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The Macroeconomic Implications of Household Debt: An Empirical Analysis

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Multi-equation econometric frameworks are used to investigate the impact of household debt on aggregate performance in US. In the vector autoregression analysis capturing the transitory feedback effects, we observe a bidirectional positive feedback process between aggregate income and debt. According to the estimation of vector error correction models, there are negative long-run relationships between household debt and output. The empirical model has also been extended to include investment and corporate debt. The results are in contrast with the results of empirical model without corporate sector variables. The negative long-run relationship between household debt and GDP ceases to exist as shown by the positive cointegrating coefficients in the cointegrating equations. Impulse response functions from these extended empirical models also indicate that investment may be an important channel through which household debt affects output.

J.E.L. Codes: C32, E21, E32
Keywords: Household Debt, Financial Instability Hypothesis, Cointegration, VAR, VECM
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An Empirical Analysis

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May 22, 2011

Abstract

Multi-equation econometric frameworks are used to investigate the impact of household debt on aggregate performance in US. In the vector autoregression analysis capturing the transitory feedback effects, we observe a bidirectional positive feedback process between aggregate income and debt. According to the estimation of vector error correction models, there are negative long-run relationships between household debt and output. The empirical model has also been extended to include investment and corporate debt. The results are in contrast with the results of empirical model without corporate sector variables. The negative long-run relationship between household debt and GDP ceases to exist as shown by the positive cointegrating coefficients in the cointegrating equations. Impulse response functions from these extended empirical models also indicate that investment may be an important channel through which household debt affects output.

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1 Introduction

The U.S. has experienced a significant increase in household debt relative to income. Figures 1 depicts the ratios of consumer, mortgage, and household debt (sum of mortgage and consumer debt) relative to gross domestic product (GDP). Household debt outstanding as a share of GDP, for example, increased from about 45 percent in 1975 to nearly 100 percent in 2009. Although there is more fluctuation in the consumer debt-GDP ratio, a clear upward trend is observed, especially since 1985. Mortgage debt seems to be a dominating component

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Figure 1: Debt Outstanding as Share of GDP (1951Q4-2009Q1)

of household debt, and the household and mortgage debt-GDP ratios seem to show close co-movements.

The figure 2 depicts the evolution of debt-net worth ratios. This provides additional evidence of the substantial increase in debt. The pattern is similar to debt-GDP ratios. There is a clear upward trend in all ratios. In general, the liability side has grown more rapidly than the asset side over the sample period. Similar to the debt-GDP ratios, household and mortgage debt-net worth ratios seem to show close co-movements.

Figures 3 depicts two measures of the debt service burden: Household Financial Obligations as a percent of Disposable Personal Income (FODSP) and Household Debt Service Payments as a Percent of Disposable Personal Income (TDSP). Recently, these series have been considered important debt burden measures and are used by the Federal Reserve as primary measures of the household debt burden (Greenspan, 2004). These two series are available starting in 1980.¹ Both measures also show upward trends, indicating that households’ financial positions have been continuously worsening.

These levels of debt accumulation eventually proved untenable—as has been broadly implicated in the recent recession. This provides motivation for our present research. Specifically, we will investigate the impact of household debt to real GDP from the perspective of

¹The debt service ratio measures the share of income committed by households for paying interest and principal on their debt. The financial obligations ratio, in addition to including debt payments, incorporates households’ other recurring expenses—such as rents, auto leases, homeowners’ insurance and property taxes—that may be subtracted from the uncommitted income available to households (Greenspan, 2004).
Minsky’s financial instability hypothesis (FIH).

This paper is organized as follows. Section 2 discusses Minsky’s financial instability hypothesis applied to household debt. Section 3 presents our empirical modeling strategy. Section 4 provides empirical evidences on the relationship of household debt to aggregate output in the US macroeconomy. Section 5 concludes.

2 Minsky’s Financial Instability Hypothesis Applied to Household Debt

Heterodox, especially post-Keynesian thoughts on the effect of debt on macroeconomic problems are strongly influenced by Hyman Minsky’s financial instability hypothesis. Minsky’s theory clarifies the two-sided aspects of debt-financed spending. During the boom-phase of the business cycle, debt-financed household spending (and investment as traditionally emphasized) provides a source of additional economic stimulus. However, as the economy experiences a prolonged phase of prosperity, more debt-financed spending occurs and the debt-to-income ratio eventually rises. The balance sheets of businesses and households deteriorate and the system becomes financially fragile. The system becomes highly vulnerable

\[2\] Research on the impact of debt on growth and cycles usually emphasizes corporate debt as a prime source of investment fluctuations and hence output fluctuations. Household debt played little role in Minsky’s works, and most subsequent research also largely neglected household debt.
to negative shocks, potentially resulting in a severe economic downturn.

Minsky’s financial instability hypothesis has been applied to household debt by Palley (1994) and Cynamon and Fazzari (2008). Palley (1994) used a linear multiplier-accelerator model to analyze the cyclical aspects of consumer borrowing in the business cycle. In his model, a rise in consumer debt initially increases consumption and hence promotes growth, but eventually the accumulation of debt becomes excessive. This implies that there is a transfer of income from low saving agents (debtors) to high saving agents (rentiers) at an increasing rate due to the debt service payments. The debt service burden then reduces consumption and output level. This provides a mechanism of a credit-driven cyclical process of output. Cynamon and Fazzari (2008) provide a very informative discussion of household debt from a Minskian perspective. They observe that, from the 1980s to the early 2000s, the US experienced consumption expansion accompanied by significant household debt accumulation. Cynamon and Fazzari (2008) argue that, although this provided a substantial macroeconomic stimulus, this unprecedented rise in household debt could have planted the seeds for financial instability and a nontrivial economic downturn.

As Cynamon and Fazzari (2008)’s argument implies, Minsky’s financial instability hypothesis can be read as highlighting distinctive debt effects depending on the time frame in consideration. Debt financed household spending may provide a source of additional economic stimulus in the shorter time period, but eventually the accumulation of debt could becomes excessive, generating negative impact on consumption and output level in the long run (probably through the higher debt service payment and frugal consumer behavior due to excessive debt level). The system could become highly vulnerable to negative shocks, potentially resulting in a severe economic downturn. From this point of view, there are dis-
tistinguishing effects of debt in the short and longer time period. We approach our empirical investigation from this theoretical perspective.

3 Empirical Methods

To our knowledge, Palley (1994) is the only empirical study that has analyzed household debt (more specifically consumer debt) and the business cycle from the perspective of Minsky's financial instability hypothesis. Palley argues that an increase in debt should raise GNP, while an increase in the debt service burden should reduce GNP. (This is based on the theoretical idea presented in the previous section.) His empirical results are based on an autoregressive distributed lag model of the following form.

\[ \text{output}_t = \beta_0 + \beta_1 \text{time} + \beta_2 \text{output}_{t-1} + \beta_3 \Delta \text{consumerdebt}_t + \beta_4 \text{debtservicepayment}_t + \beta_5 \text{interestrate}_t + \varepsilon_t \]

All variables are in per capita units. Palley’s simple ADL or unrestricted VAR model does not capture the distinguishing effects of debt in the short-run and longer run. More appropriate econometric models should be based on the idea of cointegration, which would capture the long-run relationship between the variables. Once the existence of cointegration relations are established, one can use a variant of error correction models via Granger representation theorem.

In a single equation framework, one can, for example, utilize dynamic OLS (DOLS) by Stock and Watson (1993) to capture the distinguishing effects between short-run and long-run.

\[ y_t = \beta_0 + \theta_1 x_t + \theta_2 z_t + \beta_1 \Delta y_{t-1} + \beta_2 \Delta x_t + \beta_3 \Delta x_{t+1} + \beta_4 \Delta y_{t-1} + \beta_5 \Delta y_{t+1} + \beta_6 \Delta z_{t-1} + \beta_7 \Delta z_{t-1} + \beta_8 \Delta z_{t+1} + \beta_9 \Delta z_{t+1} + \varepsilon_t \]

where \( \beta_0 \) is the intercept term and \( \varepsilon_t \) is a representation of a white noise error process. The long-run relationship between \( y_t, x_t, \) and \( z_t \) is captured by the cointegrating equation \( y_t = \beta_0 + \theta_1 x_t + \theta_2 z_t \), and the rest of parameters for the differenced variables \( (\beta_1, \beta_2, \beta_3 \text{ etc.}) \) summarize the short-run dynamic adjustment process. This single equation framework is appropriate for the case in which \( x_t \) and \( z_t \) are weakly exogenous.

3In this respect, Minsky’s financial instability hypothesis could be seen as a long wave theory. See Minsky (1964, 1995).

4Palley’s unrestricted VAR model of changes in consumer debt, consumer debt burden, and GNP shows that shocks to the changes in consumer debt and the consumer debt burden generate an initial positive and negative GNP response, respectively, both followed by a cyclical and damped response in each case. Based on these results, Palley emphasizes consumer debt and its burden as an important factor for explaining the cyclical process.

5Granger representation theorem establishes that error correction and cointegration are equivalent representations for any set of I(1) variables if they share common trend. (Enders 2004)

6The points that satisfy the cointegrating equation can be thought of as attractors in a dynamic system perspective. In fact, the attractor is the basis of the concept of cointegration (Granger and Terisvirta, 1993).

7In general a variable \( x_t \) is weakly exogenous for the parameter set \( P \) if the marginal distribution of \( x_t \) contains no useful information for conducting inference on \( P \) (Enders, 2004, pg. 378).
One can also utilize the multiple equation framework of the VECM. The VECM method allows for the simultaneous modeling of multiple endogenous variables. For example, a three-variable VECM can be written as

\[ \Delta y_t = \alpha_{11}y_{t-1} + \theta_1 x_t + \theta_2 z_t + \beta_{12}\Delta x_{t-1} + \beta_{13}\Delta z_{t-1} + \varepsilon_{1t} \]  
\[ \Delta x_t = \alpha_{21}y_t + \theta_1 y_{t-1} + \theta_2 z_t + \beta_{22}\Delta x_{t-1} + \beta_{23}\Delta z_{t-1} + \varepsilon_{2t} \]  
\[ \Delta z_t = \alpha_{31}y_t + \theta_1 y_{t-1} + \theta_2 z_t + \beta_{32}\Delta x_{t-1} + \beta_{33}\Delta z_{t-1} + \varepsilon_{3t} \]

The long run relationship between \( y, x, \) and \( z \) is captured by the cointegrating relationship, \( (y_t + \theta_1 x_t + \theta_2 z_t) \), and \( \alpha_{11}, \alpha_{21}, \) and \( \alpha_{31} \) are adjustment coefficients, which indicate the speed of adjustment of the endogenous variables from a disequilibrium state toward the equilibrium. With the speed of the adjustment parameters, the differenced lagged variables account for the short-run dynamic adjustment processes. In this paper, we utilize the VECM approach to distinguish the effects of debt, output, and other variables on each other in the shorter and longer time periods.

4 Empirics

4.1 Three Variable System of Debt, GDP and Networth

We first examine the three variable system of debt, GDP, and net worth. The main question of this study is the relationship between debt and GDP. One channel through which debt can influence GDP is the balance sheet effect through the consumption function (Mishkin, 1977, 1978). An increase in assets will have a positive effect on consumption and an increase in liabilities will depress consumption. Mishkin (1977, 1978) distinguishes the debt and financial assets in the estimation of balance sheet effect on the consumption. We simply add a net worth variable to control for the effect from the asset side. In this paper, we consider all consumer, mortgage, and household debt to see whether different composition of debt provide different results. Figures 4 and 5 present the graphs of the log levels and growth rates (first difference of logarithms) for these variables. We first investigate the stationarity properties of each series, since this is a necessary step for investigating cointegration between the variables. Cointegration will be then investigated, and based on the results, an appropriate empirical model will be implemented to study the interrelationships between the variables.

4.1.1 Unit Root Tests

In this section, the stationarity properties of the data are formally investigated. Two methods for the test are employed: the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test. For the technical discussion, we largely follow Enders (2004).

