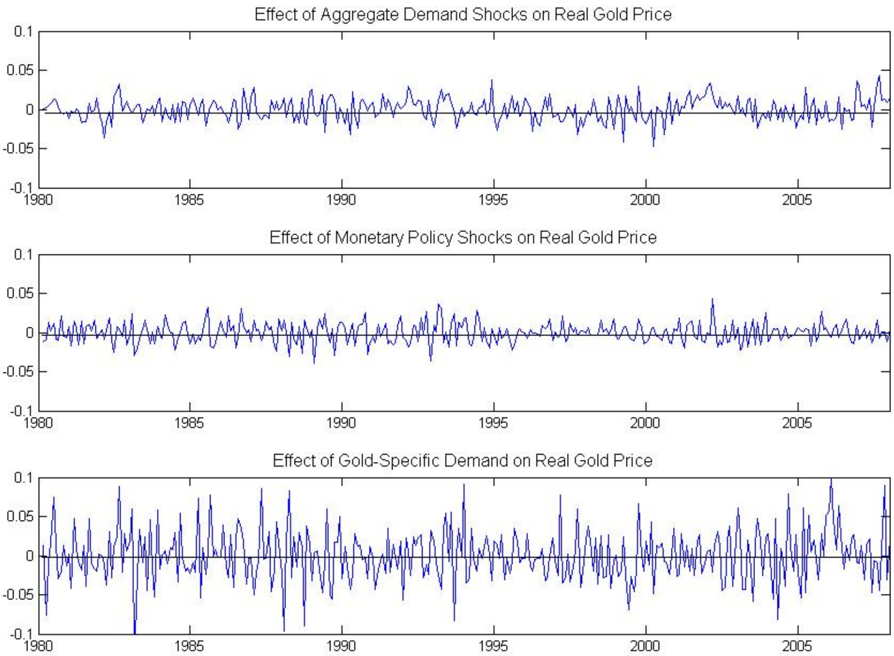
Effect of Aggregate Demand Shocks on Real Gold Price
0.1
0.05
0
-0.05
-0.1
1980
1985
1990
1995
2000
2005
Effect of Monetary Policy Shocks on Real Gold Price
0.1
0.05
0
-0.05
-0.1
1980
1985
1990
1995
2000
2005
Effect of Gold-Specific Demand on Real Gold Price
0.1
0.05
0
-0.05
-0.1
1980
1985
1990
1995
2000
2005

Table 1 Multiple Linear Regressions

	Model 1		Model 2		Model 3	
	Monthly	Annual	Monthly	Annual	Monthly	Annual
Volatility	-0.01	.14	.00	.11	-	-
Consumer Expectations	-.21	-.67	-.18	-.42	-.20	-.16
`Bond Premium	6.81	19.48	3.05	-.08	-	-
`Inflation Expectation	-2.58	-9.04	.50	.79	-.43	2.87
Real Interest Rate	-4.43**	-6.92**	--3.27**	-3.21	-3.01**	-2.52*
~Dollar Value	-5.98**	0.00	-6.07**	-.25	-6.21**	-.45
S&P 500	0.80	3.14	.71	4.58	-	-
~Industrial Production	.52	1.36	.64	.30	.26	.00
Cargo Freight Rate	-.19	-0.29	-	-	-	-
Intercept	30.52	68.20	25.97	39.48	27.59	18.68
R-square	0.08	0.50	0.07	0.36	0.07	0.25
No. of Observations	359	29	363	30	363	30
The dependent variable is monthly/annual gold return						
**p-value < .05, *p-value < .1						
` = logged, ~ = differenced						

Table 2 Multiple Linear Regression

	Simple Linear Regressions	Multiple Linear Regression
Volatility	.0004	-
Consumer Expectations	-.0503**	-.03809*
`Bond Premium	.0211**	-
`Inflation Expectation	.0126*	.0030
Real Interest Rate	-.0025**	.0011
~Dollar Value	-.0064**	.0059**
S&P 500	-	-
~Industrial Production	-.0084**	-.0044
Cargo Freight Rate	.0001	-
Intercept	-	.1752
R-square	-	.92
No. of Observations	363 or 367	363
The dependent variable is the residual of monthly gold returns regressed on the change in the CRB Index		
**p-value < .05, *p-value < .1		
` = logged, ~ = differenced		

Table 3: Variance Decomposition of the Real Gold Price

Period	u_1^t	u_2^t	u_3^t	u_4^t	u_5^t
1	2.2618	0.1557	1.5417	95.5197	0.5211
2	2.0475	0.069	3.8326	92.5343	1.5165
3	1.2933	0.0563	5.4692	91.9857	1.1955
4	1.0228	0.042	5.2007	92.6111	1.1234
5	0.9499	0.0955	4.8305	92.8185	1.3055
6	0.8465	0.0862	4.4274	92.8748	1.7652
12	4.696	0.6195	3.0013	88.9245	2.7587
18	7.9203	0.3876	2.7583	85.4925	3.4413
50	20.0083	1.9262	2.6079	72.7334	2.7242
100	19.9422	8.5212	3.1065	64.4125	4.0175
200	20.91	9.2381	3.4905	62.2001	4.1613

Pension Incentives and Premature Retirement

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Pension Incentives and Premature Retirement

Fan Fei

Abstract

This is a study of people's retirement timing under defined benefit pension plans (DB plans). The actuarial structure of DB pensions generally creates strong incentive for people to stay with their employers at least to their early retirement ages, not to retire beforehand. Tracking respondents covered by DB plans in the Wave I (1992 cohort) of the Health and Retirement Study (HRS) until they left their 1992 employers, we found that a significant percentage of people (about 17%) left their jobs prior to their early retirement ages. Why did people leave prematurely? Several possible hypotheses were considered and examined. Through simple tabulation analyses, we found that workers in the early leaving group tend to have significantly smaller pension benefits and significantly poorer knowledge about their pensions. The impact of self-reported health status and early retirement windows were not evident. Logistic regressions showed that conditional on age dummies, pension size and having basic pension knowledge was strongly negatively correlated to premature departure. Both excellent and poor health statuses correlate positively with early departure. Accepting early out window also has a significantly positive correlation with early departure.

