Appendix

Appendix A: Alternative Models Diagnostic

We first wanted to implement a developed model**, Model 1**, with 6 variables:

- Euro Area Inflation
- EA GDP growth
- Euribor 3m yoy change
- Euro Real effective exchange rate (account for external impact)
- EA Government expenditure yoy growth (account for fiscal policies)
- Corporate loans yoy growth (account for banking industry)

Table A.1 shows that the diagnostic of this model was poor, but the stability was good.

Model 2: in the US, the Fed must also target full employment. We wanted to include employment to measure its interactions with monetary policy in Euro Area. Here, we took the yoy change of Unemployment to have a stationary series, but the implemented model had a very poor diagnostic. The system was unstable, the cumulative sum of the recursive residuals in the stability plot were almost reaching the boundaries.

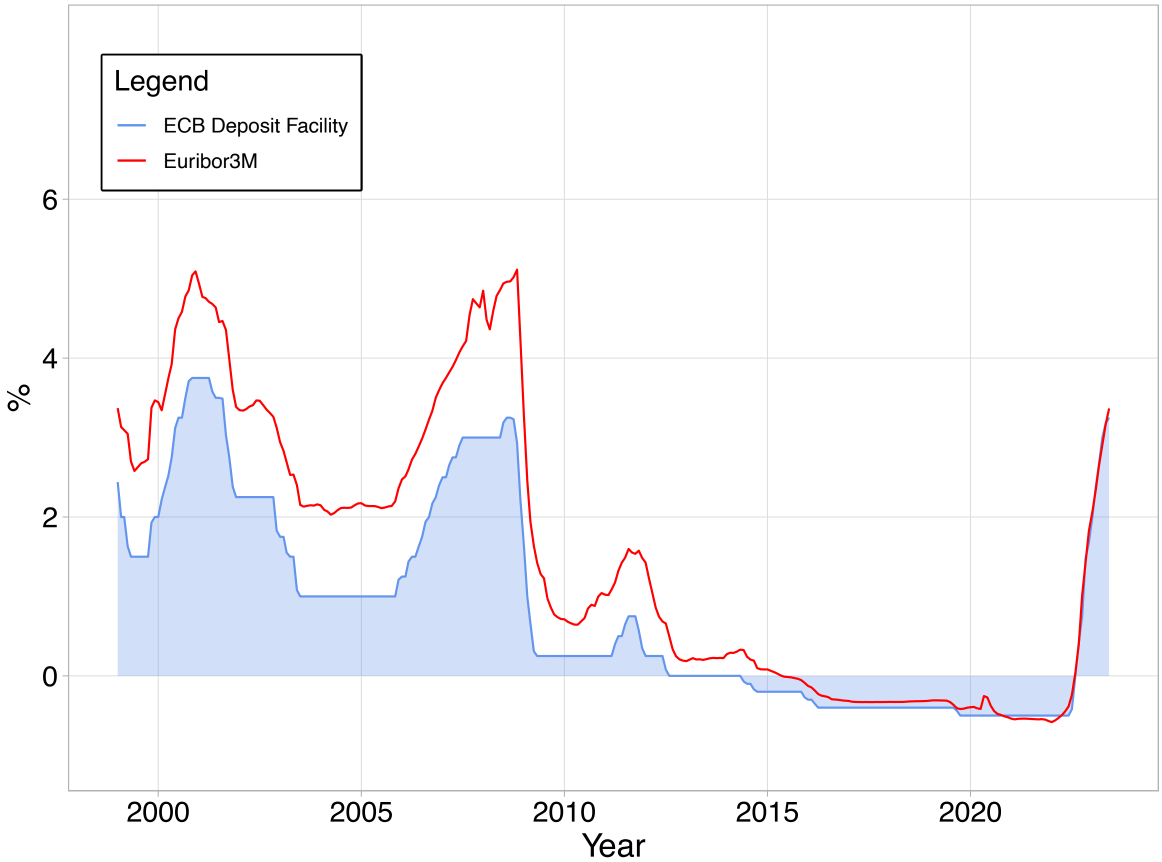
Model 3: As explained in chapter 2, Exchange rate is one of the transmission channels used for monetary policy to influence the economy. We considered a model with our 3 basis variables and EA Real Effective Exchange Rate to assess its impact in monetary policy transmission. The system was unstable, the cumulative sum of the recursive residuals in the stability plot were almost reaching the boundaries, and diagnostic tests were unfavorable.