In general form, the ADF testing equation can be expressed as

\[ \Delta Y_t = a_0 + \gamma Y_{t-1} + a_2 t + \sum_{i=2}^{P} \beta_i \Delta Y_{t-i+1} + \varepsilon_t \]  

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Figure 4: Variables in The Logarithmic Level

Figure 5: Log Variables in First Difference
The graphs of logarithmic household debt, net worth, consumer debt, mortgage debt, and GDP indicate that an upward trend exists in the variables (see figure 4). The question is whether the data generating processes of the variables are trend stationary or contain components of stochastic trends plus drift terms (and possibly linear time trends). In testing for a unit root, it is important to mimic the actual data generating process. An incorrect model specification results in a loss of test power. We have tested unit roots for the general and no-time trend cases using both ADF and PP methods (see table 1). The tests for GDP, mortgage debt, and net worth indicate unit roots for both the general case (equation 5) and the no time trend case. Since these series clearly show upward trends, drift terms need to be included for the testing equations. The ADF tests for household and consumer debt for the general form (recall equation 5) indicate that the series are stationary at a 10 percent significance level. Without linear time trends, the tests indicate evidence for unit roots. PP tests provide the same results. In this situation, we followed the procedure suggested by Dolado et al. (1990). For example, for the household debt series (denoted here as a Y), we estimate the following ADF equation:

$$
\Delta Y_t = a_0 + \gamma Y_{t-1} + \sum_{i=2}^{3} \beta_i \Delta Y_{t-i+1} + \epsilon_t
$$

(6)

We then calculate the following F-statistics to determine whether the linear time trend should be present or not.

$$
\phi_i = \frac{[SSR(\text{restricted}) - SSR(\text{unrestricted})]/r}{SSR(\text{unrestricted})/(T-k)}
$$

(7)

where SSR(\text{restricted}) and SSR(\text{unrestricted}) are the sums of the squared residuals from the restricted and unrestricted models; r is the number of restrictions; T is the number of usable observations; and k is the number of parameters estimated in the unrestricted model. This calculation yields,

$$
\phi_3 = \frac{[0.005717 - 0.008305]/2}{0.008305/(227-5)} = 0.000206/0.0000374 = 5.51
$$

(8)

The critical value of $\phi_3$ with a sample size of 100 is 6.49 and with a sample size of 250 is 6.34 at the 5 percent significance level. Since $T = 227$ here, we do not reject the null hypothesis, $\gamma = a_2 = 0$. In other words, the restriction $\gamma = a_2 = 0$ is not binding. In this case, the data generating process should not contain a linear trend. With this conclusion, we can now proceed to test for a unit root without a linear trend term. The test result confirms that the series has a unit root.\footnote{Select two lags for the household debt case.}

\footnote{However, at 10 percent significance level, the critical value of $\phi_3$ with the sample size 100 is 5.47, and 5.39 with the sample size 250. In this case, we reject the null hypothesis, and hence the restriction is binding. In other words, there could be three possibility: (1) $\gamma \neq 0, a_2 = 0$; (2) $\gamma = 0, a_2 \neq 0$; (3) $\gamma = a_2 \neq 0$. In this case, we retest for the presence of a unit root using the standardized normal distribution (t-distribution in practice therefore) since, if a trend is actually present in household debt, the limiting distribution of $\gamma$ is normal (Enders (2004, pp.214)). The calculated t-statistic is -1.061859, which indicates that $\gamma = 0$. We}

8
Table 1: Unit Roots Tests for Log-Transformed Variables

<table>
<thead>
<tr>
<th></th>
<th>PP</th>
<th>ADF</th>
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<tr>
<td>Real GDP</td>
<td>-1.442351</td>
<td>-1.395512</td>
</tr>
<tr>
<td></td>
<td>(0.5610)</td>
<td>(0.5842)</td>
</tr>
<tr>
<td>Household Debt</td>
<td>-1.827598</td>
<td>-1.061859</td>
</tr>
<tr>
<td></td>
<td>(0.3665)</td>
<td>(0.7309)</td>
</tr>
<tr>
<td>Net worth</td>
<td>-1.123686</td>
<td>-1.170049</td>
</tr>
<tr>
<td></td>
<td>(0.7067)</td>
<td>(0.6876)</td>
</tr>
<tr>
<td>Consumer Debt</td>
<td>-2.170379</td>
<td>-1.38</td>
</tr>
<tr>
<td></td>
<td>(0.2178)</td>
<td>(0.5915)</td>
</tr>
<tr>
<td>Mortgage Debt</td>
<td>-1.239714</td>
<td>-0.840077</td>
</tr>
<tr>
<td></td>
<td>(0.6574)</td>
<td>(0.8053)</td>
</tr>
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</table>

ADF and PP test statistics with p-values are reported. Lag lengths are selected by SIC. Drift term, but no time trend in the estimating equations.
The null hypothesis is that the variable has a unit root. MacKinnon (1991, 1996) one-sided critical values and p-values are used.

For the consumer debt case, \(10\)

\[
\phi_4 = \frac{[0.019050 - 0.018083]/2}{0.018083/(227 - 5)} = \frac{0.0004835}{0.0000815} = 5.93
\] (9)

As in the household debt case, we do not reject the null hypothesis \(\gamma = a_2 = 0\) at a 5 percent significance level, but do reject the null at the 10 percent level. We use the five percent significance level, and test for a unit root without a linear trend. The result confirms that the series has a unit root. (The PP test also confirms the result as well.) We conclude the all series are nonstationary (without quadratic trend term.) The first-differenced series are stationary according to both ADF and PP tests. All series are therefore integrated of order 1. Table 1 summarizes these results.

4.1.2 Cointegration

Cointegration analysis reveals the long-run relationship between economic variables, if any exists. The variables are cointegrated if they share a common stochastic trend, and if they are linearly related to each other across the variables. A linear combination of the variables, therefore, should provide a stationary variable.\(^11\) The unit root test results indicate that the individual variables in the series have stochastic trends, which is a necessary but not sufficient condition for the existence of cointegration between them. We use the cointegration tests developed by Johansen (1988). His methodology is VAR based and utilizes a maximum

\(^\text{10}\)SIC selected two lag lengths.
\(^\text{11}\)Of course, cointegrating relationships might be nonlinear. Unfortunately this possibility is assumed away in this investigation, which is confined to linear combinations of the variables.
Table 2: Cointegration Rank Tests (2 lags): Log Y, D_H, and NW

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<thead>
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<th>Data Trend:</th>
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<td>Intercept</td>
<td>No Trend</td>
<td>Intercept</td>
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| Trace       | 1 | 0 | 0 | 0 | 1 |
| Max-Eig     | 1 | 0 | 0 | 0 | 0 |

Cointegration rank tests of the system of log-transformed GDP, household Debt, and net worth with two lags.
Significance level: 5 percent
Critical values based on MacKinnon et al. (1999)

likelihood estimation method.

Following the procedure in recommended Enders (2004), the lag lengths are selected by information criteria in a vector autoregression of undifferenced data. The lag length results for three variable system are reported in tables 10, 11, and 12 in appendix D, while the cointegration results are given in tables 2, 3, and 4. (Mathematical notations are utilized to shorten the title of tables. Y, C, NW, and I denote GDP, consumption, net worth, and investment respectively. D_H, D_M, D_C, and D_F denote household, mortgage, consumer, and corporate debt respectively.) Cointegration test statistics differ depending on the specification of the data generating process and cointegrating relations across the variables. As shown in figure 4, it is reasonable to assume that all the data have linear time trends. It is also assumed that a cointegration vector contains a constant, but no linear trend, since there is no plausible argument for a linear trend in the cointegrating vectors for the set of variables in our study. The third specification in each of tables 2, 3, and 4 are therefore relevant results. Without regard to the lag length specifications, the three variable system with either household and mortgage debt (tables 2 and 3) is not cointegrated. The test statistics show that the cointegration test results of the three variable system with consumer debt depend on the lag length specification. With either one or three lag lengths (in first differences), the system with consumer debt possesses one cointegrating relationship. With either two or four lag lengths (in first differences), the system with consumer debt possesses no cointegrating relations (see table 4 for the result with 4 lags). Given that household debt includes consumer debt, it may not be reasonable that the system with consumer debt contains a long-run equilibrium if the system with household debt does not possess a long-run equilibrium. We proceed to the VAR analysis of first-differenced series (rather than VECM) with the conclusion of no cointegration.

4.1.3 VAR Analysis: Short-Run Perspectives

Because the series exhibit unit roots, we express them in first differences, which transform the variables into growth rates. The lag lengths of the VAR are selected based on the information criteria in tables 13, 14, and 15 in appendix D. The lag lengths are selected by the majority of the information criteria. A constant is specified in the VAR estimations.

\[\text{The results are not reported here.}\]
Table 3: Cointegration Rank Tests (4 lags): $\log Y$, $D_M$, and $NW$

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<td>Max-Eig</td>
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Cointegration rank tests of the system of log-transformed GDP, mortgage debt, and net worth with four lags.
Significance level: 5 percent.
Critical values based on MacKinnon et al. (1999)

Table 4: Cointegration Rank Tests (4 lags): $\log Y$, $D_C$, and $NW$

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Cointegration rank tests of the system of log-transformed GDP, consumer debt, and net worth with four lags.
Significance level: 5 percent.
Critical values based on MacKinnon et al. (1999)
VAR allows us to examine the interaction of the variables via impulse responses.\textsuperscript{13} We produced impulse response results in figures 6, 7, and 8. The impulse response figures include two standard error bands constructed by Monte Carlo methods with 1000 repetitions as an indication of statistical significance. The reported figures are generalized impulse responses. The advantage of generalized impulse responses is that the results do not depend on the specific restriction of the error structures. This is appropriate since there is no clear theoretical guidance for the restriction of the error structures.\textsuperscript{14} The results show that positive household, consumer, mortgage debt growth rate shocks are associated with an increase in the growth rate of GDP, and a positive GDP growth rate shock is associated with an increase in the growth rate of debt. (These positive feedbacks are statistically significant for some periods as the two standard error bands indicate.) Therefore, we observe a bidirectional positive feedback process between aggregate income and all debt measures.

Note that, by using the first differenced variables, the shocks to variables only have temporary effects. Impulse responses in this case only capture transitory effects. The results are in accordance with one aspect of Minsky's financial instability hypothesis: in the transitory phase, we observe a bidirectional positive feedback process between aggregate income and debt accumulation.

4.2 Cointegration and Vector Error Correction Model

In the previous section, the evidence of cointegration was largely absent. One of the possible explanations might be the absence of a relevant variable, especially consumption, since consumption should be a main channel through which household debt and net worth should affect output. For this reason, we add consumption to the three variable system of debt, net worth, and GDP, creating a four variable system, and again using the three alternative measures of debt.

Cointegrating relationships between variables are again investigated via the Johansen test (Johansen, 1988). Again following the procedure recommended by Enders (2004), the lag lengths for the estimating equations are selected by information criteria utilizing a vector autoregression of undifferenced data. The lag length results for four variable systems are reported in tables 16, 17, and 18 in appendix D.

Various model selection criteria provide different lag lengths as the optimal one. It is reasonable to assume that all the data have linear time trends (see figures 4 and 9).\textsuperscript{15} We again assume that the cointegration vector contains a constant, but no linear trend, since there is not a plausible argument for linear trend in the cointegrating vectors for these four variables. The third specification in tables 5, 6, 7, and 8 are therefore the relevant results. The results of cointegration tests depend on the lag lengths. For example, for the system with total household debt (table 5), the trace test indicates one cointegrating relationship in the system with a two-lag specification. However, using mortgage and household debt with seven lags, both the trace and the max-eigenvalue test indicate two cointegrating relationship in the system (tables 6 and 7).\textsuperscript{16}

\textsuperscript{13}With variance decomposition, they are together called innovation accounting.
\textsuperscript{14}Impulse response and variance decomposition analysis with a Cholesky ordering is presented in B.
\textsuperscript{15}Both PP and ADF test confirm that the log transformed real consumption is I(1) variable.
\textsuperscript{16}With lag lengths suggested by some information criteria, neither the trace or max-eigenvalue tests
Figure 6: Generalized Impulse Responses of the Growth Rates of Household Debt, GDP and Net Worth

Table 5: Cointegration Rank Tests (2 lags): Log Y, D_{HH}, C, and NW

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<td>1</td>
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Cointegration rank tests of the system of log-transformed GDP, household debt, consumption, and net worth with two lags. Significance level: 5 percent. Critical values based on MacKinnon et al. (1999)
Figure 7: Generalized Impulse Responses of the Growth Rates of Mortgage Debt, GDP and Net Worth

Table 6: Cointegration Rank Tests (7 lags): Log Y, DH, C, and NW

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Cointegration rank tests of the system of log-transformed GDP, household debt, consumption, and net worth with seven lags. significance level: 5 percent
Critical values based on MacKinnon et al. (1999)
Figure 8: Generalized Impulse Responses of the Growth Rates of Consumer Debt, GDP and Net Worth

Table 7: Cointegration Rank Tests (7 lags): Log $Y$, $D_M$, $C$, and $NW$

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Cointegration rank tests of the system of log-Transformed GDP, mortgage Debt, consumption, and net worth with seven lags. Significance level: 5 percent
Critical values based on MacKinnon et al. (1999)
Figure 9: Log-Transformed Real Personal Consumption Expenditure: Level and First-Differenced

Table 8: Cointegration Rank Tests (3 lags): $\log Y$, $D_C$, $C$, and $NW$

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Cointegration rank tests of the system of log-transformed GDP, consumer debt, consumption, and net worth with three lags. Significance level: 5 percent. Critical values based on MacKinnon et al. (1999)
The systems with one cointegrating relation are studied first. The VECM estimation results are presented in tables 19 and 20 in appendix D. There is no evidence for the system with mortgage debt to have a cointegrating relationship. More detailed tests of the Johansen test results are presented in tables 31 and 32 in appendix D.