Key words: Pension incentives, Retirement timing, Pension knowledge, Pension wealth, Self-reported health, Early retirement window

JEL specifications: J26

1. Introduction

The world is experiencing an unprecedented population aging that will be profound and enduring. This is especially prominent and serious for developed countries like the United States. As of 2007, 17.2% of U.S. population was over 60 years old. 12.4% of the population was over 70 years old. These figures will increase to 23.8% and 17.7% by 2025, and 26.4% and 20.6% by 2050.[2] Older workers who are retired have to rely on cash flows generated by their cumulated wealth and other members in the society (in form of Social Security, Medicare etc) for the rest of their lives. By the time of retirement, the wealth of a typical American household normally includes real estate(s), financial assets, private pensions and Social Security. How important is pension among these? There have been estimates that "the wealth equivalents of pension and social security together amount to almost half of the wealth held by all households. The figure is even higher-over sixty percent-of total wealth for households who are in the 45th to 55th percentile of wealth holders."[3] Therefore, pension studies, as an essential part of labor economics and welfare economics, has become more and more significant.

A pension plan is a legally binding contract having an explicit retirement objective. There are two broad categories of pensions: public and private. Most developed countries have public pension plans very similar to the Social Security program in the United States. Private pension plans include IRA (Individual Retirement Accounts), Keogh plans (HR10 plans) and employer-provided pension

[2] The figures and predictions are from ***World Population Ageing 2007*** by United Nations Department of Economic and Social Affairs.
[3] See Gustman, Mitchell, Samwick and Steinmeier (1997).

plans. The focus of this paper is one type of "employer-provided pension plan: "defined benefit (DB) plan".[4] A "traditional" defined benefit plan provides an annuity for an employee upon that employee's retirement, the size of which is determined by a formula that usually incorporates the employee's pay (typically the average salary in last few years), years of employment and age at retirement. The monthly/annual retirement benefits under DB plans are assured, which means it is the employers' responsibility to make investment decisions with their pension fund, bear the investment risks and give their retirees the guaranteed benefits regularly.

Pensions, just as safety nets in other forms, will alter people's behavior. In particular, labor economists have studied how pensions influence retirement decisions. Defined-benefit pensions have two particular features of interest: first, most defined benefit pensions tend to exhibit a J-shaped benefit accruals.[5] Here "accrual" is the increment of present value of one's pension benefit, from one more year of service in the pension-providing employer. J-shaped benefit accruals means that the present value of pension benefits accumulates very slowly during one's early years in the company but accelerates significantly in one's mid-ages. Second, defined benefit plans normally specify a "normal retirement age (NR)" and an "early retirement age

[4] Apart from DB plans, defined contribution (DC) plan is another important category of employer-provided pension plans, which is now the mainstream. Under a DC plan, each participant has an individual account to which the employee and the employer contribute. The employee then chooses where to invest. (Usually the employee has multiple investment options.) DC pensions are mostly portable, i.e., the retirement account can be carried with the person as he/she moves to a new job. And he/she and the new employer can go on contributing to it on top of the existed contribution. At the time of retirement, what a person has in his/her account is his/her retirement benefits. The retirement benefits depend both on the amount he/she is contributed and on the investment decisions. The employees bear the investment risks in DC plans. 401(k), 403(b), TSP (Thrift Saving Plans) are typical DC plans. Besides, there are cash balance plans and hybrid plans provided by some employers.

[5] The reasons why firms want to adopt this "J-shaped" pension design might be multi-fold: first, the J-shaped accrual pattern has actuarial advantages: the interest discounting becomes less of a matter as people get closer to retirement age. Also, by heightening the potential loss of being fired or leaving at young ages, this design can stabilize labor force and can keep employees from shirking in their jobs for most of their careers etc. See Gustman and Steinmeier (1988) for more discussion on these. What we are interested in is that this kind of structure creates incentive against premature departure, as will be mentioned later.

(ER)”, both of which depend on years of employment in that firm (“tenure years”) as well as age per se and are different among individuals in the same plan under most circumstances[6]. The “normal retirement age” is the earliest age after which you can retire and get the assured retirement benefits right away. The “early retirement age”, which is normally two to five years younger than the normal retirement age[7], is the earliest age you can retire from the job and get a “reduced annual benefit”. For plans having both NR and ER specifications, there is usually a huge accrual spike at early retirement age, which means one’s pension wealth (in present value) will greatly increase if he/she stays one more year to pass that age,. There will be a modest increment in pension accrual from ER to NR and another smaller accrual spike at NR. After NR, the accrual can sometimes be negative.[8] In theory, these features of DB pensions create strong incentives on people’s retirement timing: on one hand, it “punishes” the departures prior to ER (in that case one will miss the accrual spike), deterring some retirement intentions; on the other hand, it doesn’t provide any financial incentive for people to stay past NR, discouraging the labor supply of older people. Combining these two effects, one should naturally expect a “retirement peak” around ER in response to these structures.[9]

The data used in this study is Health and Retirement Study (HRS), a longitudinal dataset that has linked the pension plans and the people who are covered by them. HRS combines self-reported data (HRS biennial core surveys),

[6] There are plans in which ER and/or NR doesn’t depend on when the worker started.
[7] ER can be 7 to 10 years before NR.
[8] See Table 22 in Gustman, Mitchell, Samwick and Steinmeier (1997) and Fig 2 in Samwick (1998) for reference.
[9] For DB plans without ER, NR will play the role of ER.

employer-reported data and Social Security Administration (SSA) data on pensions and collects extensive information including people's health (physical and mental), job and income history, financial status (well-being and knowledge) and also employment and retirement planning. These features make HRS a really powerful source for this study.

