# The Dynamics of Household Debt and GDP:
## Reconsidering Minsky from an empirical perspective
## (US, 1980-2016)

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## Abstract

In this paper we attempt to empirically examine the existing post-1980 relationship between US output and household debt from a business cycle perspective. Contrary to conventional cycle theories whose starting point is usually an exogenous shock on the real side of the economy, my study is based on a post-Keynesian perspective considering crises ignited endogenously in the financial sector that are exported to the real sector. According to Minsky's Financial Instability Hypothesis, credit expansion (specifically, we focus on HH debt) plays a double role on the real economy. On the one hand it appears to be a source of economic stimulus in the short run by encouraging autonomous consumption and residential investment but on the other, it may have deflationary long run effects on aggregate demand and output due to the raise of the burden of debt. Together with this, an over indebted economy has proved to be extremely fragile to any possible exogenous shock. In order to investigate these issues several econometric techniques have been used. Since cointegration relationship seemed to be present between my main variables, both an ECM and a VECM have been estimated. My main results seem to indicate that while credit expansion may boom the economy in the short run, the increase of the burden of debt ends up depressing aggregate demand and output (long run effect).

# 1. Introduction

During the last three decades, modern economies have witnessed a rushing process of financialization. It is characterized by a higher share of finance in aggregate value added. Also, by a higher weight of bank credit to GDP. In this paper we shall concern with mortgage loans and consumption credits to households. Household outstanding debt as share of GDP has increased from about 45 percent in 1975 to nearly 95 percent in 2007. Together with this, we also observe an upward trend of HH Debt Service Payment as Percentage of Disposable Income (DSR), a commonly used measure for the household burden of debt (Greenspan, 2004). How may have this household credit expansion affected the real economy?

After the experience of the Great Recession and the previous booming period, it has become clear for many economists that the financial system and in particular the role of commercial banks with their ability to provide credit to agents should not be considered any more as a secondary player in the story of business cycles (Werner, 2005). Contrary to the neoclassical view of the 'rational expectations school' which considers the origin of cycles to be exogenous (Lucas, 1975)(Barro, 1984), other authors have focused their attention on the growing importance of those cycles that are ignited endogenously in the financial sector and eventually exported into the real side of the economy. Post-Keynesian economist Hyman P. Minsky (1975, 1986) contribution with his so called 'financial instability hypothesis' (FIH), provides an excellent approach into the forces standing behind these endogenous cycles. Following this Post-Keynesian line, it is also worth mentioning the work of other authors such as Taylor & O'Conell (1985) or Asada (2011).

Minsky's main argument refers to the fact that economic booms sow the seeds of financial crashes and the consequent economic recessions. During periods of prosperity banks become more confident and relax credit conditions for business and households: lower interest rates, softer collateral requirements, longer repayment time... While credit expansion may boom the economy in the short run, the subsequent excessive leverage of agents together with the increasing tendency from 'hedge' finance to largely 'speculative' or even 'Ponzi' (fraudulent) finance which in turn makes the system fragile to any fatal exogenous shock, may sentence the economy to death. The *coup de grâce* is precisely shot when banks close the door to further credit and agents cannot meet their financial obligations.

This theoretical framework and the above mentioned evidence of the significant increase in household debt relative to income, provides strong motivation to my present research. In this paper we attempt to empirically examine the existing post-1980[1] relationship between US output and HH debt with the objective to verify whether Minskian forces have actually been significant and present during this period. To this end, we will largely build on the work carried out by Palley (1994), Kim (2013) and Kim (2016) which empirically investigates this very same issue.

Kim (2016) approaches household debt driven business cycles from an empirical perspective. Multi-equation econometric frameworks are used to analyse the relation between aggregate income and household debt. In particular, his study attempts to empirically distinguish the short-run and the long run dynamics for the US economy, implementing both a vector autoregression (VAR) and vector error correction (VECM) model. His main conclusion suggests the existence of a negative long run relationship between household debt and GDP when further introducing real consumption as an endogenous variable[2]. Previous studies such as Palley (1994) and Kim (2013) provide similar evidence despite employing different methodologies such as dynamic Ordinary Least Squares (DOLS).

This paper contributes to the literature by studying the very same issue from a different angle. We share Kim's (2016) motivation of understanding the short run and long run impact of HH debt on GDP. Thus, multi-equation models provide the relevant framework due to reverse causality issues that may otherwise arise. It may seem natural to focus on the short run coefficients and the cointegration equation of the VECM specification (Kim, 2016). However, does this methodology actually answer the question we have in mind? Does finding a negative HH debt cointegration coefficient provide evidence for a negative long run effect of today's excessive over-accumulation of debt? In our view, Impulse Response Function (IRF) analysis provides more suitable and relevant information to support credit driven business cycles. Furthermore, my results suggest that omitting the evolution of the nominal price index of dwellings significantly affects the conclusions.

The paper is organised as follows. Section 2 introduces the formal and empirical model. Section 3 describes the data used and its quality. Section 4 is devoted to the single

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[1] During the early 80s, Federal Reserve chairman Paul Volcker grants the liberalization of banks and financial agents. This is why my study is going to be focused in this specific period.

equation model which provides a first approximation into the relation between my variables. Section 5 focuses on the multi equation set up and finally, Section 6 concludes the paper.

## 2. A stylized theoretical framework

In sharp contrast with classical and neoclassical economists' general acceptance of Say's law, John Maynard Keynes proposed in his General Theory (1936) the *principle of effective demand* according to which, production in period t adjusts to the expected demand. Under this approach, output is demand driven. It is driven by that part of demand which is not induced (proportional to the current output level) but autonomous. Easy credit conditions enhance the autonomy of this part of aggregate demand. The Income-Expenditure model we will present next will constitute the building block of my econometric model.[3] The equilibrium condition implied by this model[4] is:

$$Y=C+C_0+I_r+I_f+G \quad [1]$$

Induced consumption is $C=cY^d$, where $c$ is the average propensity to consume and $Y^d=Y(1-t)$ is the disposable income of households ($t$ is the tax rate). This allows us to express income as a multiple of autonomous demand. The multiplier is $\mu=1/(1-c(1-t))$. Hence:

$$Y=\mu( C+C_0+I_r+I_f+G) \quad [2]$$

Since we are interested in the variables under the control of households, we may group the terms in [2] as follows: $Y=\mu(H+Z)$, where $H=C_0+I_r$ would be our variable of interest. Following Post- Keynesian theory, we may argue that $H$ component is a function of credit to households since almost 100 per cent of residential investment is financed with mortgage loans. Thus:

$$H= f(\text{HH credit}) \text{ with } df(\cdot)/d(\text{HH credit})>0 \quad [3]$$

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[3] This theoretical framework is nowadays widely accepted among economists, at least in the short run when prices are considered to be fixed. Note that in my particular specification, I have assumed a closed economy in order to simplify my analysis. Closed models are appropriate for big countries like the US.

[4] Y: output level, C: induced consumption, $C_0$: autonomous consumption, $I_r$: residential investment, $I_f$: corporate investment, G: government expenditure.

Rewriting expression [3] in growth rates we get:

$$g_Y = w_H \cdot g_H\,(HH\ credit) + w_Z \cdot g_Z \quad [4]$$

where $\omega_{(\cdot)}$ accounts for the weight of these two sources of growth. Note that the growth of the H component $-g_Y-$ is a function of household credit. As already commented, our main interest is to understand the effect that credit to households may have on $g_Y$. Based on Minsky's FIH, we may hypothesize the following:

**(1)** Credit expansion (household indebtedness) has a positive effect on income (short-run effect). $\Delta\, HH\ Credit \equiv \Delta HH\ debt \rightarrow \Delta H \rightarrow \Delta Y.$

**(2)** Credit expansion may be responsible of the increase of the burden of debt (debt service ratio) which will eventually have deflationary effects on demand and income (long - run effect). $\Delta\, HH\ Credit \rightarrow \Delta Service\ Debt \rightarrow \nabla Y.$

We move next to consider the appropriate empirical specification to test Minsky's FHI. For the single equation approach, since cointegration relationship appears to be present (the analysis is discussed in section 6), an ECM model will be estimated to study the effect of HH debt growth and debt service ratio growth on output growth (see M1 below). We will control for two variables that, according to equation [4] above, may account for other determinants of growth, namely, corporate investment and government expenditure growth. Together with this, as suggested by Kim (2013), we will also control for HH net worth growth which may be correlated with HH debt and output through the so called "wealth effect". In an extended version, we will finally introduce a dummy variable to investigate potential different effects of my variables of interest during the period of the Great Recession. We should highlight that this model provides only a first approximation to the question in mind. Note that we are imposing exogeneity on HH debt, which may be clearly violated by the presence of reverse causality and thus, our estimators will be inconsistent.

**[M.1] Single equation model**[5]

$$dY_t = \mu + (\rho_1 - 1)(Y_{t-1} - \beta_0 - \beta_1 HH\ debt_{t-1}) + \varphi_1 dY_{t-1} + \vartheta_0 dHH\ debt_t \\ + \vartheta_2 dHH\ debt_{t-1} + \delta_0 dDSR_t + \delta_1 dDSR_{t-1} + \epsilon_t$$

[5] The prefix d- indicates growth rates.

If hypothesis (1) and (2) are to be fulfilled, then $\vartheta_{(\cdot)} > 0$ and $\delta_{(\cdot)} < 0$. If there exists a negative long run equilibrium relationship, then $\beta_1 < 0$.