Equations (10) and (11) are the estimated long-run equilibrium relationships. Cointegrating vectors are normalized with respect to the GDP coefficient. All the coefficients in both equations (10) and (11) are significant at the 5 percent level, except for the coefficient for net worth in equation 11. (The coefficient for net worth in equation 11 is significant at the 10 percent level.) The signs of the coefficients are, one could argue, in accordance with Minsky's financial instability hypothesis. Both household debt and consumer debt have negative relationships with the level of output in the long run.\(^{17}\)

\[
GDP = 0.76298 + 0.94827 \text{Consumption} + 0.104065 \text{NetWorth} - 0.087421 \text{HouseholdDebt}
\]  
\[
(10)
\]

\[
GDP = 0.926025 + 1.26691 \text{Consumption} + 0.18075 \text{NetWorth} - 0.422445 \text{ConsumerDebt}
\]  
\[
(11)
\]

Tables 19 and 19 in appendix D also show the adjustment coefficients. Note that adjustment coefficients measure the feedback effects of the disequilibrium onto the variables in the VECM. For the system with household debt, the adjustment coefficients of consumption and net worth indicate that these variables do not adjust significantly to short-run deviations from the equilibrium. For the system with consumer debt, the adjustment coefficients of all variables, except consumer debt, do not adjust significantly to short-run deviations from the equilibrium. This suggests the possibility of weak exogeneity of these variables to the parameters of interest. Weak exogeneity of the endogenous variables means that disequilibrium in the cointegrating relationship does not feed back onto these variables themselves. Estimators of and inference on the other parameter values (for example cointegrating vector) conditional on these weakly exogenous variables do not suffer from a loss of information. Tables 21 and 22 in appendix D report estimation of the VECM with the restriction of weak exogeneity on these variables.

The results assuming weak exogeneity (tables 21 and 22 in appendix D) can be contrasted with the results without the imposition of weak exogeneity (Tables 19 and 19 in appendix D). First of all, the restrictions could not be rejected according to the likelihood ratio tests. For the system with household debt, the signs of the long-run coefficients are preserved, but the cointegrating coefficients for net worth and household debt are no longer significant (see equation 12).\(^{18}\) For the system with consumer debt, the signs of the long-run coefficients are preserved, but the cointegrating coefficient for net worth is no longer significant (see equation 13).

\[
GDP = 1.00549 + 0.976 \text{Consumption}
\]  
\[
(12)
\]

\(^{17}\)Since the variables in natural logarithms, the coefficients could be interpreted as elasticities.

\(^{18}\)A further restriction of cointegrating coefficient for net worth being zero does not change the result for household debt; the cointegrating coefficient for household debt is still insignificant.
\[
GDP = 1.078851 + 1.331061\text{Consumption} - 0.458947\text{Consumer Debt}
\] (13)

As shown in table 21 of appendix D, the growth rate of household debt adjusts negatively to disequilibrium, as indicated by the negative adjustment coefficients of the variable's equation. However, the short-run dynamic adjustment parameters (parameters of lagged differences) of household debt are also insignificant in all equations except its own. Household debt not only does not have any long-run relationships with consumption, GDP, and net worth, but also may not have any impact on them in the short run according to this result. According to the estimated long-run relationship, consumer debt has a negative relationship with GDP (equation 13). In the short run, as shown in table 22 of appendix D, the growth rate of consumer debt adjusts negatively to disequilibrium as the negative adjustment coefficients of the equation for this variable indicates. The direct impact of the growth rate of consumer debt to the other variables is mixed, as the short-run (lagged) dynamic adjustment parameters of the growth rate of consumer debt have mixed signs. The growth rate of consumer debt has a positive direct impact on the growth rate of GDP with the first lag, but a negative impact with the third lag. A rather puzzling fact is that the growth rate of consumer debt has a negative effect on the growth rate of consumption with the third lag, but no positive effect within the shorter lags (the coefficients for them are not significant).

4.2.1 Residual Diagnostics

Figures 10 and 11 show the residuals of the cointegrating relations (deviations from the long-run equilibrium). Tables 23 and 24 in appendix D report the ADF and PP tests for stationarity.\(^{19}\) Both formal tests and visual inspection of the graphs support stationarity.

Figures 12 and 13 display the plots of the residuals of the VECM for each endogenous variable. There are no serial correlation problems as shown in tables 25 and 26 in appendix D. Tables 27 and 28 in appendix D present normality tests of the residuals. Residuals of the system with consumer debt are multivariate normal.\(^{20}\) Residuals of the growth rate of household debt are non-normal according to the Jarque-Bera test. The joint hypothesis of multivariate normality is also rejected by the Jarque-Bera test at the 5 percent significance level.\(^{21}\) This suggests that the current model for the household debt may not be an appropriate representation of the data generating process.

4.2.2 More Than One Cointegrating Vector

As tables 6 and 7 show, with longer lag lengths (suggested by likelihood ratio tests), the system has more than one cointegrating vector in the characterization of the long-run equilibrium. In this section, we investigate this case. Tables 33 and 34 in appendix D provide

\(^{19}\)The reported results are from the estimating specification without an intercept. The results are quantitatively the same from the the estimating specification with an intercept. The results are also robust to the different model selection criteria.

\(^{20}\)The normality test results depend on the orthogonalization methods; for example, using orthogonalization using residual covariance (Urza, 1997), some individual and joint tests reject the null of normality.

\(^{21}\)The other orthogonalization methods do not produce any stronger evidences for the normality of the residuals.
Figure 10: Residuals of Cointegrating Relations: the System with Household Debt

Figure 11: Residuals of Cointegrating Relations: the System with Consumer Debt
Figure 12: Residuals of VECM for Endogenous Variables: the System with Household Debt

Figure 13: Residuals of VECM for Endogenous Variables: the System with Consumer Debt
detailed information on the Johansen cointegration tests for this case.

Multiple cointegration brings an additional complication. It requires identification restrictions on each cointegration vector, so that each can be distinguishable from the others. Economic theory could provide such restrictions (for example, consumption function and investment function). In a conventional consumption function, household debt is not a separate argument since it is already accounted for in the net worth term. For this reason, we will identify each cointegrating vector by excluding the net worth term in the first cointegrating vector and the debt term in the second cointegrating vector. This provides sufficient binding restrictions for identification of long-run relations. The estimation results of the VECM with additional weak exogeneity restrictions are reported in tables 29 and 30 in appendix D.\(^{22}\)

We first note that, for both systems, about 120 parameters are estimated. This is more than half of the sample points. There is a rather dramatic reduction in the degrees of freedom. We therefore need to be cautious when interpreting these results. The cointegrating relations, which include debt terms, are presented here.

\[
GDP = 1.3511 + 0.94098\text{Consumption} - 0.002048\text{HouseholdDebt}
\] (14)

\[
GDP = 0.94774 + 1.00636\text{Consumption} - 0.042558\text{MortgageDebt}
\] (15)

Both household and mortgage debt terms have negative coefficients. A higher level of debt is associated negatively with GDP in the long run. According to the second cointegrating relations presented in the tables 29 and 30, net worth also has a negative relationship with GDP. This is a sharp contrast to the conventional positive wealth effect.\(^{23}\)

The growth rates of household and mortgage debt adjust negatively to the first disequilibrium and positively to the second disequilibrium, as the adjustment coefficients of each variable’s equations indicates. However, the short-run dynamic adjustment parameters (parameters of lagged differences) of household and mortgage debt are mostly insignificant. Only the sixth short-run dynamic adjustment parameter of household debt in the GDP equation exhibits a positive impact of the growth rate of debt on the growth rate of GDP. The growth rate of household debt has a negative impact on the growth rate of consumption according to fifth and seventh short-run dynamic adjustment parameters, but a positive impact according to the sixth short-run dynamic adjustment parameter in the consumption equation. None of dynamic adjustment parameters of mortgage debt in the GDP equation is significant. Only the first dynamic adjustment parameters of household debt in consumption and net worth equations are significant and positive.
Figure 14: Residuals of Cointegrating Relations: the System with Household Debt

Figure 15: Residuals of Cointegrating Relations: the System with Mortgage Debt
4.2.3 Residual Diagnostics

Figures 14 and 15 show the residuals of cointegration relations. Tables 35 and 36 in appendix D report the ADF and PP tests for stationarity.24 Both formal tests and visual inspection of the graphs support stationarity. The residuals of first and second cointegrating relation are quite similar in each system (especially for the system with household debt).25

Figures 16 and 17 display plots of the residuals of the VECM for each endogenous variables. We cannot reject the absence of serial correlation at 5 percent significance level as shown in tables 37 and 38 in appendix D. Tables 39 and 40 in appendix D present the normality tests of the results. The hypothesis that the residuals are multivariate normal is strongly rejected for both systems according to Jarque-Bera test. The joint hypothesis of multivariate normality are also rejected. However, the results depend on the orthogonalization method. For example, with the Cholesky ordering orthogonalization method, the residuals are multivariate normal. The joint hypothesis of multivariate normality also cannot be rejected according to Jarque-Bera test. The models are clearly sensitive to the identification restrictions on their error structures.

4.2.4 Impulse Response Functions

The impulse response functions of the VECM for the four-variable models are presented here. Figures 18, 19, and 20 plot the order-invariant generalized impulse response analysis. Note that the impulse responses do not die out to zero as the time span after the impulse increases. This reflects the nonstationarity of the data generating process where a shock can have permanent effects (Lütkepohl, 2005, pg.264).26

A positive consumer debt shock is associated with a permanent increase in consumption coupled with a permanent increase in GDP. There is also a permanent increase in consumer debt when there is a positive shock to consumption. However, a positive GDP shock is associated with a long-term reduction in consumer debt. This indicates that the negative long-term relationship between GDP and consumer debt in the cointegrating equation may be due to the negative casual channel from GDP to consumer debt.

A positive shock to household debt is also associated with a permanent increase in consumption coupled with a permanent increase in GDP (see figure 19). Household debt permanently increases when there is a positive shock to consumption. However, unlike in the consumer debt case, a positive GDP shock is associated with only a temporary reduction

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22We initially estimated a VECM without weak exogeneity restrictions. The long-run restrictions were not binding, and some of the adjustment coefficients were not significant. After imposing additional weak exogeneity restrictions on these insignificant adjustment coefficients, joint tests of long-run and weak exogeneity restrictions could not be rejected at the 5 percent significance level, and the results are reported in tables 29 and 30 in appendix D.

23This may indicate mis-specification of our system of estimating equations.

24The reported results are from the estimating specification without an intercept. The results are quantitatively the same as the estimating specification with an intercept. The results are also robust to the different model selection criterions.

25This may indicate that the first and second long-run equilibria might be essentially redundant.

26With one cointegrating vector, there is no evidence of the long run equilibrium relationships between household debt and GDP as shown in the table 21 in appendix D, and the equation 12. We therefore do not produce the impulse responses for the specific system.
Figure 16: Residuals of VECM for Endogenous Variables: the System with Household Debt

Figure 17: Residuals of VECM for Endogenous Variables: the System with Mortgage Debt
in household debt. The result regarding mortgage debt is essentially identical to the result regarding household debt (see figure 20). This is a somewhat puzzling result because the cointegration equations 14 and 15 exhibit negative relationships between GDP and household debt as well as mortgage debt. Finally, note that a positive shock to net worth is associated with a permanent increase in consumer, mortgage, and household debt.
Figure 18: Generalized Impulse Responses of the System with Consumer Debt (without Corporate Sector Variables and with One Cointegrating Relationship)
Figure 19: Generalized Impulse Responses of the System with Household debt (without Corporate Sector Variables and with Two Cointegrating Relationships)
Figure 20: Generalized Impulse Responses of the System with Mortgage Debt (without Corporate Sector Variables and with Two Cointegrating Relationships)
4.3 Discussion

Based on Minsky’s FIH applied to the household sector, one of the key theoretical perspectives of this study is that debt should have two-sided effects. Debt-financed household spending may provide a source of additional economic stimulus in the shorter period, but eventually the accumulation of debt could become excessive, generating a negative impact on consumption and output levels in the long run. The system could become highly vulnerable to negative shocks, possibly resulting in a severe economic downturn. The effect of debt thus varies between short and longer time periods.

We investigated the relationship between household debt and aggregate income in the US from this perspective. In the VAR analysis in growth rates, which captures the transitory feedbacks among the growth rates of debt, GDP, and net worth, we observed a bidirectional positive feedback process between aggregate income and debt. This is in accordance with the short-run perspective of Minsky’s FIH. To distinguish between the short-run and long-run aspects of Minsky’s FIH, we first investigated cointegrating relations between debt, GDP, net worth, and consumption via Johansen tests. Based on these tests, we estimated VECMs, which explicitly distinguish the long-run relationships of the endogenous variables via cointegration, and capture the short-run dynamics via adjustment parameters. According to the VECM estimation, there is a negative long-run relationship between debt and output as shown in equations (13), (14), and (15). This is a supportive evidence for the long-run perspective of Minsky’s FIH applied to the US household sector.

However, this interpretation requires some caution. Minsky’s FIH cannot be easily summarized by a simple statement that “debt has positive effects in the short run, but negative effects in the long run”. In reality, an explosion of household debt may not result in a financial crisis and recession. There are other factors which may work to contain the effect of household debt explosion (e.g., central bank monetary policy or financial sector regulation). Therefore, data does not necessarily predict the potentially disastrous effect of household. However the recent Great Recession confirms a possibility of a financial crisis resulting from an explosion of household debt.