Table A.1: Diagnostic tests of our alternative models

	Serial Correlation test	**Normality test**	**Heteroscedasticity**	**Stability**
Criteria	***p-value > 0.05***	***p-value > 0.05***	***p-value > 0.05***	***Plot within boundaries***
Model 1	< 0.01	<< 0.01	< 0.01	OK
Model 2	<< 0.01	<< 0.01	<<0.01	Not OK
Model 3	<< 0.01	<< 0.01	<<0.01	Not OK

Appendix B: Interest rates comparison

Figure B.1: ECB Deposit Facility vs Euribor-3m



Source: ECB Data Portal https://data.ecb.europa.eu/#dashboard-tab-1

The plot shows a big similarity between ECB deposit facility and Euribor-3m evolution. Hence, we assumed Euribor-3m was a good choice to include in our model estimations.

Appendix C: Estimated VAR Model Coefficients

Table C.1: Estimated VAR Model Coefficients

	$GDP\ growth$	$Inflation$	$Euribor3m$
$GDP.l1$	1.774 ***	-0.029	0.029 .
$Infl.l1$	0.302 **	1.104 ***	0.030
$E3M.l1$	0.178	0.121	1.688 ***
$GDP.l2$	-0.801 ***	0.082	-0.030
$Infl.l2$	-0.224	0.038	0.008
$E3M.l2$	-0.093	-0.221	-0.924 ***
$GDP.l3$	-0.802 ***	-0.016	-0.008
$Infl.l3$	-0.041	-0.214 *	-0.014
$E3M.l3$	0.186	0.177	0.368 **
$GDP.l4$	1.403 ***	-0.070	0.054
$Infl.l4$	-0.286 .	0.172 .	-0.019
$E3M.l4$	-0.298	-0.211	-0.112
$GDP.l5$	-0.640 ***	0.082	-0.064
$Infl.l5$	0.048	-0.242 *	-0.022
$E3M.l5$	0.005	0.052	-0.110
$GDP.l6$	-0.410 *	0.045	0.018
$Infl.l6$	0.113	0.246 *	0.000
$E3M.l6$	0.324	-0.047	0.110
$GDP.l7$	0.693 ***	-0.191 .	0.036
$Infl.l7$	0.102	0.131	0.044
$E3M.l7$	-0.348	0.071	0.030
$GDP.l8$	-0.305 .	0.086	-0.058
$Infl.l8$	-0.082	-0.299 **	0.005
$E3M.l8$	-0.079	-0.112	-0.164

