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DEBT AND THE U.S. GREAT MODERATION

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Abstract

During the Great Moderation, borrowing by the U.S. nonfinancial sector structurally exceeded GDP growth. Using flow-of-fund data, we test the hypothesis that this measure of debt buildup was leading to lower output volatility. We estimate univariate GARCH models in order to obtain estimates for the volatility of output growth. We use this obtained volatility in a VAR model with excess credit growth and control variables (interest rate and inflation) over two periods, 1954-1978 (before the Great Moderation) and 1984-2008 (during the Great Moderation). We so test whether the relation between excess credit growth and GDP volatility changed between the two periods, controlling for the stance of monetary policy, for inflation, and for the endogeneity of credit to growth (as well as for other endogeneities). Results from Granger causality tests, impulse response functions and forecast error variance decompositions suggest that changes in our 'excess credit growth' measure of debt in the nonfinancial sector were among the causal factors of the decline in output volatility during the Great Moderation. We discuss implications.

Key Words: great moderation, credit, VAR, causality
JEL codes: E44, C32, C51, C52

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DEBT AND THE U.S. GREAT MODERATION

1. Introduction

In the mid-1980s, two shifts occurred in the US economy. The first was that macroeconomic volatility declined strongly within a few years. This 'Great Moderation' lasted for more than two decades, until the Great Crash of 2007. The second was that borrowing by the real sector increased strongly within a few years, to a level that was structurally above the level of growth. It remained high for over two decades, until the Great Crash of 2007. Access to credit may decrease output fluctuations since "credit demand appears to contain a significant countercyclical component, which arises from the desire of households and firms to smooth the impact of cyclical variations in income on spending or production" (Bernanke and Gertler, 1995:44).

In this paper we pursue this explanation, focusing specifically on the level of indebtedness in the real sector. We use the 'Z' tables on the U.S. flow of funds to observe borrowing by the real sector in excess of growth. We so obtain a measure for the growth in debt held by the real sector at the macro level, which we link to output volatility at the macro level. We hypothesize that the growth in debt in the real sector was among the causal factors of the lower volatility of output during the Great Moderation. Our hypothesis is related to a number of financial-sector explanations of the Great Moderation, and consistent with a wider literature on credit and macro volatility. But we break new ground in two areas.

First, no study to date has directly analyzed the link between output volatility during the Great Moderation and borrowing by the real sector - that is, excluding borrowing for investment in the 'finance, insurance and real estate' sectors (or 'FIRE' sectors, in the classification of the National Income and Product Accounts). A number of studies have focused on FIRE-sector wealth buildup resulting from financial innovations and its possible effect on output moderations, through a wealth effect on income (e.g. Den Haan and Sterk, 2011). The channel through which debt-financed wealth accumulation affects output volatility is different from the effect of debt-financed activity, which we analyze.

A second contribution is that we observe not just credit flows (as other studies do), but the growth in borrowing by the real sector in excess of output growth. We so focus on the growth in the debt-to-GDP ratio that is due to borrowing by the real sector. This goes beyond simply

testing for the effect of credit on volatility. Other studies have shown that credit flows to the real sector normally move together with output growth (Board, 2012), and that credit moderates industrial output volatility (Larrain, 2006). To show that this occurred also during the Great Moderation would not be a test of our hypothesis, but rather confirmation that credit to the real sector was smoothing output growth, as it normally does. But a special feature of the Great Moderation was that growth in credit flows to the real sector structurally exceeded nominal GDP growth (as we show in the next section) - even when excluding the growth in credit to finance, insurance and real estate (i.e. not to the real sector), where most of the credit growth was occurring. Plausibly, credit growth in the real sector has a more direct impact on real-sector volatility. We therefore test whether real-sector credit growth in excess of GDP growth was causally linked to the lower volatility of output during the Great Moderation. This has not been analyzed to date.

Our empirical approach is to first estimate the conditional standard deviation of output growth. Using this obtained measure for output volatility, we then estimate a number of reduced-form VAR models for two subsamples with quarterly data, 1954Q3-1978Q4 (before the Great Moderation) and 1984Q1-2008Q1 (during the Great Moderation, which ended in 2008, as Barnett and Chauvet (forthcoming) and Bean (2011) argue). We examine lags of excess credit growth in this system of equations, including (obtained) real output growth volatility, the inflation rate and the federal funds rate. We find robust evidence that the increased growth of borrowing beyond GDP growth was a causal factor in the greater macroeconomic tranquility that characterized the Great Moderation.

The paper is organized as follows. The next section presents in more detail the argument that real-sector credit growth in excess of GDP growth was causally linked to the lower volatility of output during the Great Moderation. We also explore trends in bank credit and in growth, consistent with the argument. In section 3 we make connections to the literature. In section 4 we present the methodology. Section 5 presents the data and reports the results from the analysis. Section 6 concludes with a summary, reflections and suggestions for future research.

2. Argument and Empirical Trends

The Great Moderation era saw declines in the volatility of a number of macroeconomic variables in the U.S., as in many other countries (Bernanke, 2004; Cecchetti et al., 2006; Ćorić, 2012). The standard deviation of U.S. quarterly growth and inflation declined by half and by two thirds since 1984, respectively (Blanchard and Simon, 2001). Stock and Watson (2002) find that the standard deviation of U.S. GDP growth declined from 2.6-2.7% in the 1970s and 1980s to 1.5% in the 1990s. Also employment volatility strongly declined (Kim and Nelson, 1999; Warnock and Warnock, 2000). In this paper we focus on the decline in output volatility and hypothesize that the increase in borrowing by the nonfinancial sectors lowered volatility during the Great Moderation, in contrast to earlier years.

In Figure 1 we show the long-term development of the growth in bank credit in the U.S. The stock of bank loans relative to GDP quadrupled from 1952 to 2008, with most of that growth occurring during the Great Moderation, and with credit flows to the finance, insurance and real estate sectors accounting for most of the increase. By the end of the Great Moderation, bank credit to the "FIRE" sectors had increased from 30% of GDP in 1952 (the start of the data series) to 81% of GDP in 1984, to 260% of GDP in 2008. Most of this rise, in turn, was due to growth in mortgage debt. After the Great Moderation, FIRE-sector debt dropped sharply relative to GDP.

[Figure 1 HERE]

Much has been written on the role of mortgage debt in U.S. macro dynamics, including the Great Moderation puzzle. Our focus is different. For also bank credit to the nonfinancial sectors (that is, credit to nonfinancial business, to government and nonmortgage credit to households) rose strongly during the Great Moderation: from 87% of GDP in 1952 to 99% in 1984 and to 143% of GDP in 2008 (Figure 1). This implies a more than threefold rise in the annual growth rate of the (real-sector) credit-to-GDP ratio, from 0.4% in 1952-1983 to 1.4% annually over 1984-2008.[1] We show this in Figure 2 below, which plots the growth in credit to the nonfinancial sectors and the growth in nominal GDP.[2] We also compute the difference between the two growth rates and

[1] Note that this is different from the total-credit-to-GDP ratio, which rose even faster.
[2] See the Appendix for data construction details.

label this variable "excess credit growth". [3] The underlying relation is that growth of credit to the nonfinancial sector leads to proportionate growth in levels of both debt and activity, so that the credit/GDP ratio is stable and excess credit growth moves around zero. This is apparent in the horizontal part of the graph in Figure 1 on the left, before the Great Moderation. The growth in nonfinancial sector borrowing (bank credit) creates purchasing power which adds proportionally to GDP, if expended on domestic goods and services and not on net financial asset acquisition (which is ruled out from our data definition). Growth in bank credit to the nonfinancial sectors is so the financial counterpart of growth in transactions of goods and services. As Caporale and Howells (2001) note, "loans cause deposits and those deposits cause an expansion of GDP transactions" – at least, to the extent that loans and the deposits they create are used for transactions in goods and services rather than asset transactions (that is why we excluded from the definition of exces credit growth "FIRE" sector debt, which captures the bulk of debt that finances asset transactions). We so focus on the degree to which activity (not wealth accumulation, or asset price increases) was debt-financed.

