International Interest Rate Interdependence

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April 15, 2017

1 Introduction

In its simplest form, monetary policy is conducted to determine interest rates consistent with a broader objective set forth by legislative authorities. In the United States, the "Federal Reserve Act" set forth by Congress establishes the mandate of the Federal Reserve, "so as to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates" (US Congress, 1977). Similarly, in the Euro Area per the "Treaty on the Functioning of the European Union," "The primary objective of the European System of Central Banks… shall be to maintain price stability. Without prejudice to the objective of price stability, the ESCB shall support the general economic policies in the Union with a view to contributing to the achievement of the objectives of the Union" (European Commission, 2007). These mandates are indicative of broader themes not specific to any single country or central bank—determine monetary policy to mitigate the volatility of both inflation and economic activity. Recognizing this underlying objective, policy *rules* that systematically utilize available information to stabilize the economy are especially appealing. One such widely used rule is the Taylor rule, pioneered by John B. Taylor.

In its initial, most basic form, the Taylor rule is specified as follows

$$r = 2 + p + 0.5y + 0.5(p - 2)$$

Where r is the federal funds rate, p is inflation and y is the deviation of real GDP from potential. The mechanics of the rule suggest that, when inflation or GDP growth are above potential, interest rates increase in response. Further, this simple rule with the given coefficients is remarkably powerful for fitting actual policy performance in Taylors sample (202). This simple postulation gives rise to a number of other potential components and considerations, notably the use of forward-looking Taylor rules (see Clarida et al. (1998)) and Taylor rules with persistence (those that incorporate previous realizations of the rate and weight them accordingly). With simple transformations (as detailed in the methodology section below), one can move beyond assuming coefficients as above to directly *estimating* those coefficients from data to generate empirically derived Taylor rules for monetary policy.

One largely untapped extension of the simple Taylor rule of particular note in this analysis, is the role of international interdependency. Taylor directly acknowledges the value of this component in interest rate determination citing evidence regarding Norges Bank and the role of foreign rates in the determination of domestic monetary policy. The intuition is straightforward. Classical Taylor rules typically incorporate parameters that are indicative of a closed economy. However, it is naïve to assume that interest rates are determined with absolutely no regard for international considerations, whether they are macroeconomic conditions in a foreign economy or foreign interest rate determination. Given the degree of global economic interconnectedness, it is reasonable to assume central banks in a number of countries would take into consideration the role of other central banks in setting interest rates. As such, Huston and Spencer (2005) find evidence to support the use of the Taylor rule for modeling the *global* monetary environment, while Gerlach and Schnabel (1999) and Peersman and Smets (1999) find that European Monetary Union interest rates throughout the 1990s can be accurately modeled with a Taylor rule consisting of inflation and output gap parameters. Bergin and Jorda (2004) and Clarida et al. find strong evidence of monetary policy interdependence in Euro Area countries largely in the form of a follower relationship with Germany, and do so primarily by exploiting exogenous shocks or adjustments in policy.

Regarding more heterogeneous interdependence between non-Euro Area countries, specifically, Ullrich (2003) utilizes "Taylor-type policy rules," incorporating decision variables from the respective foreign central bank, to find that there are "significant differences in reaction functions" and, more importantly, that "the Fed seems to influence the ECB but not vice versa" (5). Belke and Cui (2010) extend this analysis utilizing vector error collection models (VECMs) to test for "interdependence and a possible leader-follower relationship" (-780) between the ECB and Federal Reserve, finding strong evidence of long-run interdependence. I seek to contribute to the work of these authors in the context of ECB and Federal Reserve interdependence recognizing this topic is relatively understudied and open to exploration, particularly with more novel estimation techniques such as full information maximum likelihood.

The goals of this analysis are threefold: 1) to contribute to the existing literature on econometric estimation of monetary policy rules by conducting empirical analysis of the Taylor Rule using a number of unique specifications; 2) to extend the "classical" Taylor rule by incorporating open-economy components to assess the potential role of international interdependencies consistent with the brief existing literature; and 3) to assess the sensitivity of these results to changes in vintages and changes in indicators for economic activity, utilizing the unique, composite Labor Market Conditions Indicator of the Federal Reserve. I will detail the econometric specifications and data, and attend to these objectives systematically in the following sections.

2 Data & Methodology

To empirically evaluate the role of policy rules in interest rate determination, I begin with the ordinary specification of the Taylor rule with persistence

$$(1) R_t = [r + \pi_t + \gamma \bullet (\pi_t - \pi^*) + \beta \cdot (y_t - y^*)] \cdot (1 - \lambda) + \lambda \cdot R_{t-1}$$

Where R_t is the policy rate predicted by the Taylor rule, r is the real or natural interest rate, π_t is the current value of inflation, π^* is the target inflation rate, y is the measure of economic activity, y^* is the measure of "full employment" economic activity, and R_{t-1} is a lag of the policy rate. While this is the classical specification of the Taylor rule and can be useful when coefficients are assumed a priori, it is not linear in the parameters and, as a result, is not appropriately specified for regression estimation. For the purposes of this analysis, I will defer to the reduced form specification of the Taylor rule, derived as follows

$$R_t = [r + \beta\pi^*](1 - \lambda) + \gamma(1 - \lambda)(y_t - y^*) + (1 - \lambda)[1 + \beta]\pi_t + \lambda R_{t-1}$$
$$(2) R_t = \phi_0 + \phi_1(y_t - y^*) + \phi_2\pi_t + \lambda R_{t-1}$$

This serves as the basis for the structural equation used in empirical estimation of the Taylor rule.

Conducting this analysis of the Taylor rule, I will employ three different estimation strategies, and extend the analysis to both the federal funds rate in the United States and the Eonia rate in the Euro Area. First, I estimate the respective policy rate with OLS, which serves as a "closed-economy" Taylor rule containing only domestic variables. As such, the closed-economy model closely follows the specification above, such that

$$(3) R_t = \phi_0 + \phi_1(y_t - y^*) + \phi_2\pi_t + \lambda R_{t-1} + \epsilon_t$$
$$(4) R^e_t = \phi^e_0 + \phi^e_1(y^e_t - y^{*e}) + \phi^e_2\pi^e_t + \lambda^e R^e_{t-1} + \epsilon^e_t$$

Where $(y_t - y^*)$ is a measure of economic activity (more below), π_t is the current value of inflation and R_{t-1} is a lag of the policy rate—superscripts correspond to EU variables. Note that while the reduced-form coefficients are not directly equivalent to those in the classical Taylor rule specification, they serve as reasonable, empirically valid substitutes in this analysis. As detailed in the Introduction, to assume interest rate determination vis-à-vis the Taylor rule occurs in vacuum is naïve at best. As such, I subsequently utilize two open-economy models to incorporate potential interdependencies in Taylor rules. The first, is a vector auto-regression model to be estimated with OLS specified as follows

$$(5) R_t = \phi_0 + \phi_1(y_t - y^*) + \phi_2\pi_t + \phi_3 R_{t-1} + \phi_4(y^e_t - y^{*e}) + \phi_5\pi^e_t + \phi_6 R^e_{t-1} + \upsilon_t$$
$$(6) R^e_t = \phi^e_0 + \phi^e_1(y^e_t - y^{*e}) + \phi^e_2\pi^e_t + \phi^e_3 R^e_{t-1} + \phi^e_4(y_t - y^*) + \phi^e_5\pi_t + \phi^e_6 R_{t-1} + \upsilon^e_t$$

This specification is a natural extension of the closed-economy model above, where the foreign economy variables are merely excluded. If we are willing to accept that interest rates are not determined completely exogenously of one another, then excluding these coefficients amounts to misspecification. Further, I suggest that this regression equation is appropriately identified since we take the lagged foreign policy rates to be exogenous of the current domestic policy rate in each equation. The final estimation strategy employed in this methodology is a simultaneous dynamic model estimated with full-information maximum-likelihood (FIML), as follows

$$(7) R_t = \phi_0 + \phi_1(y_t - y^*) + \phi_2\pi_t + \theta R_t^e + \lambda R_{t-1} + \epsilon_t$$

$$(8) R_t^e = \phi_0^e + \phi_1^e(y_t^e - y^{*e}) + \phi_2^e\pi_t^e + \theta^e R_t + \lambda^e R_{t-1}^e + \epsilon_t^e$$

In this equation, we recognize that R_t^e and R_t are endogenous components while the remaining variables are exogenous. As such, the equation is identified when utilizing a simultaneous dynamic estimation method such as FIML to account for the endogenous components of the specified regression equations. Further analysis will be conducted using CFIML to constrain insignificant results from FIML regressions for graphical impulse response analysis to demonstrate directly the interdependency (or lack thereof) implicit in interest rate determination.

To conduct this analysis, I rely on data from several sources to effectively populate the Taylor rule Equations. The dependent variable in all regressions, regardless of specification, is the policy rate of either the EU or the US. As such, there are series of annual data dating from 1994 for both the Eonia Rate (from the ECB Statistical Data Warehouse) and the Federal Funds Rate (from the St. Louis Federal Reserve Bank FRED database). Inflation indicators, output gap indicators, and raw unemployment data are all sourced from the International Monetary Fund World Economic Outlook (WEO) database. Note that most series exhibit some degree of autocorrelation—while this does not automatically suggest there will be serial autocorrelation in the residuals or a spurious regression, Newey-West standard errors will be used in all estimations (with the exception of CFIML) and any notable issues with Durbin-Watson Statistics will be reported where necessary.There are two additional nuances I seek to exploit in this analysis to assess the sensitivity of the Taylor rule to changes in assumptions.

