Creativity in the financial market – are consumers close enough to taste it?

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Abstract

This study contributes to the understanding of the empirical linkages between macroeconomic variables and financial markets by examining the impact of financial innovation on consumption volatility. Using a general autoregressive conditional heteroscedasticity (GARCH (1,1)) process the relationship between financial innovation and consumption volatility is estimated. The results reveal that innovations in the form of securitization have contributed to an increase in consumption growth prior to the financial crisis and an increase in consumption volatility throughout the examined period. Suggesting that financial innovation played an important role in the period preceding as well as the aftermath of the financial crisis. In contrast, innovations in the form of derivatives have contributed to a decrease in consumption volatility. Therefore, this study highlights both the 'bright' and 'dark' sides of financial innovation.

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1. Introduction

Understanding the empirical linkages between macroeconomic variables and financial markets has long been a goal of financial economics. Financial markets affect the macro economy mainly through their impact on consumption and investment (Romer, 2012). In addition, consumption and investment have important feedback effects on financial markets. The relation between consumption and financial markets is captured in the Consumption CAPM. However, this model has difficulty explaining historically observed data. A possible way to improve the Consumption CAPM is to take uncertainty surrounding future consumption into account. With this modification, historical data can be explained, adding more credibility to the relation between macroeconomic variables and financial markets.

On the other hand, financial markets affect the macro economy by facilitating production- and consumption activity as well as economic growth (Frame & White, 2004). Improvements in the financial sector (i.e. financial innovation) will therefore impact the real economy. Two opposing trends in the research of the effect of financial innovation on macroeconomic variables can be distinguished. Advocates of financial innovation argue that it facilitates risk sharing which in turn decreases income volatility (Allen & Gale, 1994). However, opponents argue that financial innovation, measured as a new type of security, leads to an increase in risk taking. This in turn causes an increase in market volatility and a decline in the stability of the banking sector. Given its impact on the real economy, either positive or negative, finanical innovation might have played an important role in the recent financial crisis.

This research continues the study of the impact of financial innovation on the real economy. Specifically, the relationship between financial innovation and consumption volatility is estimated using a general autoregressive conditional heteroscedasticity (GARCH (1,1)) process. The results reveal that innovations in the form of securitization have contributed to an increase consumption volatility. Furthermore, securitization increased consumption growth prior to the financial crisis. Suggesting that financial innovation played an important role in the period preceding as well as the aftermath of the financial crisis. In contrast, innovations in the form of derivatives have contributed to a decrease in consumption volatility. Derivative securities reduce the risk on bank's balance sheet, contributing to a more stable banking sector. Bank stability, in turn, supports consumption growth and reduces consumption volatility.

This study, therefore, highlights the 'bright' and 'dark' sides of financial innovation and reaffirms the relationship between financial markets and macroeconomic variables. It can be concluded that financial innovation represents an important component of financial markets that should be taken into account when macroeconomic policy is formed.

2. Literature review

2.1 The Consumption CAPM

One of the first to investigate the link between the real economy and financial markets theoretically is Merton (1973). His model builds on the well-known (and also criticized) Capital Asset Pricing Model (CAPM) developed by Sharpe (1964) and extended by Lintner (1965). Critics of the CAPM argue that the assumptions underlying the model are too rigid and that the model does not provide a complete description of the structure of security returns. For instance, Jensen, Black and Scholes (1972) find that the expected excess returns on high beta assets are lower than suggested by the CAPM and vice versa. Resulting in a relative negative or positive abnormal return, measured by alpha. Supported with this evidence, the single factor (beta) in the CAPM might not capture all the relevant risk.

The traditional form of the CAPM is also questioned by Merton (1973). Unlike the single period maximization of the CAPM, he develops a theoretical model in which the consumer/investor takes the relationship between current period returns as well as future returns into account, making it an intertemporal capital asset pricing model. Merton (1973) argues that investors are not only compensated for systematic risk, but also for bearing the risk of unfavorable shifts in the investment opportunity set. An unfavorable shift is defined as a change in the investment opportunity set such that (future) consumption will fall for a given level of (future) wealth. With this model, Merton (1973) is one of the first to assume that there is a relationship between macroeconomic variables and financial markets. However, tests to investigate whether this intertemporal CAPM is able to explain the empirical discrepancies of the CAPM discovered by Jensen, Black, and Scholes (1972) were not performed.

Breeden (1979) continuous this line of research by estimating a continuous time model, known today as the Consumption CAPM. The Consumption CAPM, like the CAPM, is a single beta model. However, beta in the Consumption CAPM does not measure the sensitivity of an asset's return with the market portfolio, as with the traditional CAPM. Instead, it measures the sensitivity of an asset's return with aggregate consumption. Suggesting that an asset's covariance with aggregate consumption represents all the relevant risk and thus all that is necessary for asset pricing. This implies relatively large (small) equilibrium expected returns on assets with relatively large (small) covariance with aggregate consumption.

2.1.1 The equity premium puzzle

So far the Consumption CAPM is only explained in theory, it still has to be tested empirically. Mehra and Prescott (1985) carry this out by examining whether the model is able to explain observed returns; specifically, the difference in yield between short-term default free debt and the average real annual yield on the S&P 500. From 1889 to 1978 the average real annual yield on the S&P 500 equaled seven percent. In contrast, the average yield on short-term default-free debt was less than one percent.

Mehra and Prescott (1985) test whether the theoretical model of Breeden (1979) is able to explain this differential.

They vary both the relative risk aversion and the discount factor, representing preference parameters, to calculate the possible set of values for the difference between the equity risk premium and the risk-free rate. The resulting difference ranges between zero and four. The historically observed risk-free return of 0.80 percent and equity premium of six percent is clearly inconsistent with the predictions of the model. This finding, that observed returns cannot be reconciled with the theoretical Consumption CAPM, is known as the equity-premium puzzle. Based on the Consumption CAPM, the relative risk aversion should be equal to 25 to be able to rationalize the size of the equity premium, which is an extraordinary level (Mehra & Prescott, 1985).

2.2 Consumption volatility and asset pricing

Research so far is inconclusive on whether there is a relationship between macroeconomic variables and financial markets. The equity premium discovered by Mehra and Prescott (1985) reveals a puzzle that has yet to be explained.

2.2.1 Consumption volatility and the equity premium

Bansal and Yaron (2004) try to solve the equity premium puzzle by incorporating another measure of consumption: consumption volatility. As explained by Tédongap (2015), an investor dislikes uncertainty surrounding his future consumption and consumption growth. Therefore, an asset is unattractive if it delivers a low payoff in times of high uncertainty in future consumption growth. Consequently, investors want to be compensated for holding such an asset.

Bansal and Yaron (2004) explore the idea that news about growth rates of consumption and uncertainty (consumption volatility) alters perceptions regarding expected growth rates and economic uncertainty. They argue that asset prices could be fairly sensitive to news about future consumption growth and consumption volatility news. Negative news being the forecast of smaller consumption growth or higher consumption volatility and vice versa. They separate the growth rates of both consumption and dividends into a persistent expected growth rate and a conditional volatility component. The volatility component in consumption growth is used as a measure for economic uncertainty and is assumed to follow a stochastic volatility process. Taking the two channels in account, the equation for the equity premium will now have two sources of systematic risk: (1) fluctuations in consumption growth and (2) fluctuations in consumption volatility.

Incorporating consumption volatility (which fluctuates over time) in the model allows for a time-varying risk premium. As a result, it generates an equity premium that is comparable to the one observed in real data (real: 6.33, model: 6.48). Thus, their model based on both expected growth rates and economic uncertainty can explain the equity premium puzzle, which in turn partly saves the consumption CAPM. It can be concluded that this model is not only able to support the consumption

CAPM model, it also shows the importance of macroeconomics in asset pricing (Bansal & Yaron, 2004).

2.2.2 Covariation of consumption and excess return

Tédongap (2015) expands the study of Bansal and Yaron (2004) by assuming that consumption volatility can be estimated by a general autoregressive conditional heteroscedasticity (GARCH) process. In his model, the expected excess return of an asset, with a specified holding period and a risk horizon, depends linearly on three covariances: (1) its covariation with changes in realized consumption, (2) its covariation with changes in expected consumption growth and (3) its covariation with changes in consumption volatility. An investor wants to be compensated for holding an asset with a relatively large and negative covariation between changes in consumption volatility and excess return. This is because such assets pay less in bad states of the economy characterized by sharp increases in macroeconomic uncertainty. In addition, investors want to be compensated for holding an asset with a relatively large and positive covariation between changes in expected consumption growth and excess return. This is motivated by investors who fear the possible repercussions on their future wealth and would like to increase their precautionary savings or smooth their consumption. Consequently, investors require a relatively higher risk premium for holding those assets (Tédongap, 2015).

The empirical performance of Tédongap's (2015) model is examined on standard portfolio sets; the 25 size and book-to-market portfolios and the 25 size and long-term reversal portfolios. In addition, factors corresponding to the uncovered anomalies such as the value factor, size factor and the long-term reversal factor are added. The results clearly show a negative and significant relation between the covariation of excess return with changes in consumption volatility and stock returns, which is as expected from theory. Furthermore, the results using the 25 size and book-to-market portfolios and the 25 size and long-term reversal portfolios, reveal that the three factor model created by Tédongap (2015) is able to explain the value-, size- and long-term reversal anomaly across various risk horizons and holding periods. This conclusion adds more credibility to the relation between macroeconomic variables and financial markets.

2.3 Financial innovation and the real economy

As described in the previous studies, consumption is an important channel through which the macro economy affects financial markets. This channel also works the other way around; financial markets affect the macro economy through their impact on consumption and investment (Romer, 2012). In this section, the latter channel is discussed. Specifically, the impact of financial innovation on macroeconomic variables is examined.

Frame and White (2014) argue that financial markets are important as a facilitator for production- and consumption activity as well as economic growth. Therefore, improvements in the financial sector will have an impact on the real economy. This raises the importance of financial innovation. A financial innovation represents something new that reduces costs, reduces risks, or provides an improved product/service/instrument that better satisfies participant's demands (Frame & White, 2004). In the last few decades, multiple innovations such as ATMs and new financial instruments were introduced. Unfortunately, there is a relative lack of empirical studies examining the impact of these innovations on the financial market or the real economy. Nonetheless, financial innovation could represent a key factor in the channel between macroeconomics and financial markets and is studied next.

2.3.1 Impact of financial innovation

The reason or trigger that induces firms to innovate remains an open question. Few researchers have tried to answer it, and the majority seem to agree that regulation is one of the key drivers behind it (Miller, 1986 and Ben-Horim & Silber, 1977). However, predicting the timing of innovation is a difficult task. Ben-Horim and Silber (1977) use a linear programming approach to examine the impact of regulation constraints on financial innovation, measured by patents. Their theory predicts that an exogenous change in the optimization of the firm, caused by regulation, induces the innovation of new financial instruments or practices. This positive relationship is confirmed by their model. Miller (1986) adds tax changes to the short list of possible impulses for the creation of new financial products. The motives underlying financial innovation is still a fruitful research area for the future.

