STOCKHOLM SCHOOL OF ECONOMICS

Department of Economics

5350 Master's Thesis in Economics

Academic Year 2016-17

Government Spending Multipliers in a Liquidity Trap: Evidence From a Panel of Advanced Economies

Robert Boyle (40912)

Abstract

When interest rates are close to their zero lower bound, much of New Keynesian theory suggests that government multipliers are elevated and provides clear mechanisms that generate these larger multipliers. However, empirical evidence on both the size of multipliers and the predicted channels is more mixed. Previous research has not focused much on the liquidity trap episode that followed the 2008 crash. Additionally, much of the research into output multipliers dependent on the binding lower bound has only considered the economies of the United States and Japan. This thesis sheds new light on the effects of government spending at the zero lower bound. To do this, it uses local projection methods to empirically investigate multipliers during the post-2008 liquidity trap for a panel of advanced economies (Euro Area, United Kingdom and United States). This research finds that multipliers are enlarged when rates are close to the lower bound. While there is some evidence that multipliers are larger in liquidity traps that have a longer expected duration, there is limited evidence of the expected inflation channel.

Keywords: Government spending, liquidity trap, New Keynesian, state-dependent, local projection
JEL: E12, E52, E58, E62, E63

Supervisor: Jesper Lindé
Date submitted: 15th May 2017
Date examined: 30th May 2017
Examiner: Johanna Wallenius
Discussants: Amanda Löfgren & Bensam Solomon

Acknowledgements

I am very grateful to Jesper Lindé, my supervisor, who gave excellent help, advice and guidance throughout the process, as well as providing some extremely helpful Matlab code.

I would also like to thank other students for their insightful feedback, both during seminars and elsewhere.

I would particularly like to thank my family, especially my parents, and friends for all the support they have given me throughout my studies.

Contents

List of Figures

List of Tables

1 Introduction

Since the beginning of the financial crisis in 2008, discussion of how effective government spending is at boosting output has only increased in prominence. Beforehand, due to much research on the subject, it was thought that the response of output to increase in government spending was relatively muted. However, this was in a macroeconomic environment in which the nominal interest rates set by central banks were not close to their zero lower bound (hereafter ZLB). After central banks slashed interest rates to very low levels in response to the crash, some commentators argued that governments should embark on a large increase in government spending. This was in part because monetary policy could no longer stabilise the economy on its own, but also because many New Keynesian models suggest that government spending multipliers are larger at the ZLB. This is because monetary policy tends to be more accommodative in this situation.

While the view that government spending is very effective in a liquidity trap is not universally shared in the theoretical literature, it is an implication of a majority of models, such as those presented in Christiano *et al.* (2011) and Woodford (2011), as well as model simulations by Coenen *et al.* (2012). However, the empirical evidence is on the size of these multipliers is more mixed. Some, such as Ramey & Zubairy (2014) and Miyamoto & Nguyen (2016), find that multipliers are larger when interest rates are near the lower bound, while Crafts & Mills (2013) and Ramey (2011b) suggest that there is no difference.[1] Clearly there needs to be further research into this area. To this end, this study examines the effects of government spending on output depending on whether or not the lower bound on interest rates is binding, and evaluates whether these multipliers are in line with theoretical predictions.

The previous studies have perhaps been rather limited by the small number of liquidity trap episodes that can be studied and, perhaps for this reason, tend to focus on the United States and Japan or on episodes from the early twentieth century. For instance, a large part of the analysis in Ramey (2011b) is based on the ZLB episode after the Great Depression in the US. This thesis aims to shed new light on government spending multipliers by analysing the effects of government spending in the liquidity trap that followed the financial crisis of 2008 for a panel of advanced economies. It looks at output multipliers using data from the Euro Area, United Kingdom and United States. The advantages of this strategy are two-fold: firstly, as interest rates are still very low in these economies, this study has an advantage over other analyses of this post-2008 episode that are already completed as it uses a more up to date sample. Secondly, it examines the effects of government spending in the Euro Area and UK, which is not too common in the literature.

Following the analysis of output multipliers, this thesis goes on to examine whether multipliers are larger

[1] These papers (and others) are discussed more exhaustively in the literature review.

because of the mechanisms predicted by New Keynesian models. In particular, Woodford (2011) and others suggest that one of the key mechanism through which output multipliers are elevated is due to the inflationary effect of government spending.[2] Higher inflation causes a fall in the real interest rate when monetary policy is accommodative at the ZLB. This further stimulates output. Compared to the case where the ZLB is not binding, the central bank would respond to the increased output and inflation by increasing the nominal interest rate, thus crowding out private spending and choking off any large output multipliers. This is known as the expected inflation channel (Dupor & Li, 2015).

There is limited evidence for this channel in the literature, for instance in studies of Japan (Miyamoto & Nguyen, 2016) and the US (Dupor & Li, 2015; Roulleau-Pasdeloup, 2017). Therefore, it is worth examining this prediction further, for a panel of economies, by empirically testing whether expected inflation responds differently to government spending shocks depending on whether the ZLB on interest rates is binding.

Furthermore, given the forward-looking nature of agents in these models, Erceg & Lindé (2014) suggest that the output multiplier should be larger the longer the expected duration of the ZLB episode. If the expected duration is long, then monetary policy is expected to be accommodative for a long time, meaning that the policymaker will not raise rates and crowd out private spending. Given that liquidity traps have been persistent since the 2008 crisis, this issue is very relevant.

To my knowledge, the effect of the expected duration of the liquidity trap on the output multiplier has not been empirically tested before. Yet the standard New Keynesian model suggests that this mechanism is theoretically plausible. To this end, this study investigates whether multipliers depend on the number of periods in which the policy rate is expected to be close to the ZLB.

Given these issues and questions discussed, the overarching aim of this thesis is to examine the effects of government spending in different states and the drivers of differences in these multipliers.

The remainder of the thesis is structured as follows: section two provides an overview of the existing literature; section three provides a more in depth discussion of the theoretical channels; section four briefly outlines the data used; section five discusses the empirical strategy; section six presents the results; section seven then empirically examines some other predictions of the New Keynesian model; section eight discusses the results; and section nine concludes.

[2] Note that the theoretical basis behind all of the predictions discussed in this section are discussed in more depth in section 3.

2 Related Literature

There is a significant body of literature that attempts to calculate fiscal multipliers using a variety of different methods. These studies are predominantly based on government spending in the United States, but many have extended their analysis to other countries. In the large part, these studies find modest fiscal multipliers in the aggregate. However, after the onset of the financial crisis in 2008, which led to recession and liquidity traps, there was a renewed debate as to how best to aid recovery in the affected countries. There was an increased need to investigate whether fiscal policy was more effective in an environment in which the effectiveness of monetary policy had largely been exhausted compared to a situation where monetary policy was not accommodative. This section will first discuss the literature on aggregate fiscal multipliers and some of the methods used. It will then examine some of the theoretical models that predict large multipliers in a liquidity trap and in particular the inflation expectations mechanism. The section will end with a discussion of more recent empirical studies of the impacts of fiscal policy in a liquidity trap.

2.1 Aggregate Fiscal Multipliers and Identification Methods

One of the most crucial aspects when developing a strategy to estimate government spending multipliers is how to identify exogenous government spending shocks. This issue arises because, while the researcher wants to investigate the impact of government spending on output, it is clear that policymakers partly base their government spending decisions on macroeconomic conditions; there is reverse causality between government spending and output. Therefore, it is important to identify changes in government spending that are independent of the macroeconomic environment. Despite many different strategies used over a wide variety of countries, most studies find relatively similar multipliers to each other with Ramey (2011a), in her review of the multiplier literature, suggesting that most aggregate studies estimate multipliers ranging from 0.6 to 1.8. This is supported by the review undertaken by Hall (2009) who suggests multipliers tend to be within the range of 0.5 and 1. However, Ramey also notes that these multipliers tend to be relatively imprecise as the standard errors are quite large. This section will discuss some of the identification methods and some of the papers that they are used in.

Many researchers analyse the impact of government spending on economic variables using structural vector autoregression models, relying on timing restrictions to identify fiscal shocks. This approach is characterised by Blanchard & Perotti (2002) who argue that government spending should be ordered before output, or other endogenous macroeconomic variables, in the Cholesky ordering. This means that those variables do not affect government spending contemporaneously. They are therefore able to identify the fiscal shock as it implies that a change in government spending is not caused by changes in the macroeconomy in the same quarter. This analysis was undertaken for the United States and they found a positive, but small multiplier of 0.9. An advantage of this method is that it is relatively simple to implement and does not require a lot of data collection. The analysis was extended by Perotti (2005) to analyse other countries including the UK, Germany and Canada. He corroborates Blanchard & Perotti (2002) by showing that the impact was also positive and significant for those countries.

This identification method relies on the assumption that there are decision lags in fiscal policy. The argument is that it takes time both to understand that the economy has changed and to react by changing fiscal policy. If this is the case then macroeconomic variables do not contemporaneously affect government spending. However, this identification strategy has been criticised for the United States by Barro & Redlick (2011) and Ramey (2011b). They argue that a large part of spending automatically responds to cyclical variations in revenue. However, Miyamoto & Nguyen (2016) argue that this identification strategy may be more appropriate in other settings, in particular Japan. This identification approach is common in the literature as exemplified by Auerbach & Gorodnichenko (2012b), Auerbach & Gorodnichenko (2012a) and Fatás & Mihov (2001). Galí *et al.* (2007) use similar techniques, but with a larger model, and find smaller multipliers of around 0.5.

Another way of identifying shocks is to impose sign restrictions. Mountford & Uhlig (2009) employ a large scale SVAR model using sign restrictions. To identify shocks they employ a criterion function that finds the Cholesky decomposition that produces the impulse responses that best match their predicted signs. For instance tax revenue shocks are identified when the tax revenue response increases but the government spending response does not. Equally, government spending shocks are identified when government spending does increase, while tax revenue remains unchanged. Canova & Pappa (2011) also employ the sign restriction method for a panel of the UK, US and Euro Area (though they examine each country individually) and find that, while they could not reject aggregate multipliers different from one, the effectiveness of fiscal policy does depend on the extent of monetary accommodation in the economy.

Others have attempted to identify the government spending shocks by exploiting variation in military spending, using it as an instrumental variable. The idea is that changes in defence spending are determined more by geopolitical events than by the domestic economy. If this is the case then changes in military spending could be treated as exogenous. Some identified shocks in this manner and estimated fiscal multipliers using a simple regression. Hall (2009) and Barro & Redlick (2011) both find multipliers below one over a long time period, with Hall finding 0.55 for the 1930-2008 period and Barro & Redlick finding multipliers ranging from 0.59 to 0.77 after extending the data to 1917. However, Ramey (2011a) notes that it is possible that the events leading to higher government spending could have further influences on the economy other than the impacts of increased government spending, for instance when governments introduced rationing during the Second World War. Further there are other clear drawbacks with this method, particularly outside the US. There tends to be limited variation in defence spending and defence spending makes up a relatively small share of the overall budget in other countries. These two factors might indicate that it is a poor instrument for other countries.

Some authors have gone further with the defence spending approach and have looked to build a narrative by identifying episodes where there were large build-ups in military spending. For example Ramey & Shapiro (1998) analyses the Korean War, the Vietnam War and the Reagan period. Ramey (2011b) developed a defence news series that focuses on unanticipated changes in government spending that are linked to political and military events.[3] She finds that the multiplier for the US ranges somewhere between 0.6 and 1.2. However, as she focuses on military build-up periods, this rather limits the sample that can be used. Others that use the narrative approach include Eichenbaum & Fisher (2005) who take the military build-up after 9/11 as exogenous government spending and Fisher & Peters (2010) who use excess market returns of military contractors as a proxy for government spending, under the logic that increased military spending would increase the stock returns of the military contractors.

As an additional point, numerous studies have argued that many of these methods on their own, in particular the Blanchard & Perotti (2002) VAR approach, are invalid as they do not account for anticipated government spending. If government spending is anticipated in the periods before the stimulus is enacted, then private agents are likely to have reacted to these predictions, thus leading to bias in the estimation of the effect of government spending on output. Critics of methods that do not take expectations into account include Ramey & Shapiro (1998), Ramey (2011a) and Leeper *et al.* (2013). A number of adjustments have been proposed to counter this, including adding a forecast of government spending into the VAR or using the difference between actual government spending and forecasted government spending, as in Auerbach & Gorodnichenko (2012b) or by estimating a fiscal rule and taking the residuals as the unanticipated government spending shock, as in Corsetti *et al.* (2012) and Miyamoto & Nguyen (2016).

While the validity of all of these methods can be argued, much of the applications discussed above have been in aggregate settings. However, it is important to consider that multipliers might be different depending on the state of the economy, both theoretically and empirically.

[3] It is necessary to measured unanticipated changes as she showed that some changes in US military spending are anticipated several quarters before they actually occur. If this is the case then agents will have already made decisions based on a large expected change in government spending. Therefore the effect in the period of spending will be biased.

2.2 Theoretical Models of Fiscal Multipliers in Liquidity Trap

After nominal interest rates fell near to their ZLB following the 2008 financial crisis, many worried that the aggregate multipliers discussed above were not valid for the specific environment that many advanced economies found themselves in. Given the change in situation, there has been increased research into the effects of fiscal policy in different states of the economy. There has been a lot of theoretical research into the effects using New Keynesian dynamic stochastic general equilibrium (DSGE) models to investigate fiscal multipliers in a liquidity trap environment, in particular whether multipliers are larger in states in which monetary policy is accommodative. As the aim of this thesis is to empirically examine the effects of government spending depending on the state of the ZLB, it is important first to consider the theoretical predictions. This section will give a brief discussion of some of the theoretical ideas, while section 3 will provide a more in depth discussion of the theory based on the model in Erceg & Lindé (2014).

Many researchers, such as Christiano *et al.* (2011), find theoretical support for larger multipliers at the ZLB. However, before discussing the mechanisms they posit, it is worth considering why the ZLB is important. They consider an economy which is hit by a large fundamental shock, which reduces the real potential interest rate. If the shock is so large, then the potential rate becomes so low that the central bank cannot set a policy rate low enough to close the output gap; the potential rate becomes unobtainable. Therefore, at that point in time there is a discrepancy between the actual and potential interest rate. Now, if the government increases fiscal spending, there will be a slight increase in the real potential rate. However, the difference in monetary response is crucial. When the ZLB is not binding, the policymaker would respond by raising the policy rate, which crowds out private spending. But when the ZLB is binding and the policy rate is already too high, the central bank would not raise the policy rate in response to this slightly higher potential rate.

Christiano *et al.* (2011) discuss the two mechanisms through which government spending increases output in the New Keynesian model. The first one is closely related to the above discussion in that monetary policy is more accommodative at the ZLB. This means that private spending is not crowded out, so government spending increases output more when the ZLB is binding.

Secondly, as increased government spending leads to a larger output gap at the ZLB, production and demand for workers rises This increases marginal cost and, since some firms cannot raise prices immediately due to price stickiness, leads to higher expected inflation.[4] There is higher expected inflation because the firms will raise their prices in the future in response to the higher marginal cost. In a liquidity trap, the increase in expected inflation reduces the real interest rate, leading to a rise in private spending. This produces a virtuous circle

[4] This mechanism is explained in more depth in section 3.

where increased private spending leads to increased inflation expectations. This is known as the expected inflation channel (Dupor & Li, 2015). This second mechanism is more controversial than the first, and indeed the large multipliers found in the baseline specification of Christiano *et al.* (2011) are largely driven by the expected inflation effect.[5]

Indeed, Woodford (2011) also shows theoretical support for the inflation expectations channel of the fiscal multiplier. He argues that multipliers are larger when the liquidity trap is expected to last longer, as monetary policy would be accommodative for a longer period of time.[6] Whereas, after the liquidity trap is over, policy will then follow a Taylor rule, meaning that the monetary authority's response to government spending would lead to some crowding out of private spending. Coenen *et al.* (2012) (in a study of seven different DSGE models) and Davig & Leeper (2011) also provide theoretical support for larger multipliers and the expected inflation channel.

Given that multipliers differ depending on the expected duration of the liquidity trap, as noted by Woodford (2011), it is important to consider what determines the expected duration. Unlike many other studies, Erceg & Lindé (2014) develop a model where the duration of the liquidity trap is determined within the model. In particular, the duration depends on the length of time at which the real potential interest rate is unobtainable. They argue that government spending affects the duration of the ZLB episode, as the real potential rate is determined by the extent of government spending. Small increases in government spending in a liquidity trap can have large multiplier effects, but these multipliers diminish as the size of the fiscal stimulus increases and the expected duration of the liquidity trap falls. Again, this paper provides theoretical backing of the two channels of the fiscal multiplier, but acknowledges that government spending can help policymakers to lift the nominal interest rate off the ZLB. This is an interesting finding as, at times during the post-2008 liquidity trap episode, the expected length of the liquidity trap has been long, indicating that there should be large fiscal multipliers.