5 An Extension: Incorporating Corporate Sector Variables

Investment has traditionally been emphasized as the main source of economic fluctuations, and corporate debt has been emphasized as a source of investment fluctuations. A closely related theoretical study by Isaac and Kim (2010) also shows that corporate debt has a significant effect on macroeconomic performance and stability via investment behavior. The main channel through which household debt has an effect on macroeconomic performance is...
Table 9: Cointegration Rank Tests (1 lag): Log Y, D_C, C, D_F and I

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Cointegration rank tests of the system of log-transformed GDP, consumer debt, consumption, corporate debt, and investment with one lag.
Significance level: 5 percent
Critical values based on MacKinnon et al. (1999)

and stability is also the investment financing behavior in the theoretical study. Therefore our empirical model is extended to include corporate debt and an investment variable.

In this section, we focus on consumer debt. (We also discuss the results in terms of household and mortgage debt as well.) Investment is corporate non-financial gross fixed capital investment. Corporate debt is the stock of outstanding corporate credit market liabilities excluding equities. Both are deflated by the personal consumption price index and expressed in logarithms. (See the data appendix A for more detailed information.)

The system consists of the five variables:

\[ [\text{GDP, consumption, consumer debt, investment, corporate debt}] \] (16)

Table 41 in appendix D reports the lag length selection tests for the VAR system 16. The Schwarz and Hannan-Quinn information criteria are followed to choose one lag length for the differences in the variables. Both the ADF test and PP tests confirm that corporate debt and investment both have a unit root. Table 9 summarized the cointegration results under diverse assumptions. As in the previous section, the third specification is the relevant one for our study.

Table 42 in the appendix D reports the estimated results of the VECM. The long-run cointegrating relationship shows that all the variables have positive relationships with GDP in the long run.\(^{29}\) This is in contrast to the previous result, which exhibited a negative relationship between consumer debt and output.\(^{30}\)

\(^{29}\)This result is sensitive to the lag length specification. With 3 lags length (following AIC), the consumption coefficient is insignificant.

\(^{30}\)Similar results have been obtained by the estimation of the VECM system with household and mortgage debt. These results are also sensitive to the lag length specification. With a longer lag length (4 lags), the consumption coefficient is insignificant in the cointegrating relationships.
Figure 21: Impulse Responses of the System with Consumer Debt (with Corporate Sector Variables and One Lag)
Figure 22: Impulse Responses of the System with Mortgage Debt (with Corporate Sector Variables and Four Lags)
Figure 23: Impulse Responses of the System with Household Debt (with Corporate Sector Variables and Four Lags)
Figure 21 plots the impulse response functions of the five-variable system with consumer debt. A shock to consumer debt is accompanied by an increase in consumption and GDP. Investment as well as corporate debt permanently increase in response to a shock to consumer debt.

The impulse response analysis is sensitive to model selection. With longer lag lengths, the mapped impulse response functions in figure 36 in appendix C show that a shock to corporate debt has an initially positive effect on investment, but, over time, the effect become negative. However, a shock to corporate debt is still accompanied by a permanently positive effect on GDP. The impulse response functions of the system with household and mortgage debt with longer lags show the same response of investment when there is a shock to corporate debt as shown in figures 22 and 23. This is consistent with the emphasis on the positive effect of corporate debt on investment in the short run, but a negative effect in the long run. Corporate borrowing provides the source for the new investment, but over time it depresses investment due to the increased debt service payments. Both mortgage and household debt also respond negatively over time after initially responding positively to a shock to GDP and consumption, as shown in the graphs 22 and 23.\(^3\) This is a rather puzzling result since the both mortgage and household debt have a positive coefficient in the cointegrating equations.

5.1 Discussion

The long run response of investment is negative when there is a shock to consumer, mortgage, or household debt (see figures 22, 23, and 36 in appendix C). These impulse response functions are qualitatively similar to the impulse response function of investment in response to a shock to corporate debt. A positive shock to household, consumer, or mortgage debt increases corporate debt permanently as shown in all impulse response functions. This shock has a positive effect on investment initially, but a negative effect in the long run. According to this result, investment is still a dominant channel of macro-fluctuation related to the debt of the household sector.\(^4\) However, it is rather puzzling that GDP permanently increases when there is a shock to corporate debt, even when investment decline permanently.

From a broader perspective, our empirical result may be consistent with the idea of a “Paradox of Goldilocks” (Barbera, 2009). That is a prolonged period of prosperity can generate an environment that encourage more risky financial behavior, and therefore leads to a more financially fragile economy. For example, Greenwood-Nimmo (2009b) empirically found that the relatively tranquil time of the US economy between 1971 and 2008 had induced US corporations to increase their liability-income ratios.

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\(^3\) With a shorter lag length specification, the impulse response functions of the system with household and mortgage debt are qualitatively similar to the impulse response functions of the system with consumer debt. (Compare the figure 37 in appendix C with figure 21.

\(^4\) This is also consistent with the theoretical conceptualization in Isaac and Kim (2010). Debt-driven household expenditure may initially boost investment and increase corporate borrowing via higher demand, but results in a negative effect on investment due to higher corporate debt service payments in the long run.
6 Concluding Remarks

In this paper, we investigated the relationship between household debt and aggregate income in U.S. In the growth VAR analysis capturing the transitory feedback among the growth rate of debt, GDP, and net worth, we observed a bidirectional positive feedback process in the short run between aggregate income and debt. On the other hand, according to the VECM estimation of cointegrating relationships, there is a negative long-run relationship between various measures of household debt and output.

The empirical model was also extended to investment and corporate debt. The results contrast with the results of the model without corporate sector variables. The negative long-run relationship between household debt and GDP ceases to exist as shown by the positive cointegrating coefficient. However, these extended empirical results indicate that investment is still the dominant channel of macro fluctuation related to household debt.

Our empirical work can be extended and improved in several ways. First, more consistent theoretical model could significantly improve the empirical model structure. For example, recall that, for the VECM with multiple cointegrating relations, an arbitrary identification restriction was employed for the cointegrating vectors. A theoretical model could provide guidance for such restrictions.

Recently, Greenwood-Nimmo (2009a) has found that an interest rate shock increases the debt service burden of firms, and hence can contribute to an increase in financial fragility. (He utilizes a VECM with long-run identifying restrictions based on a Minskyan model.) Based on this result, he argues that inflation-targeting monetary policy might generate financial fragility in an economy. Our empirical work provides a basis for a similar study regarding household sector. In other words, an extended study could ask whether an interest rate shock would increase the debt service burden of households and hence if it could contribute to an increase in financial fragility.

Financial sector debt has grown significantly in the US. It accounted for about 10 percent of US total debt in the early 1970, but about a third of US total debt in 2005. The financial sectors’ debt-GDP ratio grew from 66 percent in 1997 to over 100 percent in 2005 (Foster and Magdoff, 2009). This phenomenon has been pointed out as an important transformation of the economy for new sources of investment outlets and profit generation. Our empirical study lacks financial sector debt. Future study should address this issue.

References


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33 This perspective is especially prominent in the analysis from the monopoly-capital theory approach. See Foster and Magdoff (2009).


### A Data Appendix: Sources and Definitions

BEA: Bureau of Economic Analysis  
http://www.bea.gov/

FED Flow of Fund: Federal Reserve Board Flow of Fund  
http://www.federalreserve.gov/releases/z1/Current/data.htm

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**PCE:** personal consumption expenditures

Consumer debt is households and nonprofit organizations consumer credit liability from Federal Reserve statistical release Z.1, FED Flow of Funds. The identification number is Z1/Z1/LA153166000.Q for the seasonally adjusted and Z1/Z1/FL153166000.Q for the non-seasonally adjusted series.

Household debt is households and nonprofit organizations credit and equity market instruments liability from Federal Reserve statistical release Z.1, FED Flow of Funds. The identification number is Z1/Z1/LA154102005.Q for the seasonally adjusted and Z1/Z1/FL154102005.Q for the non-seasonally adjusted series.

Mortgage debt is households and nonprofit organizations home mortgages liability from Federal Reserve statistical release Z.1, FED Flow of Funds. The identification number is

Household net worth is households and nonprofit organizations net worth (market value) asset from Fed Flow of Funds (Federal Reserve statistical release Z.1:FL152090005.Q).

FODSP is Household Financial Obligations as a percent of Disposable Personal Income from Fed Flow of Fund (FOR/FOR/DTFDpercentYPD.Q).

TDSP is household debt service payments as a percent of disposable personal income from Fed Flow of Fund (FOR/FOR/DTFpercentYPD.Q).

Investment is the gross fixed investment of non-farm nonfinancial corporate business from Fed Flow of Funds (Federal Reserve statistical release Z.1:FA105019005.Q).

Corporate debt is the credit market liabilities of domestic nonfinancial sectors from Fed Flow of Funds (Federal Reserve statistical release Z.1:LA384104005.Q).

B Additional Impulse Response Analysis of VAR

VAR models allow us to examine the interaction of the variables via impulse responses.\textsuperscript{34} This analysis requires identification restrictions to recover structural noise terms from the observed errors. We impose the following simple Choleski restriction:

\[
\begin{align*}
e_{Ht} &= b_{H1}e_{Ht} \\
e_{Gt} &= b_{G1}e_{Gt} + b_{G2}e_{Ht} \\
e_{Nt} &= b_{N1}e_{Gt} + b_{N2}e_{Ht} + b_{N3}e_{Nt}
\end{align*}
\]

(17)

Economically, the above ordering reflects the assumption that that the change in the growth rate of income affects debt with a lag, but the change in the growth rate of debt has an immediate effect on the growth rate of income. Both the changes in the growth rates of household debt and GDP have immediate effects on net worth, but the change in the growth rate of net worth has an effect on growth rate of household debt and GDP only with a lag. All VARs are set up with a constant here. The impulse response figures include two standard error bands constructed by Monte Carlo methods with 1000 repetition as indicators of statistical significance.

\textsuperscript{34}Together with variance decomposition, they are called innovation accounting.
Figure 24: Impulse Responses with the Ordering of Growth Rates of Household Debt, GDP and Net Worth.

Figures 24, 26, and 28 show the impulse responses of the VAR systems with household, mortgage, and consumer debt, respectively. The restriction 17 is used. Our discussion focuses on the result for the interaction between the growth rate of household debt and GDP. With the specified ordering, we observe that positive shock to the rate of debt growth is associated with an increase in growth rate of GDP, although the response of the debt growth rate to the GDP growth rate shock is negligible and statistically insignificant most of time. However, the opposite results are produced with reverse ordering as shown in figures 25, 27, and 29.
Figure 25: Impulse Responses With the Ordering of Growth Rates of Household Net Worth, GDP, and Household Debt.
Figure 26: Impulse Responses with the Ordering of Growth Rates of Mortgage Debt, GDP, and Net Worth.
Figure 27: Impulse Responses with the Ordering of Growth Rates of Household Net Worth, GDP, and Mortgage Debt.
Figure 28: Impulse Responses with the Ordering of Growth Rates of Consumer Debt, GDP, and Net Worth.
Figure 29: Impulse Responses with the Ordering of Growth Rates of Household Net Worth, GDP, and Consumer Debt.

Figures 30 presents the forecast error variance decomposition of the system with the restriction 17. The variance of the growth rates of debt and net worth are mostly explained by their own error variance. Roughly 19 percent of the variance of the GDP growth rate is due to the shocks to the growth rate of household debt after the second quarter. The shocks to the growth rate of net worth explain about 16 percent of the forecast error variance of the GDP growth rate. Qualitatively similar conclusions are found in the case of the growth rates of mortgage and household debt, as shown in figures 31 and 32.

Similarly to the impulse responses, the results for the variance decomposition depend on the restriction of error structures. The variance decompositions of the systems with the reverse restrictions (ordering) are presented in the figures 33, 34, and 35. With the reverse restrictions, we now observe that shocks to the growth rate of GDP explain about 18 percent of the variance of household debt growth rate, and roughly 27 percent of consumer debt growth rates.
Figure 30: Variance Decomposition with the ordering of growth rates of household debt, GDP and net worth
Figure 31: Variance decomposition with the ordering of growth rates of mortgage debt, GDP and net worth
Figure 32: Variance decomposition with the ordering of growth rates of consumer debt, GDP and net worth
Figure 33: Variance decomposition with the ordering of growth rates of household net worth, GDP and household debt.
Figure 34: Variance decomposition with the ordering of growth rates of household net worth, GDP and mortgage debt.
Figure 35: Variance decomposition with the ordering of growth rates of household net worth, GDP and consumer debt.
C Additional Impulse Response Analysis of VECM

Figure 36: Impulse response of the system with consumer debt (with corporate sector variables and three lags)
Figure 37: Impulse response of the system with household debt (with corporate sector variables and one lag)
### D Tables

<table>
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<tr>
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*Raghavendra Tables 10: Lag Length Selection for a VAR: Log Y, D_H, and NW*

| Lag length selection for the VAR system of log-transformed GDP, household debt, and net worth according to alternative criteria |
| * indicates lag order selected by the criterion |
| LR: sequential modified LR test statistic (each test at percent level) |
| FPE: Final prediction error |
| AIC: Akaike information criterion |
| SC: Schwarz information criterion |
| HQ: Hannan-Quinn information criterion |
### Table 11: Lag Length Selection for a VAR: $Log Y$, $D_M$, and $NW$

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Lag length selection for the VAR system of log-transformed GDP, Mortgage Debt, and Net Worth according to alternative criteria.