Two separate directions within the research of the impact of financial innovation on macroeconomic variables can be distinguished. On the one hand, financial innovation facilitates risk sharing, decreasing income volatility (Allen & Gale, 1994). Allen and Gale (1994) argue that investors initially face undiversified risks concerning their future income. The investors are able to share these risks using new securities, introduced by financial innovation. Sharing risk, enables them to smooth their income (and thus consumption) across states. Furthermore, Dynan, Elmendorf and Sichel (2006) state that financial innovation is one of the drivers leading to the stabilization of economic activity in the mid 1980s. Their results indicate that financial innovation contributed to the long term decline in the volatility of economic activity over the period 1965 through 2004. On the other hand, a new type of security can also lead to an increase in risk taking. Wagner (2007) shows that new credit derivative instruments have both increased liquidity and risk taking in the banking sector. This risk taking has negatively effected the stability of the banking sector by increasing the probability of default. Keys, Mukherjee, Seru and Vig (2010) find that innovations in the form of securitization and other derivative securities have also contributed to aggressive risk taking. Furthermore, the securitization process has led to a reduction in the ex-ante incentives of financial intermediaries to carefully screen and monitor the borrowers (Allen & Charletti, 2006). Lastly, Zapatero (1998) shows that financial innovation has led to an increase in market volatility instead of a decrease as argued by Allen and Gale (2004).

2.3.2 Financial innovation and market volatility

Zapatero (1998) examined the effects of financial innovation on market volatility. Two types of economies are considered: an incomplete market and a complete market economy. They differ in the availability of additional information and risky securities. The additional information added to the economy represents an index or a statistic that is computed and publicly released (i.e. signal). Financial innovation is either measured with a new risky security or with the signal. Market volatility is measured as the volatility in interest rates. The model introduces a pessimistic and an opportunistic consumer. They are rational, have identical preferences and maximize their life-time utility derived from consumption. These consumers differ in their beliefs about the drift of the aggregate consumption/dividend process. They both believe that the drift belongs to a normal distribution, however the optimist beliefs that the mean is larger than the pessimist, hence the denomination. In addition, they both know the exact volatility structure of the dividend process.

The results indicate that in the incomplete markets setting, the introduction of the signal increases the volatility of the interest rate (i.e. market volatility) in the short run and decreases it in the long-run. Subsequently, Zapatero(1998) compares the two complete market settings with the same amount of available information but different risky securities. This shows that when a new risky security is added, the interest rate increases through an increase in the volatility of the share of wealth of the individuals. If the new security is traded, the individuals will change their portfolios, causing a higher volatility in their share of wealth. In conclusion, financial innovation solely measured by additional information does not increase market volatility in the long-run. However, financial innovation, measured by either a new risky security or a risky security together with new information, does increase market volatility. In addition, it increases the volatility of individual's wealth (Zapatero, 1998).

2.3.3 Financial innovation and growth

Beck, Chen, Lin and Song (2014) continue the research of the impact of financial innovation on a cross-country and industry level. They assess the relationship between financial innovation and real sector growth, sector volatility, and bank fragility, highlighting both the 'bright' and 'dark' sides of financial innovation. Their financial innovation variable is constructed using different indicators of Research and Development (R&D) activities across countries and years. To estimate the impact of financial innovation on the real economy, an additional explanatory variable measuring a country's growth opportunities is incorporated in their model. Theory suggests that growth opportunities are an important link between financial innovation and financial intermediaries. Financial intermediaries choose and monitor those projects with the highest growth opportunities. Financial innovation supports the project's decision making process and helps monitor these projects more efficient. With this in mind, growth opportunities are assumed to have an indirect relation with the real economy. They are therefore incorporated as an interaction term with financial innovation.

The results reveal a difference in the impact of financial innovation on a county's growth rate for different regulatory frameworks and capital market depth; it's impact is more pronounced in countries with deeper capital markets and stricter capital market regulation. However, the level of financial innovation has no clear relation with the real economy. In contrast, the interaction term of financial innovation and growth opportunities shows a significant positive effect on a county's gross domestic product (GDP) growth rate. Suggesting that it is not financial innovation per se that is associated with faster economic growth, but rather higher levels of financial innovation in countries and periods with high growth opportunities. As a conclusion they state, that financial innovation has its 'dark' sides by decreasing the stability of banks which increases its profit volatility. However, on the 'bright' side it also induces bank growth which in turn leads to a higher supply of credit and risk diversification for both firms and households. Both effects are in line with previous research by Wagner (2007), as mentioned above. On net, financial innovation allows countries to grow faster by helping them exploit exogenously given growth opportunities (Beck et al., 2016).

2.3.4 Financial innovation and the financial crisis of 2007-2009

Since financial innovation is an important aspect of financial markets and given that it has an impact on both the real economy as well as individual's wealth, it may have played an important role in the recent financial crisis. Various researchers and economists have examined the structure of the financial market prior to the financial crisis of 2007-2009 to try to determine the causes that led to its collapse. It is argued that the main factors that helped create conditions that led to inflated financial markets and accordingly the crises were: improper incentive schemes, deregulation and financial innovation (Crotty, 2009). This latter possible cause of the development of the financial crisis, financial innovation, is studied more extensively by Boz and Mendoza (2014). The financial crisis in the U.S. was preceded by an expansion in financial innovation creating new financial instruments such as mortgage backed securities. In addition, this period was characterized by an increase in household credit, residential land prices, and leverage ratios.

Boz and Mendoza (2014) model financial innovation as a structural change that introduces a regime with a higher leverage limit. Furthermore, households are risk averse and face a credit constraint. In this new environment two regimes can occur: one in which the high ability to leverage continuous and one in with a lower ability to leverage; both with unkown propabilities. The results reveal that, only after observing a first realization of the state of high ability to leverage (optimistic state), agents are very optimistic and assign high probabilities to that state, underestimating the relevant risk. These very optimistic agents increase their leverage positions, even willing to 'overborrow' and 'undersave' than what is optimal in the rational expectations model. When the first signal of the state with lower ability to leverage (pessimistic state) is recieved, the opposite effect takes over and agents start to 'underborrow' and 'oversave'. The correction to the pessimistic state causes a large correction in bond holdings. During the optimistic phase, households tend to overconsume, although they adjust their consumption levels to the long-run equilibrium quickly. After the pessimistic signal is observed, consumption drops dramatically (Boz & Mendoza, 2014).

Their model explains a significant part of the increase in household credit (about two-thirds) and land prices (about two-fifths) in the period preceding the financial crisis. However, it overestimates the reversal in household credit after the pessimistic signal is received. An explanation for the overestimation could be that the available bond option in the model is a one-period bond, while the average maturity of household debt is much larger, hence making it difficult to abrubtly decline household's debt levels. As a conclusion it can be stated that financial innovation, in an environment with imperfect information and credit frictions, was a central factor behind the credit and land price booms that led to the crisis. In addition, it fulfilled an important role in the transmission mechanism that drove the crisis itself (Boz & Mendoza, 2014).

3. Methodology

Supported by the literature studies covered in the previous section, it can be assumed that a relationship between financial innovation and the real economy exists. However, researchers have opposing views on the sign, either positive or negative, of its effect. Beck et al. (2016) reveal that financial innovation allows countries to grow faster by helping them exploit exogenously given growth opportunities. However, measured by either a new risky security or a risky security together with new information, financial innovation can also increase market volatility (Zapatero, 1998).

This research continuous the study of the impact of financial innovation on the real economy. The model presented in the research of Boz and Mendoza (2014) suggests that financial innovation contributed to the increase in household credit in the period preceding the financial crisis. In addition, financial innovation increases the volatility of individual's wealth (Zapatero, 1998). Both studies suggest that financial innovation could have an impact on aggregate consumption. So far, and to my knowledge, no study examines the impact of financial innovation on consumption. This study fills the gap by investigating the relationship between financial innovation and consumption volatility.

All things considered, financial innovation is assumed to have an effect on consumption volatility. Therefore, the following hypothesis is examined:

Hypothesis: Financial innovation has a significant impact on consumption volatility.

The hypothesis is tested using a significance level of five percent. When a *p*-value smaller than five percent is estimated, significant influence of financial innovation on consumption volatility is concluded. Different variables are used to measure financial innovation. The variables used capture both a broad concept of financial innovation and specific innovations. Following Tédongap (2015), consumption volatility is estimated by a general autoregressive conditional heteroscedasticity (GARCH) process.

3.1 The model

To examine the relationship between financial innovation and consumption volatility, a GARCH (*p,q*) process is implemented. This paragraph provides a summary of the model specification. Bansal and Yaron (2004) already measure consumption volatility as a stochastic process. They show that consumption volatility is important to be able to explain the equity premium puzzle. Nonetheless, estimating consumption volatility by a general autoregressive conditional heteroscedasticity (GARCH) process might be more appropriate. The reason for this is that future consumption and consumption growth is subject to uncertainty (Tédongap, 2015). Uncertainty is captured in the variance of the error terms of a model predicting consumption growth. In addition, periods of high uncertainty, such as the recent financial crisis, can cluster together. Volatility clustering of the error terms, in which large shocks (small) tend to follow large shocks (small) in either direction, can be modelled by a GARCH process. This is because a GARCH process allows for the variance of the error term to depend upon its history (Verbeek, 2012).

An autoregressive conditional heteroskedastic (ARCH) process distinguishes between the unconditional and conditional variance of the error terms. It allows the latter to change over time as a function of past errors while the former remains constant (Engle, 1982). The GARCH process is an extension of the ARCH process and provides a more flexible framework to capture the dynamic structure of conditional variances (Bollerslev, 1986). A GARCH process specifies an equation for both the conditional mean and the conditional variance. The conditional mean equation is a linear regression function that contains both constant and explanatory variables. The conditional mean equation of this study of consumption growth is stated as

$$\Delta c_t = x_t' \theta + \varepsilon_t$$

The explanatory variables, x_t', are discussed in the next paragraph. Since Campbell and Mankiw (1989, 1990 & 1991) argue that time series on consumption and income appear to be closer to log-linear than linear, the included explanatory variables are converted into logarithms. Lower-case letters are used to denote log variables. Additional assumptions on the (conditional) distribution of ε_t have to be made to be able to estimate the model by maximum likelihood. It is assumed that

$$\varepsilon_t = \sigma_t z_t$$

$$z_t \sim NIID(0,1)$$

This implies that the distribution of ε_t, conditional on information I_{t-1}, is normal with mean zero and variance σ_t^2.

$$E(\varepsilon_t^2 | I_{t-1}) = \sigma_t^2$$

$$\varepsilon_t | I_{t-1} \sim N(0, \sigma_t^2)$$

It does not suggest that the unconditional distribution of ε_t is normal. This because σ_t becomes a random variable when it is not conditioned upon I_{t-1}. The unconditional distribution generally has fatter tails than a normal distribution (Verbeek, 2012). The uncertainty about future consumption growth is represented by the conditional variance equation of the error terms.

$$\sigma_t^2 = \omega + \sum_{j=1}^{p} \alpha_j \varepsilon_{t-j}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + \gamma FI_t + w_t'\delta$$

Non-negativity of σ_t^2 requires that $\alpha_j \geq 0$, $\beta_j \geq 0$ and $\gamma \geq \bar{\gamma}$. A high conditional variance implies more uncertainty. The coefficient γ measures the impact of financial innovation, FI_t, on consumption volatility. To guarantee a positive conditional variance, its lower limit is restricted to $\bar{\gamma}$. The coefficient γ is tested using a significance level of five percent. An estimated *p*-value smaller than five percent, associated with the coefficient γ, results in a rejection of the null hypothesis of no impact of financial innovation on consumption volatility. Consequently, significant influence of financial innovation on consumption volatility is concluded. Different variables are used as a measure for financial innovation, which are discussed in the next paragraph. In addition, control variables ($w_t'\delta$) affecting consumption volatility are also included. The appropriate lag length (*p, q*) of the GARCH process is determined using Information Criteria and a likelihood-ratio test. The considered Information Criteria are the Akaike Information Criterion (AIC) and the Schwarz's Bayesian Information Criterion (SBIC).

