

Tampere University
School of management

Private Debt: Cycles and Growth

Master's thesis

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Abstract

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The level of private debt in the developed world is at historically high levels. This thesis investigates whether the private debt is associated with the economic crises and low growth rates experienced today. The purpose of the thesis is to answer three questions regarding private debt motivated by Steve Keen's work on private debt. First, is the level of private debt connected to lower economic growth. Second, are recessions preceded by growth in debt and followed by deleveraging deeper. Third, is the extension and accelerating expansion of private debt connected to other macroeconomic variables.

The research questions are answered using econometric panel data models including LSDV and VAR models and the Jordà local projections framework. In addition, Reinhart and Rogoff's famous analysis is extended to private debt. Recently available panel data on private debt from the Bank of International Settlements and Jordà-Schularick-Taylor Macrohistory Database are used as the source of data.

The findings of the thesis are consistent with Keen's arguments. High levels of private debt are associated with lower economic growth, arguably even more substantially than government debt. Recessions preceded by growth in debt and followed by deleveraging have been the worst recessions, and the extension and accelerating expansion of private debt can explain changes in GDP, unemployment, and house prices.

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1. Introduction

The purpose of this thesis is to investigate the role of private debt in an economy. The level of private debt relative to the size of the economies is higher than it has been historically in developed nations (Jordà, Schularick and Taylor, 2016). According to some economists such as Steve Keen the role of private debt is often overlooked. Private debt may play a role in economic development both in the long term and cyclically, especially in recessions that involve deleveraging. Private debt can also help explain the formation of asset bubbles, and the related economic crises such as the Great Recession and the Great Depression. In addition, private debt may be useful in identifying possible economic crises and their characteristics in the future.

The following quote by Ben Bernanke, the Chairman of the United States' Federal Reserve, highlights the commonly held view that private debt is at least mostly neutral:

"Fisher's idea was less influential in academic circles, though, because of the counterargument that debt-deflation represented no more than a redistribution from one group (debtors) to another (creditors). Absent implausibly large differences in marginal spending propensities among the groups, it was suggested, pure redistributions should have no significant macroeconomic effects." (Bernanke, 1995, 17)

This thesis explores the different view that debt has macroeconomic effects and may even be the cause of economic crises and the low growth rates encountered in many developed economies. The work of post-Keynesian economist Steve Keen (2017), a proponent of the theory that private debt is not neutral, is presented in support of the view. The work of other authors are also presented in support of the view, particularly supporting the view that private debt is associated with boom-bust cycles such as the Great Recession.

The purpose of this thesis is to investigate three prominent questions inherent to Keen's (2017) argument. First, is high level of private debt associated with lower economic growth. Second, are recessions characterized by credit extension before the recession and a deleveraging during the recession deeper. And finally, does the extension of debt and the acceleration of debt drive other macroeconomic variables in the short run.

To answer the first question, Reinhart and Rogoff's (2010) analysis is repeated for private debt. The analysis is further extended by a segmented LSDV model which is meant to address possible factors that may introduce bias into the analysis. An answer to the second question is provided by a regression model following the popular methodology of

IMF (2012), popularized before by Romer and Romer (1989). Finally, to answer the question regarding dynamics of debt a panel autoregressive model is used to analyze the short run dynamics between debt and other macroeconomic variables, robustness checked by local projections.

2. Keen, Private Debt, and Cycles

In this chapter Steve Keen and Keen's views on private debt are presented. In addition, some supporting evidence for how private debt is associated with financial crises and in particular the Great Recession is presented by Kindleberger (2005), Gjerstad and Smith (2014) and possible other authors.

2.1 Steve Keen and Keen's Model

Keen is an economist of the post-Keynesian tradition. In 2001 Steve Keen published a book called *Debunking Economics*, which questioned the foundations of economic theory, and most importantly for this thesis questioned the view that private debt has no real effects. In 2017 Keen published his second book *Can we avoid another financial crisis?* predicting a financial crisis based on the high levels of debt and credit expansion experienced in the developed world.

Dutch economist Dirk Bezemer (2009) searched for people who predicted the global financial crisis of 2008. According to Bezemer Steve Keen was among 12 individuals who forecast the global financial crisis beforehand, in a provocative article titled *No one saw this coming* (Bezemer, 2009). What makes Steve Keen relevant among the individuals is that Keen has detailed the ideas clearly in a rigorous fashion. Further, according to Keen (2017), private debt was the primary reason for why the global financial crisis happened, and for why growth rates among many economics are low today. The consensus is arguably that the financial crisis was not generally anticipated, for example Bernanke stated the following before the Great Recession:

"Housing markets are cooling a bit. Our expectation is that the decline in activity or the slowing in activity will be moderate, that house prices will probably continue to rise."
Bernanke, February 15 2005, U.S: House representatives hearing, according to New York Times (as cited in 2007).

The framework Keen uses to analyze economics and find out that debt may play a significant role in an economy can be outlined by two core principles. First, Keen believes that there are significant issues with deriving macro level behavior from micro level behavior based on Sonnenschein's (1972) and Gorman's (1953, pg. 63) theorems, adopting similar view in economics as Anderson (1972) famously adopted in natural sciences. Second, Keen does not believe equilibrium models are the best way to model economics, motivated by Lorenz's (1963) model as an example. (Keen, 2011)

Based on the two principles, Keen adopts a dynamic modelling approach to modelling economics. In Keen's approach dynamic relations are defined on macroeconomic relationships. Models where private debt may play an important role in the economy can be created using the approach. The aim of this section is to present Keen's (1995) model, which is based on the principles. (Keen, 2017, Chapter 2)

Keen's (1995) original model, which helped him forecast the housing crisis is influenced by Minsky's instability hypothesis. Minsky was a professor of economics at Washington university, arguably best known for his instability hypothesis. The Minsky instability hypothesis was formulated by Minsky as an explanation for how periods of great instability such as the Great Depression form. The hypothesis is motivated by the debt deflation theory of Great Depression, formulated by Fisher (1933) along with the work of Keynes, arguably mostly *The General Theory of Employment, Interest and Money* (Keynes, 1936).

Originally the hypothesis was verbal and not mathematical. As in Fisher's (1933) model, in the instability hypothesis debt plays a significant part in the development of economic crises. Minsky's work can be accessed in various books and research papers he has authored. The financial instability hypothesis is detailed in Minsky's book *Can it happen again?* (Minsky, 1982) the name referring to the Great Depression, in his book *John Maynard Keynes* (Minsky, 1975a) and finally in the working paper *The financial instability hypothesis* (Minsky, 1975b). Keen (2011) has also given a summary of the hypothesis. A summary of Minsky's boom-bust cycle is given above, based mostly on Keen (2011).

Consider an economy that is in a state of growth, with some debt inherited from the previous market cycles. At this stage, remembering the past, banks and firms are conservative in their projected cash flow estimates and adopt a risk averse position demanding a high premium for risk. However, economic growth increases the profits of the banks and firms as most investment succeed under the conservative behavior. Motivated by profits, the conservativeness and risk aversiveness start to decline among both banks and investors. As a result, the amount of investment and asset prices start growing. Increasing leverage becomes an attractive option since the optimistic sentiment is shared by the all of the market participants, the debt-to-equity ratio of the market participants starts rising. (Keen, 2011)

A state of euphoria starts developing in the markets. Both the lenders and borrowers have a high expectation of the future. Asset prices are further revalued upwards as the

conservativeness declines and risk premiums are found too high. Financial institutions start accepting liability structures that using the past expectations they would not have. Firms adopt a less liquid position as their debt-to-equity ratio rises, making them even more vulnerable to rising interest rates. As a result, the decrease in liquidity starts to increase interest rates. (Keen, 2011)

Central to the hypothesis are three types of financing. The first type consists of hedge financing, where agents finance their borrowing with future cashflows. This type of financing will perform well for as long as income remains steady. The second financing strategy, called the speculative strategy is riskier. In the speculative financing strategy, the agents rely on cash flows to pay back only the interest of their debts, creating a vulnerable position to moves in asset prices. The third type of financing strategy is the riskiest, the Ponzi financing strategy. In the Ponzi financing strategy the borrowers do not have the cash flows to even cover the interest payments. Instead, increasing asset prices are relied upon to pay for the interest. (Keen, 2011)

During the euphoria more and more Ponzi financiers start participating in the market motivated by the increasing asset prices, increasing asset prices, interest rates and the amount of debt even further. The rising interest rates and increasing debt to equity ratios start affecting the viability of investments, while simultaneously speculative Ponzi financing is increasing. As the process continues, the Ponzi financiers will eventually have to sell assets to cover their debt payments. In turn, the entry of new sellers to the markets will eventually stop the increase in asset prices. The Ponzi financiers now have trouble financing their debt, since their strategy was predicated upon increasing asset prices. The banks increase interest rates even further as the Ponzi financiers have trouble paying back their debts. From here the process starts working in reverse. Assets are sold, as prices are no longer expected to rise, and the income generating capacity of the assets is not found sufficient. The euphoria shifts into a panic, and a possible depression is created. (Keen, 2011)

Note that the above summary does not characterize the Minsky's cycle completely. For example, the income distribution and rate of inflation may matter during the bust. Some versions of the hypothesis may also require an initial shock, while for example the Keen's (2011) description does not.

To model the essence of Minsky's boom-bust cycle, Keen starts from the Goodwin's (1967) model as his basis. Goodwin's (1967) model is a simplistic dynamic model of an economy, conforming to Keen's (2011) principles. The model contains two classes; investors and workers. When the model is simulated it creates an endogenous dynamic cycle between unemployment and wage's share of the economy. In essence, the cycle is created by assuming workers demand higher wages if the level of employment is high than when it is low – a Phillip's curve. During high employment higher wages are demanded cutting into the profit of the investors and therefore investment and output, unemployment starts falling, wages fall, therefore investment becomes profitable again, unemployment rises, and the cycle repeats. (Keen, 2011, Chapter 13)

Keen's (1995) model introduces a few extra assumptions to the Goodwin (1967) model. In Keen's model, the investors are more willing to invest during economic booms than slumps. More crucially, Keen introduces a banking sector and debt to the model in addition to the workers and investors. The debt finances the investment of the investors in excess of profit in the model. Thus, during a boom the investors borrow money to finance the investment. (Keen, 2011, Chapter 13)

In Keen's (1995) model, with the introduction of the financial sector, a new dynamic in comparison to Goodwin's (1967) model becomes possible. The investors can now accumulate debt in the long term by borrowing to finance their investments. This dynamic of incurring debt on "euphoric expectations" can drive the system to instability, since the investors are eventually capable of incurring more debt than the system can finance. The model can depending on the initial values generate two different types of boom bust cycles which end up crashing an economy. The exact cycles are not detailed here, but importantly a high level of debt plays a key role in generating the cycles, and the cycles display several key characteristics of the Minsky instability hypothesis.

Keen's model shows that it is possible to create at least somewhat realistic models where debt plays crucial importance. Keen (2017, Chapter 2) notes that even though the model was simplistic and was not intended to capture all the nuances of modern economies, the model still possessed many of the basic features of the Great Recession. For example, the declining cyclical behavior of unemployment and inflation that was observed during the crisis was also present in Keen's (1995) model.

Since the creation of the model Keen has created different dynamic models of varying complexity, some of which are available on his website. To execute the models Keen is running an ongoing effort of developing dynamic modelling software called Minsky, which is available from his website along with the Keen's original model of the Minsky instability hypothesis. The software is meant for economic modelling, and especially modelling economies which include debt and modern banking sectors. The software includes Godley tables as a special feature, which are Keen's take on double entry accounting tables allowing for an easy creation balance sheets. The special feature allows for easy addition of realistic banking sectors, debt and financial flows to the models.

2.2 Role of Credit

A further reason why debt is crucial according to Keen (2011), is based on the role of credit. In general, whenever a bank makes a loan and therefore debt is created, new money is also created. Keen summarizes the crucial concept:

"Whenever a bank makes a loan, it simultaneously creates a matching deposit in the borrower's bank account, thereby creating new money." Keen (2017, 33).

In addition, whenever a new bank loan is made, the loan finances the purchase of some asset, good or a service. The new spending adds to the current aggregate expenditure which equals the turnover of the existing money supply. In essence, according to Keen (2011, Chapter 11), the additional debt adds to the total demand within an economy, even if the borrowed money is used to finance the purchase of existing goods.

Based on the concept Keen (2017, Chapter 3) argues that aggregate demand equals approximately the sum of nominal GDP (e.g. turnover of existing money) summed with the change in private debt (e.g. credit). Therefore, if aggregate demand is related to asset prices and unemployment, the change in change in debt (e.g. acceleration of debt) is related to change in unemployment and asset prices. The ratio of the acceleration of debt relative to nominal GDP has been defined *Credit Impulse* by Biggs, Mayer and Pick (2010). Keen's argument therefore gives three variables to consider.

First, the debt-to-GDP ratio, which together with interest rates roughly determines the cost of the financial sector to a society. At high levels the debt may become a problem as the cost of the financial sector potentially displaces investment and wages. In addition, the financial sector which directs substantial amount of investment in an economy may at

times prefer financing speculative investments such as housing at the expense of entrepreneurial investment, further directing investment to unproductive causes. (Keen, 2011, Chapter 13)

Second, the credit-to-GDP ratio, which reveals how much aggregate demand is generated by new credit extension during a given period. Keen (2011, Chapter 13) notes that credit can be beneficial when it is financing investment, however a danger arises if credit becomes a substantial part of the total demand. This is because a high amount of credit can often be associated with Ponzi style financing. The high growth rate will experience disruption in the future, which can generate a financial crisis. (Keen, 2011, Chapter 13)

Third, the Credit Impulse or acceleration of debt relative to GDP, which according to Keen is the driver of changes in both the GDP and unemployment and is the key driver of cyclicity in an economy. Keen argues that to maintain stable unemployment, the rate of growth of aggregate demand should approximately equal the rate of growth of employment and labor productivity, which according to Keen are relatively stable. Therefore, a stable unemployment is hard to attain if the acceleration of debt has a lot of variance. (Keen, 2011, Chapter 13)

Tables 2.1 and 2.2 show how a slow-down in credit may hypothetically create a recession according to Keen (2011), contrasting a slow-down of debt accumulation from initially high level of debt and faster debt growth (table 2.1), to initially lower level of debt and slower growth of debt (table 2.2). In the tables, the total demand is calculated as credit summed with GDP, as defined by Keen. Keen has presented similar tables in various of his presentations, and the table 13.2 from Keen (2011) demonstrates the same concept.

Table 2.1. The effect of balancing debt to output ratio with high initial amount of debt and faster debt growth.

Initial debt ratio:	125%	Output growth rate: 10%				Debt growth rate: 20%	
Year:	0	1	2	3	4	5	6
Output:	\$1,000	\$1,100	\$1,210	\$1,331	\$1,464	\$1,611	\$1,772
Debt:	\$1,250	\$1,500	\$1,800	\$2,160	\$2,592	\$3,110	\$3,421
Debt to output ratio:	125%	136%	149%	162%	177%	193%	193%
Change in credit:	-	\$250	\$300	\$360	\$432	\$518	\$124
Total demand:	-	\$1,350	\$1,510	\$1,691	\$1,896	\$2,129	\$2,083
Demand growth rate:	-	-	11.90%	12.00%	12%	12.30%	-2.20%

Table 2.2. The effect of balancing the debt with lower initial value of debt and slower growth in comparison to table 1.

Initial Debt Ratio:	50%	Output growth rate: 10%				Debt Growth Rate: 20%	
Year:	0	1	2	3	4	5	6
Output:	\$1,000	\$1,100	\$1,210	\$1,331	\$1,464	\$1,611	\$1,772
Debt:	\$500	\$600	\$720	\$864	\$1,037	\$1,244	\$1,369
Debt to output ratio:	50%	55%	60%	65%	71%	77%	77%
Change in credit:	-	\$100	\$120	\$144	\$173	\$207	\$124
Total demand:	-	\$1,200	\$1,330	\$1,475	\$1,637	\$1,818	\$1,896
Demand growth rate:	-	-	10.80%	10.90%	11%	11.10%	4.30%

Contrasting tables 2.1 and 2.2, when the debt to output ratio levels in year 6, in table 2 where the debt increases rapidly the aggregate demand growth drops more, all the way to negative. The argument is that the reduction in demand causes real effects to the economy, such as the deleveraging process outlined by Minsky.

Keen (2017, Chapter 3) notes that the creation of credit is generally not a huge part of aggregate demand, as can be verified from figure 2.1 which plots credit and the overall debt as percentage of GDP in the USA. However, it is a very volatile part capable of turning negative, and can therefore have a significant impact on demand.

It is both the high level of debt and the fast growth of debt that can create financial crises according to Keen (2017, Chapter 4). This is because the high growth rate of debt ensures that the effect of the stagnation of credit extension will have larger effects on aggregate demand. Further, the already high level of debt makes it difficult for the economy to generate more aggregate demand through credit extension, and in addition creates a possibility of more substantial debt deflation.