This releationship between credit and growth, which has been amply documented (see Levine (2004) and Ang (2008) for overviews), is one reason why movements in nominal GDP and movements in credit to the real sector are so closely linked. It is because, as explained by Minsky (1982:6), "over a period during which economic growth takes place, at least some sectors finance a part of their spending by emitting debt…". Empirically, the Federal Reserve observes in its 'Guide to the Flow of Funds' that "over long periods of time there has been a fairly close relationship between the growth of debt of the nonfinancial sectors and aggregate economic activity" (Board, 2012:76). Figure 2 shows that the growth in the stock of credit to the nonfinancial sectors indeed closely tracks the growth in nominal GDP from the start of the time series in the early 1950s until about 1984, but not during the Great Moderation.

[Figure 2 HERE]

In most quarters during the Great Moderation, the growth in the stock of credit to the nonfinancial sectors exceeds the growth in nominal GDP, sometimes substantially. The difference indicates borrowing which is (by definition) not itself expended on domestic goods

[3] Since we focus on debt financed by bank credit, not debt financed by government bonds, we study the private deficits counterpart, not public debt and deficit.

and services - if it was, this would have raised GDP growth to the level of credit growth. In order to bring out how this differed from the pre-Great Moderation years, in Figure 2 we plot the cumulative difference between the growth rates of nominal GDP and credit to the nonfinancial sectors. This "excess credit growth" stock was mostly negative between 1952 and 1970, when the economy was growing faster, on average, than the growth of lending to the real sector. Through the 1970s cumulative "excess credit growth" remained at a positive but fairly constant and low level. It took off in the early 1980s and remained high (and increasing in most years) during the Great Moderation.

[Figure 3 HERE]

There are several possible channels through which the real sector's debt growth can temporarily rise above GDP growth, and so deviate from the long-term parity noted in Board (2012:176). We discuss two channels here and test a reduced form hypothesis below. One channel is debt-financed net financial asset acquisition by the real sector. Every dollar borrowed and spent on assets rather than on goods and services increases debt and financial wealth but not activity, in the first instance. Our measure aims to exclude most of this by excluding the statistical categories of "FIRE" sector credit flows, which finance financial and real estate transactions rather than real-sector activity. But interfering with statistical classifications, there is extensive evidence that during the Great Moderation nonfinancial firms increasingly realized their returns in financial transactions (e.g. Krippner, 2005). For instance, nonfinancial firms borrowed to finance stock repurchases realizing capital gains and subsequently finance consumption or investment out of this debt-financed wealth.[4] If this occurs in countercyclical manner, this might stabilize GDP. This 'wealth effect' has been estimated for home equity withdrawal and consumption (Greenspan and Kennedy, 2008) supported by mortgage growth, which may also have contributed to stability during the Great Moderation (Grydaki and Bezemer, 2013). This is excluded from our statistical measure for excess credit growth, but other borrowing by

[4] Lazonick (2011) presents data on 373 companies in the S&P 500 Index in January 2008 that were publicly listed in 1990. He shows that they expended an annual average of $106.3 billion (or $285 million per company) on stock repurchases in 1995-1999, up from $25.9 billion in repurchases (or $69 million per company). This was equal to 44% of their combined net income (up from 23 percent of their combined net income in 1990-1994). Combined, the 500 companies in the S&P 500 Index in January 2008 repurchased $489 billion of their own stock in 2006, representing 62 percent of their net income, and $595 billion in 2007, representing 89 percent of their net income. Lazonick (2011) also notes the dramatic increase in stock repurchases after 2003, which may be linked to the upswing in excess credit after 2003 observable in Figure 3.

nonfinancial forms may also have been spent on asset acquisitions (including own stock acquisitions).

Another channel through which 'excess credit growth' may contribute to output stability is debt-financed spending on imports. This increases both imports and - in the same amount - consumption or investment. Since the rise in imports and the rise in consumption or investment cancel out in the national income definition, debt-financed spending on import does not directly raise GDP but it does increase the debt/GDP ratio. In a second-round effect, because of substantial spillover effects of imports on the transport and retail sectors and on activity generally (e.g. Acharya and Keller, 2008), debt-financed imports, if countercyclical to the business cycle, may induce additional activity that stabilizes GDP.[5]

In noting these links of asset acquisition and external balances with excess credit growth, nothing is implied about causality. Looser loan standards and low interest rates may have induced borrowing and consumption, leading to a rise in imports; or *vice versa* some external shock which decreased external balances may have induced more borrowing. A related paper by Fogli and Perri (2006) posits causality from external balances to lower incentives to accumulate precautionary savings, and an equilibrium permanent deterioration of external balances, consistent with our second channel. Explicitly testing for these causal relations is beset by pervasive endogeneities.[6] It is not even implied that there is causality between excess bank credit flows to the nonfinancial sector and the trade balance at this level: this can also be viewed as a macroeconomic identity (the current account deficit equals the capital account surplus). The same holds for excess credit growth and net asset acquisition.

This is why below we test a reduced form of our hypothesis, rather than explicitly testing for causality between external balances and excess credit growth, or between net asset acquisition and excess credit growth. Both these ways in which excess credit growth is used are likely to moderate GDP through second-round impacts. To the extent that variations in activity stimulated by excess credit growth (through either or both of these channels) are countercyclical to the business cycle, excess credit growth smooths GDP. This is what we will test.

[5] Indeed, we found that during the Great Moderation, trend-corrected excess credit growth correlated negatively with trend-corrected growth in the U.S. balance of payments on goods and services over 1984-2007, with a correlation coefficient of -.30. We also observed that this was not the case before or after the Great Moderation years, when the correlation was positive (correlation coefficient .24 over 1961-1983). Data and analysis are available on request.

[6] We thank James Kennedy for drawing our attention to this point.

Our hypothesis fits in with other studies which linked U.S. growth patterns with the rise in private deficits. For instance Godley (1999:1) noted that "during the last seven years … rapid growth could come about only as a result of a spectacular rise in private expenditure relative to income. This rise has driven the private sector into financial deficit on an unprecedented scale." More specific to the volatiltiy of growth, Davis and Kahn (2008) find that an important part of the decline in macro volatility is explained by changes in aggregate volatility in the durable goods sector, but *without* a decline in the uncertainty of incomes. This is understandable if part of durable goods consumption was financed with debt, not income. Davis and Kahn (2008) ascribe the lower volatility to real-sector supply-side factors such as better supply chain management (especially, inventory control) and a shift from employment and production from goods to services. Their finding is however also consistent with a supply-side change driven by the greater credit availability that was typical of the Great Moderation (as Dynan et al (2006) document), which would also have the effect of loosening the link between the dynamics of income and consumption.

3. Connections to the Literature

That credit stabilizes output is no new finding. We already noted studies by Bernanke and Gertler (1995) on the countercyclical tendency of consumer credit and Larrain (2006) on the stabilizing properties of credit with respect to industrial output. Iacoviello (2005) estimates a monetary business cycle model with nominal loans and finds that "nominal debt dampens supply shocks, stabilizing the economy under interest rate control" (Iacoviello, 2005:739). "Credit View" literature (Bernanke and Blinder, 1988; Bernanke, 1993; Bernanke and Gertler, 1995) and accelerator models (Kiyotaki and Moore, 1997; Campbell, 2005) theorize how the credit system may either amplify or dampen exogenous shocks. A broader strand of literature connects credit conditions to the business cycle and the economy's volatility (e.g. Bliss and Kaufmann, 2003; Mendicino, 2007), making the general point that financial development tends to stabilize growth (Easterly et al., 2000).

It is therefore unsurprising that among the many explanations of the Great Moderation, a good number involve the financial sector.[7] This is the more relevant because of well documented

[7] Research has identified as possible causes for the Great Moderation better inventory management (McConnell and Perez-Quiros, 2000; Kahn et al., 2002; McCarthy and Zakrajsek, 2007), labor market changes and demography

financial innovations and deregulations of lending practices and loan markets during the Great Moderation, such as relaxed collateral constraints, lower down payments and rates of amortization for durable goods purchases on household borrowing (Campbell and Hercowitz, 2005). Dynan et al. (2006) show empirically the influence of financial innovation on consumer spending, housing investment, and business fixed investment. Guerron-Quintana (2009) makes the same point theoretically in a model of the demand for money with portfolio adjustments. In a simulated version of the model he suggests that the Great Moderation can be partially attributed to financial innovations in the late 1970s: when moving toward a more flexible portfolio, the model can account for almost one-third of the observed decline in the volatilities of output, consumption, and investment. Jermann and Quadrini (2006) similarly show in a general equilibrium model how innovations in financial markets can generate a lower volatility of output, together with a higher volatility in the financial structure of firms. More specific to the Great Moderation years, part of the moderation in output volatility may be due to changing responses to monetary shocks (Clarida et al., 2000) and improvements in monetary policy (Bernanke, 2004; Lubik and Schorfheide, 2003; Boivin and Giannoni, 2006; Akram and Eitrheim 2008).