* indicates lag order selected by the criterion.

LR: sequential modified LR test statistic (each test at 5 percent level).

FPE: Final prediction error.

AIC: Akaike information criterion.

SC: Schwarz information criterion.

HQ: Hannan-Quinn information criterion.

### Table 12: Lag Length Selection for a VAR: $Log Y$, $D_C$, and $NW$

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Lag length selection for the VAR system of log-transformed GDP, consumer debt, and net worth according to alternative criteria.

* indicates lag order selected by the criterion.

LR: sequential modified LR test statistic (each test at 5 percent level).

FPE: Final prediction error.

AIC: Akaike information criterion.

SC: Schwarz information criterion.

HQ: Hannan-Quinn information criterion.
Table 13: Lag Length Selection for a VAR: Growth Rates of $Y$, $D_H$, and $NW$

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Lag Length Selection for the VAR system of growth rate of GDP, household debt, and net worth.

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5 percent level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Table 14: Lag Length Selection for a VAR: Growth Rates of $Y$, $D_M$, and $NW$

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Lag Length Selection for the VAR system of growth rate of GDP, mortgage debt, and net worth.

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5 percent level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion
Table 15: Lag Length Selection for a VAR: Growth Rates of $Y$, $D_C$, and $NW$

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Lag Length Selection for the VAR system of growth rate of GDP, consumer debt, and net worth.
* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5 percent level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion
Table 16: Lag Length Selection for a VAR: $\log Y$, $D_{H}$, $C$, and $NW$

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* Lag length selection for a VAR System of GDP, household debt, consumption, and net worth.
* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5 percent level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion
### Table 17: Lag Length Selection for a VAR: $Log Y$, $D_m$, $C$, and $NW$

<table>
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<td>3018.464</td>
<td>52.6326</td>
<td>2.91e-17*</td>
<td>-26.72490*</td>
<td>-25.9279</td>
<td>-26.40311*</td>
</tr>
<tr>
<td>4</td>
<td>3030.593</td>
<td>22.4046</td>
<td>3.02E-17</td>
<td>-26.69</td>
<td>-25.6478</td>
<td>-26.2692</td>
</tr>
<tr>
<td>5</td>
<td>3048.022</td>
<td>31.5606</td>
<td>2.98E-17</td>
<td>-26.7029</td>
<td>-25.4154</td>
<td>-26.1831</td>
</tr>
<tr>
<td>7</td>
<td>3069.008</td>
<td>15.07568</td>
<td>3.30E-17</td>
<td>-26.6037</td>
<td>-24.8257</td>
<td>-25.8858</td>
</tr>
</tbody>
</table>

Lag length selection for a VAR system of GDP, mortgage debt, consumption, and net worth.
* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5 percent level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

### Table 18: Lag Length Selection for a VAR: $Log Y$, $D_c$, $C$, and $NW$

<table>
<thead>
<tr>
<th>Lag</th>
<th>LogL</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1011.848</td>
<td>NA</td>
<td>1.34E-09</td>
<td>-9.07971</td>
<td>-9.0184</td>
<td>-9.05496</td>
</tr>
<tr>
<td>1</td>
<td>2803.58</td>
<td>3502.756</td>
<td>1.51E-16</td>
<td>-25.0773</td>
<td>-24.7708</td>
<td>-24.9535</td>
</tr>
<tr>
<td>2</td>
<td>2956.836</td>
<td>294.0861</td>
<td>4.39E-17</td>
<td>-26.3138</td>
<td>-25.76205*</td>
<td>-26.09106*</td>
</tr>
<tr>
<td>3</td>
<td>2982.847</td>
<td>48.97558</td>
<td>4.01e-17*</td>
<td>-26.40403*</td>
<td>-25.607</td>
<td>-26.0822</td>
</tr>
<tr>
<td>7</td>
<td>3027.428</td>
<td>16.26662</td>
<td>4.80E-17</td>
<td>-26.2291</td>
<td>-24.4511</td>
<td>-25.5113</td>
</tr>
</tbody>
</table>

Lag length selection for a VAR system of GDP, consumer debt, consumption, and net worth.
* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5 percent level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion
Table 19: VECM Estimation (2 lags): Log Y, $D_H$, C, and NW

<table>
<thead>
<tr>
<th></th>
<th>CointEq1</th>
<th>D(LOG CON)</th>
<th>D(LOG HOU-DEBT)</th>
<th>D(LOG WORTH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co integrating Eq:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOGC GDP -1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>LOGCONS C U S T O MATION -1</td>
<td>-0.4827</td>
<td>-0.02914</td>
<td>-0.11182</td>
<td>0.144219</td>
</tr>
<tr>
<td>LOGHOUSEHOLD DEBT -1</td>
<td>0.087421</td>
<td>[2.33274]</td>
<td>[2.33274]</td>
<td>[2.33274]</td>
</tr>
<tr>
<td>LOGNET WORTH -1</td>
<td>0.01406</td>
<td>[2.03768]</td>
<td>[2.03768]</td>
<td>[2.03768]</td>
</tr>
<tr>
<td>C</td>
<td>-0.75298</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error Correction:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CointEq1</td>
<td>-0.09702</td>
<td>-0.02914</td>
<td>-0.11182</td>
<td>0.144219</td>
</tr>
<tr>
<td>D(LOG GDP -1)</td>
<td>0.021222</td>
<td>0.090375</td>
<td>0.084768</td>
<td>-0.30787</td>
</tr>
<tr>
<td>D(LOG GDP -2)</td>
<td>-0.02926</td>
<td>-0.04109</td>
<td>0.07273</td>
<td>-0.30523</td>
</tr>
<tr>
<td>D(LOG CON)</td>
<td>0.357346</td>
<td>0.084558</td>
<td>0.062803</td>
<td>0.360671</td>
</tr>
<tr>
<td>D(LOG CON -2)</td>
<td>0.271885</td>
<td>0.109049</td>
<td>-0.05825</td>
<td>0.416325</td>
</tr>
<tr>
<td>D(HOUSEHOLD DEBT -1)</td>
<td>2.99630</td>
<td>[1.80000]</td>
<td>-0.67393</td>
<td>1.343441</td>
</tr>
<tr>
<td>D(HOUSEHOLD DEBT -2)</td>
<td>0.02074</td>
<td>[0.00071]</td>
<td>[0.00071]</td>
<td>1.05590</td>
</tr>
<tr>
<td>D(LOG NET WORTH -1)</td>
<td>0.085338</td>
<td>0.087054</td>
<td>0.02274</td>
<td>0.10697</td>
</tr>
<tr>
<td>D(LOG NET WORTH -2)</td>
<td>3.37485</td>
<td>[4.13705]</td>
<td>[1.16038]</td>
<td>2.062705</td>
</tr>
<tr>
<td>C</td>
<td>0.02024</td>
<td>0.00524</td>
<td>0.002605</td>
<td>0.000210</td>
</tr>
<tr>
<td>Adj. R-squared</td>
<td>0.32922</td>
<td>0.29603</td>
<td>0.649075</td>
<td>0.872658</td>
</tr>
<tr>
<td>S.E. equation</td>
<td>0.030233</td>
<td>0.167681</td>
<td>0.63452</td>
<td>0.834041</td>
</tr>
<tr>
<td>F-statistic</td>
<td>0.013643</td>
<td>0.009468</td>
<td>0.007919</td>
<td>0.102762</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>0.007799</td>
<td>0.006508</td>
<td>0.006941</td>
<td>0.021761</td>
</tr>
<tr>
<td>Akaike AIC</td>
<td>12.03313</td>
<td>6.801745</td>
<td>44.95613</td>
<td>1.884927</td>
</tr>
<tr>
<td>Schwarz SC</td>
<td>731.0569</td>
<td>822.7509</td>
<td>842.8005</td>
<td>551.8842</td>
</tr>
<tr>
<td>Mean dependent</td>
<td>-6.79474</td>
<td>-7.16093</td>
<td>-7.38745</td>
<td>-4.77431</td>
</tr>
<tr>
<td>S.D. dependent</td>
<td>0.007764</td>
<td>0.006565</td>
<td>0.013942</td>
<td>0.007277</td>
</tr>
<tr>
<td>Determinant resid covariance (adj.)</td>
<td>1.87E-17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determinant resid covariance</td>
<td>1.56E-17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>3108.71</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akaike information criterion</td>
<td>-26.9575</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schwarz criterion</td>
<td>-26.2309</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

VECM estimation of the system of log-transformed GDP, Household debt, consumption, and net worth with two lags.
T-statistics in parenthesis.
Cointegrating vector normalized with respect to GDP coefficient.
Table 20: VECM Estimation (3 lags): $\log Y$, $D_C$, $C$, and $NW$

<table>
<thead>
<tr>
<th>Cointegrating Eq</th>
<th>CointEq1</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOGGDPE.1</td>
<td>1</td>
</tr>
<tr>
<td>LOGCONSUMPTION.1</td>
<td>-1.26691</td>
</tr>
<tr>
<td></td>
<td>[-10.2335]</td>
</tr>
<tr>
<td>LOGCONSUMERDEBT.1</td>
<td>0.422445</td>
</tr>
<tr>
<td></td>
<td>[4.96423]</td>
</tr>
<tr>
<td>LOGNETWORK.1</td>
<td>-0.18075</td>
</tr>
<tr>
<td></td>
<td>[-1.88844]</td>
</tr>
<tr>
<td>$C$</td>
<td>0.936025</td>
</tr>
</tbody>
</table>

**Error Correction:**

<table>
<thead>
<tr>
<th></th>
<th>D(LOGGDPE)</th>
<th>D(LOG CONS)</th>
<th>D(LOGCON-DEBT)</th>
<th>D(LOG WORTH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CointEq1</td>
<td>-0.00381</td>
<td>0.002301</td>
<td>-0.07391</td>
<td>0.03452</td>
</tr>
<tr>
<td></td>
<td>[-0.11416]</td>
<td>[0.19151]</td>
<td>[-4.29306]</td>
<td>[0.78577]</td>
</tr>
<tr>
<td>$D(LOGGDPE.1)$</td>
<td>-0.10193</td>
<td>0.011504</td>
<td>0.085306</td>
<td>-0.30363</td>
</tr>
<tr>
<td></td>
<td>[-1.13528]</td>
<td>[0.157002]</td>
<td>[0.87523]</td>
<td>[-1.22839]</td>
</tr>
<tr>
<td>$D(LOGGDPE.2)$</td>
<td>-0.009401</td>
<td>-0.03615</td>
<td>0.038509</td>
<td>-0.3556</td>
</tr>
<tr>
<td></td>
<td>[-1.07816]</td>
<td>[-1.47913]</td>
<td>[0.41741]</td>
<td>[-1.45139]</td>
</tr>
<tr>
<td>$D(LOGGDPE.3)$</td>
<td>-0.1134</td>
<td>-0.11624</td>
<td>-0.00257</td>
<td>-0.25647</td>
</tr>
<tr>
<td></td>
<td>[-1.36262]</td>
<td>[-1.69605]</td>
<td>[-0.02548]</td>
<td>[-1.23404]</td>
</tr>
<tr>
<td>$D(LOGCONSUMPTION.1)$</td>
<td>0.379948</td>
<td>0.085294</td>
<td>0.229907</td>
<td>0.536766</td>
</tr>
<tr>
<td></td>
<td>[3.11342]</td>
<td>[0.89310]</td>
<td>[1.75095]</td>
<td>[1.62325]</td>
</tr>
<tr>
<td>$D(LOGCONSUMPTION.2)$</td>
<td>0.221823</td>
<td>0.127683</td>
<td>0.132624</td>
<td>0.56011</td>
</tr>
<tr>
<td></td>
<td>[1.78258]</td>
<td>[1.24686]</td>
<td>[1.00352]</td>
<td>[1.65259]</td>
</tr>
<tr>
<td>$D(LOGCONSUMPTION.3)$</td>
<td>0.105926</td>
<td>0.231906</td>
<td>0.145419</td>
<td>0.574747</td>
</tr>
<tr>
<td></td>
<td>[0.89854]</td>
<td>[2.41300]</td>
<td>[1.14683]</td>
<td>[1.78770]</td>
</tr>
<tr>
<td>$D(LOGCONDEBT.1)$</td>
<td>0.155798</td>
<td>0.067811</td>
<td>0.433131</td>
<td>-0.18701</td>
</tr>
<tr>
<td></td>
<td>[2.08557]</td>
<td>[1.08239]</td>
<td>[5.241155]</td>
<td>[0.89238]</td>
</tr>
<tr>
<td>$D(LOGCONDEBT.2)$</td>
<td>-0.00351</td>
<td>0.065943</td>
<td>0.214291</td>
<td>0.042979</td>
</tr>
<tr>
<td></td>
<td>[-0.04532]</td>
<td>[1.08119]</td>
<td>[2.54009]</td>
<td>[0.20150]</td>
</tr>
<tr>
<td>$D(LOGCONDEBT.3)$</td>
<td>-0.14649</td>
<td>-0.13442</td>
<td>-0.00433</td>
<td>0.05813</td>
</tr>
<tr>
<td></td>
<td>[-2.17653]</td>
<td>[-2.42650]</td>
<td>[-0.03926]</td>
<td>[0.31374]</td>
</tr>
<tr>
<td>$D(LOGNETWORK.1)$</td>
<td>0.086587</td>
<td>0.08753</td>
<td>0.030132</td>
<td>0.138634</td>
</tr>
<tr>
<td></td>
<td>[3.58688]</td>
<td>[4.23608]</td>
<td>[1.15069]</td>
<td>[2.02026]</td>
</tr>
<tr>
<td>$D(LOGNETWORK.2)$</td>
<td>0.067794</td>
<td>0.041721</td>
<td>0.024627</td>
<td>0.048921</td>
</tr>
<tr>
<td></td>
<td>[2.51632]</td>
<td>[1.80137]</td>
<td>[0.84203]</td>
<td>[0.62096]</td>
</tr>
<tr>
<td>$D(LOGNETWORK.3)$</td>
<td>0.033497</td>
<td>0.011567</td>
<td>-0.02667</td>
<td>0.069938</td>
</tr>
<tr>
<td></td>
<td>[1.21206]</td>
<td>[0.51011]</td>
<td>[0.85179]</td>
<td>[1.31770]</td>
</tr>
<tr>
<td>$C$</td>
<td>0.002551</td>
<td>0.005129</td>
<td>-0.00165</td>
<td>-0.00914</td>
</tr>
<tr>
<td></td>
<td>[2.23501]</td>
<td>[5.48910]</td>
<td>[-1.31240]</td>
<td>[-0.04516]</td>
</tr>
</tbody>
</table>