The arguments can be illustrated empirically. According to Keen, the most significant recessions in the USA, such as the Great Depression and the Great Recession, have followed from too much debt and too fast credit growth. The relationship between credit, debt and the crises can be verified from figure 2.1. Before each of the significant recessions in the history of United States private debt had grown rapidly to historically high levels before the recession, and the growth started slowing before the recession. (Keen, 2017)

An effect defined as *debt trap* by Keen (2017) is also visible from figure 2.1. During the Great Depression, even as debt was paid back (e.g. credit turned negative), the debt-to-

GDP ratio increased for some time, because of the fall in nominal GDP. The reduction in nominal GDP was arguably connected to the fall in demand, which in turn was associated with the reduction in credit. The *debt trap* makes lowering the level of private debt difficult for an economy.

Figure 2.1 in addition reveals why Keen (2017) was predicting a financial crisis. The consistent run-up in debt relative to GDP all the way from the 50s had to eventually stop, triggering decline in credit followed by a crash. As figure 2.1 shows, this happened during the Great Recession. However, the predicament was not the same in all countries. Countries such as Australia averted the global financial crisis almost completely. Keen attributes Australia's success in averting the crisis to the fact that more debt-taking was enabled throughout the crisis by homeowners' grants and new demand from China. Credit (e.g. change in debt) did not turn negative during the crisis in Australia. Today, Australia has even higher debt-to-GDP ratio than before the crisis, which makes a crisis possible in the future. (Keen, 2017)

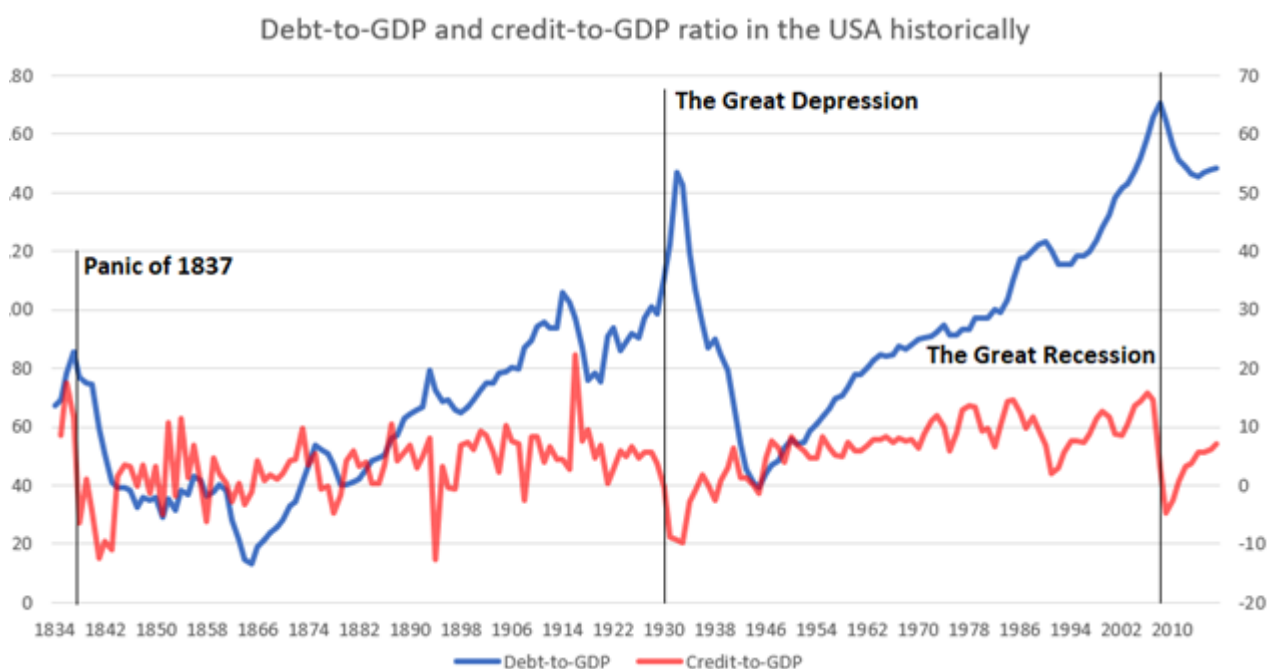


Figure 2.1. Debt-to-GDP and credit-to-GDP ratio historically in the United States (in percentage). Credit is defined as change in debt from the same quarter past year. Source: Census, FRB, Measuring worth. See appendix C for more details.

Based on Keen's (2011) presentation, three relevant factors of the argument are considered empirically. First, the level of private debt should predict lower GDP growth, because of the possibly lower extension of credit during the times of high debt, and the

institutional factors associated with high levels of debt. Second, the extension and acceleration of credit should be associated with a stimulating effect on the economy, especially in the short run. Third, recessions should be able to be predicted using the level of private debt, and it is feasible that recessions with high debt build-up before the recession and a deleveraging during the recession should be deeper, as was the case contrasting USA and Australia during the Great Recession.

2.3 Kindleberger and Asset Bubbles

Empirical research has been conducted regarding Minsky's instability hypothesis and more specifically the relationship between bubbles and credit. *Manias, Panics, and Crashes: A History of Financial Crises* by Kindleberger (2005) covers financial bubbles from the famous tulip mania of the seventeenth century. Kindleberger (2005, Chapter 2) was aware of Minsky's instability hypothesis and used it as a framework to interpret his own work. However, Kindleberger additionally studied international bubbles, noticing that asset bubbles often spread from one country to another in what Kindleberger defined as *contagion*. Kindleberger (2005) defines bubbles as an unsustainable movement in prices for an extended period of 15 to 40 months.

Kindleberger's (2005, Chapter 1) thesis was that speculative manias result from the pro-cyclical changes in credit; increase in credit and therefore asset prices during good economic times could develop into speculative manias, and a contraction of credit and decreasing asset prices during bad times into panics and crashes. By a mania Kindleberger (2005, Chapter 3) refers to a period which is characterized by a lack of rationality close to a "mass hysteria" (p. 38), the stage is the first stage of an asset bubble. The lack of rationality during the mania concerns the very optimistic expectations of the future.

Kindleberger (2005) regarded credit expansion as "fueling the flames" (p. 64) of an asset bubble. Based on observation Kindleberger developed two axioms. His axiom number one was that inflation depends on the growth of money. The second axiom was that asset price bubbles depend on the growth of credit. Kindleberger observed that all speculative manias expand based on the extension of credit. However, not all expansion of credit result in manias. It is noteworthy that credit as defined by Kindleberger did not only include credit extended by the banks. Historically gold discoveries, clearing house certificates, bills of

exchange, call money and different type of substitutes for money all were capable of expanding asset bubbles. (Kindleberger, 2005, Chapter 4)

Kindleberger (2005, Chapter 5) proposed that the standard model for sequence of events that lead to financial crises is that first some shock propels an economic expansion. The expansion then turns into a boom, and the euphoric stage of the cycle with over optimistic expectations develops. However, at some point a pause and an eventual fall in the asset prices likely creates distress and a crash or a panic may follow. Based on his study of the many different bubbles, the cycle was observably biological in its regularity according to Kindleberger (2005, Chapter 5).

During the stage of euphoria Kindleberger (1978, Chapter 2) noted a reversal between the objective and the process in the lenders; the lenders can be so enthusiastic that they do not think how the borrowers would make the interest payments without additional loans. The speculation according to Kindleberger (2005, Chapter 2) often developed in two stages, in the first stage market participants react to the shock in economic expansion in a manner that could be described as rational, while in the second stage optimistic expectations of further capital gains play dominant role in the valuation. During the second stage market insiders may also participate in the process, attempting to talk up asset prices, and sell the assets to market outsiders near the peak of the bubble. Kindleberger (1978, Chapter 7) documents that various kinds of actual fraud is also often associated with the euphoric stage of the bubble, for example a well-known example is the Enron scandal and other scandals during the dotcom bubble in the 2000s.

Kindleberger suggests association between rising prices and national income during the stage of euphoria for two reasons. The first reason for the association is the wealth effect. Households that feel richer because of the higher asset prices will spend more, increasing national income. The second connection is between the stock market and investment spending. The increase in stock prices enables firms to finance more capital at a lower cost, and therefore finance new investment projects that would have not been profitable before. The important association between prices and income is part of the reason for what develops the self-reinforcing cycle of euphoria. (Kindleberger, 2005, Chapter 6)

As Minsky's hypothesis predicts, during the euphoria a Ponzi mindset develops in the asset markets. Kindleberger quotes from Chicago Tribune editorial:

“In the ruin of all collapsed booms is to be found the work of men who bought property at prices they knew perfectly well were fictitious, but who were willing to pay such prices simply because they knew that some still greater fool could be depended on to take the property off their hands and leave them with a profit.” According to Kindleberger (as cited in 2005, 117).

Between the euphoria and a possible onset of a crisis is a period Kindleberger (2005, Chapter 5) defines as *financial distress*. Financial distress refers to a hazardous situation, where important firms and banks may be on the verge of bankruptcy. Kindleberger (2005) outlines many possible reasons for the distress, however the primary characteristic of the distress can be summarized as the market participants losing confidence in the markets, caused by factors such as rising interest rates, capital outflows, bankruptcies or stagnation in the expected increase of asset prices. During the phase bank officials may start realizing how extended credit has become, and how high the expectations have built. A crash may follow the period of financial distress immediately, even years later, or the distress may subdue.

Kindleberger (2005, Chapter 5) discusses what finally triggers the onset of the crisis. While Kindleberger (2005) attributes the initial cause of a crisis to the expansion of credit and speculation, the immediate cause may be any incident that further undermines confidence, triggering sales of assets. Examples include a relevant bankruptcy, revelation of fraud, relevant new information, refusal of credit to a borrower, an accident or some other change of view that leads a market participant to sell large positions.

Finally, as a result of a relevant event, a crash or a panic may develop. By a crash Kindleberger (2005, Chapter 6) refers to substantial fall in asset prices or a failure of an important bank or firm. A panic on the other hand can be characterized as fright causing a rush to safety, for example to government bonds. Financial crises may have both characteristics or only one.

As the crisis develops Kindleberger (2005) notes that a system of positive feedback starts working in a reverse order. Reduction in asset prices results in reduction of the value of the collateral that banks hold. As result, banks are more reluctant to extend more loans. Firms start selling inventories as the prices are declining, further pushing down prices. Household start selling investment securities as the increase in prices is no longer expected, which results in even further decline in asset prices. More bankruptcies take

place as asset prices fall and demand declines. A severe crisis such as the Great Depression may occur as the cycle continues and as more and more credit removed from the system. (Kindleberger, 2005, Chapter 5)

2.4 Private Debt and the Great Recession

Neo-classical experimental economists Steven D. Gjerstad and the Nobel laureate Vernon L. Smith have also researched bubbles and authored a book *Rethinking Housing Bubbles: The Role of Household and Bank Balance Sheets in Modelling Economic Cycles* on housing bubbles. The inspection includes the housing bubble associated with the Great Recession. Gjerstad and Smith (2014) identify several key factors in the formulation of housing bubbles. The authors examine the course of events, fallout and causes of the Great Recession. Gjerstad and Smith (2014, Chapter 2) argue that money and credit are major contributor to the formation of asset bubbles, as they generate a new inflow of cash which adds to the growth of a bubble. Debt has even further consequences from the balance sheet view. (Gjerstad and Smith, 2014)

Gjerstad and Smith (2014) describe the Great Recession as a balance sheet recession. The argument is that the crisis is caused in large part for the reason that some market participants in the economy suffer from highly levered and weak balance sheets, even having negative equity. The weak balance sheets for consumers are caused by two factors; large amount of debt on the liability side of the balance sheets, and declining house prices on the asset side. Banks also suffer from the weak balance sheets as the value of the mortgages they have extended declines.

The damaged balance sheets make banks less likely to lend as they want to act cautiously to rebuild the lost equity. Consumers on the other hand cut back and pay down debt to rebuild their equity. Households have been shown to cut back more when indebted in response to a shock to household assets (Mian and Sufi, 2014). Gjerstad and Smith (2014, Chapter 2) note that at the end of 2012, a few years after the recession, 21.5 percent of people still had negative equity.

According to Gjerstad and Smith (2014), the housing bubble of the Great Recession started its formation in the year 1997. As was noted by Kindleberger (1978, Chapter 2), bubbles often expand in two stages. Gjerstad and Smith (2014) have a similar view of the housing bubble. The first stage according to the authors were the years 1997-2001. During

the first stage real house prices reached their previous peak of the year 1989. The authors argue that particularly the extensive tax cuts to housing and public housing policy was the reason for the increase in house prices during the first stage. The policies encouraged especially the low-middle-income (LMI) families to borrow. Banks started extending more loans to the LMI households, even if their ability to pay was unchanged (Mian and Sufi, 2014). (Gjerstad and Smith, 2014, Chapter 3)

The second stage of the housing bubble took place from 2001 to early 2006. During the second stage, a serious inflow of new credit flooded the housing market, increasing housing prices. The net flow of mortgages increased from less than 300 billion in 1999 to over a trillion in 2006. As the mortgage credit grew, loans were extended to less credit-worthy borrowers, as the lending standards quickly deteriorated. In addition to banks extending mortgage credit, the market also attracted a lot of foreign capital, increasing house prices even further. (Gjerstad and Smith, 2014, Chapter 3)

Gjerstad and Smith (2014, Chapter 6) also outline few reasons for the high credit growth during the second stage of the bubble. The expansive monetary policy from the federal reserve provided some more fuel to the bubble starting from 2001 according to the authors. However, perhaps more important were the new financial products that created a sense of security. The new financial products included primarily the mortgage backed securities (MBS) and credit default swaps (CDS). MBSs were pooled and trampled mortgage obligations of varying quality (Mian and Sufi, 2014).

The CDSs were used to insure the MBSs for losses. However, the CDSs were unregulated and were not subjected to actuarial scrutiny, the issuer did not need to set any reserves or collateralize the securities to prepare for possible losses. This made selling CDSs very lucrative from investor's perspective, guaranteeing a profit for as long as the housing market was not troubled. The market was flooded by CDSs by companies such as AIG, creating a false sense of safety. In 2008 when house prices had fallen for some time, the tail risk that AIG had taken realized bankrupting the company. (Gjerstad and Smith, 2014)

The surge of credit into the market ended in 2005, when it became apparent that substantial amount of credit was extended to borrowers that may not be able to pay. The leverage in the market had also become extreme, National Association of Realtors noted that 45 percent of first-time home owners made no down payment, the lenders were therefore very vulnerable to possible decline in housing prices. Particularly the lower-

income borrowers had been drawn into unsustainable positions by arrangements such as low teaser rates, ARM loans, and negative-amortization loans. Once the housing market started stagnating at the end of the year 2006, re-financing mortgages based on higher house prices became impossible. Delinquencies started increasing as house prices stagnated, especially in the states where house prices had increased the most. (Gjerstad and Smith, 2014, Chapter 3)

During the Great Recession, as house prices fell banks started suffering from impairment in the flow of mortgage payments since borrowers would no longer pay for their mortgages, losses on defaults on the mortgages perpetuated by the low down-payments were also a problem for the banks. Borrowers and home owners also lost their equity rapidly, creating the balance sheet recession and high unemployment primarily because of the loss in aggregate demand. The damaged balance sheets persisted long into the future. (Gjerstad and Smith, 2014, Chapter 3)

The fundamental reason for the housing bubble and the Great Recession according to Gjerstad and Smith (2014, Chapter 6), was the “bubble mentality” (p. 146). The reasoning is very similar to the work of Kindleberger (2005) presented earlier, market participants got caught up in a self-reinforcing loop of high expectations relating to the asset prices, in this case house prices. First a substantial stimulus to mortgage finance was experienced justified by the tax cuts and other public policies. As a result, house prices started to rise as a response to the inflow of credit into the market. The home price appreciation justified more lending, and the cycle could persist for as long as the lenders believed their investments were secure and new buyers could be attracted into the market by the future capital gains.

Overall, Gjerstad and Smith (2014) show that the Great Recession can be interpreted as a case of a boom-bust cycle leading to a financial crisis as outlined by Kindleberger (2005), and modelled by Keen (1995). Kindleberger passed away before the bubble collapsed and unfortunately could not comment on it. Combined with Keen’s (2017) argument that credit extension has a stimulus effect through its money creation capacity, the prospect of banks and borrowers reducing debt on their balance sheets may prolong the recovery as aggregate demand is removed, offering another explanation for why the damaged balance sheets create a slow recovery. The different authors also reveal the crucial importance of private debt in the creation of the crises.

Mian and Sufi (2014) have argued that debt is subsidized by public policy, which has incentivized the extension of credit too greatly. Keen (2017) has also argued that the private debt levels have become too high especially in the developed world. What makes private debt difficult to deal with is that, based on Gjerstad and Smith (2014), Kindleberger (2005) and Keen (2017), when the debt is initially extended, the transaction appears only beneficial. The investors are benefitting from the potentially profitable asset purchases and the banks have more income generating assets. Further, the asset prices may increase pushing the economy into a bull market. The period where debt increases may be easy to classify as an economically robust time (for example, the twenty-year span ending to the Great Recession is often referred to as the “Great Moderation” (Bernanke, 2004)). However, in the longer run as the Great Recession shows, excessive private debt can be consequential.

3. Previous Studies on Debt

While government debt has generally been of more interest as a focus of research, there are econometric studies investigating the effects of private debt. The studies often focus on the housing crisis of 2008. International organizations such as IMF, OECD and BIS have studied private debt in various studies and reports. A handful of independent researchers have also published journal articles regarding various questions relating to private debt.

The three different factors regarding Keen's argument are considered; the relationship between the level of debt and GDP growth, the dynamics between private debt and the macroeconomy and finally the relationship between recessions and private debt.