First, I will explore three different economic activity indicators to determine what is the "best" indicator for explaining policy rates: output gap (output above or below of potential output), unemployment gap (unemployment above or below natural or full employment), and, for the United States, the Federal Reserve's Labor Market Conditions Index (LMCI). While the output gap is fairly self-explanatory and taken directly from the IMF WEO, a few words on unemployment gap and LMCI are appropriate. Unemployment gap is calculated as the level of unemployment in excess of the natural rate of unemployment. While there is data readily available for a natural unemployment rate in the United States, no such data series exists for the EU (to my knowledge). To ensure the measures are constructed with the same underlying calculations, I determine the "natural" unemployment rate by running a Hodrick-Prescott filter on the raw unemployment data to determine the non-cyclical component of the series. This is conducted for both EU and US data, and then subtracted out from the raw unemployment data to construct the unemployment gap measure. For the US, I also have the opportunity to explore the role of the Federal Reserve's composite measure of labor market conditions, LMCI, which combines 19 different labor market indicators into a single index. This indicator provides a more robust indicator for the broader labor market conditions beyond one-dimensional indicators like unemployment or output gap alone. As a result, one might suspect it provides a more holistic sense of economic activity than the other indicators.

Second, I will explore the sensitivity of the calculations to vintages. Recognizing that both the WEO and LMCI indicators are subject to revisions (the WEO, biannually, and the LMCI, monthly), I will assess three vintages of data. The first selection utilizes data from the October 2014 WEO and LMCI indicators from approximately this release. This results in an estimation sample of 1994-2013. The second vintage utilizes data from the October 2016 WEO and LMCI indicators as of March 2017—I explore two estimation samples, 1994-2013 (the "true" vintage with respect to the older sample), and 1994-2016, which gauges the role of new observations in estimation. This combination of specifications, vintages, and economic activity indictors offers a highly robust analysis of the Taylor rule and its sensitivity to changes in key assumptions. In reporting the results of this analysis in the subsequent section, I begin with the closed-economy specification, reporting the coefficients from different vintages and economic activity indicators for each policy rate, then move to both open-economy specifications. FIML coefficient tables are not separated by dependent variable—since the equations are estimated simultaneously, it is

Table 1: Closed Economy ECB Taylor rules for the Eonia Rate

	October 2014 WEO 1995-2013		October 2014 WEO 1995-2013		October 2016 WEO 1995-2016	
	(1)	(2)	(3)	(4)	(5)	(6)
Lag Eonia Rate	0.772***	0.808***	0.799***	0.790***	0.748***	0.749***
Inflation	0.407	0.693	0.42	0.674	0.217	0.526**
Economic Activity^	0.339***	-0.344	0.315***	-0.337	0.334***	-0.358**
Constant	-0.379	-1.099	-0.442	-0.997	0.167	-0.545

Ôdd columns utilize output gap as the economic activity measure; even utilize unemployment.
*** p<0.01, ** p<0.05, * p<0.1

Table 2: Closed Economy US Taylor rules for the Federal Funds Rate

	October 2014 WEO 1995-2013			October 2014 WEO 1995-2013			October 2016 WEO 1995-2016		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lag Eonia Rate	0.533***	0.758***	1.031***	0.625***	0.664***	1.015***	0.644***	0.737***	0.980***
Inflation	0.14	0.328	0.399	0.127	0.185	0.392	0.178	0.355	0.286
Economic Activity^	0.408***	-0.354	0.136***	0.356	-0.546	0.125***	0.339***	-0.343**	0.120***
Constant	1.477	-0.241	-1.285*	0.6	0.487	-1.206*	0.401	-0.231	-0.779*

T̂he first column ((1), (4), and (7)) in each vintage utilizes output gap as the economic activity measure; the second ((2), (5), and (8)) utilizes unemployment; and the third ((3), (6), and (9)) utilizes the US Labor Market Condition Indicator.
*** p<0.01, ** p<0.05, * p<0.1

appropriate to indicate the results for both equations side-by-side. Lastly, I will conduct impulse responses on the simultaneous model coefficients developed from CFIML estimation to graphically illustrate potential international interdependencies.

3 Results

The reduced-form coefficients of the closed economy Taylor rule regressions are are detail in Table 1 and Table 2. For the closed-economy ECB Taylor rules, I find the results to be largely consistent across vintages. In all estimated regressions, the lagged policy rate is the most statistically and economically significant variable, ranging in a tight band from 0.748 to 0.808, suggesting remarkably high persistence of previous policy rates in Eonia rate determination. The only other variable that is reliably significant is the WEO output gap measure, ranging from 0.315 to 0.339, suggesting there is an economically valuable role for economic activity in closed-economy interest rate determination in the ECB. The only regression that differs significantly is in column (6), which includes the unemployment gap for the 1995-2016 vintage. Here, I observe statistically and economically significant coefficients for economic activity (i.e. unemployment gap) at -0.358, inflation at 0.526 and the lagged policy rate at 0.749. The sign of the economic activity coefficient is expected, since high unemployment in excess of the natural rate ought to correspond with a decrease in the interest rate, the magnitude of the lagged policy rate is consistent with other estimated coefficients, and the inflation coefficient is more in line with the supposed inflation-targeting mandate of the ECB. Before qualifying this individual regression as the "best" approximation for the Eonia rate, I will attend to the other specifications—if the Eonia rate depends on US variables, the closed-economy regression is inappropriate.

The general trend observed in the closed-economy ECB Taylor rules holds for the US Taylor rules as well—in all estimated regressions, the lagged federal funds rate is highly statistically and economically significant, though ranging in a wider band from 0.533 to 1.031. In the standard Taylor rule, the coefficients are assumed to be less than 1 (a persistence parameter of greater than 1 implies that more than 100% of the information from the past is relevant in the current rate), so the large coefficients in columns (3), (6), and (9) may be cause for concern. However, note that the constant in these regressions is negative and significant. So, with respect to the constant, these coefficients seem appropriate. Further, this is likely an anomaly related to the use of the reduced-form coefficients as opposed to the "true" coefficients from the original Taylor rule. These results notwithstanding, the coefficients imply that the US federal funds rate is determined with a high degree of persistence, though not as high as the ECB. Inflation is never significant across all vintages and specifications, suggesting it's overall contribution to the determination of the interest

Table 3: Open Economy ECB Taylor rules for the Eonia Rate (VAR)

	October 2014 WEO 1995-2013			October 2014 WEO 1995-2013			October 2016 WEO 1995-2016		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lag Eonia Rate	0.566***	0.581**	0.575***	0.566***	0.567***	0.577***	0.550**	0.574***	0.556***
Lag FFR	0.201	0.232	0.278**	0.221*	0.230*	0.284**	0.188	0.189	0.224
EU Inflation	0.398	0.266	0.424	0.356	0.333	0.413	0.085	0.262	-0.001
US Inflation	0.305	0.43	0.274	0.344	0.374	0.282	0.389	0.317	0.414**
EU Economic Activity^	0.027	0.005	0.101	-0.001	0.066	0.098	0.048	0.027	0.141**
US Economic Activity^	0.084	-0.12	0.029	0.083	-0.156	0.029	0.081	-0.24	0.018
Constant	-1.044	-1.353***	-1.393**	0.6	-1.277	-1.406**	-0.619	-0.860***	-0.592

^The first column ((1), (4), and (7)) in each vintage utilizes output gap as the economic activity measure; the second ((2), (5), and (8)) utilizes unemployment; and the third ((3), (6), and (9)) utilizes the US Labor Market Condition Indicator and output gap for EU.
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Open Economy US Taylor rules for the Federal Funds Rate (VAR)

	October 2014 WEO 1995-2013			October 2014 WEO 1995-2013			October 2016 WEO 1995-2016		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lag Eonia Rate	0.45	0.560*	0.726***	0.536*	0.493*	0.755***	0.578**	0.603**	0.769***
Lag FFR	0.155	0.231	0.191	0.137	0.242	0.172	0.164	0.242	0.196
EU Inflation	1.116**	1.460***	1.057*	1.189**	1.318***	1.072*	0.845*	1.068**	0.848*
US Inflation	-1.191	-1.556*	-1.175	-1.218	-1.462*	-1.141	-0.587	-0.88	-0.906*
EU Economic Activity^	0.326**	-0.37	0.102***	0.323*	-0.526	0.096***	0.380**	-0.42	0.105***
US Economic Activity^	-0.134	0.511	0.148	-0.26	0.534*	0.1	-0.321*	0.593**	0.156
Constant	1.15	0.029	-0.127	0.249	0.432	-0.247	-0.472	-0.551	-0.291

^The first column ((1), (4), and (7)) in each vintage utilizes output gap as the economic activity measure; the second ((2), (5), and (8)) utilizes unemployment; and the third ((3), (6), and (9)) utilizes the US Labor Market Condition Indicator and output gap for EU.
*** p<0.01, ** p<0.05, * p<0.1

rate is minimal.

The LMCI indicator is reliably significant across vintages, ranging from 0.120 to 0.136 in magnitude, while output gap is significant in both the October 2014 WEO, 1995-2013 sample and the October 2016 WEO, 1995-2016 sample. The magnitude of the coefficient (0.408, 0.356, and 0.339, respectively) is consistent across the vintages, while statistical significance is not. The unemployment gap indicator is only significant in the 1995-2016 vintage, with the expected sign and a magnitude of -0.343 consistent with the results from the ECB regressions. Based on these results, at first pass, it appears the LMCI indicator may be the most reliable for economic activity in the US, whereas unemployment seems to far underperform both LMCI and output gap, though the size of the parameter implies less weight on economic activity when using LMCI than output gap, which is likely a result of the construction of the indicator itself (more on this below).

The results from the open-economy VAR estimation, in Table 3 and Table 4 are far less consistent, across both vintages and specifications. For the Eonia rate, again, the lagged rate is statistically and economically significant across all regressions, ranging in an even narrower band of 0.550 to 0.581, likely more indicative of the "true" persistence parameter in the determination. Of note is the role of the lagged federal funds rate, particularly in the October 2014 WEO, 1995-2013 sample, which is significant (at the 10% level) across all specifications ranging from 0.221 to 0.284. While the federal funds rate coefficient is only significant in one other specification (column (3)), the range for the magnitude is consistent across vintages and specifications. As such, it is likely that the determination of Eonia rate does consider the role of interdependency. Beyond this, however, there is little to be gleaned from the VAR. US economic activity measures and EU inflation are never significant and US inflation and EU economic activity measures are only significant in the October 2016 WEO, 1995-2016 sample (column (9)), taking values of 0.414 and 0.141 respectively. So, while the results regarding the persistence parameter are sound, I posit the VAR regression serves primarily to justify the use of the simultaneous FIML estimation for modelling the Taylor rule, and, given the significance of the federal funds rate in the October 2014 WEO vintage, casts doubt on the efficacy of the closed-economy model for the Eonia rate.

