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European Exchange Rate Adjustments in Response to COVID-19, Containment Measures and Stabilization Policies

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Abstract

This paper estimates the effects of nine exchange rates for european countries vis-a-vis the Euro in the COVID pandemic. Using data on COVID cases, three containment and two stabilization measures relative to the euro area counterparts, it is shown that a more severe spread of the virus leads to a depreciation of the domestic currency. The same holds with respect to stricter movement restrictions, health care measures and more supportive monetary policies. More expansionary fiscal policies by the domestic country on the other hand lead to an appreciation of the currency. Two extensions show that the results differ with respect to whether the country is a scandinavian or eastern european country and whether the euro area countries or the other european countries introduce the measures.

Keywords: Exchange rates, COVID-19, Europe, stabilization policies, containment measures, panel VAR

JEL classification: E44, E52, E62

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1 Introduction

The COVID pandemic, starting in 2020, had large effects on financial markets. While it is well documented with respect to e.g. stock prices (see among others Heyden and Heyden 2020, Baker et al. 2020, Feyen et al. 2021, Kapar et al. 2021, Klose and Tillmann 2021, Rehman et al. 2021, Davis et al. 2022, Klose and Tillmann 2022, Klose and Tillmann 2022a or Shafiullah 2022), the empirical evidence on exchange rates is still quite scarce. Some notable exceptions are Narayan (2020), Feng et al. (2021), Konstantakis et al. (2021), Li et al. (2021), Zhou et al. (2021), Aquilante et al. (2022) or Beckmann and Czudaj (2022). Nevertheless, the COVID crisis can be seen as a rare disaster and as such it is supposed to have effects on the exchange rate (Farhi and Garbaix, 2016).

The COVID crisis is also special due to the mix of containment and stabilization measures introduced by the policymakers. So besides the pure spread of the pandemic also these policy changes have to be taken into account. This is exactly what we do by building different dimensions in containment as well as stabilization policies and try to quantify the effects of those on bilateral exchange rates towards the Euro. Differentiating between the dimensions is necessary since different containment and stabilization measures may influence financial market variables in a different way or to a different extent. Therefore, we divide containment measures into three categories: First, measures of closures, second, measures of movement restrictions and third, measures to support health care. While we would e.g. suppose that the prior two measures lead to a depreciation of the currency once they become stricter compared to the foreign country, this is less clear with respect to health care measures as e.g. better vaccination policies may result in an economy recovering faster thus inducing an appreciation, while the reverse may be true with respect to facial coverings obligations or requirements to protect elderly people.

The same holds with respect to stabilization policies. Here we differentiate into fiscal and monetary policies. While more expansionary fiscal policies in the domestic country should induce an appreciation, the reverse would be true with respect to a more expansionary monetary policy in the home country.

This being said it is always important to look at relative differences in the spread of the pandemic and the various containment and stabilization policies. We do so by using the spot exchange rates of nine european countries vis a vis Euro and build the relative differences between the countries and the euro area with respect to the spread of COVID cases, the three containment and two stabilization measures besides the price differences as a natural determinant of exchange rate adjustments. Those nine exchange rates are estimated jointly in a panel-VAR to identify common evolutions over all countries. However, we also split-up the sample as robustness checks according to different dimensions. These are on the one hand, only countries with a completely flexible exchange rate towards the euro and on the other hand geographical differences. Moreover, we check whether there are differences if we take not the whole euro area but only the five largest countries into account and whether euro area or other european countries are responsible for the change in the exchange rates.

The results indeed indicate first, the domestic currency depreciates once the pandemic gets more severe at home than in the euro area. Second, stricter movement restrictions and health care measures at home than in the euro area lead to a depreciation of the domestic currency. Third, more expansionary fiscal policies at home lead to a appreciation of the domestic currency while the reverse is true with respect to more expansionary monetary policies.

The remainder of the paper is organized as follows: In section 2 we present a literature review. Section 3 documents the data used and the construction of the various variables. In section 4 we explain the panel-VAR model used. Section 5 presents the results, while section 6 finally concludes.