3.1 Reinhart and Rogoff, a Relevant Study on Public Debt

Carmen Reinhart and Kenneth Rogoff's names are often present in the literature surrounding debt. They are perhaps most known for their ideas on formation of financial crises which are detailed in the book *This Time Is Different: Eight Centuries of Financial Folly*. The authors have also published a simple, but famous study on the effects of government and external debt called *Growth in a Time of Debt* (Reinhart and Rogoff (2010)), which shows that government debt is negatively associated with growth.

The primary dataset the Reinhart and Rogoff used included 20 developed economies in an unbalanced panel from the year 1790 to 2009. The analysis method was a simple comparison of means between four different categories of debt ratios. The four categories of the level of debt were created based on the level of government debt-to-GDP ratio. The thresholds between categories were set every 30 percentage points, with debt-to-GDP levels below 30 percent reported as low, 30 to 60 percent as medium, 60 to 90 percent as high and finally 90 percent and over as very high. The authors reported the average and median real GDP growth in each category for each country. In addition, all the observations were pooled and the analysis was repeated with the pooled observation, further reporting the average inflation for each category.

Reinhart and Rogoff's (2010) result for the pooled analysis was that in the highest debt-to-GDP category the average growth rate was very slightly negative, while for the category where the level of debt was below 30 percent relative to GDP the growth was on average almost four percent. The authors did not check for statistical significance, although the finding is almost certainly statistically significant.

Later an excel spreadsheet error was found in the study, revealing that the GDP growth in the very high debt category was not negative (Herndon, Ash and Pollin, 2014). However, the real GDP growth in the very high debt category was still substantially lower at 2.4 percent than the growth in the low debt group, where growth was almost four percent. The results Reinhart and Rogoff (2010) presented for each of the individual countries were similar, although there were a few exceptions which included Australia, Belgium, Canada and Spain, in these countries the very high debt category had a higher growth rate than the lowest debt category. Further, Austria, Denmark, Germany, Norway and Portugal had no observations in the highest debt category.

Reinhart and Rogoff (2010) also included a similar figure to figure 2.1 in their publication, showing how private debt has developed in the USA. The authors may have repeated their analysis for private debt had the appropriate historical data existed. Today the data exists, and the analysis on private debt can be expanded to private debt.

In addition to the excel spreadsheet error, Reinhart and Rogoff's (2010) methodology could be criticized for numerous econometric grounds, taking some of these additional considerations into account when examining the relationship between private debt and real GDP is one object of this thesis.

3.2 On Dynamics of Private Debt

The dynamics of private debt have been previously investigated by at least Mian, Sufi and Verner (2017). Mian and Sufi from the University of Princeton and Chicago are the authors of a book *House of Debt: How They (and You) Caused the Great Recession, and How We Can Prevent It from Happening Again* published in 2014. The book could be said to be a less formal exposition of the research they have conducted on the importance of private debt and the mechanics of the financial crisis of 2008, at least up until the year 2014. Mian and Sufi's (2014) core argument is in some respects similar to that of Keen's (2017) and Gjerstad and Smith's (2014), the authors believe that private debt plays a role through the

aggregate demand channel, also emphasizing the damaged balance sheet aspect, which according to them may caused households to spend less and therefore create a worse recession.

Mian et al. (2017) analyzed the relationship between dynamics of business debt, household debt and GDP growth using a panel vector autoregressive model and ordinary regression methods. The analysis of Mian et al. (2017) is presented in some detail for comparative purposes.

Mian et al. (2017) start by building a large unbalanced panel dataset with variables including household debt and firm debt from the BIS dataset and various other macro variables from other sources. The debt data that is used includes only the debt of the non-financial sector. The dataset the authors built appears to be made publicly available for future use.

Mian et al. (2017) document a full dynamic relation between the household debt-to-GDP ratio, firm debt-to-GDP ratio and real GDP growth. According to Mian et al. (2017), the relation is most easily visible from a recursive VAR specification. To identify the VAR specification, the authors use Cholesky decomposition with the ordering; real GDP growth (in log), firm debt-to-GDP ratio and household debt-to-GDP ratio. The Cholesky ordering lists the variables in order of exogeneity, e.g. real GDP growth is the most exogenous. The meaning of the ordering is that the variables first in the order affect the variables later in the order contemporaneously, while otherwise the variables affect each other only through a lag.

Mian et al. (2017) use the orthogonalized impulse responses obtained from the VAR specification to document the dynamic relation. The impulse responses the authors present capture the contemporaneous and delayed effects on one variable as a response to a shock in a other variable or itself. The authors show three impulse responses, most importantly the response of real GDP growth to a positive shock to household debt-to-GDP ratio and to firm debt-to-GDP ratio.

The focus on Mian et al.'s (2017) article is studying the medium-term effect of debt four to six years after the shock. One motivation for not studying the longer run effects is that the statistical properties of prediction many years to the future may not be ideal. Further, the research question of the authors is mostly related to the medium run dynamics. However, the long run effects of debt more than six years into the future are still reported.

Mian et al. (2017) reveals that a positive shock to household debt-to-GDP ratio initially (one year after the shock) increases real GDP. The GDP increases for one more year, but then fades shortly, five years after the shock real GDP declines to the initial level. Six to 10 years after the shock GDP has declined to a level lower than the initial starting point. A positive shock to firm debt-to-GDP ratio initially has an inverted effect to household debt, leading to a negative effect on GDP one year after the shock. However, the effect declines quickly and reverts itself by year five. Thus, Mian et al. (2017) conclude that household debt and firm debt has had a distinct effect on GDP growth.

Mian et al. (2017) also use local projection to robustness check the analysis, which the authors note are well suited for the task. Local projections are an alternative to VAR models for calculating impulse responses, originated by Jordà (2005). Jordà (2005) asserts that local projections offer numerous advantages such as being more robust to misspecification, being simpler to estimate than VARs using standard regression techniques, providing straight forward statistical inference and being able to accommodate non-linearities. The estimation of local projections is presented in more detail in section 4.4.3.

Mian et al. (2017) use two different specifications for the robustness checking by the local projection method, one including a trend and one omitting the Great Recession, presumably since there is a reason to believe that during the Great Depression the dynamics were emphasized. Omitting the Great Recession makes the long run negative effect of household debt disappear, however other specifications do not alter the finding. The authors also estimate the local projections in first differences, but this does not alter the finding.

3.2 Recessions, Crises and Private Debt

The relationship between private debt and recessions has quite recently been analyzed, especially motivated by the Great Recession and the availability of the data. The relationship between crises, private debt and excessive credit expansion has generally been found to be strong, for example by the research conducted by Jordà, Schularick and Taylor and IMF. The conclusions support Keen's (2017) argument that excess credit build up is associated with recessions.

Jordà, Schularick and Taylor (2013) published an article detailing the relationship between credit expansion and recessions using the local projections framework. To quote the article as Mian and Sufi (2014) have, the conclusions of the analysis were:

“We document, to our knowledge for the first time, that throughout a century or more of modern economic history in advanced countries a close relationship has existed between the build-up of credit during an expansion and the severity of the subsequent recession.”
Jordà et al. (2013).

Since the conclusion Jordà et al. (2016) also found that it is possible to use mortgage debt and business debt to predict recessions by using methods such as logistic regression. By this time the development of the Jordà-Schularick-Taylor Macroeconomic Database which includes historical private debt data of various countries from the year 1870 onwards was well on its way, which allowed the authors to analyze the effects of private debt historically even before the World War II period and contrast it to today.

Jordà et al. (2016) documented that since the World War II households have been leveraging up on mortgage debt. Mortgage debt has risen by a factor of approximately eight relative to GDP, while other debt has only risen by a factor of approximately three. The increase in mortgage debt has been the primary reason for the increasing debt-to-GDP ratio (see figure 4.1). According to the authors, the debt has also increased relative to the value of the stock of houses, even though house ownership has increased.

The rise in mortgage debt is particularly relevant when considering the other conclusions of the study (Jordà et al. 2016). One finding of their analysis is that the rise in mortgage debt since the World War II period has had economic consequences, causing instability in the financial system in the form of mortgage lending booms. Further, the following housing busts have generally left economies with deeper recessions and lower growth rates. The effect of other debt such as firm debt is more modest in comparison.

Similar conclusions to Jordà et al. (2016) have been reached before by IMF (2012), although their data did not span centuries. IMF (2012) studied whether household debt deepens recessions and weakens recoveries. The procedures IMF used to study the effects of household debt are briefly detailed for the purpose of using them for further analysis and demonstrating additional findings.

IMF (2012) analyzed the role between housing busts, recessions and household debt using two different panel models. The first analysis was a simple analysis of whether household debt-to-income ratio can explain the gap in consumption loss created by the Great Recession. The debt data used from the analysis was primarily from OECD and Eurostat.

For the first analysis IMF's (2012) finding was that the gap in consumption was larger in countries that experienced faster debt growth in the four years prior to the Great Recession than in the countries where the growth in debt was more modest. For each additional 10 percentage point rise in household debt-to-income ratio prior to the crisis, the consumption loss was 2.6 percentage points larger, a statistically significant result. The result was also economically substantial, in some countries the debt-to-income ratios had increased up to 80 percent.

In the second analysis IMF (2012) also analyzed if the hypothesis that credit expansion before housing busts and recessions cause deeper recessions in general. The report followed methodology by Cerra and Saxena (2008), popularized before by Romer and Romer (1989), analyzing 25 economies using OECD data from the 1980s. Similar methodology is presented in more detail in section 4.3.1. In the methodology the busts and recessions across all countries were separated into two categories; those having a high debt build-up before the bust, and those having a low debt build up before the bust.

The results of the IMF (2012) report reveals that for both recessions and housing busts, the busts with high housing debt build-up before the recession are deeper. Five years after the housing bust, the group with high debt build-up experienced approximately four percentage point lower GDP compared to the other group.

4. Analysis of Private Debt

In this section the three research questions are analyzed using econometric methods based on the studies presented in the previous section. First, the data used for the analyses is presented. Second, the Reinhart and Rogoff's study is recreated for private debt, also comparing the results to public debt. Third, debt and recessions are analyzed by similar methods to IMF (2012), taking Keen's argument that higher debt build up after the busts should result in less severe busts. Finally, a panel VAR model is fit on the data on debt, following Mian et al. (2017), on specifications motivated by Keen (2017, Chapter 2).

4.1 Data

A description of the data used for each of the analyses presented in the thesis is available in appendix D. The analyses use two different datasets. The first dataset is called from Jordà-Schularick-Taylor Macrohistory Database. The creation of the dataset has been a significant effort and the dataset has gone through revisions in the past. The dataset includes 17 advanced economies from the year 1870 to the year 2016 in the most recent iteration (as of May of 2019).

The dataset has been compiled from many different sources by many different people. A documentation file citing the sources for each variable, country and year is available (Jordà, Schularick and Taylor, 2017). The most important variables for the analysis on the effects of debt is of course the data on loans, which is split into four categories: total loans, household loans, mortgage loans, and business loans.

All of the categories only include debt incurred by the non-financial sector. It is important to note that the data on total loans is a stock variable of the total outstanding loans, and not a flow of net total lending that occurred during a year. According to Keen, not appreciating the distinction has lead to errors before. The following quote by the originators of the datasets makes the sentiment very clear.

“Total lending or bank loans is defined as the end-of-year amount of outstanding domestic currency lending by domestic banks to domestic households and non-financial corporations (excluding lending within the financial system). Banks are defined broadly as monetary financial institutions and include savings banks, postal banks, credit unions, mortgage associations, and building societies whenever the data are available. We excluded brokerage houses, finance companies, insurance firms, and other financial institutions.” Jordà et al. (2013).

The dataset contains a few breaks, mostly centered around the World War II period. The dataset is almost certainly the most comprehensive dataset on private debt available today in terms of the time dimension, making it fit for analyses requiring historical data.

The second dataset uses data from the Bank for International Settlements (BIS), Organisation for Economic Co-operation and Development (OECD) and from the Maddison database (Bolt, 2018).

BIS publishes various statistics which are helpful for analyzing the formation of asset bubbles. The data they report most importantly includes data on private sector debt and house prices. BIS credit statistics report total debt for households, corporations and the non-financial private sector. The debt data is divided into total credit and bank credit. This thesis uses the total credit figure for all the analyses. Total credit referred to by BIS is defined as the stock of debt, not a change in debt as defined by Keen.

Total credit is a broad measure, including various different forms of private debt. The data is intended to capture total debt of households and firms in the economy, including the debt financed by foreign and domestic banks and non-bank institutions (Mian et al. 2017). The total debt reported by BIS is thus higher than reported by Jordà-Schularick-Taylor database. In addition, the series are presented in quarterly format, unlike the Jordà-Schularick-Taylor database. As in Mian et al. (2017) the data is turned into yearly format for the purpose of the analysis. The BIS data series is unbalanced, debt data is available for some countries starting from the 50s, while for others the availability may start much later. The real house price index data for the analyses is also taken from BIS, the data set that is used is their selected house price series. Unfortunately, the data does not cover as many years as the debt data.

Quarterly data for unemployment is taken from the OECD. The OECD data is also imbalanced, observations for some countries are available as far back as the 1940s, while for other countries the data is only available at a much later date. For unemployment statistics, the harmonized series is used to make the statistics more consistent between different countries. Finally, the Maddison project database is used for the historical GDP data. Maddison database has compiled information on GDP and income levels of 169 countries over the very long run. Specifically, the 2018 version of the dataset is used.

In addition to the BIS dataset and Jordà -Schularick-Taylor database IMF, OECD and Eurostat in Europe also publishes data on private debt. The datasets will likely be useful in future analyses.

4.2 Economic Growth and the Level of Private Debt

This chapter shows that high levels of private debt has been negatively associated with real GDP growth for over a century. The investigation is separated into two parts, the first part recreates the original Reinhart and Rogoff's (2010) study for private debt. The second part uses a segmented LSDV model to address possible econometric criticisms targeted towards the methodology. The primary interest is in how private debt affects growth at moderate and high levels, which are experienced in most developed nations today.

The analysis also contrasts private debt to public debt, for the reason that public debt has arguably been relevant in societal discussion, while the role of private debt is not as often discussed. This is relevant today since the level of private debt is higher than it has been historically and in addition higher than the public debt, as shown in figure 4.1.

Data from Jordà-Schularick-Taylor Macrohistory Database is used for both of the analyses. Regular (not PPP adjusted) real GDP series for the analysis is constructed by multiplying the per capita series by the population. The debt-to-GDP ratio series is created by dividing the total loans series by the nominal GDP series included in the database.

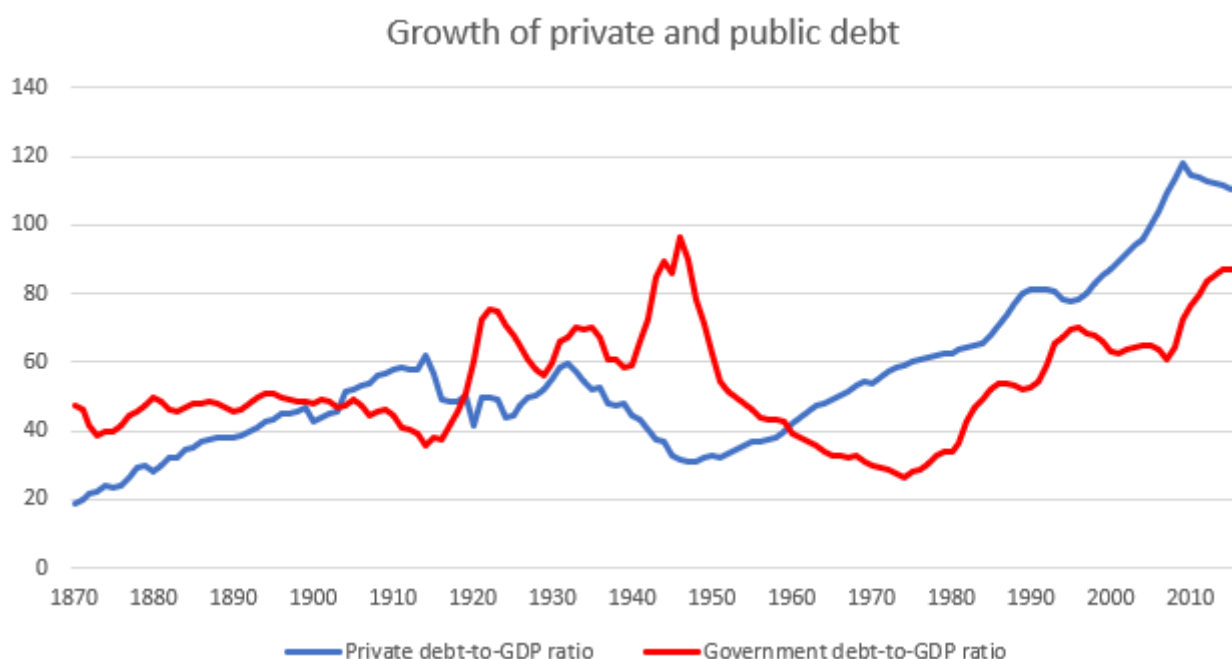


Figure 4.1. Average private and public debt-to-GDP ratio in the Jordà-Schularick-Taylor Macrohistory Database since 1870. Source: Jordà-Schularick-Taylor Macrohistory Database.