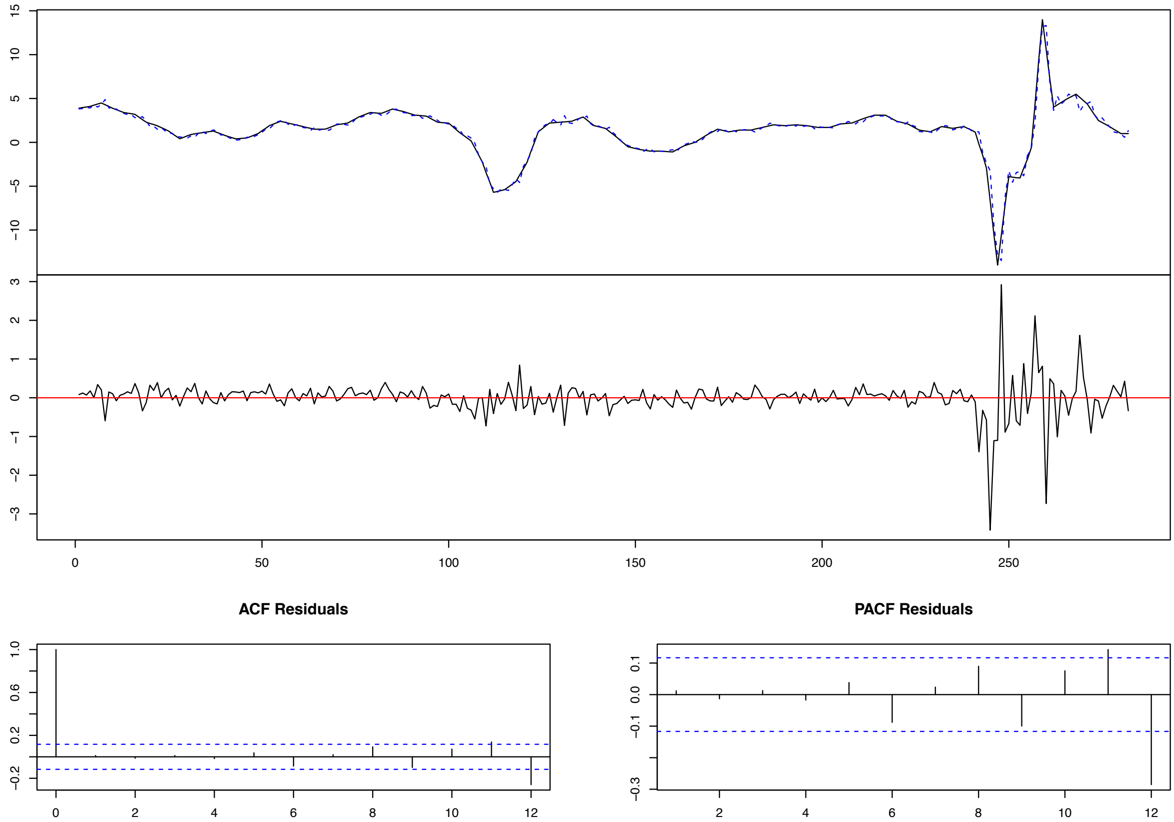
$GDP.l9$	0.136	0.129	0.034
$Infl.l9$	-0.129	0.043	-0.019
$E3M.l9$	0.610	0.251	-0.014
$GDP.l10$	-0.247 .	-0.181 *	-0.011
$Infl.l10$	0.061	-0.000	-0.030
$E3M.l10$	-0.710	-0.119	0.275 *
$GDP.l11$	0.060	0.075	-0.040
$Infl.l11$	0.237	0.143	0.0279
$E3M.l11$	0.297	0.014	-0.447 ***
$GDP.l12$	0.046	-0.003	0.030 .
$Infl.l12$	-0.216 .	-0.202 **	0.001
$E3M.l12$	0.017	-0.003	0.218 ***
$Const$	0.179 .	0.129 **	-0.042 *

$Notes$: $gdp.l1$ means coefficient associated with the lag one value of the GDP growth.

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Appendix D: VAR diagnostics plots

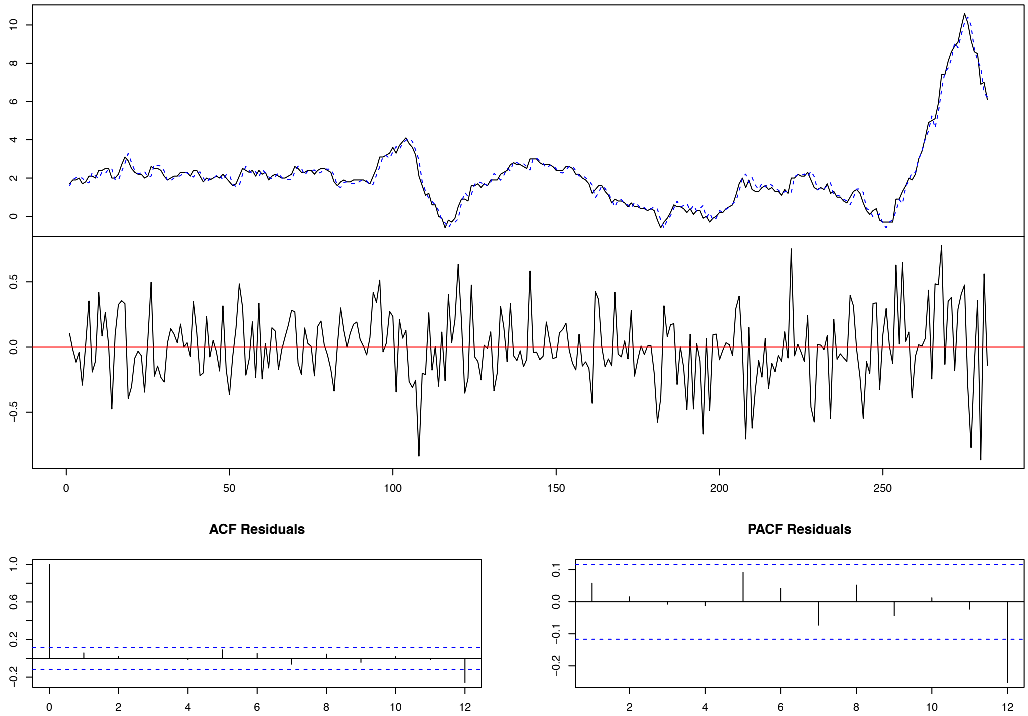
Figure D.1: Diagram of fit and residuals for GDP growth