The squared error term can be divided into two separate components: its conditional expectation and a surprise term, v_t, uncorrelated with I_{t-1}.

$$\varepsilon_t^2 = E(\varepsilon_t^2 | I_{t-1}) + v_t$$

$$E(v_t | I_{t-1}) = 0$$

$$v_t \sim NIID(0,1)$$

The surprise term, v_t, can therefore be defined as

$$v_t \equiv \varepsilon_t^2 - \sigma_t^2$$

If z_t does not follow a standard normal distribution, the maximum likelihood procedure may still provide consistent estimators. This is because, under weak assumptions, the first-order conditions of the maximum likelihood procedure are also valid. The estimation is then referred to as quasi-maximum likelihood estimation (Romer, 2012). It is also possible to make alternative assumption on the distribution of z_t. The appropriate distribution is determined by plotting the error terms. A standardized *t*-distribution or a Generalized Error Distribution (GED) is chosen if the distribution of z_t is not in accordance with the normal distribution.

Given the surprise term and the conditional variance, the GARCH (*p,q*) process can be interpreted as an autoregressive moving average process (ARMA) in ε_t^2.

$$\varepsilon_t^2 = \omega + \sum_{j=1}^{p} \alpha_j \varepsilon_{t-j}^2 + \sum_{j=1}^{q} \beta_j \varepsilon_{t-j}^2 - \sum_{j=1}^{q} \beta_j v_{t-j} + v_t$$

The root of the autoregressive part equals $\alpha_j + \beta_j$, so that stationarity requires $\alpha_j + \beta_j < 1$. Since the restrictions for non-negativity of σ_t^2 already required α_j and β_j to be larger than zero, a stationary solution exists if $0 \leq \alpha_j + \beta_j < 1$. Values of $\alpha_j + \beta_j$, close to one imply that the persistence in volatility is high. Taking the expectation of the squared error term, the unconditional (constant) variance becomes

$$\sigma^2 = E(\varepsilon_t^2) = \frac{\omega}{1 - \sum_{j=1}^{p} \alpha_j - \sum_{j=1}^{q} \beta_j}$$

3.2 Explanatory variables x_t'

As argued by (Beck et al., 2016), the impact of financial innovation on the banking sector and the real economy is more pronounced in a country with deep capital markets and strict capital market regulation. Therefore, this study examines the relationship between consumption volatility and financial innovation in the United States. The United States represents a country that meets these conditions. The next section explains the explanatory variables, x_t', included in the mean equation of the GARCH (*p,q*) process.

3.2.1 Income and consumption

Following previous studies, lagged values of income growth, the log consumption-income ratio and interest growth rate are added in the conditional mean equation predicting consumption growth (Campbell & Mankiw, 1989, 1990 & 1991). The log consumption-income ratio turns into an 'error-correction term' when the permanent-income hypothesis is assumed to be true. This is because it implies that consumption and income are cointegrated (Engle & Granger, 1987).

This study measures consumption (i.e. consumption volatility) by real personal consumption expenditures per capita on services and non-durable goods. Furthermore, income is measured by real disposable personal income per capita. Both income and consumption volatility are available on a quarterly basis, and reported in seasonally adjusted values. To incorporate the effect of financial markets, the quarterly averaged three-month Treasury bill rate is used.

3.2.2 Liquidity constraints

The excess sensitivity of consumption to income is often interpreted as evidence that liquidity constraints are important for understanding consumer spending (Zeldes, 1989). Also, deregulation may have relaxed liquidity constraints in such a way that consumption is able to move with permanent income (Campbell & Mankiw, 1991). Consequently, the impact of liquidity constraints is captured in the coefficient associated with the income variable. This study, therefore, does not include a separate variable measuring liquidity constraints.

3.3 Specification issues

Before the conditional mean equation can be estimated, two specification issues have to be addressed. The first specification issue concerns the possible correlation between the explanatory variables and the error term ε_t. This issue originates from the permanent income hypothesis, proposed by Friedman (1957). He argues that an individual's consumption in a given period is determined by his or her lifetime income. This implies that an individual's consumption is not determined by their income in that same period but by their lifetime income. If the permanent income hypothesis is true, the error term will be correlated with the explanatory variables. The solution to this problem is to use Instrumental Variables (IV), where any lagged stationary variable is an appropriate instrument (Campbell & Mankiw, 1991).

A second specification issue concerns the data used. Data on both consumption and income is only available on a quarterly basis instead of points in time, meaning that the data is time-averaged. Time-averaged data causes the error term in the conditional mean equation to follow an MA(1) process. However, the parameter estimates will be consistent when twice-lagged instruments are used. Using twice lagged instruments accounts for first-order auto- and cross correlations in the error term caused by time-averaged data. It also accounts for a white noise measurement error in the levels of consumption and income leading to a MA(1) process in the error term. Furthermore, some durability might exist in the goods labelled 'non-durables and services' leading again to an MA(1) process in the error term (Campbell & Mankiw, 1991).

3.4 Measures of financial innovation FI_t

Gauging innovative activity in the financial sector is challenging. As shown in the literature review, several studies use different measures to calculate financial innovation. Therefore, this study also measures financial innovation using different variables. The variables used capture both a broad concept of financial innovation as well as specific innovations. Along these lines, this study tries to identify the different channels through which financial innovation impacts consumption volatility. This section explains the different measures of financial innovation, FI_t, included in the conditional variance equation of the GARCH (p,q) process.

3.4.1 Off-balance-sheet items

As revealed in several studies, regulation can be assumed to be one of the key drivers behind innovation (Miller, 1986 and Ben-Horim & Silber, 1977). Beck et al. (2016) argue that capital requirements, faced by banks, have led to an increase in new products that can be booked off the balance sheet. In this way, financial innovation has allowed banks to avoid regulatory capital requirements, which are charged on balance sheet items only. Therefore, a consequence of new regulation faced by banks might result in an increase in off-balance-sheet items. Financial innovation, measured by the sum of off-balance-sheet items, represents a broad measure that captures innovation induced by regulation.

Off-balance-sheet data is provided for US depository institutions and collected from the database of the Board of Governors of the Federal Reserve System. A depository institution is a financial institution that is legally allowed to accept monetary deposits from consumers such as banks and credit unions. The off-balance-sheet data is part of the Enhanced Financial Accounts, which tries to paint a more detailed picture of financial intermediation in the United States. Reported off-balance-sheet items include unused commitments such as credit card lines, construction loan commitments, revolving open-end lines and other unused commitments. In addition, it includes letters of credit and derivatives. The derivatives consist of credit-, interest- and other derivatives.

The variable measuring financial innovation using off-balance-sheet items is reported relative to total assets held by depository institutions. Data is available on a quarterly basis from 1990 up to and including 2016. However, values for credit derivatives are only available from 2006 through 2016. Therefore, the complete length of the dataset covers the period 2006 through 2016.

3.4.2 R&D Expenditures

Another broad variable used to measure financial innovation is Research and Development (R&D) expenditures. The R&D measure is the main gauge of financial innovation in the study of Beck et al. (2016). It includes both total intramural (within firm) and extramural (acquired from outside) expenditures of financial and insurance activities. This study also implements R&D expenditures as a broad measure for financial innovation. The original dataset of Beck et al. (2016) is enlarged with newly available data.

Data is collected from the Analytical Business Enterprise Research and Development database (ANBERD). This database collects internationally comparable data of R&D expenditures across industries and time. It is primarely based on an enterprise survey of the OECD/Eurostat and includes 32 nations from 1987 through 2014. Unfortunately, reported data for the United States is only available for the period 2002 up to and including 2014. Therefore, the data is complemented by annually reported R&D expenditures of the OECD Structrual Analysis database (STAN). Data points provided by the STAN database are primarely based on countries' annual national accounts and complemented by results form national business surveys of the OECD/Eurostat. Merging both databases, financial innovation can be measured annually by R&D expenditures from 1996 through 2014.

The STAN database reports values for financial R&D intensity relative to the value added in the financial intermediation sector. Therefore, the data collected from the ANBERD database is adjusted appropriately; the value of R&D expenditures of financial intermediation is divided by gross value added of the financial intermedation collected from the OECD datatabase. In addition, R&D

expenditures are only reported once a year. As a result, the GARCH (p,q) has to be estimated again with annual values instead.

3.4.3 Securitization

Various studies, such as Zapatero (1998), measure financial innovation using a new security. For example, Wagner (2007) uses new credit derivative instruments as a measure for financial innovation. Keys. et al (2010) use both securitization and other derivative securities as a measure for financial innovation. In addition, Beck et al. (2016) construct an indicator of the securitization capacity of a country. This study measures financial innovation using both securitized assets and derivatives to be able to capture a more specific concept of financial innovation.

To measure financial innovation using securitized assets, the same approach as Beck et al. (2016) is used. The sum of the outstanding values of all securitized assets, including asset-backed securities (ABS), collateralized debt obligations (CDO), and mortgage-back securities (MBS) is calculated to measure financial innovation. Data for all types of securitized assets is available per quarter and collected from the database of the Board of Governors of the Federal Reserve System. The Financial Accounts of the United States have been consulted to acquire the necessary values.

Firstly, the variable measuring total outstanding asset-backed securities (ABS) is constructed. It combines total reported value of outstanding asset-backed securities with asset-backed commercial paper issued by U.S.-chartered depository institutions. Secondly, the total value of outstanding MBS is calculated by the sum of MBS issued by U.S.-chartered depository institutions, a federal agency, a government-sponsored enterprise (GSE) and mortgage real estate investment trusts. Both values are added together and divided by GDP, collected from the Bureau of Economic Analysis database, to provide a specific measure of financial innovation. Data is available since 1984 up to and including 2016.

3.4.4 Derivatives

Financial innovation is also measured using derivatives. The derivative variable takes swaps, forward contracts and other derivatives, that are part of either credit derivatives, interest rate derivatives or other derivatives into account. Other derivatives include, among others, foreign exchange derivatives. The total notional amount is received from the off-balance-sheet items of depository institutions provided by the Board of Governors of the Federal Reserve System. The same database has been consulted for the regulation induced measure of financial innovation; off-balance-sheet items.

The measure of financial innovation, using derivatives, is reported relative to total assets held by depository institutions. To construct the variable, the total notional amount of the three types of derivatives is added together. As with the off-balance-sheet items measure of financial innovation, the complete dataset is only available after 2005. This is because values for credit derivatives are only available from 2006 through 2016. Therefore, the complete length of the dataset covers the period 2006 up to and including 2016.

3.4.5 Credit card debt

So far, specific and broad measures of financial innovation have been discussed that may have had an impact on consumption volatility. However, also an indirect measure of financial innovation might be important. As mentioned in the literature review, the financial crisis in the U.S. was preceded by both an expansion in financial innovation creating new financial instruments and an increase in household credit. Boz and Mendoza (2014) focus on the role of financial innovation affecting household's ability to borrow and conclude that financial innovation, in an environment with imperfect information and credit frictions, was a central factor behind the credit and land price booms that led to the crisis. Considering this, a measure that captures the increased ability to borrow is relevant to the estimated process.

To measure the role of financial innovation affecting household's ability to borrow, credit card debt is considered. This because credit card balances have experienced an increase in amount outstanding preceding the financial crisis and a decrease after[2]. In addition, it is the most common type of debt used by US households[3]. Therefore, measuring financial innovation using credit card debt is appropriate. Data is collected from the Center for Microeconomic Data (CMD) of the Federal Reserve Bank of New York. The CMD centralizes the collection, acquisition, and analysis of microeconomic data at the New York Fed. It builds on two large data collection projects: the New York Fed Consumer Credit Panel and Survey of Consumer Expectations. The variable credit card debt is calculated relative to total household debt and is reported quarterly from 1999 up to and including 2016.