4.2.1 Recreation of Reinhart and Rogoff's Study for Private Debt

The goal of the following analysis is to reproduce Reinhart and Rogoff's (2010) analysis treating private debt as the dependent variable instead of public debt. Figure 4.2 is constructed as in Reinhart and Rogoff (2010), by pooling all the observations in the dataset and creating four categories of different real GDP growth levels based on debt-to-GDP ratio. The same results for individual countries are reported in table 4.1. Additionally, for comparison purposes the pooled effect of the original Reinhart and Rogoff (2010) study is recreated for government debt and is available in appendix A.

A legitimate question is whether the thresholds should be selected differently for private debt, since the quantity of private debt relative to GDP has been different in general, as seen from figure 4.1. However, statistically the thresholds work quite well, spreading the observations between categories more evenly than in Reinhart and Rogoff's (2010) original analysis. The counts in each category are presented in table 4.1. Therefore, the original thresholds of below 30 (low) percent, 30 to 60 percent (moderate), 60 to 90 percent (high) and 90 percent and above (very high) are used.

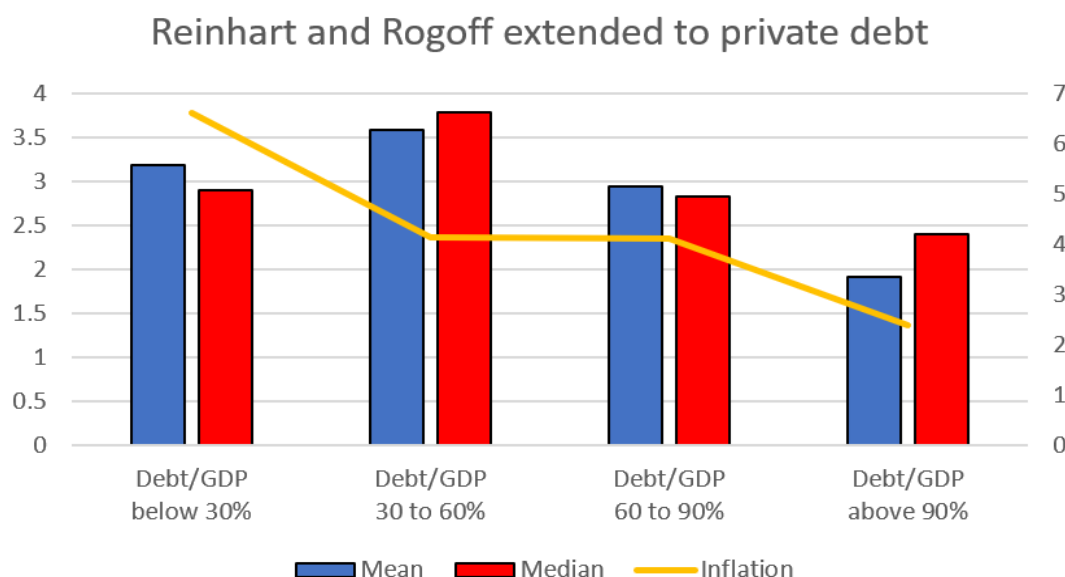


Figure 4.2. Recreation of Reinhart and Rogoff's (2010) analysis for private debt. GDP growth rate (left), inflation (right) in percentages. Inflation is measured as the average inflation. Source: Jordà-Schularick-Taylor database.

The result in figure 4.2 show that in the highest debt-to-GDP category both the mean and the median real GDP growth are higher in the low debt-to-GDP category, at approximately three percent, than in the very high debt-to-GDP category at approximately two percent. However, the real GDP growth in the moderate category is higher than in the low category at approximately 3.5 percent. This is different to the result for public debt in the original study, where such non-linearity was not present.

As in Reinhart and Rogoff's (2010) analysis inflation is also reported in figure 4.2, and the result is that a higher level of private debt predicts lower inflation. While inflation is not the primary interest of the thesis, lower inflation for high levels of debt is consistent with Keen's arguments regarding credit, since a high level of debt is correlated with lower credit growth, which predicts lower inflation, because of the loss in aggregate demand.

The statistical significance of the difference between the means of categories two and four was assessed using an independent sample t-test for two samples. The findings are statistically significant.

Table 4.1. Reinhart and Rogoff (2012) country-specific debt table extended to private debt.

Country	Period	Total loans / GDP			
		Below 30 percent	30 to 60 percent	60 to 90 percent	90 percent and above
Australia	1871-2016	3.8	2.9	3.7	3.0
Belgium	1885-2016	1.9	3.4	2.1	2.8
Canada	1871-2016	5.3	3.5	2.7	3.4
Switzerland	1871-2016	2.9	2.2	3.5	2.1
Germany	1871-2016	5.2	3.8	2.5	1.2
Denmark	1871-2016	1.7	2.1	4.0	2.1
Spain	1900-2016	2.1	5.5	3.9	1.4
Finland	1871-2016	3.1	3.5	0.6	0.8
France	1900-2016	1.9	7.6	2.4	1.6
UK	1880-2016	1.9	1.9	3.2	2.0
Italy	1871-2016	2.4	2.9	2.2	-0.5
Japan	1876-2016	4.3	4.8	3.8	2.2
Netherlands	1900-2016	8.3	3.3	2.4	2.4
Norway	1871-2016	5.7	3.2	3.6	1.6
Portugal	1871-2016	2.5	4.8	3.7	1.0
Sweden	1880-2016	3.5	3.3	2.3	2.0
USA	1880-2016	4.7	3.2	1.3	n.a.
Average:		3.60	3.65	2.81	1.82
Median:		3.06	3.34	2.67	2.02
Number of observations = 2282		579	772	543	388

Notes: n.a. denotes no observations in the category. Minimum and maximum of each category is highlighted in bold. Some missing observations mostly during WW2 are present. Source: Jordà-Schularick-Taylor database.

For individual countries, table 4.1 highlights debt in general having similar effects to figure 4.2. The non-linear effect is again present and in general the moderate debt category has the highest growth rate. Out of the 17 countries, the countries where the extremely high debt category had higher growth than the moderate debt category are Australia and UK. In contrast, similar exceptions for public debt were Australia, Belgium, Canada and Spain, meaning Australia has been an exception in both of the analyses. Table 4.1 in addition reveals that in no country was the highest GDP growth rate experienced in the very high debt-to-GDP ratio category, meaning that the finding is quite robust.

Based on the results the effect of high level of private debt appears similar to the effect of high level of public debt in Reinhart and Rogoff's (2010) study when the mistake is corrected. However, the GDP data that is used is different, as are the years included. Reinhart and Rogoff's (2010) original study had four additional countries, which were Austria, Greece, Ireland and New Zealand, while the analysis did not include Switzerland. The error in the study was caused by not including some of the countries in the analysis. To address the different data and make a proper comparison, recreating Reinhart and Rogoff's original analysis using Jordà-Schularick-Taylor dataset is possible since government debt data is included in the data set.

Recreating the pooled analysis (presented in appendix A) of the original study reveals a smaller impact for government debt than for private debt. The means for each category were 3.67, 3.05, 2.56, 2.15 from lowest to highest category of government debt-to-GDP ratio, while the corresponding medians were 3.7, 3.02, 2.76, 2.02. The threshold effect of the very high debt category having negative GDP growth is not present using the Jordà-Schularick-Taylor dataset. The relationship between government debt and real GDP growth appears quite linear.

Based on the analysis, the overall effect of increasing private debt from the moderate debt category to the very high debt category is associated with approximately 1.8 percentage point loss in real GDP growth, while the change from the low government debt category to the very high category predicts approximately 1.7 percentage point drop in real GDP growth. The effect of debt therefore appears substantial.

4.2.2 Segmented LSDV Model

Reinhart and Rogoff's (2010) methodology could be criticized on econometric grounds for ignoring possible country-specific effects and time-effects. Each country has a different average level of GDP growth for many external factors, which there is no reason to necessarily expect the ratio of debt-to-GDP explains. Additional debt possibly lowers real GDP growth from the country-specific level in every country. The country-specific levels of GDP growth can be included in the modeling process to address the concern.

The methodology may also be criticized for not including time effects. It is possible that because of some external factors there is a trend in GDP growth. Omitting the trend leads to an omitted variable bias if the trend is also correlated with the debt variable, which is a

concern considering that GDP growth has generally decreased while debt has increased as time has passed. Another concern is clustering in the time domain; if there are periods where the debt of each country is high while GDP growth is low because of external factors, the analysis may become biased.

For these reasons a segmented least squared dummy variable (LSDV) model is used to address the possible biases. The specification that is used has the form

$$Y_{it} = \alpha_i + \lambda_t + \beta X_{it} + \sum_{j=1}^K \theta_j D_{it}^j (X_{it} - \kappa_j) + \epsilon_{it}, \quad (1)$$

where Y_{it} is real GDP growth at country i and time t and X_{it} is the debt-to-GDP ratio. The dummy variable D_{it}^j for each j is set to zero if $X_{it} - \kappa_j$ is negative and one otherwise. The knot points κ_j for each j are constants representing the where the slope of the regression slope is allowed to change. The knot points are selected so that $0 < \kappa_1 < \kappa_2 < \dots < \kappa_K$. The error term of the model is ϵ , which is the convention used in all models presented in this thesis.

For the parameters that are estimated from equation 1, parameter α_i denotes country-specific fixed effects. The parameter λ_t represents the time specific fixed-effects which are included to address cross country variations in time. In some specifications the time-specific fixed-effects may be replaced by trend polynomial $\sum_{k=1}^P \lambda_k t^k$. The time trend may further be multiplied by a country dummies in order to have a separate time trend for each country.

In equation 1, the term $\sum_{j=1}^K \theta_j D_{it}^j (X_{it} - \kappa_j)$ addresses the non-linearity of the model, by altering the slope at the knot points. The parameter θ_j denotes how much the regression slope changes at each threshold κ_j , while the actual slope after the knot point (e.g. for levels of debt-to-GDP between κ_j , and κ_{j+1}) is given by $\beta + \sum_{i=1}^j \theta_j$. To obtain statistical significance of the coefficients for each segment, for example, the model can be rewritten as

$$Y_{it} = \alpha_i + \lambda_t + \theta_0 X_{it} + \sum_{j=1}^K \theta_j^* (D_{it}^j (X_{it} - \kappa_j) - D_{it}^{j-1} (X_{it} - \kappa_{j-1})) + \epsilon_{it}, \quad (2)$$

and setting $D_{it}^0 = 1$ for all i, t and $\kappa_0 = 0$. Now $\theta_j^* = \beta + \sum_{i=1}^j \theta_i$ and therefore θ_j^* gives the slope of each segment directly. The models can be further rewritten as

$$Y_{it} = \alpha_i + \lambda_t + \sum_{j=1}^{K+1} \theta_{j-1} (D_{it}^{j-1} (X_{it} - \kappa_j)^p - (D_{it}^j (X_{it}^p - \kappa_j^p) - (\kappa_j - \kappa_{j-1})^p)) + \epsilon_{it}, \quad (3)$$

which also allows for easy addition of segments for any order of polynomial p , when testing for non-linear effects in any of the segments, note that $D_{it}^{K+1} = 0$. However, linear segments fit the data quite well in the analysis. Non-linear segments were not used, this may be of interest in the future.

The knot points are selected by considering the previous analysis for private debt motivated by Rogoff and Reinhart. The first knot point should be somewhere between zero and 60 percentage points based on figure 4.2. A second knot does not appear necessary but could be put around 90 percentage points to test for nonlinear effects of high levels of debt. Based on the considerations, the final values for knot points were chosen as 35 percent and 100 percent.

The analysis also includes government debt as a control variable. A relevant question regarding private debt is whether the effect of private debt adds to government debt. In addition, the specification allows comparing the effect of government debt and private debt on real GDP growth. Government debt's effect will not be segmented since the effect appears linear.

4.2.3 Results from Segmented LSDV Model

The results of the segmented LSDV regression model are shown in table 4.2, where various specifications based on the methodology presented in the section 4.2.2 are detailed. The objective of the models is to primarily answer the question of whether the results of Reinhart and Rogoff's analysis for private debt holds even when the potential biases are taken into account. Of particular interest is levels of debt that are moderate or high as experienced in most countries today. As a robustness check a control for outliers is also included. The analysis is further robustness checked by lagging the debt variable by one time period, thus giving the interpretation that real GDP growth is explained by the level of private debt-to-GDP at the start of the year. In this specification the possible trend

is in addition included for each of the countries. The results of the robustness check are presented in appendix B.

Table 4.2. Growth and private debt.

Models	Dependent variable: Real GDP Growth				F.E	T.D	Trend	O
	Total loans / GDP	When below 35%	When above 100%	Government Debt/GDP				
Model 1	-1.4****			-1.1****				
Model 2	-1.7****			-1.4****	X			
Model 3	-0.8			-1.5****	X	X		
Model 4	-1.5****			-1.5****	X		X	
Model 5	-1.0*			-1.6****	X	X		X
Model 6	-1.9****			-1.3****	X			
Model 7	-1.8***			-1.8****	X	X		
Model 8	-3.3****			-1.6****	X		X	
Model 9	-2.6***			-1.8****	X	X		X
Model 10	-2.3****	4.1***						
Model 11	-2.9****	4.6****			X			
Model 12	-1.5*	2.3*			X	X		
Model 13	-3.5****	1.9*			X		X	
Model 14	-1.3*	0.5			X	X		X
Model 15	-2.1****	1.6*		-1.1****				
Model 16	-2.6****	2.0**		-1.1***	X			
Model 17	-1.9**	-1.2		-1.7****	X	X		
Model 18	-3.2****	-1.5		-1.5****	X		X	
Model 19	-1.8***	-0.3		-1.8****	X	X		X
Model 20	-1.7*	0.7	-0.8		X	X		X

Notes: F.E. indicate country fixed effects, T.D times dummies and O outliers of below or above 20 percent growth. The trend is a second order polynomial. Statistical significance of the break points is tested as a change from the primary effect (first column). The coefficients are interpreted as the slope of the regression line in each category. Minimum/maximum in bold. Models 1 to 5 estimated separately for the types of debt. Source: Jordà-Schularick-Taylor database.

In the table 4.2 models one to five explain real GDP growth by private debt and government debt independently, while models six to nine explain real GDP growth jointly. The different between the models is in whether the fixed effects, trend, time dummies or outliers are included to control for the possible biases. In none of the models from one to nine is the non-linear effect of private debt modelled.

In models 10 to 14 real GDP growth is explained by private debt only, including the non-linear effect, by allowing change of slope of the regressor at the threshold of 35 percent debt-to-GDP ratio. Models 15-19 further adds government debt-to-GDP ratio as a control variable to the same specifications as models 10 to 14. Finally, model 20 including fixed effects, time dummies, and controls for outliers also allows the slope of the regression change at the threshold of 100 percent debt-to-GDP ratio.

In the table 4.2, the second column refers to the regression coefficient of the model, in models 1-9, it is read as a regular regression coefficient. For the models 10-19 the column reports the effect of private debt above the 30 percent threshold. In model 20 it is read as the effect of debt between the 30 percent and 90 percent thresholds. It is the most relevant column in the table 4.2, since the column reports the effect of lowering or increasing private debt when the level of debt is sufficiently high.

The independent models for private debt and government debt without the segmentation for private debt shows that even without the added non-linearity, private debt is still negatively associated with real GDP growth, even when fixed effects and time effects are included in the model. Only in the case where time dummies and outliers are included the result is statistically not significant, but still negative. Further, Reinhart and Rogoff's (2010) original result revealing that public debt is negatively associated with GDP holds even when the additional effects are taken into account.

When the effects of private and public debt are modelled jointly in models 6 to 9, the effects for each of the coefficients for both private and public debt are more negative than when they explain GDP growth independently. The result shows that the negative effects of public and private debt add together rather than subtract, even when controlling for fixed effects or time effects.

The models 10-15 together with models 1-5 show that above the 35 percent threshold the effect of private debt becomes more negative. The effect of private debt after the 35 percent threshold becomes larger in every model from 10-15 compared to the equivalent models 1-5 without the segmentation. Further, in the segment where private debt is low (below 35 percent of GDP), the effect of private debt is always positive in this specification, showing the same non-linear effect as in the initial analysis following Rogoff and Reinhart (2010).

The models 15-19 show that the effect of government debt still adds to private debt when the non-linear effect is included in the private debt. In fact, for most of the models the coefficients are higher than for the individual specifications for private debt and government debt. Additionally, the addition of government debt to the model diminishes the non-linear effect of private debt, even turning the effect of private debt negative below the 35 percent threshold debt-to-GDP ratio in some models.

Finally, model 20 is used to show that there is no threshold where the effect of private debt is amplified. The coefficient for the change in slope at the threshold of 90 percent debt-to-GDP ratio is not statistically significant and has a lower coefficient than the slope at the 30 to 90 percent debt-to-GDP ratio.

The question of whether there is a threshold for private debt in the 35 percent debt-to-GDP range is difficult to answer based on table 4.2. In some models the change in slope is significant, while in others it is not. Including a trend or country-specific fixed effects appear to amplify the negative effect of debt, while time dummies can also subdue the effect. The robustness check where real GDP growth is explained by the level of debt at the beginning of the year reveals a similar pattern, as shown in appendix B. Adding a trend for each country has a similar effect to the trend that is shared between the countries, amplifying the negative effect of private debt.