However, the literature is far from unanimously supporting the discussed mechanisms for generating large multipliers, the expected inflation channel in particular. Roulleau-Pasdeloup (2017) augments the standard New Keynesian model to include search and matching frictions, including downward nominal wage rigidities. In the face of the same fundamental shock as discussed above, this model generates larger output multipliers at the ZLB, but smaller increases in inflation. This is predicated on the assumption that a ZLB episode is accompanied by a large degree of slack. As a recession tends to involve disinflation, downward nominal wage rigidity implies that the recession causes real wages to rise. As firms cannot cut nominal wages, they are more likely to adjust to the new situation by reducing quantities rather than prices, in this setting. Therefore, there is a greater fall in

[5] They find a multiplier of 3.7, which are around three times larger than their standard multiplier.
[6] As agents are forward-looking in these models, expectations are important.

employment in a recession in a setting with downward wage rigidities compared with flexible prices.

In the model presented by Roulleau-Pasdeloup (2017), a government spending shock leads to an increase in demand for final goods, which creates a demand for workers. In the case where there is more unemployment (in the recession), it is easier, and less costly to recruit additional workers as the potential employees have less bargaining power. Therefore, there is a smaller effect on real wages, and thus marginal cost and inflation. Conversely, in the case of an economy in expansion, where government spending leads to a comparatively larger increase in inflation, the monetary policymaker (following its Taylor rule) responds by increasing the nominal interest rate. This leads to a dampening of the increase in output compared to the recession case, where there is not the same large increase in the policy rate. The paper argues that the larger multipliers at the ZLB are less due to any inflationary effects of government spending and more to do with the ease of recruiting workers.

The above discussion is based on a liquidity trap driven by a fundamental taste-shock that reduces the potential real rate. However, there is a small literature that discusses liquidity traps driven by confidence shocks. Indeed, Mertens & Ravn (2014) discuss an expectations-driven liquidity trap. In this model, the liquidity trap arises as agents face a confidence shock, suddenly becoming more pessimistic about their future income, causing consumers to desire less consumption. Because of nominal rigidities, firms counter this by reducing prices and output. In response, the monetary authority must cut nominal interest rates, as otherwise the lower inflation would lead to higher real rates and further saving. A sufficiently large confidence shock will lead the nominal interest response to be constrained by the ZLB. This means that the real interest rate is too high, indicating an excess desire to save. Consequently, there are further decreases in consumption, prices and therefore the real interest rate, inducing an even greater desire to save. This continues in a vicious circle until incomes fall by enough to eliminate the excess saving.[7] This sequence of events, which results in lower incomes, actually confirms the initial pessimism.

While Mertens & Ravn (2014) note that the outcome of this type of liquidity trap is not dissimilar to the outcome in a fundamental shock-driven trap, the effects of fiscal policy differ dramatically. Crucially, in the expectations-driven case, fiscal stimulus leads to disinflation. This produces an increase in the real interest rate, which crowds out the private sector and further reinforcing their pessimistic expectations. In this case, government spending multipliers are lower at the ZLB compared to normal times and, in particular, the expected inflation response to government spending is the opposite of the response predicted by the New Keynesian models discussed earlier. In fact, Aruoba *et al.* (2016) estimate a model that suggests that the Japanese liquidity trap is more likely to be due to low confidence rather than a shock to fundamentals. However, they suggest that

[7] This is similar to the paradox of thrift where higher desired savings in aggregate decreases aggregate demand such that actual savings decrease in equilibrium.

the post-2008 liquidity trap in the United States was less likely to be caused by low confidence, and more likely to be fundamental.[8]

Others that have criticised the large multipliers predicted by the New Keynesian model include Kiley (2016) who suggests that predicted multipliers are more plausible in a model that considers sticky information (as first proposed by Mankiw & Reis (2002)) rather than sticky prices[9]. Nevertheless, sticky-price models are much more common in the theoretical literature and it is worth testing their implications.

Clearly there is some disagreement about the implications of government spending at the ZLB. While a majority discuss a liquidity trap generated by a fall in the real potential rate, some suggest models where the liquidity trap is caused by persistently low expectations. Given the extremely different implications of government spending in these models, it is worth investigating fiscal multipliers empirically. If large multipliers at the ZLB are found, not only would it suggest that fiscal policy should be more expansionary in these liquidity traps, but it would also lend support to the fundamental liquidity trap theories, at least for the episodes investigated.

2.3 Empirical Analysis of Fiscal Multipliers and Expected Inflation Channel

Given the theoretical dispute over the impact of government spending on output at the ZLB, it is important to analyse these theories by empirically estimating fiscal multipliers across different states of the economy.[10] This section will review some of the studies that investigate state-dependent multipliers.

While the focus of this thesis is on the impact of fiscal policy in a liquidity trap, much of the state-dependent multiplier literature focuses on other types of state. For instance Auerbach & Gorodnichenko (2012b) find that multipliers are larger in a recession than in an expansion in the United States. Auerbach & Gorodnichenko (2012a) then extend that analysis to a panel of OECD countries and find similar results. Others, such as Gordon & Krenn (2010) and Fazzari *et al.* (2015) have measured multipliers for the United States depending on the extent of slack in the economy. Again, they find that multipliers are larger in slack states. Conversely, Ramey & Zubairy (2014) do not find evidence for differences in multipliers across states of unemployment. It is important to note these papers as there is a wide literature on state-dependent multipliers, and the methods used in these studies are also applicable to measuring multipliers depending on the state of the policy rate.

Research into the effects of government spending at the ZLB has produced more mixed results. Alongside estimating multipliers in different states of unemployment, Ramey & Zubairy (2014) also investigate whether

[8] Additionally, others such as Cogan *et al.* (2010) and Drautzburg & Uhlig (2011) show that multipliers might only be slightly larger in a liquidity trap scenario.

[9] In fact, Chung *et al.* (2015) present some evidence to suggest that a sticky-information model might fit the US data just as well as a sticky-price model.

[10] That is, whether fiscal multipliers differ in a state where the ZLB is binding compared to a state where it is not binding.

multipliers differ when the nominal interest rate is near its ZLB using data from the United States. Using the Ramey (2011b) defence news series as the measure of fiscal shocks, they exploit both the recent ZLB episode and the period after the Great Depression. In fact, they find that multipliers are higher at the ZLB. However, these multipliers are low, and much lower than those predicted by theoretical models (Christiano *et al.*, 2011; Woodford, 2011). They argue that monetary accommodation does not necessarily make fiscal policy very effective.

In fact, there are others who find that multipliers do not differ across ZLB states. For example, Crafts & Mills (2013) find multipliers below unity even when interest rates are near zero for the UK, using a quarterly sample between 1922 and 1938. Indeed, Ramey (2011b) also estimates her model for a subsample of US data between 1939 and 1951 and does not find larger multipliers for this period. On the other hand, Sheremirov & Spirovska (2015) estimate the effect of defence spending for a panel of 100 countries. They find that multipliers are greater when monetary policy is more accommodative or if fiscal policy is debt-financed rather than tax-financed. While these studies use the defence news identification strategy, Cwik & Wieland (2009) notes that methods based on defence news typically result in smaller multipliers than models based on a Cholesky decomposition, thus emphasising the importance of the identification strategy.

One of the issues with estimating multipliers at the ZLB is the limited experience of ZLB episodes in advanced economies. This is evident, given the number of studies into multipliers using early 20th century ZLB episodes. To this end, a number of studies have used the Japanese environment to investigate the impact of government spending at the ZLB. This is because it has had a longer period at the ZLB than most. Indeed, Miyamoto & Nguyen (2016) estimate multipliers in a liquidity trap and non-liquidity trap environment using a regime-switching model. In fact, they find evidence that multipliers are larger in a liquidity trap compared with normal times (1.5 compared to 0.6).[11]

In addition, Wieland (2017) investigates the impact of the negative supply shock resulting from the Great East Japan Earthquake. New Keynesian theory suggests that, at the ZLB, capital destruction or government spending leads to higher marginal costs, which leads agents to expect prices rises and therefore higher inflation. This leads to lower real interest rates and large effects on output. He verified that expected inflation rose after the earthquake, while nominal interest rates did not, indicating a fall in real interest rate. However, Japan experienced a large fall in output following the earthquake. He argues theoretically that if it is the case that lower productivity (from the earthquake) is not expansionary, then government spending should not be able to crowd in private consumption. While not directly estimating fiscal multipliers, it critiques the idea that these

[11] Others use Japanese data to estimate multipliers dependent on the extent of slack in the economy. Auerbach & Gorodnichenko (2014) and Brückner & Tuladhar (2013) both find evidence of higher multipliers in periods of slack.

multipliers are large in a ZLB environment. However, caution should be applied when considering the Japanese case given the argument of Mertens & Ravn (2014) that the Japanese liquidity trap is different to those found in many other economies in that it is driven more by pessimistic expectations.

While evidence is mixed on state-dependent fiscal multipliers, others also investigate the channels of these multipliers proposed by the theoretical models. Researchers suggest that, if the expected inflation response to government spending does not differ across ZLB states, then the expected inflation channel can be ruled out. Roulleau-Pasdeloup (2017) extends the model in Ramey & Zubairy (2014) to examine the expected inflation channel and finds that inflation rises at a greater rate in normal times compared to a liquidity trap. This finding leads him to develop the model with labour market frictions that was discussed in section 2.2. While Miyamoto & Nguyen (2016) find that CPI inflation expectations respond positively to fiscal shocks at the ZLB, compared to a negative response when monetary policy is not accommodative.

Another to investigate this expected inflation channel is Dupor & Li (2015) who extends the analysis of the effects in a liquidity trap to periods in which monetary policy was passive rather than active. It is argued that, before Paul Volcker became Chairman of the Federal Reserve, US monetary policy was passive in that it responded to increases in inflation with a less than proportionate increase in nominal interest rates,[12] thus decreasing real interest rates and leading to further inflation. They suggest that the response in a liquidity trap, where monetary policy does not respond to government spending, is just an extreme version of passive policy and that it is valid to examine if fiscal policy was more effective at boosting output in the pre-Volcker periods. They identify government spending shocks using the Fisher & Peters (2010) series and find that government spending did not have a substantial inflationary effect during the passive policy era. While their consumption multipliers have large standard errors making it difficult to discuss state-dependent multipliers, their study does reject the expected inflation channel as a possible mechanism that could generate large multipliers. They then specifically look at the 2009 Recovery Act and find that a model with a high output multiplier would predict 5.23% inflation in the first year, while the evidence suggests that there was only 0.5% inflation.

Clearly, there is far from consensus about the effects of fiscal policy in different states of the economy. While there are many studies that show that the output multiplier is likely to be larger in ZLB states, there are also some that do not find much difference between the states. Therefore, it is important to further study the effects of fiscal policy in order to increase understanding of the validity of the predictions made by the theoretical New Keynesian models provided by authors such as Woodford (2011) and Christiano *et al.* (2011). Additionally, while much of the previous analysis has focused on the United States and to some extent Japan, there have also

[12] In other words, they did not follow the Taylor principle.

been liquidity traps in the Euro Area and UK since the financial crisis. This means that it is now possible to exploit more episodes and examine multipliers across more countries.

3 Theory of New Keynesian Fiscal Multipliers

With the help of a stylised New Keynesian model, this section will discuss the mechanisms through which government spending can lead to larger increases in output and inflation expectations in a liquidity trap. This theoretical discussion will form the basis of the predictions that will be investigated using the data. The model follows Erceg & Lindé (2014) who use a standard log-linearised version of the New Keynesian model with a zero bound constraint on interest rates. The benefit of this framework is that it allows exit from the liquidity trap to be determined endogenously by the model itself, rather than fixed arbitrarily.[13]

3.1 The Model

The model is outlined below where the eleven key equations discussed. The simple New Keynesian model can be largely characterised by the IS curve, which represents optimal decision-making by households; the New Keynesian Phillips curve, which represents optimal decision-making by firms; and the policy rule, which follows a Taylor rule when away from the ZLB and is equal to the negative of the steady state nominal interest rate otherwise. As all variables have been log-linearised, they are measured as either percent or percentage point deviations from their steady state levels.

Equation 1 describes the household decision in terms of the output gap and the real interest rate gap. The output gap x_t depends negatively on the extent to which the real interest rate $(i_t - E_t\pi_{t+1})$ is greater than its potential rate r_t^{pot} and the expected output gap in the following period. It depends inversely on the real interest rate gap as a high real interest rate would encourage consumers to save rather than consume in the current period. $\hat{\sigma}$ determines the sensitivity of the output gap to real interest rate deviations. Equation 2 shows that this sensitivity depends on the household's intertemporal elasticity of substitution in consumption σ, as it measures the willingness of households to respond to the deviation by changing their consumption decision; the steady state government spending share of output g_y, as output is made up of consumption and government spending, so the consumer response must be scaled by their share of output; and a small adjustment factor v_c.

$$x_t = E_t x_{t+1} - \hat{\sigma}\left(i_t - E_t\pi_{t+1} - r_t^{pot}\right) \tag{1}$$

[13] Much of the previous research had worked with models that imposed an exogenous end to the liquidity trap, for instance Eggertsson & Woodford (2003) and Christiano *et al.* (2011).

$$\hat{\sigma} = \sigma(1-g_y)(1-\nu_c) \tag{2}$$

Equation 3 describes the firms' price setting decision. Current inflation π_t depends on expected inflation in the next period and the output gap. The sensitivity to changes in the output gap depends on the composite parameter κ_x, which is described in equation 4. The model uses a Calvo-Yun contract structure where firms face a constant probability $(1-\xi_p)$ of being able to change its price in a given period. Equation 4 shows that the extent to which inflation responds to changes in the output gap depends on the probability of being able to re-optimise the price, as otherwise the firm would not be able to increase its price in response to greater demand, so inflation would not increase; and the sensitivity of marginal costs to the output gap φ_{mc}, as firms optimally maintain a constant mark-up on marginal cost so an increase in the output gap that leads to an increase in marginal cost will lead them to optimally increase prices. In fact, φ_{mc} is the sum of the absolute values of the slopes of the labour supply and labour demand schedules that would occur under flexible prices. This is shown in equation 5 where the sensitivity of marginal cost to the output gap depends inversely on the Frisch elasticity of labour supply $1/\chi$, as a large elasticity indicates that only a small increase in the wage is required to generate the additional hours worked required to meet the additional demand; inversely to the sensitivity of the output gap to interest rate changes $\hat{\sigma}$; and inversely to the labour share of production $(1-\alpha)$ as marginal cost responds to the extent that labour is actually used in production. It is important to note that for ease of explanation, a cost-push shock has not been included in the New Keynesian Phillips curve.

$$\pi_t = \beta E_t \pi_{t+1} + \kappa_x x_t \tag{3}$$

$$\kappa_x = \frac{(1-\xi_p)(1-\beta\xi_p)}{\xi_p}\varphi_{mc} \tag{4}$$

$$\varphi_{mc} = \frac{\chi}{1-\alpha} + \frac{1}{\hat{\sigma}} + \frac{\alpha}{1-\alpha} \tag{5}$$

Equation 6 shows that the nominal interest rate, set by the central bank, follows a Taylor rule in normal times where the policymaker raises rates in response to a positive output gap and to inflation. It is important that interest rates respond more than proportionately to a change in inflation so that the Taylor principle holds.[14]

[14] In response to an increase in inflation, the ultimate aim of policy is to increase real interest rates to reduce demand and thus inflation. If the policymaker increases nominal rates by less than the increase in inflation, then in fact real rates have risen, which leads to further inflation.