**R-squared** 0.349993, **Adj. R-squared** 0.310103, **Sum sq. resid** 0.012394, **S.E. equation** 0.007919, **F-statistic** 8.770467, **Log likelihood** 780.0502, **Akaike AIC** -6.77921, **Schwarz SC** -6.56731, **Mean dependent** 0.097788, **S.D. dependent** 0.00553, **Determinant resid covariance (dof adj.)** 3.47E-17, **Determinant resid covariance** 2.68E-17, **Log likelihood** 3025.983, **Akaike information criterion** -26.2742, **Schwarz criterion** -25.3061

Table 21: VECM Estimation with restrictions (2 lags): Log Y, D_H, C, and NW

<table>
<thead>
<tr>
<th>Cointegration Restrictions:</th>
<th>θ_1 = 1, θ_2 = 0, θ_4 = 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restrictions identify all cointegrating vectors</td>
<td></td>
</tr>
<tr>
<td>Lr test for binding restrictions (rank = 1):</td>
<td></td>
</tr>
<tr>
<td>Chi-sq(2)</td>
<td>2.022556</td>
</tr>
<tr>
<td>Cointegrating Eq:</td>
<td></td>
</tr>
<tr>
<td>LOGGDP_{-1}</td>
<td>-0.97716</td>
</tr>
<tr>
<td>LOGCONSUMPTION_{-1}</td>
<td>[1.20, 2.560]</td>
</tr>
<tr>
<td>LOGHOUSEDEBT_{-1}</td>
<td>0.05825</td>
</tr>
<tr>
<td>LOGNETWORTH_{-1}</td>
<td>[-0.38, 0.45]</td>
</tr>
<tr>
<td>C</td>
<td>-0.99472</td>
</tr>
<tr>
<td>Error Correction:</td>
<td></td>
</tr>
<tr>
<td>ContEqq</td>
<td>-0.99138</td>
</tr>
<tr>
<td>D(LOGGDP)</td>
<td>0.020735</td>
</tr>
<tr>
<td>D(LOGGDP_{-1})</td>
<td>[0.039, 0.07]</td>
</tr>
<tr>
<td>D(LOGGDP_{-2})</td>
<td>[0.33509, 0.13847]</td>
</tr>
<tr>
<td>D(LOGCONSUMPTION)_{-1}</td>
<td>0.738112</td>
</tr>
<tr>
<td>D(LOGWORTH)</td>
<td>0.27377</td>
</tr>
<tr>
<td>D(LOGHOUSEDEBT_{-1})</td>
<td>0.02019</td>
</tr>
<tr>
<td>D(LOGHOUSEDEBT_{-2})</td>
<td>[0.02328, 0.07288]</td>
</tr>
<tr>
<td>D(LOGNETWORTH_{-1})</td>
<td>0.005157</td>
</tr>
<tr>
<td>D(LOGNETWORTH_{-2})</td>
<td>[3.49856, 4.17824]</td>
</tr>
<tr>
<td>C</td>
<td>0.002012</td>
</tr>
</tbody>
</table>

R-squared: 0.335737, Adj. R-squared: 0.308187, Sum sq. resids: 0.013586, S.E. equation: 0.007912, F-statistic: 12.18643, Log likelihood: 781.3393, Akaike AIC: -6.7977, Schwarz SC: -6.64682, Mean dependent: 0.007764, S.D. dependent: 0.009513.

Determinant resid covariance (dof adj.) 1.88E-17, Determinant resid covariance 1.57E-17, Log likelihood 3102.707, Akaike information criterion -26.949, Schwarz criterion -25.2951.

VECM estimation of the system of log-transformed GDP, household debt, consumption, and net worth with two lags with restrictions on adjustment coefficients.

T-statistics in parenthesis.

Cointegrating vector normalized with respect to GDP coefficient.

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Table 22: VECM Estimation with restrictions (3 lags): Log $Y$, $D_C$, $C$, and NW

<table>
<thead>
<tr>
<th>Cointegration Restrictions:</th>
<th>0.581937</th>
<th>Probability</th>
<th>0.900543</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restrictions identify all cointegrating vectors</td>
<td>LOGGDP(1)</td>
<td>-1.33106</td>
<td>[-9.98892]</td>
</tr>
<tr>
<td>LR test for binding restrictions (rank = 1):</td>
<td>LOGCONSUMPTION(1)</td>
<td>0.458447</td>
<td>[5.1129]</td>
</tr>
<tr>
<td>LOGCONDEBT(1)</td>
<td>-0.16152</td>
<td>[-1.56785]</td>
<td></td>
</tr>
<tr>
<td>LOGNETWORTH(1)</td>
<td>1.078851</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>0.022554</td>
<td>0.005629</td>
<td>-0.00164</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.349941</td>
<td>0.356515</td>
<td>0.658222</td>
</tr>
<tr>
<td>Adj. R-squared</td>
<td>0.310979</td>
<td>0.209969</td>
<td>0.666132</td>
</tr>
<tr>
<td>Sum sq. resid</td>
<td>0.012824</td>
<td>0.000907</td>
<td>0.016663</td>
</tr>
<tr>
<td>S.E. equation</td>
<td>0.007919</td>
<td>0.005185</td>
<td>0.008594</td>
</tr>
<tr>
<td>P-statistic</td>
<td>3.775775</td>
<td>5.38992</td>
<td>35.52223</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>780.0463</td>
<td>824.0443</td>
<td>761.5222</td>
</tr>
<tr>
<td>Akaike AIC</td>
<td>-5.77197</td>
<td>-7.16853</td>
<td>-6.61524</td>
</tr>
<tr>
<td>Schwarc SC</td>
<td>-5.67284</td>
<td>-6.96664</td>
<td>-6.40335</td>
</tr>
<tr>
<td>Mean dependent</td>
<td>0.007768</td>
<td>0.008521</td>
<td>0.011334</td>
</tr>
<tr>
<td>S.D. dependent</td>
<td>0.006834</td>
<td>0.007333</td>
<td>0.018476</td>
</tr>
</tbody>
</table>

VECM estimation of the system of log-transformed GDP, consumer debt, consumption, and net worth with three lags with restrictions on adjustment coefficients.

T-statistics in parenthesis.

Cointegrating vector normalized with respect to GDP coefficient.
Table 23: Cointegrating Vector (Unit Roots Tests): $\log Y$, $D_H$, $C$, and $NW$

<table>
<thead>
<tr>
<th>Method</th>
<th>Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADF - Fisher Chi-square</td>
<td>15.6647</td>
<td>0.0004</td>
</tr>
<tr>
<td>PP - Fisher Chi-square</td>
<td>9.64284</td>
<td>0.0081</td>
</tr>
</tbody>
</table>

Unit Roots Tests on the Residuals of Restricted Cointegrating Vector: The System with Household Debt
Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. Zero lag is selected by SIC. Null: unit root

Table 24: Unit Roots Test (One Cointegrating Vector): $\log Y$, $D_H$, $C$, and $NW$

<table>
<thead>
<tr>
<th>Method</th>
<th>Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADF - Fisher Chi-square</td>
<td>13.3831</td>
<td>0.0012</td>
</tr>
<tr>
<td>PP - Fisher Chi-square</td>
<td>13.7446</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Unit Roots Tests on the Residuals of Restricted Cointegrating Vector: the System with Consumer Debt
Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. Zero lag is selected by SIC\textsuperscript{35}

Table 25: Serial Correlation LM tests of the system with household debt

<table>
<thead>
<tr>
<th>Lags</th>
<th>LM-Stat</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>22.23406</td>
<td>0.1358</td>
</tr>
</tbody>
</table>

Null hypothesis: no serial correlation at lag order 2. P-values from chi-square with 16 df.

Table 26: Serial Correlation LM tests of the system with consumer debt

<table>
<thead>
<tr>
<th>Lags</th>
<th>LM-Stat</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>23.52065</td>
<td>0.1005</td>
</tr>
</tbody>
</table>

Null hypothesis: no serial correlation at lag order 2. P-values from chi-square with 16 df.
Table 27: Normality tests of the residuals of the system with household debt

<table>
<thead>
<tr>
<th>Equation</th>
<th>skewness(1)</th>
<th>Kurtosis(1)</th>
<th>Jarque-Bera(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DlogGDP</td>
<td>0.02892</td>
<td>3.280078</td>
<td>1.578565</td>
</tr>
<tr>
<td></td>
<td>(0.033601)</td>
<td>(1.544964)</td>
<td>(0.4542)</td>
</tr>
<tr>
<td>Dconsumption</td>
<td>-0.006</td>
<td>3.062202</td>
<td>0.328428</td>
</tr>
<tr>
<td></td>
<td>(0.001445)</td>
<td>(0.326984)</td>
<td>(0.8486)</td>
</tr>
<tr>
<td>Dhouseholddebt</td>
<td>0.09695</td>
<td>3.911025</td>
<td>8.922115</td>
</tr>
<tr>
<td></td>
<td>(0.376177)</td>
<td>(8.545938)</td>
<td>(0.0116)</td>
</tr>
<tr>
<td>Dnetworth</td>
<td>-0.2832</td>
<td>3.629705</td>
<td>5.672041</td>
</tr>
<tr>
<td></td>
<td>(3.112481)</td>
<td>(2.55956)</td>
<td>(0.0587)</td>
</tr>
<tr>
<td>Joint tests</td>
<td>3.523704</td>
<td>12.97744</td>
<td>16.50115</td>
</tr>
<tr>
<td></td>
<td>(0.4743)</td>
<td>(0.0114)</td>
<td>(0.0357)</td>
</tr>
</tbody>
</table>

Chi-square statistics in parenthesis for skewness and Kurtosis tests. p-values in parenthesis for Jarque-Bera tests. For joint tests of skewness and Krutosis tests, Chi-square statistics with p-values are reported.
Orthogonalization: Residual Correlation (Doornik-Hansen). Null hypothesis: residuals are multivariate normal. 10 and 5 percent critical values for $\chi^2(1)$ are 2.71 and 3.84 respectively.

