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Has Quantitative Easing Affected the Predictive Power of the Yield Curve? Evidence from Nine Advanced Economies

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ABSTRACT

Since the global financial crisis in 2007-2008 several central banks around the world have introduced Quantitative Easing. Earlier literature has proven that this has caused significant downward pressure on yields in many economies. This study examines if the introduction of Quantitative Easing has changed the predictive power of the yield curve on future economic activity in nine advanced economies. The empirical results show that the yield spreads ability to predict future economic activity varies across lag lengths and countries where the highest goodness of fit is achieved for the United States. Furthermore, this study provides some indications that the level of a central banks balance sheet has some effect on the marginal effect of the yield spread on future economic activity. However, more research is needed to understand the effects caused by Quantitative Easing entirely.

Keywords: *Yield curve, Recession, Monetary policy, Quantitative Easing*

Table of Content

1. Introduction

The ability to predict business cycle turning points and future recessions are of great importance to policymakers, business, investors and households. In the late 1980s and early 1990s, empirical researchers started investigating the relationship between the yield curve and future economic activity. These papers stated that there exists a relationship and an inversion of the yield curve implies a future economic downturn (see, e.g. Stock and Watson, 1989, Chen 1991, Estrella and Hardouvelis, 1991). Consequently, the slope of the yield curve has become one of the most observed economic variables by market watchers, central bankers and professional economists.

In 2019, the yield curve inverted in several economies around the world, which caused a resurgence in the discussion about whether the yield curve as a predictor of future economic activity still holds. Several studies that have investigated possible instability in the relationship between the yield spread, and future economic activity concludes that the instability is consistent with other evidence of instability in the economy. For instance, Stock and Watson (2003), Estrella, Rodrigues and Schich (2003) and Schrimph and Wang (2010) all point out changes in how central banks conduct monetary policies as explanations for the instability in the relationship between the yield spread and future economic activity.

Chinn and Kucko (2015) also provides evidence that the predictive power of the yield curve deteriorated during the Great Moderation, that started in the late 1980s, until the Great Recession in 2007-2008. The paper brings up several possible aspects, including the fact that several countries have approached the zero lower bound in recent years. The authors argue that when a country reaches the zero lower bound, the central bank cannot lower the short-term interest rate further and might instead try to lower long-term rates. This will flatten the yield curve if the procedure is successful and might deteriorate the relationship between the yield curve and economic activity. So, there is reason to believe that how central banks' conduct their monetary policy seems to influence the relationship between the yield curve and future economic activity.

Since the global financial crisis in 2007-2008 central banks' in several economies have introduced unconventional monetary policies. One example is negative policy rates, another is the significant expansions of central banks' balance sheets, often is referred to as Quantitative Easing.

The effectiveness and channels through which Quantitative Easing affect the real economy have been at the centre of the academic and policy debate. The existing literature has mainly focused on the reaction of asset prices to the introduction of Quantitative Easing (Di Maggio et al., 2019). Kuttner (2018) provides an overview of the research on the effect on these alternative instruments by the central banks. Several studies are brought up that conclude that the Quantitative Easing programmes have had significant downward pressure on yields in many economies. However, few studies have empirically analysed which effect the Quantitative Easing has had on the relationship between the yield curve and future economic activity.

Therefore, the purpose of this study is to investigate this effect closer and examine the effect across nine advanced economies: Australia, Canada, Germany, Italy, Japan, Norway, Sweden, the United Kingdom and the United States. Using quarterly data, every country in the sample is analysed using within sample regressions at five different lag lengths: 1, 2, 4, 8 and 12 (that is one quarter up to three years lag). The findings show that the yield spreads ability to predict future economic activity varies across lag lengths and countries where the highest goodness of fit is achieved for the United States. Furthermore, this study provides some indications that the level of a central banks balance sheet has an effect on the marginal effect of the yield spread on future economic activity. However, more research is needed to understand the effects caused by Quantitative Easing entirely.

The remainder of the paper is organised in the following way. Section 2 provides a literature review on the yield curve as a predictor of future economic activity as well as theoretical explanations to the linkage between short and long -term interest rates. Section 3 presents an overview of the unconventional monetary policies that have been applied with a focus on Quantitative Easing. The empirical methodology is presented in section 4, and section 5 gives an overview of the data used in this study. The result is presented in section 6, and the final section discusses the empirical findings and gives some concluding remarks.

2. Literature Concerning the Yield Curve and Economic Activity

There exists an extensive literature on the relationship between the yield spread and future economic activity. The expectation hypothesis is often stated to give some theoretical explanation to the relationship between the yield curve and future economic activity. The essence of the hypothesis is that the long-term interest rate is an average of the current and expected future short-term interest rates, such that:

$$i_t^L \approx \frac{1}{n}\left[i_t + E[i_{t+1} + \cdots + i_{t+n-1}|\Omega_t]\right] \quad (1)$$

This arbitrage condition implies that investors obtain the same expected return on short-term and long-term instruments. An underlying assumption is that investors are risk-neutral, which implies a flat yield curve if investors expect no changes in future short-term rates. However, since long-term bond prices are more sensitive to fluctuations in the interest rate market and therefore more volatile one must introduce a risk premium on the right-hand side in eq 1 if the investor is risk-averse.

$$i_t^L \approx \frac{1}{n}\left[i_t + E[i_{t+1} + \cdots + i_{t+n-1}|\Omega_t]\right] + \rho_t \quad (2)$$

Consequently, the yield curve will be upward sloping even if the expectations are that the short-term interest rates will be constant over time due to the risk premium (Sørensen and Whitta-Jacobsen p.464-465, 2010). In a scenario where the short-term interest rates are expected to fall, there will be a downward sloping (inverted) yield curve since the long-term interest rate will be less than the short-term interest rate. Low short-term interest rates are associated with economic downturns for two reasons. The first reason is that lower economic activity decreases private sector demand for credit and the second is that the monetary authority is likely to decrease the policy rate to counteract the downturn. Thus, a downward sloping yield curve could imply an expected future downturn in the economy (Chinn and Kucko, 2015).

Over the past 30 years, extensive research has been conducted to empirically examine the yield curve ability to predict future economic activity. These studies have mainly investigated two types of dependent variables: discrete variables such as different recession indicators or continuous variables such as growth in Industrial Production, GNP or real GDP.

Some of the earliest studies that investigate the relationship between the yield spread and future growth dates to the late 1980s and beginning of the 1990s; include Stock and Watson (1989), Chen (1991), Estrella and Hardouvelis (1991). These papers focus on US data and find a highly significant relationship between the term-structure spread and economic activity with a horizon ranging around one to eight quarters. Estrella and Hardouvelis (1991), which look on the specific question of the most optimal forecast horizon, concludes that the results are most significant between four and six quarters ahead. For these OLS regressions, the R-squared was around 30 per cent which, implies that the yield spread explains around one-third of the fluctuations in future growth. Furthermore, Estrella and Hardouvelis (1991) introduced a probit model that evaluates the yield curve's ability to forecast impending recessions one year ahead, which is measured as a binary variable using the definition from National Bureau of Economic Research (NBER). It could be concluded that the model was quite successful in predicting recessions in the future, and the result seemed to be stable for US data.

Bernard and Gerlach (1998) extended the work of Estrella and Hardouvelis (1991) to eight countries (Belgium, Canada, France, Germany, Japan, Netherlands, the United Kingdom and the United States). The paper states that the slope of the yield spread has information about the probability of a future recession in all eight countries in their analysis and concludes that the explanatory power peaks between two to five quarters. However, the pattern is not equal across the countries; in Germany, Canada and the United States, the information content seems to be higher than in the other countries. Furthermore, In Japan and the Netherlands, the information content appears to be limited compared to the other countries. Bernard and Gerlach (1998) state that further research is needed to determine the cause of these differences. However, the authors state that one possible explanation can be differences in the regulation of financial markets. This is because in the presence of financial regulation, the interest rate might not completely reflect financial market participants expectations about the future state of the economy.

Estrella and Mishkin (1998) also extended the work of Estrella and Hardouvelis (1991) to examine the performance of various financial variables in out-of-sample predictions of the probability of a recession in the United States using a probit model. The set of variables were selected from a broad array of candidates and include interest rates, stock price indexes, monetary aggregates and yield spreads. The result from their analysis shows that both stock prices and the yield spread can play an important role in macroeconomic prediction. Beyond one quarter out of sample forecasts, the yield spread emerges as the best individual indicator and outperforms combinations of other variables.

Stock and Watson (2003) performs an analysis of a broad set of different asset prices as predictors for real economic activity and inflation for seven developed economies (Canada, France, Germany, Italy, Japan, The United Kingdom and the United States). In their model specification, a lagged output growth is used as an additional predictor in order to evaluate the predictive power of the yield spread beyond the information contained in the lagged dependent variable. The paper concludes that the predictive power of the yield spread is varying over time and across countries. Stock and Watson (2003) also states that there exists instability in the predictive relations involving asset prices and other predictors. Furthermore, the paper concludes that the instability in the forecasts are consistent with other evidence of instability in the economy for example changes in productivity, and that there have been substantial changes in how central banks conduct monetary policies.

Several other papers have also analysed if the relationship between future economic activity and the yield spread is stable over time. One example is Estrella, Rodrigues and Schich (2003), who focus on Germany and the United States in their analysis. The paper considers discrete models which predict either inflationary pressure or recessions but also continuous models which predict future inflation or growth in industrial production. Estrella, Rodrigues and Schich (2003) uses a generalised method-of-moments method for the structural break testing and conclude that models that predict growth are more stable than those that predict inflation. Furthermore, the paper concludes that continuous models seem to be less stable over time than binary models.

Schrimpf and Wang (2010) provided a re-examination of the predictability features of the yield curve. The motivation of the re-examination was that there were concerns that the indicator properties of the yield curve might change over time and that regressions based on the term spread might suffer from parameter instability. Schrimph and Wang (2010) include four countries (Canada, Germany, the United Kingdom and the United States) in their analyses, and the focus is on out-of-sample forecasts. The paper also follows Stock and Watson (2003) and uses the lagged dependent variable as an additional to be able to judge the predictive ability of the yield spread beyond the information that exists in the history of the dependent variable. The overall results show that the predictive power of the yield curve on GDP growth has been decreasing in recent years.

Furthermore, there exists strong evidence for structural breaks in the relationship between the yield spread and the GDP growth. According to Schrimph and Wang (2010), detects three breaks for Canada and the United Kingdom, four breaks for the United States and two breaks for Germany. There are several interesting patterns in the country's break dates. Some of the break dates are linked to changes in the monetary regime, unanticipated events or specific phases of the business cycle, which also is discussed in Stock and Watson (2003).

Chinn and Kucko (2015) provides a re-examination of the relationship between the yield curve and future economic activity. Three arguments that motivate the re-examination of the relationship are stated in the paper. First, the introduction of the euro in 1999, which made the European bond market more integrated. The second is the failure of long-term interest rates to rise along with the short-term policy rate in the mid-2000s, which is linked by some people to the Great Moderation. Others have focused on some central banks' purchases of Treasury assets or pension funds' demand for long-term assets. The third argument that motivated a re-examination is the fact that the United States and Japan were close to the zero lower bound at the time. Chinn and Kucko (2015) argue that when a country reaches the zero lower bound, the central bank cannot lower the short-term interest rate further and might instead try to lower long-term rates. This will flatten the yield curve if the procedure is successful and might deteriorate the relationship between the yield curve and economic activity. In their empirical analysis Chinn and Kucko (2015), includes Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, the United Kingdom and the United States. The reason for this restriction is that these countries have liquid and robust financial markets.

Furthermore, the authors wanted to ensure that the interest rates are market-determined and that the time sample is sufficiently large (1970-2013). The conclusion from Chinn and Kucko (2015) is that the yield spread has significant predictive power over a one-year time horizon while the power weakens when forecasting growth two years ahead. Furthermore, using a rolling-window regression approach, it was concluded that the predictive power deteriorated during the Great Moderation up until the Great recession in 2007-2008. The evidence from their out-of-sample analysis is that the yield curve is significantly better than the benchmark model (AR(1)) only for Germany when the European countries are examined. Moreover, it is concluded that the relationship between the yield spread and growth has declined in recent years. Their model predicts recession relatively well for the United States, Canada and Germany while for Japan and Italy, the model does not perform well. The main conclusion from Chinn and Kucko (2015) is that the United States seems to be kind of an outlier in terms of the predictive power for the yield spread.

After the global financial crisis in 2007-2008, the issue of forecasting output gaps has been elucidated by many. Gogas et al., (2015) states the importance of being able to predict upcoming output downturns for policymakers which motivates their study. The paper investigates the forecasting ability of the yield curve in terms of the United States real GDP cycle using a Machine Learning framework. The results show that their model achieves an overall forecasting accuracy of 66.7 and 100 per cent accuracy in forecasting recession for US data.

Thus, the literature brought up in this section proofs that the yield curve has have predictive power on future economic activity. However, it has also been pointed out that the relationship is not equal across countries and time. Furthermore, the monetary policy seems to play an important role in the performance of the yield curve as predictor of future economic activity.

3. An Era of Unconventional Monetary Policies

An experience gained from the literature review is that the monetary policy seems to affect the relationship between the yield curve and future economic activity. After the Great Recession in 2007-2008, central banks in several economies around the world have adopted a whole range of new measures to influence monetary and financial conditions. These measures are often referred to as unconventional monetary policies and take many forms and some were pioneered by the Bank of Japan in the early 2000s to deal with their stubbornly low inflation (Borio and Zabai, 2016). Joyce, Miles, Scott and Vayanos (2012) brings up to explanations two explanations why central banks have turned to these alternative forms of monetary policies after the Great Recession. One is that after the crisis, the usual link between official interest rates and market interest rate broke down. Another aspect is the fact that the magnitude of the crisis in many countries meant that the Taylor rule suggested negative nominal interest rates. Since agents always have the alternative to hold non-interest-bearing cash, this causes market interest rates to be efficiently bounded to zero. One unconventional measure that has been applied by several central banks is the use of negative official interest rates. Another common form is the expansion of central banks' balance sheets which is an attempt to influence interest rates other than the usual short-term official rates. The key idea is that when the policy rate is zero, the central bank can still provide monetary expansions by supporting long-term bond prices and thus decreasing long-term yields.

The expansion of central banks' balance sheets has been referred to as Quantitative Easing if the policy focuses on the quantity of bank reserves, which are liabilities of the central bank. If the policy instead focuses on the assets side of the central bank, this has referred to as Credit Easing. Credit easing can be seen as a particular case of Quantitative Easing if they also increase the monetary base (Fawley and Neely, 2013; Dell’Ariccia et al.,2018). The former Federal Reserve chairman Ben Bernanke (2014, pp 14) famously stated about Quantitative Easing “it works in practice, but it doesn't work in theory” The meaning of this quote is that in theoretical models central bank purchases of government bonds should not have any effects on bond yields if it is assumed that the financial market is frictionless and in which investors can move freely across asset categories. The consequence is that investors who attempt to profit from market inefficiencies will reposition their portfolios offsetting the impact of central bank purchases. However, in practice, investors can have a preference to hold specific securities or find it difficult to short sell the bonds the central bank is purchasing, which causes segments in the financial markets. In this situation, if the central bank reduces the net supply of government bonds on the market by purchases, this can increase bond prices and reduce the yield of those bonds (Dell'Ariccia et al.,2018).

Quantitative Easing was first applied to Japan in the early 2000s in response to an extended period of sluggish economic conditions. With interest rates at the zero lower bound the Bank of Japan started purchasing government securities from the banking sector in the early 2000s which caused an increase in the level of cash reserves, the banks held in the system. The reasoning was that by targeting a high level of reserves; eventually, this could start affecting the broader economy, boosting asset prices and remove deflationary forces. The term Quantitative Easing was introduced to emphasise this shift in focus by the Bank of Japan. When the short rates approached the zero lower bound in the late 2008/early 2009, several central banks have followed Japan in adopting policies that led to significant increases in their balance sheet which is visualised in figure 1 (Joyce, Miles, Scott and Vayanos, 2012).

Example of central banks that has launched a variety of Quantitative Easing programmes is the Bank of England, the European Central Bank (ECB), Bank of Japan, the Federal Reserve (FED) and the Riksbank. A detailed timeline over the different balance sheet policies that have been applied is described in Appendix A. However, not all central banks that have the same developments of their balance sheet. Three examples are the Reserve Bank of Australia, the Bank of Canada and Norges Bank. The Norwegian central bank governor Øystein Olsen stated in a speech on 8 October 2019 that launching a Quantitative Easing programme is not an option as a policy instrument for Norges Bank. However, in the case for Reserve Bank of Australia and Bank of Canada has now both introduced own versions of Quantitative Easing to stem the economic fallout from COVID-19 (Lowe, 2020; Bank of Canada, 2020)

Quantitative Easing is an expansive monetary policy that was first applied to stimulate the economy in a recession. It has proven to be difficult to decrease the stimulations even when the economic conditions have improved. One example was the events of 2013 when the Federal Reserve announced its intentions to reduce the pace of monthly asset purchases under its QE3 programme and potentially end the programme in mid-2014. This caused a minor panic in the United States financial markets, and the government bond yields spiked (Rai and Suchaneck, 2014). This event is referred to as the "Taper Tantrum", and the current Federal Reserve chairman Jerome H. Powell has stated that he still carries the scars of the Fed's misstep in the spring of 2013 (Appelbaum, 2019).

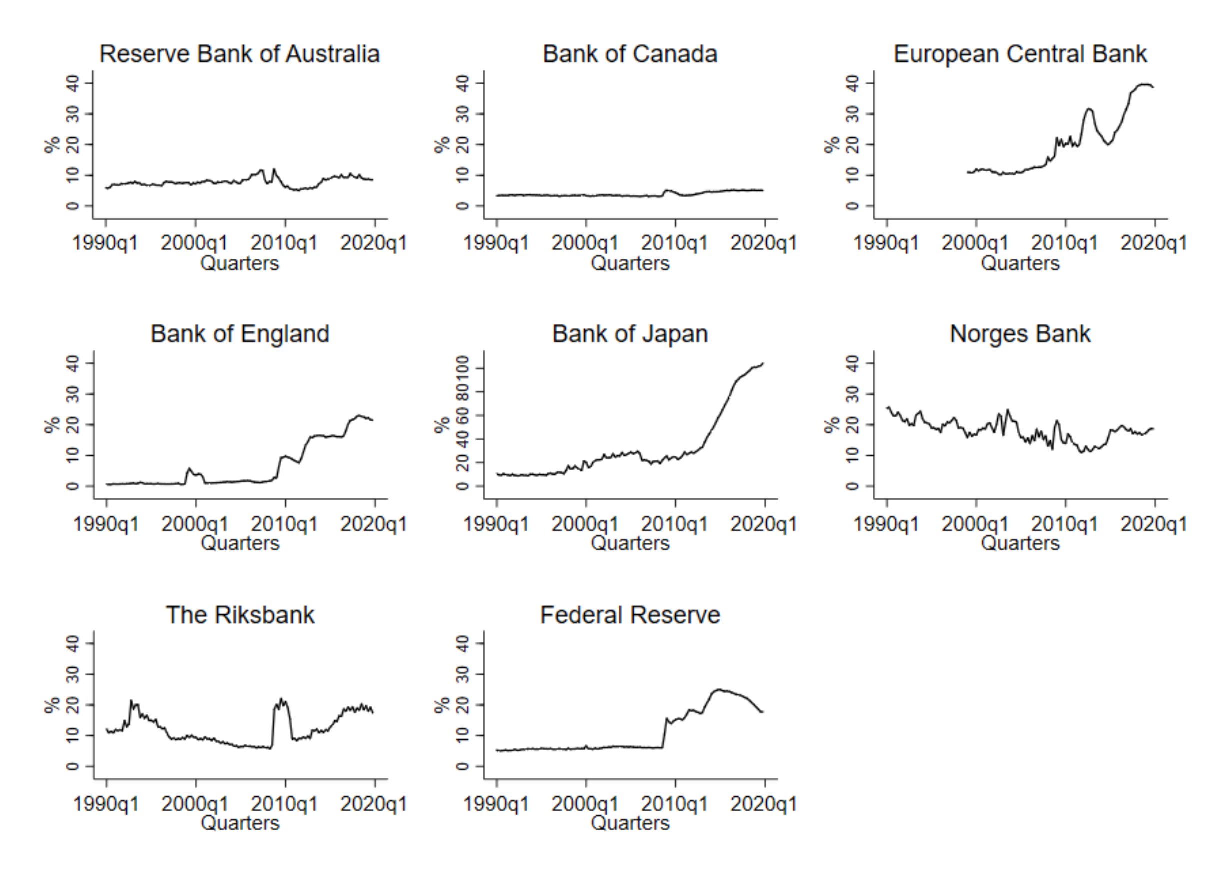

Figure 1: *Central banks' balance sheet as per cent of GDP. Source: see Appendix B. Note that Japan has a different scale due to the vast differences*

Furthermore, Powell has also expressed some concerns in March 2013 of the Federal Reserve's monetary policy, stating that "We have put in place strong incentives for risk-taking." and "We should expect that dealers and investors will take more and more risk as time passes". The reason was that holding interest rates at a low level and removing safer assets from the market has pushed investors into taking more risk.

Bank of Japan, which is the central bank that first introduced the Quantitative Easing is the country that has gone furthest in the expansion of their balance sheet. Furthermore, in September 2016, the Bank of Japan moved one step further when they introduced their Yield Curve Control. The programme allows the Bank of Japan to target both short- and long-term rates, hence, control the yield curve more efficiently. Even though Bank of Japan is the only central bank that has adopted Yield Curve Controls, there has been some consideration by other central banks to treat this as a potential policy tool (Brichetti et al. 2018). Moreover, the former Federal Reserve's chairmen Ben Bernanke (2016) and Janet Yellen (2018) both have stated that the Federal Reserve should consider adopting Yield Curve Controls.

The introduction of Quantitative Easing raises new challenges, according to Borio and Zabai (2016). The central dilemma is that the balance sheet policies have blurred the line between the government and the central bank. The purchases of government bonds in the secondary market can send incentives to government authorities to issue more government debt. Hence, the balance polices could, therefore, contribute to increased government spending.

There is now an extensive body of both empirical and theoretical literature discussing the unconventional monetary policies effect on effect on interest rates and financial prices. Both Borio and Zabai (2016) and Kuttner (2018) provides an overview of the research field and concludes that a variety of approaches has been used. Both cross-sectional and time serial approaches but also event studies. Moreover, most of the studies provide evidence that Quantitative Easing has had a negative effect on yields. One example is D'Amico and King (2013), who study how the Federal Reserve QE1 programme affected specific bond prices. The conclusion after comparing yields pre and post QE1 they found a persistent downward shift in yields averaging about 30 basis points. Using a similar approach as in D'Amico and King (2013), Meaning and Zhu (2011) found that the Quantitative Easing programmes both for Bank of England and the Federal Reserve had a significant effect on financial markets when the first stages were announced, but the effects became smaller for later extensions of the programmes. Krishnamurthy and Vissing-Jorgensen (2011) investigate the Federal Reserve's two first Quantitative Easing programmes using a case study methodology. The findings suggest that the QE1 significantly lowered the yields on mortgage-backed securities and treasury bonds. Furthermore, the effects of the QE2 was not as strong, and the yields on the latter were falling primarily through the market's anticipation of lower future federal funds rates.

Thus, taking this development into considerations one might expect that the introduction of Quantitative Easing has affected the yield curve ability to predict future economic activity. The reason is that the policy has pushed down yields in several economies. Furthermore, central banks’ have actively aimed to twist or control the yield curve with their policies. Hence, the yield curve might not entirely reflect financial market participants expectations about the future state of the economy which might have deteriorated the relationship between the yield curve and economic activity.

4. Methodology

In earlier literature, there has been used a variety of measurements for future economic activity. This study will follow Gogas et al. (2015) and use the deviations of GDP from the long-term trend (output gap) as a measure of future economic activity. The output gap is a widely used measurement when evaluating the current stance of an economy, especially for central bankers and other policy makers.

The Hodrick-Prescott filter is used in the decomposition of the GDP series to obtain the cyclical component with a value of λ is set to 1600, which is the standard among business cycle researches for quarterly data. Like most of the earlier literature, this study will use the spread between a long-term government bond and a short-term interest rate as the measure for the yield curve, which implies that a negative value of the yield spread indicates an inverted yield curve which has been a good indicator for economic downturns. Figure 2 presents the obtained output gaps plotted together with the calculated yield spreads. The shaded areas are the recession dates from the NBER (2020) or ECRI (2020) calculated with a peak-to-though approach. It can be concluded that the recession dates correspond to negative values of the output gap. Hence, using the output gap as a continuous measure for economic activity is reasonable. Figure 2 also presents the calculated yield spreads; one observation is that the yield spread declined and turned negative before the two previous recessions for the United States. However, the relationship for the other advanced economies is not as clear, which indicates the differences in the relationship which previous literature has pointed out.

The first model specification is obtained in equation 3, where $c_{t,i}$ is the cyclical component of GDP in period t for country i, and the $SPREAD_{t-k,i}$ is the yield spread in period $t-k$ for the corresponding country. The motivation of this specification is to follow previous literature before examining the effects of Quantitative Easing.

$$c_{t,i} = \beta_{0,i} + \beta_{1,i} SPREAD_{t-k,i} + \epsilon_{t,i} \tag{3}$$

Every country in the sample is analysed using within sample regressions at five different lag lengths: 1, 2, 4, 8 and 12 (that is one quarter up to three years lag). The Durbin Watson statistics indicates that there exists a high degree of serial correlation in the OLS residuals in most cases.