Minsky's FHI suggests that there may exist a positive feedback effect between HHdebt and GDP in the short run while in the long run, debt accumulation will eventually check growth. In a multiple equation framework, the short run dynamic effects may be studied from the perspective of a VAR model. We should expect to observe a positive effect between dHH debt and dGDP (Kim, 2016). Rather than focusing on the coefficients of the different lags (which may not always be significant and may even alternate sign), the underlying dynamics between a set of endogenous variables are depicted in a much more illustrative way via IRFs. They enable us to capture the response of a variable to a positive (orthogonal) shock in another. Kim (2016) shows that positive shocks to HH debt (under the different versions considered by the author) are associated with an increase in the growth rate of GDP while a positive shock on the latter is associated with an increase in the growth rate of debt.

The (Vector) Error Correction Model representation (VECM) allows us to define the first difference of a cointegrated random vector $y = (gdp\ debt)'$ as:

$$\Delta y_t = \alpha \underbrace{(\beta' y_{t-1} + \mu)}_{z_t} + \sum \Gamma_i \Delta y_{t-1} + \gamma + \tau t + \epsilon_t$$

One could think of $z_t = 0$ as the point in which $gdp_t$ and $debt_t$ are in equilibrium. If we were out of equilibrium and the system was stable, the two variables would then adjust and correct back to the equilibrium evolution path. VECM models allow us to study the short-run deviations from this long-run relationship. Thus, the cointegration equation captures the long run relationship in the sense that it is a time invariant equilibrium relationship or "centre of gravity". It depicts the underlying correlation between the evolution path of two I(1) random variables whose linear combination happens to be I(0) and can then be modelled in an error correction form. Note that we are not talking about long run causality neither in the sense we usually refer to in cross-sectional data, nor in the dimensionality sense employed in time series analysis.

Our interpretation on Minsky does not focus on whether the suggested equilibrium correlation between HH debt and GDP is negative bur rather on the "causal" relationship between our variables. In the VECM framework, causality is expressed by dynamics. They can be visualized via the conduction of the IRF of a well specified model. In this way, we are able to observe how one variable evolves over time in response to a shock in another. In contrast with VAR models in where shocks are always temporary, cointegration may imply persistence (permanent shocks). In the spirit of Minsky's FHI, we would expect to observe that HH debt shocks on GDP are negative after considerable periods of time.

**[M.2] Multiple equation model**

$$dY_t = \mu_{01} - \alpha_{01}(Y_{t-1} - \beta_0 - \beta_1 HH\ debt_{t-1}) + \gamma_{11} dY_{t-1} + \gamma_{12} dHH\ debt_{t-1} + \epsilon_t$$

$$dHH\ debt_t = \mu_{02} - \alpha_2(Y_{t-1} - \beta_0 - \beta_1 HH\ debt_{t-1}) + \gamma_{21} dY_{t-1} + \gamma_{21} dHH\ debt_{t-1} + \epsilon_{2t}$$

The long run relationship is given by the cointegration equation $(Y_{t-1} - \beta_0 - \beta_1 HH\ debt_{t-1})$. The differenced lagged variables $dY_{t-1}$ and $HH\ debt_{t-1}$, account for the *short run* dynamic effects and $\alpha_{(\cdot)}$ refers to the adjustment coefficients.

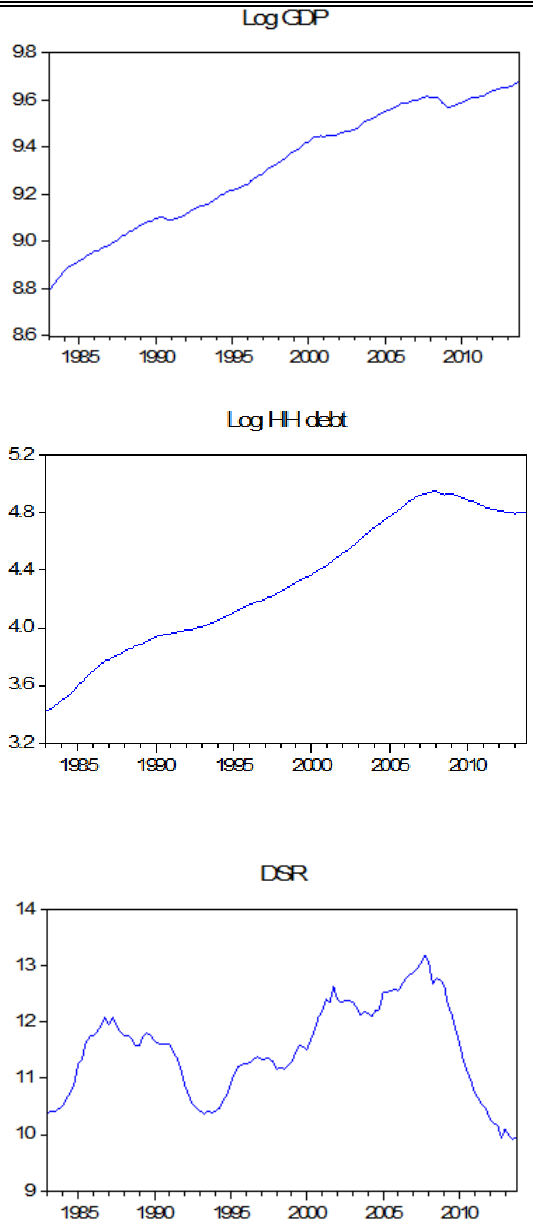
## 3. Description of the data

The country and time frame selected for my empirical analysis has facilitated the access to data of exceptional quality in terms of absence of measurement errors and sample size[6]. Following Kim (2013) and in accordance with the theoretical set up, we have transformed all my nominal variables to real terms (except DSR, which is a ratio). To that end, HH debt and HH Net worth have been deflated by the personal consumption price index from the Bureau of Economic Analysis (BEA). Furthermore, we have taken logs of all my variables (except DSR) in order to smooth my series and to obtain growth rates whenever we take first differences on them. The figure below shows plots of my three main variables in levels: GDP, HH debt, and DSR.

Clear upward trends can be observed in the first two series. DSR is a ratio that is supposed to rise if HH debt increases faster than output. We observe that this is the case from 1995 to 2007. The high rates of growth of output, credit and house prices were able to hide the problem for a decade. But when the crisis arrived the burden of debt showed its deflationary impact. The recovery requires, among other things, a fall in the DSR to normal levels (around 10 percent).

[6] Seasonally adjusted quarterly data, from 1983Q1 to 2013Q4 in the Single Equation Model. Seasonally adjusted quarterly data, from 1980Q1 to 2016Q2 in the VEC model. Main source: Bureau of Economic Analysis and Federal Reserve Flow of Fund (see Appendix A for further details)

Figure 1. GDP, HH debt and DSR.




One of the most crucial steps in the analysis of my data is to verify if the assumption of stationary actually holds since it is essential in order to apply consistently the econometric techniques we are going to use. When looking at the time series plots and correlograms (Figure 3, Appendix A), it seems to be clear that they are trending and non-stationary presenting probably a unit root. This, because we can observe that the one lag partial autocorrelation of the variables in levels nearly takes the unit value while the autocorrelation function slowly decays to zero. Hence, we proceed to test the presence of a unit root in the generating process of my data by conducting the augmented Dicky-Fuller test (ADF). The ADF equation can be written in general terms as:

$$\Delta Y_t = a_0 + \gamma Y_{t-1} + a_2 t + \sum_{i=2}^{p} \beta_i \Delta Y_{t-i+1} + \varepsilon_t.$$

We will test the following hypothesis:

$H_0: \gamma = 0 (unit\ root) vs\ H_1: \gamma < 0\ (stable\ root\ or\ stationary)$. In order to perform the test correctly (taking into account the correct t-statistics, depending on the specification of the estimated model), we will follow sequentially five main steps as proposed in Table 1. Optimal lag selection is based on Schwarz Information Criterion.

Table 1 below reports results examining the unit root properties of the variables for this sample. Since we fail to reject the ADF null in all cases, all my variables seem to possess a unit root and hence, although being non stationary in levels, they will be stationary after taking first differences. These results are in accordance with the ones obtained by Kim (2013) and Kim (2016) for a similar sample. He, however, founded that unit roots were not present if the sample was taken previously (taking data from 1951Q4 to 1982Q4). This indicates fundamental differences between earlier and later periods in terms of the data generating process.

**Table 1. ADF test**

| | *Step 1* | *Step 2* | *Step 3* | *Step 4* | *Step 5* | |
|---|---|---|---|---|---|---|
| | **Trend and constant (ADF test)** | **$H_0: \gamma = a_2 = 0$ (Wald test)** | **Constant (ADF test)** | **$H_0: \gamma = a_0 = 0$ (Wald test)** | **None (ADF test)** | **Conclusion** |
| **Log Y** | -1.53 (0.81) | 2.27 (0.1069) | -1.71 (0.41) | 7.35*** (0.001) (Use Normal dist.) | – | I(1) |
| **Log HH debt** | -2.85 (0.18) | 4.62** (0.011) (Use Normal dist.) | – | – | – | I(1) |
| **DSR** | -1.75 (0.72) | 2.53* (0.08) | -2.05 (0.26) | 2.11 (0.12) | -0.20 (0.60) | I(1) |
| **Log G** | -2.39 (0.37) | 5.00*** (0.008) (Use Normal dist.) | – | – | – | I(1) |
| **Log I** | -2.55 (0.30) | 3.31** (0.03) (Use Normal dist.) | – | – | – | I(1) |
| **Log Net worth** | -1.87 (0.66) | 2.14 (0.18) | -1.18 (0.67) | 12.31*** (0.00) (Use Normal dist.) | – | I(1) |

*,**,*** denote significance at 10, 5 and 1 percent levels, respectively.

t-statistics are presented with their corresponding p-value in parenthesis.