3.5 Control variables $\boldsymbol{w_t'\delta}$

The relationship between financial innovation and consumption volatility is estimated while holding other factors, that are also found to influence consumption volatility, constant. Without the inclusion of these control variables, the estimated effect would suffer from omitted variable bias. The first control variable captures the impact of financial integration on consumption volatility. Existing literature suggests that the impact of financial integration on macroeconomic volatility is ambiguous. Kose, Prasad and Terrones (2003) show that financial openness increases consumption volatility. On the other hand, financial integration is also found to have a negative impact on consumption volatility (Baxter & Crucini, 1995). This study measures financial integration using foreign direct investment (FDI), relative to GDP, and invested in the US. Financially integrated economies seem to attract a disproportionately large share of FDI inflows (Prasad, Rogoff, Wei, & Kose, 2003). In addition, a

[2] Appendix, Figure 1
[3] Appendix, Figure 2

positive relationship exists between FDI and economic growth (Borensztein, De Gregorio, & Lee, 1998).

The second set of control variables captures the impact of trade on consumption volatility. Kose, Prasad and Terrones (2003) reveal that both trade openness and the terms of trade increase consumption volatility. In contrast, financial market development significantly reduces the impact of the terms of trade volatility on consumption volatility (Andrews & Rees, 2009). This means that greater access to financial markets allows households to smooth their consumption. Following both studies, the impact of trade on consumption volatility is measured using the terms of trade and a trade openness variable. Trade openness is measured by the ratio of real exports and real imports relative to GDP. Lastly, a control variable measuring access to financial markets and financial deepening is estimated by the ratio of M2 to real GDP. Data for all control variables is collected from the database of the Federal Reserve Bank.

3.6 Robustness check

To examine the robustness of the results, the volatility of consumption is measured in another manner. Following Campbell and Mankiw (1989, 1990 & 1991), consumption growth is estimated using an instrumental variable (IV) approach. The resulting error terms are extracted and modelled as a GARCH (*p*,*q*) process. Consequently, the different measures of financial innovation are included in the variance equation of the GARCH (*p*,*q*) process to examine whether they significantly impact consumption volatility.

As previous research suggests, income growth, consumption growth and interest rate growth are included as instruments. To account for the specification issues mentioned above, the included instruments are lagged at least twice. Given the log-linear relationship of consumption and income, the instruments are converted into logarithms.

4. Data

4.1 Preliminary statistics

To ensure that the GARCH (*p,q)* process can be properly estimated, the data is tested and, when needed, converted. In this section, preliminary statistical tests are conducted to guarantee valid results.

4.1.1 Stationarity

The explanatory variables are converted into logarithms to account for the log-linear relationship of consumption and income. To be able to estimate consumption growth correctly, the included variables are modified to meet the stationarity condition. Using an Augmented Dickey Fuller (ADF) test the variables are tested for the presence of a unit root. To ensure that the distributional results are valid, the Akaike Information Criterion (AIC) and the Schwarz's Bayesian Information Criterion (SBIC) are used to determine the appropriate number of lags p for the autoregressive (AR(p)) process (Verbeek, 2012).

The null hypothesis of a unit root in the ADF-test can be rejected for the variables income growth, consumption growth and interest rate growth[4]. However, the consumption-income ratio appears to be non-stationary, rejecting cointegration proposed by Engle and Granger (1987). It is striking that no evidence of cointegration between income and consumption can be found in this dataset. To make sure that this result is valid, an Engle-Granger test is performed. Comparing the test result with the appropriate critical values does not lead to a rejection of the null hypothesis of no cointegration[5]. Therefore, the consumption-income ratio does not convert into an error-correction term as suggested by Engle and Granger (1987). In order to prevent spurious regression results, the consumption-income ratio is not taken into account in the conditional mean equation.

4.1.2 The GARCH (*p,q*) process

Considering all the variables, the GARCH (*p,q*) process is stated as follows

$$\Delta c_t = x_t'\theta + \varepsilon_t$$

with
$$x_t'\theta = \mu + \theta_1 \Delta y_{t-2} + \theta_2 \Delta i_{t-2}$$

and
$$\sigma_t^2 = \omega + \sum_{j=1}^{p} \alpha_j \varepsilon_{t-j}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + \gamma FI_t + \delta_1 \left(\frac{X+I}{GDP}\right)_t + \delta_2 TOT_t + \delta_3 \frac{M2}{GDP_t} + \delta_4 \left(\frac{FDI}{GDP}\right)_t$$

where y_t represents the income variable, i_t the Treasury bill rate, $\left(\frac{X+I}{GDP}\right)_t$ the trade openness control variable, TOT_t the terms of trade control variable, $\frac{M2}{GDP_t}$ the financial depth control variable and $\left(\frac{FDI}{GDP}\right)_t$ the financial integration control variable. To account for the specification issues previously discussed, it is estimated using twice-lagged explanatory variables. Subsequently, the error term of the conditional mean equation is extracted and its distribution is plotted relative to the normal distribution[6]. The graphs show that the conditional mean is not significantly different form zero and the distribution can be approximated by the normal distribution. Therefore, the assumption of a normal distributed error term ε_t, conditional on information I_{t-1}, underlying the GARCH(*p,q*) process is assumed to be met.

Furthermore, the appropriate lag length of the GARCH (*p,q*) process is determined. It is approximated using the largest dataset covering the period 1984 through 2016. When the correct lag length is determined, the impact of financial innovation on consumption volatility is estimated. Different model specifications, varying both the included ARCH and GARCH effects from one to two, are estimated. The AIC, SBIC and the likelihood-ratio test of the different models are compared to be able to select the model that fits the data most accurately. Comparisons are made among the

[4] Appendix, Table 1
[5] Appendix, Table 2
[6] Appendix, Figure 7, 8 and 9

different process specification. Lastly, the choice is down to three model specifications: GARCH (1,2) and GARCH (2,1) and GARCH (1,1). Comparing the information criteria and the likelihood-ratio test it can be concluded that a GARCH (1,1) process is preferred above all the other specifications[7]. Therefore, consumption volatility is estimated by a GARCH (1,1) process. Summary statistics and graphs of both the explanatory variables and the measures of financial innovation are reported in, respectively, Table 5 and 6 and Figure 3-6 and 10-14 in the Appendix.

5. Results

Firstly, the GARCH (1,1) process is estimate with neither the inclusion of financial innovation measures nor control variables. It is estimated twice, using both quarterly and annual data. Considering the results of the mean equation, it can be concluded that income growth significantly affects consumption growth. In both the quarterly and annually estimated processes, a one percent increase in income growth increases consumption growth with 0.278 percent and 0.541 percent, respectively. The coefficients are both larger than zero, and smaller than one. Therefore, two types of consumers can be identified - one consuming their permanent income and the other consuming their current income. This result is in line with previous research of Campbell and Mankiw (1989, 1990 & 1991). In addition, the effect is not altered when consumption growth is estimated using instrumental variables[8].

On the contrary, consumption growth is not significantly affected by changes in the interest growth rate. This contrasts with the findings of Campbell and Mankiw (1989, 1990 & 1991), who find a significant and positive relationship between the quarterly average three-month Treasury bill rate and consumption growth. Analyzing the quarterly estimated variance equation, it can be stated that both the lagged squared error term and the lagged variance term are able to explain the variation in consumption volatility. Adding the coefficients together generates an outcome close to one, implying that the persistence in volatility is high. However, neither the lagged error term nor the lagged variance term is able to explain the variation in consumption volatility when the process is estimated using annual data. Nevertheless, both GARCH (1,1) processes generate a stationary solution.

Different measures of financial innovation are included in the variance equation to estimate the impact of financial innovation on consumption volatility. The results are shown in Table 2. Including the different measures of financial innovation measures in the variance equation, reduces the impact of income growth on consumption growth. Specifically, income growth is only able to predict consumption growth in the largest two datasets. The impact of the interest growth rate on consumption growth is not altered when financial innovation measures are considered.

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[7] Appendix, Table 3 and 4

[8] Appendix, Table 7

Table 1.
Estimated output of the GARCH (1,1) process

Variable	(1)	(2)
Mean equation		
Income growth	0.278	0.541
	(0.034)**	(0.260)*
Interest rate growth	0.001	-0.008
	(0.001)	(0.006)
Variance equation		
Constant	$1.32*10^{-6}$	0.000
	$(3.31*10^{-8})$**	(0.000)**
ε_{t-1}^2	-0.090	0.623
	(0.001)**	(0.530)
σ_{t-1}^2	1.031	-0.241
	(0.000)**	(0.252)
R^2	-0.657	0.107
Number of observations	129	16
Period	1984Q1-2016Q4	1999-2014

Note: Standard errors in parentheses.
** and * denote significance at the 1% and 5% levels, respectively.

Furthermore, it can be concluded that innovations in the form of securitization have contributed to an increase consumption volatility. In contrast, innovations in the form of derivatives have contributed to a decrease in consumption volatility. The two effects are small but, nonetheless, significant (*p*-values are smaller than five percent). Therefore, it can be stated that the influence of financial innovation, measured by a new risky security, goes beyond its impact on market volatility (Zapatero, 1998). Financial innovation not only increases market volatility as a whole, it directly impacts the consumer. Consumption volatility is, however, not significantly affected by R&D expenditures, off-balance-sheet items and credit card debt (*p*-values are larger than five percent). Therefore, the null hypothesis of no impact of financial innovation on consumption volatility can only be rejected for the securitization and derivative measure of financial innovation.

The results show that a one-dollar increase in the outstanding value of securitized assets (relative to GDP) increases consumption volatility with $4.71*10^{-8}$. While a one-dollar increase in the outstanding value of derivatives (relative to total assets) decreases consumption volatility with $1.20*10^{-6}$. Therefore, the reduction in the ex-ante incentives of financial intermediaries to carefully screen and monitor borrowers, caused by securitization, resulted in an increase in consumption volatility. It could be that consumers who were not creditworthy, received approval on new credit and increased their spending of non-durables and services. Once the first term of their credit passed, it became apparent they could not afford it, causing a reduction in the consumption of non-durables and services. In addition, the complexity of the securitization process induced the creation of new securities that were too complex to price correctly and to monitor appropriately. All in all, the securitization process contributed to an increase in consumption volatility.