2 Literature review

This paper is related to various strands of literature. Quite obvious is the connection to the topic of exchange rate determination in the COVID crisis. In this nexus Narayan (2020) is to the best of our knowledge the first to present empirical results. Using hourly data of the Yen/US-Dollar exchange rate he shows that the emergence of the COVID crisis changed the exchange rate from being non-stationary to a stationary process. So he concludes that the crisis has changed the resistance of the Yen to shocks. Feng et al. (2021) estimate using a system GMM approach the exchange rate volatility of 20 currencies. They find that an intensification of the crisis leads to higher volatility as well as containment measures applied while the reverse is true with respect to government stabilization measures. Focusing on the Euro/US-Dollar exchange rate Konstantakis et al. (2021) evaluate whether the COVID crisis has changed the role of fundamentals. They find that this is indeed the case. Li et al. (2021) use the US-Dollar and Yuan exchange rate towards the Euro to estimate the short and long term effects of COVID cases and deaths. They find that the domestic currency depreciates with a rising spread of the virus at home. Most notably, this is not only a short lived effect but seems to have also long term consequences. Zhou et al. (2021) estimate the effects of the COVID pandemic and fiscal as well as monetary stabilization measures for 27 industrialized or developing countries. They can indeed show that there are differences between these two groups, either with respect to the spread of the pandemic but also with respect to the effectiveness of stabilization policies. Using effective exchange rates for 57 countries Aquilante et al. (2022) estimate panel-VARs just like we do with respect to the spread of the pandemic and aggregated containment as well as government support measures. They find that a higher number of new COVID cases tend to depreciate the currency, while containment and support measures are not found to exhibit a significant influence. The latter result may be possibly due to the high level of aggregation in the data and in the fact that those measures are not measured relative to what the other countries have done. Finally, Beckmann and Czudaj (2022) estimate the response of abnormal returns in exchange rate forecasts to containment and government fiscal responses in the COVID crisis for 65 bilateral exchange rates with the US-Dollar. The authors show that these measures can indeed explain part of the excess returns.

Of course the response of the exchange rates to the COVID pandemic can also be seen in the broader context of exchange rate adjustments in times of crises or rare disaster events. E.g. Fratzscher (2009) or Beckmann and Czudaj (2017) conduct empirical studies with respect to the global financial crisis of 2008/09, although those studies naturally focus more on the changing influence of macroeconomic fundamentals and not on integrating new determinants like it is the case in the COVID crisis.

Finally, this paper tackles the issue of the effects of exchange rates on changes in monetary or fiscal policies. While the response of the exchange rate to monetary shocks is well known (see e.g. Dornbusch 1976 or Eichenbaum and Evans 1995), the role of fiscal policy shocks is less certain. Monacelli and Perotti (2010) find in a VAR framework that the real exchange rate tends to depreciate in the wake of a government spending shock. Using the very same model class Kim and Roubini (2008) find, that a higher fiscal deficit leads to a depreciation of the currency. But Alberola et al. (2021) argue that also an appreciation is possible, since the reaction of the currency depends crucially on whether the additional debt accumulated by government spending is backed future fiscal surpluses.

This paper fits into this literature in several ways: First, we are the first paper to focus exclusively on european countries and thus on countries that, if not part of the euro area itself, are having their highest trading shares with countries of the euro area, thus the euro area is the natural counterpart for our analysis. Second, we focus on the spread of the virus as well as containment and stabilization measures simultaneously. To do so, we constructed, third, on a very detailed database to model various sectors of containment policies as well as fiscal and monetary stabilization measures separately.

3 Data

This section describes in detail, how the variables used in the VAR model are constructed, including those of the robustness checks and extensions performed. In total, we collected data from the 19 member countries of the euro area and of nine other european countries. These are Croatia, the Czech Republic, Denmark, Hungary, Iceland, Norway, Poland, Romania and Sweden.[1] The sample period covers daily data (excluding weekends) for the years 2020 and 2021. Since we use the number of COVID infections as one explanatory variable, the sample starts for most countries in late January 2020 or February 2020 as the first cases in the sample countries were reported at that time.

3.1 The construction of the variables

Since we want to compare the reaction of exchange rates of nine countries towards the Euro, we first have to construct euro area wide data. Since only stabilization measures are conducted on a euro area level by the common central bank, the European Central Bank (ECB), all other country specific variables need to merged to a euro area wide aggregate. In order to do so, we construct euro area variables for the number of COVID infections by adding up the individual infections in all 19 euro area countries. For containment and fiscal stabilization indices those are weighted averages of the 19 national indices. The weighting is determined by the share of each countries' GDP in 2019 as the last year being not influenced by the COVID pandemic.