The study is limited to DB pension holders. Researchers can calculate DB pension benefits relatively accurately with the help of based on employer-provided plan descriptions. Also, because of above-mentioned structures of DB plans, we can define a benchmark for premature departure, which is the ER[10], without much dispute. On the contrary, in DC plans, the employee's contribution to the account is often voluntary and therefore may vary from year to year. Also, a typical DC plan is portable; the contribution into the account can be carried over if the person changes jobs. So to get the cumulated benefits in the account of a person nears his/her retirement one has to track the person's whole job history, which is difficult to do and the data from past jobs is of poor quality based on field experience. Moreover, it is hard to define a clear benchmark for "premature departure" from one employer for DC plan holders. It is for these reasons we leave DC plans out of the picture for this study.

We choose workers from the first HRS cohort who were covered by DB plans on their current job when first interviewed in 1992 and track them until they left their

[10] For DB plans that don't specify an ER, I treat NR as ER. So for the following analyses, the ER can either mean ER for plans that specify both ER and NR, or NR for those plans without an ER.

1992 employers.[11] The reasons we use 1992 HRS cohort are two-fold. First, there is a database created by Bob Peticolas and Tom Steinmeier in which they calculated ER, NR and present value of pension benefits at multiple ages for 1992 HRS population with DB pensions. Such work is very hard to imitate given the time and resource available to the author.[12] To take advantage of that database, I use 1992 HRS cohort. Secondly, there is enough time-span (14 years, from 1992 to 2006) for us to observe enough “events” in the population, which makes my analysis more accurate.[13]

In this study, I intend to find out how well people respond to the pension incentives and try to find possible factors that might explain departures prior to ER. One factor that comes into my mind is the size of the pension. It is straightforward that the size of the pension can be viewed as a proxy of its influence on people’s behavior. One should naturally hypothesize that people with larger pension plans care more about it and may be more hesitant to miss the “bonus” at ER. As this effect is expected to be stronger among workers who understand the incentive, I consider the correlation between pension size and financial knowledge.

Given the importance of pensions for people’s wellbeing after retirement, one might think that workers should be well-informed about the rules governing their employer-and government-provided pensions. But often they are not. Gustman and Steimeier (2000) investigated what workers knew about their pensions and social

[11] For the subjects haven’t retired from their 1992 employers, we track them until 2006 survey, the latest one available.

[12] One has to get access to the restricted data—SSA Administrative data and employer-provided Summary Pension Descriptions (SPD)—to do this and it involves sophisticated estimations and imputations.

[13] “Event”, or “failure”, is a term in survival analysis meaning “final outcome of observations”. Here “events” mean “retirement” and whether or not it happens “before ER”. Too few “events” always raise doubt about the representativeness and convincingness of the results.

security. They compared the self-reported social security, DC and DB pension values to the government/employer reported figures. They also reported the discrepancies between self-reported and employer-reported NR and ER. They found the overall “pessimistic” pattern (people tend to underestimate their benefits) of in self-reported variables. Then they reported positive effects of pension knowledge on accuracy of people’s retirement expectations (better-informed people are more likely to retire closer to the ages they said they were planning to do so.). Lusardi and Mitchell (2006) defined people’s “financial literacy” from three basic questions in 2004 HRS survey. They then found people had poor financial literacy and that financial literacy was strongly correlated in positive ways with self-reported “carefulness” of retirement planning and wealth accumulation.

In line with these studies, I hypothesize pension knowledge should be negatively correlated with the behavior of premature departure: people who have better knowledge about their pensions will be more aware of them and respond to the incentive mechanism implied in the pension structure more sensitively. I have to emphasize here that the pension information in the PV database (pension type, NR, ER and pension value at specific ages) are employers’ records or estimations based on SSA data, people’s own reports of earning history and employers’ SPDs, therefore reasonably objective and accurate. I treat them to be “real”. People’s answers to “what type of pension do you have”, “what is the earliest age at which you would be eligible to receive reduced/full retirement benefits” and “what amount do you expect to have for retirement benefit” etc are what they “perceive” their pensions would be. I consider those to be people's pension knowledge. The idea is to match people's "self-reported" (i.e. "self-perceived") pension information with the actuality and compare across the two groups (early-leaving vs. non-early-leaving) to see whether the hypothesis holds. I consider two easy pension knowledge indicators in this study: I whether or not one can correctly specify his/her pension type; what is the difference between one's self-reported ER and/or NR and those shown in PV database.

Health is a determinant in people's retirement decisions as it is in many other aspects of seniors' life. HRS has collected rich information on respondents' physical and mental health statuses, in both subjective and objective measures. Dwyer and Mitchell (1998) showed that the self-rated (subjective) health measures were not endogenous, so I choose two simple general health ratings: "how do you feel about your health" and "how is it comparing to two years ago (last survey)" and see their influence on retirement behavior.

The fourth factor that might contribute to leaving one's employer before ER is "Early Retirement Window". Early retirement windows are special incentives to stimulate retirement at a particular time. Typically, if a firm wants to downsize, it will make "Early Retirement Window" offers to targeted employees. Window offer receivers are allowed one to three months to make a decision whether to accept the offer and leave. Incentives take the forms of cash bonuses, improvement in or accelerated eligibility for pension benefits, and health insurance continuation.[14] It is possible that these events, occurred more often since 1990s, may influence some who

[14] See Charles Brown (2002) for more information on "early retirement window offers" in wave 1 to 4 of HRS.

would otherwise retire at or past ER to retire prior to ER because they are allured by the generosity of the window offer or they feel pessimistic about the prospect of the firm and would rather jump off the boat earlier. We hypothesize receiving, and more importantly, accepting early retirement window offers correlate positively to early departures.

The remainder of the paper is organized as follows. Section 2 described the data source, sample restrictions and definitions of key variables. In Section 3 I investigate the correlation between workers' pension size, pension knowledge, self-reported health status and early retirement window offers and their retirement behavior. Section 4 present and discuss the results from several logistic regression models. Section 5 concludes.