The present paper is consistent with each of these finance-driven and credit-driven accounts of the Great Moderation (which operated in conjunction with other, nonfinancial factors, to be sure). What it adds is a focus on the growth in indebtedness at the macro level (credit growth in excess of GDP growth); and specifically, on growth of debt levels connected to real-sector activity rather than to asset and property markets (as in Den Haan and Sterk, 2011). We now proceed to assess the testable implication of our hypothesis, namely that causality between excess credit growth and volatility of output growth was stronger during the Great Moderation than it was before the Great Moderation, such that excess credit growth decreased volatility of output growth.

(Jaimovic and Siu, 2009), oil shocks (Nakov and Pescatori, 2010), changed responses to those and other shocks (Gambetti et al., 2008) or broader factors such as institutions (Acemoglou et al., 2003; Owyang et al. (2007), external balances (Fogli and Perri, 2006), the size of the economy (Canning et al., 1998), and development levels (Acemoglu and Zilibotti, 1997; Easterly et al., 1993)- or simply to "good luck" (Ahmed et al., 2002; Cogley and Sargent, 2005; Primiceri, 2005; Sims and Zha, 2006; Gambetti et al., 2008; Benati and Surico, 2009).

4. Methodology

Modeling Volatility

In the literature, the volatility of economic growth has been measured as the standard deviation of economic growth or alternatively, as the conditional variance captured by univariate or multivariate GARCH models (Bollerslev, 1986 based on Engle's (1982) ARCH model; Engle and Kroner, 1995).[8] To obtain such estimates, we test for the existence of ARCH effects (i.e. volatility clustering), which causes volatility levels to correlate positively over time. If there are ARCH effects, the (univariate) conditional variance is best estimated in an ARCH(p) model (Engle 1982). The conditional mean equation is then:

$$y_t = \mu + \sum_{h=1}^{z} \varphi_h y_{t-h} + \varepsilon_t,\ \varepsilon_t \mid \psi_{t-1} \sim N\left(0, \sigma_t^2\right) \tag{1}$$

where, y_t, μ,φ_h, ε_t are vectors of the dependent variable, intercept, autoregressive term and the innovation vector, respectively, and ψ_{t-1} is the information set at time *t-1*. Given an estimate for the conditional mean, this allows us to obtain the conditional variance in the equation:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 \tag{2}$$

where σ_t^2 is the conditional variance, α_0 the intercept and α_i the ARCH terms of the variance equation (with $i = 1,..., p,$). The estimated variance should be positive; therefore we impose $\alpha_0 > 0$ and $\alpha_i \geq 0$ for $i \geq 1$. In addition, since we require long-run stationarity, we impose the condition $\sum_{i=1}^{p} \alpha_i < 1$.[9]

An improvement upon this basic structure is the more parsimonious GARCH model (Bollerslev, 1986), where also the lag structure is flexible. A GARCH(p,q) model accommodates autoregressive as well as moving-average components in the heteroskedastic variance. Compared to equation (2), the equation for heteroskedastic variance is:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 \tag{3}$$

[8] An analytical survey of multivariate GARCH models is in Bauwens et al. (2006).
[9] Nelson and Cao (1992) provide analytically the inequality constraints for univariate GARCH models.

where β_j now denotes the GARCH component parameters, with $\beta_j \geq 0$ and $\sum_{i=1}^{p}\alpha_i + \sum_{j=1}^{q}\beta_j < 1$ for $i \geq 1$ and $j \geq 1$.

However, this assumes that the response of volatility to positive and negative shocks is symmetric. Because of the squared lagged error term in equation (3), the conditional variance is a function of the magnitudes of lagged residuals, but not of their signs. In reality, a negative shock ("bad" news) tends to increase volatility more than a positive shock ("good" news) of the same magnitude, especially in financial time series. Accounting for this asymmetric responses (or 'leverage effect'), we estimate two asymmetric specifications for the conditional variance, which are both widely used. The first is the Exponential GARCH (EGARCH) model (Nelson, 1991) which does not require non-negativity constraints:

$$ln\left(\sigma_t^2\right) = \alpha_0 + \sum_{j=1}^{q}\beta_j\, ln\left(\sigma_{t-j}^2\right) + \sum_{i=1}^{p}\alpha_i\left|\varepsilon_{t-i}/\sigma_{t-i}\right| + \sum_{k=1}^{r}\lambda_k\left(\varepsilon_{t-k}/\sigma_{t-k}\right) \tag{4}$$

In equation (4), the conditional variance is in log-linear form. So regardless of the magnitude of $ln\left(\sigma_t^2\right)$, the implied value of σ_t^2 is non-negative. It is therefore possible for the coefficients to take negative values. Also, instead of using the value of ε_{t-i}^2 as in equation (3) the EGARCH model uses the standardized value of ε_{t-i}. This allows for a more natural interpretation of the size and persistence of shocks (Nelson, 1991). A third advantage of the EGARCH model is that it allows for leverage effects, as noted. These effects occur if $\lambda_k < 0$.

Another option is to estimate a general form of the Threshold ARCH model (Zakoian, 1994), namely the Threshold GARCH (or TGARCH) model (Glosten et al., 1993). The TGARCH model has an additional term accounting for possible asymmetries. The conditional variance is now given by:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p}\alpha_i\varepsilon_{t-i}^2 + \sum_{j=1}^{q}\beta_j\sigma_{t-j}^2 + \sum_{k=1}^{r}\gamma_k d_{t-k}\varepsilon_{t-k}^2 \tag{5}$$

Here we impose the non-negativity constraints: $\alpha_0 \geq 0,\ \alpha_i \geq 0,\ \beta_j \geq 0,$ and $\sum_{i=1}^{p}\alpha_i + \sum_{k=1}^{r}\gamma_k \geq 0.$

In equation (5), d_{t-k} is a dummy variable which is equal to one if $\varepsilon_{t-k} < 0$ and equal to zero if

$\varepsilon_{t-k} \geq 0$. This ensures that if $\gamma_k > 0$, then negative shocks will have larger effects on volatility than positive shocks. If $\gamma_k \neq 0$, then there is a threshold effect.

Vector Autoregressive Models and Tests for Causality

Once we have obtained this estimate for output volatility (i.e. the conditional standard deviation), we can then move on to the aim of this paper, which is to analyze any causality between output volatility and other variables. We do this in a Vector Autoregressive (VAR) model where one can capture the interdependencies between multiple time series (Sims, 1980). Since we have no prior on causality, all variables are treated as endogenous, allowing for the value of a variable to depend on its own lags and on the lags of all the other variables in the model. The system of equations in a VAR model is:

$$y_t = \mathrm{A}_0 + \mathrm{A}_1 y_{t-1} + ... + \mathrm{A}_p y_{t-p} + \varepsilon_t \tag{6}$$

where y_t is an (n x 1) vector with the n variables included in the VAR (endogenous variables), A_0 reflects an (n x 1) vector of intercept terms, A_i denote (n x n) matrices of coefficients (with $i=1,...p$) and ε_t is an (n x 1) vector of error terms.

Once we obtained estimates of the system of equations (6) we conduct three analyses. First, we conduct Granger causality tests. A series x_t "Granger-causes" a series y_t if changes in x_t precede changes in y_t , so that values of x_t improve predictions of y_t, but y_t does not help predict x_t (Granger, 1969). A second analysis is to estimate impulse response functions (IRFs), which reflect the dynamic relationship between the variables.[10] IRFs trace the effect of a 1 standard deviation shock to one of the innovations (error terms) on current and future values of the endogenous variables. A shock to the *i*th variable is so transmitted to the other endogenous variables in the VAR system (and also, of course, directly affects the *i*th variable itself). IRFs represent the moving average evolution of the system, describing how one variable responds to a shock to itself or to any other variables. Sims (1980) notes that examining the IRFs might be the most effective way of checking for Granger Causality in multivariate frameworks. Another way of characterizing the dynamic behavior of the VAR is to conduct the forecast variance decomposition analysis (suggested also by Sims, 1980).

[10] Following Sims (1980), we compute the orthogonalized impulse response, where the underlying shocks are orthogonalized using the Cholesky decomposition method.