Table 2.
Estimated output of the GARCH (1,1) process using different measures of financial innovation included in the variance equation

Variable	(1)	(2)	(3)	(4)	(5)
Mean equation					
Income growth	0.061	0.485	0.253	0.061	0.139
	(0.041)	(0.251)	(0.051)**	(0.039)	(0.048)**
Interest rate growth	0.001	-0.005	-0.000	0.001	0.001
	(0.001)	(0.012)	(0.001)	(0.001)	(0.001)
Variance equation					
Constant	0.000	0.000	$-6.13*10^{-5}$	0.000	$5.33*10^{-5}$
	(0.000)	(0.005)	$(2.96*10^{-5})$*	(0.000)	$(9.57*10^{-5})$
$\boldsymbol{\varepsilon_{t-1}^2}$	0.150	0.149	0.150	0.150	0.150
	(0.299)	(0.505)	(0.129)	(0.277)	(0.194)
$\boldsymbol{\sigma_{t-1}^2}$	0.600	0.600	0.600	0.600	0.600
	(0.488)	(1.220)	(0.226)**	(0.471)	(0.389)
Off-balance-sheet items	$-1.21*10^{-6}$				
	$(6.58*10^{-7})$				
R&D		-0.001			
		(0.001)			
Securitization			$4.71*10^{-8}$		
			$(1.34*10^{-8})$**		
Derivatives				$-1.20*10^{-6}$	
				$(5.58*10^{-7})$*	
Credit card debt					$9.73*10^{-5}$
					(0.000)
Trade openness	-0.000	$2.78*10^{-5}$	$8.97*10^{-6}$	-0.000	$-1.89*10^{-6}$
	(0.001)	(0.007)	(0.000)	(0.001)	(0.000)
Terms of trade	$-1.37*10^{-6}$	$-1.12*10^{-6}$	$2.84*10^{-7}$	$-1.33*10^{-7}$	$-5.82*10^{-7}$
	$(1.06*10^{-6})$	$(6.50*10^{-5})$	$(1.12*10^{-7})$*	$(7.71*10^{-7})$	$(9.82*10^{-8})$**
Financial depth	0.000	0.000	0.000	$0.00*10^{-5}$	$7.24*10^{-5}$
	(0.000)	(0.010)	$(4.00*10^{-5})$**	(0.000)	(0.000)*
Financial integration	$-3.16*10^{-7}$	$5.77*10^{-7}$	$-3.60*10^{-7}$	$-3.09*10^{-9}$	$-2.29*10^{-7}$
	$(5.17*10^{-7})$	$(3.59*10^{-5})$	$(1.35*10^{-7})$**	$(4.66*10^{-7})$	$(4.38*10^{-7})$**
R^2	-0.129	0.097	-0.661	-0.129	-0.453
Number of observations	44	16	129	44	72

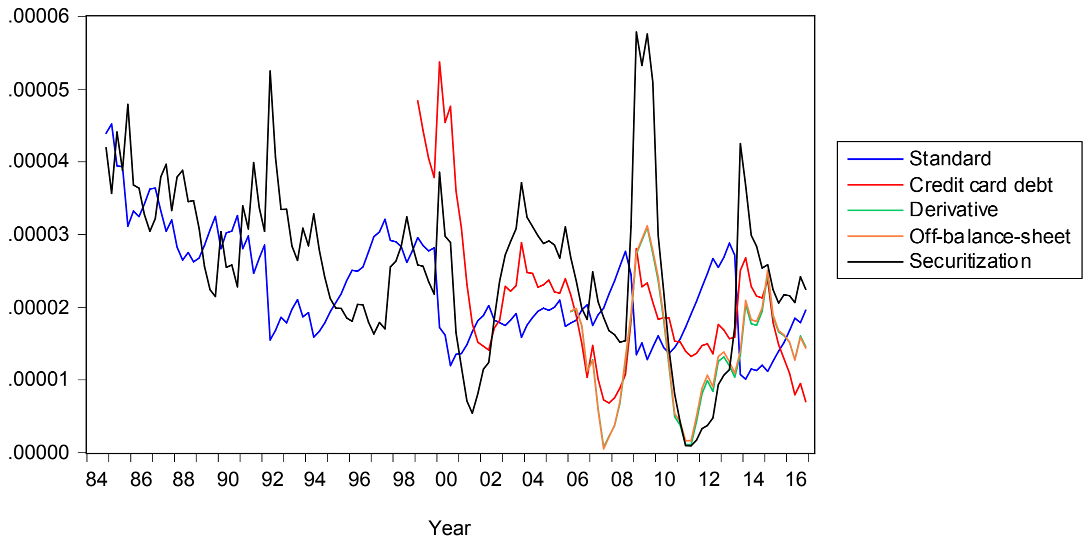
Note: Standard errors in parentheses.
** and * denote significance at the 1% and 5% levels, respectively.

The negative impact of derivatives on consumption volatility is difficult to reconcile with existing literature. According to Wagner (2007), new credit derivative instruments increased both the liquidity of bank assets and risk taking in the banking sector. The latter indirect effect offsets the former direct effect, therefore, reducing bank stability. In contrast, this study shows that the incentive to take on an amount of new risk is more than offset by the increase in liquidity. The conflicting result might be caused by the derivate measure of financial innovation, which contains not only credit derivatives but also other derivatives. Higher asset liquidity, induced by derivatives, directly benefits the stability of the banking sector by reducing the risk on bank's balance sheet (Wagner, 2007). Subsequently, a more stable banking sector decreases the probability of a bank run and might also increase consumer confidence within the same sector. In addition, a highly liquid bank can offer consumers a more reasonable price on their loans as compared to a bank in distress. As a result, an increase in the value of outstanding derivatives decreases consumption volatility. However, the results of the GARCH (1,1) processs, estimated using the error term of the IV regression, contradicts the above-mentioned conclusion. Specifically, the different measures of financial innovation do not have a significant impact on consumption volatility when consumption volatility is estimated using instrumental variables[9]. Therefore, the results should be interpreted with caution.

The conditional variance of consumption across time, estimated using the GARCH (1,1) process, is shown in Figure 1[10]. The graph distinguishes between the different measures of financial innovation. All are compared to the standard process, which neither includes financial innovation measures nor control variables. The standard process identifies the stabilization of economic activity in the mid 1980s, which is accompanied by a reduction in the conditional variance. In addition, an increase in the conditional variance of consumption is observed in the 1990s, during the recent financial crisis and in 2011, when the debate centered around the raising of the federal government debt ceiling. The graphs, incorporating a measure of financial innovation, are able to distinguish between additional crises. For example, the recession of the late 1980s and the savings and loan crisis of 1989-1990, which are both accompanied by an increase in the conditional variance. Furthermore, the graphs including a measure of financial innovation, experience approximately the same trend.

Figure 1.

Conditional variance of consumption across time



To be able to describe the relationship between financial innovaiton and consumption in more detail, the financial innovation measures are also included in the mean equation. The measures of financial innovation are lagged twice to account for the specification issues mentioned above. Table 3 displays the results of the GARCH (1,1) process when the different measures of financial innovation

[9] Appendix, Table 8
[10] The annually estimated conditional variance is shown in Figure 15 in the Appendix

are included in the mean equation. It shows that all quarterly estimated measures of financial innovation significantly impact consumption growth. In contrast, the annually estimated measure of financial innovation, R&D expenditures, does not significantly affect consumption growth. Both results hold when the impact of financial innovation on consumption growth is estimated using an IV regression[11]. It is noteworthy that, financial innovation measured by R&D expenditures is neither able to explain the variation in consumption volatility nor consumption growth. This is curious since it should help countries exploit growth opportunities (Beck et al., 2016). A possible interpretation could be that consumers cannot take advantage of these growth opportunities presented by financial innovation.

Table 3 also shows that a positive relationship between financial innovation, measured by credit card debt, and consumption growth exists. Increasing the outstanding credit card debt value (relative to household debt) by one increases consumption growth by four percent. Therefore, it can be concluded that the ability to borrow increases consumption growth, which is as expected. In addition, financial innovation, measured by a new security, positively affects consumption growth. Although relatively small, a one-dollar increase in the value of securitized assets (relative to GDP) and a one-dollar inrease in the value of derivatives (relative to total assets), increases consumption growth by $1.36*10^{-3}$ and 0.02 percent, respectively. Lastly, a postive relationship between the off-balance-sheet measure of financial innovation, capturing a broad concept of financial innvation, and consumption growth exists. Specifically, a one-dollar increase in the value of off-balance-sheet assets (relative to total assets) increases consumption growth with 0.02 percent. The significance of the off-balance-sheet measure of financial innovation might be caused by the influence of the derivative measure. This because the off-balance-sheet measure mainly consist of derivative securities. More strength is added to this argument when the conditional variance graph is examined. Both conditional variances reflect the same trend. Nonetheless, this seems to be irrelevant for the relationship between consumption volatility and off-balance sheet items. Furthermore, it is striking that both securitized assets and derivative securities increase consumption growth while they have opposing influences on consumption volatility.

Since financial innovation may have had an important role in the recent financial crisis, a comparison of the impact of financial innovation is made between the period preceding and after the financial crisis. The sample is divided into two periods (1) preceding the financial crisis (1984Q/1999Q1 through 2006Q4) and (2) after and including the financial crisis (2007Q1 through 2016Q4). The off-balance-sheet and derivative measures of financial innovation are only available after 2005 which makes it impossible to estimate their impact on consumption growth in the period preceding the financial crisis. This also applies to the R&D expenditures measure of financial innovation; the period preceding the financial crisis contains too few data points to be able to estimate

[11] Appendix, Table 9

its impact. Nevertheless, the impact of financial innovation on consumption growth, measured by both credit card debt and securitization, can be compared.

Table 3.
Estimated output of the GARCH (1,1) process using different measures of financial innovation included in the mean equation

Variable	(1)	(2)	(3)	(4)	(5)
Mean equation					
Income growth	0.021	0.391	0.163	0.021	0.022
	(0.060)	(0.737)	(0.034)**	(0.060)	(0.054)
Interest rate growth	0.001	-0.005	0.001	0.001	0.002
	(0.001)	(0.006)	(0.001)	(0.001)	(0.001)**
Off-balance-sheet items	0.000				
	$(5.20*10^{-5})$**				
R&D		0.018			
		(0.056)			
Securitization			$1.36*10^{-5}$		
			$(1.36*10^{-6})$**		
Derivative				0.000	
				$(5.27*10^{-5})$**	
Credit card debt					0.040
					(0.007)**
Variance equation					
Constant	$1.67*10^{-5}$	0.000	$6.37*10^{-5}$	$1.63*10^{-5}$	$2.22*10^{-5}$
	$(6.51*10^{-5})$	(0.014)	$(9.50*10^{-6})$**	$(2.25*10^{-5})$	$(3.05*10^{-5})$
$\boldsymbol{\varepsilon^2_{t-1}}$	0.150	0.145	0.150	0.150	0.150
	(0.223)	(0.592)	(0.097)	(0.193)	(0.152)
$\boldsymbol{\sigma^2_{t-1}}$	0.600	0.597	0.600	0.600	0.600
	(0.792)	(1.999)	(0.182)**	(0.607)	(0.319)*
Trade openness	0.000	0.002	$-5.74*10^{-5}$	0.000	$4.36*10^{-5}$
	$(6.51*10^{-5})$*	(0.022)	$(6.95*10^{-5})$	(0.000)	(0.000)
Terms of trade	$-5.15*10^{-7}$	$-4.02*10^{-6}$	$-4.30*10^{-5}$	$-5.49*10^{-7}$	$-2.67*10^{-7}$
	$(7.36*10^{-7})$	(0.000)	$(3.28*10^{-8})$**	$(4.84*10^{-7})$	$(2.42*10^{-7})$
Financial depth	$-8.11*10^{-5}$	-0.001	$-3.44*10^{-5}$	$-9.68*10^{-5}$	$8.93*10^{-6}$
	$(5.49*10^{-5})$	(0.007)	$(3.28*10^{-5})$	$(1.07*10^{-5})$**	$(2.00*10^{-5})$
Financial integration	$2.56*10^{-7}$	$2.47*10^{-6}$	$1.06*10^{-7}$	$3.07*10^{-7}$	$-5.87*10^{-8}$
	$(1.87*10^{-7})$	$(2.61*10^{-5})$	$(1.24*10^{-7})$	$(1.26*10^{-7})$*	$(1.33*10^{-7})$
R^2	0.022	0.093	-0.399	0.023	0.156
Number of observations	42	16	129	42	70

Note: Standard errors in parentheses.
** and * denote significance at the 1% and 5% levels, respectively.