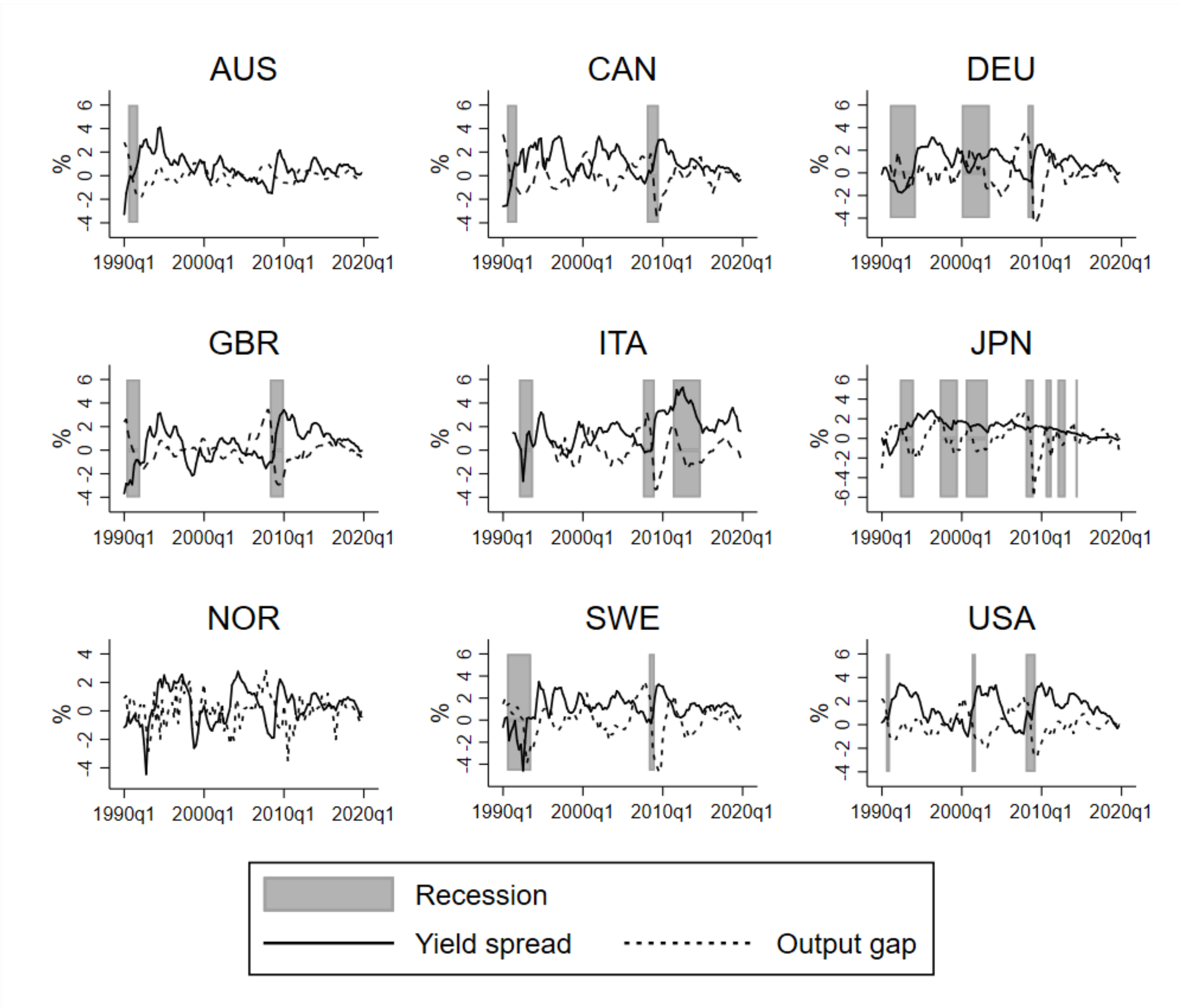

Figure 2: *Yield spreads between 10-year government bonds and 3-month Treasury bills (or closest equivalent, see Appendix B) for all countries in the analysis. The output gaps are obtained by the Hodrick-Prescott filter. The shaded area are recession indicators from NBER or ECRI (no data for Norway).*

Therefore, to account for these characteristics of the estimated residuals, this study uses Newey-West robust standard errors for all model specifications where it was needed. This procedure has been used by several papers before (Estrella and Hardouvelis, 1991; Estrella and Mishkin, 1998; Chinn and Kucko 2015). Following Estrella and Hardouvelis (1991) the lag length of the Newey and West correction was chosen after observing the estimated autocorrelation functions of the OLS residuals.

The focus of this study is to investigate if the introduction of Quantitative Easing has affected the relationship between the yield spread and future economic activity. To measure the level of Quantitative Easing, I use the central banks' balance sheets as a percentage of GDP in nominal terms in the second model specification. Furthermore, an interaction term between the yield spread and the Quantitative Easing variable is also introduced in the model.

$$c_{t,i} = \beta_{0,i} + \beta_{1,i}SPREAD_{t-k,i} + \beta_{2,i}QE_{t-k,i} + \beta_{3,i}(SPREAD_{t-k,i} * QE_{t-k,i}) + \epsilon_{t,i} \quad (4)$$

Notice that equation 4 can be rewritten as

$$c_{t,i} = \beta_{0,i} + \left(\beta_{1,i} + \beta_{3,i}QE_{t-k,i}\right)SPREAD_{t-k,i} + \beta_{2,i}QE_{t-k,i} + \epsilon_{t,i} \quad (5)$$

$$c_{t,i} = \beta_{0,i} + \widetilde{\beta_{1,i}}SPREAD_{t-k,i} + \beta_{2,i}QE_{t-k,i} + \epsilon_{t,i} \quad (6)$$

Where $\widetilde{\beta_{1,i}} = \left(\beta_{1,i} + \beta_{3,i}QE_{t-k,i}\right)$. Since $\widetilde{\beta_{1,i}}$ changes with the level of Quantitative Easing, the effect of the yield spread on the future output gap is no longer constant; the level of the Quantitative Easing will affect the impact of the yield spread on the future output gap.

In the third model specification, this paper follows Stock and Watson (2003) and Schrimpf and Wang (2010) when a lagged dependent variable is introduced as an additional predictor in the model. The reasoning is the same as in previous literature: to be able to evaluate the predictive power of the model beyond the information contained in the lagged dependent variable.

$$c_{t,i} = \beta_{0,i} + \beta_{1,i}SPREAD_{t-k,i} + \beta_{2,i}QE_{t-k,i} + \beta_{3,i}\left(SPREAD_{t-k,i} * QE_{t-k,i}\right) + \beta_{4,i}c_{t-k,i} + \epsilon_{t,i} \quad (7)$$

In the fourth model and final specification, I will follow Estrella and Hardouvelis (1991) and introduce a set of information variables available at time *t* ($X_{t,i,j}$) in the model specification as controls.

$$c_{t,i} = \beta_{0,i} + \beta_{1,i}SPREAD_{t-k,i} + \beta_{2,i}QE_{t-k,i} + \beta_{3,i}\left(SPREAD_{t-k,i} * QE_{t-k,i}\right) + \sum \beta_{i,j}X_{t-k,i,j} + \epsilon_{t,i} \quad (8)$$

As in previous cases, equation 8 can be rewritten in the following way.

$$c_{t,i} = \beta_{0,i} + (\beta_{1,i} + \beta_{3,i}QE_{t-k,i})SPREAD_{t-k,i} + \beta_{2,i}QE_{t-k,i} + \sum\beta_{i,i}X_{t-k,i,j} + \epsilon_t \quad (9)$$

$$c_{t,i} = \beta_{0,i} + \widetilde{\beta_{1,i}}SPREAD_{t-k,i} + \beta_{2,i}QE_{t-k,i} + \sum\beta_{i,j}X_{t-k,i,j} + \epsilon_{t,i} \quad (10)$$

Where $\widetilde{\beta_{1,i}} = \left(\beta_{1,i} + \beta_{3,i}QE_{t-k,i}\right)$ as in the previous cases. This is the total marginal effect of the yield spread in period $t-k$ on the output gap in period t $\left(c_{t,i}\right)$ for country *i*. Depending on the signs of the estimated coefficient it can be determined how the Quantitative Easing has affected the relationship between the yield spread and future economic activity.

5. Data

As stated in the introduction, I include nine advanced countries in the analysis: Australia, Canada, Germany, Italy, Japan, Norway, Sweden, the United Kingdom and the United States. The sample period is between the first quarter of 1990 to the fourth quarter of 2019[1]. Numerous aspects motivate the specific choice of countries and time-period. Firstly, there is a variety of the level of Quantitative Easing that has been applied among the countries. Secondly, only countries with free capital movements with inflation-targeting central banks were selected. This is also the motivation of the selected time-period since before the 1990s; several countries had restricted capital movements. Due to the variety in the sample, this forms a foundation of comparison and also of the robustness regarding the result.

In the Hodrick-Prescott decomposition, quarterly real GDP is used to obtain the cyclical component. The real GDP series are collected from Datastream, where further details are displayed in Appendix B.

As in the majority of the earlier literature, this study will use the spread between a 10-year government bond and a 3-month Treasury bill (or closest equivalent) as the measure for the yield curve. These time series are collected from OECD, apart from the short-term interest rate for Japan (Appendix B provides further details).

Moreover, this study uses the central banks' balance sheets as a percentage of GDP in nominal terms to measure the level of Quantitative Easing. The data of the central banks' balance sheets are collected from either Datastream of the respective countries central bank (see Appendix B). For Germany and Italy, a common Quantitative Easing variable is made since both are euro-members. Here a common nominal GDP series for the total euro area from Eurostat is used. In all other cases, the GDP series are collected from Datastream where more details can be found in Appendix B. In most cases this should be a sufficient measurement of the magnitude of the balance sheet policies that have been applied in each country. However, the Bank of Norway has a relatively large balance sheet even though Quantitative Easing has not yet been applied, which is a limitation of using the total balance sheet as a measurement for Quantitative Easing

[1]. For Germany and Italy, the data begins in the first quarter of 1999 since this study focuses on the period after the euro was introduced.

The control variables that are introduced in the final model specifications are the OECD Business Confidence Index (BCI) and the expected future inflation rates from the IFO Institute World Economic Services (WES). According to OECD, the BCI provides information on future economic developments and, the index is based upon surveys on changes in production, stocks and orders of finished goods in the industry sector. Regarding the expected inflation rates, which are collected from Datastream, there exist some limitations since the data available was on a 1-year horizon, causing some matching problems in the regressions. However, this was the data that covered all countries for the full sample period, and the inflation expectations should provide some information about future economic activity even on those lag lengths that do not match.

6. Empirical Results

6.1. The Yield Spread as the Only Predictor

In this section I turn to the results from the first model specification, where it could be concluded that the results vary across lag lengths and countries. The results are fully described in tables 1 to 5, and the predictive values are visualised in Appendix C.

For Australia, the yield spread performed poorly as a predictor for future output gaps over all lag lengths with the highest R-squared statistics of 9.2 per cent, which is achieved on the shortest lag length. The coefficient of the yield spread is negative at lag 1 to 4 and positive at lag 8 and 12. However, none of these are significant at any of the conventional statistical significance levels. Canada has its best fit on lag 12 with an R-square statistic of 16.1 per cent and a significant positive coefficient for the yield spread. However, the estimated coefficient on the first lag of the yield curve is significantly negative.

The finding for Germany is that the yield spread performs poorly as a predictor of future output gaps with its highest R-squared of 6.2 on the shortest lag length. Nevertheless, the coefficient of the yield spread on this lag length is only significant negative on a 10 per cent level. The result for the United Kingdom is that the best performance is on the shortest lag with an R-squared of 12.5 per cent. It can also be concluded that the coefficient of the yield spread on the first lag is significant negative, as in the case of Canada.

For Italy, the estimated coefficients of the yield spread were negative across all lag lengths. However, none was significant and the goodness of fit according to R-squared, is weak across the lags. Moreover, the predictive power is weak for Japan as well, with weak R square statistics across the lag lengths and no significant results.

The results for Norway show significant positive coefficients on lag 8 and lag 12 with an R-squared of 14.4 per cent respectively 14.1 per cent. Sweden provides significant positive results on lag 4 and lag 8, the goodness of fit according to the R-squared are 18.7 per cent and 10.3 per cent for these lag lengths.

The last country in the analysis is the United States which shows significant negative coefficients on the first and second lag. Furthermore, the coefficient on the last lag is significantly positive for the United States. The highest goodness of fit is achieved on the first lag with an R-square of 29.3 per cent, which is the best fit across lag lengths and countries.

Taking the results from this model specification into consideration, it seems to be an inconsistency in the predictive power across countries which also previous literature concludes. However, the significant negative coefficients on the shorter lag lengths are not found in the existing literature. The interpretation is that with a negative coefficient, an inverted yield curve implies an increase in the future output gap instead for a downturn in the economy. This is also an indication that further analysis of the yield spread and future economic activity is needed to understand these results further.

Table 1: *Regression results from Model 1 with lag length at 1 quarter.*

MODEL 1									
VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-1}$	-0.184	-0.340***	-0.319*	-0.257**	-0.217	-0.0647	0.102	-0.0215	-0.450***
	(0.113)	(0.121)	(0.190)	(0.119)	(0.158)	(0.235)	(0.130)	(0.211)	(0.0977)
Constant	0.0959	0.347*	0.294	0.107	0.415	0.0897	-0.0431	0.0112	0.623***
	(0.122)	(0.193)	(0.315)	(0.196)	(0.387)	(0.237)	(0.163)	(0.360)	(0.206)
Observations	119	119	116	119	96	119	119	119	119
R-squared	0.092	0.144	0.062	0.125	0.061	0.002	0.014	0.000	0.293
Durbin Watson (OLS)	0.271	0.346	0.360	0.240	0.262	0.460	1.092	0.270	0.432

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2: *Regression results from Model 1 with lag length at 2 quarters*

MODEL 1									
VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-2}$	-0.129	-0.189	-0.167	-0.153	-0.150	0.00141	0.164	0.232	-0.381***
	(0.0796)	(0.115)	(0.181)	(0.106)	(0.154)	(0.245)	(0.116)	(0.192)	(0.107)
Constant	0.0398	0.158	0.155	0.0337	0.285	0.0314	-0.0749	-0.284	0.514**
	(0.116)	(0.215)	(0.334)	(0.206)	(0.415)	(0.266)	(0.158)	(0.347)	(0.240)
Observations	118	118	116	118	96	118	118	118	118
R-squared	0.051	0.047	0.017	0.047	0.029	0.000	0.036	0.035	0.215
Durbin Watson (OLS)	0.265	0.304	0.341	0.220	0.263	0.452	1.089	0.269	0.344

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

***Table 3**: Regression results from Model 1 with lag length at 4 quarters*

MODEL 1 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-4}$	-0.0319	0.0106	0.0487	0.00369	-0.0287	0.0851	0.116	0.530***	-0.211
	(0.0709)	(0.124)	(0.201)	(0.104)	(0.183)	(0.247)	(0.119)	(0.147)	(0.139)
Constant	-0.0479	-0.0894	-0.0451	-0.0633	0.0544	-0.0612	-0.0598	-0.642*	0.260
	(0.133)	(0.271)	(0.359)	(0.225)	(0.464)	(0.294)	(0.148)	(0.326)	(0.326)
Observations	116	116	116	116	96	116	116	116	116
R-squared	0.003	0.000	0.001	0.000	0.001	0.003	0.018	0.187	0.065
Durbin Watson (OLS)	0.228	0.248	0.324	0.203	0.252	0.450	1.107	0.331	0.259

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4: *Regression results from Model 1 with lag length at 8 quarters*

MODEL 1 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-8}$	0.117	0.147	0.203	0.116	-0.0573	0.207	0.323***	0.391**	0.0950
	(0.100)	(0.150)	(0.168)	(0.115)	(0.161)	(0.208)	(0.104)	(0.161)	(0.173)
Constant	-0.110	-0.218	-0.198	-0.106	0.106	-0.233	-0.131	-0.512	-0.154
	(0.125)	(0.300)	(0.312)	(0.228)	(0.430)	(0.237)	(0.134)	(0.330)	(0.402)
Observations	112	112	112	112	96	112	112	112	112
R-squared	0.054	0.029	0.025	0.028	0.004	0.016	0.144	0.103	0.014
Durbin Watson (OLS)	0.254	0.275	0.318	0.210	0.251	0.466	1.292	0.316	0.249

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

***Table 5**: Regression results from Model 1 with lag length at 12 quarters*

MODEL 1 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-12}$	0.0917	0.334***	0.158	0.106	-0.156	0.159	0.318***	0.0745	0.282**
	(0.0626)	(0.116)	(0.153)	(0.0725)	(0.126)	(0.258)	(0.115)	(0.201)	(0.139)
Constant	-0.0441	-0.386*	-0.187	-0.0476	0.281	-0.217	-0.123	-0.158	-0.430
	(0.0947)	(0.216)	(0.273)	(0.209)	(0.375)	(0.272)	(0.141)	(0.339)	(0.288)
Observations	108	108	108	108	96	108	108	108	108
R-squared	0.043	0.161	0.016	0.025	0.032	0.009	0.141	0.004	0.120
Durbin Watson (OLS)	0.292	0.340	0.315	0.224	0.256	0.467	1.247	0.251	0.295

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

6.2. Introducing Quantitative Easing

The analysis now moves to the results from the second model specification, where Quantitative Easing is introduced. The results from this model specification are fully described in tables 6 to 11, and the predicted values are presented in Appendix D. As in the previous model specification, the result is not comprehensible across the countries in the analysis.

In the case of Australia, no lag length provides significant results, and the goodness of fit is relatively low. Canada provides significant result on the longest lag length with a positive estimated coefficient on the yield spread and the QE variable. The coefficient on the interaction term is significantly negative, which implies that an increased balance sheet of the central bank seems to have a dampening effect on the marginal effect of the yield spread on the future output gap. This lag length also provides the highest goodness of fit for Canada with an R-squared of 24 per cent.

For Germany, the best fit (R-squared of 23.8 per cent) is achieved on the shortest lag length. Furthermore, the estimated coefficient of the yield spread is significantly negative on this lag length. The result for the United Kingdom also indicates that the best fit is achieved on the shortest lag length. The goodness of fit is 13.4 per cent according to the R-squared statistics, and the estimated coefficient of the yield spread is negative. However, this estimate is only significant on a 10 per cent level.

In the case of Italy, the significant result is only achieved on lag 8, yet the highest R squared is achieved on the first lag. On lag 8, the coefficient of the yield spread is positive but only significant on a 10 per cent level. The estimated coefficient of the QE variable is significantly positive, and the coefficient of the interaction term is significantly negative. As in the case of Canada, it seems that increased Quantitative Easing has a dampening effect of the marginal effect of the yield spread. No significant result is achieved in the case for Japan with weak goodness of fit across the lag lengths.

Furthermore, no significant result is achieved for Norway as well, yet the goodness of fit is relatively high on the 2 last lag lengths. In the case of Sweden, significant negative coefficients are achieved on the QE variable on the two first lag lengths. Moreover, the goodness of fit is highest at the eighth lag length, where the estimated coefficients are significantly positive for the yield spread and, the QE variable and, the estimate for the interaction term is negative.

So, the indication is similar as for the other cases where an increased Quantitative Easing seems to have a dampening effect on the marginal effect of the yield spread. For the United States, the results are significant on several lag lengths. However, as in the first model specification, the coefficients of the yield spread on the two first lags are significant negative. The estimated coefficient of the QE variable is also negative on these lags yet only significant on a 10 per cent level. Furthermore, the estimated coefficients of the interaction term on these lag lengths are positive and significant on 10 per cent respectively 5 per cent level. The interpretation of this it seems to that if the Quantitative Easing increases this will make the marginal effect less negative. Hence, damper the marginal effect but in the opposite way compared to the other countries. As in the first model specification, the coefficients change the sign on the longer lag lengths. On the last lag length, the estimated coefficients of the yield spread, and the QE variable are significant and positive. Furthermore, the estimated coefficient of the interaction term is significant and negative, making the interpretation the same as for the other countries. It can also be concluded that the highest R-squared is achieved for the United States at the shortest lag length, as in the first model specification. Further analysis of the marginal effects of the yield spread on future output gaps will be discussed further in the final model specification.

Table 6 *Regression results from Model 2 with lag length at 1 quarter*

MODEL 2 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-1}$	-0.674	0.312	-1.771**	-0.303*	-0.975	-0.108	-0.777	-0.752	-0.666***
	(0.754)	(0.858)	(0.846)	(0.157)	(0.624)	(0.424)	(0.612)	(0.600)	(0.178)
QE_{t-1}	-0.00667	-0.292	-0.0620	0.00893	-0.0390	-0.00242	-0.0337	-0.203***	-0.0377*
	(0.0655)	(0.204)	(0.0378)	(0.0233)	(0.0493)	(0.00503)	(0.0357)	(0.0670)	(0.0193)
$SPREAD_{t-1} * QE_{t-1}$	0.0676	-0.186	0.0471	0.00579	0.0266	0.000504	0.0464	0.0533	0.0251*
	(0.0958)	(0.240)	(0.0441)	(0.0206)	(0.0226)	(0.0216)	(0.0340)	(0.0491)	(0.0131)
Constant	0.134	1.522*	2.162**	0.0314	1.607	0.199	0.587	2.549***	0.916***
	(0.544)	(0.852)	(1.033)	(0.253)	(1.118)	(0.397)	(0.659)	(0.878)	(0.328)
Observations	119	119	83	119	83	119	119	119	119
R-squared	0.105	0.229	0.238	0.134	0.164	0.003	0.046	0.194	0.318
Durbin Watson (OLS)	0.267	0.369	0.432	0.243	0.278	0.460	1.139	0.336	0.454

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 7 *Regression results from Model 2 with lag length at 2 quarters*

MODEL 2 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-2}$	-0.382	0.416	-1.418	-0.175	-0.353	-0.0328	-0.950	-0.256	-0.624***
	(0.603)	(0.772)	(1.176)	(0.132)	(0.631)	(0.436)	(0.589)	(0.592)	(0.192)
QE_{t-2}	0.0369	-0.204	-0.0599	0.0146	0.0116	-0.00117	-0.0344	-0.144**	-0.0383*
	(0.0636)	(0.212)	(0.0527)	(0.0236)	(0.0532)	(0.00603)	(0.0338)	(0.0635)	(0.0200)
$SPREAD_{t-2} * QE_{t-2}$	0.0356	-0.172	0.0506	-0.00116	0.00104	0.00148	0.0589*	0.0359	0.0283**
	(0.0804)	(0.209)	(0.0558)	(0.0191)	(0.0230)	(0.0219)	(0.0324)	(0.0425)	(0.0130)
Constant	-0.259	0.985	1.723	-0.0388	0.542	0.0715	0.574	1.497	0.793**
	(0.525)	(0.901)	(1.475)	(0.264)	(1.273)	(0.492)	(0.617)	(0.953)	(0.368)
Observations	118	118	82	118	82	118	118	118	118
R-squared	0.063	0.103	0.100	0.055	0.086	0.000	0.084	0.133	0.246
Durbin Watson (OLS)	0.262	0.320	0.352	0.222	0.268	0.452	1.151	0.340	0.354

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 8 *Regression results from Model 2 with lag length at 4 quarters*

MODEL 2 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-4}$	0.380	0.632	-1.053	0.0142	0.506	0.0323	0.00916	0.404	-0.443*
	(0.322)	(0.665)	(1.488)	(0.107)	(0.661)	(0.434)	(0.786)	(0.700)	(0.228)
QE_{t-4}	0.0887	0.0597	-0.0708	0.0171	0.0696	0.00116	-0.0389	-0.0344	-0.0348
	(0.0678)	(0.245)	(0.0712)	(0.0231)	(0.0490)	(0.00737)	(0.0344)	(0.0810)	(0.0278)
$SPREAD_{t-4} * QE_{t-4}$	-0.0554	-0.175	0.0718	-0.00849	-0.0315	0.00611	0.00543	0.00933	0.0276*
	(0.0463)	(0.168)	(0.0681)	(0.0172)	(0.0216)	(0.0237)	(0.0397)	(0.0432)	(0.0153)
Constant	-0.734	-0.270	1.176	-0.111	-0.850	-0.171	0.648	-0.218	0.491
	(0.590)	(1.101)	(1.859)	(0.279)	(1.398)	(0.615)	(0.644)	(1.283)	(0.506)
Observations	116	116	80	116	80	116	116	116	116
R-squared	0.053	0.012	0.036	0.005	0.064	0.005	0.033	0.193	0.095
Durbin Watson (OLS)	0.259	0.257	0.262	0.205	0.242	0.451	1.131	0.326	0.257

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 9 *Regression results from Model 2 with lag length at 8 quarters*

MODEL 2 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-8}$	0.775	0.950	1.168	0.175	1.143*	0.0214	1.056	1.525***	0.222
	(0.614)	(0.847)	(1.190)	(0.130)	(0.652)	(0.412)	(0.643)	(0.561)	(0.268)
QE_{t-8}	0.0271	0.263	0.0359	0.0255	0.115**	0.00584	-0.0350	0.161**	0.0288
	(0.0583)	(0.317)	(0.0609)	(0.0284)	(0.0553)	(0.00650)	(0.0304)	(0.0643)	(0.0298)
$SPREAD_{t-8} * QE_{t-8}$	-0.0904	-0.227	-0.0320	-0.0210	-0.0567**	0.0220	-0.0391	-0.0835**	-0.0167
	(0.0778)	(0.219)	(0.0573)	(0.0212)	(0.0238)	(0.0258)	(0.0323)	(0.0373)	(0.0145)
Constant	-0.306	-1.143	-1.254	-0.130	-1.980	-0.668	0.488	-2.564**	-0.349
	(0.470)	(1.366)	(1.482)	(0.278)	(1.407)	(0.471)	(0.583)	(0.993)	(0.606)
Observations	112	112	76	112	76	112	112	112	112
R-squared	0.089	0.042	0.101	0.037	0.123	0.049	0.180	0.199	0.021
Durbin Watson (OLS)	0.270	0.282	0.307	0.211	0.276	0.479	1.327	0.412	0.249

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 10: *Regression results from Model 2 with lag length at 12 quarters*

MODEL 2 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-12}$	-0.208	2.318***	1.911	0.121	0.310	0.176	-0.624	0.964	0.606**
	(0.341)	(0.693)	(1.268)	(0.0789)	(0.633)	(0.406)	(0.595)	(0.717)	(0.260)
QE_{t-12}	-0.0132	0.536**	0.101	-0.00434	0.0528	0.00833	0.00486	0.0458	0.0743**
	(0.0379)	(0.257)	(0.0740)	(0.0306)	(0.0565)	(0.00702)	(0.0364)	(0.0753)	(0.0337)
$SPREAD_{t-12} * QE_{t-12}$	0.0413	-0.561***	-0.0993	-0.00138	-0.0227	0.00416	0.0500	-0.0656	-0.0431**
	(0.0498)	(0.183)	(0.0631)	(0.0180)	(0.0222)	(0.0331)	(0.0308)	(0.0437)	(0.0189)
Constant	0.0541	-2.241**	-2.065	-0.0249	-0.649	-0.533	-0.192	-0.841	-0.910**
	(0.310)	(1.066)	(1.576)	(0.271)	(1.260)	(0.423)	(0.702)	(1.159)	(0.445)
Observations	108	108	72	108	72	108	108	108	108
R-squared	0.052	0.240	0.078	0.026	0.044	0.021	0.175	0.064	0.160
Durbin Watson (OLS)	0.298	0.364	0.305	0.225	0.229	0.476	1.283	0.297	0.304

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

6.3. The Predictive Power Beyond the Lagged Output Gap

This section presents the result for the third model specification where the lagged output gap is introduced in the model specification to be able to evaluate the predictive power of the model beyond the information contained in the lagged dependent variable. This naturally increases the goodness of fit of the model due to the persistent characteristics of the output gap. Tables 11 to 15 show the complete range of the results for this model specification. Furthermore, the visualisation of the predicted values across the lag lengths is described in Appendix E.

For Australia, the results indicate that the yield spread does not provide any additional predictive power beyond the information contained in the lagged output gaps since no other significant estimates are achieved. As in previous cases, significant results are achieved on the longest lag for Canada. The estimated coefficient of the yield spread is positive, and the interaction term is negative, which implies the same interpretation as before. An increasing level of Quantitative Easing seems to have a reducing effect on the marginal effect of the yield spread. The significant negative coefficient of the lagged output gap can be linked to the characteristics of the business cycle. Furthermore, in this specification, some significant result is also achieved on the eighth lag length which is similar as in the last lag yet with a yield spread coefficient only significant on a 10 per cent level.