Results for estimation of the federal funds rate with the VAR are similarly inconsistent. The lagged federal funds rate and US inflation rate are reliably significant across vintages and specifications, but vary in a wider range: the lagged federal funds rate from 0.450 to 0.769 with an

Table 5: Open Economy Simultaneous Taylor rules – October 2014 WEO (1995-2013)

	Eonia (1)	FFR (2)	Eonia (3)	FFR (4)	Eonia (5)	FFR (6)
Lag Domestic Policy Rate	0.565***	0.548	0.515***	1.203	0.559***	1.078**
Domestic Inflation	0.699***	0.194	0.703***	0.82	0.729***	0.458
Economic Activity^	0.117*	0.424**	-0.278**	-0.158	0.081***	0.140***
Foreign Policy Rate	0.292***	-0.067	0.348***	-0.724	0.315*	-0.083
Constant	-1.23**	1.505	-1.262***	-0.86	-1.343***	-1.351

^The first simultaneous regression (columns (1) and (2)) utilizes respective domestic output gaps as the economic activity measures; the second (columns (3) and (4)) utilizes respective domestic unemployment; and the third (columns (5) and (6)) utilizes the US Labor Market Condition Indicator for US and output gap for EU.
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Open Economy Simultaneous Taylor rules – October 2016 WEO (1995-2013)

	Eonia (1)	FFR (2)	Eonia (3)	FFR (4)	Eonia (5)	FFR (6)
Lag Domestic Policy Rate	0.563***	0.725*	0.513***	0.947*	0.558***	1.062**
Domestic Inflation	0.677***	0.253	0.724***	0.493	0.709***	0.448
Economic Activity^	0.130**	0.37	-0.194*	-0.479	0.130**	0.128***
Foreign Policy Rate	0.300***	-0.204	0.351***	-0.457	0.322***	-0.083
Constant	-1.182***	0.535	-1.306***	0.141	-1.308***	-1.265

^The first simultaneous regression (columns (1) and (2)) utilizes respective domestic output gaps as the economic activity measures; the second (columns (3) and (4)) utilizes respective domestic unemployment; and the third (columns (5) and (6)) utilizes the US Labor Market Condition Indicator for US and output gap for EU.
*** p<0.01, ** p<0.05, * p<0.1

insignificant coefficient in column (1), while US inflation ranges from 0.845 to 1.460 with varying significance levels across specifications and vintages. The inflation coefficients suggest an outsize contribution of inflation levels to the setting of the federal funds rate—coefficients of greater than 1 suggest that changes in inflation rates are reflected with changes in the federal funds rate greater than 100%. This is a dramatic departure from the results of the closed-economy that I suspect will fail to hold in fail to hold in the simultaneous equation model. Results for economic activity coefficients are largely in line with the results from the closed economy, with no value attributed to the unemployment gap, significance exhibited by both the output gap and LMCI indicators, and greater economic significance attributed to output gap, specifically.

While the lagged foreign policy rate (Eonia) is never significant, the role of other foreign variables (EU inflation and economic activity) varies widely by specification and vintage. I find three instances of large, statistically significant, negative coefficients for EU inflation in columns (2), (5), and (9) and coefficients of mixed signs and magnitude for EU economic activity in columns (5), (7) and (8). Economic explanations for these variables are tenuous at best, and largely unintuitive. Negative coefficients on EU inflation suggest that as inflation in the EU rises, the federal funds rate in the US decreases in response. I do not have an explanation, technical or economic, for this behavior, particularly in the absence of a direct link to the EU policy rate. The positive coefficients for economic activity in columns (5) and (7) correspond to EU unemployment gap, which suggests that increases in EU unemployment in excess of the natural rate predict increases in the federal funds rate. One plausible link to explain this relationship could be a displacement of labor from the EU to the US, driving US unemployment down in the process which could encourage an increase in the federal funds rate. I do not have an explanation, technical or economic, for the negative coefficient on EU economic activity. Considering all of these coefficients are weakly statistically significant, I do not feel a narrative seeking to justify the significance and contribution to the determination of the federal funds rate is warrant. Instead, I hope to ameliorate these tensions with the simultaneous model, suggesting the coefficients are more likely a result of an inherent limitation in the identification of the VAR regression.

Table 7: Open Economy Simultaneous Taylor rules – October 2016 WEO (1995-2016)

	Eonia (1)	FFR (2)	Eonia (3)	FFR (4)	Eonia (5)	FFR (6)
Lag Domestic Policy Rate	0.499***	0.695*	0.453***	0.959	0.502***	1.113***
Domestic Inflation	0.392**	0.21	0.493***	0.526	0.419**	0.364
Economic Activity^	0.147*	0.340*	-0.226**	-0.294*	0.129**	0.126***
Foreign Policy Rate	0.305***	-0.082	0.366***	-0.345	0.301***	-0.199
Constant	-0.375	0.379	-0.661**	-0.414	-0.43	.-0.853

^The first simultaneous regression (columns (1) and (2)) utilizes respective domestic output gaps as the economic activity measures; the second (columns (3) and (4)) utilizes respective domestic unemployment; and the third (columns (5) and (6)) utilizes the US Labor Market Condition Indicator for US and output gap for EU.

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

The results of the simultaneous dynamic modeling are remarkably consistent across vintages and specifications, and differences exhibit reliable patterns either within those specifications or vintages. The FIML estimation approach is especially suited to the Taylor rule equation for Eonia. For all specifications and vintages, all coefficients are statistically significant (at least at the 10% level) using Newey-West standard errors. The lagged Eonia rate ranges narrowly between 0.453 and 0.565, with an average coefficient magnitude of 0.525, suggesting an almost equal weighting of past rates and new data for determination of the new rate. EU inflation ranges narrowly between specifications, but is markedly larger in magnitude in the smaller time samples—whereas the coefficient ranges from 0.392 to 0.493 in the larger sample, it ranges from 0.677 to 0.729 in the 1995-2013 sample. The average coefficient for inflation is 0.574, suggesting a significant economic contribution of inflation to determining a given Eonia rate. Output gap measures are less economically and statistically significant, on average, ranging from 0.081 to 0.147, with an average coefficient value of 0.122, suggesting a much smaller contribution to the overall rate relative to the previous rate and inflation considerations. Unemployment gap measures, similarly, vary in a narrow range, have the expected sign, and are of a smaller magnitude than persistence and inflation parameters with an average value of -0.233. Lastly, the foreign policy rate (in this case, the federal funds rate), is highly statistically significant and remarkably consistent in terms of magnitude across vintages and specifications, with an average value of 0.322. This suggests clear interdependency between the US and EU in determination of the Eonia rate, the magnitude of which is greater than domestic activity.

Regarding the federal funds rate, we observe coefficient estimates that are largely in line with the significance levels and magnitudes of the closed-economy regression. Attending first to non-results, there are no instances of significant coefficients for inflation or the foreign Eonia rate. Further, regressions utilizing the unemployment gap measure generate very few significant results (e.g. a mildly significant coefficient for economic activity in the 1995-2016 sample and a mildly significant coefficient for the lagged federal funds rate in the 1995-2013 sample with October 2014 WEO data). This has been a consistent finding across estimation methods and vintages, implying the unemployment gap in this form dramatically underperforms the other two indicators. Focusing attention on the regressions with output gap, as the economic activity indicator, results are mixed—coefficients vary from 0.340 (in the full sample vintage) to 0.424 (in the October 2014 WEO vintage) with mixed significance levels, including an insignificant coefficient in the 1995-2013 October 2014 WEO vintage. Similarly, lagged federal funds rate coefficients are of similar magnitude to those in the closed economy, but none are significant at more than the 10% level. In contrast, coefficients for lagged federal funds rates and LMCI are remarkably significant and consistent across vintages, ranging from 1.062 to 1.113 and 0.126 to 0.140, respectively. The characteristics of the federal funds rate Taylor rules in this context offer significant evidence to suggest that 1) LMCI improves upon the output gap as a measure of economic activity (further supported by higher R2 values in regressions containing the indicator in previous specifications); and 2) the Federal Reserve actively targets economic activity, but does not exhibit the same behavior regarding price stability.

After conducting FIML estimation, acknowledging variables that are broadly insignificant, I conduct CFIML regressions to constrain insignificant coefficients to 0 (see Appendix, Figures A.12-A.14), to more accurately capture the role of interdependency (particularly in the context of the

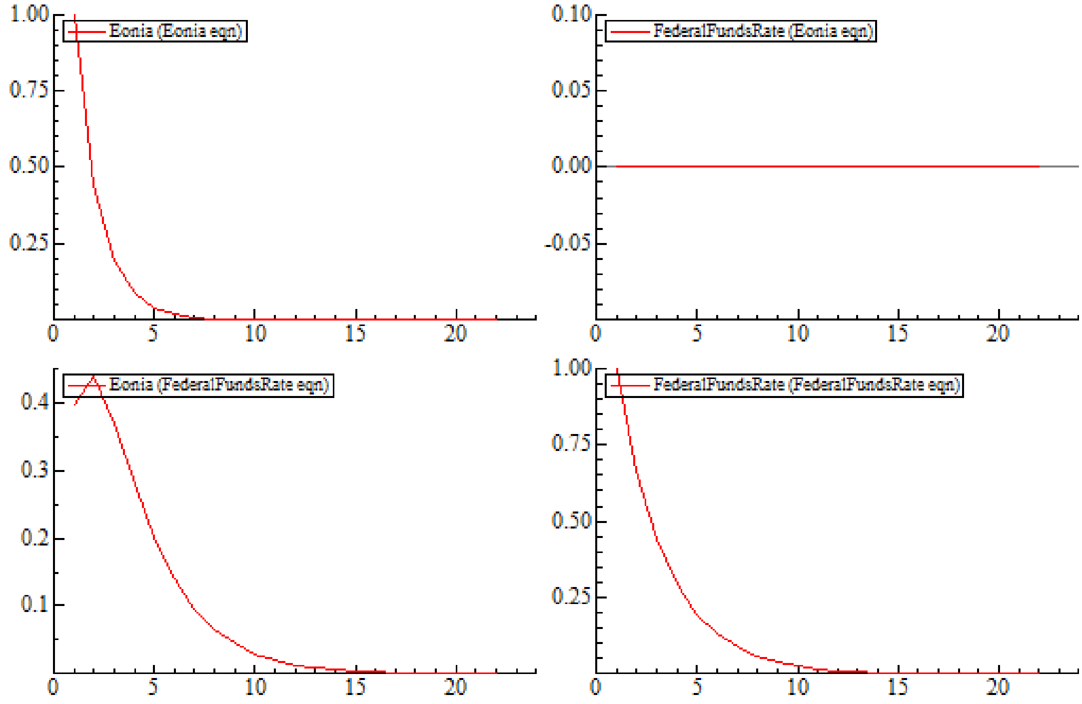

Figure 1: Impulse Response for CFIML, October 2016 WEO (1995-2016), Output Gap Measures