Notes: Generated with our 3-variables VAR model estimated on monthly data from January 1999 to June 2023.

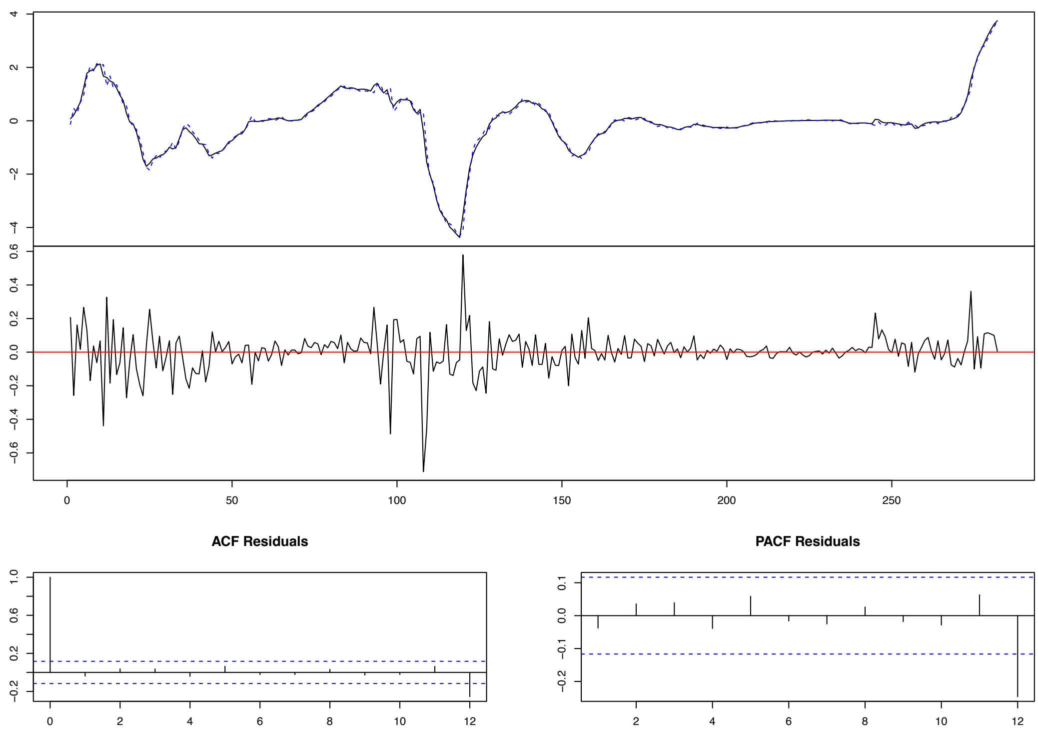
The plots D.1, D.2 and D.3 show how accurately our model estimations fits to the data. The Autocorrelation function plots of the residuals show no autocorrelation as the spikes quickly drop within the boundaries.

Figure D.2: Diagram of fit and residuals for Inflation



Notes: Generated with our 3-variables VAR model estimated on monthly data from January 1999 to June 2023.

Figure D.3: Diagram of fit and residuals for Euribor 3m change



Notes: Generated with our 3-variables VAR model estimated on monthly data from January 1999 to June 2023.