2. Data

2.1 The Health and Retirement Study (HRS)

The data for this study comes from Health and Retirement Study (HRS) database. Initiated at University of Michigan and mainly sponsored by National Institute on Aging, HRS is a nationwide survey project started from 1992. In that year, a nationally representative sample of those who were born between 1931 and 1941 was interviewed. Over the next six years, younger and older birth cohorts were added and followed longitudinally.[15] Thus, since 1998, it interviews about 22,000 Americans age 50 and older every two years. The design is to track the respondents

[15] Older cohorts include those who were born between before 1931. Younger cohorts are added every five years. The idea is to form a representative sample of Americans aging 50 and older.

until their deaths[16], collecting longitudinal data on physical and mental health, disability, employment status and job history, housing, financial status (wealth and income), family support systems and retirement planning among other topics. In 1998 and 2004, new cohorts targeting population with more recent birth years were added in.

An important innovation in HRS is that on top of the survey data, it collects information about the respondents or the households from other sources. Putting these different sources together enables us to know more about human behavior. For instance, we can get the respondents' payroll tax records from the Social Security Administration and compute the benefits for which they will be eligible when they retire. One can then compare these calculated values with respondents' own estimates of their Social Security benefits. Similarly, one can utilize employer-provided pension descriptions to estimate respondents' pension benefits and compare them with self-reported data. To protect respondents' confidentiality, such data are available only upon requests and approvals. Fortunately, information derived from the confidential pension descriptions was made available without restriction, and this Pension Present Value Database is used in this study.

2.2 Variables and Sample

I use "employment" section and "health" section of the HRS core datasets, HRS Cross-wave Tracker File (2006) and the 1992 HRS Pension Present Value database established by Bob Peticolas and Tom Steinmeier for this study.

[16] In reality, of course there are missing cases (loss of contact), and refusals in later waves.

2.2.1 Sample Restriction

I study only those who were part of the original 1992 HRS cohort, for the two reasons mentioned in the Introduction. I impose the following restrictions to all 1992 HRS population to get the sample for my analysis.

1) The person has to be "currently employed" when first interviewed in 1992[17];

2) The person's pension information—pension type, NR and/or ER—for the "current" job (in 1992) is available in the Pension Present Value database;

3) His/her birth year and month in the Tracker File is non-missing.

Since the event we track is departure from 1992 employers, we would like to wipe out those who had been retired in 1992. The first restriction did that. The second restriction have two data-cleaning functions: first, we only include those who showed to be under a DB plan in PV database in our sample. Also, we require the NR and/or ER information in PV database to be available. Assuming the NR/ER calculation in PV database to be "actuality", we can use that information and the birth year and birth month data in the Tracker File to determine whether one leaves "early" or not (see 2.2.2 for more). As the data availability for other variables discussed below varies, the sample size is not always the same for different parts of the analysis.

2.2.2 Retirement Timing

Firstly we would like to find people's actual retirement ages, ER, NR and then decide whether one left from 1992 employer prior to their ER or not. Respondents'

[17] Given that the SPDs were collected in 1993, only those who were interviewed in 1992 could have been included in the Present Value database.

birth year and birth month are in HRS Cross-wave Tracker File (2006). Since we include only people who had a job in 1992 interview, in subsequent waves, there are always questions under “employment” session “whether you left the employer in the previous wave or not”, “if so, when”. We can infer the month and year that the respondent left his or her 1992 employer by taking the first nontrivial figures on “when (you left your employer in the previous wave)” questions. Then we can calculate the retirement age by taking the difference of retirement year and birth year, adjusting for one if retirement month is “smaller” than birth month. For technical purposes mentioned later, we define “retirement age” to be one’s age at 2006 interview (the latest interview to date) for those who hadn’t left their Wave 1 employer till then. We define “retired” dummy to be one if one had a non-missing retirement year, zero otherwise. Respondents’ NR and ER data are available in the Present Value database. By comparing actual retirement age and ER (or NR, if ER is not available), we can generate “early leaving” dummy being one if one’s “actual” retirement age is smaller than the ER (he/she left before ER), zero otherwise.

2.2.3 Pension Wealth

We use “Scenario 1”[18] calculation in the PV database to be the pension wealth of individuals at specific ages (in 1992, at ER, NR etc). CPIAUCNS (Consumer Price Index for All Urban Consumers: All Items) is used to transform the figures into 2008 dollars.

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[18] “Present values of pensions were calculated for nine scenarios, each of which is compounded using a particular combination of the interest rate, the wage growth rate, and the inflation rate. Most users will probably want to use values from the first scenario, which uses the intermediate values for all three rates.”---from the codebook of the Present Value database constructed by Bob Peticolas and Tom Steinmeier.

2.2.4 Pension Knowledge

As previously mentioned, as we have more objective and more accurate pension information in PV database, we consider the survey data in HRS cores to be one's "pension knowledge". For this study, we only look at two simplest questions asked under the "employment" section of the 1992 survey. One asked the respondent to identify his/her own pension type: whether "the (retirement) plan is based on a formula involving age, years of service and salary"—a DB plan—or "money is accumulated in an account for you"—a DC plan. The other question states "what is the earliest age at which you could leave this employer and start to receive pension benefits?" We treat answers to this question people's self-perceived ER. We then compare these indicators of pension knowledge with the data in PV database. We do this for early-leaving group and non-early-leaving group separately.