# 4. Single Equation Model

In this section and the following one we will have the opportunity to empirically investigate the main issue of interest: understanding the relationship between household debt and GDP. In particular, since there seems to be evidence of cointegration, we attempt to estimate an ECM model capturing the effect of HH debt growth and DSR growth (burden of debt growth) on GDP growth (i.e. short- run adjustments) and the long run equilibrium between HH debt and output (cointegration equation). Note that the underlying effects could have been captured by estimating a simple ARDL model.

As shown in Table 3 below, three models have been estimated. Appendix B reports the outputs of some specific tests regarding residuals white noise assumption and correct specification. In short, Ljung-Box and Jarque- Bera test suggests that all three models are free of autocorrelation and that residuals are normally distributed. Neither of them shows signals of serial autocorrelation, nor evidence of conditional or unconditional heteroskedasticity. After the introduction of the interaction term between dHH net worth and dI in model 1, all my models appear to be correctly specified (Ramsey test). In terms of IC and $R^2$, all three models seem to be very similar.

**Table 3. ECM regression. 1983Q1-2013Q4**

| Dependent variable: dGDPt | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| Constant | -0.061 [0.069219] | -0.041[0.058] | 0.001 [0.0008] |
| $dGDP_{t-1}$ | -0.017 [0.073] | -0.014[0.087] | 0.003 [0.079] |
| $dGDP_{t-2}$ | 0.090 [0.057] | 0.080[0.065] | 0.110 [0.074] |
| $dHH\ debt_t$ | 0.009 [0.055] | -0.004[0.060] | 0.014 [0.060] |
| $dHH\ debt_{t-1}$ | 0.147*** [0.056] | 0.139** [0.060] | 0.129** [0.059] |
| $dDSR_t$ | -0.088** [0.037] | -0.084** [0.040] | -0.082** [0.038] |
| $dDSR_{t-1}$ | -0.130***[0.037] | -0.114***[0.036] | -0.105***[0.036] |
| $dG_t$ | 0.191*** [0.022] | 0.201*** [0.058] | 0.217*** [0.057] |
| $dI_t$ | 0.179*** [0.022] | 0.172*** [0.022] | 0.167*** [0.023] |
| $dNet\ worth_t$ | 0.060*** [0.016] | 0.051*** [0.014] | 0.051*** [0.016] |
| $(dNet\ worth * dI)_t$ | -1.509*** [0.508] | | |
| $LGDP_{t-1}$ | 0.010 [0.009] | 0.007 [0.008] | |
| $LHH\ debt_{t-1}$ | -0.007 [0.005] | -0.005 [0.004] | |
| $(GR * dHH\ debt)_t$ | | -0.493*** [0.125] | -0.569***[0.131] |
| $(GR * dDSR)_t$ | | -0.017[0.080] | 0.005 [0.084] |
| $(GR * dG)_t$ | | -0.416** [0.169] | -0.525***[0.167] |
| $R^2$ | 0.68 | 0.67 | 0.66 |
| Akaiki/ BIC | -8.26/ -7.96 | -8.21/ -7.86 | -8.21/ -7.91 |
| Correlogram (correlated residuals?) | No | No | No |
| Ramsey test | (0.4975) | (0.1100) | (0.093) |

Focusing my analysis in model 1 we first of all observe significant positive coefficients of HH debt growth indicating that, caeteris paribus, an increase of this variable will have a positive impact on output growth. The burden of debt appears to have negative effects on output growth since both the short- run and one lag multiplier of DSR growth are negative. On the other hand, control variables affect positively income growth. The coefficients of the cointegrated variables appear to be non-significant. My position to this issue is the following: first, since the estimation and validation outcomes prove to be similar either by including the terms in levels or when omitting them (since they are not significant), it seems that my conclusions will not be seriously affected by this issue (compare model 2 and 3)[7]. Second, the reason for this to happen could be due to either weak evidence of cointegration or alternatively, misspecification of the error correction term (see the following section).

Model 2 main innovation is about the inclusion of a dummy variable that takes the value one during the 2008 recession as defined by the US National Bureau of economics (from 2007Q4 to 2009Q2). HH debt growth, DSR growth and government expenditure growth interaction with this variable allows me to investigate potential differential effects during this period. Significant negative coefficients are found for HH debt and government expenditure growth which seem to indicate two crucial things. First, that credit expansion may only boom the economy whenever it is already growing while during recessions, the effect is much lower if not absent. Second, and more interestingly, the fact that the positive effect of government expenditure growth on output growth is also lower for this period. This finding may be relevant as far expansionary fiscal policy is concerned. We could argue that during recessions, if agents are highly indebted, fiscal policy seems to be ineffective.

## 5. Multiple Equation Model

This final section is devoted to the estimation of a VECM in where long run and short run effects together with feedbacks effects between my two variables of interest (HH debt and GDP) will be captured. Before proceeding to present my results and Impulse-Response functions it is essential to investigate the presence of cointegration between my variables. Our main concern when testing for cointegration is to check if there exist a stationary or I(0) linear combination of my I(1) variables. If this is the case, we may rely on Granger's Representation Theorem to assert that there exists at least one ECM

[7] Nonetheless, I should take into account that model 3 is misspecified, this is, as long as HHdebt and GDP are cointegrated, the appropriate form is not an ARDL model but and ECM model. This problem is similar to the one appearing when estimating a linear model when the 'true' model is actually non-linear.

representation such that each variable responds to the deviation from the 'long-run equilibrium' (Enders, 2010). The Johansen methodology uses the $\lambda_{trace}$ and $\lambda_{max}$ tests statistics to test the null of non-cointegration.

We will consider three different specifications of the model proposed by Kim (2016). Thus, we will closely follow his analysis conducting a careful diagnosis checking. Our results are summarized in Appendix D in different panels[8].

## 5.1 HH debt and GDP model

As a starting point, let us consider the basic model in where only HH debt and real GDP are assumed to be endogenous. In section 2 we already checked that our variables are I(1), which is a necessary condition for cointegration. We should however verify whether there exist a stationary linear combination of these two I(1) variables. To test for cointegration, we must first specify how many lags to include. Following Nielsen (2001), our selection criteria is based on the comparison of the optimal choice according to the final prediction error (FPE), Akaike's information criterion (AIC), Schwarz', Bayesian information criterion (SBIC), and the Hannan and Quinn information criterion (HQIC). In Panel 1 of Appendix D, we can see that it is optimal to either include two or three lags.

We conduct Johansen's multiple-trace test method (Johansen, 1988) with a linear time trend (Figure 1 above seemed to indicate the presence of a trend in the data). However, following Kim (2016), I assume that the cointegration equation contains a constant but not a linear trend[9]. Table 2 in P1.D summarizes the results of the test. We reject the null of zero cointegration relationship for the case of two lags but we fail to reject it when considering three or more lags (at a 5% significance level).

We proceed with the estimation of the VEC model. We are interested in four types of parameters: (1) the parameters in the cointegrating equation, (2) the adjustment coefficients (which indicate the direction and velocity of adjustment when the system is out of its long run equilibrium) and (3) the short-run coefficients. The estimation results indicate three main aspects (see Table 3 of P.1.D). First of all, positive long run relationship is observed between our variables of interest. Secondly, the error correction parameters are

[8] P1.D would for example refer to panel 1 of appendix D.

[9] There is no theoretical argument in favour of a long run equilibrium with a trend between HH debt and real GDP.

significant and make the system stable. Finally, short run effects appear to be not significant. We should check several crucial aspects in order to validate our model.

*Cointegration Equation (1)*

$$lgdp = 0.42ldebt + 6.22$$

Inference on the adjustment parameters will depend on the stationarity of the cointegrating equation. While graphical inspection seems to show mean reversion (Figure 1, P.1.D), Dicky-Fuller test concludes the presence of a unit root in the residuals. Thus, we cannot claim that the residuals of the cointegration equation are stationary. Together with this, we should test for serial correlation in the residuals. The results in Table 4 indicate presence of serial correlation. According to Gonzalo (1994), underspecifying the number of lags in a VECM could lead to serial correlation and increase the finite-sample bias in the parameter estimates. Hence, we refit the model with four lags instead of three. The main conclusions in terms of the long run relationship and non-stationary residuals remain unchanged. Since we cannot rely on inference of a non-validated model, we do not proceed in the analysis.

## 5.2 HH debt, GDP, Net Worth and Consumption as endogenous variables

We move to consider the model presented in Kim (2016). Despite his sample covers period 1952 to 2009, we focus on period 1980 to 2016. In our view, it is interesting to observe whether the main derived conclusions are sensible to considering a different time period. Furthermore, the time frame we consider is relevant as HH debt has little weight prior to 1980 and we are able to account for the dynamics in the aftermath of the Great Recession. For each presented model, we are conducting the same steps as in section 6.1. All results are displayed in P.2.C.

We will first look at the version when only HH debt, GDP and net worth are endogenous. In this case, we only find weak evidence for cointegration. When further introducing consumption, Johansen test for cointegration indicates the presence of a single cointegration equation for a considerable set of lags, including the optimal ones. This is the model presented in Kim (2016). We do observe a negative significant long run equilibrium relationship between HH debt and GDP. Real personal consumption is positively correlated with real GDP in the cointegration equation while net worth is no longer significant. Recall that looking at the cointegration equation informs us about the equilibrium relationship or centre of gravity to which potential deviations will adjust. Taking the case of consumption, it is reasonable to relate an error correction model to permanent and transitory consumption. It is not easy, however, to provide a theoretical based argument to an equilibrium relation between HH debt and GDP.