The results, displayed in Table 4, show that separating the sample into the two sub-samples reduces the impact of securitization on consumption volatility. In addition, the overall relationship between credit card debt and consumption volatility is not altered by the separation. Table 4 reveals that the positive impact of securitized assets on consumption growth is mostly concentrated in the period preceding the financial crisis. This empowers the argument stating that securitization made it relatively easy for consumers to obtain credit, leading to an increase in consumption. The overall positive relationship between securitization and consumption volatility could be assigned to the positive impact of securitization on consumption growth in the period preceding the financial crisis.

Furthermore, the use of credit card debt for the consumption of non-durables and services is also concentrated in the period preceding the financial crisis. This is in line with the data, which reveals a that the period preceding the financial crisis was characterized by an increase in household credit. It could be that consumers were optimistic in the early sub-sample, underestimating the relevant risk of additional credit. Therefore, the higher ability to leverage, provided by financial innovation, induces consumers to 'overborrow' than to what is rationally optimal. However, no sign of a reversal effect can be found once consumers received the pessimistic signal of a new crisis. Both results are in line with previous research of Boz and Mendoza (2014). This reinforces the argument that financial innovation has played an important role in the recent financial crisis, since the impact of both measures of financial innovation are paticularly expressed in the period preceding the financial crisis.

The effect and significance of the control variables on consumption volatility depends on the included measure of financial innovation. Overall, it can be stated that the control variables are important to include when consumption volatility is estimated. It should be noted that the sign of the associated coefficients is often altered depending on the sample period and estimation method. Therefore, no concluding remarks can be made upon their impact on consumption volatility.

Table 4.
Estimated output of the GARCH (1,1) process distinguishing the period preceding the financial crisis from the period after the financial crisis. The measures of financial innovation are included in the mean equation.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mean equation								
Income growth	0.402 (0.078)**	0.053 (0.041)	0.279 (0.089)**	0.053 (0.037)	0.180 (0.043)**	0.051 (0.043)	-0.038 (0.72)	0.027 (0.050)
Interest rate growth	-0.001 (0.005)	0.001 (0.001)	0.001 (0.005)	0.001 (0.001)	0.000 (0.003)	0.001 (0.001)	0.007 (0.004)	0.001 (0.001)
Securitization					$1.39*10^{-5}$ $(1.31*10^{-6})$**	$3.19*10^{-7}$ $(1.49*10^{-6})$		
Credit card debt							0.054 (0.007)**	0.021 (0.011)
Variance equation								
Constant	-0.000 $(4.96*10^{-5})$*	$4.27*10^{-5}$ (0.000)	$4.07*10^{-5}$ (0.003)	$6.77*10^{-6}$ (0.000)	$9.30*10^{-5}$ $(2.36*10^{-5})$**	$4.86*10^{-5}$ $(7.71*10^{-5})$*	$1.10*10^{-5}$ $(2.46*10^{-5})$*	$4.45*10^{-5}$ $(8.45*10^{-5})$*
$\boldsymbol{\varepsilon_{t-1}^2}$	0.150 (0.263)	0.150 (0.371)	0.150 (0.554)	0.150 (0.297)	0.150 (0.168)	0.150 (0.268)	0.150 (0.477)	0.150 (0.239)
$\boldsymbol{\sigma_{t-1}^2}$	0.600 (0.366)	0.600 (0.764)	0.600 (3.168)	0.600 (0.902)	0.600 (0.212)**	0.600 (1.157)	0.600 (0.814)	0.600 (0.850)
Securitization	$-2.62*10^{-7}$ $(2.56*10^{-7})$	$2.07*10^{-8}$ $(2.25*10^{-8})$						
Credit card debt			-0.001 (0.003)	0.000 (0.002)				
Trade openness	0.000 (0.000)*	$-8.35*10^{-5}$ (0.000)	-0.000 (0.006)	$-2.28*10^{-5}$ (0.001)	-0.000 $(3.62*10^{-5})$**	$-2.68*10^{-6}$ (0.000)	$-6.39*10^{-6}$ (0.000)	$6.57*10^{-5}$ (0.000)
Terms of trade	$5.60*10^{-7}$ $(7.55*10^{-8})$**	$-5.50*10^{-7}$ $(8.36*10^{-7})$	$8.53*10^{-7}$ $(1.44*10^{-5})$	$-5.53*10^{-7}$ $(5.53*10^{-7})$	$-3.48*10^{-7}$ $(2.46*10^{-7})$	$-6.36*10^{-7}$ $(4.93*10^{-7})$	$8.03*10^{-8}$ $(5.72*10^{-7})$**	$-7.10*10^{-7}$ $(6.86*10^{-7})$
Financial depth	0.000 (0.000)	$6.24*10^{-5}$ (0.000)	0.000 (0.002)	$2.39*10^{-5}$ (0.000)	-0.000 $(2.33*10^{-5})$**	$-1.67*10^{-6}$ (0.000)	$-5.33*10^{-5}$ (0.000)	$-6.97*10^{-5}$ $(4.10*10^{-5})$*
Financial integration	$3.22*10^{-7}$ $(4.28*10^{-7})$	$-2.95*10^{-8}$ $(8.74*10^{-7})$	$3.20*10^{-7}$ $(6.73*10^{-6})$	$6.26*10^{-8}$ $(8.33*10^{-7})$	$2.79*10^{-7}$ $(7.35*10^{-8})$	$1.05*10^{-7}$ $(6.40*10^{-7})$	$5.79*10^{-8}$ $(3.59*10^{-7})$	$2.90*10^{-7}$ $(6.96 *10^{-9})$**
R^2	-1.252	-0.076	-2.193	-0.076	-0.464	-0.070	0.133	0.046

Number of observations	89	40	32	40	89	40	30	40
Sample period	1984Q1-2006Q4	2007Q1-2016Q4	1999Q1-2006Q4	2007Q1-2016Q4	1984Q1-2006Q4	2007Q1-2016Q4	1999Q1-2006Q4	2007Q1-2016Q4

Note: Standard errors in parentheses.
** and * denote significance at the 1% and 5% levels, respectively

6. Conclusion

This study continues the research of the empirical linkages between macroeconomic variables and financial markets. Specifically, financial innovation, an important part of financial markets, is examined in more detail. Using a GARCH (1,1) process, its impact on a macroeconomic variable, consumption volatility, is estimated.

The results of the GARCH (1,1) process reveal that a significant relationship between financial innovation, measured by a new risky security, and consumption volatility exists. Therefore, it can be stated that the influence of financial innovation goes beyond its impact on market volatility alone; it directly impacts the consumer. Specifically, innovations in the form of securitized assets have contributed to an increase in consumption volatility. Prior to the recent financial crisis, optimistic consumers increased their leverage position, underestimating the relevant risk. Financial intermediaries did not sufficiently screen and monitor borrowers, which made it possible for consumers to easily obtain credit. Using, among others, credit card debt, consumers increased their consumption of non-durables and services. However, once consumers obtained the first signal of a new crisis, they shied away from new credit and had difficulty paying their interest. As a result, securitization increased consumption growth prior to the financial crisis and increased consumption volatility throughout the examined period. Suggesting that financial innovation played an important role in the period preceding as well as the aftermath of the financial crisis.

In contrast, innovations in the form of derivatives have contributed to a decrease in consumption volatility. Derivatives induce aggressive risk taking as well as asset liquidity. The latter direct effect more than offsets the former indirect effect, resulting in a more stable banking sector. Bank stability, in turn, supports consumption growth and reduces consumption volatility. In conclusion, financial innovation has its ‘dark’ side by inducing new risky securities of which the risks and effects are difficult to comprehend, increasing consumption volatility. In contrast, financial innovation has its ‘bright’ by facilitating risk sharing and smoothing consumption. It should be noted, however, that both effects on consumption volatility are not robust to other estimation methods.

However, no significant influence of financial innovation, measured by off-balance-sheet items, R&D expenditures and credit card debt, on consumption volatility is found. The inability of obtaining a significant outcome associated with the off-balance-sheet measure might be caused by the variable itself. For example, the measure might not accurately reflect the fair value and the volume of off-balance-sheet items. These are called off-balance-sheet items for a reason and depository institutions are not obliged to share this information.

As a future research topic it might be interesting to examine whether financial innovation impacts total consumption, including durable goods as well. For example, the automobile and electronic market suffered from the consequences induced by the financial crisis. The consumption of durable goods was postponed until further notice. Financial innovation could be an important factor underlying this matter.

In conslusion, this study reaffirms the relationship between financial markets and macroeconomic variables. Financial innovation, created in financial markets, affects macroeconomic variables such as consumption. Therefore, financial innovation represents an important component of financial markets that should be taken into account when macroeconomic policy is formed.

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8. Appendix

Table 1.
Results of the ADF-test of the explanatory variables using appropriate lag lengths.

	Income growth	Consumption growth	Interest rate growth	Consumption-Income ratio
Observations	129	126	130	129
Test statistic (Z(t))	-7.935	-3.722	-9.205	-3.194
MacKinnon approximate p-value for Z(t)	0.000	0. 000	0.000	0.086
1% Critical Value	-2.356	-2.358	-3.500	-4.030
5% Critical Value	-1.657	-1.658	-2.888	-3.446
10% Critical Value	-1.288	-1.289	-2.578	-3.146

Note: All tests are performed with the inclusion of a time trend, except for the variable interest rate. The appropriate amount of lags included is determined using the Akaike Information Criterion (AIC) and the Schwarz's Bayesian Information Criterion (SBIC).

Table 2.
Results of the Engle-Granger cointegration test between income and consumption.

	Error term
Observations	129
Test statistic (Z(t))	-2.734
1% Critical Value	-3.984
5% Critical Value	-3.384
10% Critical Value	-3.078

Note: The critical values correspond to the critical values of the Engle-Granger cointegration test.

Table 3.
Test results of comparing GARCH(1,2) with GARCH(1,1)

	Obs.	ll(model)	df	AIC	BIC	LR
GARCH (1,2)	129	553.745	8	-1091.49	-1068.612	1.35
GARCH (1,1)	129	553.068	7	-1092.137	-1072.118	

Note: ** and * denote significance at the l%, 5% and 10% levels, respectively.

Table 4.
Test results of comparing GARCH(2,1) with GARCH(1,1)

	Obs.	ll(model)	df	AIC	BIC	LR
GARCH (2,1)	129	553.099	8	-1090.197	-1067.32	0.06
GARCH (1,1)	129	553.068	7	-1092.137	-1072.118	

Note: ** and * denote significance at the l%, 5% and 10% levels, respectively.

Table 5.
Summary statistics of the explanatory variables x_t'.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Consumption growth	131	0.004	0.004	-0.008	0.013
Income growth	131	0.004	0.009	-0.044	0.024
Interest rate growth	131	-0.023	0.355	-1.603	1.946

Table 6.
Summary statistics of the different measures of financial innovation FI_t.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Off-balance-sheet items	44	14.623	2.451	10.185	19.187
R&D	19	0.264	0.110	0.133	0.528
Securitization	132	211.950	119.040	36.680	478.410
Derivative	44	14.104	2.495	9.711	18.730
Credit card debt	72	0.075	0.018	0.057	0.110

Table 7.
IV estimation output of $\Delta c_t = \pi + \tau_1 \Delta y_t + \tau_2 \Delta i_t + \epsilon_t$.