As in the case of Australia, the results for Germany and the United Kingdom indicates that no additional predictive power beyond the information contained in the lagged output gap can be found. The results for Italy provide some significant result at the 10 per cent level across the lag lengths and a significant negative coefficient of the interaction term on the second lag length. No additional predictive power beyond the lagged output gap can be found in the case of Japan. In the case of Norway, additional predictive power is found on the last lag length with a significant positive coefficient on the interaction term. However, the estimated coefficient of the yield spread is not significant, so it is difficult to draw any further interpretations. Furthermore, for Sweden only additional significant result on the eighth lag length is achieved. On this lag length the interaction term is significantly negative, and the yield spread is significant positive.

The result for the United States is that it seems that the yield spread does not provide any additional predictive power in this model specifications. In this model specification, the variety in the predictive power of the yield spread across the countries seems to continue. Since in the most cases no additional predictive power could be found for the yield spread, it is difficult to draw any general conclusions of the effect of QE on the yield spread. However, in the cases for Sweden and Canada the pattern is the same as in the previous model.

Table 11: *Regression results from Model 3 with lag length at 1 quarter*

MODEL 3 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-1}$	0.0133	0.0562	0.0818	0.0486	0.383	-0.104	-0.512	0.195	-0.0466
	(0.221)	(0.228)	(0.574)	(0.0389)	(0.288)	(0.177)	(0.365)	(0.327)	(0.0710)
QE_{t-1}	0.0314	-0.0496	-0.0109	-0.00670	0.0260	-0.00248	-0.0232	-0.00180	-0.00659
	(0.0323)	(0.101)	(0.0209)	(0.00539)	(0.0194)	(0.00311)	(0.0205)	(0.0343)	(0.00918)
$SPREAD_{t-1} * QE_{t-1}$	0.00297	0.0203	0.0182	0.00561	-0.0156*	0.00619	0.0325	0.00473	0.00632
	(0.0296)	(0.0594)	(0.0174)	(0.00457)	(0.00902)	(0.00899)	(0.0207)	(0.0221)	(0.00476)
c_{t-1}	0.857***	0.912***	0.977***	0.925***	0.934***	0.753***	0.442***	0.918***	0.861***
	(0.0495)	(0.0423)	(0.109)	(0.0552)	(0.0663)	(0.0540)	(0.0921)	(0.0558)	(0.0478)
Constant	-0.295	0.0103	-0.187	-0.0469	-0.564	0.0701	0.393	-0.273	0.0114
	(0.276)	(0.405)	(0.783)	(0.0878)	(0.559)	(0.240)	(0.373)	(0.536)	(0.167)
Observations	119	119	83	119	83	119	119	119	119
R-squared	0.809	0.779	0.765	0.816	0.801	0.583	0.240	0.790	0.768
Durbin Watson (OLS)	0.555	1.163	1.522	1.143	0.947	1.578	2.172	1.598	1.482

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 12: *Regression results from Model 3 with lag length at 2 quarters*

MODEL 3 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-2}$	0.0628	0.142	-0.0534	0.0985	0.677	-0.0306	-0.764	0.557	-0.187
	(0.347)	(0.385)	(0.994)	(0.0643)	(0.485)	(0.290)	(0.494)	(0.520)	(0.131)
QE_{t-2}	0.0610	-0.0550	-0.0295	-0.00331	0.0588*	-0.00122	-0.0272	0.0292	-0.0187
	(0.0553)	(0.175)	(0.0393)	(0.0119)	(0.0330)	(0.00508)	(0.0256)	(0.0555)	(0.0161)
$SPREAD_{t-2} * QE_{t-2}$	-0.00605	0.00584	0.0395	0.00245	-0.0306**	0.00526	0.0491*	-0.00614	0.0163*
	(0.0472)	(0.0990)	(0.0353)	(0.00870)	(0.0151)	(0.0145)	(0.0265)	(0.0341)	(0.00852)
c_{t-2}	0.556***	0.675***	0.826***	0.738***	0.716***	0.498***	0.309***	0.780***	0.620***
	(0.0945)	(0.0864)	(0.148)	(0.118)	(0.0977)	(0.0932)	(0.0882)	(0.0853)	(0.0903)
Constant	-0.535	-0.0298	-0.0651	-0.0957	-1.087	-0.0137	0.437	-0.922	0.156
	(0.476)	(0.724)	(1.316)	(0.164)	(0.977)	(0.418)	(0.468)	(0.883)	(0.283)
Observations	118	118	82	118	82	118	118	118	118
R-squared	0.397	0.422	0.471	0.510	0.466	0.255	0.179	0.569	0.487
Durbin Watson (OLS)	0.447	0.593	0.694	0.466	0.483	0.738	1.393	0.686	0.610

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 13: *Regression results from Model 3 with lag length at 4 quarters*

MODEL 3 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-4}$	0.375	0.544	-0.642	0.108	0.687	0.0331	0.0856	0.658	-0.351
	(0.327)	(0.631)	(1.486)	(0.103)	(0.603)	(0.424)	(0.781)	(0.700)	(0.226)
QE_{t-4}	0.0884	0.0821	-0.0649	0.00782	0.0776*	0.00118	-0.0360	0.0200	-0.0314
	(0.0689)	(0.250)	(0.0703)	(0.0221)	(0.0448)	(0.00736)	(0.0331)	(0.0794)	(0.0270)
$SPREAD_{t-4} * QE_{t-4}$	-0.0549	-0.127	0.0722	-0.00545	-0.0371*	0.00658	0.00143	-0.00394	0.0254*
	(0.0465)	(0.166)	(0.0661)	(0.0141)	(0.0193)	(0.0235)	(0.0389)	(0.0439)	(0.0146)
c_{t-4}	-0.00695	0.152	0.288	0.263	0.123	0.0662	0.126	0.238**	0.134
	(0.139)	(0.147)	(0.197)	(0.222)	(0.139)	(0.155)	(0.111)	(0.102)	(0.159)
Constant	-0.731	-0.461	0.625	-0.127	-1.130	-0.182	0.591	-0.972	0.358
	(0.601)	(1.117)	(1.853)	(0.258)	(1.285)	(0.610)	(0.624)	(1.261)	(0.465)
Observations	116	116	80	116	80	116	116	116	116
R-squared	0.054	0.028	0.081	0.063	0.075	0.009	0.049	0.233	0.106
Durbin Watson (OLS)	0.257	0.269	0.301	0.251	0.256	0.460	1.192	0.388	0.270

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

***Table 14**: Regression results from Model 3 with lag length at 8 quarters*

MODEL 3 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-8}$	0.548	1.204*	0.201	0.0969	0.120	0.0174	1.004	1.039**	0.0769
	(0.392)	(0.702)	(0.975)	(0.104)	(0.382)	(0.368)	(0.635)	(0.448)	(0.286)
QE_{t-8}	0.0116	0.169	0.0155	0.0375	0.0670*	0.00585	-0.0369	0.0486	0.0235
	(0.0445)	(0.277)	(0.0443)	(0.0335)	(0.0401)	(0.00562)	(0.0311)	(0.0633)	(0.0296)
$SPREAD_{t-8} * QE_{t-8}$	-0.0705	-0.371**	-0.0318	-0.0254	-0.0240	0.0201	-0.0363	-0.0582**	-0.0133
	(0.0519)	(0.184)	(0.0483)	(0.0237)	(0.0145)	(0.0260)	(0.0320)	(0.0275)	(0.0154)
c_{t-8}	-0.316**	-0.482***	-0.662***	-0.223	-0.659***	-0.291	-0.0849	-0.448***	-0.212
	(0.129)	(0.154)	(0.178)	(0.219)	(0.111)	(0.215)	(0.0939)	(0.134)	(0.176)
Constant	-0.135	-0.461	0.119	-0.122	-0.385	-0.620	0.525	-1.044	-0.139
	(0.357)	(1.241)	(1.130)	(0.262)	(1.034)	(0.420)	(0.594)	(0.943)	(0.594)
Observations	112	112	76	112	76	112	112	112	112
R-squared	0.227	0.212	0.337	0.079	0.457	0.139	0.188	0.337	0.050
Durbin Watson (OLS)	0.306	0.329	0.401	0.220	0.373	0.568	1.302	0.481	0.253

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 15: *Regression results from Model 3 with lag length at 12 quarters*

MODEL 3 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-12}$	-0.356	2.415***	1.127	0.00330	-0.154	0.160	-0.825	0.519	0.346
	(0.300)	(0.609)	(1.182)	(0.0739)	(0.505)	(0.349)	(0.511)	(0.650)	(0.283)
QE_{t-12}	-0.0245	0.458	0.0708	0.0162	0.0231	0.00697	-0.00226	-0.0672	0.0701*
	(0.0332)	(0.281)	(0.0768)	(0.0325)	(0.0513)	(0.00692)	(0.0292)	(0.0746)	(0.0390)
$SPREAD_{t-12} * QE_{t-12}$	0.0538	-0.625***	-0.0908	-0.00902	-0.00702	0.00347	0.0604**	-0.0425	-0.0390*
	(0.0442)	(0.160)	(0.0648)	(0.0225)	(0.0175)	(0.0313)	(0.0259)	(0.0405)	(0.0209)
c_{t-12}	-0.216***	-0.250**	-0.449**	-0.339*	-0.299**	-0.244**	-0.320***	-0.402***	-0.400**
	(0.0788)	(0.0994)	(0.176)	(0.182)	(0.132)	(0.119)	(0.0764)	(0.140)	(0.157)
Constant	0.176	-1.784	-0.883	-0.0180	0.166	-0.470	-0.0615	0.635	-0.549
	(0.271)	(1.128)	(1.537)	(0.247)	(1.141)	(0.394)	(0.568)	(1.084)	(0.449)
Observations	108	108	72	108	72	108	108	108	108
R-squared	0.135	0.289	0.189	0.129	0.115	0.084	0.279	0.167	0.265
Durbin Watson (OLS)	0.325	0.406	0.380	0.248	0.270	0.516	1.491	0.346	0.350

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

6.4 The Predictive Power with Control Variables

The results from the final model specification, where the two control variables, the OECD business indicator and the WES inflation expectations are added to the second specification are now going to be presented. The tables 16 to 20 present the regression results in detail and figures in Appendix F visualises the predictive values for each country and lag length.

It can be concluded that the estimated coefficient of the yield spread is not significant at any lag length for Australia. However, the interaction term is significant negative on the fourth lag and significant positive the last lag. On these lag lengths, the estimated yield spread has its opposing sign yet not significant. Canada achieves a significant negative estimated coefficient of the QE variable on the second lag length. Furthermore, Canada provides a significant positive coefficient of the yield spread on the last lag as in the previous models. On this lag length, the QE variable also has a significant positive effect, and the interaction term has a significant negative effect as in previous models. The interpretation of this is as before; an increasing QE seems to lower the effect of the yield curve on the future output gap and eventually change the sign on the marginal effect. The highest goodness of fit according to the R squared statistics is achieved on the first lag where the yield spread, and the interaction term are not significant. Nevertheless, on this lag length, the coefficient of the QE variable is a significant negative.

For Germany, the estimated coefficients of the QE variable are significant and negative up to lag 4. Furthermore, the effect of the interaction term is significant positive on the fourth lag where the estimate of the yield spread is negative. However, the effect of the yield spread is not significant making it hard to make any further interpretations. The yield spread coefficients are significant negative on the two first lag lengths for the United Kingdom. On these lag lengths, the QE variable also has a significant negative effect on future output gaps. Furthermore, the interaction terms are not significant on these two lag lengths implying that the QE does not have any significant effect on the marginal effect of the yield spread on future output gaps. For Italy, the yield spread does not seem to have any significant effects on future output gaps in this model specification. The coefficients of the yield spread on the three first lag lengths are positive and significant for Japan. Furthermore, the estimated coefficient of the interaction term is negative, yet only significant on a 10 per cent level on the first and second lag and not significant at all on lag four.

For Norway, significant results are achieved for the yield spread on the second lag length where the estimated coefficient is negative. Furthermore, the interaction term provides a significant positive effect in this lag length. Hence, the implications of this are in line with the other significant results. In the case of Sweden, no significant results are achieved for the yield spread on a 5 per cent level or lower. However, the coefficient of the yield spread is significant positive on a 10 per cent level on the eighth lag length where the coefficient of the interaction term is also significant negative on a 10 per cent level. This is similar to the second specification yet in that case significance on 5 per cent, and lower vas achieved. Furthermore, as in the second model specification, the QE variable is significant negative on the two first lag lengths. For the United States, significant negative coefficients for the yield spreads on the two first lag lengths are achieved, as in the second model specifications. Furthermore, on these lag lengths the interaction variables are significantly positive, also in line with previous cases. Moreover, in this model specification significant results are also achieved on the fourth lag length, where the yield spread is significant negative, and the interaction term is significant positive. On the last lag length, the yield spread is significant positive, and the interaction variable is significant negative, as in the second model specification. The interpretation is similar to before and is going to be discussed more thoroughly in section 6.5.

Regarding the control variables, it can be stated that the expected inflation is significant across countries and lag lengths. However, the estimated coefficients that are significant are negative, which is rather odd. The most accurate result should be achieved on the fourth lag length since the inflation expectations are on a one-year horizon. Nevertheless, on this lag length, the significant coefficients are also negative. A negative coefficient implies that increasing expectations has a negative effect on the output gap one year ahead. This odd result stresses how difficult to predict future economic activity, hence also the inflation even for experts. Furthermore, the business confidence index (BCI) provides significant information about future economic activity on several lag lengths and across countries. The significant coefficients are positive on the shorter lag lengths, implying that increased confidence in near future business performance predicts increases in future output gaps and vice versa. Some significant negative coefficients are noted on the longer lag lengths, which implies that increased confidence in near future business indicates economic downturns in 8 or 12 quarters ahead. The explanation of this can be linked to the characteristics of the business cycles.

Table 16 *Regression results from Model 4 with lag length at 1 quarter*

MODEL 4 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-1}$	0.612	-1.000	-0.622	-0.442***	-0.597	0.699**	-1.012*	-0.675	-0.838***
	(0.520)	(0.635)	(0.773)	(0.141)	(0.713)	(0.283)	(0.516)	(0.454)	(0.154)
QE_{t-1}	0.00451	-0.446***	-0.0622***	-0.0410**	-0.0501	-0.0182***	-0.0412	-0.199***	-0.0505**
	(0.0529)	(0.139)	(0.0190)	(0.0197)	(0.0630)	(0.00470)	(0.0296)	(0.0548)	(0.0242)
$SPREAD_{t-1} * QE_{t-1}$	-0.108	0.170	0.00977	0.0130	0.0272	-0.0402*	0.0560*	0.0422	0.0339***
	(0.0674)	(0.163)	(0.0328)	(0.0126)	(0.0265)	(0.0210)	(0.0284)	(0.0316)	(0.0122)
BCI_{t-1}	0.0883	0.648***	0.900***	0.646***	1.220***	1.096***	0.413***	0.777***	0.548***
	(0.110)	(0.139)	(0.180)	(0.123)	(0.162)	(0.192)	(0.150)	(0.0862)	(0.0958)
$Expected\ inflation_{t-1}$	-0.373***	-0.287	0.243	-0.199**	0.0872	-0.362	0.242	-0.0974	0.213*
	(0.102)	(0.261)	(0.334)	(0.0983)	(0.302)	(0.249)	(0.223)	(0.200)	(0.124)
Constant	-7.763	-62.04***	-88.98***	-63.71***	-121.6***	-108.5***	-41.18***	-75.00***	-54.11***
	(11.17)	(13.72)	(17.92)	(12.00)	(17.29)	(18.88)	(15.17)	(8.508)	(9.496)
Observations	115	85	83	115	83	115	115	95	115
R-squared	0.312	0.624	0.667	0.569	0.615	0.541	0.181	0.664	0.585
Durbin Watson (OLS)	0.391	0.683	0.613	0.530	0.393	0.947	1.318	0.854	0.723

Standard errors in parentheses

*** p<0.01. ** p<0.05. * p<0.1

***Table 17**: Regression results from Model 4 with lag length at 2 quarters*

MODEL 4 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-2}$	0.713	-0.764	-1.057	-0.385***	-0.587	0.758***	-1.190**	-0.498	-0.822***
	(0.473)	(0.650)	(0.964)	(0.131)	(0.677)	(0.252)	(0.495)	(0.599)	(0.167)
QE_{t-2}	0.0177	-0.525***	-0.100***	-0.0527**	-0.104	-0.0150***	-0.0428	-0.215***	-0.0665***
	(0.0563)	(0.170)	(0.0309)	(0.0225)	(0.0740)	(0.00466)	(0.0327)	(0.0792)	(0.0243)
$SPREAD_{t-2} * QE_{t-2}$	-0.122*	0.139	0.0517	0.0196	0.0344	-0.0402*	0.0684**	0.0566	0.0383***
	(0.0644)	(0.160)	(0.0436)	(0.0133)	(0.0280)	(0.0209)	(0.0265)	(0.0434)	(0.0130)
BCI_{t-2}	0.00121	0.688***	0.967***	0.613***	1.198***	1.016***	0.433***	0.763***	0.596***
	(0.0946)	(0.193)	(0.197)	(0.133)	(0.158)	(0.158)	(0.140)	(0.107)	(0.0868)
$Expected\ inflation_{t-2}$	-0.491***	-0.879**	-0.411	-0.293***	-0.451	-0.489	0.259	-0.478**	0.0544
	(0.115)	(0.354)	(0.490)	(0.0963)	(0.370)	(0.301)	(0.204)	(0.202)	(0.161)
Constant	1.198	-64.65***	-94.24***	-60.21***	-117.7***	-100.6***	-43.21***	-73.39***	-58.45***
	(9.770)	(18.58)	(19.25)	(13.05)	(16.38)	(15.45)	(14.03)	(10.52)	(8.361)
Observations	114	84	82	114	82	114	114	94	114
R-squared	0.391	0.559	0.563	0.510	0.572	0.454	0.234	0.573	0.574
Durbin Watson (OLS)	0.424	0.622	0.571	0.456	0.458	0.831	1.383	0.817	0.627

Standard errors in parentheses

*** p<0.01. ** p<0.05. * p<0.1

Table 18: *Regression results from Model 4 with lag length at 4 quarters*

MODEL 4 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-4}$	0.658	0.0880	-1.706	-0.206	-0.380	0.630**	-0.172	0.142	-0.623***
	(0.400)	(0.768)	(1.159)	(0.161)	(0.535)	(0.311)	(0.725)	(0.793)	(0.213)
QE_{t-4}	0.0167	-0.348	-0.148***	-0.0487*	-0.127*	-0.00641	-0.0162	-0.138	-0.0695**
	(0.0568)	(0.266)	(0.0528)	(0.0283)	(0.0652)	(0.00758)	(0.0480)	(0.114)	(0.0278)
$SPREAD_{t-4} * QE_{t-4}$	-0.115**	-0.0583	0.117**	0.0190	0.0285	-0.0263	0.00829	0.0381	0.0346**
	(0.0566)	(0.193)	(0.0553)	(0.0153)	(0.0227)	(0.0186)	(0.0369)	(0.0558)	(0.0166)
BCI_{t-4}	-0.0833	0.428*	0.721***	0.374***	0.725***	0.667***	0.403***	0.406***	0.517***
	(0.0968)	(0.256)	(0.185)	(0.133)	(0.208)	(0.170)	(0.144)	(0.110)	(0.0878)
$Expected\ inflation_{t-4}$	-0.498***	-1.154***	-0.969**	-0.371***	-0.976***	-0.510**	-0.0773	-1.070***	-0.129
	(0.121)	(0.409)	(0.441)	(0.0909)	(0.351)	(0.202)	(0.252)	(0.216)	(0.239)
Constant	9.715	-38.87	-68.30***	-36.19***	-68.94***	-66.22***	-39.83***	-38.19***	-50.25***
	(9.931)	(25.72)	(17.98)	(13.03)	(20.47)	(16.72)	(14.62)	(10.30)	(8.689)
Observations	112	82	80	112	80	112	112	92	112
R-squared	0.374	0.267	0.329	0.265	0.388	0.226	0.149	0.485	0.381
Durbin Watson (OLS)	0.429	0.520	0.485	0.335	0.379	0.605	1.280	0.569	0.446

Standard errors in parentheses

*** p<0.01. ** p<0.05. * p<0.1

Table 19: *Regression results from Model 4 with lag length at 8 quarters*

MODEL 4 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-8}$	0.231	1.724	0.578	0.0404	0.525	0.0552	0.891	1.326*	0.223
	(0.487)	(1.510)	(1.246)	(0.213)	(0.905)	(0.445)	(0.565)	(0.700)	(0.267)
QE_{t-8}	-0.0372	0.157	0.0164	0.000426	0.0366	0.0139	-0.00775	0.146	0.0257
	(0.0446)	(0.423)	(0.0658)	(0.0478)	(0.103)	(0.00992)	(0.0336)	(0.0973)	(0.0383)
$SPREAD_{t-8} * QE_{t-8}$	-0.0336	-0.435	-0.0106	-0.00238	-0.0334	0.0340	-0.0363	-0.0846*	-0.0256
	(0.0662)	(0.372)	(0.0595)	(0.0265)	(0.0386)	(0.0284)	(0.0302)	(0.0453)	(0.0159)
BCI_{t-8}	-0.0917	-0.0323	-0.168	-0.0550	-0.645***	-0.163	0.0656	-0.314**	0.300**
	(0.156)	(0.203)	(0.202)	(0.189)	(0.182)	(0.290)	(0.178)	(0.131)	(0.149)
$Expected\ inflation_{t-8}$	-0.192	-0.612	-0.454	-0.177	-0.494	0.0717	-0.543**	-0.654**	-0.247
	(0.143)	(0.407)	(0.340)	(0.164)	(0.321)	(0.243)	(0.228)	(0.287)	(0.223)
Constant	10.03	3.876	16.92	5.966	65.37***	15.01	-5.300	30.34**	-29.51**
	(15.77)	(20.57)	(19.04)	(18.63)	(18.10)	(28.49)	(18.11)	(12.19)	(14.85)
Observations	108	78	76	108	76	108	108	88	108
R-squared	0.058	0.071	0.134	0.030	0.275	0.105	0.253	0.294	0.126
Durbin Watson (OLS)	0.313	0.356	0.303	0.218	0.308	0.517	1.357	0.467	0.325

Standard errors in parentheses

*** p<0.01. ** p<0.05. * p<0.1

Table 20: *Regression results from Model 4 with lag length at 12 quarters*

MODEL 4 VARIABLES	AUS	CAN	DEU	GBR	ITA	JPN	NOR	SWE	USA
$SPREAD_{t-12}$	-0.595*	2.997***	1.740	0.0770	0.445	-0.101	-0.372	0.802	0.652**
	(0.333)	(0.932)	(1.431)	(0.156)	(0.657)	(0.307)	(0.496)	(0.908)	(0.252)
QE_{t-12}	-0.0202	0.690***	0.100	0.00190	0.0816	0.00833	0.0393	0.0237	0.0683*
	(0.0293)	(0.257)	(0.0683)	(0.0548)	(0.0730)	(0.00755)	(0.0339)	(0.126)	(0.0387)
$SPREAD_{t-12} * QE_{t-12}$	0.0960**	-0.661***	-0.0957	-0.000525	-0.0375	0.0114	0.0343	-0.0633	-0.0486**
	(0.0477)	(0.219)	(0.0711)	(0.0226)	(0.0278)	(0.0310)	(0.0248)	(0.0574)	(0.0202)
BCI_{t-12}	-0.0893	0.0691	-0.214	0.0559	-0.620*	-0.264	-0.167	-0.343**	-0.000851
	(0.135)	(0.174)	(0.234)	(0.132)	(0.326)	(0.250)	(0.101)	(0.133)	(0.148)
$Expected\ inflation_{t-12}$	0.157	-0.0302	0.00814	0.131	0.169	0.0529	-0.401	-0.0265	-0.246
	(0.138)	(0.342)	(0.465)	(0.169)	(0.364)	(0.234)	(0.244)	(0.266)	(0.193)
Constant	8.592	-10.01	19.50	-5.958	61.04*	25.96	16.84*	33.93***	-0.0956
	(13.94)	(17.61)	(22.95)	(12.65)	(33.26)	(25.21)	(9.901)	(12.83)	(14.36)
Observations	104	74	72	104	72	104	104	84	104
R-squared	0.154	0.394	0.101	0.023	0.169	0.042	0.205	0.110	0.174
Durbin Watson (OLS)	0.337	0.512	0.308	0.224	0.260	0.495	1.398	0.342	0.321

Standard errors in parentheses

*** p<0.01. ** p<0.05. * p<0.1

6.5 Estimated Marginal Analysis

To illustrate in what way the Quantitative Easing affects the predictive power of yield spread of the yield spread on future economic activity, this section will present the estimated marginal effects from the final model. The reason is that it has been proved that often the yield spread, and the interaction term, has opposing sign on the significant coefficients and this analysis aims to easier visualise these effects.

First, how the average marginal effect of the yield spread change when the QE variable is set to range between low to high, ceteris paribus. The specific values were chosen to make sure that every country got reasonable values on the QE variable[2]. The average marginal effect of the yield spread is then plotted against the QE to picture the effects. Second, the expected output gap is estimated when the yield spread ranges from negative to positive values, given two different levels of the QE variable. The values chosen on the QE variable were one relatively low and another relatively high value. The estimates of the future output gap are then plotted against the yield spread to visualise the relationship changes for two different level of QE. Appendix G shows the marginal plots for every country at all lag lengths. Furthermore, I will now discuss the marginal effects for the United States, since previous literature has also pointed out the predictive power of the yield spread seems to be superior for the United States compared to other countries, which makes it an interesting case. Furthermore, in the previous part of the analysis, it has been proven that significant results are achieved for the United States throughout different lag lengths and model specifications.

Figure 3 displays the average marginal effects and the expected output gaps at the first lag length. It can be concluded that the average marginal effect becomes less negative, with a higher level of QE which is displayed in the left graph. Hence, it seems to be the case that Quantitative Easing has lowered the marginal effect of the yield spread on future output gaps. Moreover, with a QE level of 17.77 per cent, the total average marginal effect of the yield curve is no longer significant negative. Furthermore, the right graph in figure 3 also visualises this effect since with a relatively high QE level of 24.93 per cent(triangles), changes in the yield spread has a low effect on the expected future output gap. While for a low value of QE at 5.07 per cent (circles), there still exists a negative marginal effect of the yield spread on the expected future output gap.

[2] More precisely between the 1 % percentile and the 99 % percentile of the QE variable for each country.