*Cointegration Equation (2)*

$$lgdp = -2.44\ ldebt + 5.15\ lconsumption + 0.48 lnet\ worth + 23.99$$

Regarding the adjustment coefficients, we see that only the one for HH debt is significant. The intuition behind this result may be the following. We have said that variables adjust to deviations from the equilibrium. Hence, this finding suggests that HH debt is bearing the main burden of adjustment. Periods of over accumulation of debt as implied by the cointegration equation entails an adjustment conducted mostly through household deleveraging, which may in turn have implications on other variables.

The validation of the model is not entirely convincing. Despite the presence of cointegration was rather robust, the implied residuals are not stationary according to the Dickey-Fuller test. We would like to further check whether the number of cointegration equations is correctly specified and if the cointegration equation is stationary. Lüthepol (2005) suggests looking at the companion matrix and checking whether the modulus of the remaining eigenvalues is strictly less than one. Graphical analysis of Figure 1 (P.2.C) presents three cases where the eigenvalues are close to one. Unfortunately, there is no general distribution theory that allows as to determine whether an estimated unit root is too close to one.

We proceed with the consideration of impulse response functions in its generalized and orthogonalized form. An IRF measures the effect of a shock to an endogenous variable on itself or on another endogenous variable. General IRF are contaminated by the existing covariance structure of the error term vector. Orthogonalized IRF, however, derive from shocks that are exogenous to the system once the model has been identified[10]. Our analysis will mainly focus on orthogonalized IRFI as, strictly speaking, it is the appropriate way of

[10] Note that this entail imposing structural assumptions such as the contemporaneous impact restriction that is present in Choleski's lower triangular factorization.

studying the effect of one variable on another. We will show, however, that the main conclusions also hold for generalized IRFs (see P.2.C).

Figure 2: Response of GDP to an orthogonalized shock in HH debt and Consumption

| *HH debt* | *Consumption* |
|---|---|

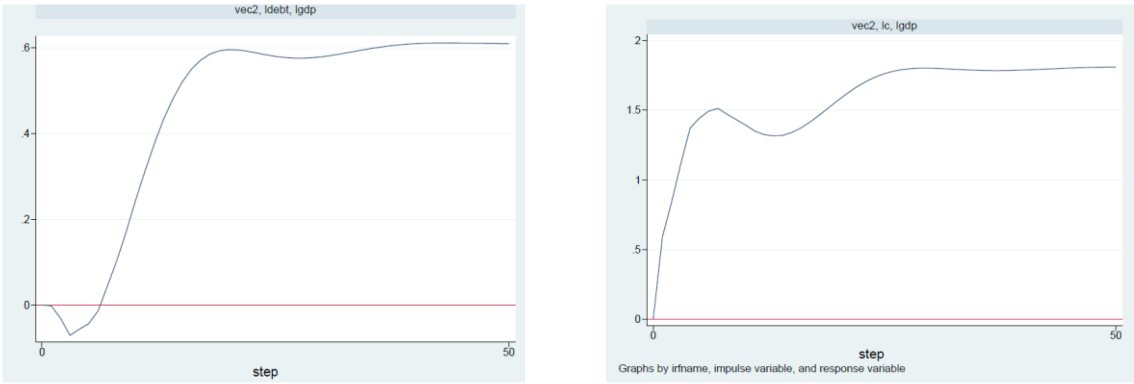



Figure 2 above presents two IRFs of interest. We clearly observe that our system is dynamically stable (responses converge in the long run) and that shocks have permanent effects[11]. In particular, a shock to consumption has a positive short run and long run effect on GDP. A shock in GDP positively affects the level of HH debt both in the short run and in the long run (see Appendix). Finally, HH debt appears to have a positive effect on GDP, stabilizing after five years. This finding, which is robust when either looking at general or orthogonalized IRFs, exemplifies that the conclusions derived from IRFs do not necessarily match with the intuition pointed out by Kim (2016). Despite we observed a negative relation in the cointegration equation between HH debt and GDP, the dynamics actually suggest that an orthogonal increase in HH debt have a positive effect both in the short run and in the long run.

## 5.3 Controlling for the evolution of housing prices

The above presented results suggest that HH debt, through its multiple (black box) channels which may affect GDP, positively impacts its level in the long run. This finding contradicts the main conclusion in Kim (2016). As the author himself points out "the positive evidence of Minsky's FIH requires caution. […] . In reality, an explosion of

[11] One limitation of IRF in the VECM is the difficulty of constructing confidence intervals for the different effects.

household debt may not result in a financial crisis and a recession. There are other factors that may work to contain the effect of household debt explosion (for example, central bank monetary policy or financial sector regulation)." Thus, it could be the case that despite we observe a negative long run equilibrium relation, the dynamics of the integrated system of the relevant variables do not follow Minsky's FHI. This would not say that such forces are not present but that, despite we may encounter financial recessions resulting from periods of over indebtedness, other forces are shaping the existing dynamics.

Here we propose an alternative explanation. In our theoretical model we proposed that GDP will evolve in accordance with household autonomous demand (among other things), where residential investment represents an important component. The construction industry is characterized by large fluctuations magnified by the pro-cyclical behaviour of banks that finance almost entirely the purchase of dwellings. We believe that the evolution of the construction sector captures a channel through which household debt may affect GDP. In the short run, a booming construction sector fuelled by a large demand of dwellings financed via mortgages may reproduce the claimed positive feedback effects. Furthermore, important over confidence and wealth effect may result from housing bubbles. On the other hand, the corrections of an over-dimensioned construction sector (both in the quantity and price dimension) will entail household deleveraging and a negative effect on GDP in the long run.

Our last model incorporates the nominal price index of dwellings (see Figure 1 of P3.C). Before exploring the presence of cointegration and analysing the VECM we look at the stationary nature of the variable and clearly conclude in Table 1 that the series contains a unit root. Our approach is to extend Kim (2016) model to incorporate the evolution of the construction sector. Johansen's multiple-trace test method with 3 lags (the optimal choice according to all selection criteria) indicates the presence of one cointegration equation at 5% significance level. This conclusion is maintained for a considerable set of (non-optimal) lags.

**5.3.1 Single cointegrating vector**

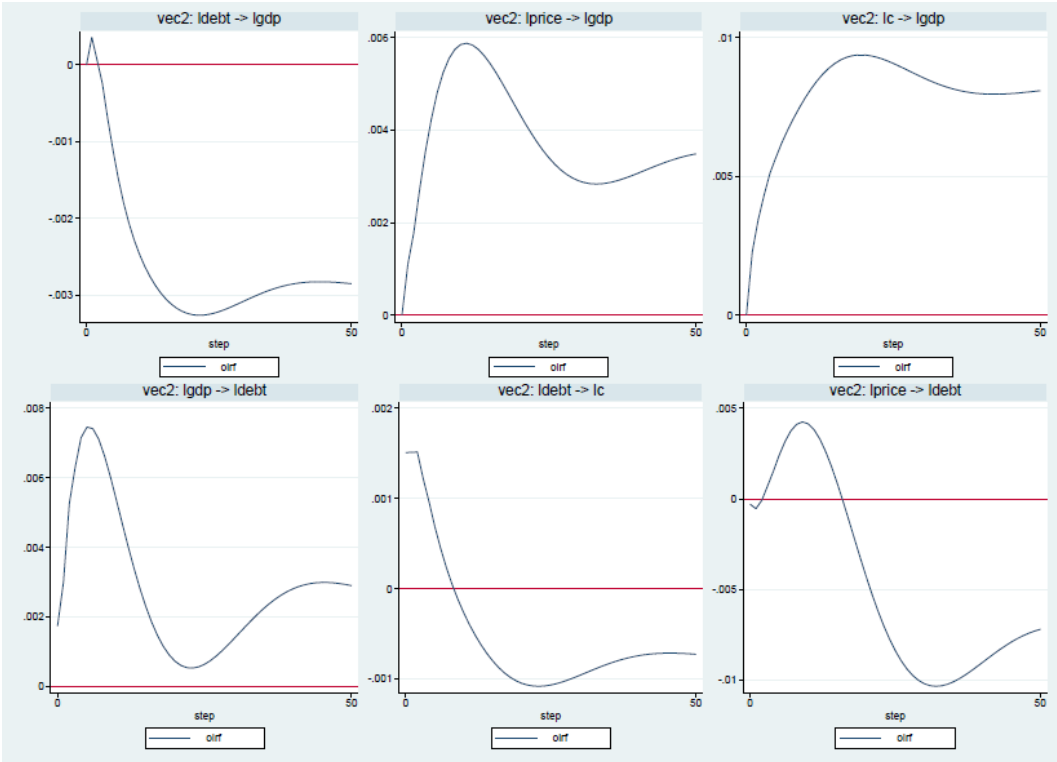
The VECM with a single cointegration equation seems to be well specified. As shown in Figure 2 of P.3.C, the residuals of the cointegrating equation seem to be stationary. This is corroborated at 5% significance level by the Dickey-Fuller test. Stability analysis based on the eigenvalues of the companion matrix indicates two possible values that are close to one, as already seen in previous models.

We observe a long run negative equilibrium relation between HH debt /house prices and GDP while a positive one between consumption and GDP. Adjustment coefficients provide relevant information about the responsiveness nature of our variables. Firstly, consumption does not seem to significantly adjust to potential deviations from the cointegrating relationship. According to the significance of the adjustment coefficients, the main burden of adjustment is born by HH debt, GDP and house prices. Finally, net worth seems to only weakly adjust to deviations.