Eonia rate) and policymaking behavior. Since coefficient magnitudes do not change dramatically when statistically insignificant coefficients are constrained to zero (which is sensible), I have opted to include the CFIML regressions separately in the Appendix. This approach does, however, directly capture the behavior of the respective central banks (i.e. the federal funds rate is determined with little to no contribution of inflation or the Eonia rate and economic activity is weakly significant in the EU using output gap measures) and provides the basis for broader conclusions about the policymaking in these institutions. Further, it provides the basis for a richer analysis with impulse response tests.

Recognizing the predominance of the LMCI and output gap indicators for economic activity in the US, I attend briefly to two impulse response tests from the October 2016 WEO 1995-2016 vintage, since it represents the most complete sample (other CFIML impulse response graphs are included in the Appendix, see figures B.3-B.12):

Results from the dual output gap measure (US and EU) impulse response tests are comforting and firmly in line with the results put forth in this analysis. The graphic suggests that shocks to lags of dependent variables in each respective equation die off (tend to 0), and do so more quickly in the EU than in the US: in 5 years rather than 10. Further, shocks to the Eonia rate do not impact the US (since Eonia is constrained) but shocks to the federal funds rate *do* impact the Eonia rate per the magnitude of the interdependency parameter from the estimation. Thus, unit increases in the federal funds rate have the contemporaneous effect of raising EU rates, with the shock dying off after about 15 years in this sample. These results are consistent across vintages, and similar responses are exhibited when the unemployment measures are used.

Consequently, impulse response to the simultaneous equation model with the LMCI indicator exhibits unintuitive characteristics. While the Eonia equation in isolation behaves similarly, as does the federal funds rate equation with respect to Eonia, unit shocks to the federal funds rate appear to result in impulse responses that tend to infinity and, subsequently, never settle down. I do not have an explanation, either technical or intuitive, for why this behavior is exhibited when using the LMCI, as it is the only change between specifications. As such, the behavior must be symptomatic of the LMCI indicator and its relationship to the federal funds rate, but more research is needed to explore the underlying causes of this result.

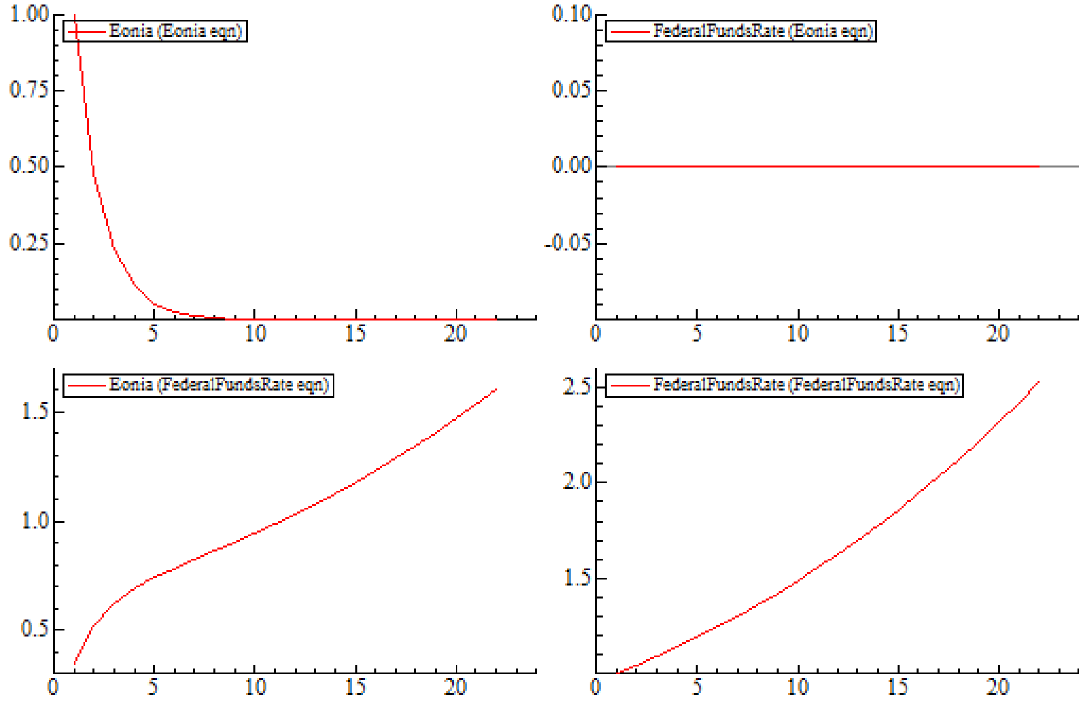

Figure 2: Impulse Response for CFIML, October 2016 WEO (1995-2016), LMCI Measure

4 Conclusion

Based on the results of this analysis, I contend that the simultaneous dynamic Taylor rule for ECB and US policy rates is the best approach for modelling interest rate determination. Recognizing the economically and statistically significant contributions of the federal funds rate to the Eonia Taylor rule implies that the closed-economy Taylor rule is inappropriate for the modelling of ECB rates. Given the paucity of significant results in the VAR estimation approach, and the robustness to changes in specification and vintage across Eonia rate regressions, I further contend that the simultaneous dynamic modelling improves upon the VAR and coincides nicely with non-technical intuition regarding the ECB. These results clearly imply significant interdependency between the federal funds rate and Eonia rate determination in the Euro Area. Further, there is clear evidence of inflation targeting by the ECB in the simultaneous dynamic model results—the inflation parameter is always significant and has the largest average magnitude of all coefficients, suggesting an outsize contribution to the determination of the overall rate.

Conversely, the results of the simultaneous dynamic model for the federal funds rate are largely in line with the significance levels and magnitude of the closed-economy model for the US rate. This is intuitively sound, since there is no regression in this analysis which suggest the Eonia rate provides a significant contribution to the federal funds rate. Thus, the interdependency is clearly asymmetrical—while the Eonia rate depend on the federal funds rate, the federal funds rate in no way depends on the Eonia rate, consistent with existing literature, particularly Ullrich (2003). This is further demonstrated with CFIML regression and subsequent impulse responses. Since nothing is technically being "added" to the simultaneous dynamic model (since Eonia is insignificant), it is sensible that the coefficients for the lagged federal funds rate and economic activity indicator (either output gap or LMCI) are of similar magnitude and significance to those in the closed-economy model. This synergy further invalidates the use of the VAR as an improved approach to estimating the Taylor rule equation in this context, especially considering the lack of coefficients with reasonable economic or intuitive explanation.

Empirically, there is little evidence that the US actively pursues price stability—inflation does not provide a statistically valid contribution to the determination of the federal funds rate in closed-economy or simultaneous dynamic regression estimation. There are statistically significant inflation parameters in the VAR regressions, suggesting there may be some evidence of this mandate, but the concerns regarding the estimation results from the VAR lead me to discount these. There is however, an empirically robust contribution of economic activity across vintages and specifications, implying significant attention to these indicators in the determination of the federal funds rate. Thus, the analysis seems to suggest the Federal Reserve may only actively fulfill one of its two mandates. This is, however, likely more a repudiation of the statistical techniques used than of the Federal Reserve's mandate—since inflation has exhibited little variation throughout this sample, the estimation techniques used would likely fail to detect significance for those coefficients.

This analysis further suggests that results found from the Taylor rule estimation are remarkably robust to changes in vintage—the revisions implicit in later editions of the WEO and LMCI do not seem to have a significant impact on the size or significance of coefficients. This is particularly apparent when comparing the 1995-2013 samples across vintages (the "pure" vintage). The addition of years to the sample in the 1995-2016 regressions does have a non-trivial impact on the size of the coefficients, the change is not dramatic enough to cause concern about the sample used. It is possible adding observations lends the regressions to converge more closely to the true population parameter, suggesting the change is valuable.

Regarding indicators for economic activity, the analysis suggests unemployment is a poor measure given the paucity of significance and profound impact on results when it is employed, particularly for the US. Both output gap and LMCI are reliably significant for the US, and though this is not the case for the EU, I posit it is due to the nature of ECB interest rate determination rather than the indicator itself. For the US, I contend the LMCI is likely the "best" indicator for economic activity—models that include the LMCI indicator have reliably higher explanatory power (R2) and more consistently coefficients both statistically and economically. There are, however, concerns about the behavior of the impulse responses in regressions that utilize LMCI. While impulse response tests with output gap provide comforting, consistent results, those with LMCI certainly do not. More research is needed in this vein, especially considering the potential for the indicator and its relatively nascent status. Taken together, I argue that the simultaneous dynamic model estimated with FIML, utilizing LMCI or output gap for the US, output gap for the EU, and for the full sample is the "best" strategy for estimating Taylor rule coefficients in this context, and far improves upon the unintuitive results of the VAR while still accounting for the non-trivial interdependence exhibited in the Eonia rate.