However, if that policy rule recommends a nominal interest rate below $-i$ then the economy is in a liquidity trap environment and that suggested policy rate is infeasible, so $-i$ is set. It is assumed that there is no interest rate smoothing in this model. While this assumption is less realistic, this strategy provides more clarity in explaining the mechanisms through which multipliers are expected to be larger.

$$i_t = \max\left(-i,\ \gamma_\pi \pi_t + \gamma_x x_t\right) \tag{6}$$

Potential output y_t^{pot} is described by equation 7 and is dependent on two exogenous shocks: a shock to consumption taste ν_t a shock to government spending g_t. Both of these shocks affect potential output positively and to the extent of that component's share of output. Both shocks are assumed to follow an AR(1) process, as seen by equation 9 for the consumption taste shock and equation 10 for the government spending shock.

$$y_t^{pot} = \frac{1}{\varphi_{mc}\hat{\sigma}}\left(g_y g_t + (1-g_y)\, \nu_c \nu_t\right) \tag{7}$$

It is assumed that $0 < \rho_\nu = \rho_g < 1$. Because of this, $(\nu_t - E_t \nu_{t+1})$ and $(g_t - E_t g_{t+1})$ are both positive when the shock is positive.[15] This means that the potential interest rate r_t^{pot} described in equation 8 varies directly with government spending and consumption taste shocks.

$$r_t^{pot} = \frac{1}{\hat{\sigma}}\left(1 - \frac{1}{\varphi_{mc}\hat{\sigma}}\right)\left(g_y\left(g_t - E_t g_{t+1}\right) + (1-g_y)\, \nu_c \left(\nu_t - E_t \nu_{t+1}\right)\right) \tag{8}$$

$$\nu_t = (1-\rho_\nu)\nu_{t-1} + \varepsilon_{\nu,t} \tag{9}$$

$$g_t = (1-\rho_g)g_{t-1} + \varepsilon_{g,t} \tag{10}$$

It must be noted that the government can issue nominal debt, so does not need to balance its budget in each period, as it can finance the budget deficit through borrowing. For completeness, equation 11 indicates the log-linearised government budget constraint, under the assumption that government debt is zero in the steady state. This indicates that the end-of-period real government debt $b_{G,t}$ is equal to the previous period's real debt multiplied by the gross interest rate, plus government spending multiplied by its output share $g_y g_t$, minus real labour income $(y_t + \varphi_{mc} x_t)$ multiplier by the labour tax rate τ_N and the output share of labour in the steady state ς_N minus lump-sum taxes τ_t.

[15] The effects die out over time, so for example $E_t \Delta g_{t+1} = E_t g_{t+1} - g_t = (\rho_g g_t + E_t \varepsilon_{t+1}) - g_t = g_t(\rho_g - 1) < 0$ as $\rho_g < 1$.

$$b_{G,t} = (1+r)\, b_{G,t-1} + g_y g_t - \tau_N \varsigma_N (y_t + \varphi_{mc} x_t) - \tau_t \tag{11}$$

The labour tax rate τ_N is set so that government spending is financed only by the labour tax and not the lump-sum taxes. That is $\tau_N \varsigma_N = g_y$ while lump-sum taxes evolve according to $\tau_t = \varphi_b b_{G,t-1}$.[16]

The model is calibrated at a quarterly frequency.[17] The discount factor $\beta = 0.995$ and the steady-state net inflation rate $\pi = 0.005$. These two parameters mean that the steady-state interest rate $i = 0.01$[18] This means that, in annualised terms, the steady state inflation rate is 2% and interest rate is 4%. As far as calibrating the utility function, log utility of consumption is used meaning that $\sigma = 1$ and the Frisch elasticity of labour supply $\frac{1}{\chi} = 0.4$, indicating price contracts last five quarters on average. The capital share of output $\alpha = 0.3$, the steady-state government share of output $g_y = 0.2$ and the scale parameter on the consumption taste shock $v_c = 0.01$. For ease of analysis, it is assumed that there is no interest rate smoothing under normal times and the Taylor rule would completely stabilise inflation and the output gap; this is done by setting γ_π and γ_x arbitrarily large. The lump-sum tax parameter $\varphi_b = 0.01$, implying that the main driver of the response of government debt in response to government spending shocks is through labour taxation. Finally, $\rho_v = \rho_g = 0.1$, implying a persistence of 0.9.

The following subsections will explain why this model predicts larger multipliers at the ZLB; explain why the expected inflation channel is significant; and explain why the expected duration of the liquidity trap could be important.[19]

3.2 The Effectiveness of Fiscal Policy in a Liquidity Trap Compared to Normal Times

Many of the New Keynesian models commonly used (Christiano *et al.*, 2011; Eggertsson, 2011; Woodford, 2011) predict that the economy will respond differently to government spending in a liquidity trap compared to during normal times. Following Eggertsson & Woodford (2003); Adam & Billi (2008); Eggertsson (2008); and Erceg & Lindé (2014), the liquidity trap scenario is generated by a negative taste shock which decreases the potential real rate.[20] In order to prevent a positive real interest deviation (real interest rate greater than potential interest rate), which would lead to a greater incentive to save and a decrease in the output gap, the

[16] As agents are Ricardian and only lump-sum taxes react to the stock of government debt, while labour tax rates do not change, the fiscal rule only affects the stock of debt and lump-sum taxes, and does not affect other macroeconomic variables.

[17] The following parameter values are taken from (Erceg & Lindé, 2014).

[18] The steady-state real interest rate $r = \frac{1-\beta}{\beta}$ and the steady-state nominal interest rate $i = r + \pi$.

[19] The simulations discussed below are undertaken using Matlab and are based on the underlying code provided by Jesper Lindé that was used in Erceg & Lindé (2014).

[20] This is because a negative taste shock reduces marginal consumption, which encourages saving, leading to a new equilibrium in the investment-savings market with a lower interest rate.

central bank would respond by reducing the nominal rate, as proposed by the Taylor rule. In fact, it is optimal for the policymaker to set the policy rate equal to the potential rate. However, if the shock is particularly large, the potential real rate would become negative and the central bank will become constrained by the ZLB; as investors would rather hold cash than save at negative interest rates (thus creating a lower bound on interest rates), the potential rate becomes so low that the policymaker cannot close the real interest rate deviation. When the economy is in the liquidity trap environment where the central bank is constrained by the ZLB, there is a negative output gap and low inflation.[21] This is the main reason why a liquidity trap is harmful in the New Keynesian model.

Given the differences between normal times and a liquidity trap state, it is worth investigating the effects of fiscal policy in the two states. Figure 1 shows the impulse responses of selected variables to a positive government spending shock (1% of steady state GDP)[22] in normal times, when the central bank can control interest rates; and in an eight quarter liquidity trap where interest rates are stuck at zero (the taste shock is scaled arbitrarily so that the liquidity trap lasts eight quarters). As shown by the effect on output, fiscal policy is very effective when monetary policy is accommodative and less so when the policy rate can react to changes in the economic environment. This section will describe the mechanisms through which the effects on output differ across these states.

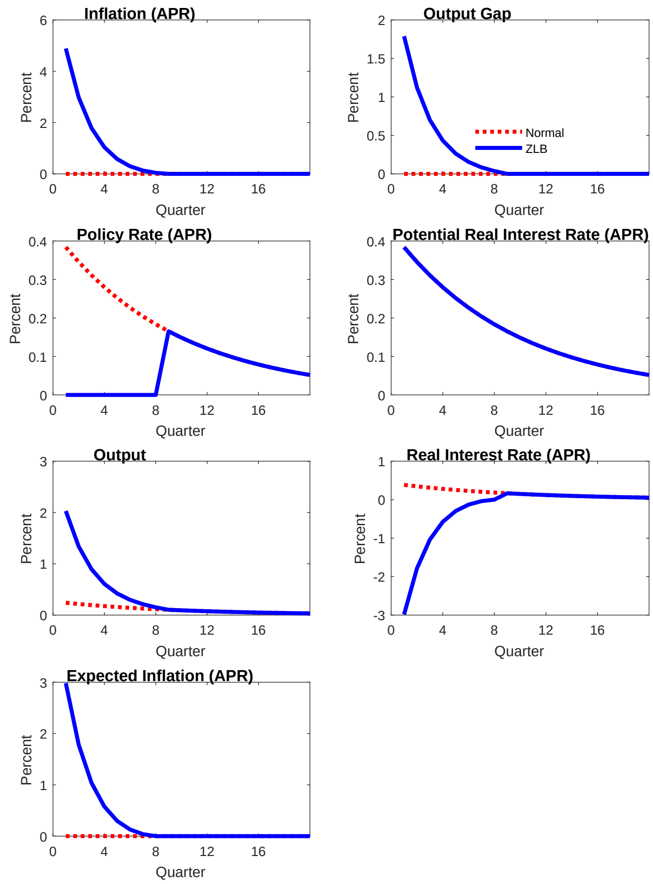
In normal times, when the central bank is not constrained by the ZLB, the effects of fiscal policy on the economy are muted. In this model, a government spending shock transmits to the economy through the potential real interest rate and potential output. As the government spending shock is transitory, it leads to an increase in the potential interest rate and potential output.[23] Without a central bank response, this increase in the potential interest rate would lead to a negative real interest rate deviation, which causes a positive output gap and higher inflation (to the extent that inflation responds to the output gap). However, in normal times the central bank follows the aggressive Taylor rule described in equation 6. This means that any deviation of inflation from target or the output gap from zero will be eliminated by the central bank raising the policy rate and crowding out private spending. As the central bank offsets much of the stimulative effect of the government spending shock, the government spending multiplier is not very large in this situation. However, in response to a government spending shock, output does respond slightly by the extent that potential output rises, as the central bank aims

[21] The size and persistence of the taste shock affect how long the liquidity trap lasts and how far the potential rate falls. The size of the real interest rate gap and the length of the liquidity trap affects the size of the negative output gap and the amount of time the economy spends in a negative output gap.

[22] Throughout this theoretical analysis, the government spending shock is calibrated to 1% of steady state GDP, i.e. a relatively small shock. As the expected duration of the liquidity trap is endogenously determined by government spending (Erceg & Lindé, 2014), it is important for this analysis to set the government spending shock at a small enough level that does not reduce the expected duration of the liquidity trap from eight quarters to seven quarters.

[23] If the shock was permanent, or in other words if $\rho_g = 0$, then potential output would still increase, but the potential interest rate would be unaffected by the government spending shock.

Figure 1: Impulses to Government Spending in Normal Times and in an Eight Quarter Liquidity Trap



to set actual output equal to potential.

These effects can be seen in figure 1 where the government spending shock increases the potential real interest rate and potential output (not shown), which leads the central bank to increase the policy rate to the level of the potential interest rate. Consequently, the deviation of the output gap from its steady-state and the deviation of inflation from the inflation target are zero. However, it can be seen that output rises slightly by the extent that the impulse raises potential output.

However, the central bank responds differently to a government spending shock when interest rates are close to the ZLB. At the ZLB, the policy rate that closes the positive real interest gap is unobtainable because the potential rate is so low. A government spending shock would increase the potential real interest rate, thus reducing the positive real interest rate deviation. So long as the government spending shock is not so large that the real potential rate rises above the ZLB, it will still be optimal for the central bank to keep the policy rate as low as possible, in order to minimise the real interest rate deviation. Therefore, monetary policy is accommodative to fiscal shocks in a liquidity trap. This means that a positive government spending shock would increase the output gap and inflation, and monetary policy would not react. Since the central bank does not increase the policy rate, it is clear that fiscal policy has a greater output multiplier when the ZLB on nominal interest rates is binding in the New Keynesian model.

Unlike in the normal case, where the policy rate tracks the potential real rate, in this eight quarter long liquidity trap the policy rate does not change after the government spending shock. The higher potential rate relative to the policy rate increases the output gap as it reduces the incentive for consumers to save and postpone consumption. This is known as the direct effect of government spending. Further, an increase in the output gap leads to increased inflation and therefore higher expected inflation. As the real interest rate is the nominal interest rate minus expected inflation $r_t = i_t - E_t \pi_{t+1}$, this means a reduction in the real interest rate. Therefore, when inflation expectations respond to the output gap, fiscal policy can lead to a reduction in the real interest rate and therefore further increases in output. This is the expected inflation effect and is a key mechanism for generating the large government spending multipliers in New Keynesian models. These two effects will be discussed in more depth in the following section.

While this model is highly stylised, it does provide predictions that can be tested. Figure 1 clearly suggests that the response of output to a government spending shock is larger in a liquidity trap compared to normal times.[24] This is one of the predictions that is investigated in this thesis. However, there are other interesting predictions of this model that require further discussion.

3.3 The Direct and Expected Inflation Channels

Figure 2 shows the effects of government spending in a liquidity trap for two different price contract durations. The purpose of this is to show the importance of the expected inflation channel. The panels on the left show the effects when firms cannot change prices, meaning that there is no expected inflation. While the panels on the right show the effects when price contracts last five quarters, where there is an expected inflation effect.[25] The figure shows the size of the deviation from the steady state when there is a large consumption taste shock that sends interest rates to the ZLB in blue; the size of the deviation from steady state when the government responds

[24] While the magnitude of the difference in output response is partly down to the aggressive Taylor rule, even with a more standard Taylor rule, output multipliers would still be larger at the ZLB.

[25] This is affected in the model by changing the value of ξ_p.

to the same consumption taste shock with an increase in government spending in red; and the difference between the two responses in yellow, which shows the effects of government spending in a liquidity trap.

In both cases, and as discussed before, a government spending shock leads to an increase in the real potential interest rate. As the ZLB is binding in both cases, the policy rate does not respond to this increase in the real potential rate. This leads to an increase in the output gap as it decreases the size of the positive real interest deviation, encouraging consumers to bring forward consumption.

However, where the two cases differ is in the response of prices to changes in the output gap. In the case where price contracts cannot be changed, the slope of the New Keynesian Phillips curve is flat, meaning that inflation does not respond to changes in the output gap.[26] While there is an output gap in figure 2, inflation does not deviate from its steady state. This case is best for examining the direct effect of government spending, as it only considers the impact of the reduction in the positive interest rate deviation.

While this direct effect does increase output, the increase in output is much more pronounced in the case where price contracts can be renewed on average every five quarters. In this case, the New Keynesian Phillips curve is upward sloping meaning that an increase in output generates inflation. The channel through which this occurs is that the increase in production requires more workers, which increases their wage and therefore the firm's marginal cost. Firms want to raise prices, though not all can straight away due to price stickiness, so it leads to increased inflation and expected inflation.

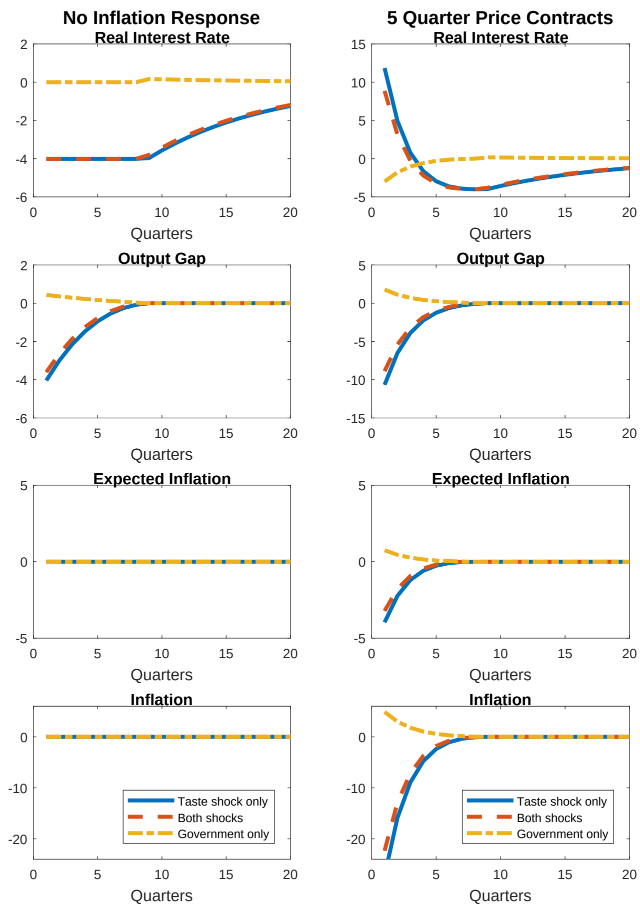
This can be seen in the panels on the right in figure 2 where inflation responds positively to the increase in the output gap caused by the government spending shock. Consequently, expected inflation increases as well in the case where it is possible for firms to reset prices; when agents observe a government spending shock they will anticipate an increase in economic activity and therefore inflation.

The increase in expected inflation is crucial for generating large multipliers in this model. As can be seen in the figure, an increase in expected inflation at the ZLB leads to a decrease in the real interest rate. This is compared to the case without an inflation response where expected inflation does no change and thus neither does the real interest rate. The reduced real interest rate further reduces the size of the interest rate deviation and leads to further increases in the output gap. This effect is circular as increases in the output gap lead to inflation, a lower real interest rate and so on.