The primary finding is that in every model the effect of private debt is negatively associated with real GDP growth. Public debt is also negatively and statistically significantly associated with real GDP growth in every model. Some variance in the effect sizes is observable in the different models concerning the effect of private debt on real GDP growth. The effect size ranges from a minimum of 0.8 percentage point drop in real GDP growth for every 100 percent increase in private debt to a maximum of 3.5 percentage point drop. For the models where the segmentation is included, the lowest effect size is 1.5 percentage point drop for every 100 percentage point increase in the debt-to-GDP ratio, when above the threshold of 35 percent debt-to-GDP ratio. Government debt's effect is more stable, being associated with approximately 1.5 percentage point drop in real GDP in almost all of the different specifications.

The conclusion of the analysis is that the effect of private debt is negative and appears to be slightly more strongly associated with growth than government debt. Especially when considering that private debt even according to the Jordà-Schularick-Taylor Macrohistory

Database, which uses a quite strict definition of private debt is on average higher than public debt, as shown in figure 4.1. Further, no country in the database has a debt of less than 35 percent relative to GDP currently, meaning a higher than the currently prevailing level of debt is associated negatively with GDP growth in all of the 17 countries.

4.3 Private Debt and Recessions

Jordà et al. (2016) and others have demonstrated that the extension of private debt can predict crashes, and the crashes after a credit boom are worse than other crashes. Keen's (2017) argument shows that while the extension of debt before the crisis may matter, it is particularly the debt build-up before the recession and stagnation or reduction of debt during the recession that should be associated with worse recessions. The purpose of this chapter is to show that the worst recessions debt has both built up before the recession and decreased during the recession.

4.3.1 Methodology

The methodology that will be employed is similar to that of IMF (2012), used before by Romer and Romer (1989). The data that is used is provided by Jordà-Schularick-Taylor database with recession dates from Howard, Martin, and Wilson (2011). The private debt data series used for the analysis is the total private loans series, IMF studied only household debt. Since the recession dates are available from 1970, only the data from that year forward is used. The data differs from IMF's analysis, which used OECD data from 1980 to 2012.

The model that is estimated is similar to IMF's (2012). However, in IMF's specification there were only two group, the category where an above median amount of credit was extended before the bust, and the group where below median amount of credit was extended before the bust. The model adds two new dummies, the four categories that are included in the model are a mix of the different categories of low debt run-up before the recession and high debt run-up after the recession.

The model specification is an auto-regressive $AR(L)$ process given by the equation

$$\Delta \log(Y_{it}) = a_i + \lambda_t + \sum_{j=1}^L \beta_j \Delta \log(Y_{i,t-j}) + \sum_{k=0}^L (\delta_k R_{i,t-k} + \theta_k U_{i,t-k} + \gamma_k D_{i,t-k} + \phi_k UD_{i,t-k}) + \epsilon_{it}, (4)$$

where a_i denotes the country fixed effects and the time dummies λ_t are included for controlling clustering in time. Y denotes real GDP (or real consumption per capita), therefore the dependent variable of equation 4 is approximately equal to the GDP growth rate (or real consumption per capita). Since GDP growth rate has some persistence the auto-regressive terms are included in the model up to lag L , which is set to two. The dummies R, U, D, UD denote the four different categories, R giving the base case recession, U giving the recession with high debt run-up, D giving the recession with high debt run-down and UD giving the recession with both high run-up and run-down. Since recessions can last a few years, lags are included for the recession dummy terms.

To populate the dummies a procedure similar to IMF's (2012) is used. First, high debt build-up and low debt build-up categories are separated from each other, by considering the median rise in debt relative to GDP from four years before the recession. Then, the high run-down and high debt run-up categories are created by similarly cutting off the groups based on the median fall in debt relative to GDP (on the onset of the crisis) two years after the recession. The four different dummies are intuitively given by the intersection of the four different categories. The amount of recessions in each category is presented in table 4.4.

The analysis was repeated using various different threshold values between the groups, also using different run-up and run-down periods. However, the results were always similar. The specification appears quite robust in this sense.

To interpret the results, cumulative impulse responses are recursively calculated from equation 4 and presented up to five years after a recession. To create the impulse response confidence bands, a cross-sectional bootstrap procedure is used. The bootstrapping method is described in more detail in the PVAR methodology section. In contrast, IMF used an analytical method to calculate the confidence bands and Monte Carlo simulations were used by Cerra and Saxena (2008) and Romer and Romer (1989). The cross-sectional bootstrap appears to give larger confidence bands.

The equation 4 is estimated with OLS as in IMF (2012), which is biased, because of the Nickel (1981) bias. However, as discussed in the various other studies using the method, the bias is not substantial when sufficient amount of data is used (Owen, 1999).

4.3.2 Results

The results of the analysis are presented in figure 4.3 and figure 4.4. Further, loss in GDP and real consumption five years after the crisis are reported in table 4.3. The figures only demonstrate the result for real GDP, while in table 4.3 an alternative specification for real consumption per capita is included in addition. The interpretation of the figure 4.3 is how real GDP reacts up to five years after a recession given the high run-up in private debt, high run-down in debt or both. Figure 4.4 shows similar figure for the difference between a regular recession and a recession given the different debt characteristics.

The upper-left panel in the figure 4.3 shows that for the group where regular recession occurs without the run-up or run-down in private debt, five years after the recession approximately 2.5 percent reduction in GDP is experienced. While this is statistically significant using the standard error band shown in the picture, it is not significant at the 95 percent level. In IMF's (2012) analysis which used somewhat different variables, the base case was not statistically significant in their analysis either.

For the group where the debt run-up before the recession is experienced, but the run-down is not, the results are displayed on the top-right panel of figure 4.3. The result reveals that slightly over four percent reduction in growth is experienced five years after the recession. In figure 4.4, it is also observable that the difference to the base case recession is slightly less than two percent. The group with high debt run-down but no run-up also experiences approximately four percent lower growth five years after a recession, presented in the bottom right panel of figure 4.3.

Finally, the results for the group with both high debt run-up before the recession and the high debt run-down after the recession. As seen from figure 4.3 lower-right quadrant, the group experiences by far the worst recessions. Five years after the recession a loss of almost eight percent in real GDP is experienced in the group, the loss is approximately four percentage points higher than experienced during a regular recession. The reduction in GDP is even higher than adding the additional effect of each of the other groups together. As is visible from table 4.4, the difference between the high debt run-up and high debt run-down category is also statistically significant when contrasted to the groups where debt run-up before the recession was high, or the run-down after the recession was high. Therefore, the conclusion of the analysis is that the recessions where debt increased before the recession and was reduced after the recession have been the worst recessions.

In table 4.3, the case where real consumption per capita is selected as the dependent variable instead of real GDP reveals a similar result to the case where real GDP was the dependent variable; the recessions preceded by high debt run-up and followed by high debt run-down have been the worst recessions. The result is somewhat stronger for real consumption per capita, with a 8.7 percentage point decrease in GDP five years after a high debt run-up and debt run-down recession.

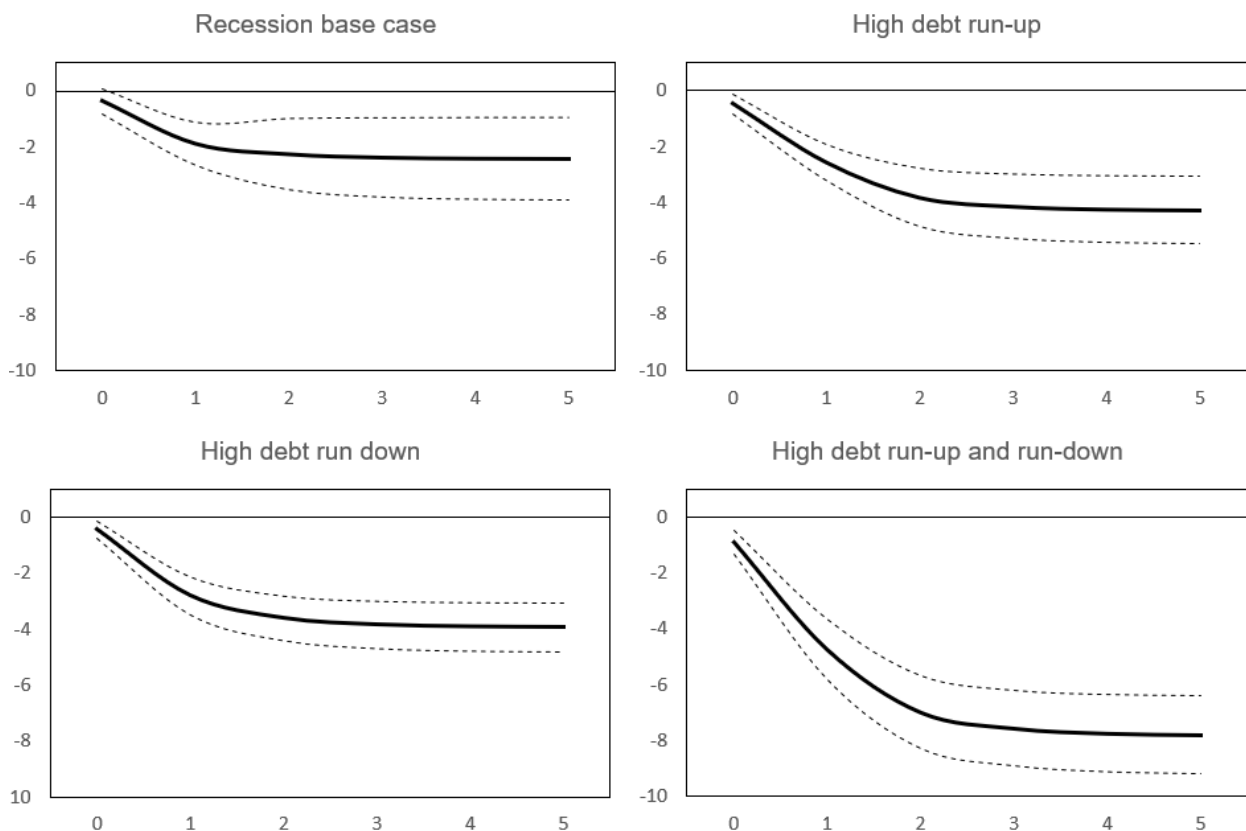


Figure 4.3. Recessions, run-up and run-down in debt, and real GDP growth. X denotes the time in years from the peak of the cycle. Y axis the change in real GDP (in percentages). One standard deviation confidence interval from cross-sectional bootstrap is included from 1,000 bootstrap trials.

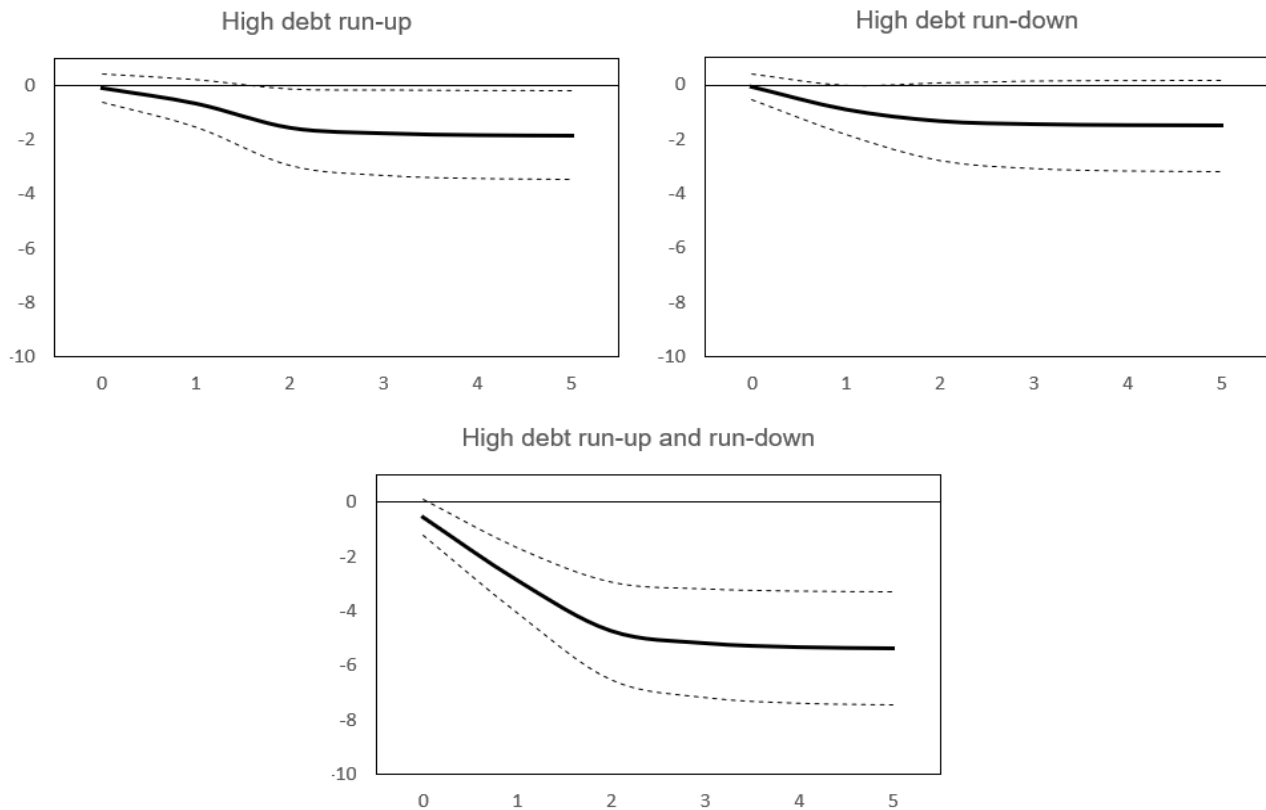


Figure 4.4. Recessions, run-up and run-down in debt, and real GDP growth, the difference between the base case recession and each of the other categories. The dependent variable is real GDP growth. One standard deviation confidence bands is included by 1,000 cross-sectional bootstrap trials.

Table 4.3. Recessions and debt run-ups and run-downs.

Response to recession (five years after the recession)	Real GDP growth	Real consumption per capita
Recession severity in category:		
Base case	-2.4	-1.9
Debt run-up	-4.3***	-4.5****
Debt run-down	-3.9****	-3.7****
Debt run-up and run-down	-7.8****	-8.7****
Differences:		
Base case, debt run-up	-1.8	-2.6*
Base case, debt run-down	-1.5	-1.7
Base case, debt run-up and run-down	-5.4**	-6.8****
Debt run-down, debt run-up	-0.3	-0.8
Debt run-up, debt run-up and run-down	-3.5***	-4.1****
Debt run-down, debt run-up and run-down	-3.9***	-5.0****

Notes: Table 6 shows the statistical significance of the cumulative impulse responses in the given category five years after a recession, based on equation 4. 782 observations from 17 countries and 46 time periods were included in the estimation, from the year 1970.

Table 4.4. Recessions included in the analysis.

Recessions (since 1970)	Low debt run up	High debt run up	Total
Low debt run down	16	32	48
High debt run down	32	17	49
Total	48	49	97

4.4 Dynamic Relation Between Private Debt and the Economy

In this section the dynamic relation between private debt and other macroeconomic variables is investigated using panel VAR analysis identified by the Cholesky scheme and robustness checked by local projections. The analysis is meant to capture the dynamic feedback relation between private debt, real GDP, unemployment, and house prices inherent to Keen's argument.

4.4.1 Motivation and Definitions

The panel VAR estimation follows similar methodology to Mian et al. (2017), however a few differences are introduced to make the specification more consistent with Keen's arguments. The variables of interest are defined somewhat differently. Mian et al. (2017) divided the level of private debt by nominal GDP to define the debt variables of interest. However, Keen's arguments indicate that unemployment, real GDP and house prices (and changes thereof) are related to credit (e.g. change in debt) and the Credit Impulse (e.g. acceleration of debt).

As noted by Mian et al. (2017), normalizing the variables by GDP is important to standardize the measurement units between the countries and giving the desirable interpretation of change in the variables relative to an economy. Not normalizing the variables could produce flawed results, as high debt growth from an insignificant amount of debt can appear large without being economically meaningful. Therefore, the private debt variables of interests for the analysis are defined as

$$Credit_t^{(x)} = \frac{\Delta(D_t^{(x)})}{NGDP_{t-1}}, \quad (5)$$

$$Acc_t^{(x)} = \frac{\Delta(\Delta(D^{(x)}))}{NGDP_{t-1}}, \quad (6)$$

where Δ denotes the change of a variable from last year. The variable $D^{(x)}$ denotes the debt of type x and $NGDP$ is the nominal GDP, which has been inferred from BIS dataset. The term $Credit_t^{(x)}$ refers to a change in debt, while $Acc_t^{(x)}$ refers to the acceleration of debt. The different types of debt used for the analysis are household debt and corporate debt, both of which are non-financial and taken from the BIS dataset. Credit acceleration could also be defined differently, for example as a change in credit. However, the definition did not have any meaningful impact on the results of the analysis.

Compared to Mian et al.'s (2017) analysis the definitions also have other properties that may be ideal for the analysis. If debt remains stagnant the level of debt relative to nominal GDP changes as GDP grows, which may give a dynamic relation even for a stagnant but positive level of debt. However, if the level of debt is stagnant, the acceleration and change in debt are always zero, and thus not affected by the growth of nominal GDP.