Moving forward, it would be valuable to explore the possible role of multiple interdependencies. The current literature surrounding this concept is brief, and there is significant room to expand. If the ECB factors in US rates for determination of the Eonia rate, it is certainly reasonable that other rates could be considered. Exploring multiple interdependencies across a system of Taylor rules would be a fruitful subject for further research. Additionally, given the power of the LMCI indicator in the estimation of the federal funds rate, the development/use of a comparable measure for the ECB would be highly beneficial for the determination of the Eonia rate.

A Tables

Table A.8: Closed Economy OLS - ECB Taylor rules
Dependent Variable: Eonia Rate

	October 2014 WEO 1995-2013		October 2014 WEO 1995-2013		October 2016 WEO 1995-2016	
	(1)	(2)	(3)	(4)	(5)	(6)
Lag Eonia Rate	0.772***	0.808***	0.799***	0.790***	0.748***	0.749***
	(-0.112)	(-0.074)	(-0.106)	(-0.0895)	(-0.095)	(-0.083)
Inflation	0.407	0.693	0.42	0.674	0.217	0.526**
	(-0.278)	(-0.431)	(-0.312)	(-0.424)	(-0.183)	(-0.211)
Economic Activity	0.339***		0.315***		0.334***	
	(0.097)		(1.876)		(0.088)	
Unemployment		-0.344		-0.337		-0.358**
		(-0.354)		(-0.312)		(-0.141)
Constant	-0.379	-1.099	-0.442	-0.997	0.167	-0.545
	(-0.767)	(-1.033)	(-0.813)	(-1.069)	(-0.419)	(-0.355)
Number of Observations	19	19	19	19	22	22
R-squared	0.884	0.82	0.894	0.822	0.866	0.863

HAC standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.9: Closed Economy OLS - US Taylor rules
Dependent Variable: Federal Funds Rate

	October 2014 WEO 1995-2013			October 2014 WEO 1995-2013			October 2016 WEO 1995-2016		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lag Federal Funds Rate	0.533***	0.758***	1.031***	0.625***	0.664***	1.015***	0.644***	0.737***	0.980***
	(-0.159)	(-0.141)	(-0.066)	(-0.187)	(-0.174)	(-0.064)	(-0.144)	(-0.118)	(-0.076)
Inflation	0.14	0.328	0.399	0.127	0.185	0.392	0.178	0.355	0.286
	(-0.332)	(-0.329)	(-0.313)	(-0.429)	(-0.358)	(-0.309)	(-0.281)	(-0.245)	(-0.223)
Output Gap	0.408***			0.356			0.339***		
	(-0.142)			(-0.215)			(-0.16)		
Unemployment		-0.354			-0.546			-0.343**	
		(-0.257)			(-0.315)			(-0.149)	
LMCI			0.136***			0.125***			0.120***
			(-0.025)			(-0.022)			(-0.022)
Constant	1.477	-0.241	-1.285*	0.6	0.487	-1.206*	0.401	-0.231	-0.779*
	(-1.311)	(-0.846)	(-0.68)	(-1.339)	(-1.086)	(-0.674)	(-0.737)	(-0.441)	(0.424)
Number of Observations	19	19	19	19	19	19	22	22	22
R-squared	0.823	0.732	0.858	0.781	0.747	0.859	0.816	0.782	0.869

HAC standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.10: Open Economy VAR - ECB Taylor rules

Dependent Variable: Eonia Rate

	October 2014 WEO 1995-2013			October 2014 WEO 1995-2013			October 2016 WEO 1995-2016		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lag Eonia Rate	0.566***	0.581**	0.575***	0.566***	0.567***	0.577***	0.550**	0.574***	0.556***
	(-0.171)	(-0.214)	(-0.174)	(-0.177)	(-0.18)	(-0.176)	(-0.2)	(-0.197)	
Lag Federal Funds Rate	0.201	0.232	0.278**	0.221*	0.23*	0.284**	0.188	0.189	0.224
	(-0.126)	(-0.151)	(-0.106)	(-0.118)	(-0.125)	(-0.105)	(-0.151)	(-0.151)	
EU Inflation	0.398	0.266	0.424	0.356	0.333	0.413	0.085	0.262	-0.001
	(-0.429)	(-0.413)	(-0.392)	(-0.431)	(-0.444)	(-0.401)	(-0.226)	(-0.293)	(-0.19)
US Inflation	0.305	0.43	0.274	0.344	0.374	0.282	0.389	0.317	0.414**
	(-0.238)	(-0.26)	(-0.277)	(-0.248)	(-0.288)	(-0.277)	(-0.17)	(-0.238)	(-0.161)
EU Output Gap	0.027		0.101	-0.001		0.098	0.048		0.141**
	(-0.101)		(-0.1)	(-0.099)		(-0.096)	(-0.091)		(-0.065)
US Output Gap	0.084			0.083			0.081		
	(-0.064)			(-0.074)			(-0.075)		
EU Unemployment		0.005			0.066			0.027	
		(-0.235)			(-0.181)			(-0.148)	
US Unemployment		-0.12			-0.156			-0.24	
		(-0.166)			(-0.164)			(-0.166)	
US LMCI			0.029			0.029			0.018
			(-0.022)			(-0.023)			
Constant	-1.044	-1.353***	-1.393**	0.6	-1.277	-1.406**	-0.619	-0.860***	-0.592
	(-0.708)	(-0.458)	(-0.575)	(-1.339)	(-0.542)	(-0.568)	(-0.366)	(-0.202)	
Number of Observations	19	19	19	19	19	19	22	22	22
R-squared	0.929	0.924	0.858	0.926	0.925	0.931	0.926	0.943	0.939

HAC standard errors in parentheses

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

Table A.11: Open Economy VAR – US Taylor rules

Dependent Variable: Federal Funds Rate

	October 2014 WEO 1995-2013			October 2014 WEO 1995-2013			October 2016 WEO 1995-2016		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lag Federal Funds Rate	0.45	0.560*	0.726***	0.536*	0.493*	0.755***	0.578**	0.603**	0.769***
	(-0.325)	(-0.266)	(-0.221)	(-0.293)	(-0.242)	(-0.195)	(-0.273)	(-0.22)	
Lag Eonia Rate	0.155	0.231	0.191	0.137	0.242	0.172	0.164	0.242	0.196
	(-0.338)	(-0.353)	(-0.329)	(-0.345)	(-0.322)	(-0.315)	(-0.307)	(-0.278)	
US Inflation	1.116**	1.460***	1.057*	1.189**	1.318***	1.072*	0.845*	1.068**	0.848*
	(-0.404)	(-0.448)	(-0.567)	(-0.438)	(-0.433)	(-0.561)	(-0.448)	(-0.424)	(-0.475)
EU Inflation	-1.191	-1.556*	-1.175	-1.218	-1.462*	-1.141	-0.587	-0.88	-0.906*
	(-0.795)	(-0.738)	(-0.727)	(-0.795)	(-0.714)	(-0.739)	(-0.518)	(-0.576)	(-0.452)
US Output Gap	0.326**			0.323*			0.380**		
	(-0.122)			(-0.154)			(-0.154)		
EU Output Gap	-0.134		0.148	-0.26		0.1	-0.321*		0.156
	(-0.259)		(-0.231)	(-0.207)		(-0.208)	(-0.177)		
US Unemployment		-0.37			-0.526			-0.42	
		(-0.337)			(-0.325)			(-0.286)	
EU Unemployment		0.511			0.534*			0.593**	
		(-0.37)			(-0.262)			(-0.279)	
US LMCI			0.102***			0.096***			0.105***
			(-0.032)			(-0.032)			
Constant	1.15	0.029	-0.127	0.249	0.432	-0.247	-0.472	-0.551	-0.291
	(-1.635)	(-1.141)	(-1.049)	(-1.481)	(-1.215)	(-0.994)	(-0.71)	(-0.447)	
Number of Observations	19	19	19	19	19	19	22	22	22
R-squared	0.871	0.851	0.88	0.861	0.859	0.88	0.869	0.853	0.891

HAC standard errors in parentheses

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

Table A.12: Open Economy Simultaneous Taylor rules - FIML & CFIML Estimation

	October 2014 WEO 1995-2013				October 2014 WEO 1995-2013				October 2016 WEO 1995-2016			
	Eonia	FFR	Eonia	FFR	Eonia	FFR	Eonia	FFR	Eonia	FFR	Eonia	FFR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lag Domestic Policy Rate	0.565***	0.534***	0.548	0.532***	0.563***	0.527***	0.725*	0.631***	0.499***	0.441***	0.695*	0.666***
	[0.07]	(-0.059)	[0.372]	(-0.143)	[0.075]	(-0.06)	[0.393]	(-0.149)	[0.112]	(-0.068)	[0.352]	(-0.121)
Domestic Inflation	0.699***	0.813***	0.194	0.00	0.677***	0.801***	0.253	0.00	0.392**	0.519***	0.21	0.00
	[0.149]	(-0.119)	[0.436]		[0.155]	(-0.12)	[0.487]		[0.178]	(-0.11)	[0.382]	
Domestic Output Gap	0.117*	0.00	0.424**	0.432***	0.130**	0.00	0.37	0.376**	0.147*	0.00	0.340*	0.365***
	[0.057]		[0.156]	(-0.12)	[0.055]		[0.229]	(-0.14)	[0.073]		[0.163]	(-0.126)
Foreign Policy Rate	0.292***	0.369***	-0.067	0.00	0.300***	0.379***	-0.204	0.00	0.305***	0.397***	-0.082	0.00
	[0.051]	(-0.049)	[0.718]		[0.056]	(-0.051)	[0.804]		[0.103]	(-0.062)	[0.629]	
Constant	-1.23**	-1.607***	1.505	1.850***	-1.182***	-1.593***	0.535	0.885	-0.375	-0.759***	0.379	0.731
	[0.333]	(-0.293)	[1.373]	(-0.619)	[0.341]	(-0.294)	[1.375]	(-0.533)	[0.394]	(-0.214)	[0.789]	(-0.404)
Number of Observations	19	19	19	19	19	19	19	19	22	22	22	22