It should be noted that the output multiplier of government spending is still larger in a liquidity trap without an inflation response compared to normal times, as outside a liquidity trap the central bank closes the output gap. However, it is clear from figure 2 that the effect on output is much larger if inflation is allowed to respond

[26] In terms of the New Keynesian model, this would be the case when $\xi_p = 1$. This would mean that $\kappa_x = 0$.

Figure 2: The Importance of the Expected Inflation Channel



to output. This mechanism is a central reason for why many New Keynesian models predict very large fiscal multipliers on output. However, as discussed before, these theories are based on rather specific assumptions, particularly to do with the type of shock that caused the liquidity trap. It is clearly important to understand the mechanisms through which fiscal multipliers are generated and to examine whether this expected inflation effect is an empirically plausible idea.

3.4 The Importance of the Expected Duration of the Liquidity Trap

Another key insight from the New Keynesian model is that the longer the expected duration of the liquidity trap, the more effective fiscal policy is in increasing output. This is largely because agents are forward-looking in these models. In fact, the Euler equation 1 can be solved forward and written as the sum of current and expected future real interest deviations as in equation 12, where T is the expected length of the liquidity trap. This equation rests on the assumption that the central bank will set the interest rate equal to the potential rate when it is possible to do so and thus close the output gap. Essentially, a longer liquidity trap means that there is a longer period in which the potential interest rate is so low that it is unobtainable. This means that, in the face of government spending, the central bank will pursue a more accommodative monetary policy for longer.

$$x_t = E_t x_{t+T} - \hat{\sigma} E_t \sum_{j=0}^{T} \left(-i - \pi_{t+j+1} - r_{t+j}^{pot} \right) \tag{12}$$

Figure 3 shows impulse responses to a government spending shock in different length liquidity traps.[27] Clearly, the policy rate deviates from the ZLB two periods earlier in the eight quarter liquidity trap.

As the direct effect of a government spending shock is brought about by the central bank not increasing the policy rate in response to increases in the real potential rate, the government spending shock will have a larger direct effect in a longer-lived liquidity trap. This is because the central bank will be accommodative of a change in the real interest rate deviation for a longer period of time. Thus, this is partly the reason why the output response is greater in a longer liquidity trap.

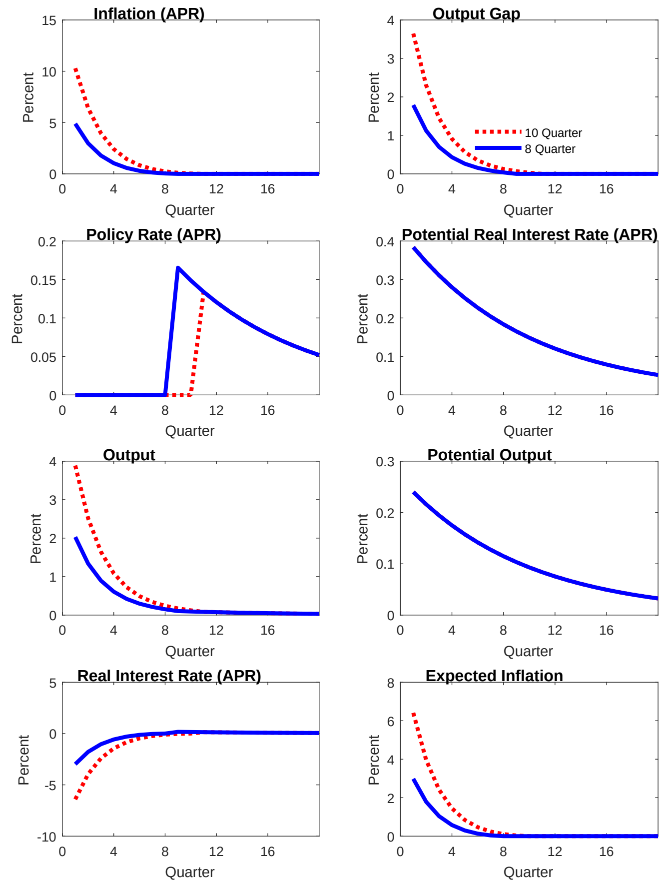
Furthermore, the length of the liquidity trap is a key determinant of the expected inflation effect. If agents expect monetary policy to be accommodative for longer, then they will expect that there will be a deviation in the output gap for longer. As the output gap leads to inflation in this model, an expected increase in the output gap will also lead to an increase in expected inflation. As shown in figure 3, government spending shocks generate significantly larger deviations in expected inflation during liquidity trap with larger expected duration. Consequently, this larger increase in expected inflation depresses the real interest rate even more, which reduces the incentive for consumers to save, and thus increases consumption and the output gap.

However, it should be noted that the increased effects associated with a longer liquidity trap depend very much on the persistence of the government spending shock.[28] If the shock is rather transitory, then the deviation of government spending from its steady state would be relatively small towards the end of the liquidity trap, particularly if the liquidity trap is already long. In the case of a short-lived government spending shock, the real potential rate would return to its steady state level sooner and the impact of the government spending shock in terms of both the direct and expected inflation effects would be muted.

[27]The ten quarter liquidity trap was generated by using a larger consumption taste shock than the typical eight quarter episode. However the government spending shock is still 1% of steady state GDP, as in all previous analysis.

[28]In this calibration, the government spending shock is relatively persistent with $\rho_g = 0.1$, meaning that a shock leading to a 1% deviation from steady state in one period will lead to a deviation from steady state of 0.9% in the next period.

Figure 3: The Effects of a Government Spending Shock with Different Liquidity Trap Durations



Nevertheless, in theory these two channels combine to generate larger fiscal multipliers in a liquidity trap compared to normal times and larger multipliers the longer the expected duration of the liquidity trap. Whilst the findings presented in this section rely heavily on a number of factors including the parameters that affect the monetary policy rule, the type of shock causing the liquidity trap and the fiscal response, it is important to understand the mechanisms through which fiscal policy affects output, particularly in an environment in which conventional monetary policy has been largely exhausted. Given these theoretical predictions, it is worth examining whether output and expected inflation respond differently to government spending shocks depending on the length of the liquidity trap.

3.5 Summary

As this New Keynesian model is very stylised, the above analysis the main thing to take from the above analysis are the theoretical predictions rather than the magnitudes.[29] Indeed, it is important to test these predictions in the data. These questions will form the basis of the empirical investigation:

- Are output multipliers larger in states where the ZLB is binding compared to normal times?
- Does expected inflation respond differently to government spending at the ZLB?
- Are output multipliers larger when the liquidity trap is expected to last longer?

4 Data

Before discussing the results of these estimations, the data and sample used must be mentioned. The sample uses quarterly data for the Euro Area, United Kingdom and United States. The sample runs from 2000Q1 to 2017Q1 for the Euro Area; 1975Q1 to 2017Q1 for the UK; and 1970Q1 to 2017Q1 for the US. The benefit of using a panel of countries is that it provides a larger set of observations when interest rates are close to the ZLB.

Much of the data is collected from the OECD Statistics and Projections Database number 100. Real GDP, real government spending and nominal tax revenue (divided by the GDP deflator) are all collected from there. All of the data is at a quarterly frequency apart from Euro Area tax revenue, which is at an annual frequency. This is converted into quarterly data using cubic spline interpolation. [30]

GDP, government spending and tax revenues are converted into per capita values by dividing by population, which is collected from the St Louis FRED. For the UK and Euro Area this population data is annual, but it is converted into quarterly data using cubic spline interpolation. Similarly, it provides monthly US data, but this is averaged over the quarter to get quarterly data.

The debt to GDP ratio is collected from a range of sources (Eurostat for the Euro Area; Office for National Statistics for the UK; and St Louis FRED for the US).

The composite leading indicator, which proxies for the authorities' expectations of the following year's growth is collected from the OECD Main Economic Indicators Database. It is CLI amplitude-adjusted and is normalised by subtracting 100 and dividing by 100.

Expected inflation is a measure of one year ahead expected inflation. For the US, mean CPI expected inflation is collected from the Philadelphia FED Survey of Professional Forecasters. For the Euro Area, mean

[29]For instance, the lack of interest rate smoothing significantly amplifies the difference in effect of government spending in the two states.
[30]This creates a smoother interpolated series than ordinary linear interpolation.

CPI expected inflation is collected from the European Central Bank Survey of Professional Forecasters. For the UK, mean expected inflation is collected from Bank of England fan charts; until 2004 it is RPIX inflation with a target of 2.5% and afterwards it is CPI inflation with a target of 2%.

The ZLB dummy is created using data on the policy rates of the three countries. These were collected from central bank websites. The dummy was given a value of 1 when the policy rate was below a certain threshold.

Overnight index swap rates data is taken from Bloomberg for all three economies. This is used as an empirical proxy for the expected path of the policy rate (which is used to calculate the expected duration of the liquidity trap). In terms of data availability, there are rates at quarterly horizons over the first two years and afterwards at annual horizons. To generate a complete set of quarterly horizons, cubic spline interpolation is used on the annual horizons.

5 Cumulative Output Multiplier Estimation Strategy

This section outlines how the impact of fiscal policy in different macroeconomic environments is investigated for a panel of economies. In particular how to examine whether the multipliers are larger when nominal interest rates are close to the ZLB. First fiscal shocks that are exogenous to the state of the economy are identified. Then these shocks are used as an instrumental variable for estimating the impact of a government spending increase on output. These methods will now be described in more detail.[31]

5.1 Identifying Fiscal Shocks

As the macroeconomic environment affects government spending decisions (for instance higher unemployment tends to lead to an increase in welfare payments), it is important to identify government spending shocks that are not driven by the macroeconomic environment. While there is a variety of identification methods, as discussed, this study uses the method that assumes that government spending does not respond contemporaneously to output.[32] The argument is that government spending does not respond to events within the same quarter as policymakers face data limitations on real-time macroeconomic performance, while also it takes time to decide on, approve and implement their policy response. While there are undoubtedly automatic stabilisers involved in government spending, these tend to occur through transfer payments, which might not be too much of an issue as the measure of government spending used in this study only includes government consumption expenditure.

[31] Note that all of this analysis is undertaken using Stata.

[32] Hereafter, this identification strategy will be referred to ask the Blanchard & Perotti (2002) identification strategy, as is common in the literature.

This identification strategy has been used by many researchers such as Blanchard & Perotti (2002), Auerbach & Gorodnichenko (2012b) and Ilzetzki *et al.* (2013).[33]

Furthermore, it is important to control for expectations when identifying exogenous shocks. Forward-looking agents will react to future government spending news before the change comes into effect. Therefore any estimation without controlling for expected changes in government spending will not capture all of the effects of government spending shocks and will bias the result. Some authors, such as Miyamoto & Nguyen (2016) and Auerbach & Gorodnichenko (2012a), do this by regressing government spending on a forecast of government spending for the same period to create unanticipated government spending. However, this thesis follows a similar method to Corsetti *et al.* (2012) in that it constructs a fiscal rule based on lagged macroeconomic variables that is used to generate predicted values of government spending.

Equation 13 attempts to describe the process of government spending, for each economy individually, in a similar way that a Taylor rule describes the process of monetary policy. This step involves regressing the log of real per capita government spending (g_t) on lags of the natural logarithm of real per capita output $(y_{t-1}$and $y_{t-2})$, government spending $(g_{t-1}$and $g_{t-2})$ and tax revenue $(tx_{t-1}$and $tx_{t-2})$ as well as lagged debt to GDP ratio $(Debt_{t-1}$and $Debt_{t-2})$ and a lagged value of a composite leading indicator (CLI_{t-1}) (which is a proxy for the policymaker's expectations of growth one year ahead of expectation formation). The regression also includes a binding ZLB dummy (ZLB_{t-1}), a constant and a time trend (t). Note that even now the Blanchard & Perotti (2002) identification strategy is exploited, where a prediction of government spending in period t does not depend on the values of other macroeconomic variables in period t, but only lagged variables.

$$\begin{aligned} g_t = {} & \beta_0 + \beta_{1,} y_{t-1} + \beta_2 y_{t-1} + \beta_3 g_{t-1} + \beta_4 g_{t-2} + \beta_5 tx_{t-1} + \\ & \beta_6 tx_{t-2} + \beta_7 Debt_{t-1} + \beta_8 Debt_{t-2} + \beta_9 CLI_{t-1} + \beta_{10} ZLB_{t-1} + \beta_{11} t + \varepsilon_t \end{aligned} \tag{13}$$

The right hand side of this equation generates a predicted value of government spending based on information at period t-1. The residual ε_t measures the difference between the log of real per capita government spending and the log of predicted real per capita government spending. This can approximately be described as total government spending divided by predicted government spending minus one. In fact these residuals are orthogonal to anticipated government spending, and are thus an identified shock that can be used in the second

[33]While these authors argue that quarterly data is necessary for this to be a strong identification method, others such as Corsetti *et al.* (2012) and Beetsma *et al.* (2006) argue that government spending does not respond to changes in output within a year, as policymakers set their budget for the year ahead. Born & Müller (2012) and Beetsma *et al.* (2009)provide empirical evidence that, on the assumption that the quarterly identification strategy is valid, government spending is also predetermined at the annual frequency. However, in case there is some cyclical component of government spending, this thesis uses quarterly data.

stage of the analysis.

5.2 Estimating Fiscal Multipliers

Now that exogenous changes in government spending have been identified, these shocks can be used to estimate government spending multipliers. Before the method is described, it is worth discussing some issues regarding the calculation of multipliers. In particular, the definition of the multiplier and the method of converting into currency units will be discussed.

Many of the earlier studies (Blanchard & Galí, 2007; Blanchard & Perotti, 2002; Canova & Pappa, 2011) into fiscal multipliers define them as the peak response of output to the initial government spending shock. The benefit of using this estimation method is that it takes full account of the impact of the initial shock; it only takes a stand on the length of time that the shock impacts output in the sense that the multiplier is calculated when the output response reaches its peak.

However, others, such as Woodford (2011), argue that it is important to consider the persistence of the government spending shock when calculating multipliers. If the government spending shock is transitory and has a small effect on overall government spending, then the multiplier implied by the Blanchard & Perotti (2002) method would be understated compared to a multiplier generated by a very persistent government shock. For this reason, Mountford & Uhlig (2009), Fisher & Peters (2010) and Ramey & Zubairy (2014) argue that the correct multiplier should be the integral of the output response divided by the integral of the government spending response to the fiscal shock. In doing this they can pinpoint how much output increases relative to an increase in government spending, rather than just the government spending shock.[34]

While there is support for both methods, and in fact many researchers such as Auerbach & Gorodnichenko (2012b) present multipliers calculated using both methods, this study concentrates on the cumulative multiplier. This is because it tends to be more common in more recent literature and the arguments of Ramey & Zubairy (2014) are plausible. It is not a perfect measure, given that it does not differentiate between government spending increases close to the impact and government spending increases close to the end of the period in question (so output would not have a chance to respond fully to the government spending increases). However, the measure of the output response to the shock divided by the initial shock misses out a significant portion of the effects of government spending shocks, namely how government spending responds to the shocks.

Another issue worth considering when defining the multiplier is how best to estimate the currency unit impact on output of a one currency unit increase in government spending, as this is the typical measure in

[34] Hereafter, this multiplier is referred to as the cumulative multiplier.

the literature. Typically studies have taken the natural logarithms of output and government spending when running the regressions. This leads to a problem as these regressions produce elasticities of output with respect to government spending, rather than a unit multiplier. To counter this, the researchers scale the multipliers by multiplying them by the average level of government spending and dividing by the average level of output. This converts the output and government spending responses into the same units and allows the researcher to see the increase in output relative to the increase in government spending. Up until a point, this method was fairly standard, however Ramey & Zubairy (2014) point out an issue with employing an ex-post conversion factor. They noted that the government spending share of output varies a lot over time. In particular, using a quarterly sample for the US between 1889 and 2015, they noted that the government spending share was much higher during the Second World War, as government spending dramatically increased. This led to a upward bias in the average government spending share of output and, therefore, higher multipliers than would be produced using a post-war government spending conversion factor. While the length of the sample examined in this study is not so long and does not include the Second World War period, there is significant variation in the government spending share of output across countries. For instance, the mean in the US is 18.9%, while the mean in the UK is 21.5%.

To counter the conversion factor issue, Ramey & Zubairy (2014) use a Gordon & Krenn (2010) transformation. This involves, instead of taking logarithms of GDP, government spending and taxes, dividing them by an estimate of potential GDP. This puts those variables into the same units so that the multipliers can be estimated without using ex-post conversion techniques. This method has been used by others including Miyamoto & Nguyen (2016). While there are other transformations, such as the one used by Barro & Redlick (2011) and Owyang *et al.* (2013) who divide all variables by output in the period in which the shock occurs, this research employs the method used by Gordon & Krenn (2010) and Ramey & Zubairy (2014). To detrend GDP, a Hodrick-Prescott filter is used.