Variable	(1)	(2)
Income growth	0.623	0.646
	(0.090)**	(0.200)**
Interest rate growth	0.008	0.004
	(0.054)	(0.005)
R^2	-1.538	0.331
Number of observations	127	14
Period	1984Q1-2016Q4	1996-2014

Note: Standard errors in parentheses.
** and * denote significance at the 1% and 5% levels, respectively. Included instruments are $\Delta c_{t-2}, .., \Delta c_{t-4}$, $\Delta y_{t-2}, .., \Delta y_{t-4}$, $\Delta i_{t-2}, .., \Delta i_{t-4}$.

Table 8.

Robustness output of the GARCH (1,1) process of the error term extracted from the IV regression. Different measures of financial innovation are included in the conditional variance equation.

Variable	(1)	(2)	(3)	(4)	(5)
Variance equation					
Constant	$2.30*10^{-5}$	0.000	$-5.49*10^{-6}$	$-2.46*10^{-5}$	$8.20*10^{-5}$
	(0.000)	(0.017)	$(5.57*10^{-5})$	(0.000)	(0.000)
$\boldsymbol{\varepsilon^2_{t-1}}$	0.150	0.148	0.150	0.150	0.150
	(0.134)	(0.914)	(0.101)	(0.128)	(0.141)
$\boldsymbol{\sigma^2_{t-1}}$	0.600	0.600	0.600	0.600	0.600
	(0.511)	(2.731)	(0.248)*	(0.438)	(0.291)*
Off-balance-sheet items	$2.61*10^{-6}$				
	$(1.92*10^{-6})$				
R&D		-0.001			
		(0.002)			
Securitization			$-3.07*10^{-8}$		
			$(3.80*10^{-8})$		
Derivatives				$2.88*10^{-6}$	
				$(1.67*10^{-6})$	
Credit card debt					0.001
					(0.001)
Trade openness	$-2.82*10^{-5}$	$-3.28*10^{-5}$	-0.001	$9.74*10^{-5}$	0.000
	(0.001)	(0.016)	(0.000)	(0.001)	(0.001)
Terms of trade	$-6.05*10^{-7}$	$-2.00*10^{-6}$	$4.55*10^{-7}$	$-4.17*10^{-7}$	$-2.74*10^{-6}$
	$(1.31*10^{-6})$	(0.000)	$(1.80*10^{-8})$**	$(1.37*10^{-6})$	$(1.69*10^{-6})$
Financial depth	$1.73*10^{-5}$	0.000	$-7.23*10^{-5}$	$-1.88*10^{-5}$	0.000
	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)
Financial integration	$2.92*10^{-8}$	$-5.09*10^{-7}$	$4.44*10^{-7}$	$1.07*10^{-7}$	$-7.64*10^{-8}$
	$(1.77*10^{-6})$	$(8.59*10^{-6})$	$(4.72*10^{-7})$	$(1.41*10^{-6})$	$(6.17*10^{-7})$
R^2	-0.001	-0.037	-0.054	-0.001	-0.017
Number of observations	44	14	127	44	72

Note: Standard errors in parentheses.

** and * denote significance at the 1% and 5% levels, respectively

Table 9.

IV estimation output of $\Delta c_t = \pi + \tau_1 \Delta y_t + \tau_2 \Delta i_t + \tau_4 FI_t + \epsilon_t$

Variable	(1)	(2)	(3)	(4)	(5)
Income growth	0.163	0.388	0.448	0.163	0.174
	(0.093)	(0.233)	(0.110)**	(0.094)	(0.086)*
Interest rate growth	0.005	0.010	0.013	0.005	0.007
	(0.002)*	(0.005)	(0.005)*	(0.002)*	(0.003)**
Off-balance-sheet items	$9.35*10^{-5}$				
	$(4.58*10^{-5})$*				
R&D		0.029			
		(0.017)			
Securitization			$7.90*10^{-6}$		
			$(2.88*10^{-6})$**		
Derivative				$9.71*10^{-5}$	
				$(4.76*10^{-5})$*	
Credit card debt					0.035
					(0.008)**
R^2	-0.170	0.528	-1.498	-0.181	-0.236
Number of observations	42	14	127	42	70

Note: Standard errors in parentheses.

** and * denote significance at the 1% and 5% levels, respectively. Included instruments are $\Delta c_{t-2}, .., \Delta c_{t-4}, \Delta y_{t-2}, .., \Delta y_{t-4}$, $\Delta i_{t-2}, .., \Delta i_{t-4}$. The other instruments measuring the impact of financial innovation are lagged twice.

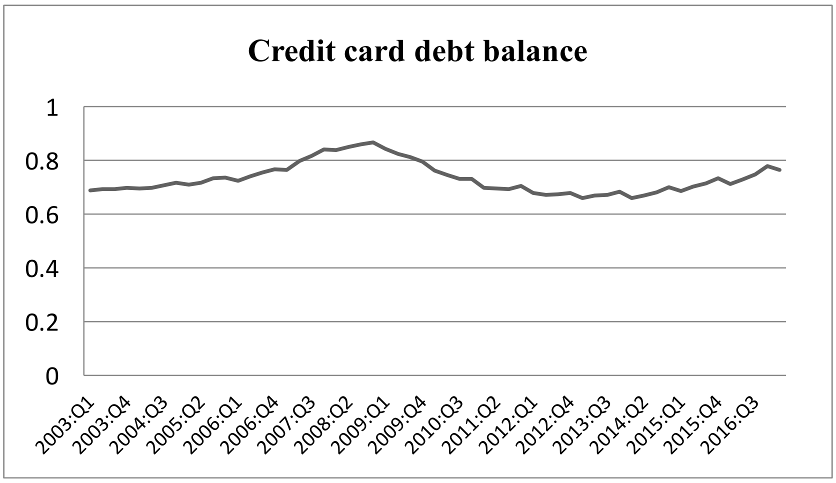

Figure 1. Credit card debt balance in trillions of dollars.

Source: Federal Reserve Bank of New York.

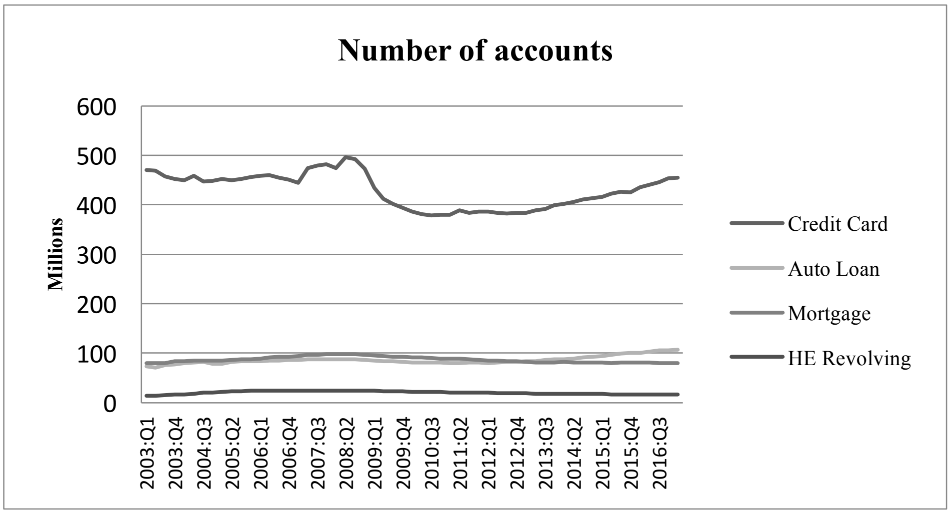

Figure 2. Number of accounts by loan type.

Source: Federal Reserve Bank of New York.

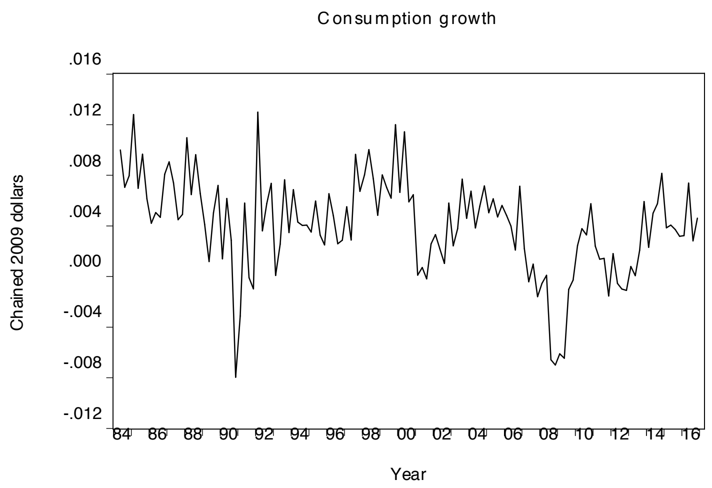

Figure 3. Graph of consumption growth across time.

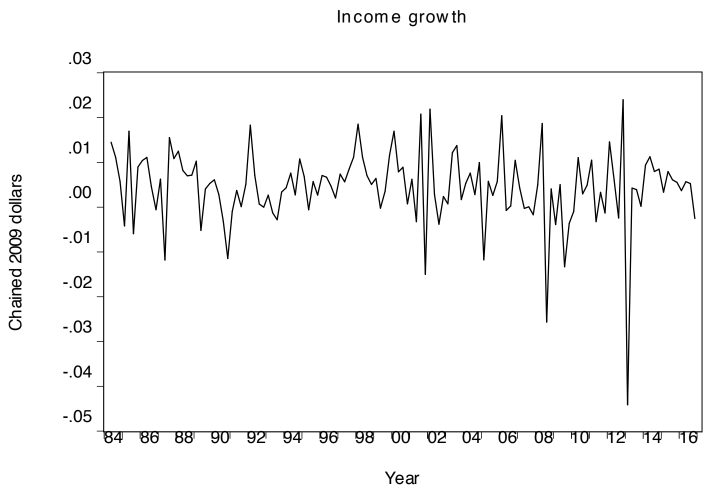

Figure 4. Graph of income growth across time.

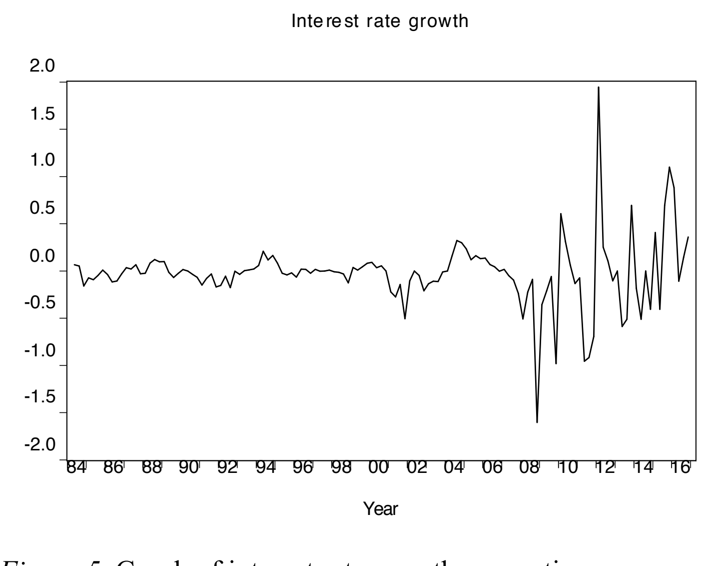

Figure 5. Graph of interest rate growth across time.