The first objective of the PVAR analysis is to analyze the relationship between credit and the level of unemployment which exists Keen (2017, Chapter 3) has detailed. In the USA credit and unemployment have been very highly correlated, especially since the 90s, as is detailed in figure 4.5. The relationship between credit and GDP growth is also reported, since Keen (2017, Chapter 4) has suggested that credit has a short-run stimulus effect on GDP, similar to reported by Mian et al. (2017), based on the aggregate demand creating capacity. Keen (2017, Chapter 4) also asserts that the shortage of credit extension is the primary reason why economies of many countries are not growing.

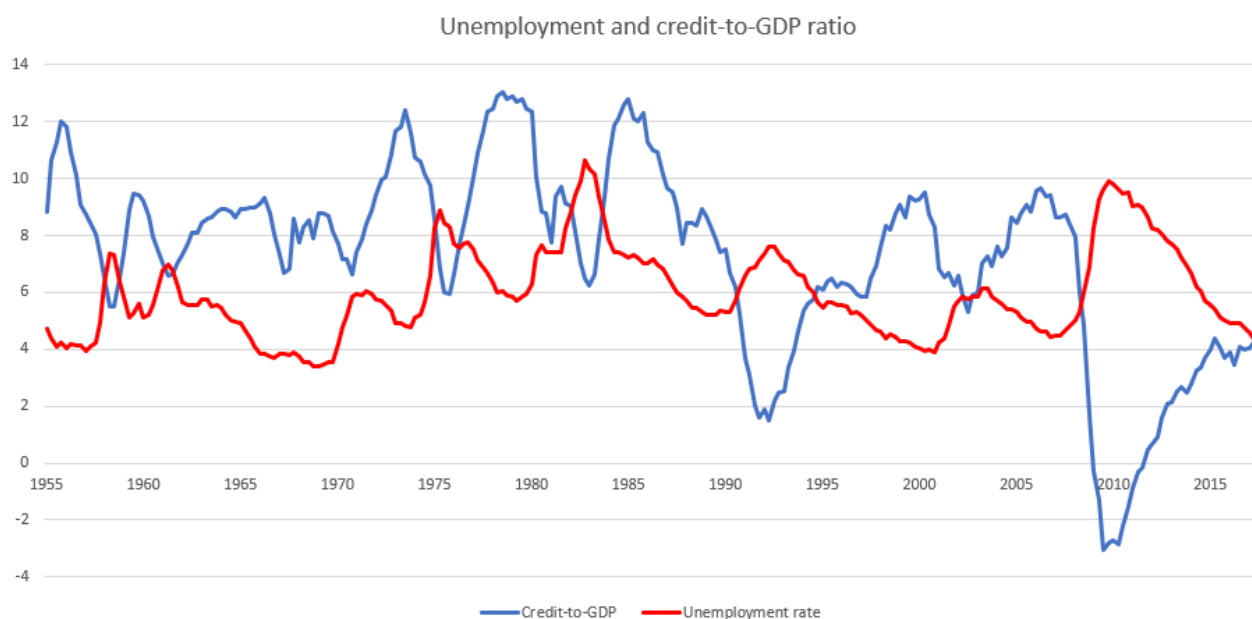


Figure 4.5. The relationship between credit-to-GDP ratio and unemployment rate in the USA (in percentages). Credit is defined as change in private debt relative to nominal GDP. Source: OECD, BIS.

The second objective of the analysis is to analyze the dynamic relationship between acceleration of debt and the change in GDP, unemployment and house prices. As outlined before, Keen believes there is a strong relationship between the variables. In his book *Can we avoid a financial crisis?* Keen (2017, Chapter 3) states that acceleration of debt is the driving factor behind the other macroeconomic variables. The relationship between acceleration of debt, GDP and house prices in the USA are detailed in figures 4.6 and 4.7.

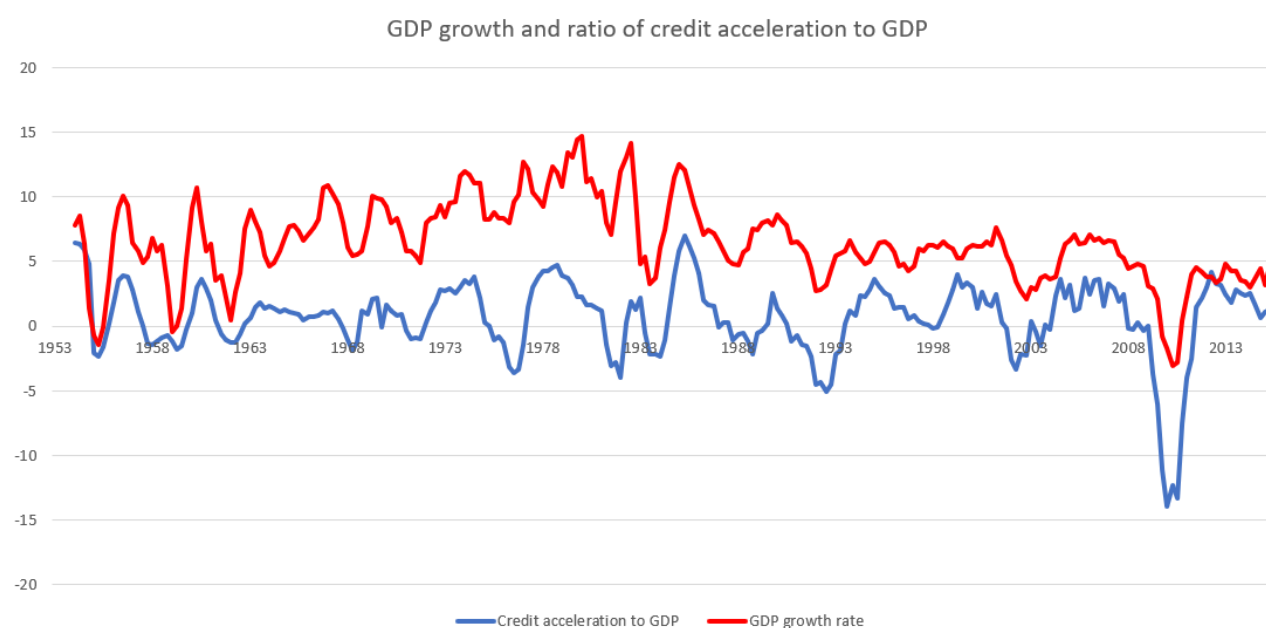


Figure 4.6. Relationship between real GDP growth rate and credit acceleration in the USA since 1953. Source: BIS, OECD.

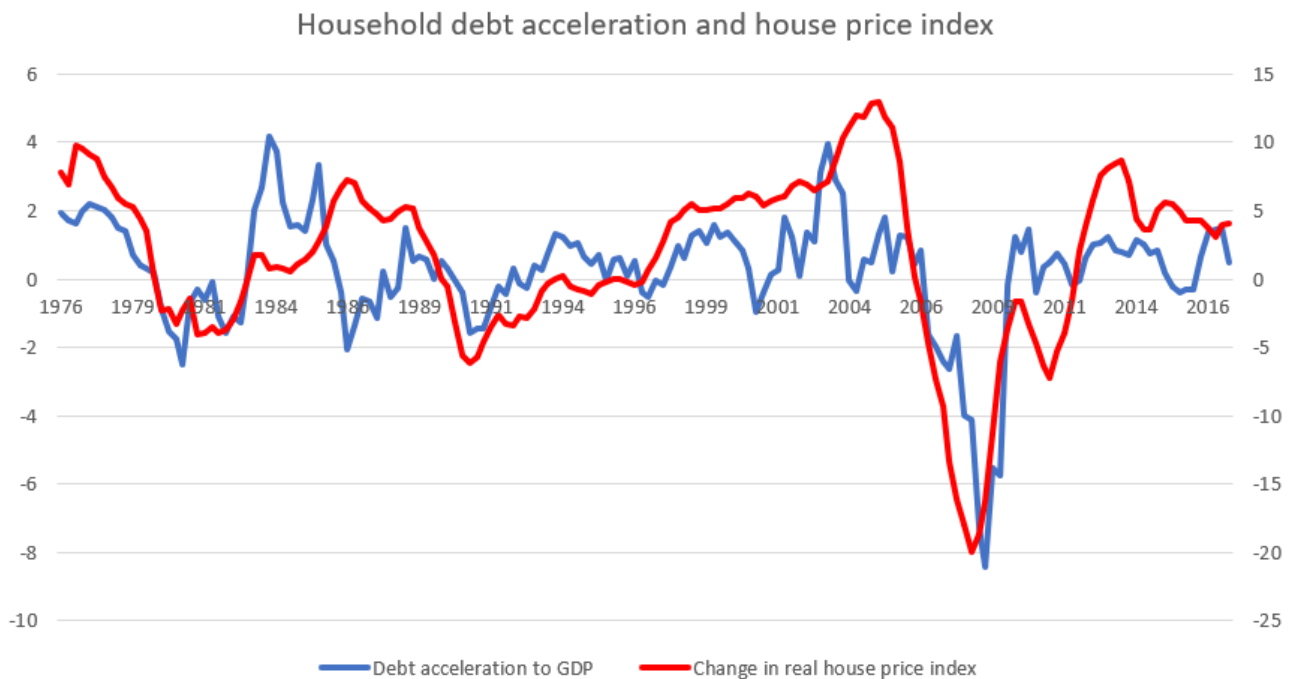


Figure 4.7. Household debt acceleration and real house price index in the USA since 70s. Source: BIS.

From figures 4.6 and 4.7 it is discernible that there has been a relationship between credit acceleration, real GDP growth and change in real house prices. Particularly in the case of the relationship between house prices and credit acceleration Keen (2017, Chapter 3) notes that the dynamics are very complicated, because of the feedback processes between the variables. Therefore, a VAR model is well suited for the task.

The unbalanced panel data for the analysis is provided by OECD, BIS and Maddison database. 26 mostly advanced economies are included in the analysis. The primary interest of the analysis is in the short run dynamics, between 1-4 years after a shock to the debt of interest.

4.4.2 Panel VAR Methodology

VAR models were popularized by Nobel laureate Sims (1980). Since then estimators have been developed for the panel context. The panel VAR (PVAR) estimation procedure used in this thesis uses an algorithm developed by Sigmund and Frestl (2019). Sigmund and Frestl (2019) follow contributions to the literature on dynamic panel data (DPD) estimation

by Anderson and Hsiao (1982), Holtz-Eakin et al. (1988), Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998).

The authors mentioned above have developed DPD estimators that address the Nickell (1981) bias, caused by the correlation between the error term and the fixed effects. To address the bias, the estimators use lags of the endogenous variable(s) as instruments. The first solution by Anderson and Hsiao was to utilize instrumental variable (IV) estimation for the instrumentation, however the generalized method of moments (GMM) estimator is more efficient. Thus, the GMM estimator is used, popularized by Nobel laureate Hansen (1982).

Sigmund and Frestl (2019) implement both the Arellano-Bond (1991) estimator, and Blundel-Bond (1998) estimator, which are also called first difference GMM and system GMM estimators respectively. The difference between the estimators is that the system GMM estimator has additional moment conditions contained in the levels of the endogenous variable, which may improve the efficiency of the estimator in finite sample context, and also addresses bias in some circumstances.

Sigmund and Frestl (2019) further extend the VAR estimators to the multiple equation contexts as required by PVAR estimation, following Binder et al. (2005). Prior to Sigmund and Frestl PVAR estimator has been implemented and popularized by Love and Zicchino (2006) and improved by Love and Abrigo (2016), who according to Sigmund and Frestl (2019) base their estimator on the first generation GMM estimator developed by Anderson and Hsiao (1982).

The models that can be estimated by Sigmund and Frestl's (2019) algorithm are of the form

$$Y_{it} = \mu_i + \sum_{l=1}^p A_l Y_{i,t-l} + \beta X_{it} + \mathbf{C}S_{it} + \epsilon_{it}, \quad (7)$$

where Y_{it} is the vector of dependent variables at intersection $i = 1, \dots, N$ and time $t = 1, \dots, T$. $Y_{i,t-l}$ are the lagged values of the dependent variables, which are included up to lag p . Sigmund and Frestl also add a vector of predetermined variables X_{it} and strictly exogenous variables S_{it} to the standard PVAR specification. Predetermined variables are variables that are determined prior to the current period, meaning they are uncorrelated

with current and future values of the error term, while exogenous variables are in addition uncorrelated with the past values of the error term.

The rest of the terms in equation 7 represent parameter estimates. If Y_{it} is denoted as an $m \times 1$ vector, then the matrix of parameter estimates A_l is an $m \times m$ matrix for each lag l , β is an $m \times k$ matrix where k is the number of predetermined variables included in the model, and C is an $m \times n$ matrix, where n is the number of exogenous variables. μ_i represent the fixed effects for each of the m equations. The error terms for each equation represented by the length m random vector ϵ_{it} is assumed to be independent and identically distributed, with a mean of zero.

Sigmund and Frestl's (2019) PVAR implementation allows removing the fixed effects by first differencing (FD), or a transform called forward orthogonal deviations (FOD) proposed by Arellano and Bover (1995). Forward orthogonal deviations is a transform where the variables are demeaned by their future values. Performing the transform means that the final observation of the data cannot be used, in contrast to first differencing where the first observation is not used. In the following analysis the forward orthogonal transformation will be used as it intuitively seems suitable for a model where the variables are mostly rather stationary. The FOD transformation has also been found to be generally superior in simulations (Hayakawa 2009). Mian et al. (2017) removed the fixed effects using the first difference transform and used OLS for the estimation in contrast.

The implementation also allows specifying whether the GMM estimation should proceed in one, two (following standard GMM literature, see Newey and McFadden (1994), and Hansen (2012)) or m steps. The m -step estimator refers to a procedure where the optimization is repeated iteratively using the weight matrix from the previous step, potentially providing further efficiency gains.

In the following analysis the one-step option is used. The reason for using the one-step estimation is that the version of the Sigmund and Frestl's package is not yet version 1.0, however at least the one step procedure should be computationally correctly configured and is also computationally more efficient than the two-step procedure, which is an advantage when working with large panel datasets. The code of the program contains a comment which indicates that specifically the correctness of the Windmeijer's correction related to the two-step procedure should be checked for correctness.

Sigmund and Frestl's (2019) package can also compute the orthogonal impulse response functions. First, Sigmund and Frestl (2019) derive the panel vector moving average representation with exogenous variable also called PVMA-X representation as

$$\mathbf{y}_{it} = \mathbf{v}_i + \left(\sum_{j=0}^{\infty} \mathbf{A}^{j-1} [\mathbf{B} \ \mathbf{C}] \right) \begin{bmatrix} \mathbf{X}_{i,t-j} \\ \mathbf{S}_{i,t-j} \end{bmatrix} + \left(\sum_{j=0}^{\infty} \mathbf{A}^j \right) [\boldsymbol{\epsilon}_{i,t-j}], \quad (8)$$

where $\mathbf{v}_i = (\mathbf{I}_m - \mathbf{A})(\mathbf{I}_m - \sum_{l=1}^p \mathbf{A}_l)\boldsymbol{\mu}_i$. \mathbf{I}_m is an $m \times m$ identity matrix. Equation 8 is a representation for PVMA-X(1) process, meaning a PVAR process with one lagged dependent variable. It is trivial that any PVAR(p) process can be represented by PVAR(1) processes as shown by Lütkepohl (2007). Based on the moving average form of the reduced form PVAR equation, the regular impulse response function is given by

$$IRF(k, r) = \frac{\partial \mathbf{y}_{i,t+k}}{\partial (\boldsymbol{\epsilon}_{it})_r} = \mathbf{A}^k \mathbf{e}_r. \quad (9)$$

In the equation r denotes the endogenous variable that the shock is directed at, while \mathbf{e}_r is a vector that equals one for the r -th column and zero otherwise (Sigmund and Frestl, 2019). Then, similarly to Mian et al. (2017), the impulse response can be orthogonalized using the Cholesky decomposition, which is unique. Orthogonalization is performed, since the error terms may be correlated with each other and therefore the shocks to the dependent variables cannot be said to be structural. To address the concern variance-covariance matrix of errors $\boldsymbol{\Sigma}_{\epsilon}$ (obtained from the error terms estimated from equation 7) is decomposed as $\mathbf{P}\mathbf{P}'$ by use of the Cholesky decomposition. Afterwards, variables $\boldsymbol{\Theta}_k = \mathbf{A}^k \mathbf{P}$ and $\mathbf{u}_{it} = \mathbf{P}^{-1} \boldsymbol{\epsilon}_{it}$ are defined to solve for the orthogonalized impulse responses. From the representation, the orthogonalized impulse response function is then given by

$$OIRF(k, r) = \frac{\partial \mathbf{y}_{i,t+k}}{\partial (\mathbf{u}_{it})_r} = \boldsymbol{\Theta}_k \mathbf{e}_r, \quad (11)$$

following Sigmund and Frestl (2019). The contemporaneous effects between the different variables and therefore the orthogonalized impulse response depends on the ordering of the variables as was mentioned earlier. This feature has been criticized, and Sigmund and Frestl's (2019) implementation can also alternatively calculate the generalized impulse response function (GIRF), suggested by Pesaran and Shin (1998). The GIRF does not depend on the ordering of the variables and could be said to order each variable first.