The method used for estimating fiscal multipliers will now be presented. This method involves using the identified shock as an instrumental variable for the cumulative change in government spending. To do this, local projection method developed by Jordà (2005) are used. The main benefits of using this method instead of a structural vector autoregression is that it does not impose the same linear restrictions on the dynamics of the responses; it does not require the same variables to be used in each equation and it is easier to incorporate non-linearities using this method. While a SVAR calculates the parameters of the model for the period t and then iterates forward to generate impulse response functions, local projections are closer to multi-step forecasts. This gives more flexibility as it limits the problems arising when the SVAR is misspecified, which can become significant over a longer horizon.

5.2.1 The Cumulative Output Multiplier

This section will describe how the cumulative multipliers are calculated. Note again that the cumulative multipliers are the integral of the response of output divided by the integral of the response of government spending.

To calculate multipliers using this method, an instrumental variable approach is used. First the estimation strategy for linear multipliers (meaning not dependent on the state of the economy) is described. The estimation procedure is relatively similar to that of Ramey & Zubairy (2014). The procedure for linear multipliers is described in equation 14, where local projection methods are used with fixed effects. In this equation, the identified government spending shock $shock_t$ is used as an instrument for cumulative government spending (normalised by trend real GDP) between $\sum_{j=0}^{h} g_{t+j}$ between period t and period t+h. In this model, $\sum_{j=0}^{h} y_{t+j}$ is the sum of output from period t to t+h normalised by trend GDP. z_{t-1} is a vector of control variables which include lags of real per capita GDP, government spending, the shock, all normalised by the same period's trend output, and the ZLB state; $\varphi_h(L)$ is a polynomial in the lag operator of order two; and $shock_t$ is the identified shock as discussed. Lags of the shock are included in the specification to control for any serial correlation in the shock. Note also that in this regression, and all following regressions, the standard errors are robust to heteroskedasticity. Fixed effects are used in all methods used in this study.

$$\sum_{j=0}^{h} x_{i,t+j} = \gamma_h + \varphi_h(L)z_{i,t-1} + m_h \sum_{j=0}^{h} g_{i,t+j} + \delta_{i,h} + \omega_{i,t+h,} \; for \; h = 0,1,2,... \tag{14}$$

The coefficient m_h describes the cumulative output multiplier at horizon h, as defined by Ramey & Zubairy (2014). It is the increase in output over the horizon h relative to the increase in government spending over the horizon h. Therefore, it is possible to construct a multiplier impulse response function as the sequence of the m_h coefficients, which are generated by running the regression in equation 14 for each horizon.

This method can be easily be adjusted to make it state-dependent. State-dependence is introduced by including a dummy variable for the ZLB state ZLB_{t-1}, which is given a value of 1 when the policy rate is at 0.5% or below and is given a value of 0 when the policy rate is above 0.5%.[35] This enables the investigation of whether the variable of interest responds differently to the shock depending on the state of the economy. The estimation strategy involves running equation 15 for all horizons, while using state-dependent instrumental variables $ZLB_{t-1} * shock_t$ and $(1 - ZLB_{t-1}) * shock_t$ for cumulative government spending depending on the state

[35] This definition of the ZLB is relatively common and has been used by Erceg & Lindé (2010), (Ramey & Zubairy, 2014) and Miyamoto & Nguyen (2016).

of the economy when the shock occurs. Note that the other regressors are the same as in the linear equation, just interacted with the state of the economy. The coefficient $m_{ZLB,h}$ describes the integral of the output response relative to the integral government spending response over the horizon h when the shock occurs in the ZLB state. While the coefficient $m_{NZLB,h}$ describes the same for the non-ZLB state. As in the aggregate case, these coefficients, and the associated standard errors, can be used to produce impulse response functions. The purpose of this section is to examine the size of these two coefficients over different horizons and to test whether they are different.

$$\begin{aligned}\sum_{j=0}^{h} y_{i,t+j} \quad = \quad & ZLB_{i,t-1}(\gamma_{ZLB,h} + \varphi_{ZLB,h}(L)z_{i,t-1} + m_{ZLB,h}\sum_{j=0}^{h} g_{i,t+j}) \; for \; h = 0,1,2,... \\ & +(1-ZLB_{i,t-1})(\gamma_{NZLB,h} + \varphi_{NZLB,h}(L)z_{i,t-1} + m_{NZLB,h}\sum_{j=0}^{h} g_{i,t+j}) + \delta_{i,h} + \omega_{i,t+h}\end{aligned} \tag{15}$$

6 Cumulative Output Multipliers

6.1 Identified Unanticipated Government Spending Shocks

The purpose of the first stage of the analysis is to identify exogenous government spending shocks that are good instruments for government spending. Table 1 reports the results of the regressions outlined in equation 13. The coefficients in the table help to form a fiscal rule, where government spending depends on past information.

While it is not the main purpose of this thesis, these regressions provide some interesting results in their own right. In particular, government spending responds negatively to a more positive economic outlook (the coefficient on CLI_{t-1} is negative for all countries, and significantly so in the case of the Euro Area). This provides evidence that government spending might be counter-cyclical. It is also worth noting that government spending is persistent as the response of government spending to lagged government spending g_{t-1} is significant and relatively large for all three countries. It is also surprising that government spending does not respond negatively to increases in the ratio of debt to GDP $Debt_t$. Indeed, given that there are no substantial differences between the three generated fiscal rules, this could perhaps be used as evidence that it is appropriate to estimate a panel multiplier, rather than just focusing on one economy.

The residuals generated from these regressions are the identified shocks $Shock_t$, where the shock can be defined as the percentage difference between total government spending in period t and the expectation of government spending in period t formed in period t-1. Note that this is the case as, at this stage, the variables have not yet been normalised by trend real GDP per capita and have instead been transformed into their natural logarithms. The identified shocks for the three economies have been plotted across time in figure 4. From inspecting these shocks visually, it does not appear that they differ systematically between the ZLB period and normal times.

Table 1: First Stage Regression Results

Regressor	EA	UK	US
Output(-1)	0.081	-0.14	0.127
	(0.116)	(0.101)	(0.094)
Output(-2)	-0.077	0.16	-0.076
	(0.129)	(0.100)	(0.088)
Government Spending(-1)	0.762	0.643	0.854
	(0.140)**	(0.083)**	(0.078)**
Government Spending(-2)	0.385	0.316	0.084
	(0.166)*	(0.077)**	-(0.074)
Tax Revenue(-1)	0.024	-0.041	-0.017
	(0.126)	(0.038)	(0.031)
Tax Revenue(-2)	0.151	0.027	0.026
	(0.137)	(0.040)	(0.033)
Debt to GDP(-1)	0.0009	-0.0007	0.0009
	(0.001)	(0.001)	(0.001)
Debt to GDP(-2)	-0.0006	0.0006	-0.0012
	(0.001)	(0.001)	(0.001)
CLI(-1)	-0.165	-0.013	-0.101
	(0.056)**	(0.073)	(0.057)
ZLB(-1)	0.009	-0.008	0.005
	(0.003)**	(0.005)	(0.004)
Time Trend	-0.002	0.000	0.000
	(0.000)**	(0.000)	(0.000)
Constant	-4.948	0.477	-0.027
	(1.043)**	(0.792)	(0.536)
R2	1	1	0.99
N	66	167	187

Note: * $p<0.05$; ** $p<0.01$. Separate regressions for each economy in the sample. The point estimates are reported in the top row and standard errors are in brackets below.

As these shocks are used as an instrument for government spending, it is important to verify that the identified shocks are a strong instrument. For the one-step estimation strategy, the Kliebergen-Papp Wald F statistic is taken from each regression. These values are plotted in figure 5 along with the Stock & Yogo (2005) weak instrument test 10% critical value of 16.38. If the F statistic is above this value, then it is not a weak instrument. Figure 5 shows that the instrument is highly relevant, particularly over short horizons.

Figure 4: Extracted Shocks for EA, UK and US

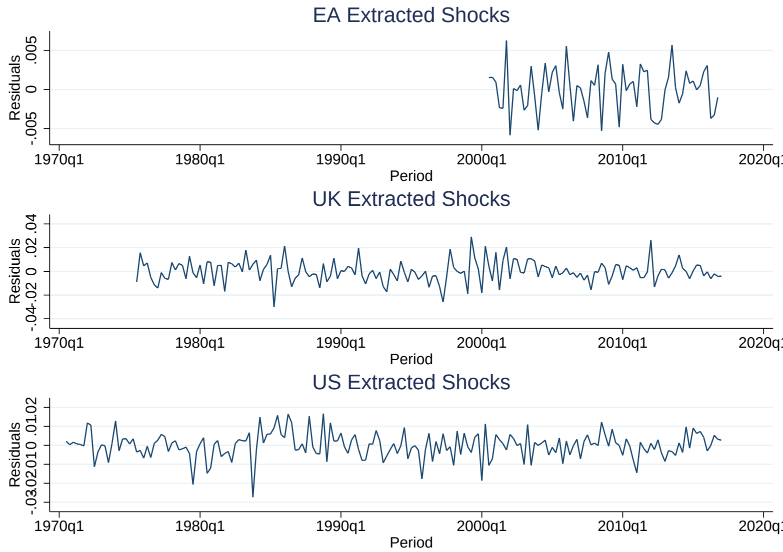
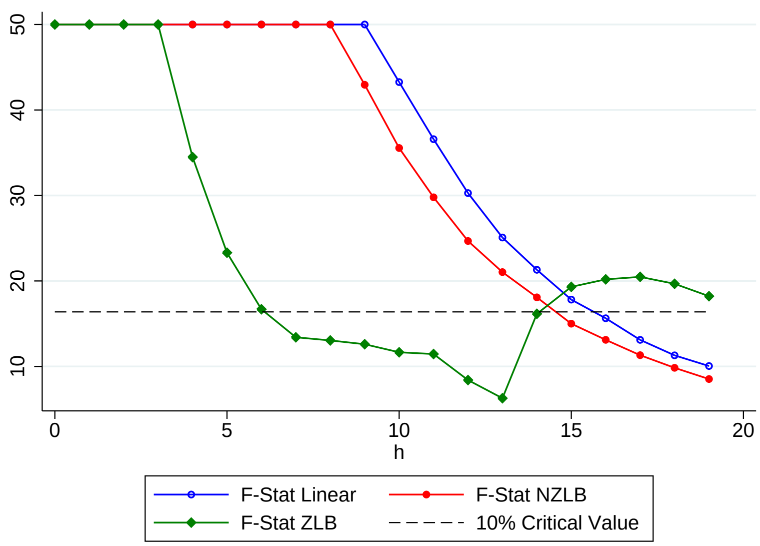


Figure 5: Instrument Relevance Test for the Identified Shocks



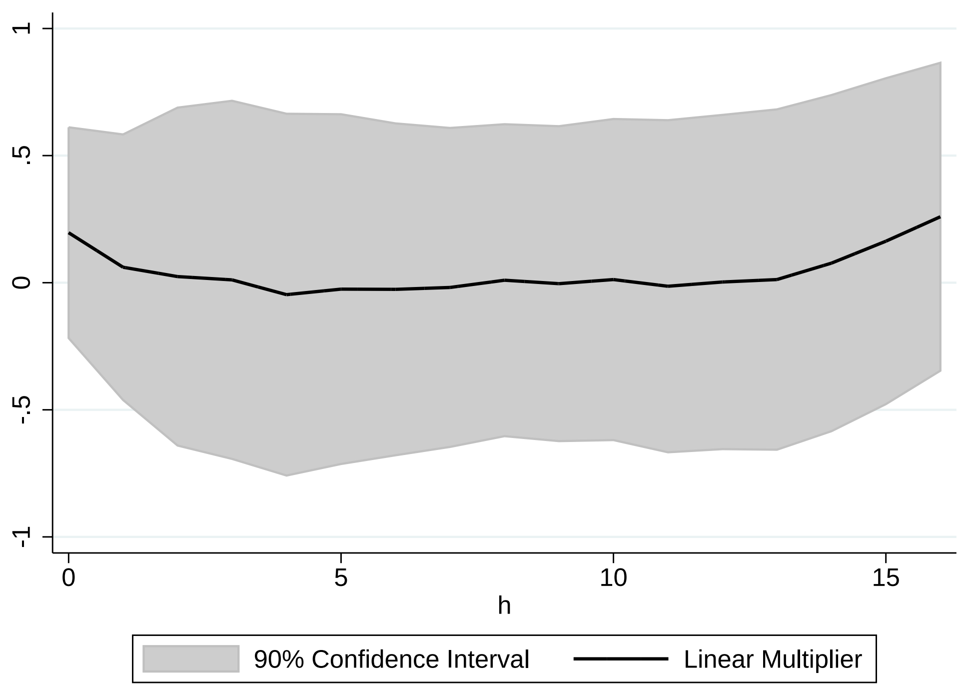
Note: This figure provides the Kliebergen-Papp Wald F statistic for a weak identification test where the blue line refers to the F statistic for the linear shock, red line for normal times and green line for ZLB cases. If the F statistic is over 50, it is capped at 50. The Stock & Yogo (2005) 10% critical value of 16.38 is plotted; the instrument is weak if the F statistic is less than 16.38.

6.2 Output Multipliers

6.2.1 Linear

Having created a relevant instrument, the methods outlined previously are applied to calculate output multipliers using an instrumental variable strategy. To calculate the aggregate cumulative multipliers[36], equation 14 is used. A plot of the cumulative multipliers and their associated 90% confidence bands for each horizon is presented in figure 6 and multipliers and associated standard errors for selected horizons are reported in the first column of table 2 (to save space multipliers are not reported for each horizon, but only for each of the first four quarters and then the eighth, twelfth and sixteenth quarter horizons).[37] The figure shows that there is a modest multiplier on impact, meaning that the contemporaneous response of government spending to the identified fiscal shock is greater than the contemporaneous response of output. As the horizon increases, this multiplier remains relatively constant, though actually becomes negative after a year and a half, meaning that one currency unit of government spending over the six quarters leads to a slight decrease in output. This trend continues for a number of years.

Figure 6: Linear Cumulative Output Multipliers



Note: This shows the aggregate sample output multiplier. The shaded area shows the 90% confidence interval.

[36]Note that in this setting, aggregate and linear are used interchangeably, as linear refers to a lack of state-dependence.

[37]Note that, as the creation of this table involves many regressions, it is only possible to summarise the results by producing this table.

The multipliers for the linear case seem to be slightly smaller than those found in other papers on the subject, for instance most of the aggregate multipliers in the literature survey by Hall (2009).[38] However, it is worth noting that the aggregate multipliers from this thesis' estimations are not significantly different from zero over any horizon. This may in part be due to large standard errors that arise because the aggregate method has to consider both normal times and the ZLB period.

Table 2: Cumulative Output Multipliers

	Linear	Non-ZLB	ZLB	P-Value
Initial Multiplier	0.116	0.024	0.822	0.023
	(0.268)	(0.300)	(0.181)	
1 Quarter Multiplier	-0.003	-0.092	0.925	0.017
	(0.292)	(0.331)	(0.268)	
2 Quarter Multiplier	0.009	-0.094	1.575	0.001
	(0.381)	(0.423)	(0.232)	
3 Quarter Multiplier	-0.001	-0.066	1.814	0.002
	(0.435)	(0.467)	(0.354)	
1 Year Multiplier	-0.164	-0.172	1.675	0.007
	(0.466)	(0.477)	(0.431)	
2 Year Multiplier	-0.417	-0.260	0.976	0.131
	(0.580)	(0.497)	(0.579)	
3 Year Multiplier	-0.844	-0.387	-0.807	0.742
	(0.830)	(0.661)	(0.872)	
4 Year Multiplier	-0.423	-0.091	0.501	0.551
	(0.926)	(0.756)	(0.776)	

Note: The values in the brackets beneath the multipliers give the standard errors. The p-values are from testing whether the ZLB and non-ZLB multipliers are different. This table just shows multipliers at some of the horizons. For a complete set of multipliers see figures 6 and 7.