5. Data and Empirical Results

We use quarterly data for the U.S. over two subsamples, 1954Q3-1978Q4 (before the Great Moderation) and 1984Q1-2008Q1 (during the Great Moderation).[11] The data construction for three of the four variables we use follows Den Haan and Sterk (2011).[12] We calculated the logarithm of real GDP (RGDP) and as control variables we include the Federal funds rates (FR) – which is stationary in first difference (I(1)) - and inflation (INF), measured by the real GDP deflator.[13] Our fourth variable is excess credit growth (EXCRED) - the difference between the growth rates of credit to the real sector and of nominal output – which is stationary at its level. We refer to the Appendix for details of the construction of EXCRED. With these four variables in a VAR framework, we control for the stance of monetary policy, for inflation, and for the endogeneity of credit to growth (as well as for other endogeneities).

After testing for the stationarity, we examine the presence of ARCH effects (clustered volatility) by conducting the ARCH Lagrange Multiplier (ARCH-LM) test, for 1 to 12 lags (Engle, 1982). Table 1 reports descriptive statistics and values of the ARCH-LM statistic for the two subsamples.

[Table 1 HERE]

All variables have positive growth rates (differenced logs) on average. All variables tend to be more volatile before the beginning of the Great Moderation than during the Great Moderation. The distribution of inflation exhibits positive skewness with few high values in both subsamples; the opposite holds for the remaining variables. Further, the kurtosis (or "peakedness") statistics

[11] We applied the Chow test for structural breaks over the whole period 1954Q3-2008Q1 and found that any quarter in 1980Q1-1983Q4 is a potential breakpoint in output volatility. This is consistent with Boivin and Giannoni (2006) who report that there is no robust breakpoint at which the Great Moderation would have started. Fang and Miller (2008) show that the time-varying variance of output falls sharply or even disappears once they incorporate a one-time structural break in the unconditional variance of output starting 1982 or 1984. The literature uses any year between the late 1970s and 1984 at the latest. To test sensitivity to choice of break point, we chose 1981Q2 as alternative breakpoint and we re-estimated the VAR. The results are similar to those obtained for the periods 1954Q3-1978Q4 and 1984Q1-2008Q1 and are available upon request.

[12] We thank Wouter den Haan for making these data available, at http://www.wouterdenhaan.com/data.htm#papers.

[13] We apply the following stationarity tests to the logs of the variables: (i) Kwiatkowski–Phillips–Schmidt–Shin (KPSS) (Kwiatkowski et al., 1992), (ii) Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979) and (iii) Phillips and Perron (PP) (Phillips and Perron, 1988). For tests (i) and (iii), the lag length was selected by the kernel-based estimator of the frequency zero spectrum, which is based on a weighted sum of the covariances. For test (ii) the selection of the number of lags in the test equations is according to the Schwartz Information Criterion (SIC). The stationarity is tested at 1%, 5%, 10% significance levels and the time trend has been taken into account in the test equation. The unit root test results are avaialable on request.

for the distributions of all the variables show more deviations from the normal distribution in the first subsample than in the second. Finally, the ARCH-LM test shows that there is evidence of ARCH effects in the squares of real output growth rate in both subsamples.[14]

We then capture the conditional standard deviation of RGDP estimating four alternative GARCH models, symmetric and asymmetric (equations (1)-(5)), accounting for autoregressive terms. Given the skewness and kurtosis of the log difference of RGDP, we assume that the error term of equation (1) is t-student distributed. Therefore, the parameters of the univariate GARCH models are estimated by maximizing the log-likelihood function:

$$l_t = -\frac{1}{2}\log\left(\frac{\pi(v-2)\Gamma(v/2)^2}{\Gamma((v+1)/2)^2}\right) - \frac{1}{2}\log\sigma_t^2 - \frac{(v+1)}{2}\log\left(1+\frac{\varepsilon_t^2}{\sigma_t^2(v-2)}\right) \tag{7}$$

where $\Gamma(.)$ is the gamma function and v is the degree of freedom ($v>2$). The log-likelihood function for the conditional t distribution converges to the log-likehood function of the conditional normal GARCH model as $v \to \infty$.

We first select the model which meets the non-negativity constraints of the coefficients and the stationarity condition (symmetric GARCH models), and/or the model which supports the existence of leverage or threshold effect (asymmetric GARCH models). From this subset, the preferred GARCH model is selected according to the minimum value of the Schwarz Information Criterion (SIC). The conditional variance of output growth is captured by a symmetric GARCH model - specifically, an AR(1)-GARCH(1,1).[15] The conditional mean and variance equations are as follows:

$$\begin{aligned} dlrgdp_t &= 0.0079 + (\,0.2906\,)dlrgdp_{t-1} + \varepsilon_t \\ &\quad (0.0007)\quad (0.0707) \\ &\quad [0.0000]\quad [0.0000] \end{aligned} \tag{8a}$$

$$\begin{aligned} \sigma_t^2 &= 1.60E-06 + (0.1153)\varepsilon_{t-1}^2 + (0.8601)\sigma_{t-1}^2 \\ &\quad (1.73E-06)\ (0.0570)\qquad (0.0589) \\ &\quad [0.3552]\qquad [0.0429]\qquad [0.0000] \end{aligned} \tag{8b}$$

[14] We only test for ARCH effects in GDP growth as we are interested in its volatility and not in the volatility of the other variables.

[15] We used 1-12 lags for the estimation of the AR(p)-(A)Symmetric GARCH models. Several conditional variance specifications have been estimated and the GARCH(1,1) performs better.

where figures in parentheses and square brackets reflect standard errors and probability values, respectively. The Lung-Box statistic indicates that the estimated model is well-specified once it does not suffer from remaining autocorrelation ($Q(p)$) and remaining ARCH effects ($Q^2(p)$).[16]

We estimate a number of reduced-form VAR models on quarterly data for the two subsamples (1954Q3-1978Q4, before the Great Moderation and 1984Q1-2008Q1, during the Great Moderation). We examine whether lags of excess credit growth (EXCRED) matter to the volatility of real output growth (denoted σ_{dlrgdp}), which was estimated as the conditional standard deviations obtained in equations (8a) and (8b). In addition to the obtained volatility of real output growth σ_{dlrgdp} (which is stationary), other variables in the system are the inflation rate (INF) and the federal funds rates (FR). We estimate VAR(p) models with $p=1,\ldots 12$. The model selection criterion is again the minimum SIC value. This procedure yields a VAR(1) model for both subsamples.[17] To examine the causal effects of the variables under investigation, we conduct Granger Causality tests, reported in Table 2.

[Table 2 HERE]

In Table 2, we detect bidirectional causality between excess credit growth and output volatility in the second subsample. This finding is consistent with the hypothesis that during the Great Moderation, borrowing by the real sector in excess of GDP growth moderated GDP fluctuations. Furthermore, we find that output growth volatility was Granger-caused by changes in monetary policy (captured in the interest rate) before the Great Moderation, while the opposite direction of causality holds during the Great Moderation. Further, we find Granger causality from excess credit growth to changes in interest rate in both subsamples. And finally, inflation Granger-causes changes in the interest rate in the second subsample but not in the first subsample, where the direction of causality is reversed. Following Sims (1980), the best way to assess our results is in IRF analyses. We do this over 12 periods in Figure 4 and Figure 5, separately for both subsamples.

[Figure 4 HERE]

[16] The corresponding values are: Q(8)=10.017, Q(12)=12.927, Q^2(8)=9.811, Q^2(12)=13.287.

[17] Although the lag order of the VAR is short, the dynamic behavior of the variables can be captured sufficiently in the first subsample. We tried also VAR(2) as indicated by Akaike Information Criterion (AIC); the qualitative results do not change. In the second subsample VAR(1) is indicated by both information criteria.

[Figure 5 HERE]

Figure 4 illustrates the IRFs before the Great Moderation. They are consistent with the Granger causality test results. A one-standard deviation shock to the change of the interest rate impacts negatively (but with increasing strength) on output volatility, until the sixth period. A one-standard deviation shock to the change of the interest rate impacts positively on inflation, with decreasing strength. And a one-standard deviation shock to excess credit growth impacts positively (with decreasing strength) on the change of the interest rate, until the fourth period.