Table 28: Normality tests of the residuals of the system with consumer debt

<table>
<thead>
<tr>
<th>Equation</th>
<th>skewness(1)</th>
<th>Kurtosis(1)</th>
<th>Jarque-Bera(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DlogGDP</td>
<td>0.03497</td>
<td>3.08681</td>
<td>0.459165</td>
</tr>
<tr>
<td></td>
<td>(0.04892)</td>
<td>(0.410245)</td>
<td>(0.7949)</td>
</tr>
<tr>
<td>Dlogconsumption</td>
<td>0.011706</td>
<td>2.635065</td>
<td>0.830798</td>
</tr>
<tr>
<td></td>
<td>(0.005484)</td>
<td>(0.825314)</td>
<td>(0.6601)</td>
</tr>
<tr>
<td>Dhouseholddebt</td>
<td>-0.20701</td>
<td>3.088991</td>
<td>1.761408</td>
</tr>
<tr>
<td></td>
<td>(1.682778)</td>
<td>(0.07863)</td>
<td>(0.4145)</td>
</tr>
<tr>
<td>Dnetworth</td>
<td>-0.26646</td>
<td>3.093393</td>
<td>2.756788</td>
</tr>
<tr>
<td></td>
<td>(2.754642)</td>
<td>(0.002146)</td>
<td>(0.252)</td>
</tr>
<tr>
<td>Joint tests</td>
<td>4.491825</td>
<td>1.316334</td>
<td>5.808159</td>
</tr>
<tr>
<td></td>
<td>(0.3435)</td>
<td>(0.8586)</td>
<td>(0.6687)</td>
</tr>
</tbody>
</table>

Chi-square statistics in parenthesis for skewness and Kurtosis tests. p-values in parenthesis for Jarque-Bera tests. For joint tests of skewness and Krutosis tests, Chi-square statistics with p-values are reported.
Orthogonalization: Residual Correlation (Doornik-Hansen). Null hypothesis: residuals are multivariate normal. 10 and 5 percent critical values for $\chi^2(1)$ are 2.71 and 3.84 respectively.
Table 29: VECM Estimation with restrictions (7 lags): Log Y, D_H, C, and NW

<table>
<thead>
<tr>
<th>Coefficient Restrictions:</th>
<th>( \delta_1 = 1, \delta_2 = 4, \theta_1 = 1, \theta_2 = 3, \alpha_{-1} = 0, \alpha_{-2} = 0, \alpha_{-3} = 0 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square (20)</td>
<td>4.844134</td>
</tr>
<tr>
<td>Co-integrating Eq.</td>
<td>( \begin{align*} \text{LOGGDPC}_t &amp; = 1.88270 \ \text{LOGCONC}_t &amp; = 0.003236 \end{align*} )</td>
</tr>
<tr>
<td>( \text{LOGCONC}_t )</td>
<td>0.003236</td>
</tr>
<tr>
<td>( \text{LOGGDPC}_t )</td>
<td>[1.88270]</td>
</tr>
<tr>
<td><strong>LOGCONSUMPTION_1</strong></td>
<td>[1.88270] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895] [1.02136]</td>
</tr>
<tr>
<td><strong>LOGGDPC_1</strong></td>
<td>[0.00800] [1.90710] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_2</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_3</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_4</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_5</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_6</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_7</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_8</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_9</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_10</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_11</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_12</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_13</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_14</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_15</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_16</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_17</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_18</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_19</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td><strong>LOGGDPC_20</strong></td>
<td>[0.00800] [1.87294] [2.25230] [1.90710] [1.85104] [1.91539] [1.50895]</td>
</tr>
<tr>
<td>C</td>
<td>0.000037</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.685969</td>
</tr>
<tr>
<td>Adj. R-squared</td>
<td>0.685969</td>
</tr>
<tr>
<td>Sum sq. resid</td>
<td>0.685969</td>
</tr>
<tr>
<td>S.E. equation</td>
<td>0.685969</td>
</tr>
<tr>
<td>Forecastic</td>
<td>0.685969</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>0.685969</td>
</tr>
<tr>
<td>Akaike AIC</td>
<td>0.685969</td>
</tr>
<tr>
<td>Schwarz IC</td>
<td>0.685969</td>
</tr>
<tr>
<td>Mean dependent</td>
<td>0.685969</td>
</tr>
<tr>
<td>S.D. dependent</td>
<td>0.685969</td>
</tr>
<tr>
<td>Determinant resid variance (dof adj.)</td>
<td>1.4584-17</td>
</tr>
<tr>
<td>Determinant resid covariance</td>
<td>2.0501-19</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>2.0501-19</td>
</tr>
<tr>
<td>Akaike information criterion</td>
<td>2.0501-19</td>
</tr>
<tr>
<td>Schwarz criterion</td>
<td>2.0501-19</td>
</tr>
</tbody>
</table>

VECM estimation of the system of log-transformed GDP, household consumption, and net work with seven lags with restrictions on adjustment coefficients.

**Notes:**
- **T** is in parenthesis.
- Co-integrating vector normalized with respect to GDP coefficient.
<table>
<thead>
<tr>
<th>Table 30: VECM Estimation with restrictions (7 lags): Log Y, D_M, C, and NW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-integration Restrictions:</td>
</tr>
<tr>
<td>$\Delta_{1}X_{1} = 1_{1}H_{1} + 4_{1}H_{2} + 1_{1}H_{3} + 0_{1}H_{4} + 0_{1}H_{5} = 0$</td>
</tr>
<tr>
<td>Co-integrating Eq:</td>
</tr>
<tr>
<td>$\tilde{DLOGMDP}<em>{-1} = \tilde{DLOGCONS}</em>{-1}$</td>
</tr>
<tr>
<td>$LOGMORTDEBT_{-1}$</td>
</tr>
<tr>
<td>$LOGWEALTH_{-1}$</td>
</tr>
<tr>
<td>$C$</td>
</tr>
<tr>
<td>Error Correction:</td>
</tr>
<tr>
<td>$\Delta_{1}X_{1} = \Delta_{1}H_{1} + 4_{1}H_{2} + 1_{1}H_{3} + 0_{1}H_{4} + 0_{1}H_{5} = 0$</td>
</tr>
<tr>
<td>Co-integrating Eq:</td>
</tr>
<tr>
<td>$\tilde{DLOGMDP}_{-1}$</td>
</tr>
<tr>
<td>$\tilde{DLOGCONS}_{-1}$</td>
</tr>
<tr>
<td>$\tilde{DLOGMORTDEBT}_{-1}$</td>
</tr>
<tr>
<td>$\tilde{DLOGWEALTH}_{-1}$</td>
</tr>
<tr>
<td>$C$</td>
</tr>
</tbody>
</table>

**Determinant resid variance (adj. adj.)**: 1.90E-17
**Determinant resid variance**: 1.94E-17
**Log likelihood**: 2698.585
**Akaike information criterion**: -267091
**Schiuwa criterion**: -24.5358

**VECM estimation of the system of log-transformed GDP, mortgage debt, consumption, and net worth with seven lags with restrictions on adjustment coefficients.**

T-statistics in parentheses.

Constating vector normalised with respect to GDP coefficient.

---

**Table 30: VECM Estimation with restrictions (7 lags): Log Y, D_M, C, and NW**

<table>
<thead>
<tr>
<th>Co-integration Restrictions: $\Delta_{1}X_{1} = 1_{1}H_{1} + 4_{1}H_{2} + 1_{1}H_{3} + 0_{1}H_{4} + 0_{1}H_{5} = 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-integrating Eq: $\tilde{DLOGMDP}<em>{-1} = \tilde{DLOGCONS}</em>{-1}$</td>
</tr>
<tr>
<td>$LOGMORTDEBT_{-1}$</td>
</tr>
<tr>
<td>0.147351</td>
</tr>
<tr>
<td>Co-integrating Eq: $\tilde{DLOGMDP}_{-1}$</td>
</tr>
<tr>
<td>$LOGMORTDEBT_{-1}$</td>
</tr>
<tr>
<td>-1.0691</td>
</tr>
<tr>
<td>Co-integrating Eq: $\tilde{DLOGMDP}_{-1}$</td>
</tr>
<tr>
<td>0.044258</td>
</tr>
<tr>
<td>Co-integrating Eq: $\tilde{DLOGMDP}_{-1}$</td>
</tr>
<tr>
<td>[4.86983]</td>
</tr>
<tr>
<td>Co-integrating Eq: $\tilde{DLOGMDP}_{-1}$</td>
</tr>
<tr>
<td>[4.86983]</td>
</tr>
<tr>
<td>Co-integrating Eq: $\tilde{DLOGMDP}_{-1}$</td>
</tr>
<tr>
<td>[4.86983]</td>
</tr>
</tbody>
</table>

**VECM estimation of the system of log-transformed GDP, mortgage debt, consumption, and net worth with seven lags with restrictions on adjustment coefficients.**

T-statistics in parentheses.

Constating vector normalised with respect to GDP coefficient.

---

**Table 30: VECM Estimation with restrictions (7 lags): Log Y, D_M, C, and NW**

<table>
<thead>
<tr>
<th>Co-integration Restrictions: $\Delta_{1}X_{1} = 1_{1}H_{1} + 4_{1}H_{2} + 1_{1}H_{3} + 0_{1}H_{4} + 0_{1}H_{5} = 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-integrating Eq: $\tilde{DLOGMDP}<em>{-1} = \tilde{DLOGCONS}</em>{-1}$</td>
</tr>
<tr>
<td>$LOGMORTDEBT_{-1}$</td>
</tr>
<tr>
<td>0.147351</td>
</tr>
<tr>
<td>Co-integrating Eq: $\tilde{DLOGMDP}_{-1}$</td>
</tr>
<tr>
<td>$LOGMORTDEBT_{-1}$</td>
</tr>
<tr>
<td>-1.0691</td>
</tr>
<tr>
<td>Co-integrating Eq: $\tilde{DLOGMDP}_{-1}$</td>
</tr>
<tr>
<td>0.044258</td>
</tr>
<tr>
<td>Co-integrating Eq: $\tilde{DLOGMDP}_{-1}$</td>
</tr>
<tr>
<td>[4.86983]</td>
</tr>
<tr>
<td>Co-integrating Eq: $\tilde{DLOGMDP}_{-1}$</td>
</tr>
<tr>
<td>[4.86983]</td>
</tr>
<tr>
<td>Co-integrating Eq: $\tilde{DLOGMDP}_{-1}$</td>
</tr>
<tr>
<td>[4.86983]</td>
</tr>
</tbody>
</table>

**VECM estimation of the system of log-transformed GDP, mortgage debt, consumption, and net worth with seven lags with restrictions on adjustment coefficients.**

T-statistics in parentheses.

Constating vector normalised with respect to GDP coefficient.
Table 31: Unrestricted Cointegration Test (2 lags): Log Y, D_H, C, and NW

<table>
<thead>
<tr>
<th>Hypothesized</th>
<th>Trace</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of CE(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None*</td>
<td>0.110098 48.48126 47.85613</td>
<td>0.0436</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.061067 22.003 29.79707</td>
<td>0.2983</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.021756 7.699479 15.49471</td>
<td>0.4981</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.011851 2.70629 3.841466</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Hypothesized Max-Eigen

<table>
<thead>
<tr>
<th>No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Statistic</th>
<th>Critical Value</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0.110098   26.47826</td>
<td>27.58434</td>
<td>0.0687</td>
<td></td>
</tr>
<tr>
<td>At most 1</td>
<td>0.061067   14.305352</td>
<td>21.13162</td>
<td>0.3406</td>
<td></td>
</tr>
<tr>
<td>At most 2</td>
<td>0.021756   4.993189</td>
<td>14.2646</td>
<td>0.7427</td>
<td></td>
</tr>
<tr>
<td>At most 3</td>
<td>0.011851   2.70629</td>
<td>3.841466</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

Unrestricted cointegration test of the system of log-transformed GDP, household debt, consumption, and net worth with two lags. * denotes rejection of the hypothesis at the 0.05 level.
MacKinnon et al. (1999) p-values reported.

Table 32: Unrestricted Cointegration Test (3 lags): Log Y, D_C, C, and NW

<table>
<thead>
<tr>
<th>Hypothesized</th>
<th>Trace</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of CE(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None*</td>
<td>0.126869 53.45726 47.85613</td>
<td>0.0136</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.052343 22.79582 29.79707</td>
<td>0.2562</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.031561 10.64538 15.49471</td>
<td>0.2343</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.014921 3.397497 3.841466</td>
<td>0.0653</td>
</tr>
</tbody>
</table>

Hypothesized Max-Eigen

<table>
<thead>
<tr>
<th>No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Statistic</th>
<th>Critical Value</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>None*</td>
<td>0.126869   30.66143</td>
<td>27.58434</td>
<td>0.0195</td>
<td></td>
</tr>
<tr>
<td>At most 1</td>
<td>0.052343   12.15045</td>
<td>21.13162</td>
<td>0.5329</td>
<td></td>
</tr>
<tr>
<td>At most 2</td>
<td>0.031561   7.247883</td>
<td>14.2646</td>
<td>0.4602</td>
<td></td>
</tr>
<tr>
<td>At most 3</td>
<td>0.014921   3.397497</td>
<td>3.841466</td>
<td>0.0653</td>
<td></td>
</tr>
</tbody>
</table>

Unrestricted cointegration test of the system of log-transformed GDP, consumer debt, consumption, and net worth with three lags. * denotes rejection of the hypothesis at the 0.05 level.
MacKinnon et al. (1999) p-values reported.
Table 33: Unrestricted Cointegration Test (7 lags): Log Y, DH, C, and NW

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>Critical Value</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.149347</td>
<td>72.57468</td>
<td>47.85613</td>
<td>0.0001</td>
</tr>
<tr>
<td>At most 1 *</td>
<td>0.098463</td>
<td>36.66597</td>
<td>29.79707</td>
<td>0.0069</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.049664</td>
<td>13.65466</td>
<td>15.49471</td>
<td>0.0929</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.010512</td>
<td>2.346027</td>
<td>3.841466</td>
<td>0.1256</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Max-Eigen Eigenvalue</th>
<th>Trace Statistic</th>
<th>Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.149347</td>
<td>35.90871</td>
<td>27.58434</td>
<td>0.0034</td>
</tr>
<tr>
<td>At most 1 *</td>
<td>0.098463</td>
<td>23.01131</td>
<td>21.13162</td>
<td>0.0269</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.049664</td>
<td>11.30863</td>
<td>14.2646</td>
<td>0.1394</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.010512</td>
<td>2.346027</td>
<td>3.841466</td>
<td>0.1256</td>
</tr>
</tbody>
</table>

Unrestricted cointegration test of the system of log-transformed GDP, household debt, consumption, and net worth with seven lags. * denotes rejection of the hypothesis at the 0.05 level.
MacKinnon et al. (1999) p-values reported.