Appendix E: Main R Code

```
library(readr)
library(tidyverse)
library(dplyr)
library(lubridate)
library(ggplot2)
library(tseries)
library(urca)
library(lmtest)
library(vars)
library(forecast)
library(svars)

## Loading Data ##
EA_hicp <- read_csv("EA_hicp.csv")
gdp_growth <- read_csv("GDP_Growth.csv")
euribor3m_gr <- read.csv("Euribor3m_gr.csv")

dat_matrix <- data.frame("date"=EA_hicp$Date, "gdp_growth"=gdp_growth$GDP,
                         "infl"=EA_hicp$HICP, "ir"=euribor3m_gr$E3M)

ts_gdp <- ts(gdp_growth$GDP, start=c(1999,1), end=c(2023,6), frequency = 12)
ts_infl<- ts(EA_hicp$HICP, start=c(1999,1), end=c(2023,6), frequency = 12)
ts_ir <- ts(euribor3m_gr$E3M, start=c(1999,1), end=c(2023,6), frequency = 12)
autoplot(cbind("GDP growth" = ts_gdp, "Inflation" = ts_infl,
               "Euribor 3m" = ts_ir), facets=TRUE) +
  xlab("Year") + ylab("%")
```

```
#### PART 1: DATA VALIDITY TESTING ####

# Stationarity Test #
# Augmented Dickey Fuller Test:
adf.test(EA_hicp$HICP) # OK 0.03
adf.test(gdp_growth$GDP) # OK 0.03
adf.test(euribor3m_gr$E3M) # OK < 0.01


# KPSS Unit Root Test #
EA_hicp$HICP %>% ur.kpss() %>% summary() # OK 0.382 < 0.463
gdp_growth$GDP %>% ur.kpss() %>% summary() # OK 0.182 < 0.463
euribor3m_gr$E3M %>% ur.kpss() %>% summary() # OK 0.238 < 0.463


#### PART 2: Reduced-form VAR MODEL ####
dat_model <- data.frame("gdp_growth" = dat_matrix$gdp_growth,
                   "inflation" = dat_matrix$infl, "euribor3m" = dat_matrix$ir)

# Lag order selection
lag_max = round((12*(nrow(dat_model)/100)^(1/4)),0)
VARselect(dat_model, lag.max=lag_max, type="const")[["selection"]]

# Reduced form estimate
var_model <- VAR(dat_model, p=12, type="const")

## Model diagnostics ##
summary(var_model)

#Serial Correlation
serial1 <- serial.test(var_model, lags.pt = 60, type = "PT.asymptotic")
```

```
serial1

#Normality test of the residuals
norm1 <- normality.test(var_model)
norm1$jb.mul

#Heteroscedasticity:
arch1 <- arch.test(var_model, lags.multi = 36)
arch1

#Testing for structural breaks in the residuals
Stability1 <- stability(var_model, type="OLS-CUSUM")
plot(Stability1)

#Impulse Response function
# INFLATION
irf_irXinfl <- irf(var_model, impulse="euribor3m", response="inflation", n.ahead=24, runs = 1000)
irf_irXinfl_cum <- irf(var_model, impulse="euribor3m", response="inflation", n.ahead=24, runs=1000, cumulative = TRUE)
plot(irf_irXinfl, main = "", xlab = "Time (month)", ylab = "Inflation (% change)")
plot(irf_irXinfl_cum, main = "", xlab = "Time (month)", ylab = "Inflation (% change)")

# GDP
irf_irXgdp <- irf(var_model, impulse="euribor3m", response="gdp_growth", n.ahead=24, runs= 1000)
irf_irXgdp_cum <- irf(var_model, impulse="euribor3m", response="gdp_growth", n.ahead=24, runs=1000, cumulative = TRUE)
plot(irf_irXgdp, main = "", xlab = "Time (month)", ylab = "GDP Growth (% change)")
plot(irf_irXgdp_cum, main = "", xlab = "Time (month)", ylab = "GDP Growth (% change)")
```

```
#### PART 3: Structural VAR MODEL ####
svar_model1 <- id.dc(var_model)

irf_svar1 <- irf(svar_model1, n.ahead=24)
plot(irf_svar1)

fevd1 <- fevd(svar_model1, n.ahead = 12)
plot(fevd1)

hd1 <- hd(svar_model1, series = 2)
plot(hd1)
```