The analysis of the IRF provides interesting results as far as the relevance of Minsky's FHI is concerned. Figure 3 below presents the responses of GDP to orthogonalized shocks of HH debt, house prices and consumption (top panel) and other IRF of interest (panel in the bottom). First of all, we can see that the long run effect of a shock of HH debt on GDP seems to follow Minsky's FHI. Thus, it seems that over-indebtedness today will have a negative repercussion in the future, when household have to adjust their balance sheets. In the short run, despite the contemporaneous response in positive, we cannot clearly conclude that HH debt fosters GDP. Housing prices, on the other hand, do have a positive impact in the short run. Our intuition is that it is evolution of house prices and the construction sector (importantly present in household autonomous consumption), the main channel through which HH debt affects GDP in the short run.

The positive response of HH debt to a shock in GDP mimics Minsky's overconfidence effects intuition. During periods of prosperity banks become more confident and relax credit conditions for business and households. Consumption positively reacts to HH debt in the short run while negatively in the long run. This matches the intuition that in the long run agents will have to deleverage and constraint their consumption. Our data, however, suggests that this effect may not be significant as we have seen that consumption adjusts little to deviations. Finally, we observe that a shock in house prices positively affects HH debt in the short run (plausibly through overconfidence effects) while negatively in the long run.

Figure 3: Orthogonalized IRFs




## 6. Conclusion

In this paper the relationship between HH debt and GDP in the US since 1980 has been studied from a business cycle perspective. Contrary to conventional cycle theories whose starting point is usually an exogenous shock on the real sector, my study has been based on Minsky's perspective which considers crises to be ignited endogenously in the financial sector and eventually exported to the real side of the economy. According to this author, while credit expansion may boom the economy in the short run, the subsequent excessive leverage of agents together with the increasing tendency from 'hedge' finance to largely 'speculative' or even 'Ponzi' (fraudulent) finance which in turn makes the system fragile to any fatal exogenous shock, may end up having a negative impact on economic performance. In order to investigate how has HH credit expansion during the considering period affected GDP, we have looked at both single equation and multiple equation models.

As a first approximation, in the ECM we have been able to capture the effect of HH debt growth and debt service ratio growth (a commonly used measure for the HH burden of debt) on output growth. We have introduced several control variables and non linearities in the model (pulse dummies and variables interactions). In accordance with Minsky's hypothesis, the increase of HHdebt growth affected positively output growth while debt service ratio growth had a negative effect on output.

The VECM has enabled us to study the dynamic relationship between our variables without the need to impose exogeneity assumptions. In contrast with Kim (2016) the empirical translation of Minsky has not focused on whether the suggested equilibrium correlation between HH debt and GDP was negative bur rather on the "causal" relationship between our variables. In an VECM framework, causality is expressed by dynamics. Thus, we have looked at IRF under different specifications.

The conduction of IRFs on Kim (2016) model suggested that, even in the presence of a negative cointegrating relation of HH debt and GDP, the effect of a shock of the former variable implied a long run positive effect on the latter. This finding does not corroborate the intuition of debt driven business cycles. Even though one could argue that there are other factors that may work to check the effects of household debt explosion, we suggest an alternative explanation. In our view, a relevant variable is being omitted. The evolution of the construction sector captured by housing prices may be a relevant channel correlated with household debt. Once this variable is taken into account, we notice that the validity of our models improves. Furthermore, HH debt (positive) shocks seem to negatively affect GDP in the long run. In the short run, the effect of household debt is rather inconclusive. Housing prices, on the other hand, appear to be an important driver of GDP growth in the short run.

Our results do not validate Minsky FHI in a generic way. However, we believe that they illustrate the existing dynamics between output that is demand driven and financial variables. In particular, our findings show that the construction sector accounts for one important channel through which household debt may affect GDP. In the short run, a booming construction sector fuelled by a large demand of dwellings and financed via mortgages may entail a positive short run effect. Furthermore, important confidence and wealth effect may result from housing bubbles. On the other hand, the corrections of an over-dimensioned construction sector (both in the quantity and price dimension) will entail household deleveraging and a negative effect on GDP.

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## Appendix A- Data

- FRED St Louis Federal Reserve Statistics (FRED)
- Bureau of Economic Analysis (BEA)
- Bank of International Settlements (BIS)

| Variables | Source |
|---|---|
| Real GDP | FRED |
| Household Debt | FRED |
| Real Fixed Private Investment | FRED |
| Real Government Expenditure | FRED |
| Household and non-profit org. net worth | FRED |
| Debt Service Ratio as a perc. of disposable income | FRED |
| Chain-type Price Index for PCE | BEA |
| Property price index | BIS |

Figure 2. GDP growth. (1983Q1-2013Q4)

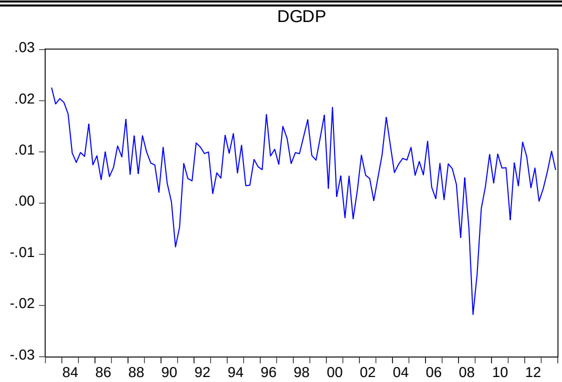
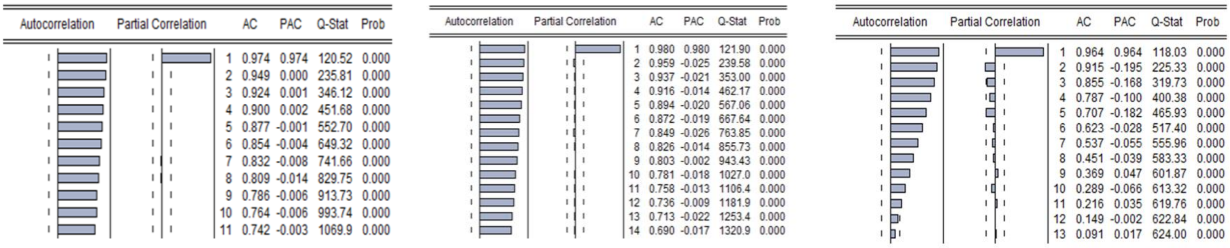


Figure 3. Correlograms (LGDP, LHH debt, DSR respectively). (1983Q1-2013Q4)



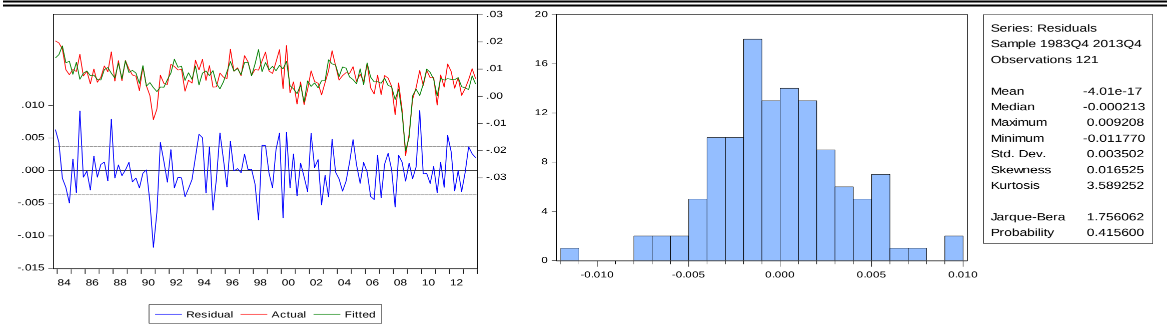
| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | 0.974 | 0.974 | 120.52 | 0.000 |
| | | 2 | 0.949 | 0.000 | 235.81 | 0.000 |
| | | 3 | 0.924 | 0.001 | 346.12 | 0.000 |
| | | 4 | 0.900 | 0.002 | 451.68 | 0.000 |
| | | 5 | 0.877 | -0.001 | 552.70 | 0.000 |
| | | 6 | 0.854 | -0.004 | 649.32 | 0.000 |
| | | 7 | 0.832 | -0.008 | 741.66 | 0.000 |
| | | 8 | 0.809 | -0.014 | 829.75 | 0.000 |
| | | 9 | 0.786 | -0.006 | 913.73 | 0.000 |
| | | 10 | 0.764 | -0.006 | 993.74 | 0.000 |
| | | 11 | 0.742 | -0.003 | 1069.9 | 0.000 |

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | 0.980 | 0.980 | 121.90 | 0.000 |
| | | 2 | 0.959 | -0.025 | 239.58 | 0.000 |
| | | 3 | 0.937 | -0.021 | 353.00 | 0.000 |
| | | 4 | 0.916 | -0.014 | 462.17 | 0.000 |
| | | 5 | 0.894 | -0.020 | 567.06 | 0.000 |
| | | 6 | 0.872 | -0.019 | 667.64 | 0.000 |
| | | 7 | 0.849 | -0.026 | 763.85 | 0.000 |
| | | 8 | 0.826 | -0.014 | 855.73 | 0.000 |
| | | 9 | 0.803 | -0.002 | 943.43 | 0.000 |
| | | 10 | 0.781 | -0.018 | 1027.0 | 0.000 |
| | | 11 | 0.758 | -0.013 | 1106.4 | 0.000 |
| | | 12 | 0.736 | -0.009 | 1181.9 | 0.000 |
| | | 13 | 0.713 | -0.022 | 1253.4 | 0.000 |
| | | 14 | 0.690 | -0.017 | 1320.9 | 0.000 |