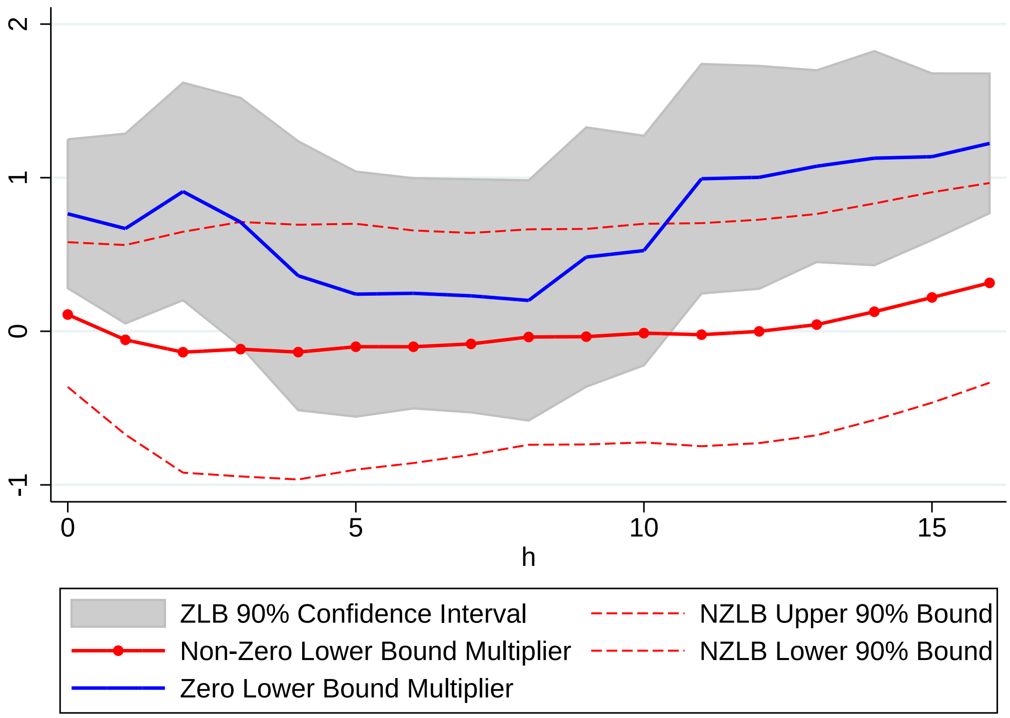
6.2.2 State-Dependent

This research now considers the importance of the state of the economy in determining output multipliers. Figure 7 presents a plot of the multipliers and the associated 90% confidence bands for the both ZLB case (blue line) and the normal times case (red line) and columns two and three in table 2 present the multipliers and

[38] Though most of these estimates do not control for anticipated government spending in the same way that this study does.

associated standard errors for selected horizons for normal times and the ZLB state respectively. In this initial estimation the ZLB dummy is equal to one if the policy rate is less than or equal to 0.5%. This means that the ZLB multiplier is the effect that government spending has on output if the policy rate is near to the ZLB when the shock occurs.

Figure 7: State-Dependent Cumulative Output Multipliers



Note: The multiplier at the ZLB is shown by the blue line, while its 90% confidence interval is shaded. The red dotted line shows the multiplier in normal times and the dashed lines show the 90% confidence bands.

The multiplier at the ZLB is 0.822 on impact compared to 0.024 in normal times (the normal times impact is not significantly different from zero). That means that a unit increase in the level of government spending leads to a 0.822 increase in output in the ZLB state, while it has a negligible impact on output in normal times. While the multiplier from the normal times estimation does not change much over the year after the shock, the multiplier at the ZLB continues to rise and peaks at 1.814 after three horizons. The multiplier in the ZLB state is relatively large over the short-term and is significantly above zero at the 10% level for the first seven quarters. In comparison, the multiplier in normal times is small and is insignificantly different from zero at the 10% level over all horizons.

It is surprising that the multiplier is so small in normal times. However, these multipliers are not significantly different from zero. Additionally, other authors, such as Miyamoto & Nguyen (2016), in a similar study to this research, in a study of the Japan liquidity trap, find that non-ZLB multipliers quickly fall below zero. Perhaps then these results are relatively in line with other studies.

Given that one of the research questions of this thesis was to investigate whether output multipliers are larger at the ZLB, it is important to test whether the difference is significant. To do this equation 15 is run with both two instruments (the state-dependent shocks) and test the null hypothesis that the ZLB multiplier is equal to the multiplier in normal times. The p-values of these tests are reported in the final column of table 2. The results show that the ZLB multipliers are significantly different from those in normal times over horizons that last between one and five quarters at the 5% level. Additionally, the six quarter horizon multipliers are significantly different at the 10% level. As the horizon increases, the estimates become less precise, and the ZLB multiplier starts to fall, though given that the shock is most relevant over the first two years, the near-term multipliers should perhaps be given greater consideration.

The combination of the magnitude of the multipliers presented in figure 7 and the finding that multipliers tend to differ across the two states provides support for the idea that government spending is more effective at boosting output when monetary policy is more accommodative. As discussed, in normal times an increase in government spending would be associated with an increase in the policy rate, thus negating some of the positive impact on economic activity. Conversely, under the assumption that the government spending shock does not quickly lead the economy to escape the liquidity trap, at the ZLB monetary policy would not respond to government spending by increasing the nominal interest rate, meaning that the effect on output would not be dampened.

6.3 Are Elevated Multipliers Due to Slack in the Economy?

These results suggest that government spending might be more effective in boosting output in a liquidity trap compared to when monetary policy responds. Nevertheless, it is possible that the ZLB episode happens to coincide with another factor, particularly as there is only one prolonged ZLB episode in the sample. Central banks approached the ZLB following the financial crisis at a time when economic performance was poor. It could be argued that the above analysis is really showing the effect of government spending when the economy is in recession, or when there is slack in the economy. As briefly discussed in the literature review, there is some evidence that multipliers tend to be larger in recessions compared to expansions (Auerbach & Gorodnichenko, 2012b; Fazzari *et al.*, 2015).

To test whether the stance of monetary policy does affect the government spending multiplier, this study estimates multipliers in recessions and compares them with multipliers in recessions in which the ZLB is binding. In this case, OECD recession indicators are used as the recession variable, where it is a dummy with value 1 if the economy is moving from the peak of the business cycle to the trough and 0 if the economy is moving towards the peak of the business cycle. Jordà (2005) local projection methodology is used as described above, only with this new state variable in place of the ZLB dummy.

The first three columns of table 3 report the multipliers in the baseline case where the liquidity trap is not considered. The first column shows the multipliers in the periods in which the economy is expanding, the second column reports the multipliers in periods in which the economy is slowing down and the third column reports the p-value of the test that these two multipliers are equal.

Table 3: Cumulative Output Multipliers in Recessions and Expansions

	Complete Sample			Post-Crash Recessions		
	Expansion	Recession	P-Value	Expansion	Recession	P-Value
Initial Multiplier	0.154	-0.096	0.628	0.183	-0.376	0.558
	(0.333)	(0.389)		(0.314)	(0.919)	
1 Quarter Multiplier	0.086	-0.351	0.507	0.089	0.708	0.442
	(0.368)	(0.551)		(0.390)	(0.690)	
2 Quarter Multiplier	0.186	-0.483	0.424	0.132	1.038	0.287
	(0.441)	(0.716)		(0.471)	(0.685)	
3 Quarter Multiplier	0.149	-0.480	0.510	0.152	1.506	0.167
	(0.551)	(0.787)		(0.533)	(0.798)	
1 Year Multiplier	-0.197	-0.583	0.734	-0.020	2.610	0.093
	(0.807)	(0.838)		(0.578)	(1.151)	
2 Year Multiplier	-0.681	-0.462	0.888	-0.150	6.312	0.060
	(1.285)	(0.800)		(0.723)	(3.390)	
3 Year Multiplier	-1.831	-0.361	0.553	-0.488	11.708	0.059
	(2.337)	(0.766)		(0.864)	(6.382)	
4 Year Multiplier	-1.342	-0.097	0.680	-0.093	4.338	0.572
	(2.930)	(0.768)		(0.980)	(7.656)	

Note: This shows the multipliers in expansions and recessions, where the right side of the table only considers recessions in the ZLB period. The values beneath the multipliers give the standard errors. The p-values are from testing whether the expansion and recession multipliers are different. This table just shows the multipliers at some of the horizons.

Perhaps surprisingly the multipliers in recession are slightly lower than those in expansion. However, the relatively large standard errors should be noted. In particular, the large p-values reported suggest that there is no significant difference between the multipliers in the two states. This already provides tentative evidence towards the idea that the larger multipliers in the above analysis are driven by monetary accommodation rather than by slack in the economy.

To further examine the effects of slack and monetary accommodation, this thesis then estimates the effect of government spending in periods in which there is a recession and the ZLB is binding. Larger recession multipliers in this case compared to recession multipliers for the aggregate sample would indicate that government spending is more effective when monetary policy cannot be used to counter the slack in the economy.

As above, the results for this sample of only post-2008 crash recessions in the fourth, fifth and sixth columns are presented in table 3. The fourth column shows the multipliers using a sample of all pre-crisis periods and post-crisis expansions (the addition of the pre-crisis recessions explains why the expansionary estimates are slightly different). The fifth column shows multipliers for post-crash recession periods, while the sixth column shows the p-value of the test that these two multipliers are equal.

The results provide some evidence for the expansionary effects of government spending when monetary policy is accommodative. Apart from the initial impact multiplier, the multipliers are larger in post-crisis recessions than in the aggregate sample recessions. In fact, the multipliers become relatively large and are above unity after two quarters. This suggests that government spending is more effective in a recession when interest rates are near the ZLB.

However, these results should be interpreted with caution, given the extremely limited number of recession observations.[39] Indeed, it also does not counter the argument that the recession was particularly large after the 2008 crash, leading to greater amount of slack and therefore greater multipliers. Therefore, there is a need for further research into this area.

7 Channels of the Output Multipliers

The evidence presented above does provide support for the New Keynesian view that output multipliers are larger when the ZLB on interest rates is binding compared to when monetary policy can respond. Given this finding, it is worth exploring other predictions regarding multipliers in New Keynesian models. In particular, this section focuses on the New Keynesian expected inflation effect and the significance of the expected duration of the liquidity trap.

[39] In particular those that estimate multipliers over a long horizon. Given that, for example, the estimation of a two year horizon multiplier requires eight quarters of observations after the initial shock, the sample of post-crisis recession observations is even more limited.

7.1 The New Keynesian Expected Inflation Effect

As discussed in section 3, New Keynesian models predict large multipliers at the ZLB. These larger multipliers are predominantly driven by the monetary policy response to the government spending shock. The ZLB setting is an extreme case where the monetary policymaker does not respond to inflation and a positive output gap by increasing the policy rate.

Many models provide supporting evidence for the direct effect on the real interest deviation leading to higher output; government spending increases the real potential rate while the policy rate remains unchanged causing consumers to bring forward consumption and an increase in the output gap. However, outside of New Keynesian models, there is less support for an additional expected inflation effect. That is, as the policymaker does not act to crowd out the higher output and inflation generated by the government spending, private agents will then expect higher inflation. With an unchanged policy rate, this leads to a fall in the real interest rate and further increases in output and inflation. This is the main driver of the larger multipliers predicted by standard New Keynesian models. Therefore it is important to test whether this channel appears in the data.

While some studies have extended their analysis of the effects of government spending to calculate inflation multipliers, this research examines this effect directly by calculating expected inflation multipliers. To do this, the method used for calculating output multipliers is extended to consider expected inflation multipliers. Equation 16 is estimated for each horizon of interest using the Jordà (2005) local projection method with fixed effects.

The dependent variable $\sum_{j=0}^{h} E_{t+j}\pi_{t+4+j}$ is the sum of all values of one year ahead expected inflation minus target between period t and period t+h. Again, the identified shock estimated in section 6.1 is used as an instrument for the cumulative government spending $\sum_{j=0}^{h} g_{t+j}$. z_{t-1} is a vector of control variables which includes lags of real per capita GDP, real per capita government spending, one year ahead expected inflation, the shock, and the ZLB state; $\varphi_{x,h}(L)$ is a polynomial in the lag operator of order two for the state x. Again, a dummy variable is applied so that the multipliers can be estimated for each state.

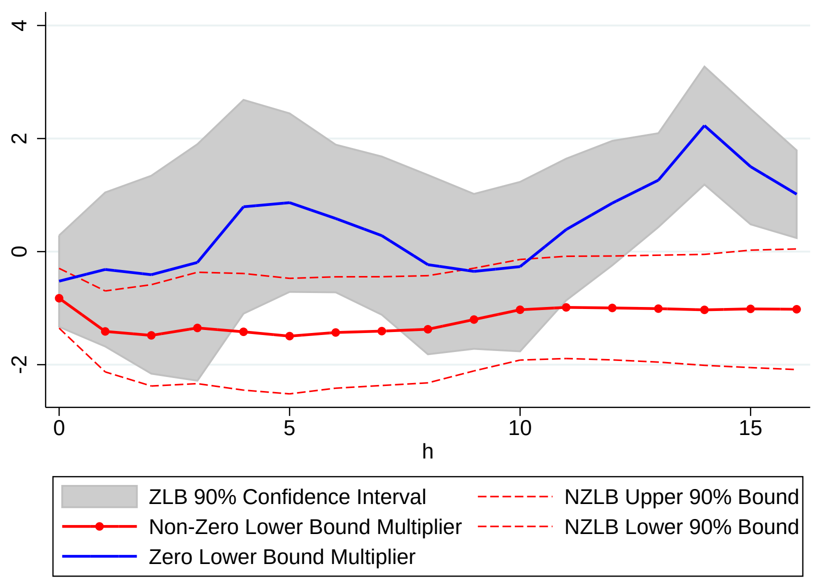
$$\begin{aligned}\sum_{j=0}^{h} E_{t+j}\pi_{i,t+4+j} \quad = \quad & ZLB_{i,t-1}(\gamma_{ZLB,h} + \varphi_{ZLB,h}(L)z_{i,t-1} + m_{ZLB,h}\sum_{j=0}^{h} g_{i,t+j}) \; for \; h = 0,1,2,... \qquad (16)\\ & +(1-ZLB_{i,t-1})(\gamma_{NZLB,h} + \varphi_{NZLB,h}(L)z_{i,t-1} + m_{NZLB,h}\sum_{j=0}^{h} g_{i,t+j}) + \delta_{i,h} + \omega_{i,t+h}\end{aligned}$$

In formulating the dependent variable in equation 16, a variety of survey-based measures of one year ahead expected inflation, described in more detail in section 4, are used. Given the problems discussed with the UK data in that they changed from reporting RPIX inflation expectations to CPI inflation expectations in 2004, this study attempts to minimise this problem by subtracting all expected inflation values by a target of 2% (except for the RPIX UK values where they followed a target of 2.5%).

Furthermore, as the dependent variable and government spending can no longer be written in the same units, they are not divided by potential output. Instead, this thesis divided per capita real government spending by a thousand so that the multipliers now show the effect of an increase in real per capita government spending of 1,000 units of currency on expected inflation (measured in the percentage point response).[40]

The state-dependent multipliers and associated 90% confidence bands are also presented in figure 8, where the blue line is the multiplier at the ZLB and the red line is the multiplier in normal times. Additionally, multipliers and the associated standard errors for selected horizons are reported in table 4 in the same manner as for output multipliers. Again, note that the variables are not normalised these values by potential output, rather they are in 1,000 units of currency.

Figure 8: State-Dependent Expected Inflation Multipliers



Note: This figure shows cumulative expected inflation multipliers for the two states. The multiplier at the ZLB is shown by the blue line, while its 90% confidence interval is shaded. The red dotted line shows the multiplier in normal times and the dashed lines show the 90% confidence bands.

These results tentatively provide support for the New Keynesian expected inflation channel in some ways, but not in others. The New Keynesian model predicts that a government spending shock should lead to a large

[40] If it had been left as one unit of currency, then the effect on expected inflation would be very small. For instance using 2017 quarter one data, a one unit increase in real government spending per capita is the equivalent of a 0.000179% increase in total real government spending for the UK, 0.000138% for the US and 0.000175% for the Euro Area. Thus, the multiplier has been scaled up so that it now shows the impact on expected inflation of a larger change in government spending.