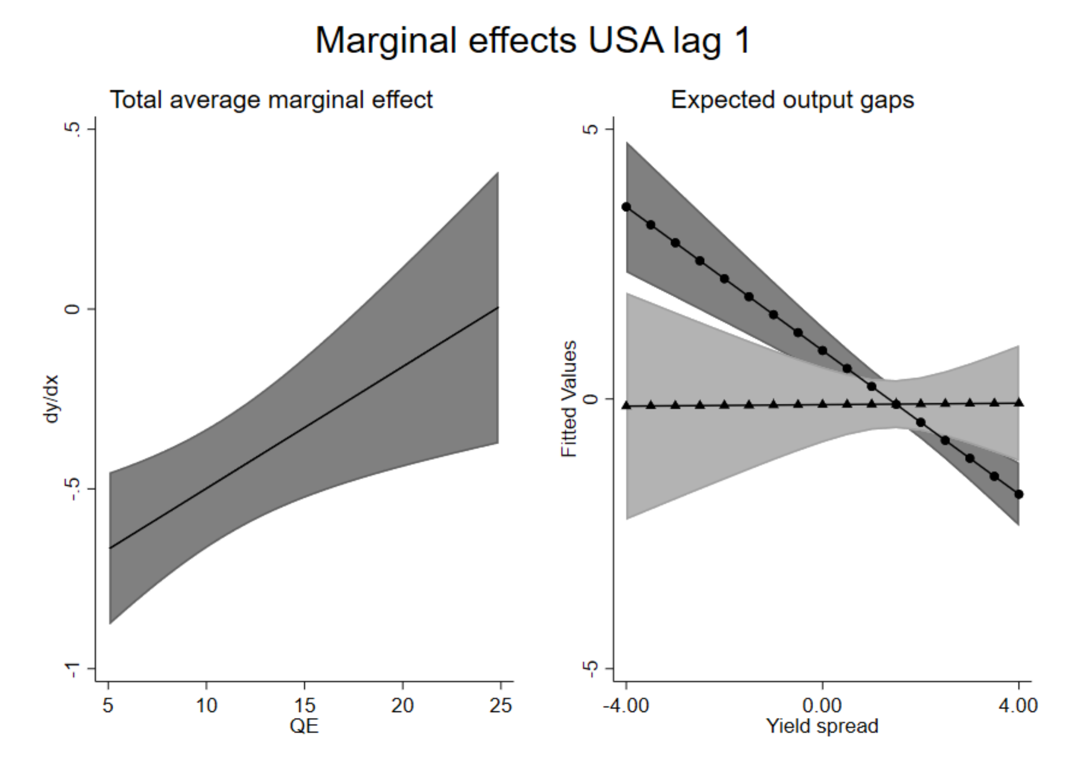

Figure 3 *Left graph: average marginal effect of the yield spread when the QE variable is set to range between low to high. Right graph: Expected future output gap plotted against yield spread given two different levels of QE at lag length 1 quarter. Low QE symbol: Circles, High QE symbol: Triangles*

Furthermore, a similar conclusion can also be made for the second lag length for the United States, as displayed in figure 4. However, now the turning point comes at a lower level of QE, more precisely at 15.97 per cent. As in the first lag length this effect is also described in the second graph in figure 4, with a low value of QE there exist a significant negative relationship, while with a high level of QE the slope is no longer significant negative. Moreover, the fourth lag length does also provide significant results for the United States. As for the two first lag lengths, the indication is that the total average marginal effects become less negative when the level of QE increases, which is visualised in figure 5. A threshold can be found at 11.97 per cent of QE since, at this level, the total average marginal effect is no longer significant negative. Furthermore, these indications can also be seen in figure 5 right graph since the level of QE changes the relationship between the expected future output gap and the yield spread for the United States.

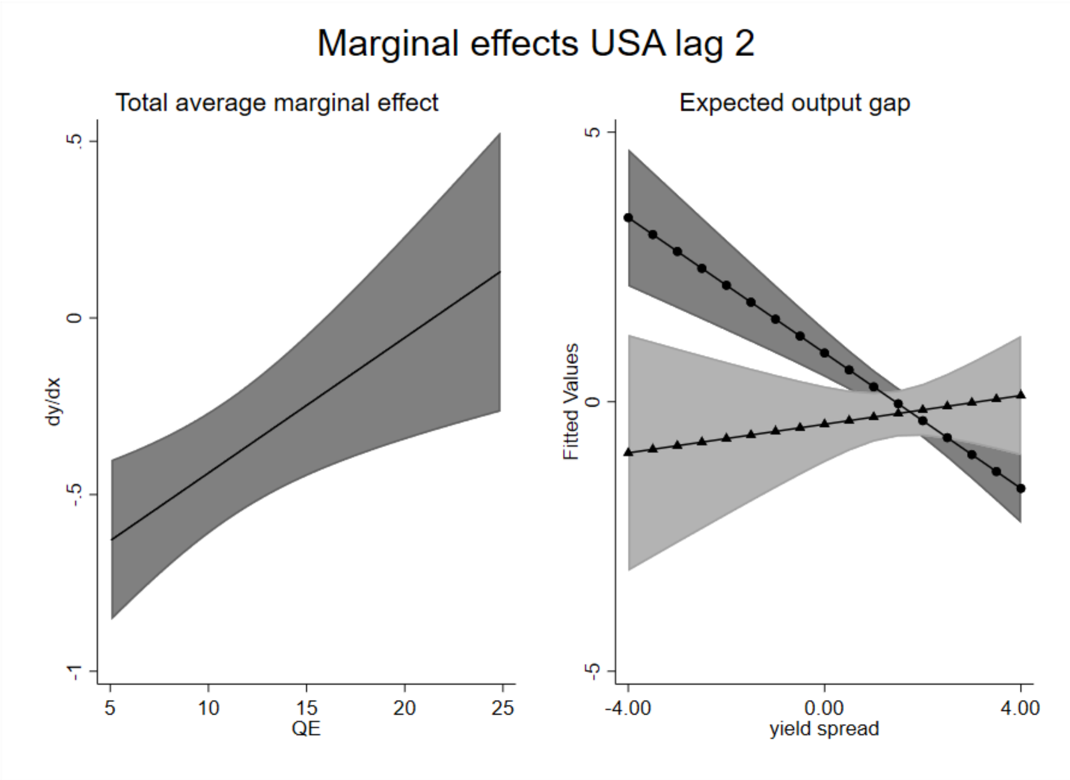

Figure 4 *Left graph: average marginal effect of the yield spread when the QE variable is set to range between low to high. Right graph: Expected future output gap plotted against yield spread given two different levels of QE at lag length 2 quarters. Low QE symbol: Circles, High QE symbol: Triangles*

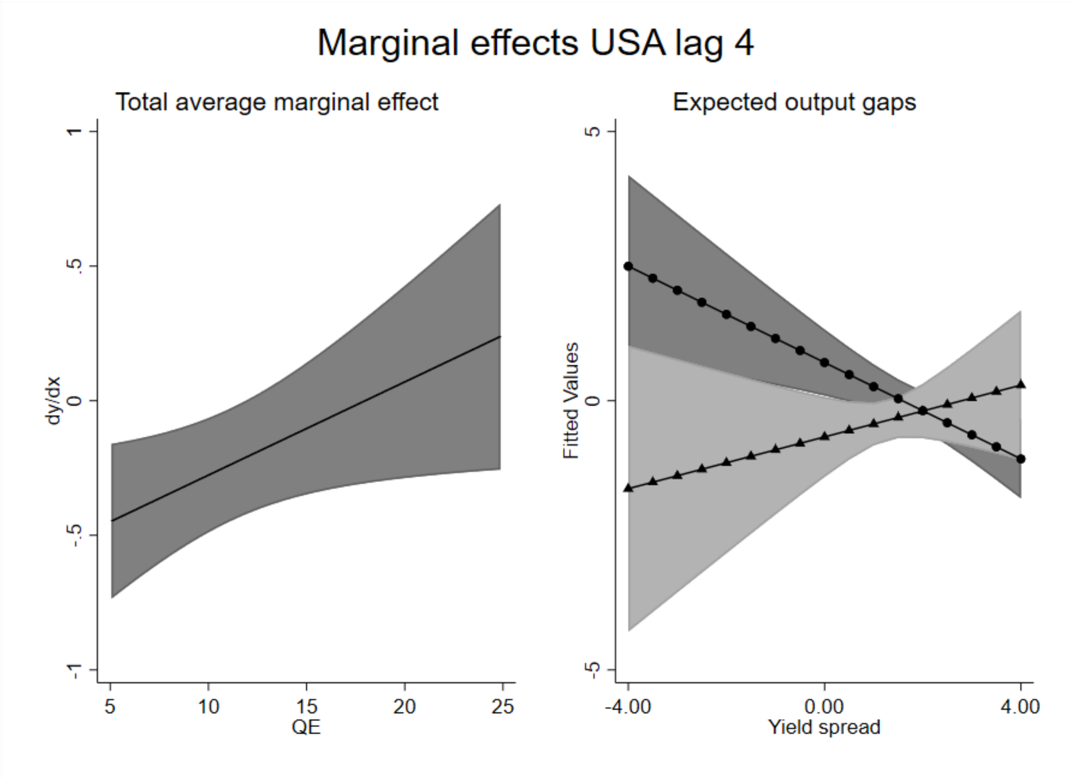

Figure 5 *Left graph: average marginal effect of the yield spread when the QE variable is set to range between low to high. Right graph: Expected future output gap plotted against yield spread given two different levels of QE at lag length 4 quarters. Low QE symbol: Circles, High QE symbol: Triangles*

At the eighth lag length, either the spread or the interaction term is significant for the United States. These results are visualised in figure 6 since the total average effect is never significant apart from zero, regardless of the level of QE. Furthermore, the insignificant result causes also that changes in the yield spread have unclear results on expected future output gaps.

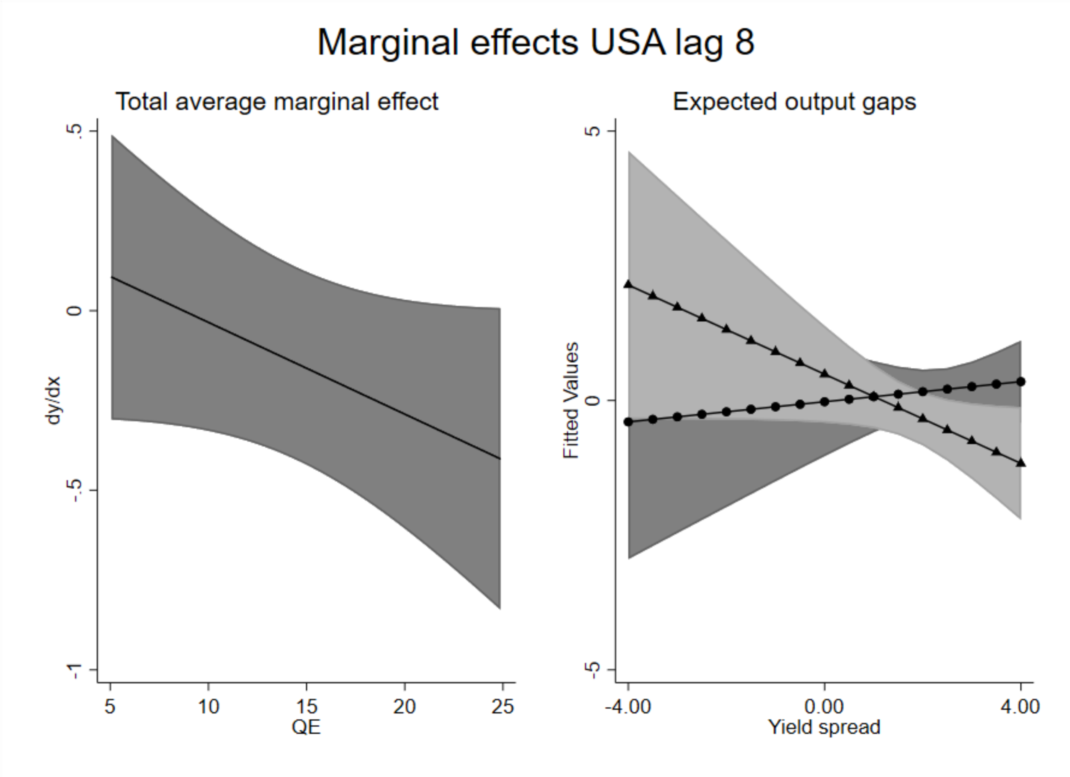

Figure 6 *Left graph: average marginal effect of the yield spread when the QE variable is set to range between low to high. Right graph: Expected future output gap plotted against yield spread given two different levels of QE at lag length 8 quarters. Low QE symbol: Circles, High QE symbol: Triangles*

Moreover, on the last lag length the United States achieves, both significant coefficients on the yield spread and the interaction term and Figure 7 visualise the marginal effects in this case. As stated before, the signs have changed for the United States on this last lag length which causes the total average marginal effect first being positive but as QE increases the effect stops being significantly positive at 6.97 QE level. These effects are also presented in the second graph in figure 7 since the slope changes with the two different level of QE.

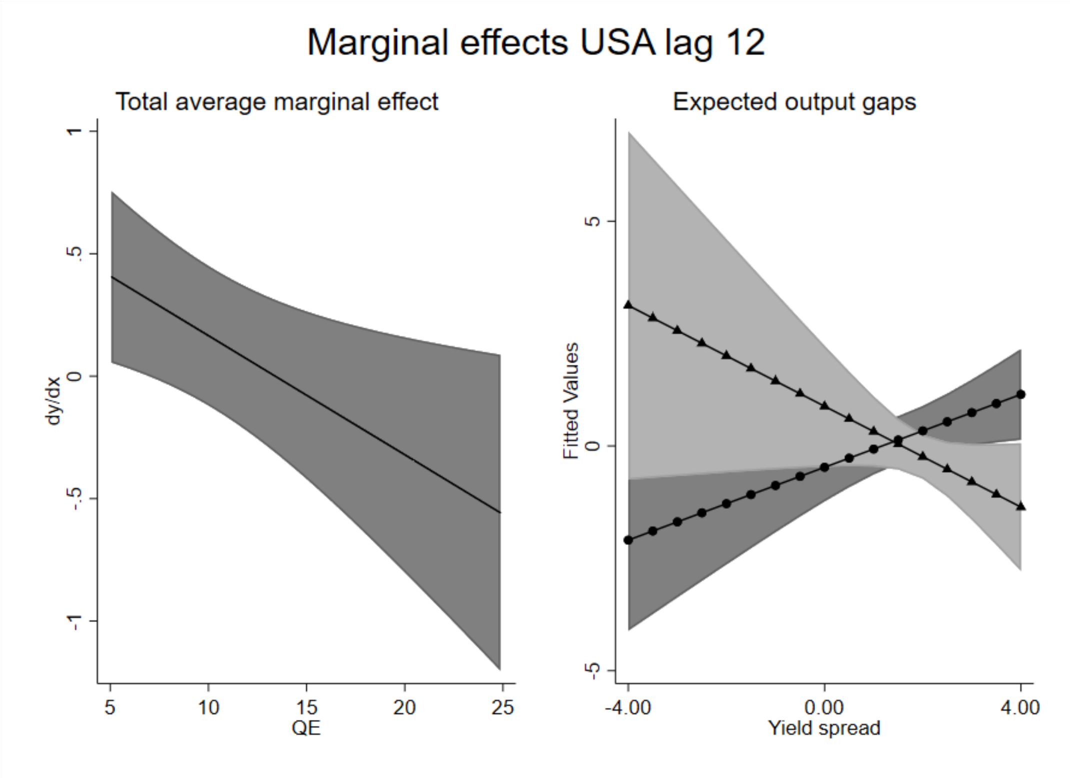

Figure 7 *Left graph: average marginal effect of the yield spread when the QE variable is set to range between low to high. Right graph: Expected future output gap plotted against yield spread given two different levels of QE at lag length 12 quarters. Low QE symbol: Circles, High QE symbol: Triangles*

In the other significant cases which are described in Appendix G, the tendency is similar. It seems to be the case that the level of QE affects the total marginal effect in an opposing way as the yield spread. However, since these effects cannot be seen across all countries and are depending on the lag length and model specification, no general conclusions can be draw regarding the Quantitative Easing effect on the yield curves ability to predict future economic activity.

7. Concluding Remarks

This study examines if Quantitative Easing has affected the relationship between the yield curve and future economic activity. Starting with a standard regression set up using the yield spread as the only predictor it can be concluded that there exists a variation in the performance of the yield spread as an indicator for future economic activity measured as the output gap, where the highest goodness of fit is found for the United States. This in line with the findings in previous literature. Yet, the significant negative effects of the yield spreads identified in this study is something that is in need of further investigation. Furthermore, introducing Quantitative Easing into the regressions, measured as the central banks' balance sheet as per cent of GDP, the variation in the performance of the yield spread as predictor continuous. Some countries provide significant results on several lag lengths and across model specifications. Two examples are Canada and the United States, who have significant yield spreads and where the Quantitative Easing variable significantly changes the total marginal effect on throughout the analysis. Other countries where the yield spread performed weekly as the only predictor also seemed to be week though out the model specifications, examples include Australia and Italy.

This study provides some indications that the Quantitative Easing variable affects the marginal effect of the yield spread on future output gaps since the tendency in the significant cases is that the coefficients of the yield spread and the interaction term have opposing signs. However, since the marginal effect of the yield spread is sensitive for the choice of lag length (changes signs) and model specification, more research is needed to understand the effect of Quantitative Easing further. Furthermore, the significant result for Norway and Canada is worrying since it shows that the QE variable has significant effects of the yield spreads the ability to predict future output gaps without having implemented Quantitative Easing. In further research, another measurement than the total balance sheet is suggested, to better uncover the effects of the level of Quantitative Easing.

Even though the robustness of the results can be questioned, this study provides some indications that the level of Quantitative Easing seems to have some effect on the total marginal effect of the yield spread on future economic activity in the form of the output gap. This leaves important information to market watchers, central bankers and professional economist to take the level of Quantitative Easing into account when using the yield spread as a predictor for future economic activity. Especially since indications show that Quantitative Easing is something that central banks around the world are going to continue with.

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Appendices

Appendix A

Table A1: *Timeline over large scale asset purchase programmes 2001-2019*

Dates	Programme	Description
Bank of England		
19-01-2009	**APF**	BoE announced the Asset Purchase Facility (APF) which implied that £50 billion of high-quality private sector assets was purchased financed by Treasury issuance (Borio and Zabai 2016).
05-03-2009	**APF/QE1**	BoE announced their first QE programme which meant that up to £75 billion of assets could be purchased. The majority of the purchases was medium- and long-term gilts and was financed by reserve issuance (Borio and Zabai 2016).
06-10-2011	**APF/QE2**	BoE announced that an additional £275 billion in assets would be purchased, financed by reserve issuance. Furthermore, the ceiling on private assets remained at £50 billion (Borio and Zabai 2016).
05-07-2012	**APF/QE3**	The third QE programme was announced by BoE, which implied that £375 billion in assets was purchased (Borio and Zabai 2016).
08-2016		The Bank of England announced that it would buy £60 billion of government bonds and £10 billion of corporate bonds due to the worries about economic growth, productivity and the uncertainty over the Brexit process. The total bond purchases had now reached £435 billion (BBC, 2016; Bank of England, 2020).
03-2020		In March 2020 the Bank of England total bond purchases reached £645 billion (Bank of England, 2020)
Bank of Japan		
19-03-2001		BoJ changed its primary target from the uncollateralised overnight call rate to the outstanding balance of the quantity of bank reserves (Fawley and Neely, 2013)
?		BoJ increased the target for bank reserves from ¥4 trillion to ¥5 trillion in an attempt to decrease the overnight call rate (Fawley and Neely, 2013)
2001-2004		Over a four year period, the target for bank reserve had increased to ¥35 trillion. At the same time, private and public debt was purchased(Fawley and Neely, 2013).

09-03-2006		BoJ reinstated the uncollareralised overnight call rate as the main policy instrument which officially ended their first QE regime (Fawley and Neely, 2013)
05-10-2010	**CME**	BoJ announced an Asset Purchase Programme which implied that ¥0.5 trillion in Japanese real estate investment trusts(J-REITs), ¥1 trillion in commercial paper and 3.5 in Japanese government bonds (JGBs) was purchased. This has been referred to as the Comprehensive Monetary Easing (CME) (Borio and Zabai, 2016).
04-04-2013	**QQE**	The Quantitative and Qualitative Easing (QQE) was announced by the BoJ which stated that the monetary base and the amounts outstanding of exchange-traded funds (ETFs) and Japanese government bonds (JGBs) should be doubled in two years. Furthermore, the average remaining maturity of JGB purchases was more than doubled (Borio and Zabai 2016). (
31-10-2014		BoJ announced an expansion of its Asset Purchasing Programme meaning that ¥80 trillion of bonds a year should be purchased per year (Bank of Japan, 2014)
09-2016		BoJ announced their Yield curve Control (YCC) programme which targeted both short-term and long-term policy interest rates. Furthermore this implied a peg on 10-year Japanese Government Bonds (JGBs) around zero percent,.(Brichetti et al 2018).
ECB		
05-10-2010	**SMP**	ECB announced their Security Markets Programme (SMP) stated that interventions in the euro area private and public debt securities markets and purchases would be sterilized (Borio and Zabai 2016).
09-06-2012	**OMT**	Overnight monetary transaction (OMT) was announced: countries that applied to the European Stability Mechanism (ESM) for aid and followed the terms and condition was permitted to have their debt purchased in unlimited amounts by ECB on the secondary market (Borio and Zabai 2016).
04-09-2014	**CBPP3**	The covered bond purchasing programme 3(CBPP3) was announced stated that the ECB would start purchasing a portfolio of euro-dominated covered bonds by monetary financial institutions in the euro-area (Borio and Zabai 2016).
04-09-2014	**APP/ABSPP**	The Asset Purchase Programme and the Asset-Backed Securities Purchase Programme was announced on the same date stated that ECB would purchase a portfolio of asset-backed securities with underlying assets consisting of claims against the euro area non-financial private sector (Borio and Zabai 2016).

22-01-2015	**PSPP**	ECB announced that bonds issued by euro area central governments, European institutions and agencies will be purchased in a Public sector purchase programme (Borio and Zabai 2016).
03-2015 to 03-2016		The monthly purchase pace averaged €60 billion from March 2015 to March 2016 (ECB, 2020)
04-2016 to 03-2017		The monthly purchase pace averaged €80 billion from April 2016 to March 2017 (ECB, 2020)
04-2017 to 12-2017		The monthly purchase pace averaged €60 billion from April 2017 to December 2017. (ECB, 2020)
01-2018 to 09-2018		The monthly purchase pace averaged €30 billion from January 2018 to September 2018 (ECB, 2020)
10-2018 to 12-2018		The monthly purchase pace averaged €15 billion from October 2018 to December 2018 (ECB, 2020)
01-2019 to 10-2019		The ECB reinvested the principal payments from maturing securities held in the APP portfolios (ECB, 2020).
12-09-2019		ECB announced that net purchases were restarted with a monthly pace of €20 billion (ECB, 2020).
FED		
25-11-2008	**QE1**	The Federal Reserve announced plans to purchase $500 billion in mortgage-backed securities (MBS) and $100 billion in government-sponsored enterprise (GSE) debt (Borio and Zabai 2016).
18-03-2009	**QE1**	The large-scale asset purchases expanded when Federal Reserve announced that $300 billion in long-term Treasuries and an additional $100 billion in GSE debt and $750 in MBS debt would be purchased (Borio and Zabai 2016).
11-03-2010	**QE2**	Additional $600 billion in US Treasuries was purchased (Borio and Zabai 2016).
21-09-2011	**MEP**	Federal Reserve announced their Maturity Extension Programme Reinvestment Policy (MEP) which implied that $400 billion in long-term Treasuries was purchased while sold an equal amount of short-term assets (Borio and Zabai 2016).
12-09-2012	**QE3**	The Federal Reserve announces that $40 billion of MBS will be purchased per month as long as the situation on the labour market does not improve substantially (Borio and Zabai, 2016).