2.2.5 Health Status

In every wave respondents are asked "would you say your health is excellent, very good, good, fair or poor?" and "compared to the last wave, would you say that your health is better, about the same or worse?"[19].We track people's answers to those questions and use the answers given in the last wave before they left in their 1992 jobs as "health status factor" that might influence their retirement decision. For instance, if a person reported he left his 1992 employer in July 1997, then we took down his

[19] The self-rating health is of five-point scale, with "1" being the best/most optimistic case ("excellent") and "5" being the worst/most pessimistic case ("poor"). The self-rating change of health is a three-point categorical variable except for Wave 2. (In wave 2 this question is of of five-point scale. In latter waves, first respondents were asked "better/worse/about the same". If the answer is "better", then ask whether it is "much better"; If the answer is "better", then ask whether it is "much better"; if the answer is "worse", then ask whether it is "much worse". It result in three variables on the health change. We could generate a five-pointer out of each three. But for now, we only consider the first health change question.

answers to the two questions in Wave 3 interview conducted in 1996 as the “health status factors” for that observation. For the people who hadn’t left by the 2006 interview, we use their health status reported in 2006 interview. The rationale here is that though health history matters, the “recent health” may affect the retirement decision more directly. For people in mid-ages, it is likely that sudden decline in health forces premature retirement. For people having chronic diseases, the last wave health rating can still catch the influence of that on retirement.

2.2.6 Early Retirement Window

In every wave there are specific questions on “whether the firm offered early out window since the last wave” and “whether you accept it”. We regard this as “early retirement window factor”. We would like to observe who took this packages and whether that is related to “early leaving” behavior.

3. Descriptive Results

3.1 Retirement Pattern and Pension Value

Individuals in the sample of this study have birth years ranging from 1930 to 1942. They were entering the age of retirement when Wave I interview took place in 1992. As previously specified, we selected only the respondents that were still in the labor force when they were interviewed for the first time to be in the sample. The pattern of their departure from their 1992 employers since then is shown in Table 1. In Table 1-1 I show the distribution of departure year. Soon after 1992, the departure peak came in 1995. There were mass departures between 1995 and 1999. Then the number of departures steadily decreased. Out of a total of 1592 respondents, there were 490 cases in which the respondents “hadn’t left their 1992 employer by the last interview in 2006” or HRS lost contact with this person permanently or for a while and couldn’t be able to identify their departure time.

In terms of age when laving 1992 employers, we observed that “retirements” began to sharply increase from age 55. Age 60 to 62 is the most “popular” retirement phase. The mass retirements continued until age 65 and then declined. (See Table 1-3) This pattern can be properly interpreted using information in Table 1-4 and the Social Security eligibility age requirement[20]: as one can see in Table 1-4, one of the three peaks of ERs is age 55, the increased number of departures at age 55 are probably the response to that. The big retirement spike at age 60 responds to another ER peak. For most people in my sample, age 62 is the minimum age at which one would be eligible for reduced Social Security benefits (the “early retirement age” for Social Security) , resulting in the largest number of “retirement”. The retirement tides continue to age 65, the “normal retirement age” for Social Security for most individuals in our sample. There are 503 observations with missing retirement age.

The distribution of DB pension wealth in the sample is highly uneven and left-skewed, as shown in Table 2. The median DB pension is about $81,500 in 1992 (in 2008 dollars), a little more than $100,000 by the time of ERs. The means are respectively approximately $175,000 and $195,000 at those times. A good number of people (more than 10%) showed to have zero pension benefit in 1992, which meant

[20] See http://www.ssa.gov/retire2/agereduction.htm for details.

they would have no pension benefit if they were to retire in 1992. This was probably due to change of jobs: their 1992 employers were probably new for them at that time and they hadn't qualified the "tenure year" requirements set by firms. Size of pension at ERs ranges from less than $1,000 to more than $1.67 million.

3.2 Pension Wealth and Early Retirement Behavior

The average pension benefits at ER and the increment from 1992 to ER of the two groups can be seen at Table 3. One can find readily the huge difference between the two groups: by ER the early-leaving group would get a mean of approximately 118,000 dollars; one the contrary, the control group would get approximately 203,000 dollars on average, nearly 80% above that of early-leaving group. On the other hand, the early leaving group outmatched the non-early leavers on the increment of pension size from 1992 to ER. The increment of pension from 1992 to ER is how much more one can get if he waits until ER to leave the employer instead of leaving the job right away in 1992, therefore it is a more proper measure of incentives. Then it seems a strange thing that people whose ER spike of pension accruals matter more to them don't take it very seriously into their retirement decisions. But this is not un-understandable. The fact that they don't respond to ER very sensitively might not an action out of financial innocence or ignorance. Actually based on this sample, one can show a positive correlation between one's pension knowledge and one's pension wealth. Their decisions of not taking advantage of the ER to retire might be because other things that one could get from work had more weights in their utility functions. An alternative hypothesis would be: people's pension wealth and retirement timing might all relate to their sophistication and personality: a sophisticated, capable person with a workaholic and/or easygoing personality is more likely to hold a high position, earning handsome salary and owning more pension benefits. And the sense of achievement from work, his career ambition and his love of social and work, among other factors, may make him/her want to work for more years instead of retiring at ER in his/her fifties. A thorough test of this “capable person tend to work past their ER” hypothesis is not easy and remains to be done.

3.3 Pension Knowledge and Early Retirement Behavior

As I discussed above, I linked the pension type and ER, NR information in the Present Value database with the HRS core dataset. And I regard the self-reported pension type and ER in HRS core as “self-knowledge”. The pension type data in the PV database is from employer-provided SPDs and can be considered accurate and “real”. The ER data is estimation based on the SPDs, respondent’s earnings and service come from the respondent reports, therefore more objective and reliable than self-reported ER. So the “mismatches” of survey data to PV database data is a proxy of “poor knowledge on one’s own pension”. The results are shown in Table4.