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | 0.964 | 0.964 | 118.03 | 0.000 |
| | | 2 | 0.915 | -0.195 | 225.33 | 0.000 |
| | | 3 | 0.855 | -0.168 | 319.73 | 0.000 |
| | | 4 | 0.787 | -0.100 | 400.38 | 0.000 |
| | | 5 | 0.707 | -0.182 | 465.93 | 0.000 |
| | | 6 | 0.623 | -0.028 | 517.40 | 0.000 |
| | | 7 | 0.537 | -0.055 | 555.96 | 0.000 |
| | | 8 | 0.451 | -0.039 | 583.33 | 0.000 |
| | | 9 | 0.369 | 0.047 | 601.87 | 0.000 |
| | | 10 | 0.289 | -0.066 | 613.32 | 0.000 |
| | | 11 | 0.216 | 0.035 | 619.76 | 0.000 |
| | | 12 | 0.149 | -0.002 | 622.84 | 0.000 |
| | | 13 | 0.091 | 0.017 | 624.00 | 0.000 |

## Appendix B. Single Equation

Figure 7. Model 1. Fitted values and Normality test (1983Q1-2013Q4)

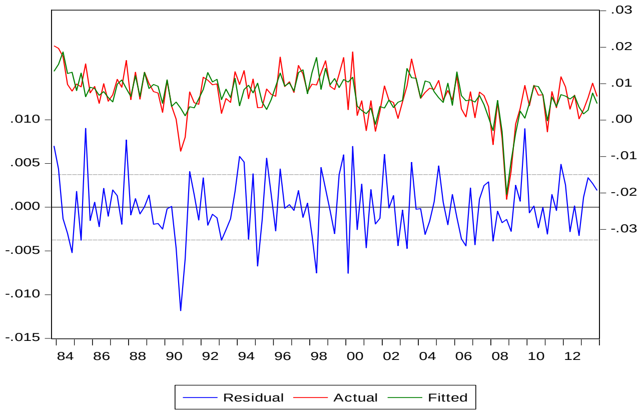



### Model 1. Ramsey test

Ramsey RESET Test
Equation: EQ_BASIC_GOOD_MODEL
Specification: DGDP C DGDP(-1) DGDP(-2) DDEBT DDEBT(-1) DTDSP DTDSP(-1) DG DI DNETWORTH DI*DNETWORTH LDEBT(-1) LGDP(-1)
Omitted Variables: Squares of fitted values

| | Value | df | Probability |
|---|---|---|---|
| t-statistic | 0.680825 | 107 | 0.4975 |
| F-statistic | 0.463523 | (1, 107) | 0.4975 |
| Likelihood ratio | 0.523039 | 1 | 0.4695 |

Figure 8. Model 2. Fitted values and Ramsey test (1983Q1-2013Q4)




Ramsey RESET Test
Equation: EQ_EXTENDED_BETTER
Specification: DGDP C DGDP(-1) DGDP(-2) DDEBT DDEBT(-1) DTDSP DTDSP(-1) DG DG*DUMMY2 DDEBT*DUMMY2 DTDSP*DUMMY2 DNETWORTH DI LDEBT(-1) LGDP(-1)
Omitted Variables: Squares of fitted values

| | Value | df | Probability |
|---|---|---|---|
| t-statistic | 1.611881 | 105 | 0.1100 |
| F-statistic | 2.598162 | (1, 105) | 0.1100 |
| Likelihood ratio | 2.957629 | 1 | 0.0855 |

# Appendix C. VECM

## *Panel 1: Section 5.1 of the paper*

Table 1: Selection criteria for VEC model with HH debt and GDP

Selection-order criteria
Sample: 1982q2 - 2016q2 Number of obs = 137

| lag | LL | LR | df | p | FPE | AIC | HQIC | SBIC |
|---|---|---|---|---|---|---|---|---|
| 0 | 218.798 | | | | .000145 | -3.16493 | -3.14761 | -3.1223 |
| 1 | 936.368 | 1435.1 | 4 | 0.000 | 4.3e-09 | -13.582 | -13.53 | -13.4541 |
| 2 | 992.341 | 111.95 | 4 | 0.000 | 2.0e-09 | -14.3407 | -14.2541 | -14.1276 |
| 3 | 1004.17 | 23.663 | 4 | 0.000 | 1.8e-09 | -14.4551 | -14.3338* | -14.1567* |
| 4 | 1008.46 | 8.5663 | 4 | 0.073 | 1.8e-09* | -14.4592* | -14.3033 | -14.0756 |
| 5 | 1008.79 | .67464 | 4 | 0.954 | 1.9e-09 | -14.4057 | -14.2152 | -13.9368 |
| 6 | 1010.3 | 3.0144 | 4 | 0.555 | 2.0e-09 | -14.3693 | -14.1441 | -13.8152 |
| 7 | 1010.64 | .68271 | 4 | 0.953 | 2.1e-09 | -14.3159 | -14.0561 | -13.6765 |
| 8 | 1015.59 | 9.8945 | 4 | 0.042 | 2.1e-09 | -14.3298 | -14.0353 | -13.6051 |
| 9 | 1018.16 | 5.1407 | 4 | 0.273 | 2.1e-09 | -14.3089 | -13.9798 | -13.499 |
| 10 | 1024.37 | 12.422* | 4 | 0.014 | 2.0e-09 | -14.3412 | -13.9774 | -13.446 |

Endogenous: lgdp ldebt
Exogenous: _cons

Final Prediction Error (FPE), Akaike's information criterion (AIC), Schwarz', Bayesian information criterion (SBIC), and the Hannan and Quinn information criterion (HQIC)

Table 2: Johansen test for HH debt and GDP

Johansen tests for cointegration

Trend: constant — Number of obs = 144

Sample: 1980q3 - 2016q2 — Lags = 3

| maximum rank | parms | LL | eigenvalue | trace statistic | 5% critical value | 1% critical value |
|---|---|---|---|---|---|---|
| 0 | 10 | 1025.4499 | | 20.4580 | 15.41 | 20.04 |
| 1 | 13 | 1032.7506 | 0.09643 | 5.8567*1 | 3.76 | 6.65 |
| 2 | 14 | 1035.679 | 0.03986 | | | |

*1 Indicates rejection of the null of less than one cointegration relationships at 1% significance level

Table 3: VECM Stata output for LGDP and HH Debt

```
Vector error-correction model

Sample:  1980q3 - 2016q2                           No. of obs      =       144
                                                   AIC             =  -14.1632
Log likelihood =  1032.751                         HQIC            = -14.05426
Det(Sigma_ml)  =  2.02e-09                         SBIC            = -13.89509

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
D_lgdp                6     .006282   0.5898   198.4018   0.0000
D_ldebt               6     .007893   0.8554   816.0869   0.0000
----------------------------------------------------------------
```

```
Cointegrating equations

Equation           Parms    chi2     P>chi2
-------------------------------------------
_ce1                 1   3696.544   0.0000
-------------------------------------------

Identification:  beta is exactly identified

                 Johansen normalization restriction imposed
------------------------------------------------------------------------------
        beta |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_ce1         |
        lgdp |          1          .        .       .            .           .
       ldebt |  -.4282275   .0070433   -60.80   0.000    -.4420321   -.4144229
       _cons |  -6.224567          .        .       .            .           .
------------------------------------------------------------------------------
```

```
Adjustment parameters

Equation           Parms    chi2     P>chi2
-------------------------------------------
D_lgdp               1   3.397636   0.0653
D_ldebt              1   6.695684   0.0097
-------------------------------------------

------------------------------------------------------------------------------
       alpha |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_lgdp       |
        _ce1 |
         L1. |  -.0534773   .0290122    -1.84   0.065    -.1103403    .0033856
-------------+----------------------------------------------------------------
D_ldebt      |
        _ce1 |
         L1. |   .0943142   .0364485     2.59   0.010     .0228765     .165752
------------------------------------------------------------------------------
```

Figure 1: Predicted cointegrated equation

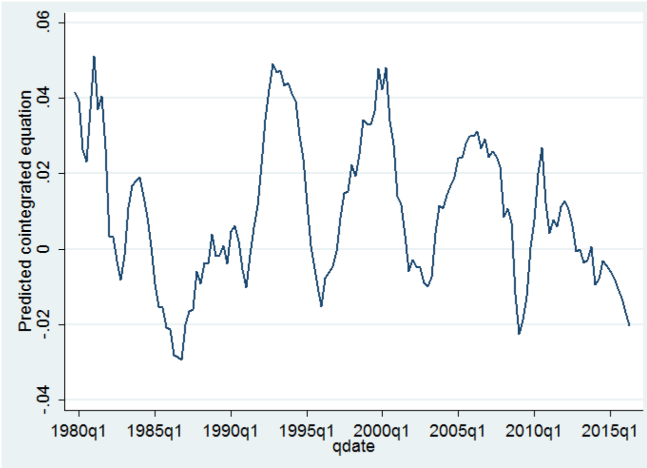



Table 4: Test for serial correlation in the VECM of Section 6.1

Lagrange-multiplier test

| lag | chi2 | df | Prob > chi2 |
|---|---|---|---|
| 1 | 9.9942 | 4 | 0.04052 |
| 2 | 11.7440 | 4 | 0.01936 |
| 3 | 4.0528 | 4 | 0.39890 |
| 4 | 1.1372 | 4 | 0.88832 |