Table 4: Cumulative Expected Inflation Multipliers

	Linear	Non-ZLB	ZLB	P-Value
Initial Multiplier	-0.738	-0.825	-0.522	0.602
	(0.300)	(0.321)	(0.491)	
1 Quarter Multiplier	-1.169	-1.412	-0.316	0.250
	(0.408)	(0.435)	(0.828)	
2 Quarter Multiplier	-1.258	-1.481	-0.409	0.377
	(0.490)	(0.545)	(1.064)	
3 Quarter Multiplier	-1.148	-1.350	-0.192	0.426
	(0.528)	(0.599)	(1.272)	
1 Year Multiplier	-1.056	-1.419	0.793	0.109
	(0.547)	(0.627)	(1.149)	
2 Year Multiplier	-1.233	-1.374	-0.231	0.340
	(0.529)	(0.576)	(0.964)	
3 Year Multiplier	-0.882	-0.997	0.858	0.024
	(0.559)	(0.559)	(0.669)	
4 Year Multiplier	-0.923	-1.020	1.016	0.013
	(0.650)	(0.649)	(0.471)	

Note: The values in the brackets beneath the multipliers give the standard errors. The p-values are from testing whether the ZLB and non-ZLB multipliers are different. This table just shows the multipliers at some of the horizons. For a complete set of multipliers see figure 8.

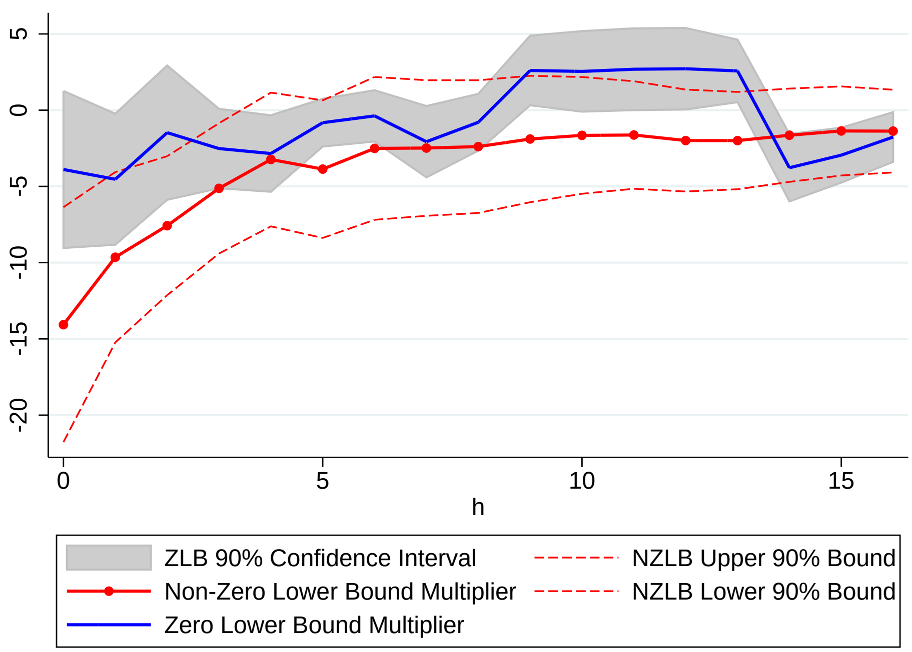
increase in expected inflation at the ZLB, as shown in the stylised example in figure 1. These results show that there is not a large increase in expected inflation in either state. In fact, the impact multiplier of expected inflation is negative initially, and not much different from zero thereafter. In this case, a government spending shock at the ZLB leads to an increase in the real interest rate on impact as the nominal interest rate would not change, but expected inflation would fall. This would encourage agents to save rather than consume further, thus limiting the effectiveness of fiscal policy.

On the other hand, the results show that the response of expected inflation is consistently higher at the ZLB compared to normal times. Perhaps this is some evidence that the expected inflation channel can lead to the elevated output multipliers found in figure 7. While expected inflation is not very responsive to government spending in ZLB periods, it seems as though it responds negatively in normal times. This would lead the real interest rate to rise by more in normal times compared to the ZLB. This is due to the responses of the two components of the real interest rate: the nominal interest rate and expected inflation. Firstly, so long as the government spending shock is not so large that the policy rate escapes the ZLB, the policymaker would only respond to the government spending shock by increasing the nominal interest rate in normal times. In combination with the larger decrease in expected inflation in normal times, the government spending shock would lead to higher real interest rates in normal times compared to the ZLB period. This provides some evidence to explain why multipliers might be larger in a liquidity trap.

However, the multipliers in the two states are tested to see if they are equal. The p-values of this test are reported in the final column of table 4. These tests show that, at no horizon, is the expected inflation multiplier significantly different at the ZLB compared with normal times. This is likely to be due to the large confidence bands, particularly for the multiplier in the ZLB state. Indeed there is a general lack of significance in these estimates (though some estimates for normal times are significant). Given this point, it is difficult to justify these impulse response functions as support for any kind of New Keynesian expected inflation channel. It might indicate that there could be a channel for these economies, but more work needs to be done.

As far as checking the robustness of these results goes, inflation multipliers are also reported in figure 9. Annual inflation in this case is generated using the GDP price deflator. While the magnitudes differ slightly between the inflation and expected inflation multipliers, the direction of the effects are similar.

Figure 9: State-Dependent Inflation Multipliers



7.2 The Expected Duration of the Liquidity Trap

Given the evidence presented showing that multipliers are larger when the ZLB on interest rates is binding, it is worth investigating the predictions of the New Keynesian model further. In particular, it is of interest to examine whether multipliers are larger in ZLB episodes with a longer expected duration. In theory, a longer expected duration of the liquidity trap implies a longer period of expected monetary accommodation. As the current output gap depends on all future expected output gaps, and future output gaps are expected to be larger if monetary policy is accommodative in that future period, the current period output gap will be larger the longer the expected duration of the liquidity trap. It should be noted that even if there is not substantial evidence for the expected inflation channel of the fiscal multiplier, equation 12 suggests that multipliers should still be (slightly) larger when the expected duration is longer.

To test for this effect, overnight index swap rates data is used as an empirical proxy for the expected path of the policy rate.[41] To begin with, the definition of the ZLB is adjusted to be binding when the nominal interest rate is expected to be below 0.5% in the next quarter according to OIS rates, rather than when the policy rate was at most 0.5%. While this does not change the sample too much, it was the case that the OIS rate for the Euro Area was below 0.5% for a large portion of the time between the onset of the financial crisis and the quarter that the ECB cut rates to 0.5% in mid-2013.

Given the similarity between this definition of the ZLB, and the definition used in the previous analysis, it is expected that multiplier results will also be similar. Indeed, this study repeats the cumulative output multiplier analysis using this definition of the ZLB state. Table 5 shows the results for the aggregate, non-ZLB and ZLB cases, as well the p-value from the test of equality between the two state-dependent multipliers. The aggregate and normal times multipliers are still insignificant at the 5% level. Furthermore, it is noticeable that the multipliers at the ZLB are smaller than those in table 2, where the previous ZLB definition is used. However, the multipliers are still above unity over horizons between two and six quarters. Additionally, the multipliers are still larger when the ZLB is expected, compared to when it is not (at least in the short-term while the instrument is still relevant). Indeed it is significantly different at the two and three quarter horizons, as shown by the p-values.

The advantage of using this new definition is that the expected duration of the liquidity trap can be controlled for. The OIS data provides an expected path of the nominal interest rate at quarterly intervals.[42] Therefore, the expected duration of the liquidity trap is the number of quarters before the OIS rate rises above 0.5%. In

[41] While this is not a perfect measure, due to issues such as time-varying risk-premia (Erceg & Lindé, 2010), it is highly linked to the expected path of the policy rate.

[42] After eight quarters, data is only provided for annual horizons, but cubic spline interpolation is used to generate the quarterly values.

Table 5: Cumulative Output Multipliers with Alternative ZLB Definition

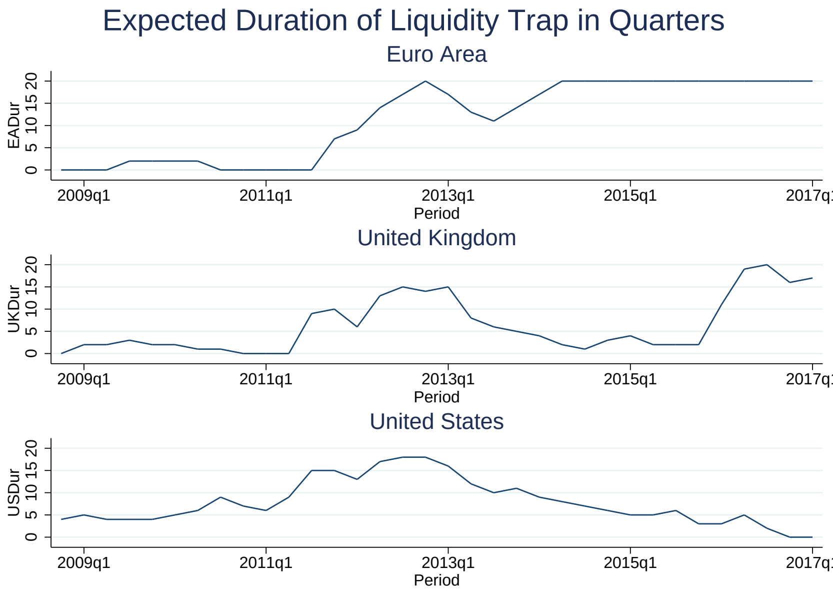
	Linear	Non-ZLB	ZLB	P-Value
Initial Multiplier	0.111	0.114	0.479	0.260
	(0.264)	(0.299)	(0.149)	
1 Quarter Multiplier	-0.006	0.035	0.522	0.248
	(0.286)	(0.314)	(0.305)	
2 Quarter Multiplier	0.005	0.066	1.052	0.041
	(0.374)	(0.409)	(0.312)	
3 Quarter Multiplier	-0.003	0.127	1.171	0.094
	(0.429)	(0.462)	(0.439)	
1 Year Multiplier	-0.166	0.049	1.106	0.136
	(0.460)	(0.489)	(0.520)	
2 Year Multiplier	-0.380	0.058	0.637	0.571
	(0.578)	(0.580)	(0.722)	
3 Year Multiplier	-0.714	0.045	-0.937	0.477
	(0.825)	(0.784)	(0.984)	
4 Year Multiplier	-0.294	0.442	-0.892	0.396
	(0.942)	(0.955)	(1.172)	

Note: This table shows cumulative output multipliers where the ZLB state is when the 1 quarter OIS rate is less than 0.5%. The values in the brackets give the standard errors. The p-values are from testing whether the ZLB and non-ZLB multipliers are different.

fact, the expected duration of the liquidity trap for the three economies is presented in figure 10. This can be used to examine whether output multipliers are larger when the liquidity trap has a long expected duration. To this end, this study adjusts the definition of the ZLB state so that observations with a low expected duration are excluded. Cumulative output multipliers are then estimated using various exclusion criteria. As found in table 6, cumulative multipliers are estimated for samples where the ZLB is expected to bind for at least two, three, four and six quarters, along with the multipliers without an exclusion (note that the multiplier without an exclusion restriction has the same results as in table 5).

In terms of the results presented in table 6, there is slight evidence of a expected duration effect. While the table presents a number of exclusion criteria, it should be noted that the number of observations that meet the ZLB criteria falls as the criteria becomes more strict. The effect of this can be seen in the standard errors presented, as the reduced number of observations makes the estimate less precise. This is important, in particular

Figure 10: Expected Duration of Liquidity Trap



Note: This figure presents the expected duration of the liquidity trap. This means that if the value in the graph is eight, then financial markets expect the liquidity trap to end in eight quarters time. In the case that the expected duration was longer than 20 quarters, the expected duration has been at 20 for the purposes of this figure.

for the multiplier when the expected duration is at least six quarters as only the initial impact multiplier is significantly different from zero at the 5% level. Perhaps then, less weight can be given to the results reported to the multipliers which consider only liquidity traps with rather long expected duration.

Additionally, the cumulative output multiplier is larger when observations with expected duration less than two are excluded compared to the unrestricted ZLB measure. Indeed, it is even larger than that when observations with expected duration of less than three quarters are excluded. This provides some support for the importance of the expected duration of the liquidity trap episode in determining the extent to which government spending affects output. While the multipliers do not differ too much, it is important to note that this could be because the sample of ZLB observations is not too different, at least for the more relaxed exclusion criteria. For instance, the definition that excludes only observations that have an expected duration of less than two quarters yields a relatively similar sample to the unrestricted definition. This means that the elevated multiplier in the case with the exclusion could well be due to the removal of those observations with a low expected duration. This is in line with the theory that the longer the expected duration of the liquidity trap, the greater the multiplier.

It could be argued that the results in table 6 could be explained by the trade-off between two effects: the expected duration effect increasing the multiplier as the criteria becomes stricter, and the stricter criteria de-

Table 6: Cumulative Output Multipliers with Different ZLB Definitions

	ZLB	2 Quarters	3 Quarters	4 Quarters	6 Quarters
Initial Multiplier	0.479	0.507	0.556	0.507	0.424
	(0.149)	(0.191)	(0.228)	(0.245)	(0.226)
1 Quarter Multiplier	0.522	0.570	0.609	0.511	0.352
	(0.305)	(0.362)	(0.434)	(0.460)	(0.480)
2 Quarter Multiplier	1.052	1.123	1.298	1.141	1.015
	(0.312)	(0.380)	(0.540)	(0.577)	(0.657)
3 Quarter Multiplier	1.171	1.228	1.427	1.189	0.977
	(0.439)	(0.517)	(0.770)	(0.815)	(0.926)
1 Year Multiplier	1.106	1.219	1.459	1.209	0.843
	(0.520)	(0.651)	(1.083)	(1.156)	(1.294)
2 Year Multiplier	0.637	0.694	0.931	0.977	1.505
	(0.722)	(0.890)	(1.328)	(1.511)	(2.180)
3 Year Multiplier	-0.937	-0.697	-0.908	-0.109	1.374
	(0.984)	(0.880)	(1.087)	(1.184)	(1.704)
4 Year Multiplier	-0.892	-0.651	-1.762	-0.801	0.750
	(1.172)	(0.993)	(2.096)	(1.824)	(1.101)

Note: This table shows the cumulative multipliers for the ZLB state where the expected duration is at least 2, 3, 4 and 6 quarters. The values in brackets give the standard errors. This table just shows the multipliers at some of the horizons.

creasing the number of observations and precision of estimates. Alternatively, due to the relatively limited sample, it could come down to the specific environment of the observations that are removed by these criteria.

8 Discussion

This thesis presents findings that suggest that government spending is more effective in boosting output when close to the ZLB for the panel of the Euro Area, United Kingdom and United States. These results are in line with some studies (Almunia *et al.*, 2010; Miyamoto & Nguyen, 2016; Ramey & Zubairy, 2014), while not so much with others that suggest that multipliers are not larger when monetary policy is accommodative (Crafts & Mills, 2013). Indeed, the findings in this study suggest that the multiplier is greater than unity, particularly after a few quarters have elapsed. While theory and some authors posit that modest aggregate multipliers are due to the crowding out effect, where monetary policymakers respond to increased government spending by increasing the policy rate, these results indicate that there might be crowding in of private consumption and investment associated with government spending at the ZLB.

However, this study differs from most others in a couple of ways. Firstly, most previous research, perhaps due to ZLB data constraints, focuses on liquidity trap episodes in the early twentieth century or episodes in Japan, which could be characterised as a special case of liquidity trap. If it is true that the Japanese liquidity trap is more driven by a lack of confidence, as suggest by Mertens & Ravn (2014), then studies on the Japanese situation will yield lower multipliers. Yet this thesis exploits a panel of countries to analyse the effect of government spending at the ZLB in the most recent crisis. To the extent that each ZLB episode is unique to the economic environment of the time, this could suggest that the results in this study should not necessarily be exactly the same as in other fiscal multiplier research. Secondly, few studies have considered government spending multipliers for the Euro Area and the UK. This panel is selected in order to produce a more generalised result on government spending multipliers, in that they are larger when interest rates are near the lower bound.

Having established larger multipliers in liquidity trap periods, it was then important to investigate the mechanisms that were driving this effect. Given that many researchers (Arin *et al.*, 2015; Auerbach & Gorodnichenko, 2012a; Fazzari *et al.*, 2015) report larger multipliers in periods of slack, it was important to check that these results were not driven by the large amount of under-utilised capacity after the crash. Surprisingly, this study finds that output multipliers are not different in recessions and expansions. However, this could in part be due to a generous definition of a recession as when an economy is moving from the peak of the business cycle to the trough. Nevertheless, this study tentatively verifies that output multipliers in a recession are larger when interest rates are close to the ZLB. While this does suggest that large multipliers might be driven by monetary accommodation, the sample of recessions at the ZLB is relatively small. Additionally, Auerbach & Gorodnichenko (2012b) argues that recessionary multipliers are larger when the recession is deeper, so it could just be that the Great Recession led to a particularly large amount of slack.