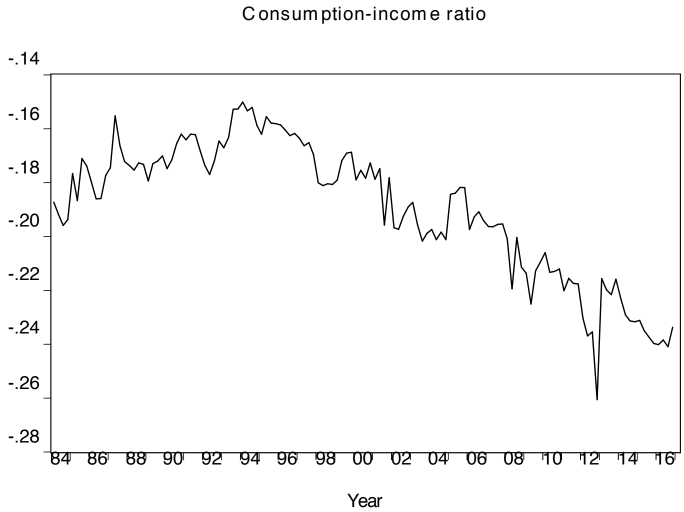

Figure 6. Graph of the variable consumption-income ratio against time.

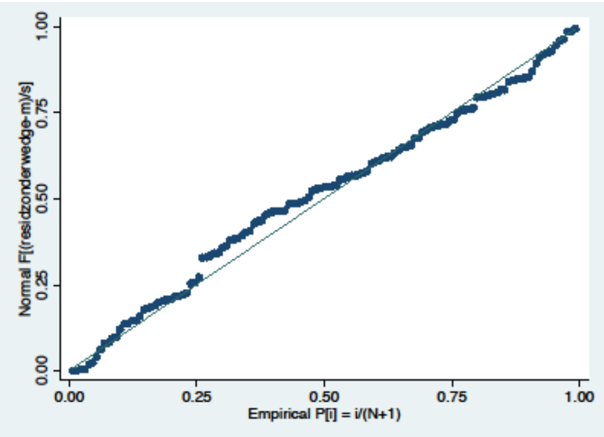

Figure 7. Probability plot of the error term of the conditional mean regression relative to the normal distribution, focusing on the center of the distribution.

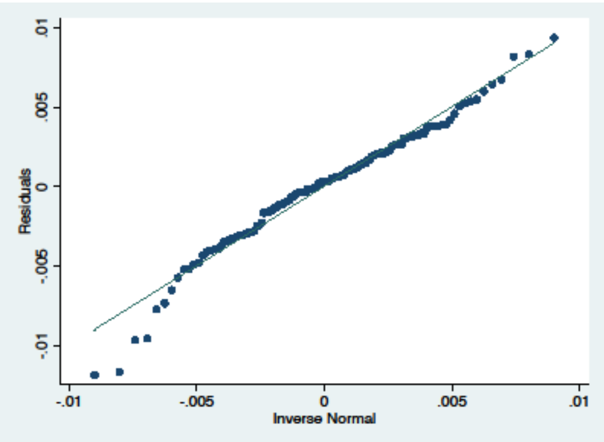

Figure 8. Probability plot of the error term of the conditional mean regression relative to the normal distribution, focusing on the tails of the distribution.

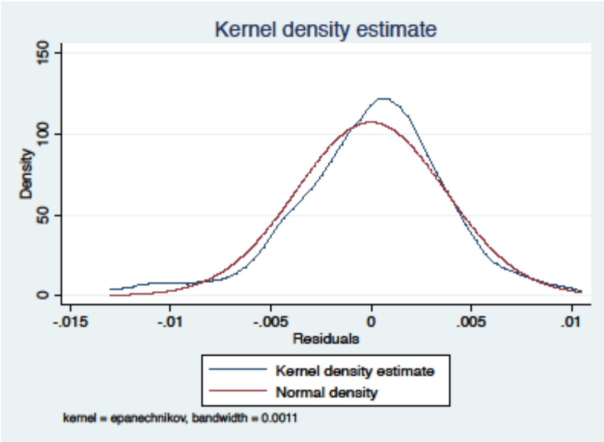

Figure 9. Plot of the density of the error term of conditional mean regression relative to the normal distribution.

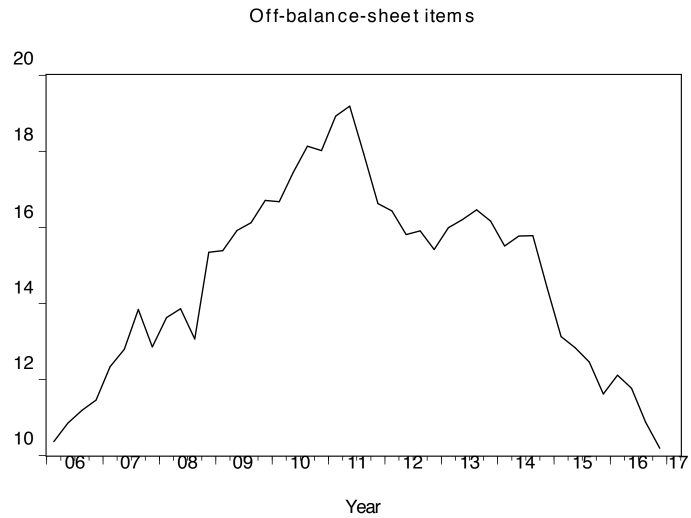

Figure 10. Graph of the off-balance-sheet measure, relative to total assets, of financial innovation across time.

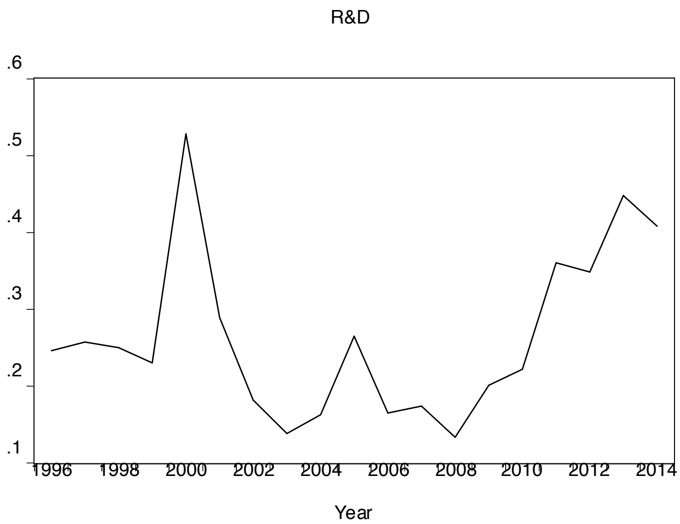

Figure 11. Graph of the R&D measure, relative to value added, of financial innovation across time.

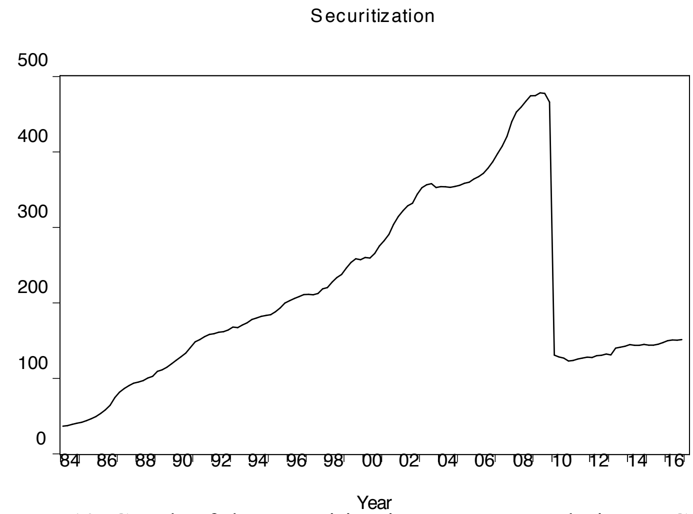

Figure 12. Graph of the securitization measure, relative to GDP, of financial innovation across time

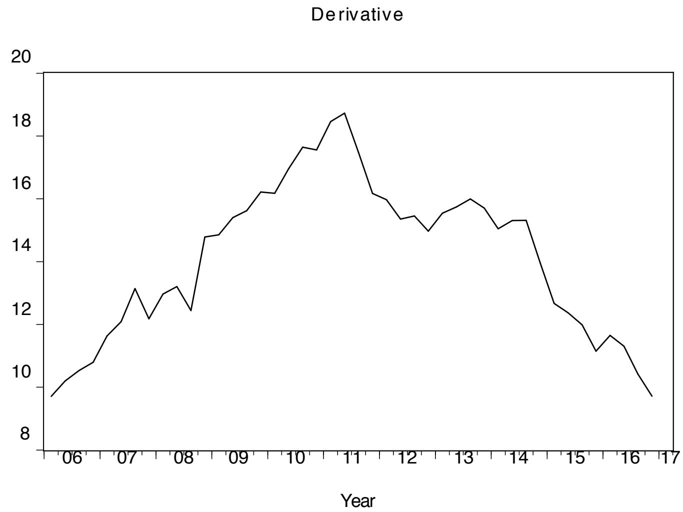

Figure 13. Graph of the derivative measure, relative to total assets, of financial innovation across time.

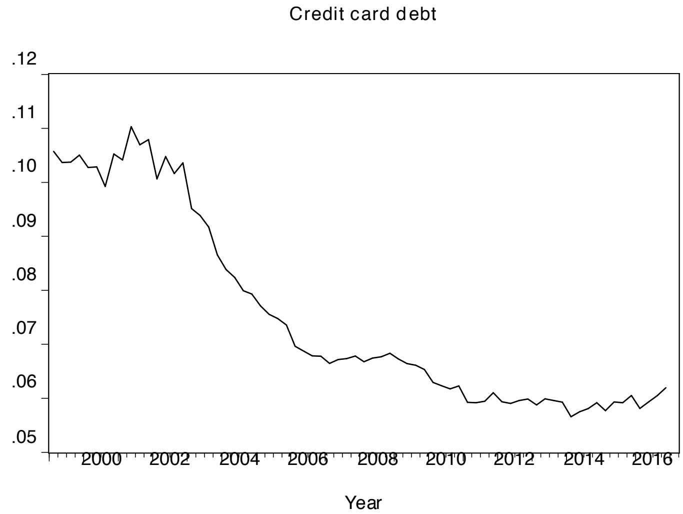

Figure 14. Graph of the credit card debt measure, relative to total household debt, of financial innovation across time.

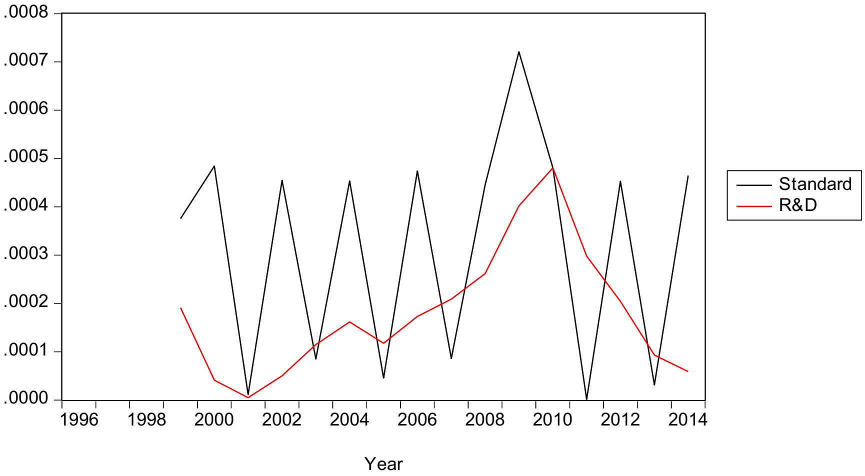

Figure 15. Graph of annual estimated conditional variance across time