H0: no autocorrelation at lag order

*Panel 2: Section 5.2 of the paper*

Table 1: Selection criteria for VEC model with HH debt , GDP, Net Worth and Consumption

Selection-order criteria

Sample: 1982q2 - 2016q2 Number of obs = 137

| lag | LL | LR | df | p | FPE | AIC | HQIC | SBIC |
|---|---|---|---|---|---|---|---|---|
| 0 | 856.321 | | | | 4.6e-11 | -12.4426 | -12.408 | -12.3574 |
| 1 | 1859.02 | 2005.4 | 16 | 0.000 | 2.6e-17 | -26.8469 | -26.6737 | -26.4207 |
| 2 | 1935.14 | 152.25 | 16 | 0.000 | 1.1e-17 | -27.7247 | -27.4129* | -26.9574* |
| 3 | 1957.01 | 43.738 | 16 | 0.000 | 9.8e-18 | -27.8104 | -27.36 | -26.7021 |
| 4 | 1974.16 | 34.298 | 16 | 0.005 | 9.7e-18* | -27.8271* | -27.2382 | -26.3778 |
| 5 | 1979.15 | 9.9882 | 16 | 0.867 | 1.1e-17 | -27.6665 | -26.9389 | -25.8761 |
| 6 | 1984.04 | 9.7666 | 16 | 0.879 | 1.4e-17 | -27.5042 | -26.638 | -25.3728 |
| 7 | 1991.92 | 15.77 | 16 | 0.469 | 1.5e-17 | -27.3857 | -26.381 | -24.9133 |
| 8 | 2003.44 | 23.028 | 16 | 0.113 | 1.7e-17 | -27.3202 | -26.1769 | -24.5068 |
| 9 | 2017.11 | 27.356* | 16 | 0.038 | 1.8e-17 | -27.2863 | -26.0044 | -24.1319 |
| 10 | 2025.9 | 17.58 | 16 | 0.349 | 2.0e-17 | -27.1811 | -25.7606 | -23.6856 |

Endogenous: lgdp ldebt lc lnw
Exogenous: _cons

Table 2: Johansen test for HH debt, GDP, Net Worth and Consumption (4 lags)

Johansen tests for cointegration

Trend: constant Number of obs = 143

Sample: 1980q4 - 2016q2 Lags = 4

| maximum rank | parms | LL | eigenvalue | trace statistic | 5% critical value |
|---|---|---|---|---|---|
| 0 | 52 | 2011.5216 | . | 55.7635 | 47.21 |
| 1 | 59 | 2028.1886 | 0.20793 | 22.4297* | 29.68 |
| 2 | 64 | 2034.4523 | 0.08388 | 9.9023 | 15.41 |
| 3 | 67 | 2037.6042 | 0.04312 | 3.5985 | 3.76 |
| 4 | 68 | 2039.4034 | 0.02485 | | |

* Indicates rejection of the null of less than one cointegration relationships at 5% significance level

Table 3: VECM Stata output for GDP, HH debt, Net Worth and Consumption

```
Vector error-correction model

Sample:  1980q4 - 2016q2                           No. of obs      =       143
                                                   AIC             =  -27.5411
Log likelihood =  2028.189                         HQIC            = -27.04436
Det(Sigma_ml)  =  5.63e-18                         SBIC            = -26.31867

Cointegrating equations

Equation           Parms    chi2     P>chi2
-------------------------------------------
_ce1                  3   348.9812   0.0000
-------------------------------------------

Identification:  beta is exactly identified
```


```
Cointegrating equations

Equation           Parms    chi2     P>chi2
-------------------------------------------
_ce1                  3   348.9812   0.0000
-------------------------------------------

Identification:  beta is exactly identified
```


```
                 Johansen normalization restriction imposed
------------------------------------------------------------------------------
        beta |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_ce1         |
        lgdp |          1          .        .       .            .           .
       ldebt |   2.443146   .4330967     5.64   0.000     1.594292       3.292
          lc |  -5.147253   1.078822    -4.77   0.000    -7.261706     -3.0328
         lnw |  -.4834723   .3300756    -1.46   0.143    -1.130409     .163464
       _cons |   23.99628          .        .       .            .           .
------------------------------------------------------------------------------

Adjustment parameters

Equation           Parms    chi2     P>chi2
-------------------------------------------
D_lgdp                1   .3564946   0.5505
D_ldebt               1   20.22894   0.0000
D_lc                  1   .4095227   0.5222
D_lnw                 1   3.943777   0.0470
-------------------------------------------
------------------------------------------------------------------------------
       alpha |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_lgdp       |
        _ce1 |
         L1. |   .0032026   .0053638     0.60   0.550    -.0073103    .0137155
-------------+----------------------------------------------------------------
D_ldebt      |
        _ce1 |
         L1. |  -.0317454   .0070582    -4.50   0.000    -.0455793   -.0179116
-------------+----------------------------------------------------------------
D_lc         |
        _ce1 |
         L1. |   .0027669   .0043236     0.64   0.522    -.0057073     .011241
-------------+----------------------------------------------------------------
D_lnw        |
        _ce1 |
         L1. |   .0363842   .0183213     1.99   0.047     .0004751    .0722933
------------------------------------------------------------------------------
```

Figure 1: Eigenvalues of the VECM companion matrix

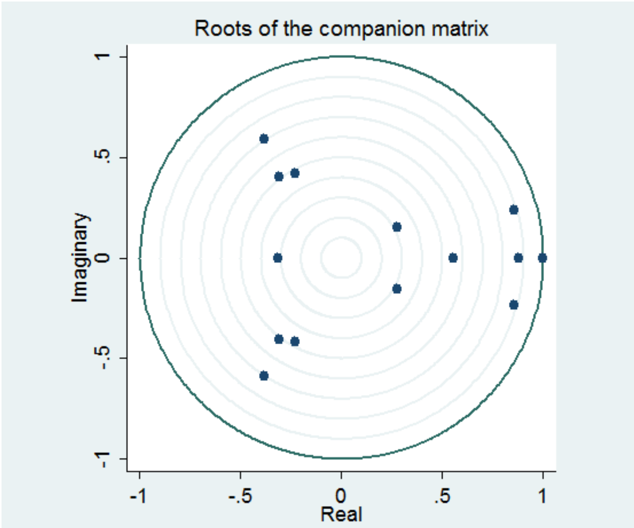
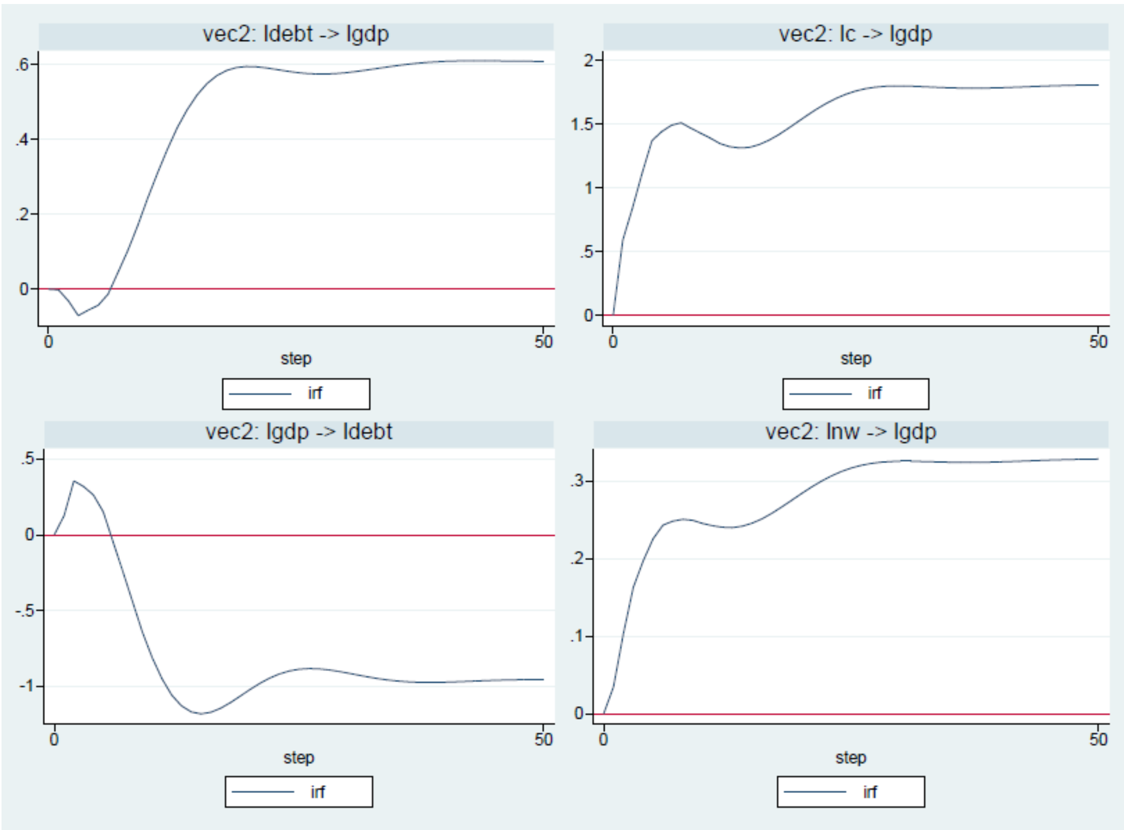



Figure 2: IRF of generalized shocks (X->Y implies the response of Y to a shock in X)