The IRFs in Figure 5, during the Great Moderation, are also in line with Granger causality tests. There are five significant effects, summarized below. Most relevant to our hypothesis, we find that a one-standard deviation shock in excess credit growth impacts negatively (with decreasing strength) on output volatility, after the second period. It is interesting to note that there is also reverse causality. A one-standard deviation shock in output volatility impacts positively on excess credit growth (and the impact is stable), after the second period. This is consistent with the view that excess credit growth is induced by concerns over volatility concerns. Neither of these causal links between excess credit growth and output volatility were observed before the Great Moderation. We summarize all significant IRF findings in Table 3.

[Table 3 HERE]

Results of the forecast error variance decomposition analysis also support the observations from Granger causality tests (Figure 6, Figure 7). We summarize the key findings in Table 4.[18]

[Table 4 HERE]

[Figure 6 HERE]

[Figure 7 HERE]

The forecast error variance decomposition analysis shows that a substantial part of output growth volatility during the Great Moderation is explained by excess credit growth, whereas almost nothing of it was explained by excess credit growth before the Great Moderation. This supports

[18] The decomposition of the forecast error variance of inflation and the federal funds rate are not reported in the table and the Figures, and are available on request.

the hypothesis that the rise in excess credit growth is among the causes of the Great Moderation change in volatility. Moreover, the importance of excess credit growth also clearly increased, relative to other macro-monetary factors. Inflation and the interest rate both explain substantial part of output volatility before the Great Moderation and much less during the Great Moderation, while the reverse is true for excess credit growth. In sum, both the IRF results and the forecast error variance decomposition analysis indicate causality from excess credit growth to output volatility during the Great Moderation (and not before the Great Moderation) such that excess credit growth moderated output volatility.

6. Summary, Discussion and Conclusions

In the mid-1980s, two shifts occurred in the US economy. The first was that macroeconomic volatility declined strongly within a few years. This 'Great Moderation' lasted for more than two decades, until the Great Crash of 2007. The second was that borrowing by the real sector increased strongly within a few years, to a level that was structurally above the level of growth. It remained high for over two decades, until the Great Crash of 2007. Since access to credit may decrease output fluctuations, we hypothesize that during the Great Moderation borrowing by the real sector in excess of GDP growth moderated GDP fluctuations.

No study to date has directly analyzed the link between output volatility during the Great Moderation and borrowing by the real sector - that is, excluding borrowing for investment in financial instruments and assets in the 'finance, insurance and real estate' sectors (or 'FIRE' sectors, in the classification of the National Income and Product Accounts). The effect of debt-financed wealth accumulation on volatility is different from the effect of debt-financed activity, which we analyze. A second contribution is that we observe not just credit flows (as most other studies do), but the growth in borrowing by the real sector in excess of output growth (or 'excess credit growth'). Using flow-of-fund data, we so focus on the growth in the debt-to-GDP ratio that is due to borrowing by the real sector. This is motivated by the theoretical equality in growth in borrowing by the nonfinancial sectors and private nominal output growth of private and external deficits are zero. We show that excess credit growth was persistently positive during most of the Great Moderation, which it was not before. We also explore data and evidence to suggest that this 'excess credit growth' growth was linked to the fall in external balances and the

rise in financial transactions by the real sector. After the mid 1980s, the nonfinancial sectors obtained debt-financed purchasing power (bank credit) which - so we hypothesize - may have been used to cushion shocks in the non-debt financed part of nominal GDP. This may run through countercyclical variations in imports and through countercyclical wealth effects.

We test the hypothesis that this "excess credit" was leading to lower output volatility. We estimate univariate GARCH models in order to obtain estimates for the volatility of output growth. We use this obtained volatility in a VAR model with the volatility of output growth, excess credit and control variables (interest rate and inflation) over two periods, 1954-1978 (before the Great Moderation) and 1984-2008 (during the Great Moderation), We so test whether the excess credit-GDP volatility relations changed between the two periods. Results from Granger causality tests, impulse response functions and forecast error variance decompositions all suggest that changes in excess credit were causing the decline in output volatility during the Great Moderation. The causality is also bidirectional.

As to the interpretation of these results, a focus on debt growth is one way to connect (as in Bean, 2011) the Great Moderation to the (2007) 'Great Crash' and the 'Great Recession' that followed. Bean (2011) discusses how low volatility in real and financial variables induced more debt-financed investment and risk taking than would otherwise have occurred in the decades preceding the Crash. Kemme and Roy (2012) show that the U.S. mortgage-driven house price boom was a good predictor of the crisis. Cross-country empirical results point in the same direction. Akram and Eitrheim (2008) find that stabilization, not acceleration of credit growth enhances stability in both inflation and output in the long run. Arcand et al. (2012) find that there can be 'too much finance': above a threshold level of the credit-to-GDP ratio, the growth effect of credit declines and turns negative. Cecchetti et al. (2012) likewise conclude that beyond a certain level, debt is a drag on growth. Reinhart and Rogoff (2009) find that a common denominator of financial crisis is a credit boom while Jorda et al. (2012) find that more credit-intensive expansions tend to be followed by deeper recessions and slower recoveries. Schularick and Taylor (2012) also analyze that financial crisis are 'credit booms gone bust'.

In line with these recent studies, this paper motivates a link between Moderation and Crash: perhaps there was a moderation of volatility partly due to immoderate credit growth not only in mortgage markets but also in the real sector. In a broader perspective, this more cautionary view on credit also fits in with Minsky's (1982) theory that 'stability is destabilizing', precisely

because of the buildup in leverage that it encourages. This implies that the causality from 'excess credit' to declining output volatility that we hypothesize may in fact be bidirectional; and that it may be the prelude to financial instability. In the 1999 study already quoted, Godley noted for the U.S. that the growth in private spending was structurally larger than the growth in private sector incomes since the early 1990s, and he wrote that "if … the growth in net lending and the growth in money supply growth were to continue for another eight years, the implied indebtedness of the private sector would then be so extremely large that a sensational day of reckoning could then be at hand." (Godley, 1999:5). These observations, linked to the present study, may lead to a re-evaluation of the nature of the Great Moderation.

Appendix: Data Construction

Given the theoretical relations explained in section 2, the empirical aim is to construct a measure for credit which (i) flows to the real sector, and (ii) which finances activity in the real sector. Both qualifications are important, since (i) most bank credit flows not to the real sector (but to the financial sectors) and (ii) a large part of credit which does flow to the real sector (namely, mortgages) does not finance activity but finances transactions in wealth. We exclude both from the credit flow in our variable in order to construct a fairly reliable measure for credit which finances activity in the real sector. Only then can we proceed to analyse whether the growth rate of this credit measure indeed maps onto activity (it does until the mid-1980s), and if it does not, whether the difference ('excess credit growth') was a causal factor in the greater stability of output growth that characterized the Great Moderation.

We utilize quarterly data from 'Z' tables in the Flow of Funds Accounts. The stock of loans from banks to the real sector is recorded in series FL394104005.Q in Z1, titled 'nonfinancial sectors credit market instruments; liability', while credit assets held by the domestic real sector are recorded in series FL384004005.Q, titled 'domestic nonfinancial sectors credit market instruments; asset'. The difference is the net flow of bank credit to the real sector. However, this includes mortgage credit, which does not directly finance activity but finances transactions in wealth. Mortgage credit is recorded in series FL383165005.Q, 'domestic nonfinancial sectors; total mortgages; liability'. Subtracting mortgage credit (FL383165005) from total credit (FL394104005) to the real sector give us a proxy for bank credit that directly finances real-sector activity.

Apart from bank credit ('credit market instruments'), real-sector activity is additionally financed by inter-firm trade credit (FL383070005.Q; see Mateut (2005) on the role of trade credit), firm-to-customer consumer credit (FL383066005.Q) and 'other loans and advances' (FL383069005.Q). We add these credit stocks (which are quantitatively small relative to the bank credit stock) to our measure. Finally, we subtract net financial investment (including home equity withdrawal; Greenspan and Kennedy, 2008). This is our measure for credit flows to the real sector. As noted in section 2, this measure is still imperfect due to financial transactions on credit in the real sector, such as leveraged mergers and acquisitions and stocks repurchases.