As an indicator of the state of the pandemic, we use the reported daily growth rate total infections. Since the reporting differs in the countries by the weekdays, we use five day averages to account for this effect. All other variables are matched to this procedure accordingly. This holds i.e. for the exchange rates, for which we calculate the five-day moving average of the daily growth rates from bilateral nominal exchange rate of the european country towards the Euro. The data are taken from the ECB data warehouse. This implies that a rise in the exchange rate is always associated with an appreciation of the Euro and vice versa. As the fundamental variable determining exchange rate changes, we take the 5 day moving average of

[1]Data on containment and i.e. stabilization measures are also available for Bulgaria, but since Bulgaria has a completely fixed exchange rate to the Euro it is excluded from the analysis.

inflation rate in the euro area and other european countries as published by the yearly growth rate of the harmonized index of consumer prices (HICP) by Eurostat. With respect to the containment and stabilization indices we take the 5 day moving average of the change in the index as the indicator. Since the exchange rate, being the variable we want to explain, is by construction dependent on either developments in the one european country as well as the euro area, we have constructed relative variables using the following formula:

$$y_{it} = z_{it} - z_{EAt}. \tag{1}$$

Here z_{it} are the variables COVID cases, inflation rates, containment and stabilization measures as explained above for the other european countries i on a certain day t, while z_{EAt} is the corresponding value on the same day for the euro area. This being said, y_{it} is the relative change of the respective variable in the other european country relative to the euro area. So e.g. a rise in y_{it} signals that z_{it} is rising faster than z_{EAt}.

Containment measures: One of the main contributions of this paper is the construction of the containment and stabilization measures initiated in various policy areas. We retrieve our containment data from the University of Oxford COVID-19 government response tracker (Hale et al., 2021). This database contains ordinal values of various containment measures. We divide these measures into three groups: (1) closure measures, (2) measures to restrict the movement of people and (3) health system measures.

The first two jointly form the stringency index calculated by the University of Oxford. However, we follow Klose and Tillmann (2022, 2022a) in the construction of this variable as they have shown that closure and movement restrictions may have very different effects on stock prices. More precisely, the closure subset consists of four different measures being school closures, workplace closures, cancellation of public events and restrictions on gatherings. Movement restrictions are also comprised out of four different measures, which are closing of public transport, stay-at-home requirements, restrictions on internal movement and international travel controls. Finally, the health system index is comprised out of six different measures being public information campaigns, testing policies, contact tracing, facial coverings, vaccination policies and protection of elderly people. The different measures and their ordinally steps are described in detail in Table 1.

For all three groups of measures, we compute an index strongly in line with the method described in Hale et al. (2021) in order to construct the stringency index.

This means each indicator is transformed into a variable ranging from 0 (no measure taken) to 100 (strictest measure taken) using the following formula

$$x_{it} = 100 \times \frac{m_{it}}{M_i}. \quad (2)$$

Here, x_{it} is the transformed 0-100 variable of a measure i at day t, m_{it} is the ordinal value of the very same measure at the same time and M_i is the maximum ordinal value the measure can take. For most of the measures, moreover, a flag value is reported, signaling whether the measure taken applies generally or is targeted to certain groups only. Those targeted measures may be either focused geographically or with respect to who has to pay the associated costs of an action. Details are presented in Table 1.

In case a flag value exists, equation (1) changes to

$$x_{it} = 100 \times \frac{m_{it} - 0.5(1 - f_{it})}{M_i}. \quad (3)$$

In this equation, f_{it} is the flag variable of a certain measure i at day t. The flag value takes the value of 1 if the measure is generally introduced and 0 if it is targeted. This flag variable guarantees that, if the measure is only targeted, the ordinal value is lowered by the factor 0.5. In case of no actions taken (thus m_{it} being zero), the flag variable is always 1, so that the transformed variable cannot become negative. The transformed variables are finally merged together by taking the arithmetic mean of the three different groups explained above, thus forming the closure, movement and health index. This being said, an increase in these indices signals a higher level of containment measures.

Stabilization measures: The second type of policy actions comprises stabilization measures taken in order to dampen the economic downturn associated with the COVID crisis. These stabilization measures are divided into two different groups. On the one hand national fiscal policy and on the other hand monetary policy. Both policy areas consist of different measures that can and have been taken by fiscal authorities and central banks. The different measures and the construction of the policy variables out of them, are described in detail in Table 2. It is important to note that we use the date of the announcement of a specific measure, not the data of its implementation, as the former is the key driver of market expectations and should thus trigger stock price changes.