However, in the following analysis the OIRF is computed as in Mian et al. (2017). GIRFs themselves have also been criticized by Hyengwoo (2013).

Bootstrap procedure is used to generate the confidence intervals for the impulse response. The authors argue that cross-sectional resampling is an effective way to bootstrap in contrast to temporal or combined resampling, based on for example Kapetanios (2008). In cross-sectional resampling, the entire cross-sections are resampled N^* times, with replacement, to construct a new dataset from the drawn cross-sections. N^* does not necessarily have to equal the original dimension N , although it is set so in the implementation. After the new dataset is constructed the parameter estimates of interest are estimated from the new dataset using the GMM estimator as detailed above. The procedure is iterated to construct the bootstrap distributions for the parameters of interest, in this case the orthogonalized impulse responses. From the bootstrap distribution the confidence intervals can be inferred.

Sigmund and Frestl (2019) have also implemented additional features such as the possibility to compute moment selection criteria (MMSC) equivalents for the common lag selection criteria AIC, BIC and HQIC based on Andrews and Lu (2001). They suggest not using the equivalent of AIC.

4.4.3 Jordà Local Projections

As in Mian et al. (2017), the VAR analysis is robustness checked using Jordà (2004) local projections. While VAR is an optimal model if the model correctly represents the data creation process (DGP) according to Jordà (2005), this is generally almost certainly not the case in econometrics contexts. Therefore, Jordà (2005) suggests a better multi-step prediction may be estimated by direct forecasting models. One reasoning is that in VARs the forecast errors are compounded on each new step of the horizon (e.g. each step of the impulse response). In local projections, the prediction is separately estimated for each horizon. The local projections can be estimated from the sequential regression equations of the form

$$\mathbf{y}_{t+s} = \alpha^s + \sum_{i=1}^L B_i^{s+1} \mathbf{y}_{t-i} + \epsilon_{t+s}^s, \quad (12) \quad s = 0, 1, \dots, h$$

where α^s is a $n \times 1$ vector of constants and \mathbf{y}_{t+s} is an $n \times 1$ vector of dependent variables, B_i^{s+1} is the matrix of coefficients for each lag i and horizon $s + 1$ (Jordà, 2005). The total

collection of h regressions are defined as *local projections*. In general, impulse responses can be obtained as the difference between two forecasts, the first forecast with the desired shock(s) taking place and the other without. Mathematically this can be expressed as (see Hamilton, 1994; and Koop et al., 1996)

$$IR(t, s, \mathbf{d}_i) = E(\mathbf{y}_{t+s} | v_t = \mathbf{d}_i; X_t) - E(\mathbf{y}_{t+s} | v_t = \mathbf{0}; X_t), \quad (13)$$

where $E(\cdot | \cdot)$ denotes the best mean squared error prediction, and $X_t \equiv (\mathbf{y}_{t-1}, \mathbf{y}_{t-2}, \dots)'$. $\mathbf{0}$ is an $n \times 1$ vector of zeros and \mathbf{v}_t is the $n \times 1$ vector of reduced form disturbances (e.g. shocks to the error term). Finally, \mathbf{d}_i contain the relevant shocks for all the n endogenous variables $i = 1, \dots, n$. For the sequential equation 12 the estimates for the impulse responses are therefore given by

$$\widehat{IR}(t, s, \mathbf{d}_i) = \widehat{B}_1^s \mathbf{d}_i, \quad (14)$$

with the choice $B_1^0 = I$, the interpretation being that an instantaneous shock to variable y_i shocks the variable an equal amount and does not shock any different variables. However, the original presentation by Jordà (2005) is not followed completely in this respect, instead estimating the contemporaneous effects by setting $s = -1$ in equation 12 and dropping the collinear explanatory variables. For setting the disturbance term \mathbf{d}_i , the interest in the following analysis is in a unit shock to the credit variables. (Jordà, 2005)

Control variables can be further added to the model. The projections can also easily be turned non-linear by adding polynomial terms $\mathbf{y}_t^2, \mathbf{y}_t^3, \dots$ and then evaluating the impulse responses at the mean level of \mathbf{y} . The local projections can in addition be identified by Cholesky decomposition, thus providing structural interpretation, similar to VAR models. In this case, a VAR is estimated first, and the Cholesky factorization is obtained from the VAR, then the orthogonal impulse response can be obtained by multiplying the impulse response similarly to equation 11.

Further, the lag length in equation 12 does not need to be the same for each horizon. The estimation of equation 14 does not need to be joint and the equation can be estimated with OLS (Jordà, 2005). However, it is apparent that OLS is biased since the equations are autoregressive, and Nickel (1981) bias applies in the panel context with country fixed effects.

The confidence bands for the impulse responses can be obtained from the standard errors of the relevant regression coefficients. Because of the form of the equations, the

autocorrelation corrected errors, such as the robust standard errors by Newey & West (1987) should be used.

4.4.4 Specification

Three different VAR specification are outlined to investigate the relationships of interest. The specifications are based on Mian et al. (2017) and Keen's (2017) arguments. The VAR specifications are estimated from equation 7, by using Sigmund and Frestl's algorithm using the Arellano Bond implementation. The VAR models are identified by Cholesky scheme to generate orthogonalized impulse responses. The confidence intervals are generated by the cross-sectional bootstrap procedure detailed in the PVAR methodology chapter 4.4.3, using 1,000 trials. Each VAR specification is estimated with maximum of five instrument lags for computational efficiency reasons. All of the specifications also include five lags based on the equivalent of BIC criterion and Mian et al. (2017).

The first specification includes the variables $\{\log(\frac{GDP}{capita}), Credit^{Corp}, Credit^{HH}, Unemployment\}$ in the given Cholesky ordering. In this ordering as in Mian et al.'s (2017) analysis for the equivalent variables, GDP growth affects business credit and household credit defined by equations 5 and 6 contemporaneously. Unemployment is put last in the ordering, this is primarily because the contemporaneous effects are under study, and the specification can be justified in the sense that unemployment is a lagging indicator.

The purpose of the first specification is to study the dynamics of unemployment, GDP, household credit and firm credit, specifically the possible stimulus effect of credit on the level of unemployment and GDP suggested by Keen.

The second specification is given by the variable ordering $\{ACC^{Corp}, ACC^{HH}, \frac{GDP}{capita} growth, \Delta Unemployment\}$. In this case the Cholesky ordering is motivated by Keen's (2017, Chapter 3) argument that credit acceleration is the driver behind changes in unemployment and GDP. The argument is also why the unemployment is differenced (year over year change) and GDP variable is defined as a growth rate, which figure 4.6 also showed were related at least in the USA. The specification is used to investigate the dynamic relation between acceleration of household debt, firm debt and the other macro variables.

The third and final specification includes the variables $\{ACC^{HH}, \frac{GDP}{capita} \text{ growth}, \text{house price change}, \Delta Unemployment\}$ in the given order. This specification is very similar to the second specification and is used to analyze the dynamic relations of household debt and house prices only. The house price change variable denotes the percentage change in house prices. The reason for not adding house prices to the second specification is primarily a matter of data. House price data is not historically available in the BIS database, reducing the available data somewhat.

The robustness check by local projections as in Mian et al. (2017) is not identified by Cholesky scheme and is estimated by OLS from equation 12, extending the equation to also estimate the contemporaneous effects. The local projections use the same variables and same amount of lags as the panel VAR models, with the exception that the variable measuring GDP in the first specification is differenced and the response cumulated for a better fit. The confidence interval is calculated by robust standard errors, with the exception of specification 1, which is bootstrapped by 1,000 cross-sectional bootstrap trials.

The responses that are presented are responses to a unit shock to the explanatory variables. It is unclear whether Mian et al. (2017) reported their responses as a response to a standard deviation shock or a unit shock. Both approaches have advantages; a standard deviation shock can be interpreted as a shock that is commonly observed in the variable, whereas a unit shock is easy to interpret as an effect size. The standard deviation of firm debt is higher than household debt, meaning a unit shock to household debt is much rarer than a unit shock to firm debt, thus in practice firm debt may be more relevant than the results indicate.

The interpretation of the impulse responses is how the response variable reacts by the specified number of years after a shock, given the unit shock to the explanatory variable. In specification two and three the response variables are growth rate of house prices or GDP and changes in unemployment. Therefore, the interpretation is what the change in the variables are at the specific times, not what the overall change is to the level of the variables by the given time after the shock.

4.4.5 Results

The resulting impulse responses from the panel VAR analysis for every specification are presented in figure 4.8, the results for the robustness check by local projections are presented in figure 4.9. Only the relevant impulse responses are presented as in Mian et al. (2017). The result reveals a favorable outcome from the perspective of Keen's hypothesis. The results are listed by specification, giving four impulse responses for the first and second specification and only one for the third specification. In the following descriptions GDP will refer to GDP per capita.

The first specification where the level of unemployment and GDP are explained by credit reveals an exceptionally similar result for GDP as Mian et al.'s (2017) result for the relationship between the debt-to-GDP ratio and real GDP.

One year after the unit shock to household credit to GDP ratio real GDP increases statistically significantly, as presented in the upper-right panel of specification one in figure 4.8. Two years after the shock GDP reaches its peak level and starts declining, and by year five the effect has turned negative. GDP continues to decline even further and eight years after the shock has become statistically significantly negative. The effect during the peak, two years after the shock is approximately 0.4 percentage point increase in real GDP, which is substantial given the credit initially increased only one percentage point relative to GDP.

A shock to firm credit presented on the upper-right panel of figure 4.8 has a negative effect on GDP one year after the shock. However, the effect diminishes subsequently, and is no longer statistically significant by year six. The effect size one year after the shock is approximately -0.06 percentage points, which is insignificant compared to the effect of household debt.

The response of unemployment rate presented in the bottom panels of specification one has a similar pattern, but in the opposite direction. A shock to household credit lowers unemployment by approximately 0.2 percentage points one year after the shock. Two years after the shock unemployment reaches its minimum, being reduced by approximately 0.4 percentage points as a result of the shock. The effect reverses quickly, seven years after the shock unemployment has already increased statistically significantly. For firm debt, there is almost no visible effect, however initially there is a statistically

significant reduction in unemployment, therefore even the extension of firm credit may have a stimulus effect on unemployment.

The results from the second specification are discussed next. On the top panels of specification two in figure 4.8, the response of GDP growth to a shock in credit acceleration is shown. A shock to household debt acceleration increases GDP growth by approximately 0.5 percentage points initially. After the shock, the increase in GDP growth gradually fades becoming statistically insignificant four years after the shock. Overall, the effect is a substantial increase in GDP, the increase is much higher than the unit shock to credit produced. Firm debt acceleration has a more modest, but similar effect to real GDP growth. In the first year GDP growth rises by approximately 0.06 percentage points, which after the effect disappears. Therefore, even firm debt acceleration appears to have a stimulus effect on GDP growth.

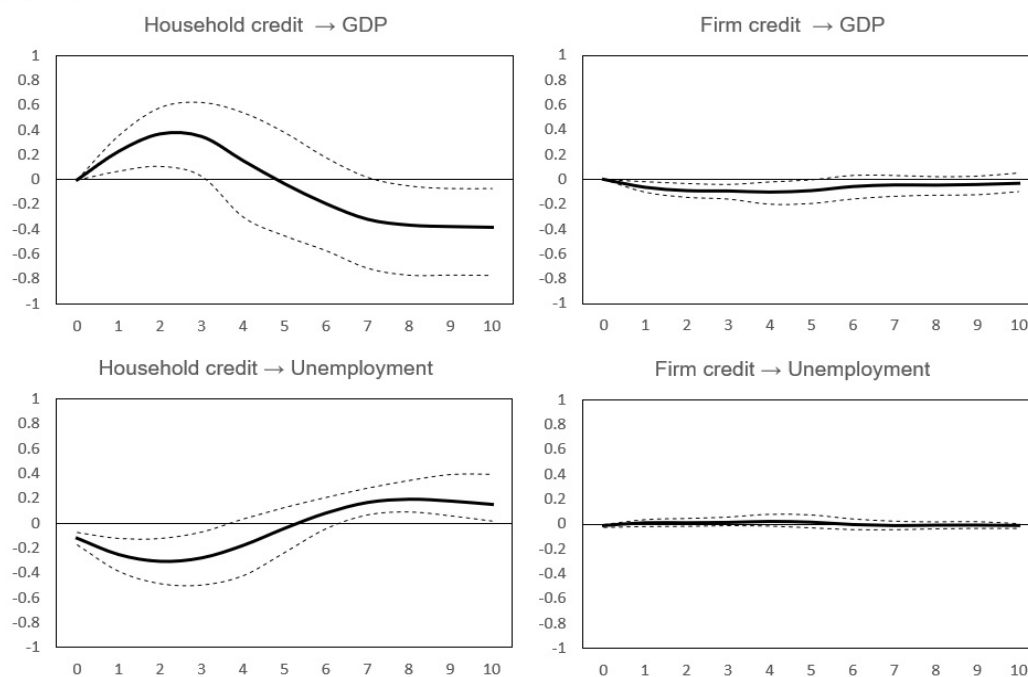
The effect of a shock to debt acceleration on change in unemployment is shown on the bottom panels of the second specification, in figure 4.8. The panels reveal that shocks to debt lower unemployment in the short run. A shock to the household debt initially decreases unemployment by 0.2 percentage points, and keeps reducing unemployment for the following two years. The effect gradually declines and eventually in year five the shock starts increasing unemployment. A shock to the firm debt only lowers unemployment statistically significantly initially, the effect is a modest 0.03 percentage point decrease in unemployment.

Finally, specification three shows only the response of house prices, given a shock to acceleration of household debt. The response reveals that initially house prices rise approximately 1.86 percentage points in response to unit shock to acceleration of household debt. In the second year household prices increase by further 1.6 percentage points. After two years the response declines and is no longer statistically significant. While the responses of other variables are not reported for being redundant or irrelevant, the effects of household debt were also consistent with the second model and also Kindleberger's (2005) argument that house prices are associated with higher GDP.

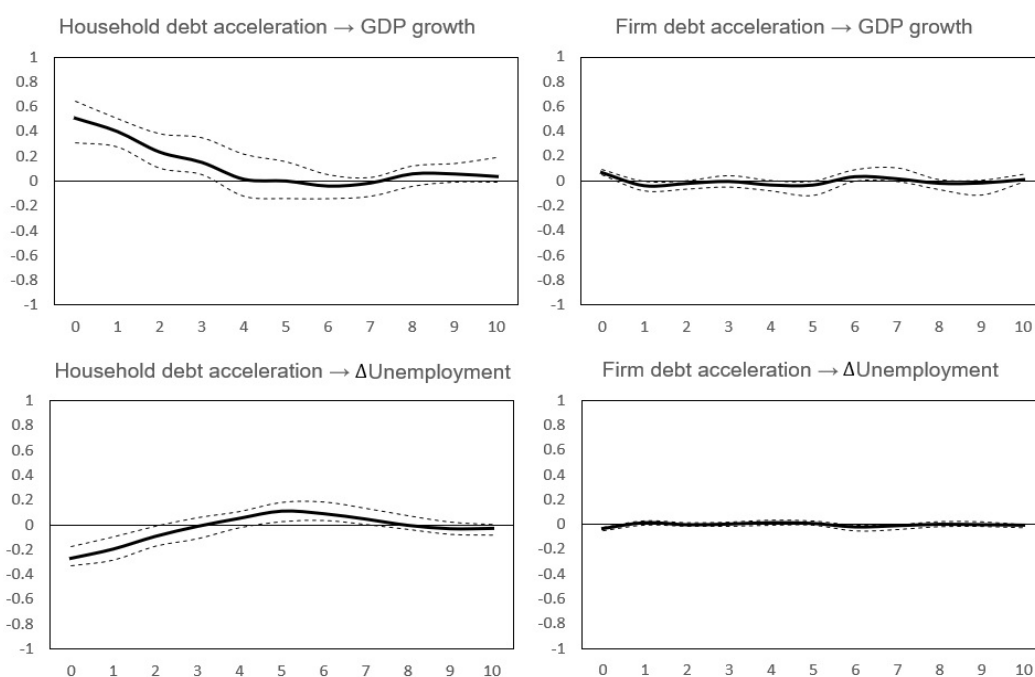
The robustness check by local projections shown in figure 4.9 reveals similar results as the VAR analysis in most cases. There are a few relevant differences. Firm debt acceleration does not have a statistically significant effect on the change in unemployment initially when the shock hits. On the other hand, firm credit does have an immediately depressing effect

on unemployment, which was not the case in the VAR specifications, since contemporaneous effects were not included in the VAR specification. The effect sizes of the different shocks are also somewhat different for the local projections, and some of the longer run effects deviate from the VAR specification as was the case in Mian et al. (2017). Most importantly, the PVAR analysis reveals that Keen's (2017) argument that private debt may explain changes in the other macroeconomic variables has in general held. Further, the model gives more evidence for Gjerstad and Smith's (2014) and Kindleberger's (2005) general argument that increase in debt may be associated with asset bubbles. The debt has what could be defined as a stimulus effect on the economy. Household credit extension in the short run boosts GDP per capita, reduces unemployment and increases house prices. While it is somewhat of an open question whether only household debt has the effect, based on the results firm debt appears to also have a modest stimulus effect in the short run.