TABLES AND FIGURES

Table 1: Descriptive Statistics

	Mean	Std dev.	Skewness	Kurtosis	LM-Statistic
1954Q3-1978Q4					
RGDP	0.0094	0.0109	-0.3512	3.5788	33.1762*** (12)
INF	0.0097	0.0064	0.8570	3.5780	-
EXCRED	0.0042	0.0380	-0.4203	7.5537	-
FR	0.0232	0.1858	-1.1955	9.2076	-
1984Q1-2008Q1					
RGDP	0.0076	0.0051	-0.1665	3.2697	3.5213* (1)
INF	0.0063	0.0024	0.6443	2.7108	-
EXCRED	0.0107	0.0352	-0.4955	2.8513	-
FR	-0.0133	0.1401	-0.6680	5.9591	-

Table 2: Granger Causality Tests

Testable Hypotheses	Pre-Great Moderation	During-Great Moderation
	Chi-square statistic	
	1954Q3-1978Q4	1984Q1-2008Q1
EXCRED does not Granger Cause σ_{dlrgdp}	0.1542 (0.6945)	4.0361 (0.0445)
σ_{dlrgdp} *does not Granger Cause EXCRED*	0.0443 (0.8333)	4.4536 (0.0348)
dlfr does not Granger Cause σ_{dlrgdp}	8.7985 (0.0030)	2.2814 (0.1309)
σ_{dlrgdp} *does not Granger Cause dlfr*	1.1296 (0.2879)	7.1043 (0.0077)
inf does not Granger Cause σ_{dlrgdp}	0.5129 (0.4739)	0.3658 (0.5453)
σ_{dlrgdp} *does not Granger Cause inf*	1.0018 (0.3169)	0.4383 (0.5079)
dlfr does not Granger Cause EXCRED	0.5303 (0.4665)	0.2002 (0.6545)
EXCRED does not Granger Cause dlfr	4.1972 (0.0405)	7.9012 (0.0049)
inf does not Granger Cause EXCRED	0.0064 (0.9360)	1.3600 (0.2435)
EXCRED does not Granger Cause inf	1.2395 (0.2656)	1.1919 (0.2750)
inf does not Granger Cause dlfr	0.6209 (0.4307)	5.2001 (0.0226)
dlfr does not Granger Cause inf	3.5578 (0.0593)	0.4183 (0.5178)

Notes: Probability values of the corresponding Chi-square statistics are in parentheses.

Table 3: Excess credit growth moderated output volatility during, but not before the Great Moderation

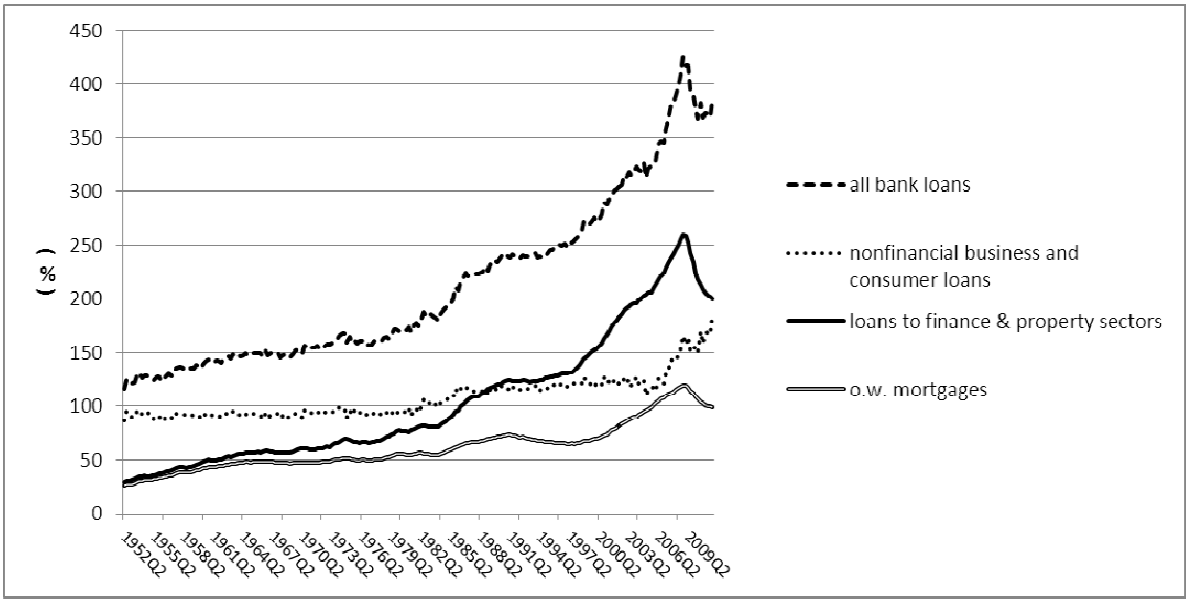
Results from impulse response functions	
Before the Great Moderation	*During the Great Moderation*
change in interest rate (-) => output volatility	excess credit growth (-) => output volatility
change in interest rate (+) => inflation	output volatility (+) => excess credit growth
excess credit growth (+) => change in interest rate	output volatility (-) => change in interest rate
	excess credit growth (+) => change in interest rate
	inflation (+) => change in interest rate

Note: In the table, *x* (-) => *y* denotes that a one-standard deviation shock in variable *x* impacts negatively on the change of variable *y*. Similarly, *x* (+) => *y* indicates a positive impact.

Table 4: Excess credit growth explains output volatility during, but not before the Great Moderation

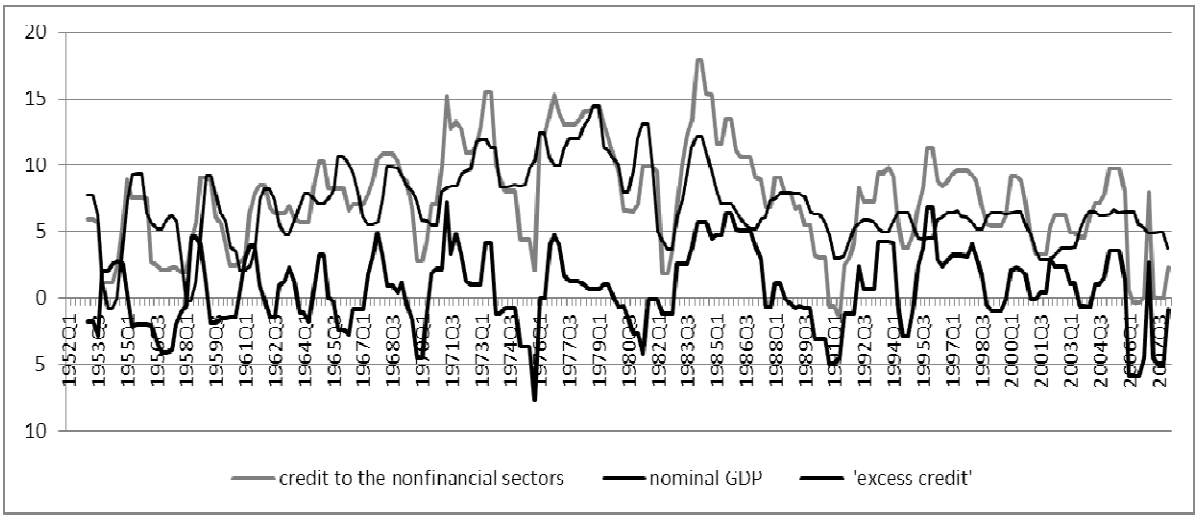
% of 12-quarters-ahead forecast error variance of output growth volatility explained by ...			
Before the Great Moderation		*During the Great Moderation*	
excess credit growth:	0.2%	excess credit growth:	16.2%
change in interest rate:	11.4%	change in interest rate:	4.2%
Inflation:	4.8%	Inflation:	0.6%

Figure 1: U.S. bank-credit-to-GDP ratios (%), 1952Q1 – 2012Q1



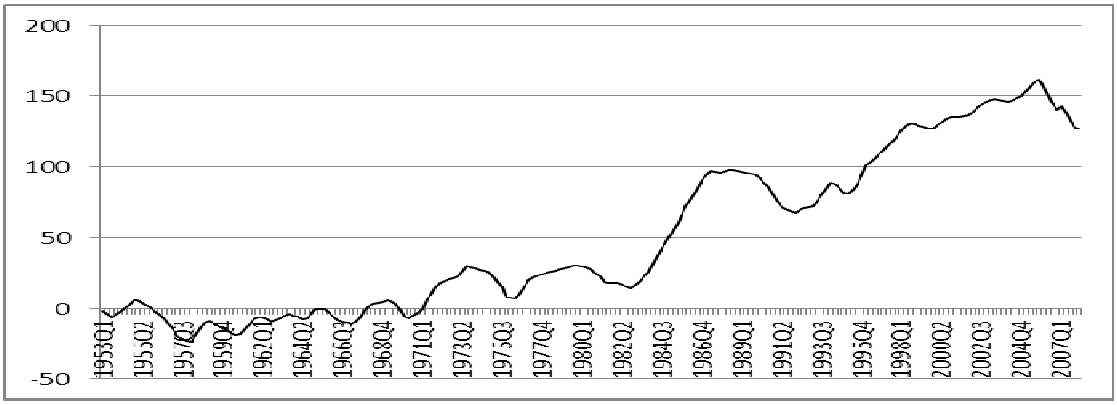
Source: Bureau of Economic Analysis, flow of funds data (Z tables).