It is common for other studies to find a lack of support for the expected inflation effect, where many find that inflation responds more positively in normal times, while at the ZLB government spending has a limited effect on inflation. In answer to the second research question, this paper also finds that the response of expected inflation (and indeed inflation) to government spending is not significantly different from zero in ZLB episodes. While the answer could be improved by accessing better expected inflation data (there is a lack of market-based data for a long sample), the robustness check of estimating the inflation multiplier suggests that these results are relatively accurate. This corroborates the findings of Auerbach & Gorodnichenko (2012a), Dupor

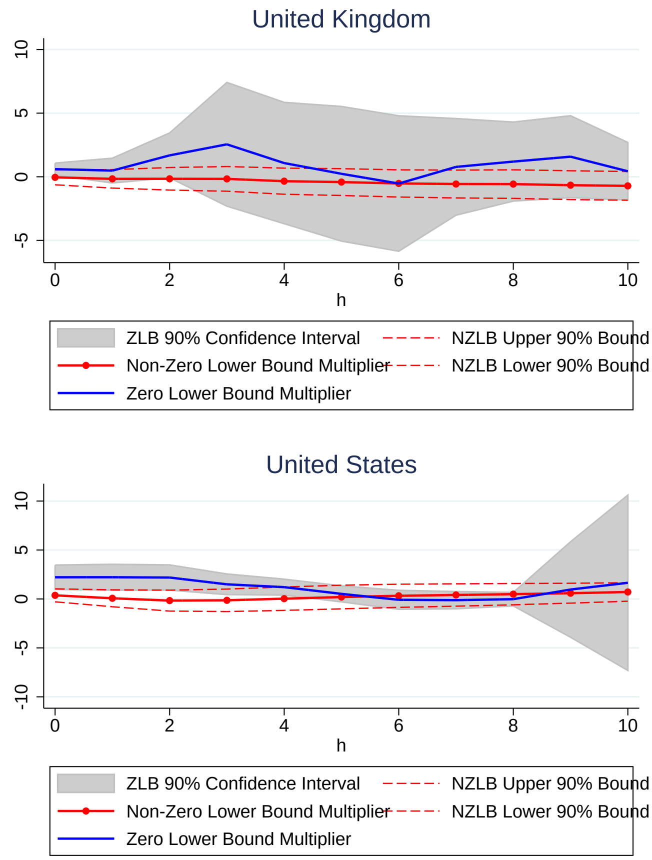
& Li (2015) and Roulleau-Pasdeloup (2017). In fact Roulleau-Pasdeloup (2017) develops a model with labour market frictions that can explain these results. It could be that labour market frictions are crucial to producing plausible predictions in the New Keynesian model.

Finally, this study provides modest support for the theory that output multipliers are larger in states in which the liquidity trap is expected to be more long-lasting. While this idea has been posited theoretically by a number of authors (Erceg & Lindé, 2014; Woodford, 2011), to my knowledge there are no other studies that investigate it empirically. There are challenges in estimating multipliers for liquidity traps with a long expected duration, given the small sample of periods where this is the case. However, this study finds that ZLB output multipliers are larger when the expected duration is at least two quarters or three quarters long compared to the aggregate ZLB output multiplier. If this finding could be made more robust, it would signal to policymakers that government spending is a particularly effective tool for boosting output when the economy is expected to remain in a depressed state for a longer period of time. It should be noted that, even if the expected inflation channel is quantitatively unimportant, the expected duration effect can still play an important role in models such as that of Roulleau-Pasdeloup (2017) where larger multipliers are driven more by the amount of slack in the economy rather than monetary accommodation itself.

In terms of external validity, this estimation procedure finds significantly higher output multipliers for a cross section of advanced economies during the ZLB period following the financial crisis. To show that the aggregate multipliers are not driven by one economy in the panel in particular, results from calculating the multipliers individually for the UK and US are shown in figure 11.[43] While there are large confidence bands due to the large reduction in observations, the point estimates are relatively similar, suggesting that these aggregated multipliers are largely applicable to both the UK and US. This provides some support to the idea that these results can be extended to other advanced economies that have encountered the ZLB on interest rates. In fact, while it can be argued that these results can be generalised to other advanced economies, further work can be done by investigating output multipliers in these other economies using this methodology. Indeed, while caution should be advised as studies have found different multiplier effects in a variety of settings, the results of this thesis tend to suggest that government spending is more effective in increasing output when monetary policy is accommodative.

[43] Note that a figure for the Euro area is not provided as the ZLB episode in the Euro Area was not long enough to produce reliable estimates.

Figure 11: State-Dependent Output Multipliers Calculated for Each Economy Individually



9 Conclusion

The purpose of this study was to answer the research questions outlined in section 3.5. Primarily the aim was to investigate whether government spending multipliers were larger when the ZLB on interest rates was binding and to further examine the channels that might drive these results. The paper found that output multipliers are enlarged when monetary policy was accommodative in the wake of the 2008 financial crisis. Through robustness checks, the study suggests that these multipliers are not just larger because the ZLB episode occurred during recession. This is important as it suggests that government spending could be an effective tool for these advanced economies to improve economic growth and perhaps escape the situation of low interest rates, low growth and subdued economic activity. Additionally, the paper suggests that these multipliers are not driven by the expected inflation effect, or at least not to the extent predicted by the standard New Keynesian model. Furthermore, there is some evidence that multipliers increase with the expected duration of the trap, indicating that government spending might be very effective at boosting output currently in the UK and Euro Area.

While the initial results in this paper are supportive of the New Keynesian model's prediction that output multipliers should be larger when the ZLB is binding, the later results suggest that more work needs to be done. This is because the finding of limited expected inflation multipliers is at odds with the key New Keynesian mechanism for generating large output multipliers.

References

Adam, Klaus, & Billi, Roberto M. 2008. Monetary Conservatism and Fiscal Policy. *Journal of Monetary Economics*, **55**(8), 1376–1388.

Almunia, Miguel, Bénétrix, Agustín, Eichengreen, Barry, O'Rourke, Kevin H., & Rua, Gisela. 2010. From Great Depression to Great Credit Crisis: Similarities, Differences and Lessons. *Economic Policy*, **25**(62), 219–265.

Arin, K. Peren, Koray, Faik, & Spagnolo, Nicola. 2015. Fiscal Multipliers in Good Times and Bad Times. *Journal of Macroeconomics*, **44**, 303–311.

Aruoba, Boragan S, Cuba-Borda, Pablo, & Schorfheide, Frank. 2016. Macroeconomic Dynamics Near the ZLB: A Tale of Two Countries.

Auerbach, Alan, & Gorodnichenko, Yuriy. 2012a. Fiscal Multipliers in Recession and Expansion. *Pages 63–98 of: Fiscal Policy after the Financial Crisis*. National Bureau of Economic Research, Inc.

Auerbach, Alan J, & Gorodnichenko, Yuriy. 2012b. Measuring the Output Responses to Fiscal Policy. *American Economic Journal: Economic Policy*, **4**(2), 1–27.

Auerbach, Alan J., & Gorodnichenko, Yuriy. 2014. *Fiscal Multipliers in Japan*. Working Paper 19911. National Bureau of Economic Research.

Barro, Robert J., & Redlick, Charles J. 2011. Macroeconomic Effects From Government Purchases and Taxes. *The Quarterly Journal of Economics*, **126**(1), 51–102.

Beetsma, Roel, Giuliodori, Massimo, & Klaassen, Franc. 2006. Trade Spill-overs of Fiscal Policy in the European Union: a Panel Analysis. *Economic Policy*, **21**(48), 640–687.

Beetsma, Roel, Giuliodori, Massimo, & Klaassen, Franc. 2009. Temporal Aggregation and SVAR Identification, With an Application to Fiscal Policy. *Economics Letters*, **105**(3), 253–255.

Blanchard, Olivier, & Galí, Jordi. 2007. Real Wage Rigidities and the New Keynesian Model. *Journal of Money, Credit and Banking*, **39**(1), 35–65.

Blanchard, Olivier, & Perotti, Roberto. 2002. An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output. *The Quarterly Journal of Economics*, **117**(4), 1329–1368.

Born, Benjamin, & Müller, Gernot J. 2012. Government Spending Shocks in Quarterly and Annual Time Series. *Journal of Money, Credit and Banking*, **44**(2-3), 507–517.

Brückner, Markus, & Tuladhar, Anita. 2013. Local Government Spending Multipliers and Financial Distress: Evidence from Japanese Prefectures. *The Economic Journal*, **124**(581), 1279–1316.

Canova, Fabio, & Pappa, Evi. 2011. Fiscal Policy, Pricing Frictions and Monetary Accommodation. *Economic Policy*, **26**(68), 555–598.

Christiano, Lawrence, Eichenbaum, Martin, & Rebelo, Sergio. 2011. When Is the Government Spending Multiplier Large? *Journal of Political Economy*, **119**(1), 78–121.

Chung, Hess, Herbst, Edward, & Kiley, Michael T. 2015. Effective Monetary Policy Strategies in New Keynesian Models: A Reexamination. *NBER Macroeconomics Annual*, **29**(1), 289–344.

Coenen, Günter, Erceg, Christopher J, Freedman, Charles, Furceri, Davide, Kumhof, Michael, Lalonde, René, Laxton, Douglas, Lindé, Jesper, Mourougane, Annabelle, Muir, Dirk, Mursula, Susanna, de Resende, Carlos, Roberts, John, Roeger, Werner, Snudden, Stephen, Trabandt, Mathias, & in't Veld, Jan. 2012. Effects of Fiscal Stimulus in Structural Models. *American Economic Journal: Macroeconomics*, **4**(1), 22–68.

Cogan, John F., Cwik, Tobias, Taylor, John B., & Wieland, Volker. 2010. New Keynesian Versus Old Keynesian Government Spending Multipliers. *Journal of Economic Dynamics and Control*, **34**(3), 281–295.

Corsetti, Giancarlo, Meier, André, & Müller, Gernot J. 2012. What Determines Government Spending Multipliers? *Economic Policy*, **27**(72), 521–565.

Crafts, Nicholas, & Mills, Terence C. 2013. Rearmament to the Rescue? New Estimates of the Impact of "Keynesian" Policies in 1930s' Britain. *The Journal of Economic History*, **73**(4), 1077–1104.

Cwik, Tobias, & Wieland, Volker. 2009. Keynesian Government Spending Multipliers and Spillovers in the Euro Area. *Centre for Economic Policy Research Discussion Papers 7389*.

Davig, Troy, & Leeper, Eric M. 2011. Monetary-Fiscal Policy Interactions and Fiscal Stimulus. *European Economic Review*, **55**(2), 211–227.

Drautzburg, Thorsten, & Uhlig, Harald. 2011. *Fiscal Stimulus and Distortionary Taxation*. Tech. rept.

Dupor, Bill, & Li, Rong. 2015. The Expected Inflation Channel of Government Spending in the Postwar U.S. *European Economic Review*, **74**, 36–56.

Eggertsson, Gauti, & Woodford, Michael. 2003. The Zero Interest-Rate Bound and Optimal Monetary Policy. *Brookings Papers on Economic Activity*, **1**, 139–211.

Eggertsson, Gauti B. 2008. Great Expectations and the End of the Depression. *American Economic Review*, **98**(4), 1476–1516.

Eggertsson, Gauti B. 2011. What Fiscal Policy Is Effective at Zero Interest Rates? *NBER Macroeconomics Annual*, **25**(1), 59–112.

Eichenbaum, Martin, & Fisher, Jonas. 2005. Fiscal Policy in the Aftermath of 9/11. *Journal of Money, Credit and Banking*, **37**(1), 1–22.

Erceg, Christopher, & Lindé, Jesper. 2010. *Is there a fiscal free lunch in a liquidity trap?* International Finance Discussion Papers 1003. Board of Governors of the Federal Reserve System (U.S.).

Erceg, Christopher, & Lindé, Jesper. 2014. Is There a Fiscal Free Lunch in a Liquidity Trap? *Journal of the European Economic Association*, **12**(1), 73–107.

Fatás, Antonio, & Mihov, Ilian. 2001. The Effects of Fiscal Policy on Consumption and Employment: Theory and Evidence. *Centre for Economic Policy Research Discussion Papers 2760*.

Fazzari, Steven, Morley, James, & Irina, Panovska. 2015. State-Dependent Effects of Fiscal Policy. *Studies in Nonlinear Dynamics & Econometrics*, **19**(3), 285–315.

Fisher, Jonas D.M., & Peters, Ryan. 2010. Using Stock Returns to Identify Government Spending Shocks. *The Economic Journal*, **120**(544), 414–436.

Galí, Jordi, López-Salido, J. David, & Vallés, Javier. 2007. Understanding the Effects of Government Spending on Consumption. *Journal of the European Economic Association*, **5**(1), 227–270.

Gordon, Robert, & Krenn, Robert. 2010. *The End of the Great Depression 1939-41: Policy Contributions and Fiscal Multipliers*. Tech. rept. National Bureau of Economic Research.

Hall, Robert E. 2009. By How Much Does GDP Rise If the Government Buys More Output? *Brookings Papers on Economic Activity*, 183 – 231.

Ilzetzki, Ethan, Mendoza, Enrique G., & Végh, Carlos A. 2013. How Big (Small?) Are Fiscal Multipliers? *Journal of Monetary Economics*, **60**(2), 239–254.

Jordà, Òscar. 2005. Estimation and Inference of Impulse Responses by Local Projections. *American Economic Review*, **95**(1), 161–182.

Kiley, Michael T. 2016. Policy Paradoxes in the New Keynesian Model. *Review of Economic Dynamics*, **21**, 1–15.

Leeper, Eric M., Walker, Todd B., & Yang, Shu-Chun Susan. 2013. Fiscal Foresight and Information Flows. *Econometrica*, **81**(3), 1115–1145.

Mankiw, N. G., & Reis, R. 2002. Sticky Information Versus Sticky Prices: A Proposal to Replace the New Keynesian Phillips Curve. *The Quarterly Journal of Economics*, **117**(4), 1295–1328.

Mertens, Karel R. S. M., & Ravn, Morten O. 2014. Fiscal Policy in an Expectations-Driven Liquidity Trap. *The Review of Economic Studies*, **81**(4), 1637–1667.

Miyamoto, Wataru, & Nguyen, Thuy Lan. 2016. Government Spending Multipliers Under the Zero Lower Bound: Evidence from Japan. *SSRN Electronic Journal*.

Mountford, Andrew, & Uhlig, Harald. 2009. What are the Effects of Fiscal Policy Shocks? *Journal of Applied Econometrics*, **24**(6), 960–992.

Owyang, Michael T, Ramey, Valerie A, & Zubairy, Sarah. 2013. Are Government Spending Multipliers Greater during Periods of Slack? Evidence from Twentieth-Century Historical Data. *American Economic Review*, **103**(3), 129–134.

Perotti, Roberto. 2005. Estimating the Effects of Fiscal Policy in OECD Countries. *Proceedings, Federal Reserve Bank of San Francisco*.

Ramey, Valerie A. 2011a. Can Government Purchases Stimulate the Economy? *Journal of Economic Literature*, **49**(3), 673–685.

Ramey, Valerie A. 2011b. Identifying Government Spending Shocks: It's all in the Timing. *The Quarterly Journal of Economics*, **126**(1), 1–50.

Ramey, Valerie A., & Shapiro, Matthew D. 1998. Costly capital reallocation and the effects of government spending. *Carnegie-Rochester Conference Series on Public Policy*, **48**, 145–194.

Ramey, Valerie A., & Zubairy, Sarah. 2014. *Government Spending Multipliers in Good Times and in Bad: Evidence from U.S. Historical Data*. Tech. rept.

Roulleau-Pasdeloup, Jordan. 2017. *The Government Spending Multiplier in a Deep Recession*. Tech. rept.

Sheremirov, Viacheslav, & Spirovska, Sandra. 2015. Output Response to Government Spending: Evidence From New International Military Spending Data. *Federal Reserve Bank of Boston*.

Stock, James, & Yogo, Motohiro. 2005. *Testing for Weak Instruments in Linear IV Regression*. New York: Cambridge University Press. Pages 80–108.

Wieland, Johannes. 2017. Are Negative Supply Shocks Expansionary at the Zero Lower Bound? *Journal of Political Economy*. (forthcoming).

Woodford, Michael. 2011. Simple Analytics of the Government Expenditure Multiplier. *American Economic Journal: Macroeconomics*, **3**(1), 1–35.