Specification 1:



Specification 2:



Specification 3:

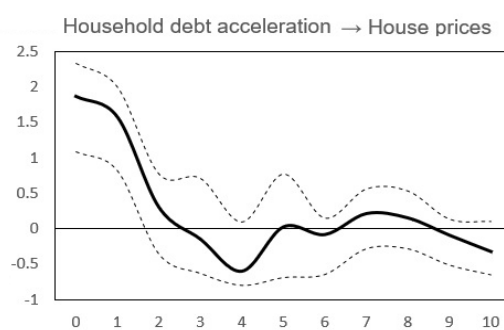
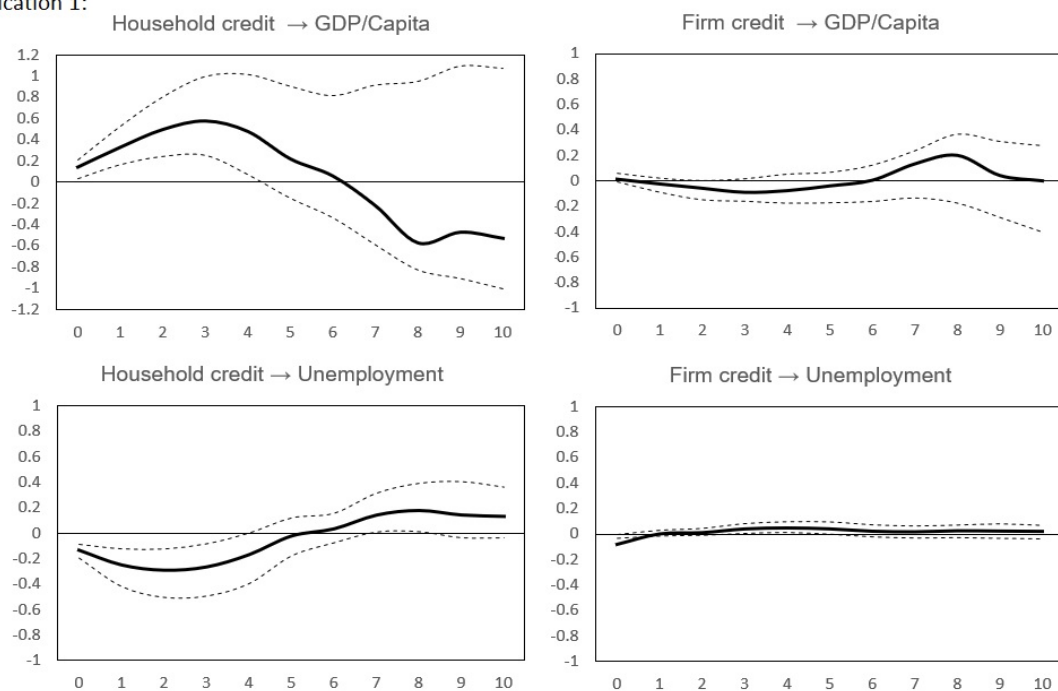
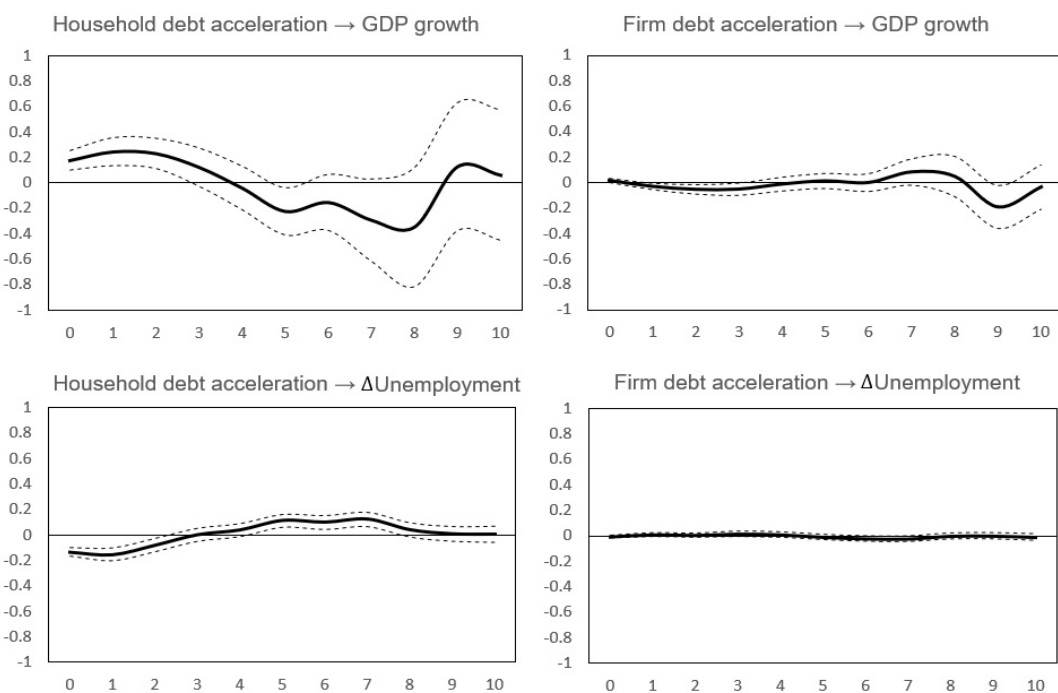


Figure 4.8. VAR impulse responses. GDP is defined as a per capita measure.

Specification 1:



Specification 2:



Specification 3:

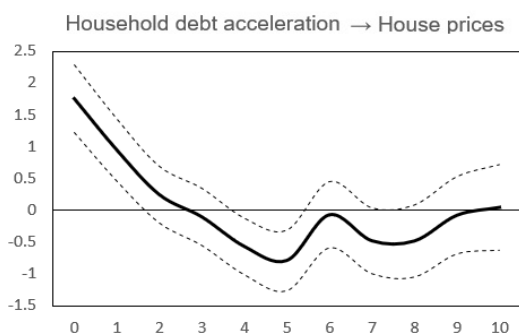


Figure 4.9. Local projection impulse responses. GDP is defined as a per capita measure.

5. Discussion and Conclusions

5.1 Discussion

Keen (2017, Chapter 4) states that we cannot have another financial crisis. This is because of the high amount of debt, and the rapid credit extension among many countries. Keen places the threshold where countries are at risk at over 150 percent debt-to-GDP ratio and over 10 percent averaged credit growth rate over the past five years, using the BIS data. Currently the countries particularly at risk are the countries where debt increased during the Great Recession. China and Australia are some of the highest risk countries.

The analyses in this thesis as well as generally have found that private debt has economic consequences. If the view is accepted, the next question of interest is how to address the issue. Some of the debt researchers including Keen (2017) have proposed different solutions, however, rigorous analysis on the possible solution has not been undertaken, and the implementational details regarding the solutions are incomplete.

Keen (2017, Chapter 6), citing research such as Bezemer (2011), Hudson (2009), King (2016), Mian and Sufi (2014), King (2016), Schularick & Taylor (2012), Turner (2016) and Wolf (2014) summarizes two basic solutions. The first solution is to use the central bank's capacity for money creation, which will dilute the existing amount of private debt. An interesting adjustment in the idea is that the money injections provided by the central bank could be directly targeted to personal bank accounts, instead of using open market operations. Another solution is to lower the amount of existing debt by forgiving the debt.

Keen (2017, Chapter 6) proposes that the two approaches of debt forgiveness and monetary easing could be melded together by using money injections to personal bank accounts, however the first mandatory use of the injection would be to pay down existing debt. This would mean a much less substantial money injection would be necessary to pay down debt. However, this approach still does not address the causes and potential problems associated with high levels of private debt.

To also address the cause and some negative consequences of debt, which is perhaps the favorable approach, Keen (2017) proposes additional solutions. The first solution is to limit bank lending by preventing banks from lending above the income generating capacity of an asset. Keen's (2017) second solution is a new type of bank loan called *Entrepreneurial Equity Loan* (EEL). The EEL loan is meant to direct more credit towards

potentially profitable entrepreneurial activity rather than asset speculation such as house price speculation. In this type of loan a bank takes equity positions in a business, but credit is still extended and therefore money is created. Further, Keen (2017) suggests that private debt should become an active policy target just like unemployment or inflation.

The possible solutions may also involve changing how banks operate. Some have suggested that the money creation capacity should be removed from private banks. Keen (2017) believes the solution is too radical. In the future the different types of solutions should be studied in order to find resolutions to the issue of excessive private debt burden and the associated economic crises. Currently the research is focusing on the effects of debt, and solutions are usually presented only to the question of how to deal with the deleveraging process once it occurs (for example IMF (2012)). Interestingly, most of the researchers generally oppose bank bailouts for various reasons, so even the matter of response may not be settled (Mian and Sufi, 2014).

Another aspect of private debt which has not gathered attention in studies is the relationship between different forms of debt. As Keen's hypothesis outlines, bank credit based debt which creates more money in an economy has different properties than other types of debt. The distinction has not been of much interest in the research, and there possibly are even larger differences between the different forms of debt than between household debt and firm debt. The differences between the different forms of debt should be studied in the future in order to gain a better understanding of how debt affects other macroeconomic variables.

Further, it may be worthwhile to repeat particularly the analyses studying the dynamics of debt using quarterly instead of yearly data. Economies react to changes quickly, and the reason why it may appear that firm debt does not have a short-run stimulus effect in some of the specifications is that the effect has already dissipated in one year. Shorter intervals can capture dynamic relations in more detail.

Econometrically, endogeneity issues perhaps warrant an inspection in the research. Most likely the most significant issues in the private debt research are the endogeneity issues where a common cause may explain both the increase in debt and the change in other macroeconomic variables under study. This is a certain possibility for the models presented in the thesis, some unnoticed variable which creates high growth, low unemployment and high debt could bias the results. The issue also extends to whether the

models can be interpreted causally or only as detailing a historical association. For example, Mian et al. (2017) note that the VAR specification is not meant to convey causal relations, rather the results of the analysis can be interpreted as describing an estimate for the dynamic relation in the past. It is hopeful that particularly the possible endogeneity issues will receive more attention in the future, and that a better understanding of the causal relations is gathered.

Finally, based on the research Keen's (2017) arguments seem at least plausible. The questions regarding private debt have also become more relevant today than before for the reason that the level of debt has reached historically very high levels in many countries. Arguments such as Keen's (2017) warrant more inspection in the future.

5.2 Conclusions

This thesis presented Keen's (1995) model of Minsky's instability hypothesis, which shows that it is possible to create a dynamic model of an economy where addition of private debt to the model alters it significantly, even producing economic crises. The research by Kindleberger (1975) and others have shown that empirically private debt has been connected to formation of asset bubbles and crises such as the Great Recession, also showing that private debt may be an important macroeconomic factor to consider in an economy.

The three research questions related to private debt that the thesis analyzed using panel data models were given an answer that is consistent with Keen's (2017) point of view.

First, private debt is associated with lower economic growth, as shown by similar methodology to Reinhart and Rogoff's (2010) analysis for public debt and an LSDV regression model. The LSDV models show that a 100 percent increase in the private debt-to-GDP ratio above the threshold of 35 percent is associated with a 1.5 to 3.2 percentage point drop in real GDP growth, which is substantial given that currently in the 17 developed countries analyzed the average debt-to-GDP ratio is approximately 110 percent. The negative effect appears stronger than the effect of government debt.

Second, similar methodology to IMF (2012) shows that the recessions which are preceded by high credit extension and followed by deleveraging have been deeper than other recessions. The drop in GDP is almost four percentage points higher five years after the recession compared to a recession in the low debt run-up and low debt run-down

category, in addition being statistically significantly lower compared to the other categories. The result is similar for real consumption as real GDP growth.

Third, panel VAR analysis shows that private debt has what could be characterized as a stimulus effect on real GDP per capita and unemployment. Both changes in household debt as well as the acceleration of household debt have predicted higher growth rates, lower unemployment and higher house prices. Firm debt appears to have a similar, but much more modest, effect.

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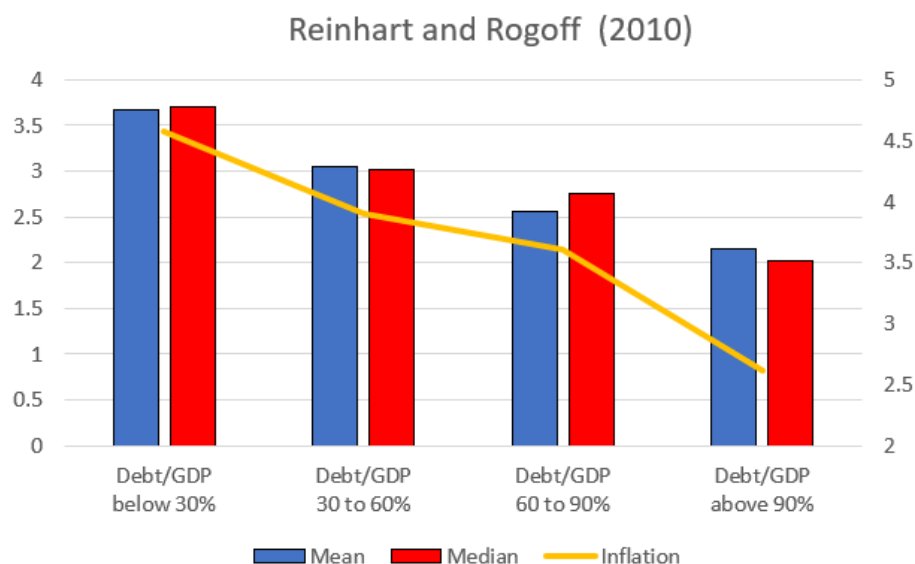
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Appendix.

Appendix A) Reinhart and Rogoff's original analysis recreated from Jordà-Schularick-Taylor database.



Notes: This is the original Reinhart and Rogoff's analysis recreated for public debt, using data from the Jordà-Schularick-Taylor Macrohistory Database. Real GDP growth is on the left, inflation on the right. Inflation is reported as an average.

Appendix B) Segmented LSDV-model, alternative specification.

Models	Total loans / GDP	Dependent variable: Real GDP Growth		Government Debt/GDP	F.E	T.D	Trend	O
		When below 35%	When above 100%					
Model 1	-1.1***			-1.3****				
Model 2	-1.4****			-1.6****	X			
Model 3	-0.6			-1.8****	X	X		
Model 4	-3.5****			-1.8****	X		XE	
Model 5	-0.4			-1.4****	X	X		X
Model 6	-1.2***			-1.5****	X			
Model 7	-1.1*			-1.9****	X	X		
Model 8	-3.2****			-1.4*	X		XE	
Model 9	-0.8			-1.4****	X	X		X
Model 10	-2.1****	4.6****						
Model 11	-2.7****	4.9****			X			
Model 12	-1.5*	3.0**			X	X		
Model 13	-3.4****	-4.7			X		XE	
Model 14	-1.0	0.2*			X	X		X
Model 15	-2.1****	0.3***		-1.1****				
Model 16	-2.6****	4.1***		-1.0***	X			
Model 17	-1.7**	2.1*		-1.5****	X	X		
Model 18	-2.8****	-5.8		-1.0**	X		XE	
Model 19	-1.6**	1.4*		-1.7****	X	X		X
Model 20	-0.9	0.2	-1.1		X	X		X

Notes: F.E. indicate country fixed effects, T.D times dummies and O outliers of below or above 20 percent growth. The trend is a country-specific second order polynomial.

Statistical significance of the break points is tested as a change from the primary effect (first column). The coefficients are interpreted as the slope of the regression line in each category. Empty cells denote that the effect is not included in the model.

Minimum/maximum in bold. Models 1 to 5 estimated separately for public and private debt. The independent variables are lagged by one year. Source: Jordà-Schularick-Taylor database.

Appendix C) On creation of figure 2.1.

The data from from 1946 onwards is taken from Federal reserve board's financial accounts guide's debt series D3. The data includes total household and business debt, but not non-financial debt. From 1916 to 1945 the debt data is taken from US Census' *Historical Statistics of the United States, Colonial Times to 1970*. The series that is used is the total private debt series, since the financial sector debt is impossible to separate from a certain date onwards. The effect of non-financial debt for the dates it can be separated is small. From 1834 to 1915 there is no direct data on debt available, instead bank loan data from *Historical Statistics of the United States, 1789 – 1957* is used. All the series are correlated quite highly, however a level difference is observable, which has been fixed by scaling.

The nominal gross domestic product data from 1952 onwards is obtained from federal reserve board's quarterly series. Historically, gross domestic product did not exist as a concept until 20th century. The longest series recorded by BEA has records back to 1929. However, Louis Johnston and Samuel H. Williamson have inferred gross domestic product data all the way back to 1790 from various sources.

Appendix D) Data used in the analyses.

Analysis	Dataset	Countries included	N	n
Reinhart and Rogoff (2010) extended to private debt and the segmented LSDV model. (Section 4.2)	Jordá-Schularick-Taylor Macrohistory Database	Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland	17	2282
Dummy variable analysis following IMF (2012). (Section 4.3)	Jordá-Schularick-Taylor Macrohistory Database. Recession dates from Howard et al. (2011).	Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland	17	782
Panel VAR analysis and local projections. (Section 4.4)	Private debt data and real house prices by BIS. Harmonized unemployment data from OECD. GDP data from Maddison database.	Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States	26	600/574/349

Note: the 600/573/349 refers to the data used in specification 1, 2 and 3 of the panel var analysis.