Figure 2: Growth of credit to the nonfinancial sectors and nominal GDP, 1952-2012 (%)



Source: Bureau of Economic Analyis. Note: Data are growth rates (in percent) of nominal Dollar figures. In this graph (but not in the analysis below), time series have been smoothed by taking the median of the current, previous and next quarter.

Figure 3: Cumulative percentage point growth of "excess credit growth", 1952-2008



Source: Bureau of Economic Analyis

Figure 4: Impulse Responses to shocks before the Great Moderation (1954Q3-1978Q4)

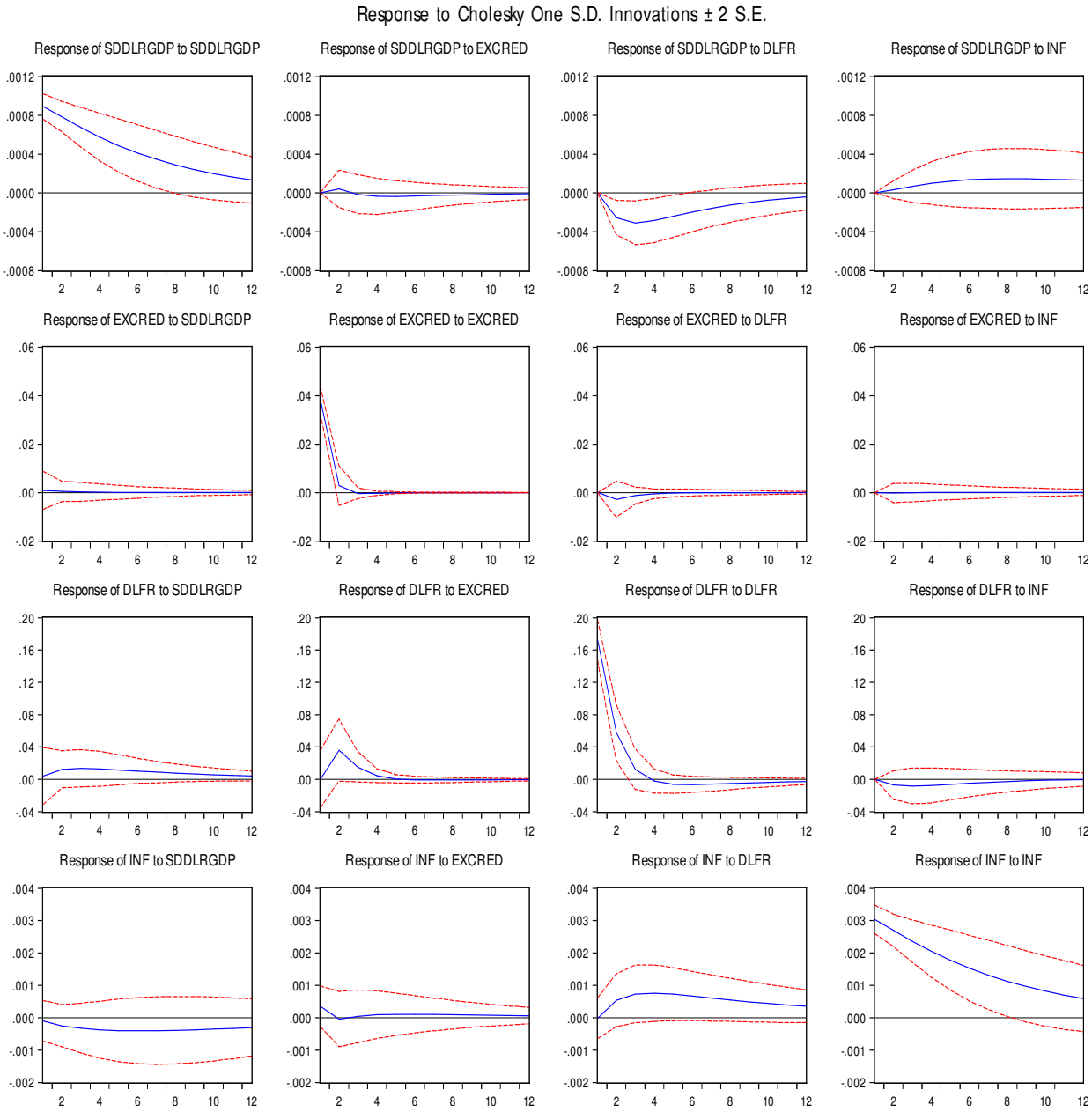


Figure 5: Impulse Responses to shocks during the Great Moderation (1984Q1-2008Q1)

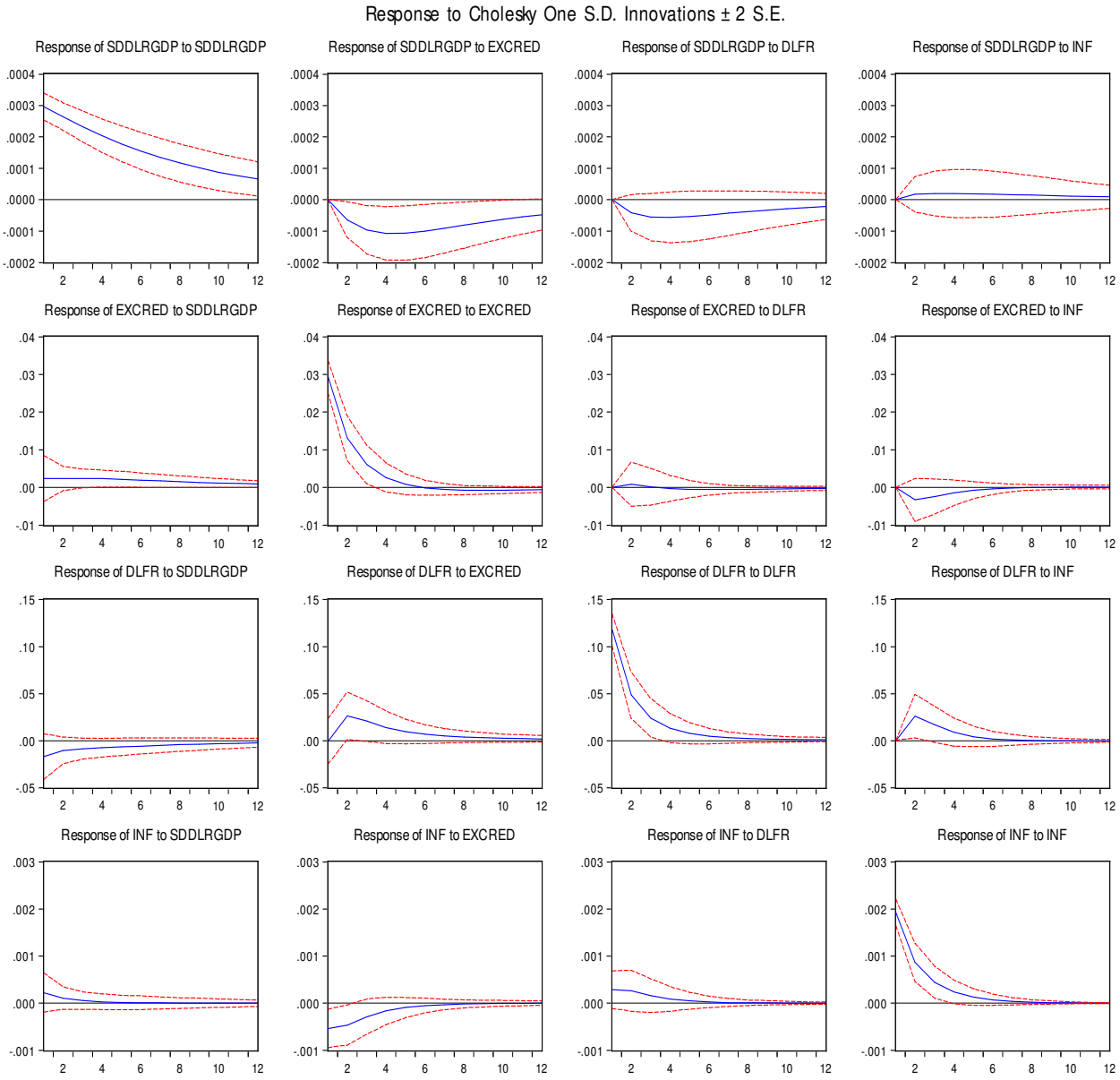


Figure 6: Variance Decompositions before the Great Moderation (1954Q3-1978Q4)