From Table 4-1, we observe that nearly 30% of early leavers gave incorrect answers to the pension type question, while 15% percent of non-early leavers made the same mistake. On the whole, early leavers had poorer knowledge in the most basic question about their pensions. It is no wonder that they are more prone to disregarding the structure of DB pensions they have in their retirement planning. From Table 4-2, less than 20% from each group reported an early retirement age that was exactly the same as estimated early retirement age from PV database, the percentage of "exact matches" are comparable across the groups. But the early leaver group tend to report self-believed ERs that were one to five years too young than the calculated ERs (23.6%, 10.8% for the control group in this category) whereas the non-early leavers' misses were more on the other side. If they would act based on their self-believed ERs, this result can explain their retirement pattern to some extents. These two findings verified out hypothesis on the pension knowledge. We should notice, however, the ER data in PV database is not absolutely "real" and accurate because it is based on limited knowledge about respondents and their self-reported job and earning history. Mismatches in Table 4-2 might also be caused by a wrongly estimated ER in PV database.

3.4 Health and Early Retirement Behavior

It is commonsense that health can affect the length of one's career and retirement timing. Here we are interested whether poor health and/or sudden worsening in health forced some to leave before ER. As a starting point, we compared respondents' self-rating health and health change variables (see Table 5). We can not see any significant results from both variables, either wave-by-wave or pooled comparison. One thing needed to mention is that we have about 300 observations in non-early-leaving group with missing values in health variables.

3.5 Early Retirement Window and Early Retirement Behavior

In Table 6, we summarized the EOW offers and acceptances to two groups wave by wave. Most EOW offers and acceptances (over 90%) happened in the non-early leaving group. The two groups showed no evident difference in being offered EOW and taking EOW. So from this perspective, we could not find evidence supporting the hypothesis that EOW had an influence on people's premature departure.

4. Logistic Regressions

Logistic regression results are presented in Table 7. We investigate the influences of factors on retirement timing and premature departure behavior. First we expand the "subject" dataset to a "subject-year" dataset: one respondent will have one observation for each year he/she stayed in the dataset (starting in 1992, ending in the retirement year; if he/she hadn't retired in 2006 interview, he/she would have (2006-1992=) 15 observations). The dependent variable for specification I to III is the "retired dummy": being one for every observation of the same person if the person had left the 1992 employer by 2006 interview, being zero otherwise. The dependent variable for specification IV and V is "early-leaving dummy": being one for every observation of the same person if the person had left the 1992 employer prior to his/her ER, being zero otherwise. The age dummies equal to one if the person was at age in that year and zero otherwise. We include different age dummies for in different specifications: for specification I to III, we put in age52 to age68; for specification IV to VI, we exclude "age66", "ag67" and "age68" because technically they "predict failure perfectly". The "atER" dummy equals to one only if the person retired at his/her ER and only being one for that retirement year, being zero otherwise. The "pastER" dummy equals to one in every year after the ER. Besides "pension type knowledge", "EOW offer" and "EOW taker" dummies mentioned above, I divide the sample into four groups according to the size of their pensions and create three dummy variables for people in the second, third and the top quartile. Two health dummies are created based on answers to the "current health status" question: the "health_good" variable is one for every observation of a same person if that person reported to have "excellent" or "very good" health in the wave just before leaving 1992 employer, zero otherwise. Similarly, the "health_poor" variable is one if a person reported to have "fair" or "bad" health in the wave just before leaving 1992 employer, zero otherwise. Those whose answer were "good" (the choice in the middle) were the base group. All these factor variables are time-invariant. (i.e.: the value of factor variables are the same for difference observations of a same person.)

The column I to III showed results on "retirement" odds. In specification I, all age dummies have odds ratio greater than one, meaning a person is more likely to retire than not at every age. "Age62" and "age65" dummies have significantly larger odds ratios: we expect to see more than eight times increase in the odds of retiring at age 62 and more than six times increase in the odds of retiring at age 65. Age 62 is the "early retirement age" of Social Security and age 65 is the normal retirement age of Social Security for HRS cohort. We can see their huge influence there. Specification II adds in "atER" and "pastER" dummies. We can see conditional on age dummies, being atER only modestly increase the odds of retirement.[21] In specification III, we

[21] I am aware that this result may be inconsistent with the theory and some existed studies based on this dataset. I haven't been able to interpret this result. However, I have made sure, to the best of my ability, that there was no

can see that "EOW accept" can increase the odds of departure, which is straightforward. That both the positive rating and the negative rating of health status increase the odds of departure is interesting. Keep in mind that what "retirement" really means here is the departure from 1992 employers. One explanation of that finding may be: while poor health can force people out of the labor market, having very good health may encourage people move for new jobs in their fifties.

The column IV to VI showed results on "early retirement" odds. In specification IV, the only independent variables are age dummies. The "older ages" tend to have smaller odds ratios, which is straight-forward: as age increases, the probability of passing the ER increases and retirement before ER decreases. "Age54" and "age57" have odds ratios that wildly overmatch others. Specification V and VI add in factor variables. Conditional on age dummies, pension size correlates with early departures in the expected directions: being in the bottom quartile by pension wealth increases the odds of premature departure by nearly 40%, being in the top quartile decreases the odds of premature departure, but the coefficients are not statistically significant. Correctly identifying one's own pension type associated with much lower odds of premature departure (odds ratio being .418), and the result is statistically significant. This verifies the strong negative correlation between one's pension knowledge and premature departure behavior. Both "optimistic/positive" and "pessimistic/negative" self-evaluations of health statuses are correlated with increasing odds of premature retirements. The positive relation between

easy mechanical mistake there.

pessimistic/negative health self-evaluation and the early leaving odds supports my hypothesis to some extents. We interpret the positive relation between optimistic health self-evaluation and the early leaving odds to be: those persons might leave not to retire, but to go to better jobs. Contrary to the finding in the previous section, where we could not see impact of early retirement window on early departure, in logistic regressions one can clearly see that accepting EOW is strongly positively correlated with premature departure.

5. Conclusion

The main goal of this study is to find out how well people respond to the retirement incentives related to DB pension structures and try to find possible factors that might explain departures prior to one's ER. Based on a sample of nearly 1,600 individuals in HRS 1992 cohort, we observe the distribution of people's retirement ages correspond well to ER and NR of Social Security and DB pensions, something consistent with the theory. The distribution of people's pension wealth is highly skewed: the median pension wealth is about 82,000 dollars (in 2008 dollars) but the average is more than 170,000 dollars.