May and June 2013	**Tapering**	The Federal Reserve first announced that it could reduce the pace of monthly asset purchases under its QE3 programme from US$85 billion per month later in 2013. This has referred to as tapering (Rai and Suchaneck,2014).
December 2013	**Tapering**	The Federal Reserve announced its intentions to begin tapering by $10 billion per month starting in January 2014. Furthermore, it was also signalled that the Programme could end in mid-2014 ((Rai and Suchaneck,2014).
The Riksbank		
12-02-2015		The Riksbank announced that 10 billion SEK of nominal government bonds would be purchased with majorities of 1 year up to 5 years (Riksbanken, 2015a).
29-04-2015		The Riksbank announced that additional 40-50 billion SEK of nominal government bonds with majorities up to 25 years would be purchased (Riksbanken, 2015b)
02-07-2015		The Riksbank announced that an additional 45 billion SEK of government bonds would be purchased (Riksbanken, 2015c)
28-10-2015		The Riksbank announced that 65 billion SEK of government bond would be purchased (Riksbanken, 2015d)
21-04-2016		The Riksbank announced that an additional 45 billion SEK of government bonds would be purchased (Riksbanken, 2016a)
21-12-2016		The Riksbank announced that an additional 30 billion SEK of government bonds would be purchased (Riksbanken, 2016b)
04-07-2017		The Riksbank announced that the purchases of government bonds would continue which implied that the total purchases of government bonds were 290 billion SEK excluding reinvestments. Furthermore, it was also announced that maturities and coupon payments would be reinvested until further notice (Riksbanken, 2017a)
20-12-2017		The Riksbank announced that the Executive Board decided to begin reinvesting in January 2018 the bonds that mature in 2019 which implies that the Riksbank's holdings of government bonds will increase temporarily in 2018 and the beginning of 2019 (Riksbanken, 2017b)

Appendix B

Real GDP	Source	Details	Code	Downloaded
AUS	Datastream	Million 2017-2018 AUD	AUGDP...T	2020-04-07
CAN	Datastream	Million 2012 CAD	CNGDP...D	2020-04-07
DEU	Datastream	Billion 2015 euro	BDGDP...D	2020-04-07
GBR	Datastream	Million 2016 GBP	UKGDP...D	2020-04-07
ITA	Datastream	Million 2015 euro	ITGDP...D	2020-04-07
JPN	Datastream	Billion 2011 Yen	JPGDP...D	2020-04-07
NOR	Datastream	Million 2017 NOK	NWGDP...D	2020-04-07
SWE	Datastream	Million 2018 SEK	SDGDP...D	2020-04-07
USA	Datastream	Billion 2012 USD	USGDP...D	2020-04-07

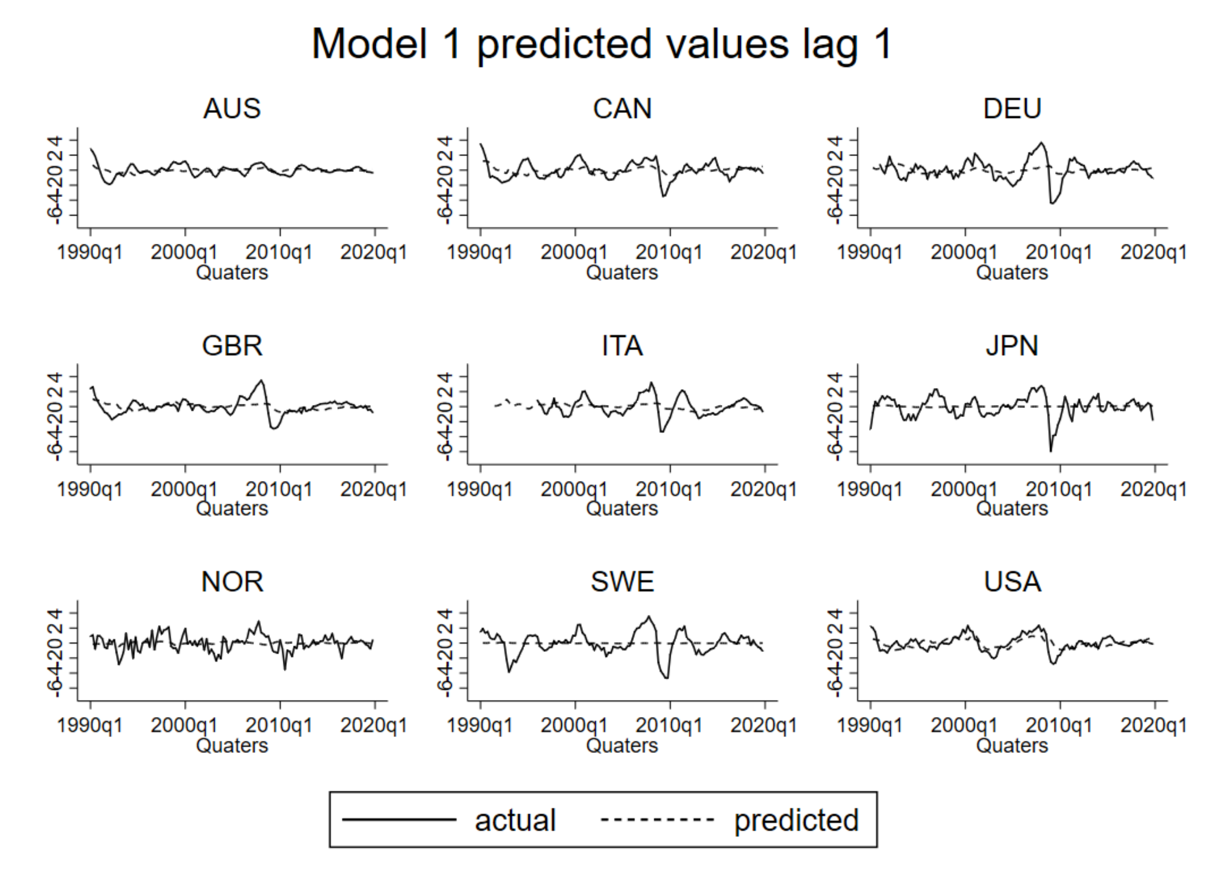
Nominal GDP	Source	Details	Code	Downloaded
AUS	Datastream	Million AUD	AUGDP...B	2020-04-09
CAN	Datastream	Million CAD	CNGDP...B	2020-04-09
DEU	Datastream	Billion Euro	BDGDP...A	2020-04-09
GBR	Datastream	Million GBP	UKGDP...B	2020-04-09
ITA	Datastream	Million Euro	ITGDP...B	2020-04-09
JPN	Datastream	Billion Yen	JPGDP...B	2020-04-09
NOR	Datastream	Million NOK	NWGDP...B	2020-04-09
SWE	Datastream	Million SEK	SDGDP...A	2020-04-09
USA	Datastream	Billion USD	USGDP...B	2020-04-09
Euro area	Eurostat	million euro		2020-04-17

Interest rates	Source	Details	Downloaded
AUS long	OECD	10-year Commonwealth treasury bonds	2020-04-07
AUS short	OECD	The estimated closing yields on 90-day bank accepted bills	2020-04-07
CANvlong	OECD	Federal Government bonds with maturities of more than 10 years	2020-04-07
CAN short	OECD	Bank of Canada's estimates of operative market trading levels for major borrower's paper (90-day corporate paper).	2020-04-07
DEU long	OECD	federal securities with residual maturities of over 9 to 10 years traded on the secondary market.	2020-04-07
DEU short	OECD	3-month "European Interbank Offered Rate	2020-04-07
GBR long	OECD	10-year bonds	2020-04-07
GBR short	OECD	3-month rates	2020-04-07
ITA long	OECD	bonds traded on the Italian Exchange (MOT) with a residual maturity of 10 years.	2020-04-07
ITA short	OECD	3-month "European Interbank Offered Rate	2020-04-07
JPN long	OECD	The reference average price for OTC bond transactions for interest-bearing 10-year government bonds1990Q1-2014Q3. 2014Q4-2019Q4 10 years newly issued government bond yields	2020-04-07
JPN short	Bank of Japan	Call Rate, Uncollateralised Overnight/Average	2020-04-17
NOR long	OECD	Norwegian central government bonds with remaining terms of 10 years, secondary market.	2020-04-07
NOR short	OECD	3-month NIBOR are euro-krone interest rates	2020-04-07
SWE long	OECD	10-year government bonds, except for 1994 for which data refer to 9-year government bonds.	2020-04-07
SWE short	OECD	90-day Treasury bills (discount notes)	2020-04-07
USA long	OECD	Government securities with outstanding maturities of 10 years	2020-04-07
USA short	OECD	3-month Treasury bills	2020-04-07

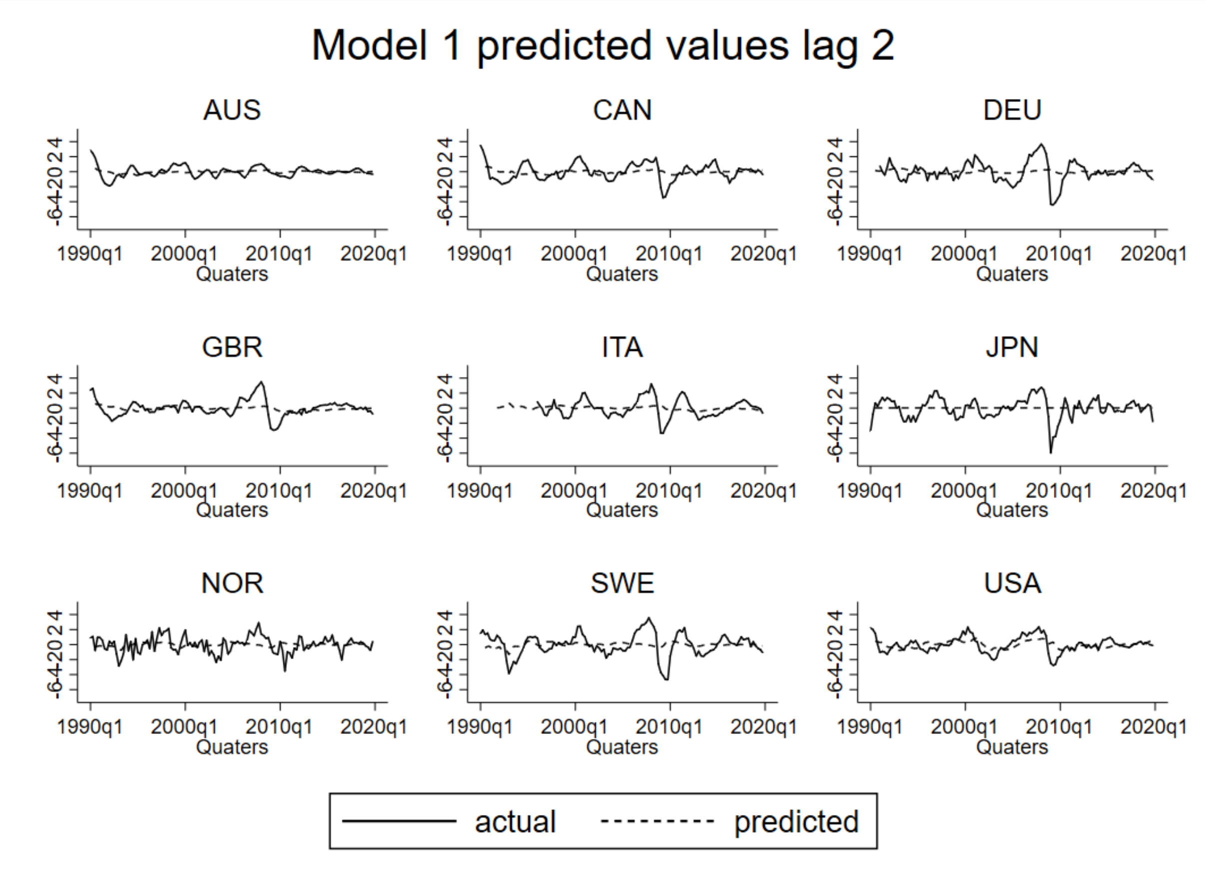
Central banks' balance sheet	Source	Details	Code	Downloaded
AUS	Datastream 1990Q1-1994Q1, Reserve Bank of Australia 1994Q2-2019Q4	Million AUD	AUOQ0C24A (1990Q1-1994Q1)	2020-04-06
CAN	Bank of Canada	Million CAD		2020-04-06
ECB	Datastream	Million Euro	EMECA..	2020-04-17
GBR	Bank of England	Million GBP		2020-04-19
JPN	Datastream	Billion Yen	JPBOJTOTA	2020-04-07
NOR	Norges Bank	Million NOK		2020-04-17
SWE	Datastream	Million SEK	SDCBASSTA	2020-04-07
USA	Datastream	Millions USD	USOATAS (1990q1-2002q4), USRATAS (2003q1-2019q4)	2020-04-07

Expected Inflation	Source	Details	Code	Downloaded
AUS	Datastream	World Economic Survey	AUIFINFRR	2020-05-06
CAN	Datastream	World Economic Survey	CNIFINFRR	2020-05-06
DEU	Datastream	World Economic Survey	BDIFINFRR	2020-05-06
GBR	Datastream	World Economic Survey	UKIFINFRR	2020-05-06
ITA	Datastream	World Economic Survey	ITIFINFRR	2020-05-06
JPN	Datastream	World Economic Survey	JPIFINFRR	2020-05-06
NOR	Datastream	World Economic Survey	NWIFINFRR	2020-05-06
SWE	Datastream	World Economic Survey	SDIFINFRR	2020-05-06
USA	Datastream	World Economic Survey	USIFINFRR	2020-05-06

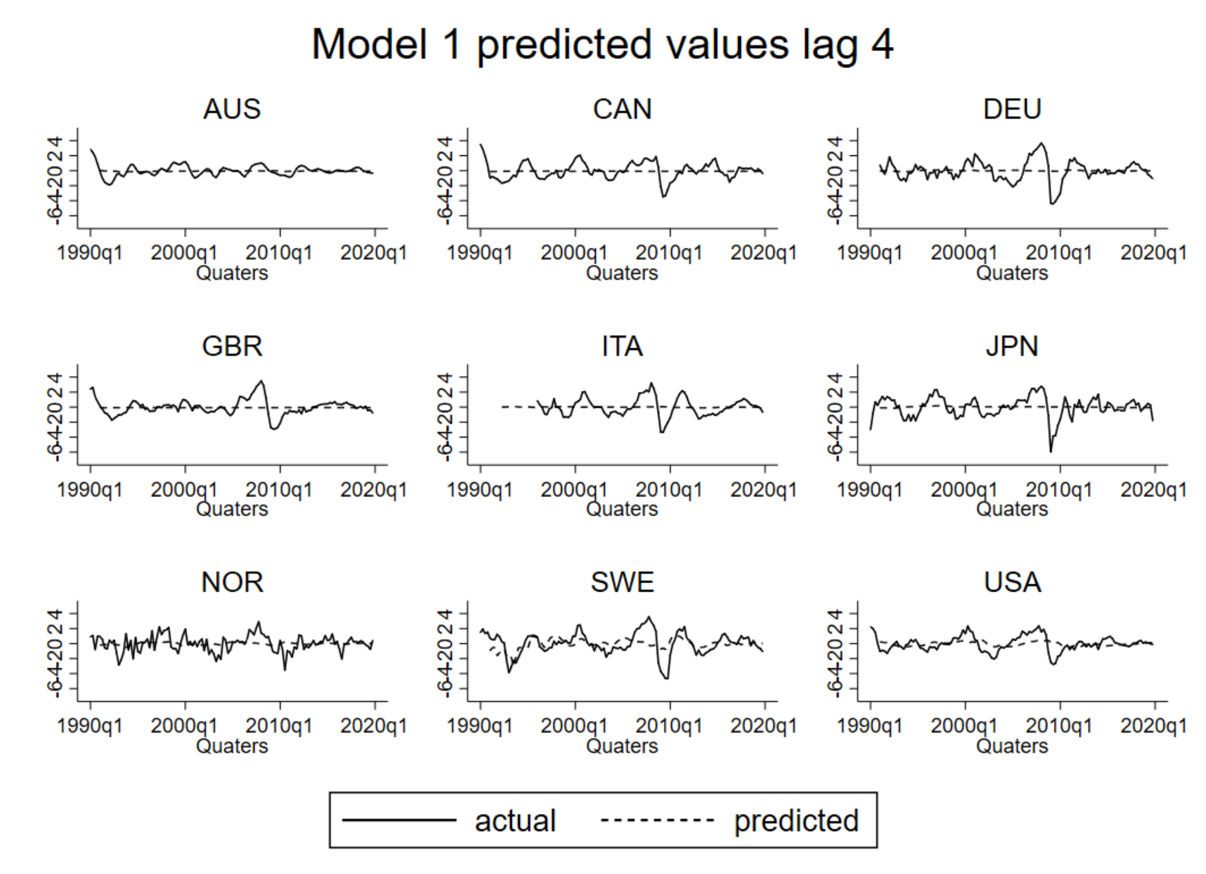
Appendix C

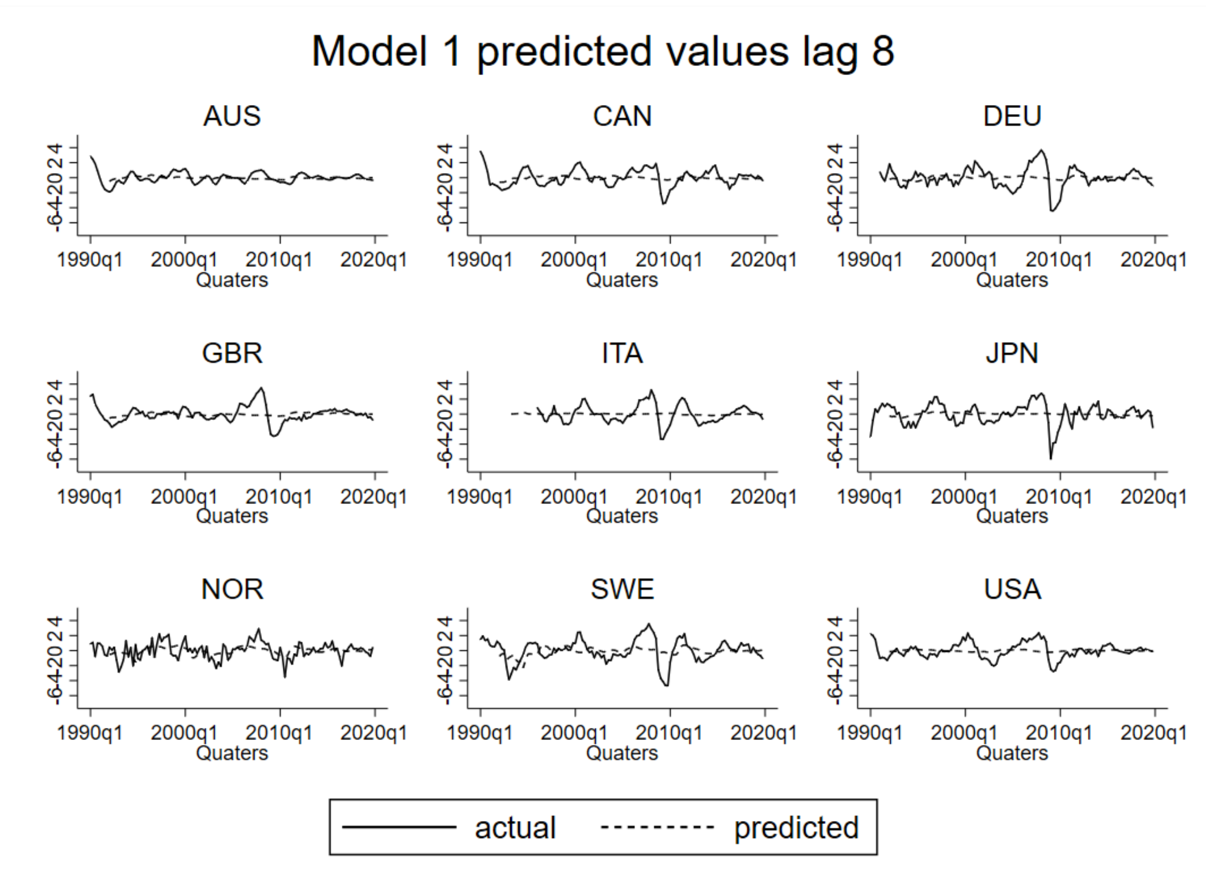


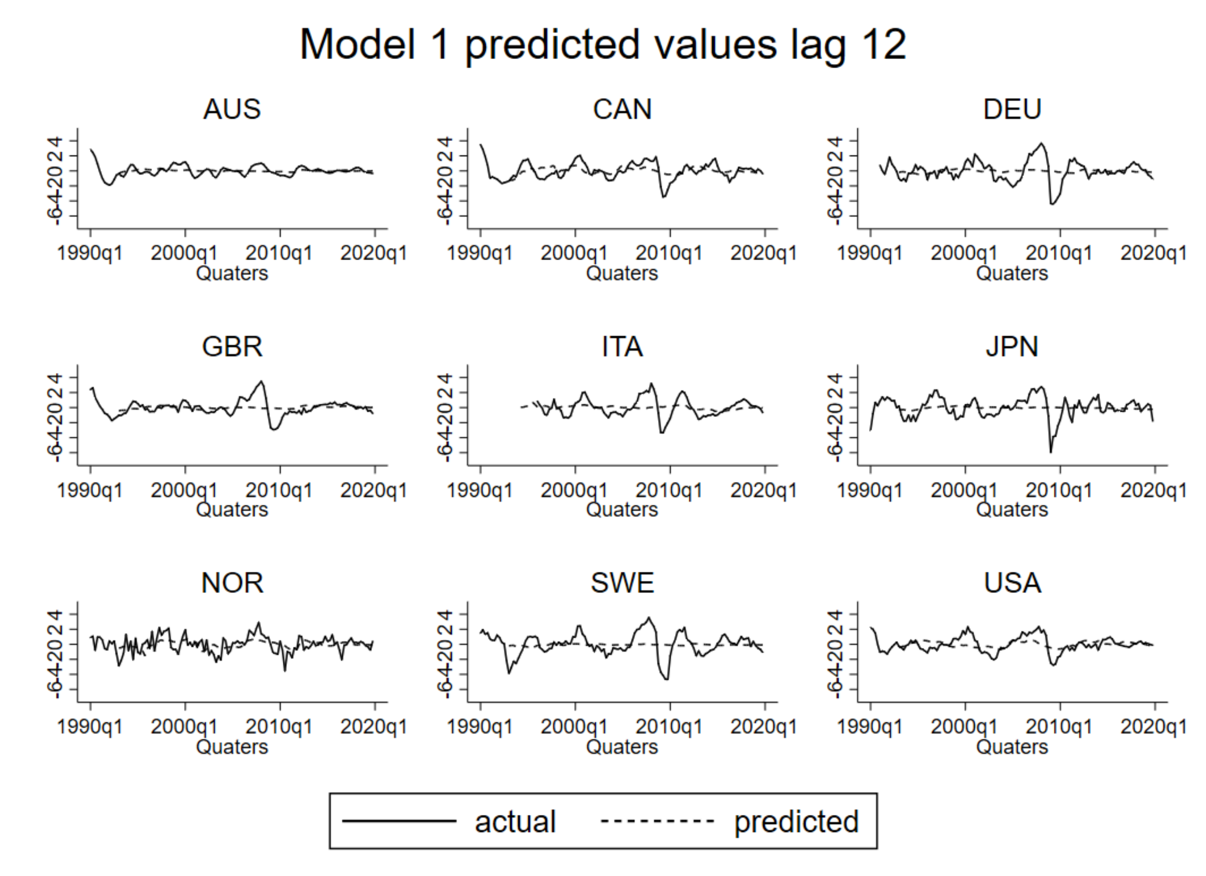
Model 1 predicted values lag 1
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1 2000q1 2010q1 2020q1
Quaters
actual
predicted



Model 1 predicted values lag 2
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1 2000q1 2010q1 2020q1
Quaters
actual
predicted

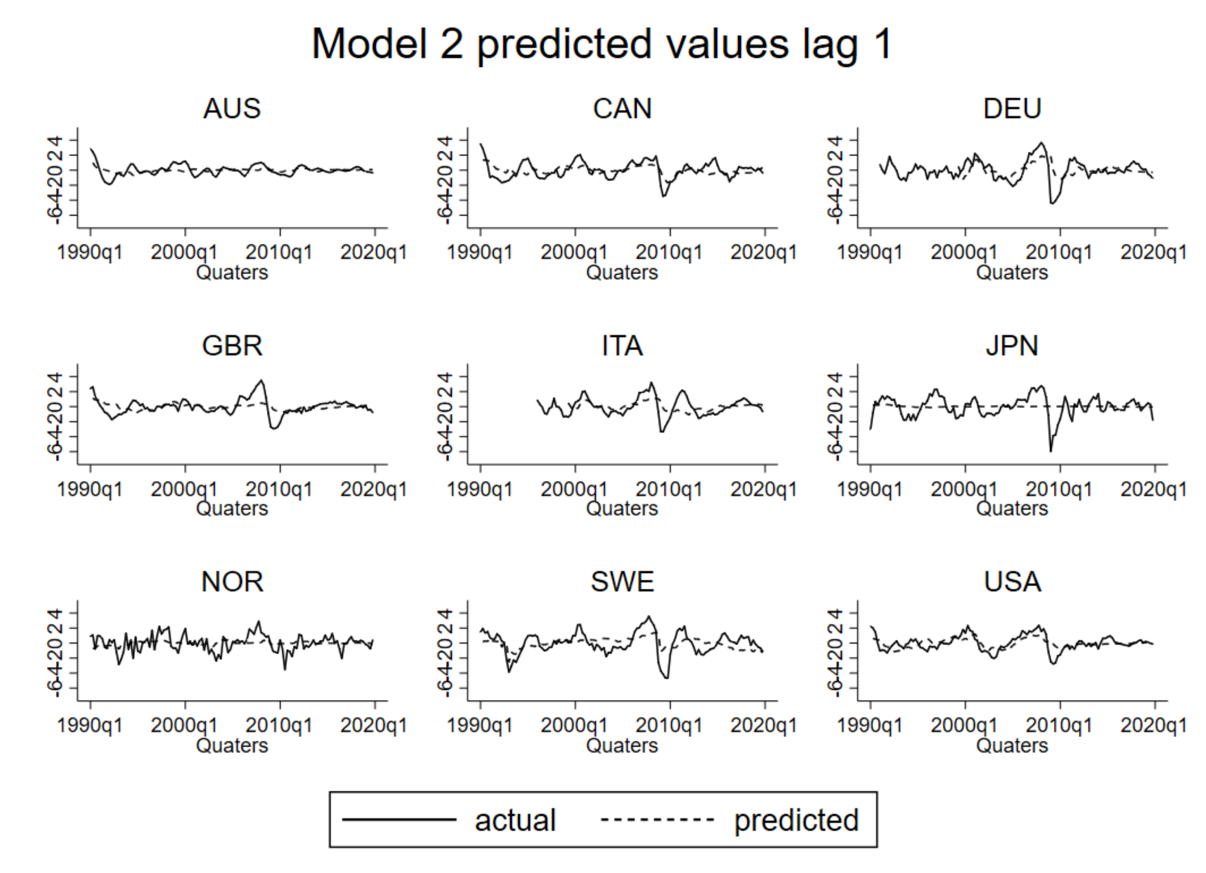

Model 1 predicted values lag 4
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2024
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted


Model 1 predicted values lag 8
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2024
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted



Model 1 predicted values lag 12
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted

Appendix D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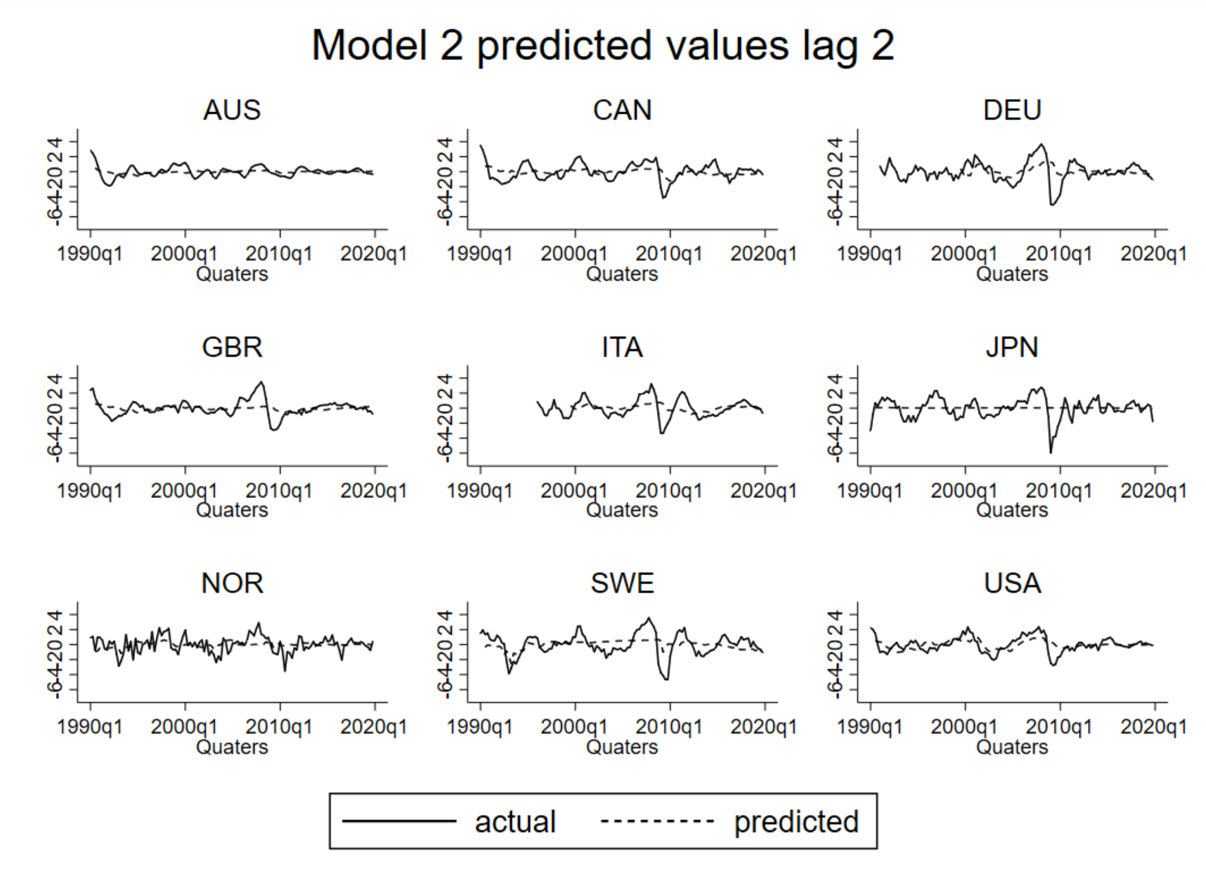
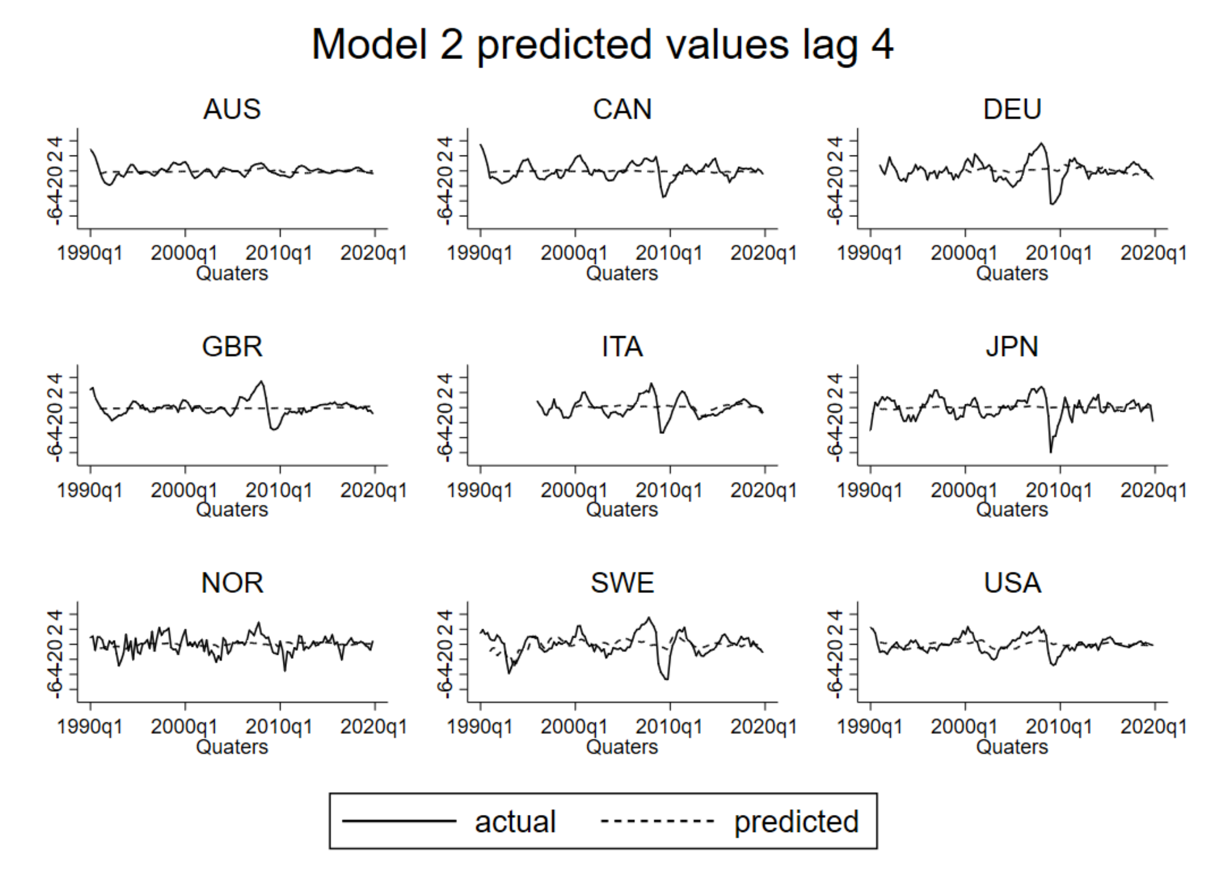
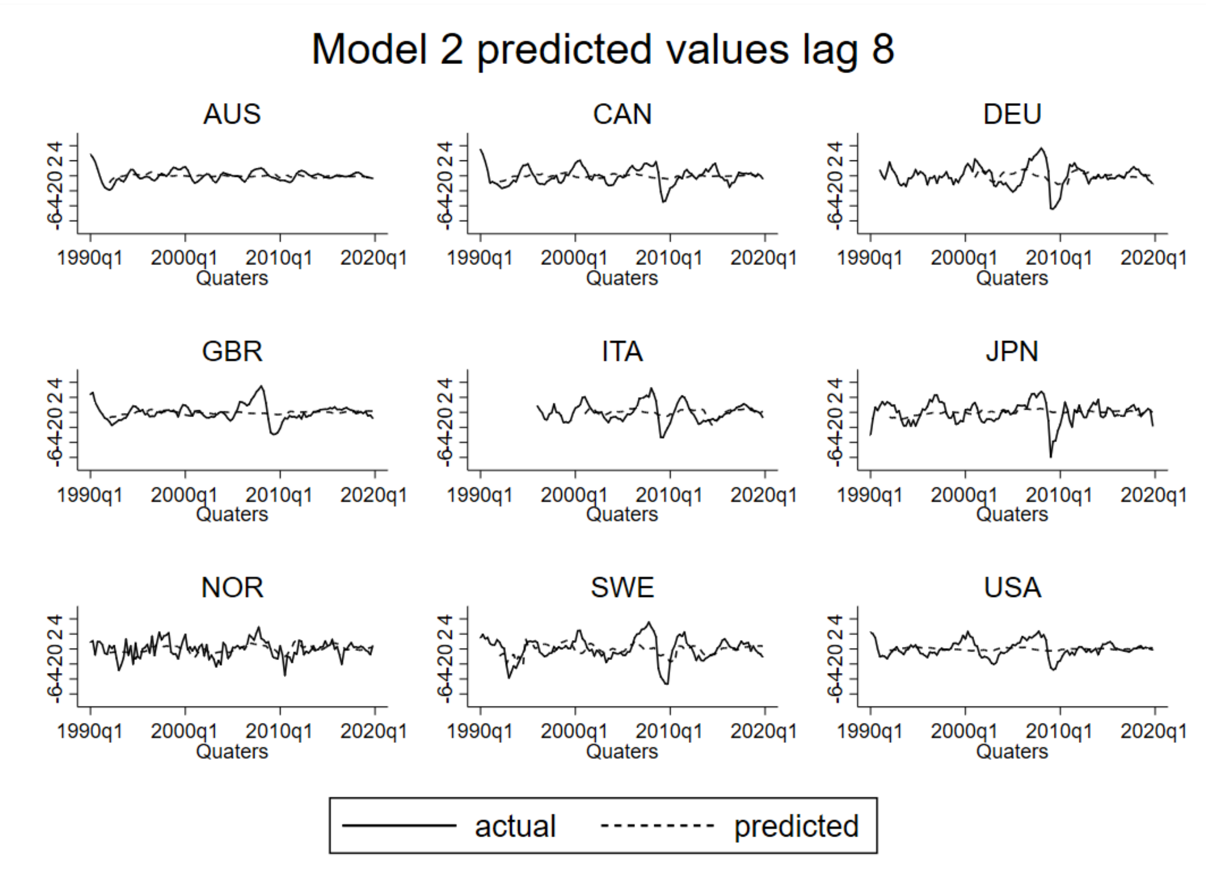
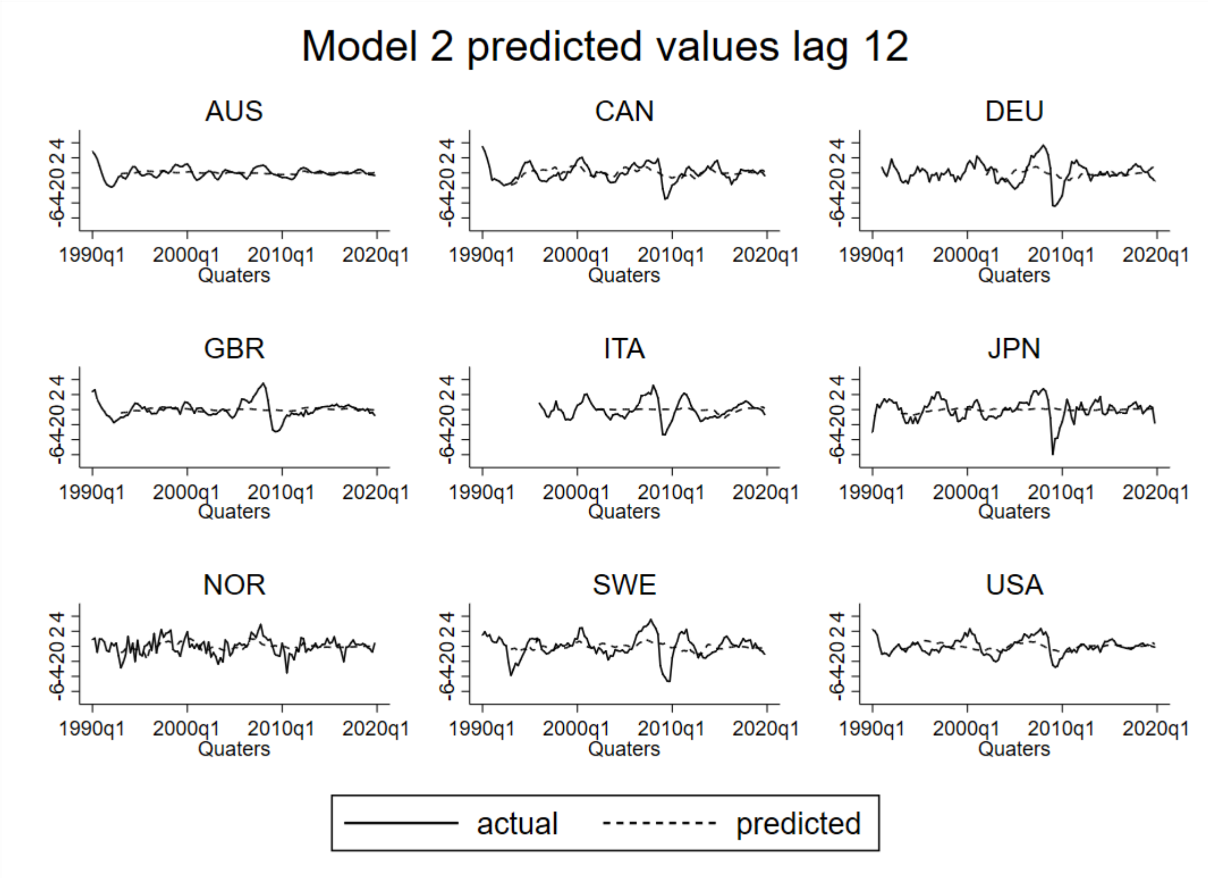
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted


Model 2 predicted values lag 2
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted


Model 2 predicted values lag 4
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted


Model 2 predicted values lag 8
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted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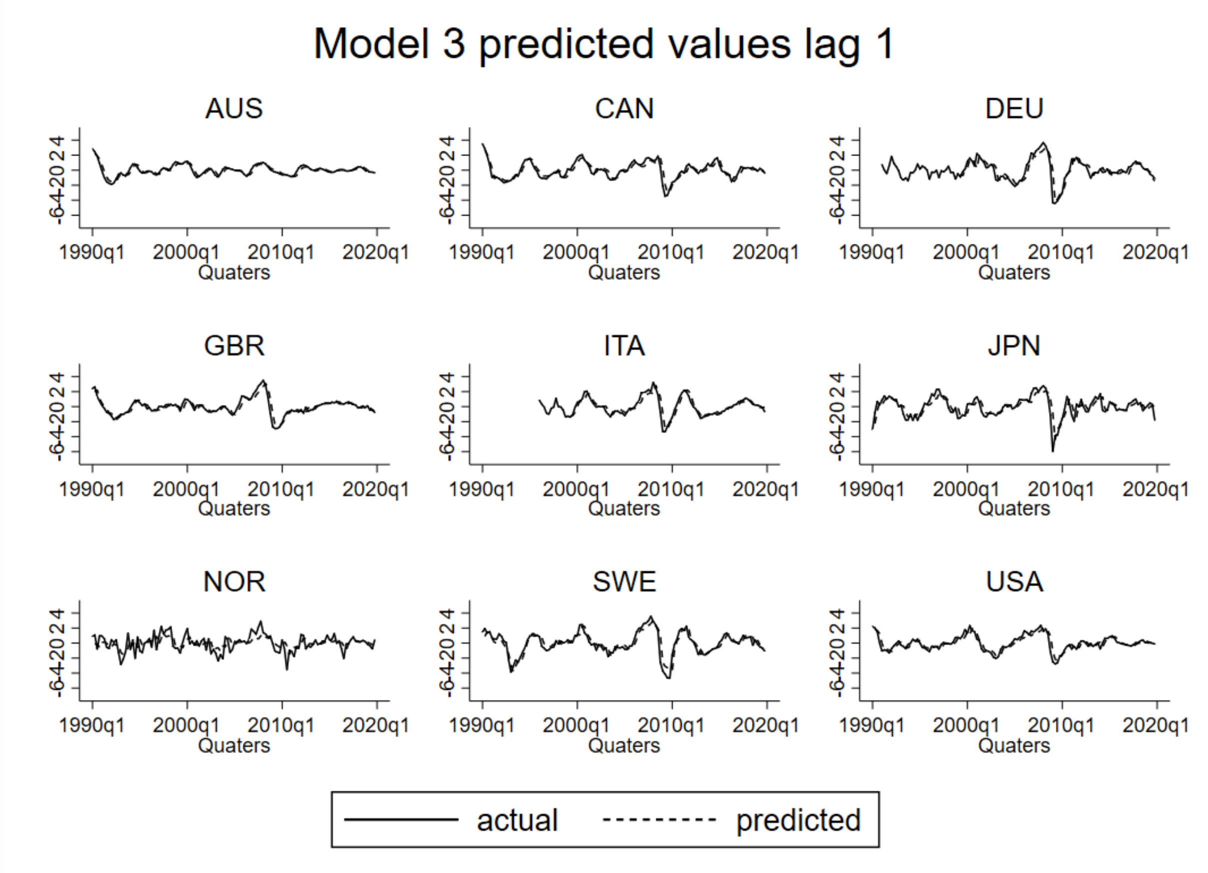
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2024
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted

Appendix E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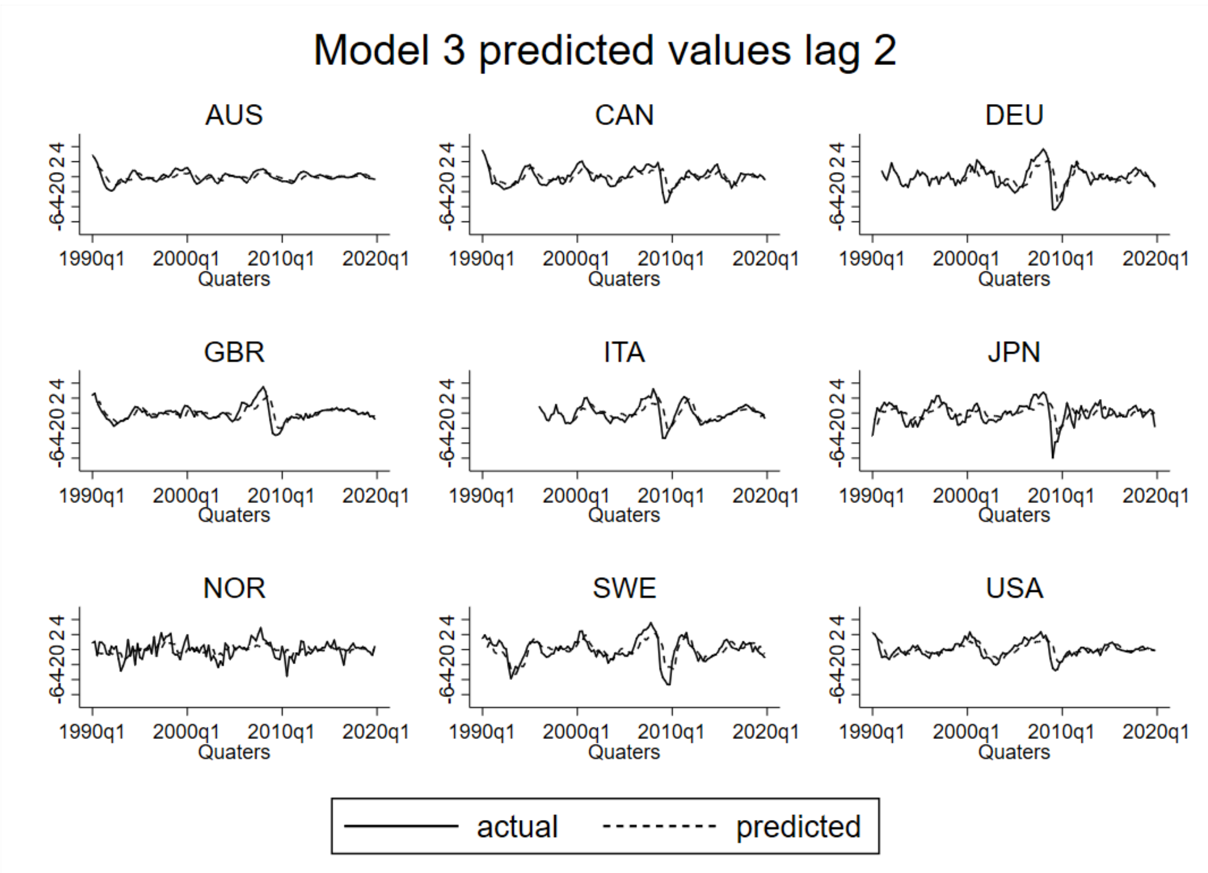
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted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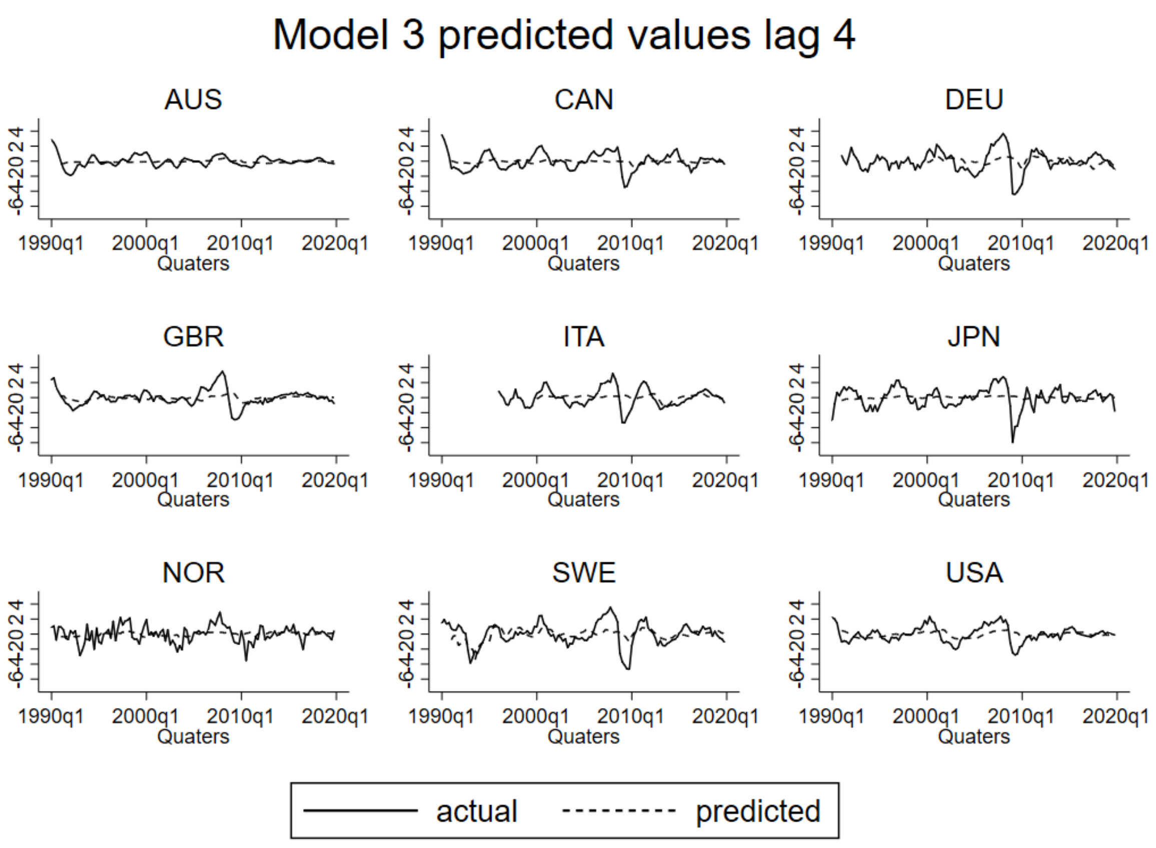
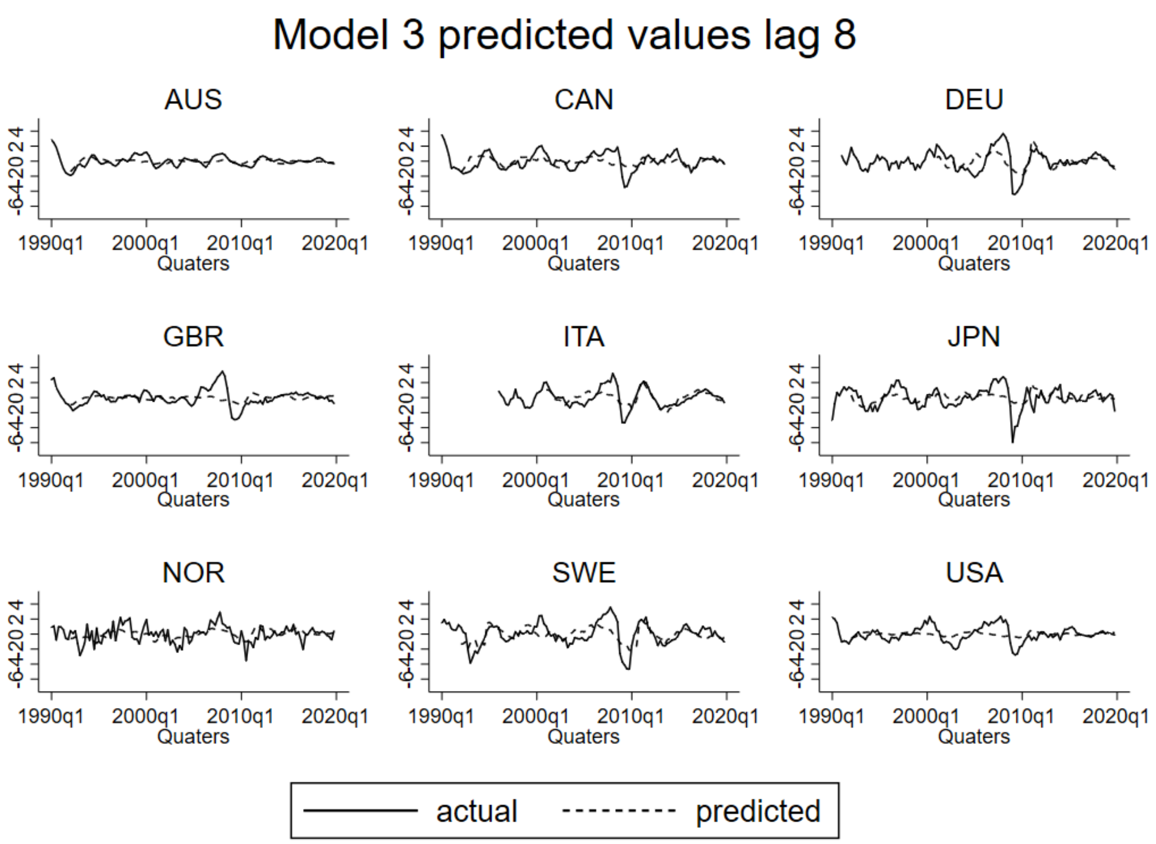
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted


Model 3 predicted values lag 4
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted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CAN
DEU
GBR
ITA
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SWE
USA
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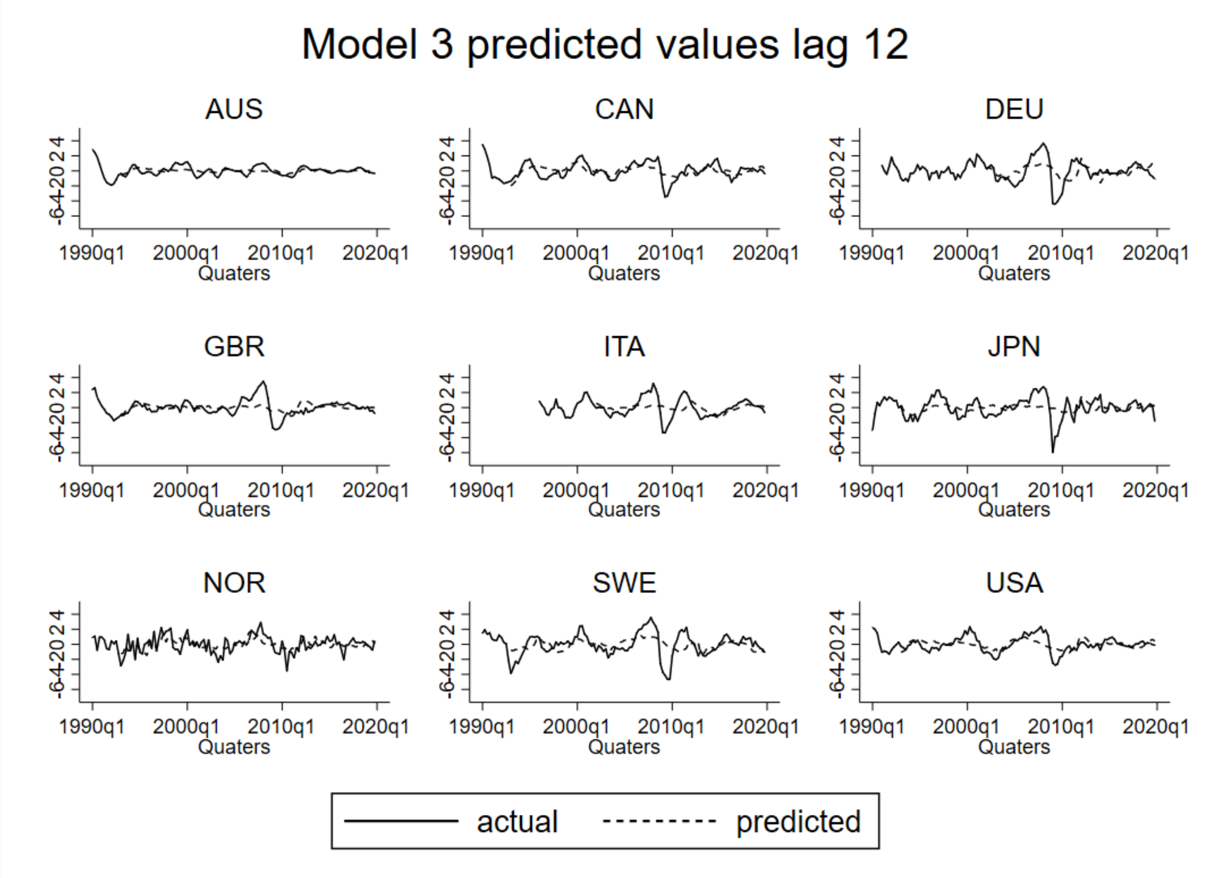
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted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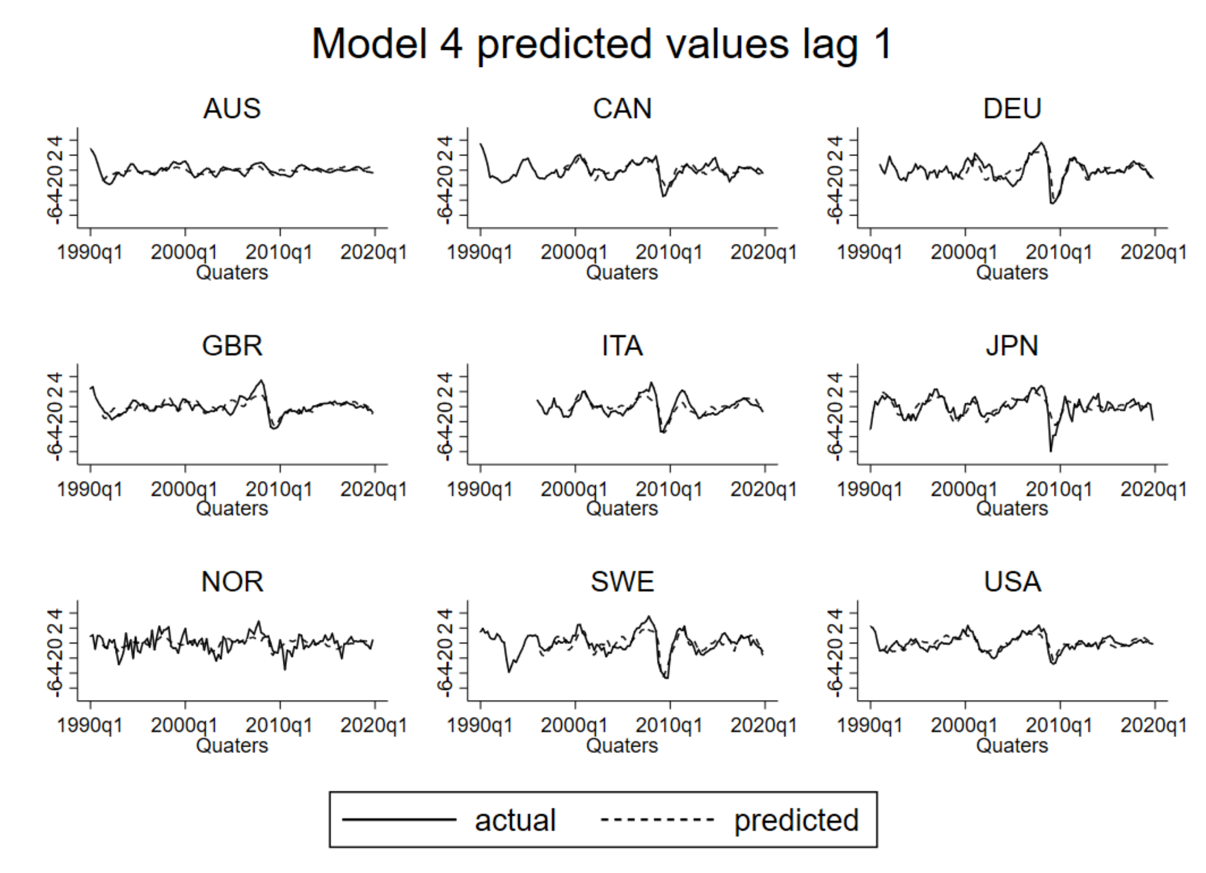
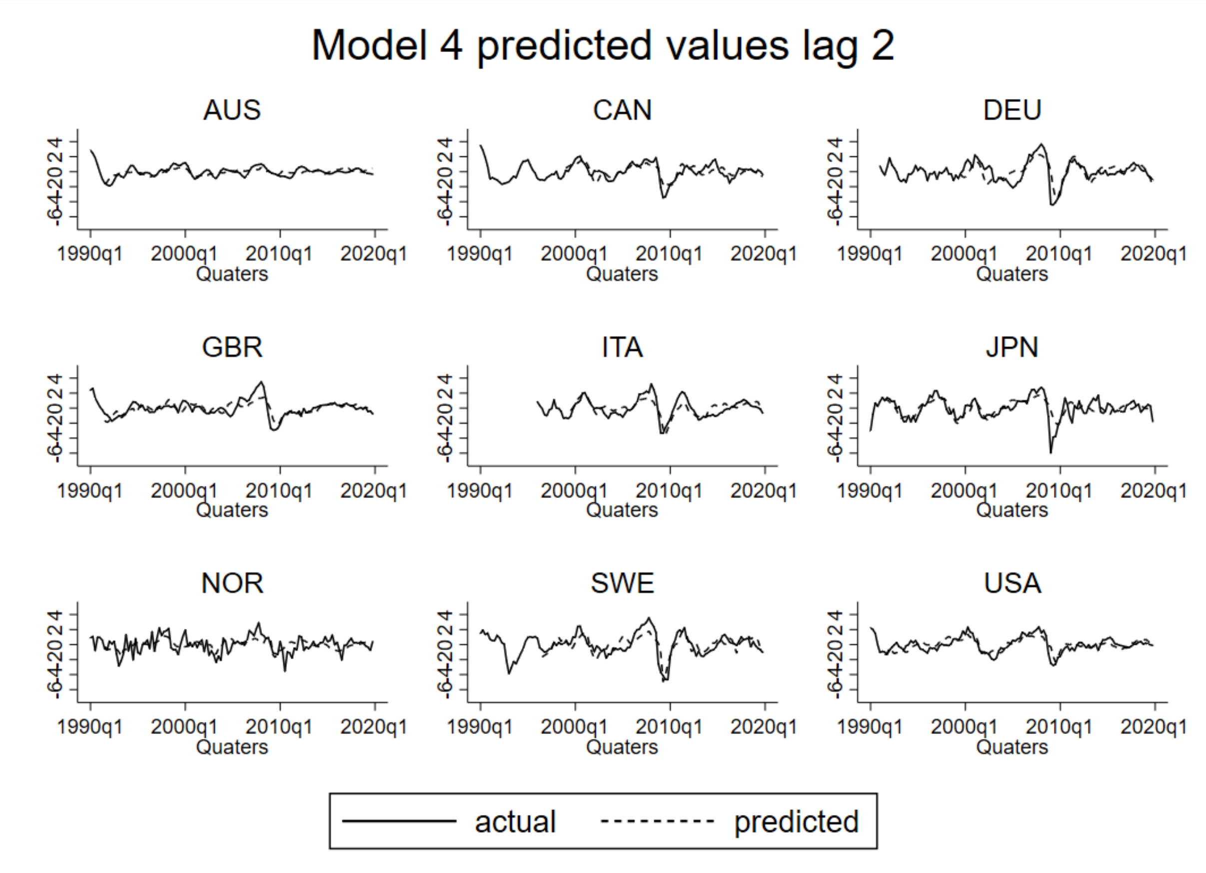
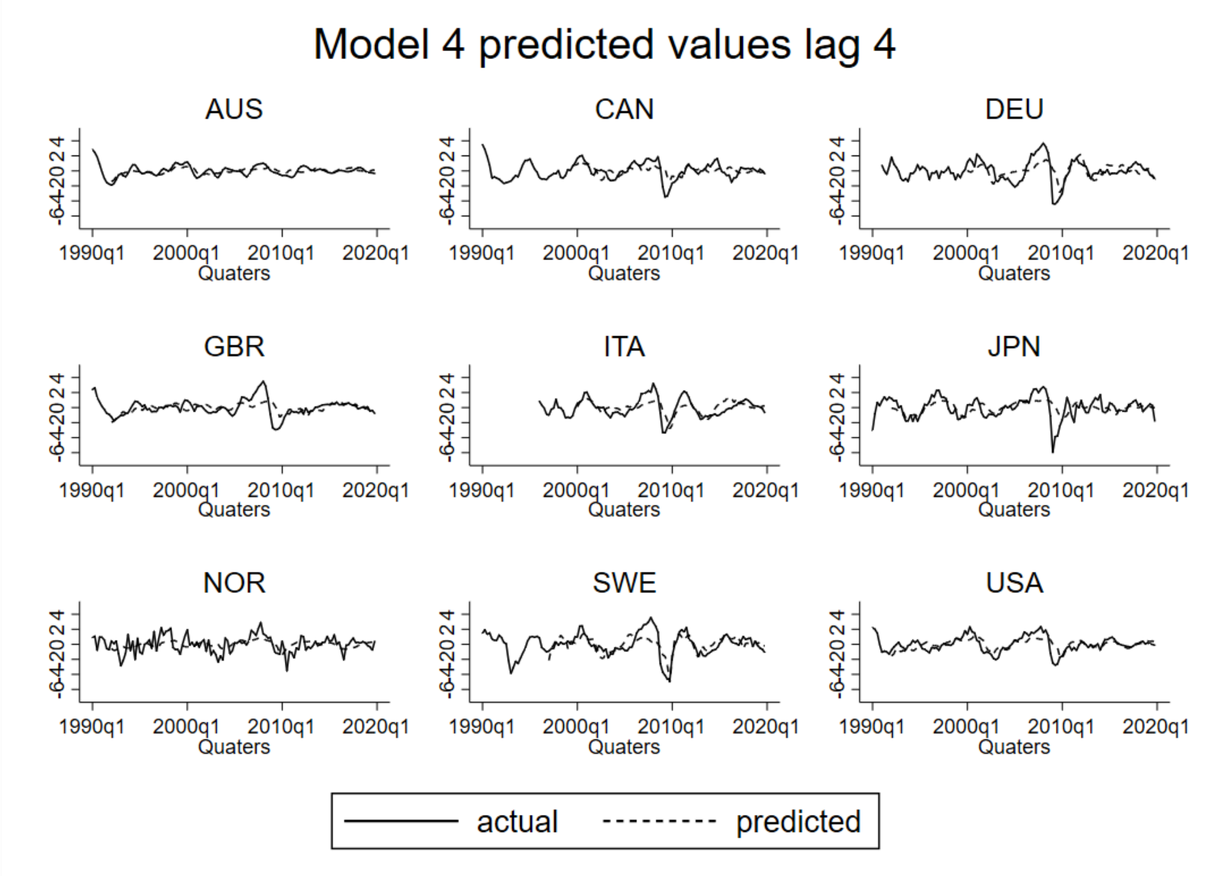
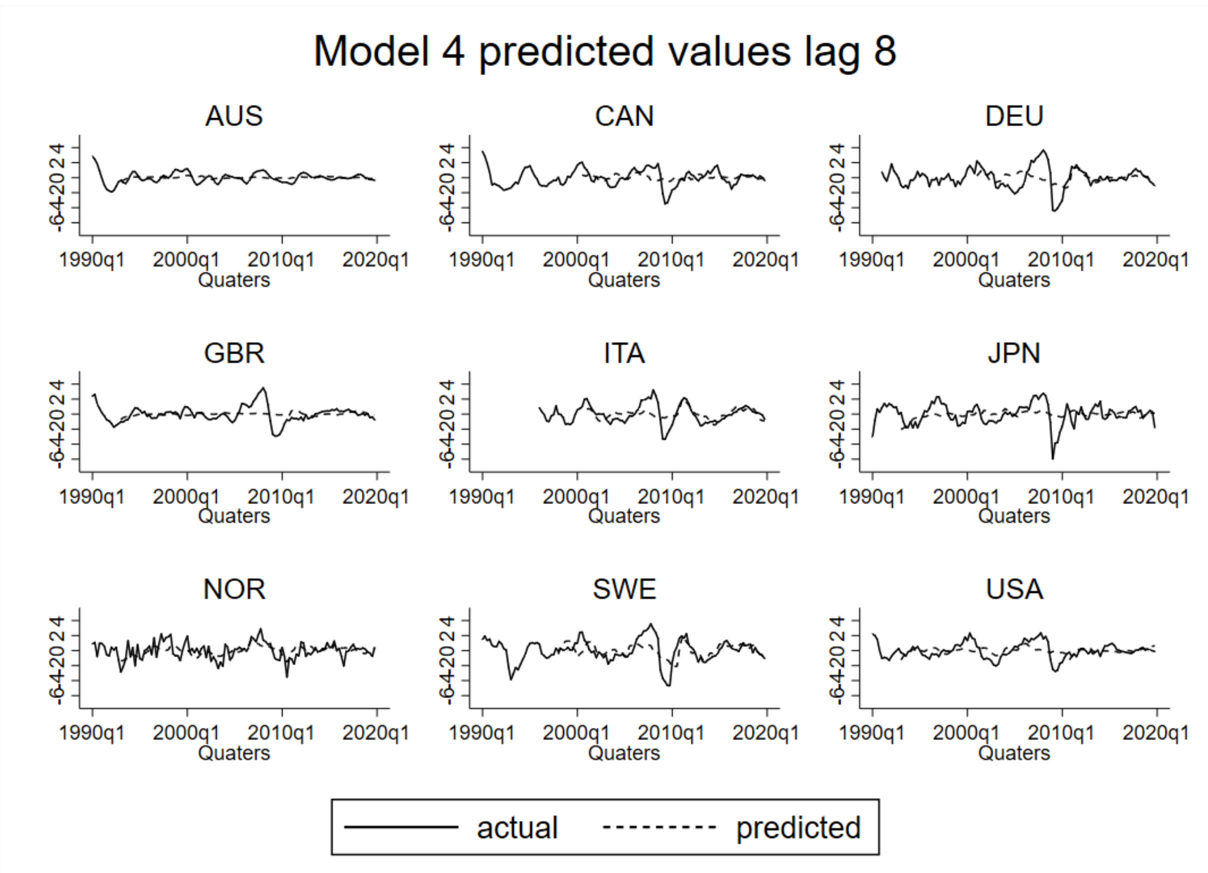
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted

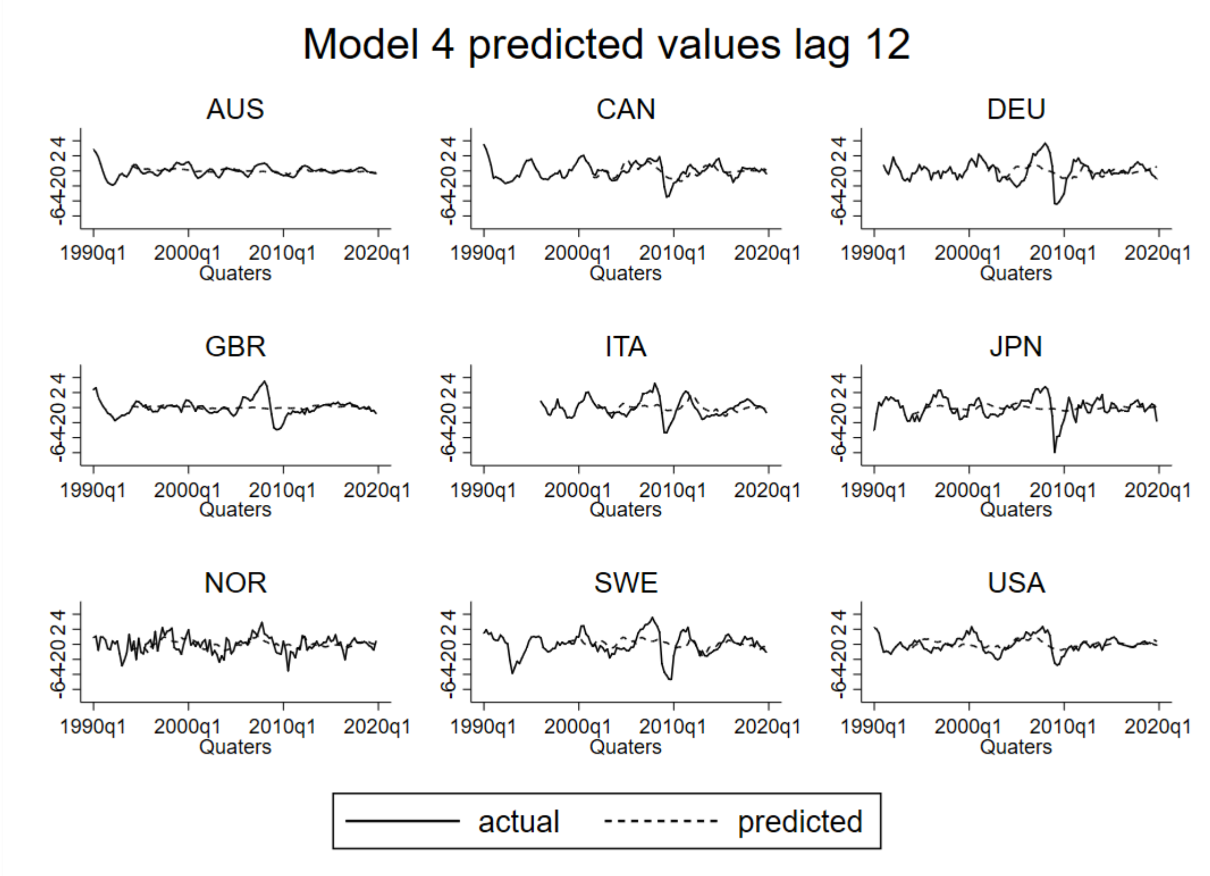
Appendix F


Model 4 predicted values lag 1
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1 2000q1 2010q1 2020q1
Quaters
actual
predicted

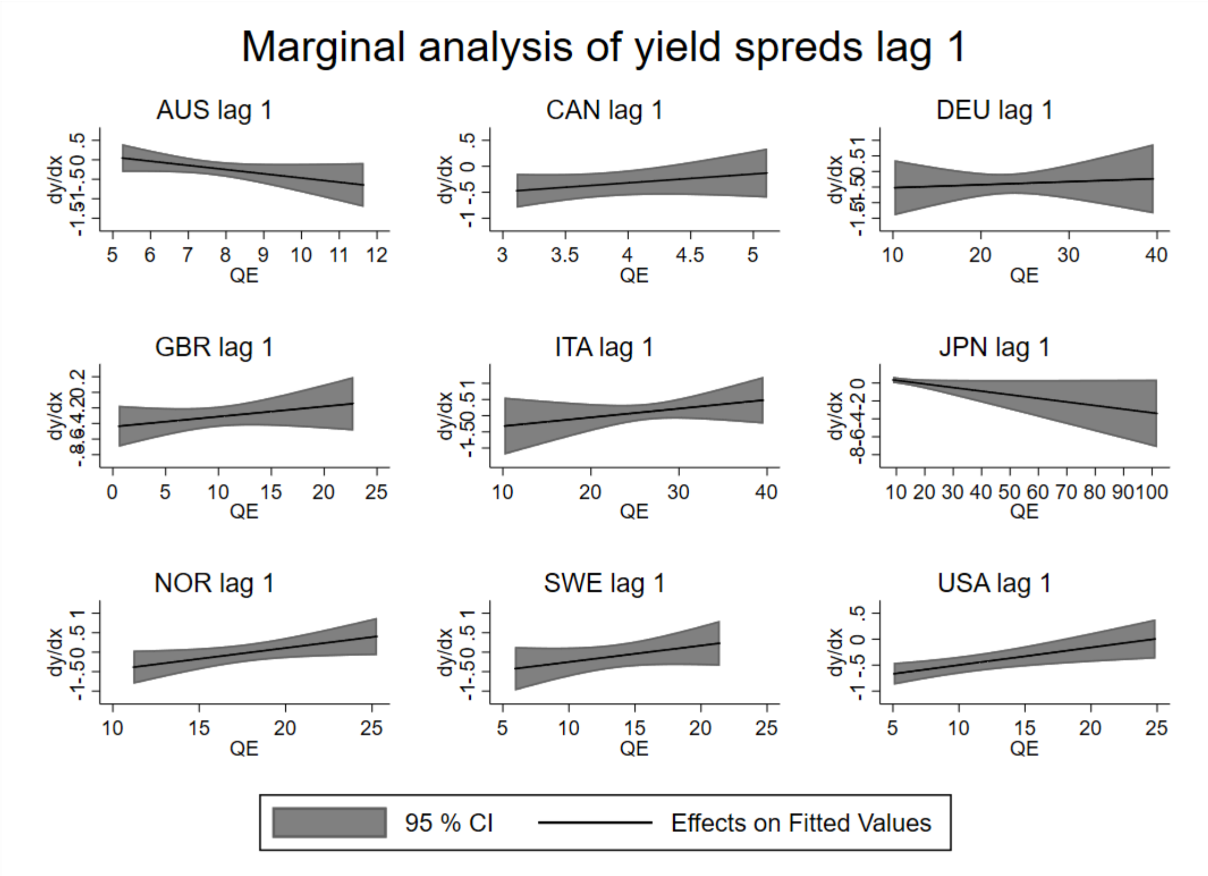

Model 4 predicted values lag 2
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1 2000q1 2010q1 2020q1
Quaters
actual
predicted


Model 4 predicted values lag 4
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1 2000q1 2010q1 2020q1
Quaters
actual
predicted

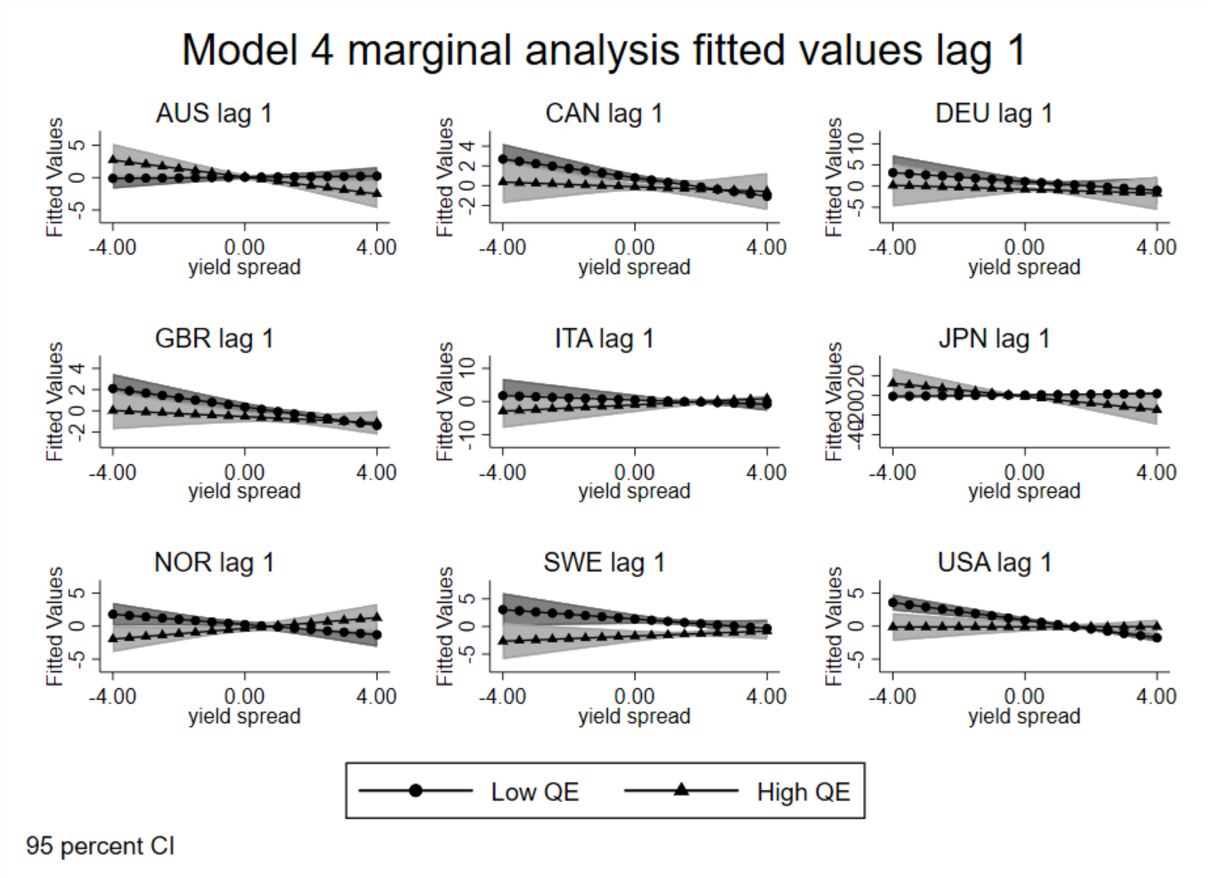

Model 4 predicted values lag 8
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2 0 2 4
1990q1 2000q1 2010q1 2020q1
Quaters
actual
predicted


Model 4 predicted values lag 12
AUS
CAN
DEU
GBR
ITA
JPN
NOR
SWE
USA
-6-4-2024
1990q1
2000q1
2010q1
2020q1
Quaters
actual
predicted