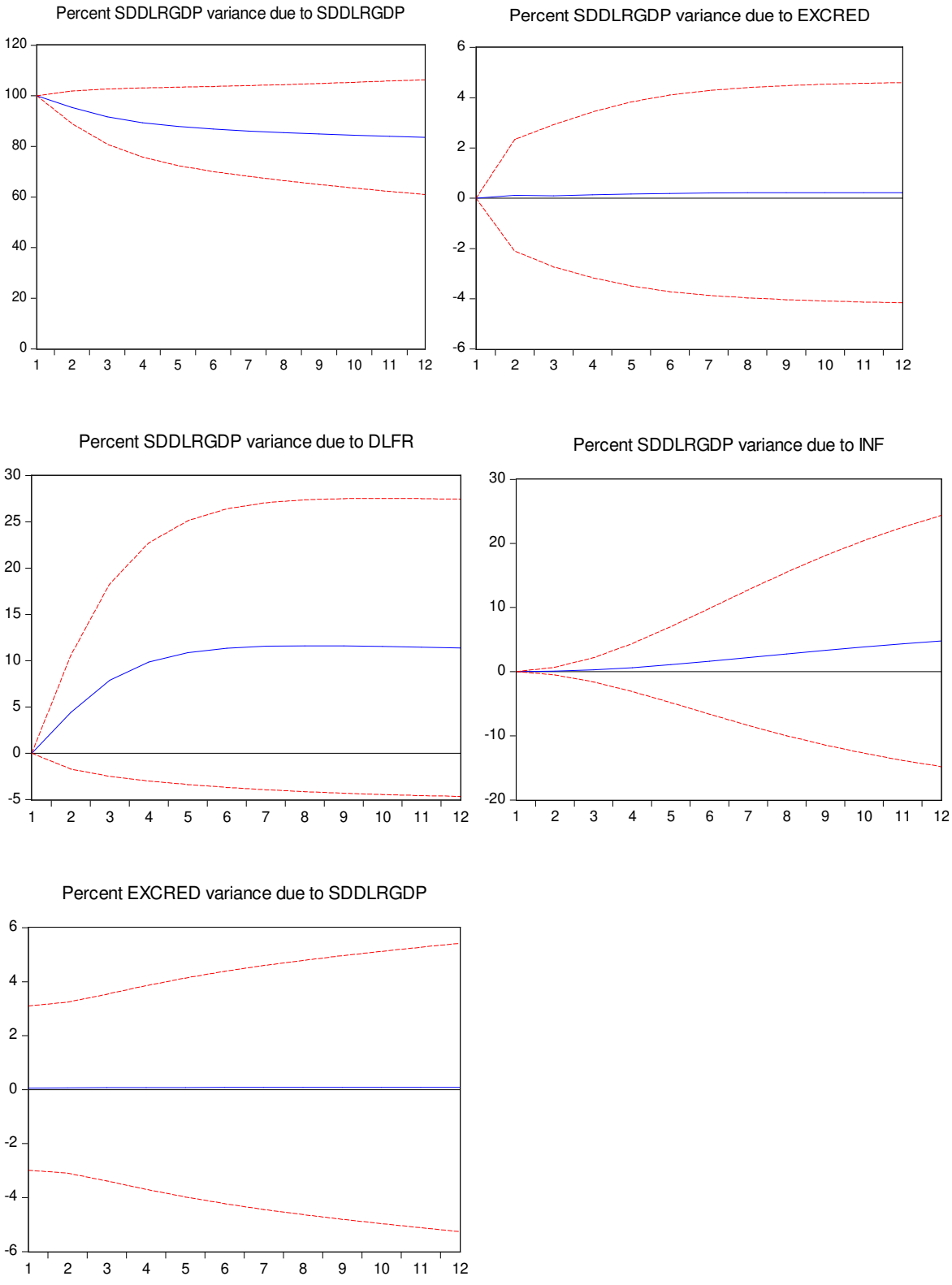
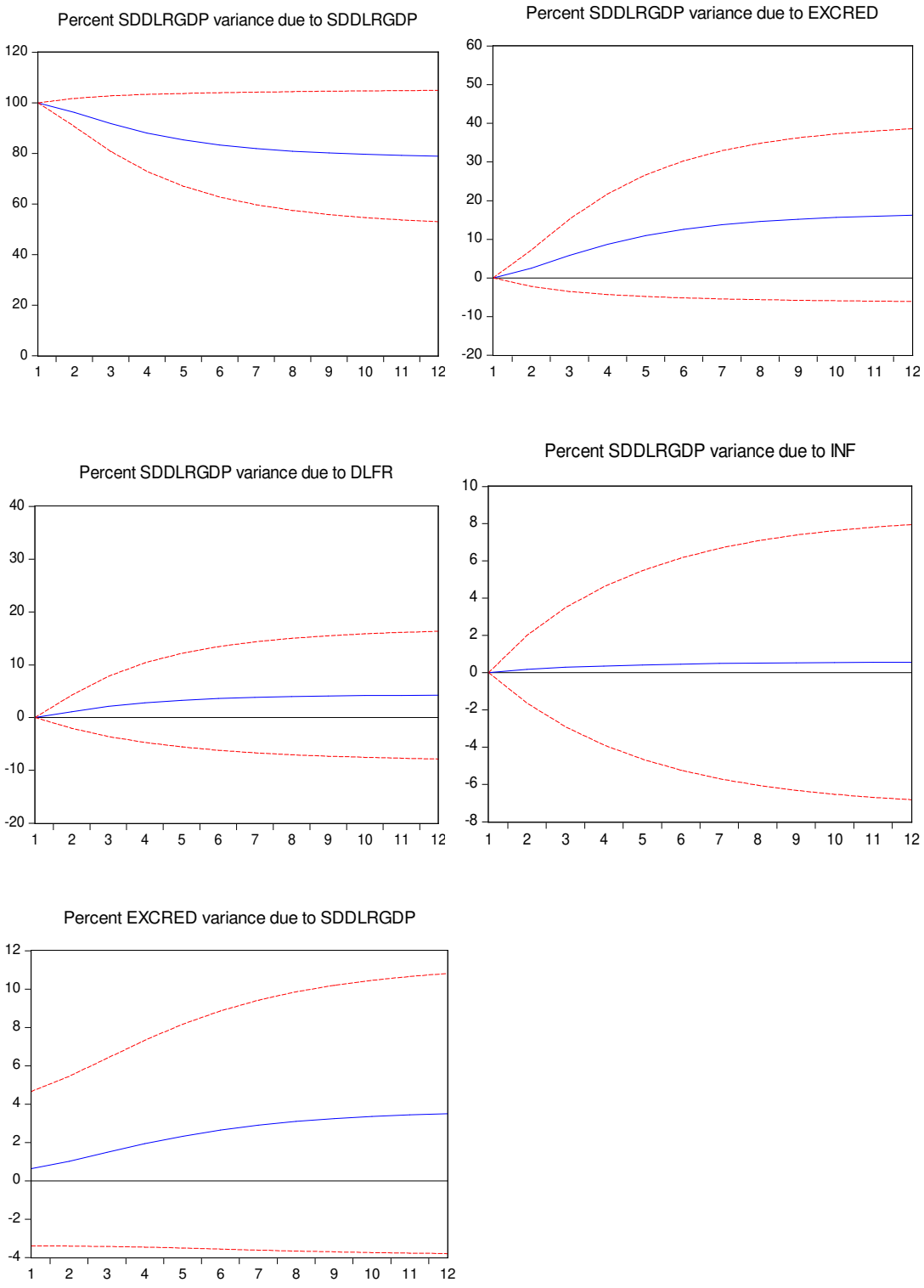


Figure 7: Variance Decomposition of the Variables during the Great Moderation (1984Q1-2008Q1)



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