Note: HAC Standard Errors are indicated above in brackets, while standard errors are indicated in parentheses. Odd numbered columns are FIML estimations, while even numbered columns are CFIML with constraints placed on coefficients depending on FIML results. This serves primarily as a demonstration of the size of the coefficients in absent of those that seem less economically significant in the estimating equation. Since FIML is estimated simultaneously, I include the Eonia and Federal Funds Rate estimations side-by-side for comparison since they are estimated together. As such, the "domestic" indicators refer to the dependent variable policy rate, and the "foreign" refers to the foreign rate (i.e. Eonia in the FFR equation and FFR in the Eonia equation). Further note that, in conducting CFIML there is no direct reporting of HAC Standard errors, so I defer to the ordinary standard errors for this regression output. In almost all instances, coefficients in CFIML are dramatically statistically significant, so I do not believe the choice of ordinary standard errors is wholly inappropriate, and still allows for meaningful interpretation of the magnitude of the coefficient. Further, the key results of this estimation technique are those reported in FIML, less so those of CFIML. Significance levels are as follows: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A.13: Open Economy Simultaneous Taylor rules - FIML & CFIML Estimation

	October 2014 WEO 1995-2013				October 2014 WEO 1995-2013				October 2016 WEO 1995-2016			
	Eonia	FFR	Eonia	FFR	Eonia	FFR	Eonia	FFR	Eonia	FFR	Eonia	FFR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lag Domestic Policy Rate	0.515***	0.494***	1.203	0.856***	0.513***	0.495***	0.947*	0.856***	0.453***	0.404***	0.959	0.862***
	[0.056]	(-0.072)	[0.764]	(-0.149)	[0.075]	(-0.072)	[0.503]	(-0.149)	[0.085]	(-0.084)	[0.582]	(-0.121)
Domestic Inflation	0.703***	0.802***	0.82	0	0.724***	0.800***	0.493	0	0.493***	0.526***	0.526	0
	[0.145]	(-0.116)	[0.644]		[0.143]	(-0.117)	[0.348]		[0.133]	(-0.109)	[0.401]	
Domestic Unemployment	-0.278**	0.00	-0.158	0.00	-0.194*	0.00	-0.479	0.00	-0.226**	0.00	-0.294*	0.00
	[0.098]		[0.304]		[0.092]		[0.304]		[0.085]		[0.161]	
Foreign Policy Rate	0.348***	0.412***	-0.724	0.00	0.351***	0.411***	-0.457	0.00	0.366***	0.430***	-0.345	0.00
	[0.043]	(-0.067)	[1.368]		[0.042]	(-0.067)	[1.012]		[0.075]	(-0.082)	[0.983]	
Constant	-1.262***	-1.592***	-0.86	0.249	-1.306***	-1.590***	0.141	0.249	-0.661**	-0.759***	-0.414	0.22
	[0.303]	(-0.291)	[0.782]	(-0.578)	[0.307]	(-0.292)	[0.882]	(-0.578)	[0.213]	(-0.217)	[0.830]	(-0.437)
Number of Observations	19	19	19	19	19	19	19	19	22	22	22	22

Note: HAC Standard Errors are indicated above in brackets, while standard errors are indicated in parentheses. Odd numbered columns are FIML estimations, while even numbered columns are CFIML with constraints placed on coefficients depending on FIML results. This serves primarily as a demonstration of the size of the coefficients in absent of those that seem less economically significant in the estimating equation. Since FIML is estimated simultaneously, I include the Eonia and Federal Funds Rate estimations side-by-side for comparison since they are estimated together. As such, the "domestic" indicators refer to the dependent variable policy rate, and the "foreign" refers to the foreign rate (i.e. Eonia in the FFR equation and FFR in the Eonia equation). Further note that, in conducting CFIML there is no direct reporting of HAC Standard errors, so I defer to the ordinary standard errors for this regression output. In almost all instances, coefficients in CFIML are dramatically statistically significant, so I do not believe the choice of ordinary standard errors is wholly inappropriate, and still allows for meaningful interpretation of the magnitude of the coefficient. Further, the key results of this estimation technique are those reported in FIML, less so those of CFIML. Significance levels are as follows: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A.14: Open Economy Simultaneous Taylor rules - FIML & CFIML Estimation

	October 2014 WEO 1995-2013				October 2014 WEO 1995-2013				October 2016 WEO 1995-2016			
	Eonia	FFR	Eonia	FFR	Eonia	FFR	Eonia	FFR	Eonia	FFR	Eonia	FFR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lag Domestic Policy Rate	0.559***	0.542***	1.078**	1.088***	0.558***	0.541***	1.062**	1.071***	0.502***	0.480***	1.113***	1.045***
	[0.058]	(-0.062)	[0.387]	(-0.122)	[0.060]	(-0.062)	[0.389]	(-0.119)	[0.097]	(-0.074)	[0.390]	(-0.099)
Domestic Inflation	0.729***	0.808***	0.458	0.00	0.709***	0.807***	0.448	0.00	0.419**	0.531	0.364	0.00
	[0.145]	(-0.118)	[0.483]		[0.154]	(-0.118)	[0.480]		[0.173]	(-0.11)	[0.389]	
EU Output Gap	0.081***	0.00			0.130**	0.00			0.129**	0.00		0.00
	[0.048]				[0.055]				[0.053]			
US LMCI			0.140***	0.146***			0.128***	0.134***			0.126***	0.133***
			[-0.031]	(-0.036)			[0.027]	(-0.033)			[0.030]	(-0.03)
Foreign Policy Rate	0.315*	0.359***	-0.083	0.00	0.322***	0.360***	-0.083	0.00	0.301***	0.343***	-0.199	0.00
	[0.039]	(-0.051)	[0.612]		[0.039]	(-0.051)	[0.621]		[0.077]	(-0.064)	[0.612]	
Constant	-1.343***	-1.592***	-1.351	-0.508	-1.308***	-1.591***	-1.265	-0.438	-0.43	-0.743***	-0.853	-0.331
	[0.332]	(-0.295)	[0.841]	(-0.457)	[0.355]	(-0.296)	[0.823]	(-0.446)	[-0.296]	(-0.215)	[-0.553]	(-0.345)
Number of Observations	19	19	19	19	19	19	19	19	22	22	22	22

Note: HAC Standard Errors are indicated above in brackets, while standard errors are indicated in parentheses. Odd numbered columns are FIML estimations, while even numbered columns are CFIML with constraints placed on coefficients depending on FIML results. This serves primarily as a demonstration of the size of the coefficients in absent of those that seem less economically significant in the estimating equation. Since FIML is estimated simultaneously, I include the Eonia and Federal Funds Rate estimations side-by-side for comparison since they are estimated together. As such, the "domestic" indicators refer to the dependent variable policy rate, and the "foreign" refers to the foreign rate (i.e. Eonia in the FFR equation and FFR in the Eonia equation). Further note that, in conducting CFIML there is no direct reporting of HAC Standard errors, so I defer to the ordinary standard errors for this regression output. In almost all instances, coefficients in CFIML are dramatically statistically significant, so I do not believe the choice of ordinary standard errors is wholly inappropriate, and still allows for meaningful interpretation of the magnitude of the coefficient. Further, the key results of this estimation technique are those reported in FIML, less so those of CFIML. Significance levels are as follows: *** p<0.01, ** p<0.05, * p<0.1

B Figures

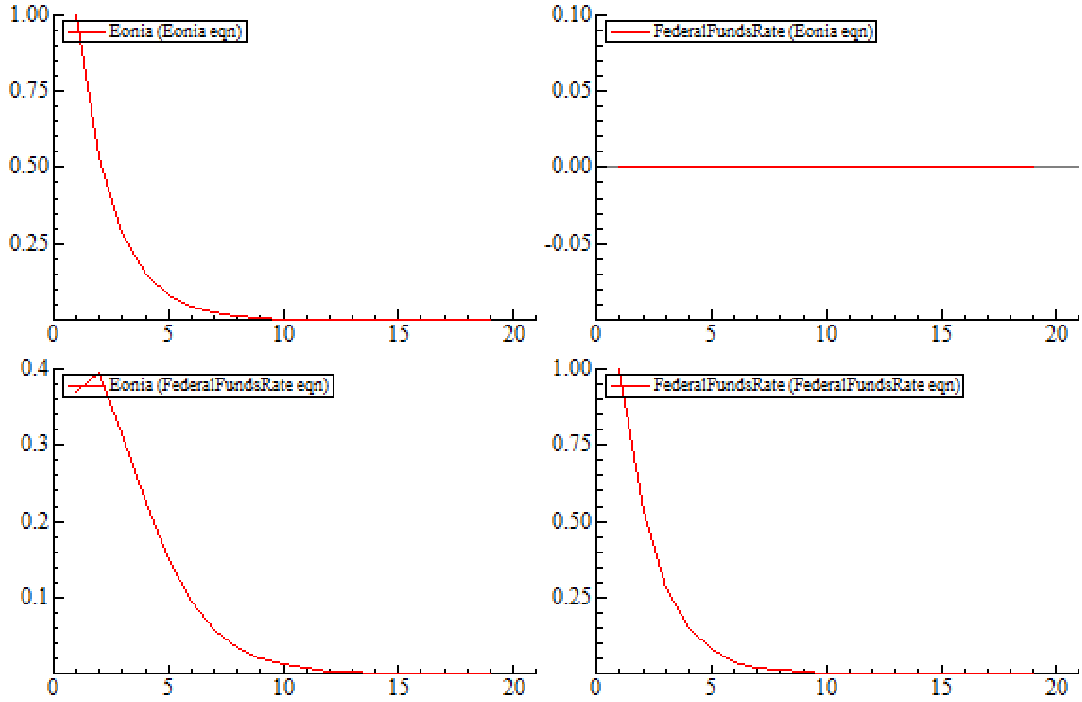

Figure B.3: Impulse Response for CFIML, October 2014 WEO (1995-2013), Output Gap Measures