*Panel 3: Section 5.3 of the paper*

Figure 1: Evolution of the nominal price index of dwellings

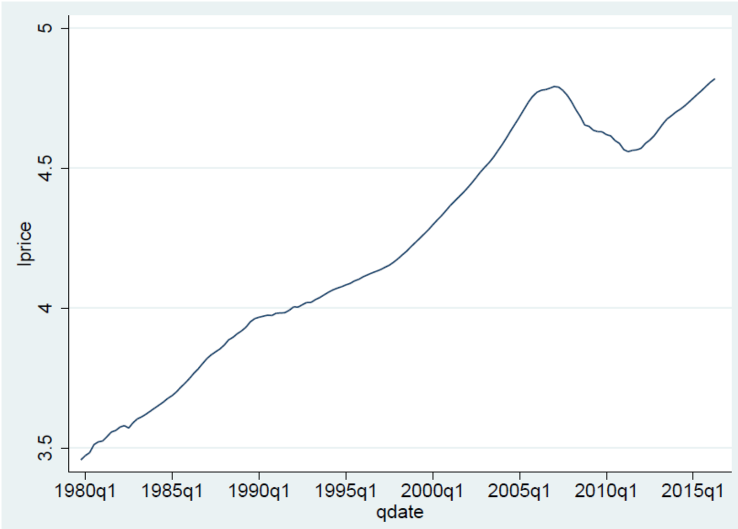



Table 1: Dickey-Fuller GLS test for Unit Root. (H0: the data has a unit root)

```
DF-GLS for lprice                                        Number of obs =   133
Maxlag = 13 chosen by Schwert criterion

               DF-GLS tau      1% Critical       5% Critical      10% Critical
  [lags]     Test Statistic        Value             Value             Value
------------------------------------------------------------------------------
    13           -1.931           -3.524            -2.782            -2.507
    12           -1.828           -3.524            -2.802            -2.526
    11           -2.443           -3.524            -2.821            -2.544
    10           -2.784           -3.524            -2.839            -2.561
    9            -2.803           -3.524            -2.857            -2.578
    8            -2.546           -3.524            -2.875            -2.594
    7            -2.928           -3.524            -2.892            -2.609
    6            -2.643           -3.524            -2.907            -2.624
    5            -2.530           -3.524            -2.923            -2.637
    4            -2.604           -3.524            -2.937            -2.650
    3            -3.215           -3.524            -2.950            -2.663
    2            -3.180           -3.524            -2.962            -2.674
    1            -2.380           -3.524            -2.974            -2.684

Opt Lag (Ng-Perron seq t) = 12 with RMSE  .0045293
Min SC   = -10.57051 at lag  2 with RMSE  .0047939
Min MAIC =  -10.5175 at lag  4 with RMSE  .0047267
```

Table 2: Johansen test for HH debt, GDP, Net Worth, Consumption and prices (3 lags-optimal)

Johansen tests for cointegration

Trend: constant — Number of obs = 144

Sample: 1980q3 - 2016q2 — Lags = 3

| maximum rank | parms | LL | eigenvalue | trace statistic | 5% critical value |
|---|---|---|---|---|---|
| 0 | 55 | 2577.8232 | . | 74.4817 | 68.52 |
| 1 | 64 | 2595.0132 | 0.21239 | 40.1016* | 47.21 |
| 2 | 71 | 2606.2301 | 0.14426 | 17.6678 | 29.68 |
| 3 | 76 | 2609.9388 | 0.05021 | 10.2504 | 15.41 |
| 4 | 79 | 2613.3036 | 0.04566 | 3.5208 | 3.76 |
| 5 | 80 | 2615.064 | 0.02415 | | |

Figure 2: Predicted cointegrated equation

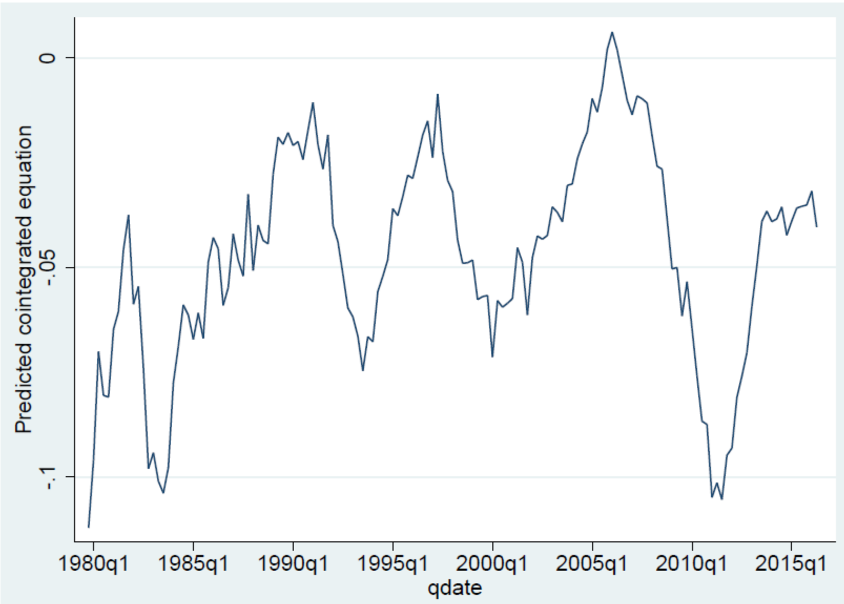


Table 3: Dickey-Fuller test for the residuals of the cointegrating equation

Dickey-Fuller test for unit root — Number of obs = 146

| | Test Statistic | 1% Critical Value | 5% Critical Value | 10% Critical Value |
|---|---|---|---|---|
| | | Interpolated Dickey-Fuller | | |
| Z(t) | -2.953 | -3.495 | -2.887 | -2.577 |

MacKinnon approximate p-value for Z(t) = 0.0395

Figure 3: Eigenvalues of the VECM companion matrix

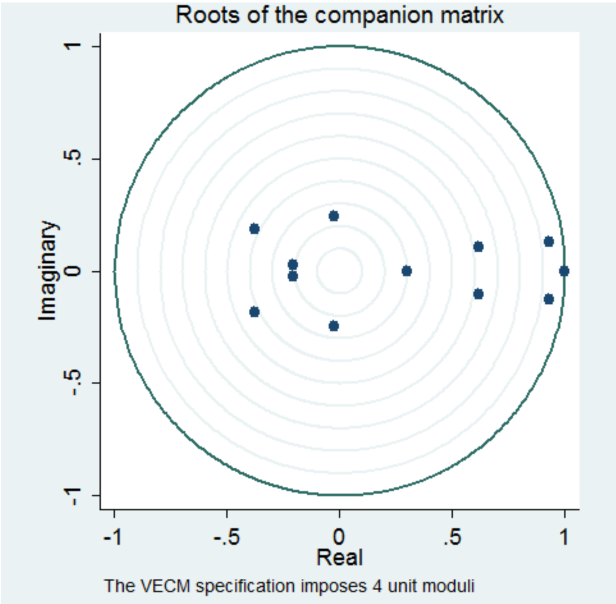


Table 4: VECM

Vector error-correction model

| | | | |
|---|---|---|---|
| Sample: 1980q3 - 2016q2 | | No. of obs | = 144 |
| | | AIC | = -35.15296 |
| Log likelihood = | 2595.013 | HQIC | = -34.61662 |
| Det(Sigma_ml) = | 1.53e-22 | SBIC | = -33.83304 |

Cointegrating equations

| Equation | Parms | chi2 | P>chi2 |
|---|---|---|---|
| _ce1 | 4 | 5168.629 | 0.0000 |

Identification: beta is exactly identified

Johansen normalization restriction imposed

| beta | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| _ce1 | | | | | | |
| lgdp | 1 | . | . | . | . | . |
| lprice | .3326086 | .0721293 | 4.61 | 0.000 | .1912378 | .4739795 |
| ldebt | .3058105 | .1052395 | 2.91 | 0.004 | .0995448 | .5120761 |
| lc | -2.046544 | .2817996 | -7.26 | 0.000 | -2.598861 | -1.494227 |
| lnw | .0495741 | .0818562 | 0.61 | 0.545 | -.1108612 | .2100093 |
| _cons | 4.700522 | . | . | . | . | . |

Adjustment parameters

| Equation | Parms | chi2 | P>chi2 |
|---|---|---|---|
| D_lgdp | 1 | 4.689475 | 0.0303 |
| D_lprice | 1 | 12.47304 | 0.0004 |
| D_ldebt | 1 | 14.98476 | 0.0001 |
| D_lc | 1 | 2.130353 | 0.1444 |
| D_lnw | 1 | 3.089847 | 0.0788 |

| alpha | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| D_lgdp | | | | | | |
| _ce1 | | | | | | |
| L1. | -.0438963 | .0202706 | -2.17 | 0.030 | -.0836259 | -.0041667 |
| D_lprice | | | | | | |
| _ce1 | | | | | | |
| L1. | -.0667545 | .0189014 | -3.53 | 0.000 | -.1038006 | -.0297084 |
| D_ldebt | | | | | | |
| _ce1 | | | | | | |
| L1. | -.1090754 | .0281775 | -3.87 | 0.000 | -.1643022 | -.0538486 |
| D_lc | | | | | | |
| _ce1 | | | | | | |
| L1. | -.025613 | .0175483 | -1.46 | 0.144 | -.0600069 | .008781 |
| D_lnw | | | | | | |
| _ce1 | | | | | | |
| L1. | -.1203228 | .068451 | -1.76 | 0.079 | -.2544843 | .0138386 |

Figure 4: IRF (generalized shocks)