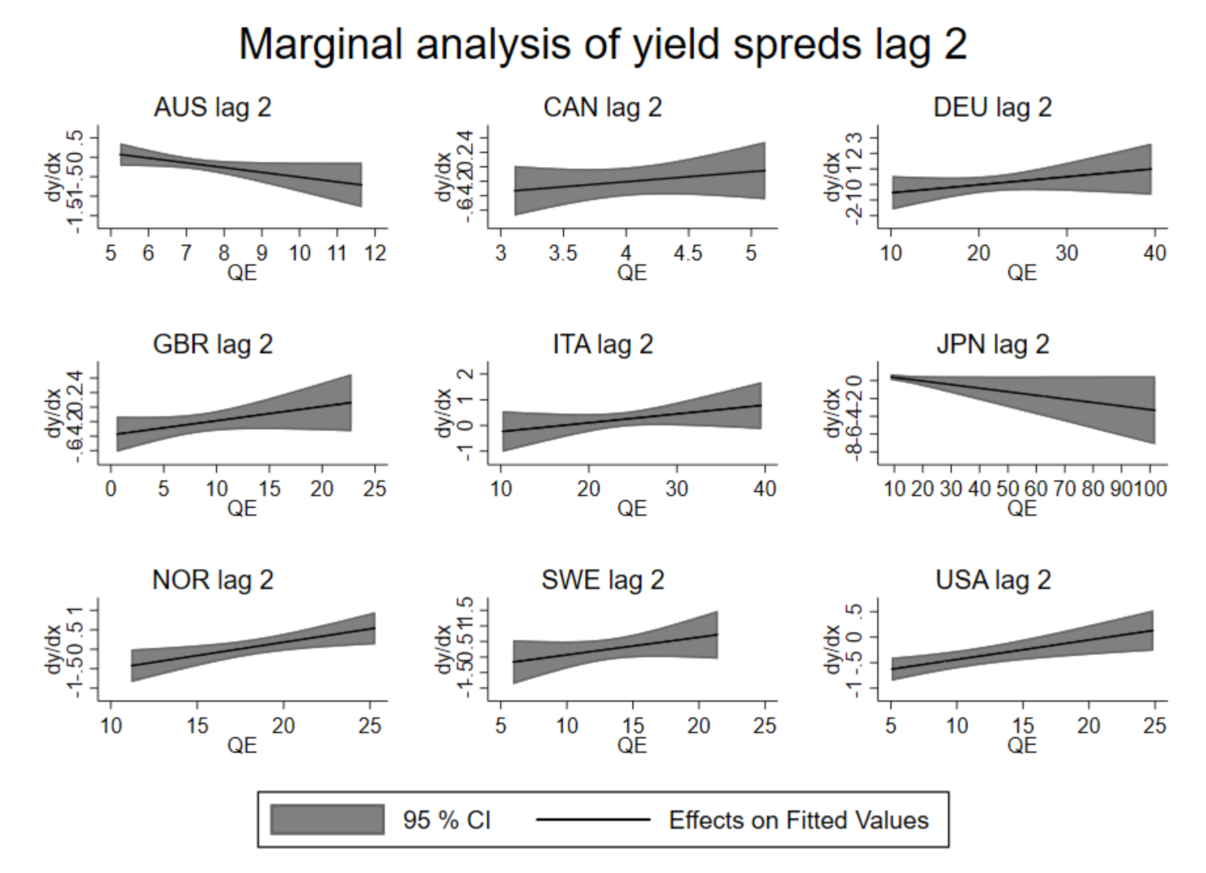
Appendix G

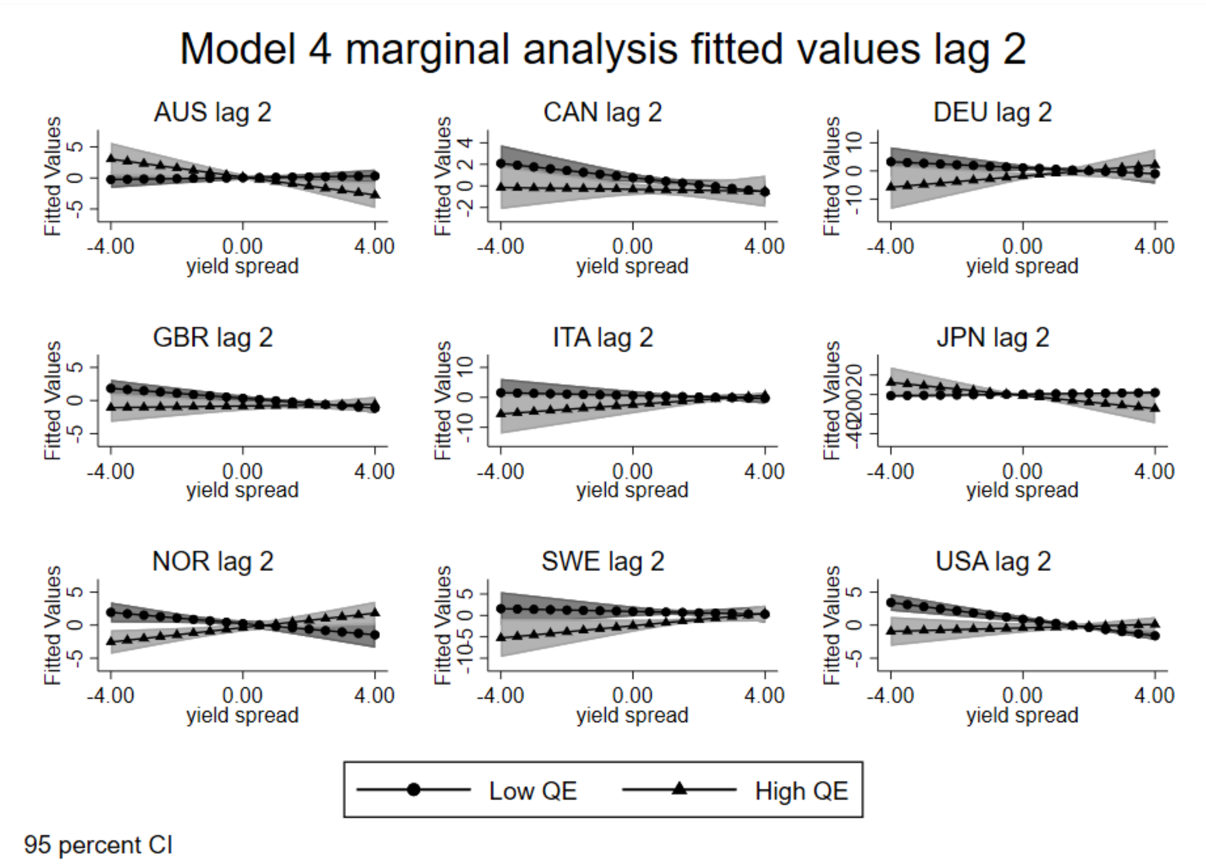


Marginal analysis of yield spreds lag 1
AUS lag 1
CAN lag 1
DEU lag 1
GBR lag 1
ITA lag 1
JPN lag 1
NOR lag 1
SWE lag 1
USA lag 1
dy/dx
QE
95 % CI
Effects on Fitted Values



Model 4 marginal analysis fitted values lag 1
AUS lag 1
CAN lag 1
DEU lag 1
GBR lag 1
ITA lag 1
JPN lag 1
NOR lag 1
SWE lag 1
USA lag 1
Fitted Values
yield spread
Low QE
High QE
95 percent CI


Marginal analysis of yield spreds lag 2
AUS lag 2
CAN lag 2
DEU lag 2
GBR lag 2
ITA lag 2
JPN lag 2
NOR lag 2
SWE lag 2
USA lag 2
dy/dx
QE
95 % CI
Effects on Fitted Values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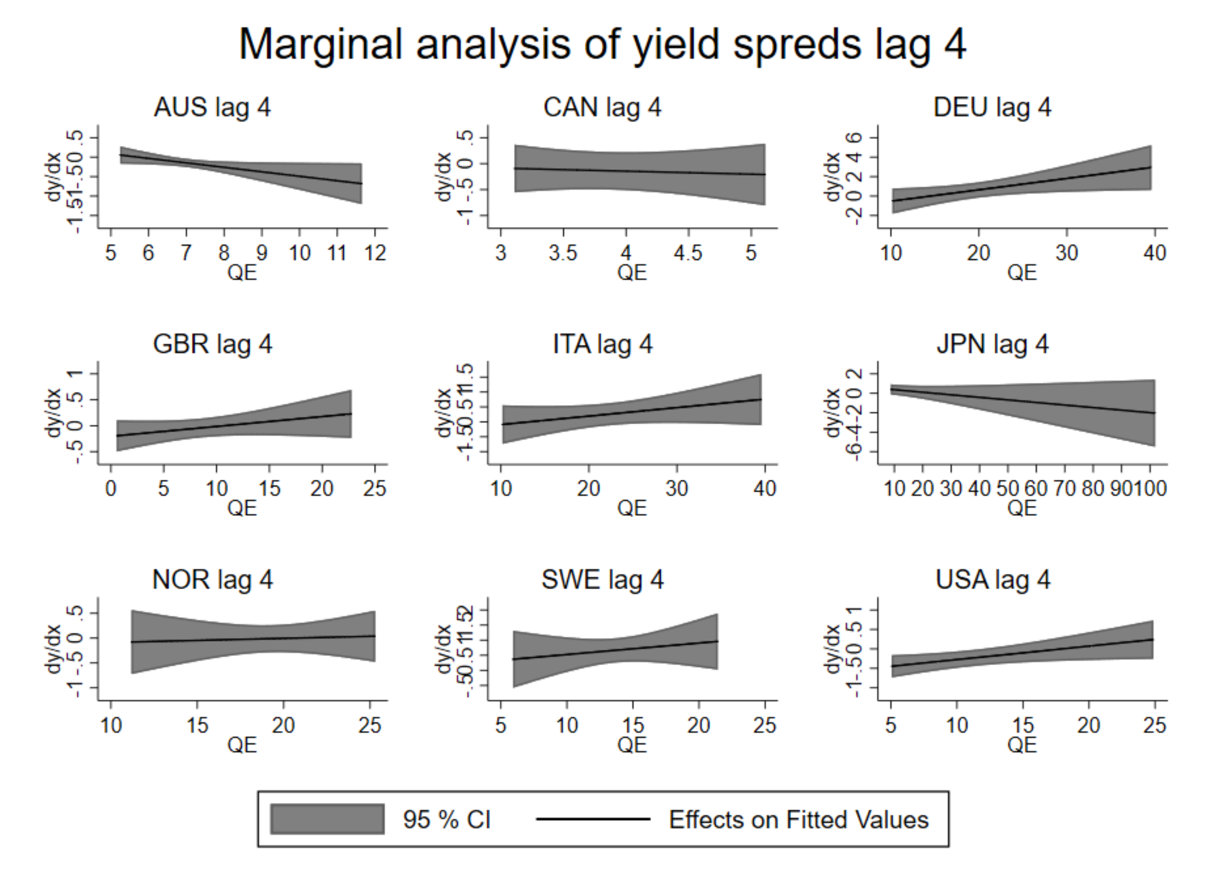
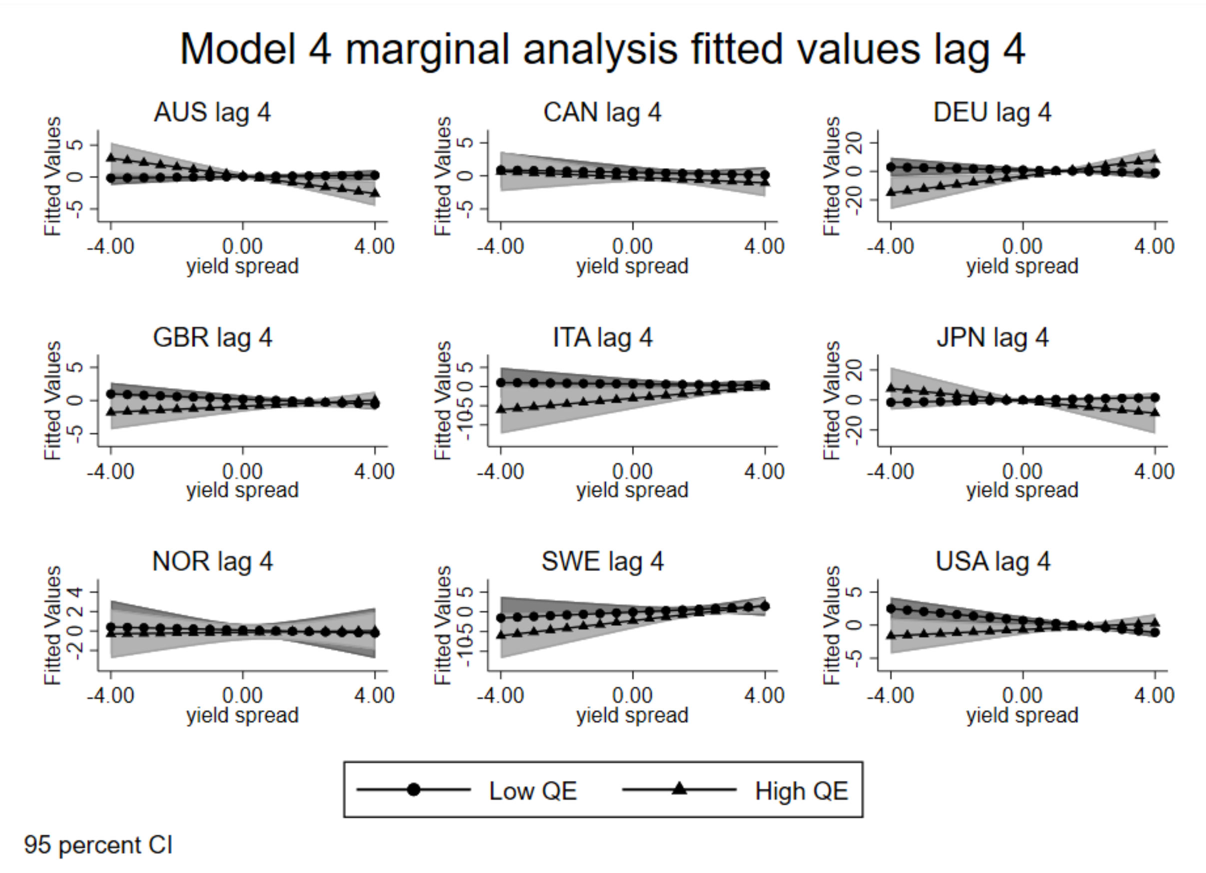
AUS lag 2
CAN lag 2
DEU lag 2
GBR lag 2
ITA lag 2
JPN lag 2
NOR lag 2
SWE lag 2
USA lag 2
Fitted Values
yield spread
Low QE
High QE
95 percent CI


Marginal analysis of yield spreds lag 4
AUS lag 4
CAN lag 4
DEU lag 4
GBR lag 4
ITA lag 4
JPN lag 4
NOR lag 4
SWE lag 4
USA lag 4
dy/dx
QE
95 % CI
Effects on Fitted Values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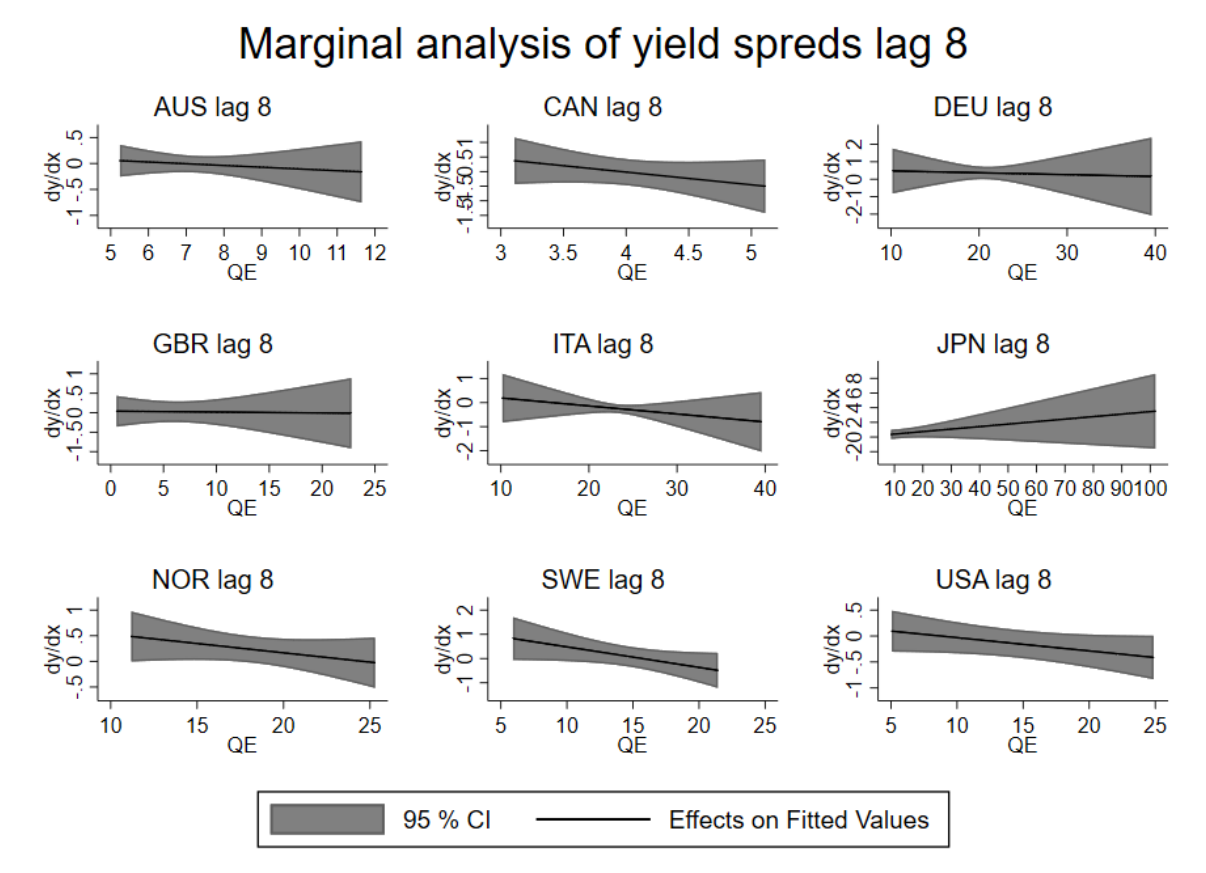
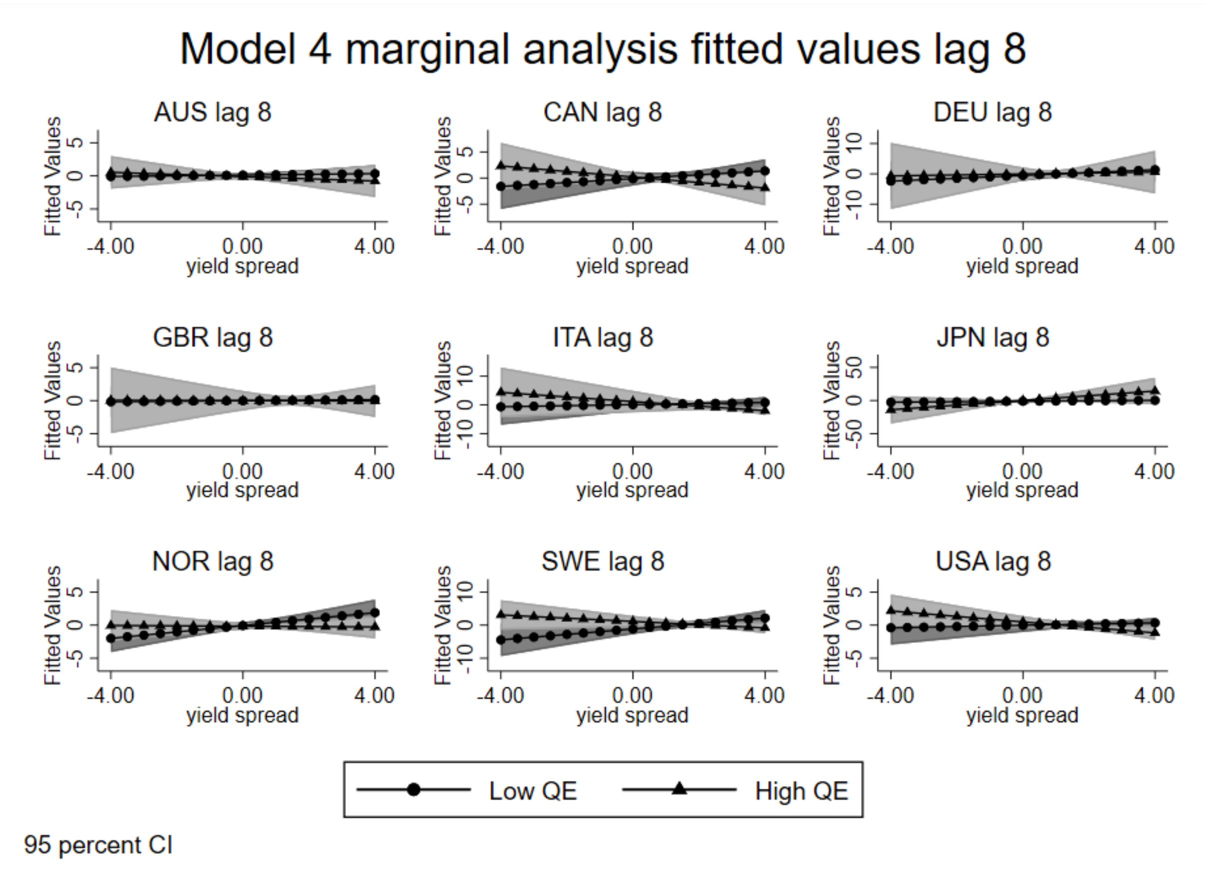
AUS lag 4
CAN lag 4
DEU lag 4
GBR lag 4
ITA lag 4
JPN lag 4
NOR lag 4
SWE lag 4
USA lag 4
Fitted Values
yield spread
-4.00
0.00
4.00
Low QE
High QE
95 percent CI


Marginal analysis of yield spreds lag 8
AUS lag 8
CAN lag 8
DEU lag 8
GBR lag 8
ITA lag 8
JPN lag 8
NOR lag 8
SWE lag 8
USA lag 8
dy/dx
QE
95 % CI
Effects on Fitted Values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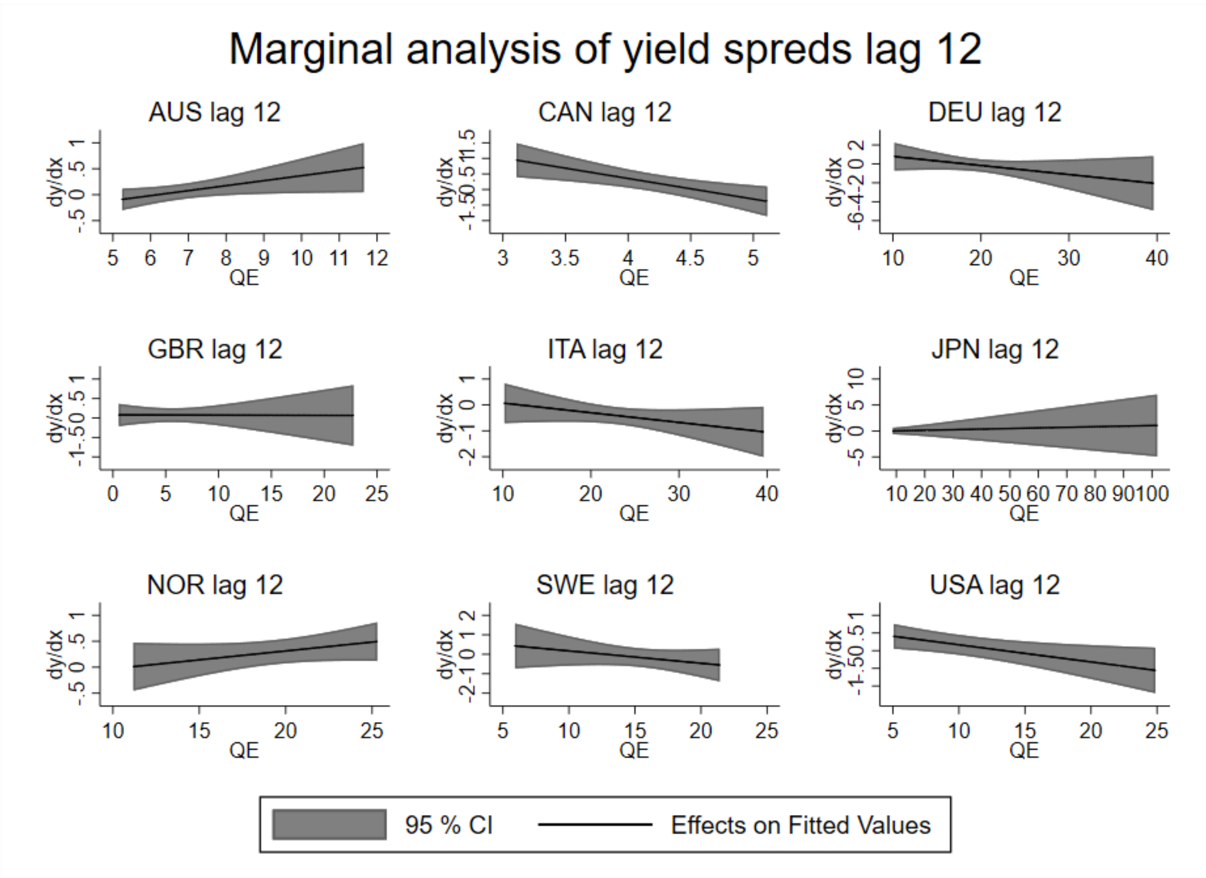
AUS lag 8
CAN lag 8
DEU lag 8
GBR lag 8
ITA lag 8
JPN lag 8
NOR lag 8
SWE lag 8
USA lag 8
Fitted Values
yield spread
Low QE
High QE
95 percent CI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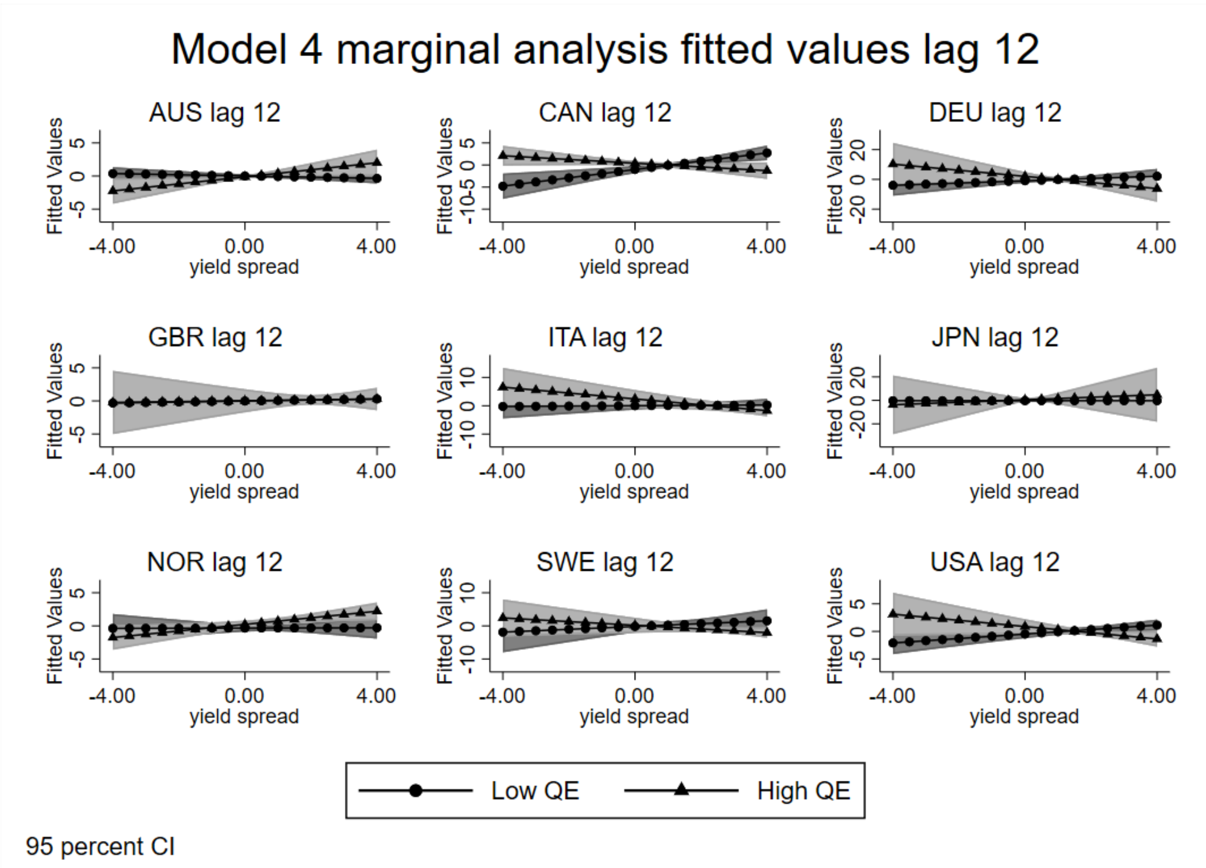
AUS lag 12
CAN lag 12
DEU lag 12
GBR lag 12
ITA lag 12
JPN lag 12
NOR lag 12
SWE lag 12
USA lag 12
dy/dx
QE
95 % CI
Effects on Fitted Values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AUS lag 12
CAN lag 12
DEU lag 12
GBR lag 12
ITA lag 12
JPN lag 12
NOR lag 12
SWE lag 12
USA lag 12
Fitted Values
yield spread
Low QE
High QE
95 percent CI