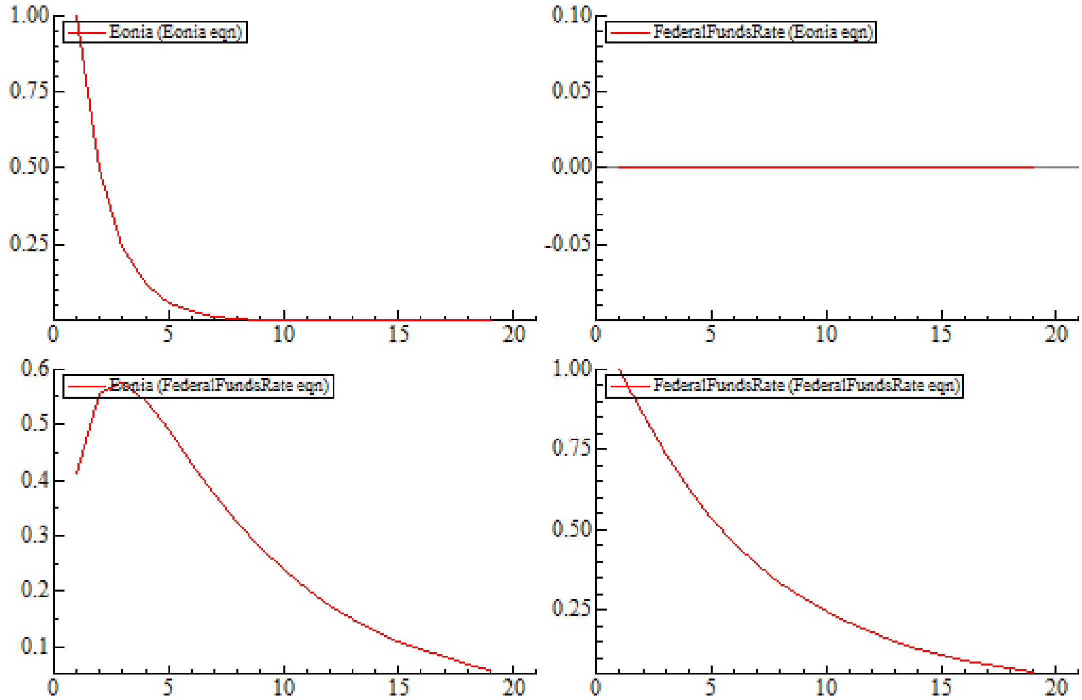

Figure B.4: Impulse Response for CFIML, October 2014 WEO (1995-2013), Unemployment

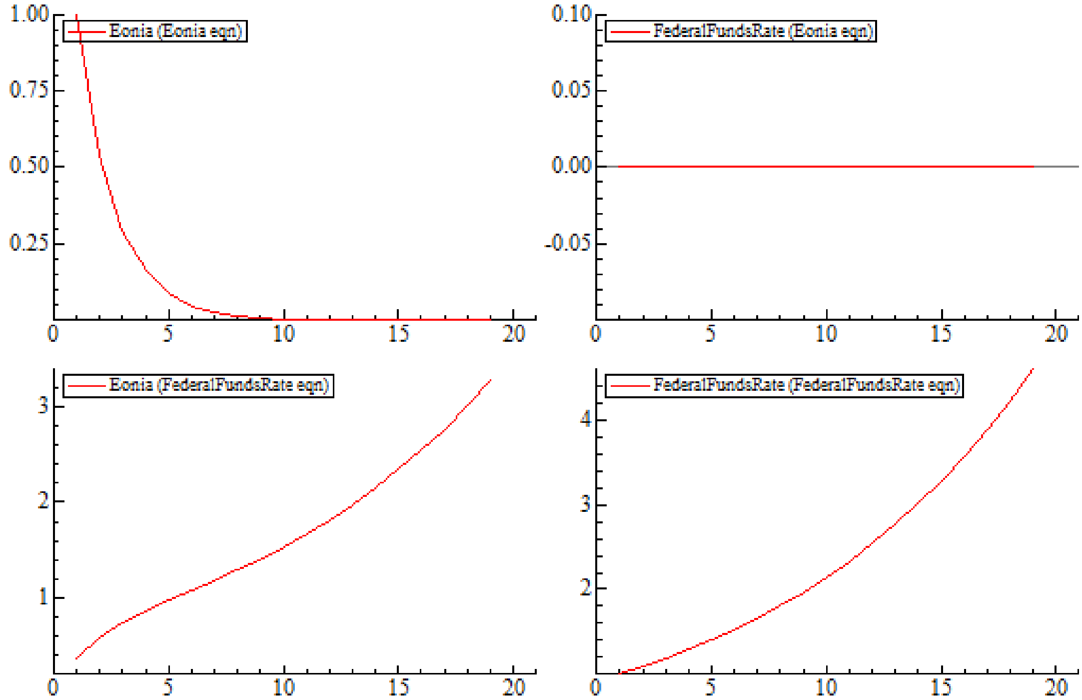

Figure B.5: Impulse Response for CFIML, October 2014 WEO (1995-2013), LMCI Measure

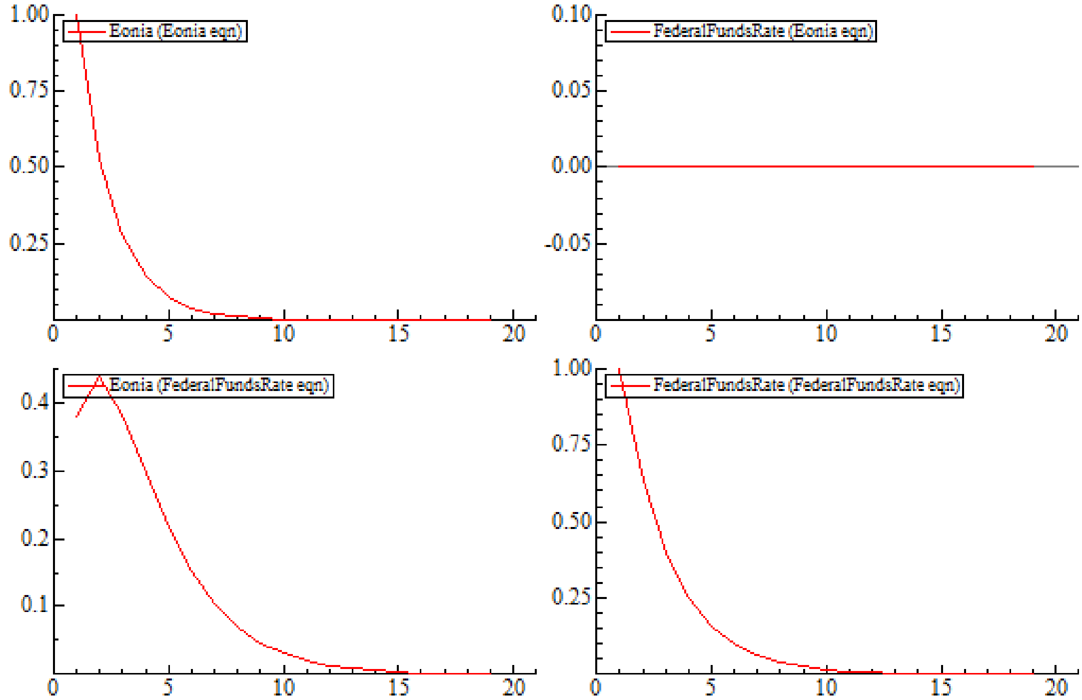

Figure B.6: Impulse Response for CFIML, October 2016 WEO (1995-2013), Output Gap Measures

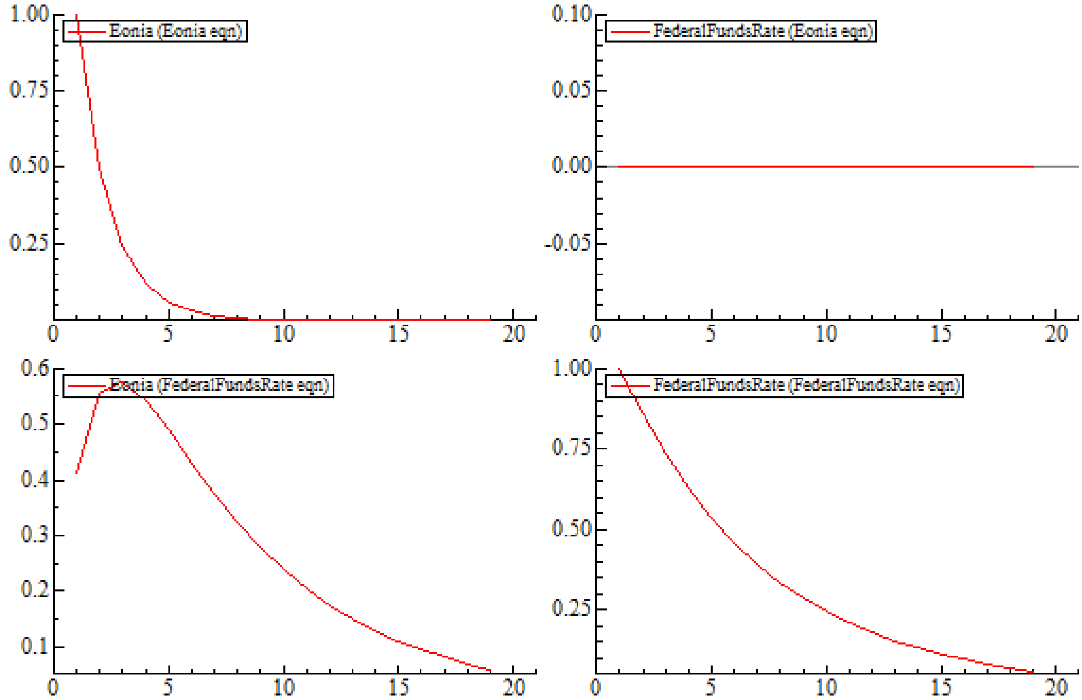

Figure B.7: Impulse Response for CFIML, October 2016 WEO (1995-2013), Unemployment Measures