Non-early-leaving group on average have significantly more lucrative pension benefits than the early-leaving group. But data on the increment of pension present value from 1992 to ER—a more proper measure of pension incentive for staying with the employers—and logistic regression models don't support the original hypothesis that people with larger pension plans are more likely to stay with the employers till

ER for the accrual spikes. The fact that they don't respond to ER very sensitively don't necessarily indicate their lack of awareness of their pensions. Instead we propose a more probable alternative hypothesis: people's pension wealth and retirement timing might all relate to their capacity and personality. A person who is more capable and more passionate on his/her work is more likely to own a bigger pension package. Also, the sense of achievement from work and the busy business lifestyle might be more important in his/her utility function than the financial advantage of retiring around ER, pushing him/her to retire at a latter age.

The results from comparative analysis on people's knowledge on their pension types and ERs and the logistic regressions show that one's basic knowledge has a strong correlation with the early departure behavior: people with poor knowledge on their pensions are more prone to leave prior to ER and miss the accrual spike.

Statistics on overall health self-evaluations don't show much difference across the two groups. But results in logistic regressions show that people with both excellent and poor self-perceived health have higher odds of premature departure. The latter fit the "poor health force people out" hypothesis. The story behind the former result might be: people with good health left 1992 employers not to retire, but to go to jobs they liked more. Data on early retirement windows show that the offer of early retirement windows don't seem to influence the retirement timing or whether or not people leave prior to ER, but the acceptance of EOW increases the odds of leaving prior to ER significantly.

Overall, this study shed some lights on understanding retirement before ER for

DB pension holders. Though the prevalence of DB pension is decreasing, the results of in this study still have implication in the design of public policy. For instance, “the-more-individual-choice-the-better” philosophy may not end up giving the less sophisticated people, often in the lower social economic status, the “seeming” benefits. Maybe more resource should allocated to personal finance education etc..This study remains a very simple one; much work should be done to verify the actual causal chain in people’s retirement behavior.

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For issue concerning survey methodology and detailed survey contents, see

http://hrsonline.isr.umich.edu/intro/sho_intro.php?hfyle=uinfo)

Table 1: Retirement Pattern

Table 1-1 Distribution of Retirement Year

Year	Number of Departures (head count)	Percentage (Weighted)
1992	19	1.1
1993	24	1.63
1994	71	4.92
1995	152	9.48
1996	130	8.77
1997	126	8.45
1998	115	7.44
1999	102	6.35
2000	91	5.52
2001	84	5.68
2002	64	3.53
2003	51	3.4
2004	35	2.15
2005	28	1.49
2006	10	0.75
Missing	490	29.34
Total	1592	100

Table 1-2 Distribution of Retirement Wave

Wave	Number of Departures (head count)	Percentage (Weighted)
2*	78	4.87
3	266	17.3
4	253	16.71
5	191	12.24
6	166	10.19
7	98	6.21
8	50	3.13
Missing	490	29.34
Total	1592	100

(*: Wave 2 counts the number of people retired between Wave 1 interview and Wave 2 interview.)

Table 1-3 Distribution of Retirement Age

Age	Number of Departures	Percentage

	(head count)	(Weighted)
<=52	14	0.41
53	15	0.83
54	25	1.5
55	56	3.66
56	48	2.6
57	57	3.76
58	60	4.13
59	81	5.18
60	126	8.1
61	104	6.4
62	191	12.34
63	92	5.76
64	64	4.26
65	82	5.47
66	40	2.33
67	25	1.31
68	7	0.56
69	9	0.64
>= 70	15	0.98
Missing	503	29.78
Total	1614	100

Table 1-4 Distribution of ER (weighted)

Age	Number of cases with that ER age	Percentage
<50	100.2	6.64
50	167.1	11.08
51	29.5	1.96
52	27.4	1.82
53	22.6	1.5
54	26.3	1.74
55	569.5	37.76
56	55.9	3.71
57	48.3	3.2
58	37.5	2.49
59	45.5	3.02
60	161.0	10.68
61	29.8	1.98
62	90.0	5.97
63	12.1	0.8
64	19.4	1.29
65	51.0	3.38
>65	14.9	1.0
Total	1509	100

Table 2: DB Pension Size
(Weighted, doesn't exclude zero values, n = 1508)

Percentile	Pension Size in 1992 (in $, in 2008 dollars)	Pension Size at ERs (in $, in 2008 dollars)
10%	0	19,274.86
25%	3,660.21	41,313.97
50%	81,487.77	102,341.8
75%	223,149.4	260,358.2
90%	459,604.6	485,867.3
95%	701,537.4	688,908.8
Min	0	994.83
Max	1,925,301	167,5593
Mean	175,594.1	194,534.9
s.d.	246,555.3	236,516.5
Skewness	2.600	2.400

Table 3: Average Pension Benefits Comparison

	Pension Value at ER (in $, 2008 dollars)		Pension Increment from 1992 to ER (in $, 2008 dollars)	
	Early leavers	Non-early leavers	Early leavers	Non-early leavers
Mean	117,559.6	202,862.8	77,196.2	12,638.2
Median	64,652.1	107,882.3	54,553.9	2,993.5
s.d.	122,471	244279.5	72,433.1	104,113.4
Skewness	1.511	2.320	1.435	1.015
Sample size	151	1357	151	1357

Table 4: Pension Knowledge Comparison

Table 4-1: Pension Type Mismatching

	Early leavers	Non-early leavers
No. of people reported DC only	59.8*	204.1*
As a percentage	28.2%	15.7%
Sample size	212.3*	1295.7*

(*: the figure is not integers because of weighting.)