Table 34: Unrestricted Cointegration Test (7 lags): Log Y, DM, C, and NW

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.139828</td>
<td>69.07273</td>
<td>47.85613</td>
<td>0.0002</td>
</tr>
<tr>
<td>At most 1 *</td>
<td>0.092889</td>
<td>35.63443</td>
<td>29.79707</td>
<td>0.0095</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.052956</td>
<td>13.99156</td>
<td>15.49471</td>
<td>0.0832</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.008578</td>
<td>1.912577</td>
<td>3.841466</td>
<td>0.1667</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Max-Eigen Eigenvalue</th>
<th>Trace Statistic</th>
<th>Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.139828</td>
<td>33.4383</td>
<td>27.58434</td>
<td>0.0079</td>
</tr>
<tr>
<td>At most 1 *</td>
<td>0.092889</td>
<td>21.64287</td>
<td>21.13162</td>
<td>0.0424</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.052956</td>
<td>12.07898</td>
<td>14.2646</td>
<td>0.1077</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.008578</td>
<td>1.912577</td>
<td>3.841466</td>
<td>0.1667</td>
</tr>
</tbody>
</table>

Unrestricted cointegration test of the system of log-transformed GDP, Mortgage debt, consumption, and net worth with seven lags. * denotes rejection of the hypothesis at the 0.05 level.
MacKinnon et al. (1999) p-values reported.
Table 35: Unit Roots Test (Two Cointegrating Vectors): $\log Y$, $D_H$, $C$, and $NW$

<table>
<thead>
<tr>
<th>Method</th>
<th>Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADF - Fisher Chi-square</td>
<td>34.604</td>
<td>0</td>
</tr>
<tr>
<td>PP - Fisher Chi-square</td>
<td>35.1281</td>
<td>0</td>
</tr>
</tbody>
</table>

Unit roots tests on the residuals of restricted cointegrating vectors: the system with household debt.
Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. Zero lag is selected by SIC. Null: individual unit root.

Table 36: Unit Roots Test (Two Cointegrating Vectors): $\log Y$, $D_M$, $C$, and $NW$

<table>
<thead>
<tr>
<th>Method</th>
<th>Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADF - Fisher Chi-square</td>
<td>29.9528</td>
<td>0</td>
</tr>
<tr>
<td>PP - Fisher Chi-square</td>
<td>30.2228</td>
<td>0</td>
</tr>
</tbody>
</table>

Unit roots tests on the residuals of restricted cointegrating vectors: the system with mortgage debt.
Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. Zero lag is selected by SIC. Null: individual unit root.

Table 37: Serial Correlation LM tests of the system with household debt

<table>
<thead>
<tr>
<th>Lags</th>
<th>LM-Stat</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>23.66747</td>
<td>0.097</td>
</tr>
</tbody>
</table>

Null hypothesis: no serial correlation at lag order 7. P-values from chi-square with 16 df.

Table 38: Serial Correlation LM tests of the system with mortgage debt

<table>
<thead>
<tr>
<th>Lags</th>
<th>LM-Stat</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>23.69527</td>
<td>0.0964</td>
</tr>
</tbody>
</table>

Null hypothesis: no serial correlation at lag order 7. P-values from chi-square with 16 df.
Table 39: Normality tests of the residuals of the system with household debt

<table>
<thead>
<tr>
<th>Equation</th>
<th>skewness(1)</th>
<th>Kurtosis(1)</th>
<th>Jarque-Bera(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LogGDP</td>
<td>0.016646</td>
<td>2.079158</td>
<td>10.62471</td>
</tr>
<tr>
<td></td>
<td>(0.010904)</td>
<td>(10.6138)</td>
<td>(0.0049)</td>
</tr>
<tr>
<td>Logconsumption</td>
<td>0.033365</td>
<td>1.991789</td>
<td>13.79687</td>
</tr>
<tr>
<td></td>
<td>(0.043789)</td>
<td>(13.75308)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Loghouseholddebt</td>
<td>0.19326</td>
<td>2.38898</td>
<td>6.452493</td>
</tr>
<tr>
<td></td>
<td>(1.445685)</td>
<td>(5.006809)</td>
<td>(0.0397)</td>
</tr>
<tr>
<td>Lognetworth</td>
<td>0.071312</td>
<td>2.393041</td>
<td>3.788376</td>
</tr>
<tr>
<td></td>
<td>(0.199678)</td>
<td>(3.588697)</td>
<td>(0.1504)</td>
</tr>
<tr>
<td>Joint tests</td>
<td>1.700056</td>
<td>32.96239</td>
<td>34.66244</td>
</tr>
<tr>
<td></td>
<td>(0.7907)</td>
<td>(0)</td>
<td>(0)</td>
</tr>
</tbody>
</table>

Chi-square statistics in parenthesis for skewness and Kurtosis tests. p-values in parenthesis for Jarque-Bera tests. For joint tests of skewness and Krutosis tests, Chi-square statistics with p-values are reported.

Orthogonalization: Residual Correlation (Doornik-Hansen). Null hypothesis: residuals are multivariate normal. 10 and 5 percent critical values for $\chi^2(1)$ are 2.71 and 3.84 respectively.

Table 40: Normality tests of the residuals of the system with mortgage debt

<table>
<thead>
<tr>
<th>Equation</th>
<th>skewness(1)</th>
<th>Kurtosis(1)</th>
<th>Jarque-Bera(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LogGDP</td>
<td>0.0529</td>
<td>2.067534</td>
<td>11.28656</td>
</tr>
<tr>
<td></td>
<td>(0.109992)</td>
<td>(11.17657)</td>
<td>(0.0035)</td>
</tr>
<tr>
<td>Logconsumption</td>
<td>-0.13407</td>
<td>2.263789</td>
<td>7.376614</td>
</tr>
<tr>
<td></td>
<td>(0.701718)</td>
<td>(6.674896)</td>
<td>(0.025)</td>
</tr>
<tr>
<td>Logmortgagedebt</td>
<td>0.239476</td>
<td>2.832039</td>
<td>2.710257</td>
</tr>
<tr>
<td></td>
<td>(2.200656)</td>
<td>(5.09601)</td>
<td>(0.2579)</td>
</tr>
<tr>
<td>Lognetworth</td>
<td>0.073915</td>
<td>2.480236</td>
<td>2.596147</td>
</tr>
<tr>
<td></td>
<td>(0.21449)</td>
<td>(2.381657)</td>
<td>(0.2731)</td>
</tr>
<tr>
<td>Joint tests</td>
<td>3.226856</td>
<td>20.74272</td>
<td>23.96958</td>
</tr>
<tr>
<td></td>
<td>(0.5206)</td>
<td>(0.0004)</td>
<td>(0.0023)</td>
</tr>
</tbody>
</table>

Chi-square statistics in parenthesis for skewness and Kurtosis tests. p-values in parenthesis for Jarque-Bera tests. For joint tests of skewness and Krutosis tests, Chi-square statistics with p-values are reported.

Orthogonalization: Residual Correlation (Doornik-Hansen). Null hypothesis: residuals are multivariate normal. 10 and 5 percent critical values for $\chi^2(1)$ are 2.71 and 3.84 respectively.
<table>
<thead>
<tr>
<th>Lag</th>
<th>LogL</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1294.051</td>
<td>NA</td>
<td>6.22E-12</td>
<td>-11.6131</td>
<td>-11.5364</td>
<td>-11.5821</td>
</tr>
<tr>
<td>1</td>
<td>3682.285</td>
<td>4647.374</td>
<td>3.53E-21</td>
<td>-32.9035</td>
<td>-32.4437</td>
<td>-32.7178</td>
</tr>
<tr>
<td>2</td>
<td>3896.84</td>
<td>407.8485</td>
<td>6.40E-22</td>
<td>-34.6112</td>
<td>-33.76817*</td>
<td>-34.27082*</td>
</tr>
<tr>
<td>3</td>
<td>3932.46</td>
<td>66.10501</td>
<td>5.82E-22</td>
<td>-34.7069</td>
<td>-33.4807</td>
<td>-34.2118</td>
</tr>
<tr>
<td>4</td>
<td>3961.39</td>
<td>52.38619*</td>
<td>5.63E-22</td>
<td>-34.74225*</td>
<td>-33.1329</td>
<td>-34.0925</td>
</tr>
<tr>
<td>5</td>
<td>3981.293</td>
<td>35.14562</td>
<td>5.91E-22</td>
<td>-34.6963</td>
<td>-32.7038</td>
<td>-33.8919</td>
</tr>
<tr>
<td>6</td>
<td>3995.566</td>
<td>24.55848</td>
<td>6.53E-22</td>
<td>-34.5997</td>
<td>-32.224</td>
<td>-33.6405</td>
</tr>
<tr>
<td>7</td>
<td>4013.669</td>
<td>30.33572</td>
<td>6.99E-22</td>
<td>-34.5376</td>
<td>-31.7786</td>
<td>-33.4237</td>
</tr>
<tr>
<td>8</td>
<td>4028.213</td>
<td>23.7153</td>
<td>7.73E-22</td>
<td>-34.4434</td>
<td>-31.3013</td>
<td>-33.1748</td>
</tr>
</tbody>
</table>

Lag length selection for the VAR system of GDP, consumer debt, consumption, corporate debt and investment.

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5 percent level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

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Table 42: VECM Estimation with restrictions (1 lag): Log Y, D_C, C, D_F, and I

<table>
<thead>
<tr>
<th>Cointegration Restrictions:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ρ₁ = 1, ρ₂ = 0, ρ₃ = 0</td>
<td>0.626431</td>
<td>0.731092</td>
</tr>
<tr>
<td>Restrictions identify all co-integrating vectors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LR test for binding restrictions (rank = 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chi-square(2)</td>
<td>0.626431</td>
<td>Probability</td>
</tr>
<tr>
<td>Co-integrating Eq</td>
<td>CointEq1</td>
<td>1</td>
</tr>
<tr>
<td>LOGGDP₁</td>
<td>-0.4594</td>
<td>0.51097</td>
</tr>
<tr>
<td>LOGCONSUMPTION₁</td>
<td>-0.08108</td>
<td>-3.52382</td>
</tr>
<tr>
<td>LOGINVESTMENT₁</td>
<td>-0.11709</td>
<td>4.46352</td>
</tr>
<tr>
<td>LOGCORPDEBT₁</td>
<td>-0.18402</td>
<td>3.88896</td>
</tr>
<tr>
<td>C</td>
<td>-2.37729</td>
<td></td>
</tr>
<tr>
<td>Error Correction:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CostEq1</td>
<td>0</td>
<td>0.120589</td>
</tr>
<tr>
<td>D(LOGGDP₁)</td>
<td>0.993287</td>
<td>0.918659</td>
</tr>
<tr>
<td>D(LOGCON₁)</td>
<td>[NA]</td>
<td>0.593172</td>
</tr>
<tr>
<td>D(LOGCONSUMPTION₁)</td>
<td>0.519652</td>
<td>0.131106</td>
</tr>
<tr>
<td>D(LOGINVESTMENT₁)</td>
<td>[4.52996]</td>
<td>[1.47061]</td>
</tr>
<tr>
<td>D(LOGCORPDEBT₁)</td>
<td>0.023303</td>
<td>-0.043323</td>
</tr>
<tr>
<td>D(LOGINVESTMENT₁)</td>
<td>[0.43606]</td>
<td>[0.94883]</td>
</tr>
<tr>
<td>D(LOGCORPDEBT₁)</td>
<td>-0.04772</td>
<td>-0.068368</td>
</tr>
<tr>
<td>Error-corrected:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.260721</td>
<td>0.223201</td>
</tr>
<tr>
<td>Adj. R-squared</td>
<td>0.215099</td>
<td>0.211767</td>
</tr>
<tr>
<td>S.E. equation</td>
<td>0.021646</td>
<td>0.005037</td>
</tr>
<tr>
<td>F-statistic</td>
<td>0.008414</td>
<td>0.006517</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>769396</td>
<td>627363</td>
</tr>
<tr>
<td>Akaike Information criterion</td>
<td>-5.69559</td>
<td>-7.19683</td>
</tr>
<tr>
<td>Schwarz Information criterion</td>
<td>-6.58244</td>
<td>-7.08324</td>
</tr>
<tr>
<td>Mean dependent</td>
<td>0.0077734</td>
<td>0.000553</td>
</tr>
<tr>
<td>S.D. dependent</td>
<td>0.008052</td>
<td>0.007341</td>
</tr>
</tbody>
</table>

VECM estimation of the system of log-transformed GDP, consumer debt, consumption, investment, and corporate debt with 1 lag with restrictions on adjustment coefficients. T-statistics in parentheses. Co-integrating vector normalized with respect to GDP coefficient.