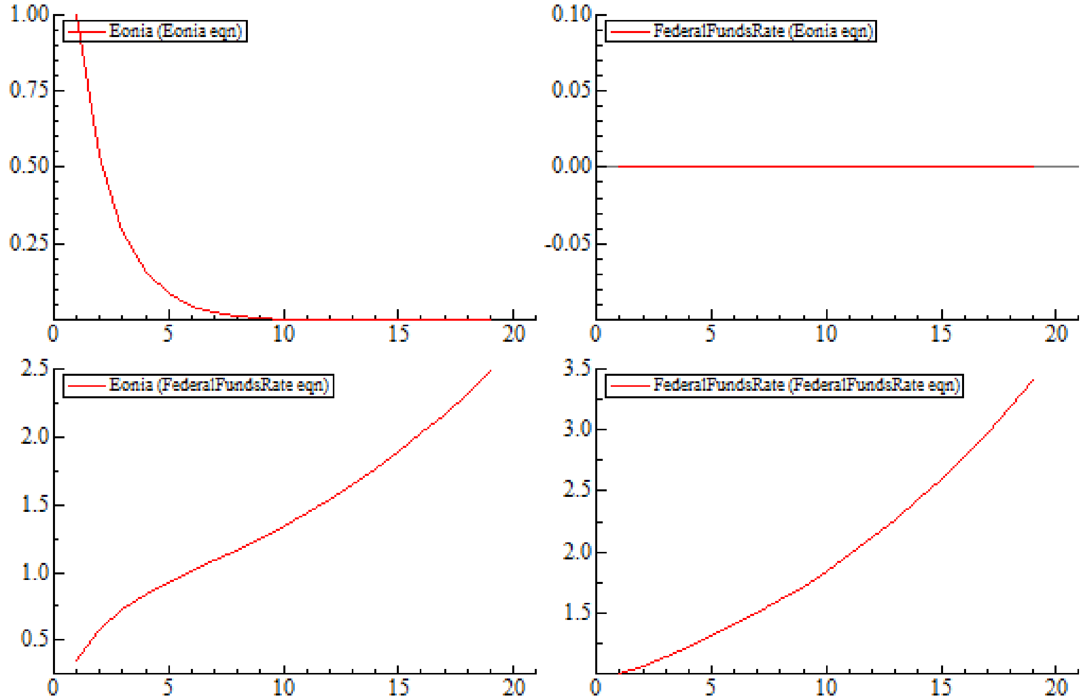

Figure B.8: Impulse Response for CFIML, October 2014 WEO (1995-2013), LMCI Measure

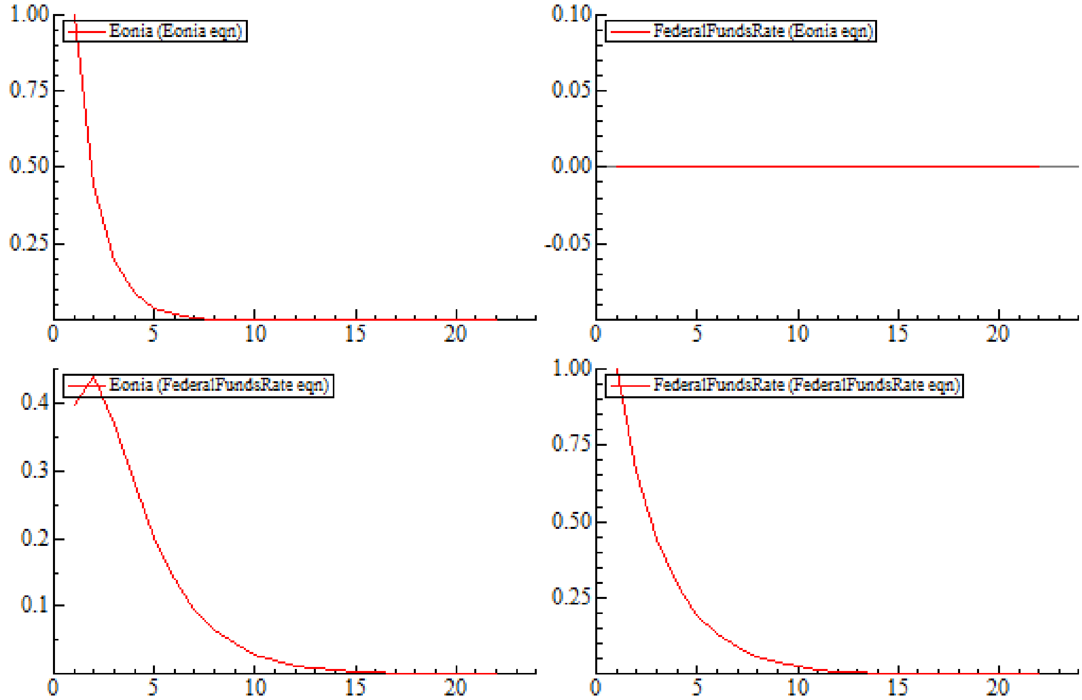

Figure B.9: Impulse Response for CFIML, October 2016 WEO (1995-2016), Output Gap Measures

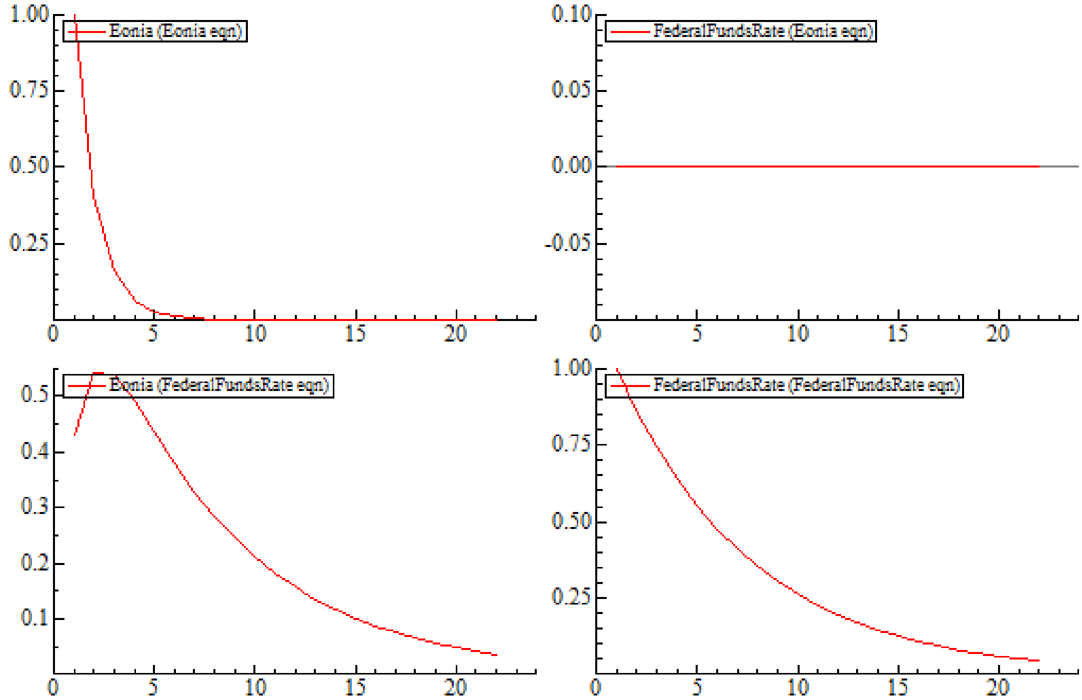

Figure B.10: Impulse Response for CFIML, October 2016 WEO (1995-2016), Unemployment Measures

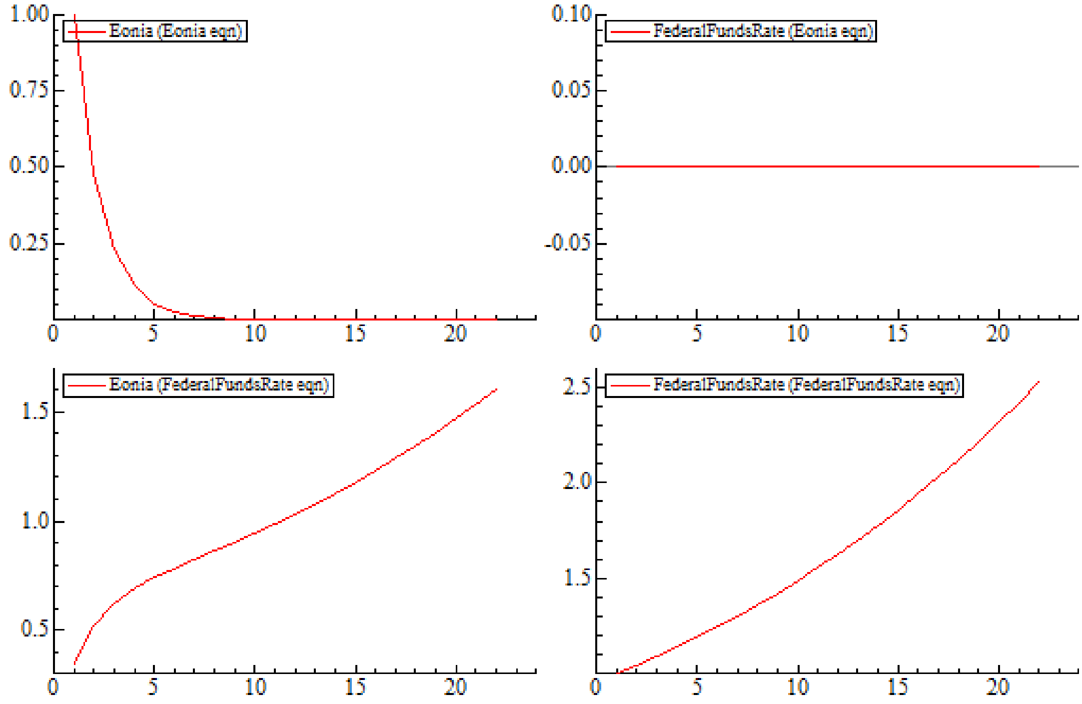

Figure B.11: Impulse Response for CFIML, October 2014 WEO (1995-2013), LMCI Measure

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