Table 4-2: ER Mismatching

	Early leavers	Non-early leavers
% of diff in [-20, -6]	8.87	2.37
% of diff in [-5, -1]	23.63	10.76
% of exact matches	17.9	19.59
% of diff in [1, 5]	15.16	22.57
% of diff in [6, 18]	3.44	22.21
% of self-reported ER missing	31	22.49
Sample size	145.7*	998.3*

(*: the figure is not integers because of weighting.)

Table 5: Self-reported Health Status Comparison

	Average health status rating (1: very good; 5: very poor)		Average health status change rating (1: better; 2: almost same; 3: worse)	
Wave	Early Leavers	Non-Early Leavers	Early Leavers	Non-Early Leavers
2	1.56 (.74)	2.17 (.93)	2.04 (.52)	2.00 (.48)
3	2.48 (1.14)	2.32 (1.08)	2.10 (.59)	2.05 (.58)
4	2.61 (.97)	2.62 (1.03)	2.15 (.56)	2.14 (.58)
5	2.43 (1.04)	2.38 (1.02)	2.02 (.42)	2.01 (.57)
6	2.36 (1.10)	2.40 (0.98)	2.18 (.72)	2.00 (.56)
7	3 (--)	2.69 (1.02)	1 (--)	2.04 (.52)
8	---	2.44 (1.07)	---	2.00 (.59)
Not retired	---	2.54 (1.00)	---	2.07 (.50)
Total	2.35 (1.07)	2.47 (1.03)	2.05 (.55)	2.10 (.56)
Sample size	133	1037	133	1037

Table 6: "Early Retirement Window" Comparison

Table 6-1: "EOW" Offers Comparison

Wave	No. of EOW Offers	No. of Offers to Non-Early Leavers	No. of Offers to Early Leavers	% of Offers to Early Leavers
0*	1103.92	981.96	121.96	11.05
2**	84.66	80.59	4.07	4.81
3	97.76	89.64	8.12	8.31
4	100.64	93.28	7.36	7.31
5	40.82	39.54	1.28	3.14
6	38.44	36.08	2.36	6.13
7	24.11	22.03	2.08	8.62
8	17.65	17.65	0	0.00
Total	1508	1360.78	147.22	9.76

(*: Wave 0 counts the number of people that don't get any EOW offers in any wave.

**Wave 2 counts the number of people got EOW offer(s) between Wave 1 and Wave 2 interview.

The figure is not integers because of weighting.)

Table 6-2: "EOW" Takers Comparison

Wave	No. of EOW Offers taken	No. of Offers taken by Early Leavers	No. of Offers taken by Non-early Leavers	% of Offers taken by Early Leavers
0*	1324.17	130.12	1,194.06	9.83
2**	16.47	0	16.47	0.00
3	48.69	6.91	41.78	14.19
4	57.31	7.36	49.96	12.83
5	18.21	0	18.21	0.00
6	25.16	1.38	23.78	5.47
7	12.56	1.46	11.10	11.66
8	5.42	0	5.42	0.00
Total	1508	147.22	1360.78	9.76

(*: Wave 0 counts the number of people that don't accept any EOW offers in any wave.

**Wave 2 counts the number of people acceptedEOW offer(s) between Wave 1 and Wave 2 interview.

The figure is not integers because of weighting.)

Table 7: Logistic regressions

The dependent variable for specification I, II and III is the “retired” dummy in a “subject-year” dataset, being 1 if the observation is a “retired” person (has left his/her 1992 employer by 2006 interview) at the “retirement year”, being 0 otherwise.

The dependent variable for specification IV V and VI is the “early-leaving” dummy in a “subject-year” dataset, being 1 if the person is an “early leaver” at his/her “retirement year”, being 0 otherwise.

Odds ratios are reported.

	Retirement Trend				Early Leaving Factors		
	I	II	III		IV	V	VI
Age52	.49 (.28)	.58 (.33)	.41 (.23)		7.74** (7.13)	7.43** (6.91)	7.45** (6.93)
Age53	1.07 (.38)	1.24 (.45)	.87 (.31)		16.73** (13.27)	15.75** (12.78)	15.65** (12.68)
Age54	1.53 (.46)	1.77 (.53)	1.27 (.38)		30.15** (22.54)	28.71** (21.92)	28.53** (21.75)
Age55	3.31** (.85)	3.54** (.93)	2.64** (.69)		19.92** (15.21)	19.15** (14.91)	18.97** (14.76)
Age60	5.42** (1.25)	5.62** (1.28)	4.54** (1.03)		13.87** (10.56)	13.24** (10.21)	13.15** (10.11)
Age61	4.29** (1.01)	4.33** (1.02)	3.69** (.86)		10.28** (8.10)	9.98** (7.95)	9.90** (7.87)
Age62	9.98** (2.24)	9.95** (2.24)	8.96** (1.99)		11.23** (8.75)	11.00** (8.67)	10.95** (8.62)
Age63	5.35** (1.28)	5.31** (1.27)	4.79** (1.14)		9.27** (7.35)	9.11** (7.27)	9.09** (7.87)
Age64	4.45** (1.10)	4.40** (1.09)	4.12** (1.14)		9.61** (7.76)	9.50** (7.70)	9.52** (7.71)
Age65	6.64** (1.61)	6.52** (1.59)	6.36** (1.54)		.71 (.86)	.71 (.86)	.70 (.86)
AtER		1.21 (.21)	1.14 (.21)		---	---	---
PastER		1.27** (.13)	1.25** (.14)		---	---	---
Pension_q1			1.04 (.08)			1.37 (.27)	
Pension_q4			.93 (.08)				.81 (.19)
Pention Type			.95 (.08)			.42** (.08)	.41** (.08)
Health_good			2.03** (.15)			1.95** (.38)	1.91** (.37)
Health_bad			1.95**			1.64**	1.65**

			(.20)			(.45)	(.46)
EOW_offer			1.07 (.10)			.32** (.12)	.31** (.11)
EOW_accept			2.58** (.27)			3.29** (1.45)	3.25** (1.45)
Pseudo R^2	.050	.051	.081		.046	.081	.080