The first group of national fiscal policies is comprised out of four different measures. In order to rely on a consistent database, we use the ESRB COVID-19 policy measures database.[2] First, fiscal impulse, comprising all direct capital injections by the federal government. In the ESRB database, those are recorded as either direct grants, tax reliefs, or equity participation. The second group consists of fiscal liquidity injections, thus measures that provide liquidity which has to be repaid at some future point in time or public guarantees. This measure is build as the sum of the positions public loans, public guarantees and public support for trade credit insurance in the ESRB-database. The third group are deferrals summarizing the positions tax deferrals as well as public or private moratoria in the database. The fourth category is other measures of fiscal nature. Since all of the policy actions in the ESRB database are measured in millions of national currency, we divided these volumes by the GDP in 2019 of the respective country in order to make the scale comparable across countries.

We merge all four of our measures using

$$x_{it}^{fiscal} = x_{it-1}^{fiscal} + \text{impulse}_{it} + 0.5 \times (\text{liquidity}_{it} + \text{deferral}_{it} + \text{other}_{it}). \tag{4}$$

Thus, the fiscal index of country i at day t is build by its lagged value plus the four different policy measures at day t. The weight of the fiscal impulses is twice as high as for the remaining measures as direct capital injections should have a larger effect than the other three measures.[3]

The second group are monetary policy measures. Those events are retrieved from the web pages of the the national central banks or from the ECB in case the country is a member of the euro area. Again, we divide the different policies into four subcategories. The first are interest rate changes, i.e. conventional monetary policy steps. Those are measured in changes in percentage points of the key interest rate. The second measure are announcements of new refinancing operations. Since the actual uptake and, hence, the magnitude of the stimulus is unknown at the time of announcement, we measure this as a 0/1 variable, meaning with every new refinancing operation announced the variable takes the value of 1 and 0 otherwise. The third set of policy events are announcements of new purchase programs. Since the quantitative amount of those measures is precisely communicated by the central banks at the time of announcement, we again divide the volume by the GDP in 2019 to make the magnitudes comparable across countries. In the fourth set of monetary policy measures we subsume all additional actions. These are e.g. changes in the

[2]The complete dataset can be retrieved from https://www.esrb.europa.eu/home/search/coronavirus/html/index.en.html.

[3]However, we also checked alternative weighting assumptions, i.e. an equal importance of all four measures or an even higher weight on impulses. The estimation results are almost equal to those from our most preferred weighting. The results are available upon request.

minimum reserve requirements or changes in collateral standards. Since the nature of those policies differs, me measure them again as a 0/1 variable.

All four sets of monetary measures are added up to a monetary index as follows

$$x_{it}^{monetary} = x_{it-1}^{monetary} - 4 \times \text{rate}_{it} + \text{refinancing}_{it} + \text{purchase}_{it} + \text{additional}_{it}. \quad (5)$$

An increase in this index should reflect a more expansionary policy. Therefore, a reduction in the key interest rate is multiplied with the factor −4, so that a 0.25 percentage point decrease is comparable to an announcement of additional refinancing operations, additional measures or an increase in purchase programs with a volume of 1 percent of GDP.[4]

This can be also seen in Table 3 where we classify the number of all containment and stabilization events per country. In total, we have 2073 containment events, where the majority tends to be announcements of tighter containment policies. We identify 769 stabilization events. While all fiscal events are expansionary, only 23 out of 241 monetary policy events appear to be restrictive. An important caveat is warranted here: we classify announcements as expansionary or restrictive based on the nature of the policies released. It is conceivable, that an expansionary fiscal policy step falls short of what markets had anticipated. Such an announcement could effectively be restrictive in nature. Whether or not polices have the intended effects thus needs to be estimated. With the identified VAR model estimated below we are able to quantify the effective contribution of policies to the evolution of stock markets.

Finally, in Figure 1 we present the the evolution of the three containment and two stabilization indices for the euro area and the nine other european countries. For the containment, closure and movement indices the waves of the pandemic are clearly visible as reflected in stricter policies in the different waves. In contrast, the health containment and the stabilization indices are almost steadily increasing.

3.2 Robustness checks and extensions

In order to check the robustness of our results, we conduct four additional estimations. The first two are pure robustness checks, thus altering the database to form alternative specifications. The last two are extensions of the model, i.e. we split-up the sample along two different dimensions.

First, it may be argued that the exchange rate is not reacting to all changes in the

[4]Again, we also altered the weighting allowing for higher or lower weights of all four measures. However, the estimation results are almost equal across all modifications.

spread of the virus, containment and stabilization measures in the euro area. This holds i.e. with respect to small countries. In order to account for this, we changed the construction of the euro area wide data. Instead of using all 19 countries, we use only the data of the largest five euro area countries. These are Germany, France, Italy, Spain and the Netherlands. Those five countries account for about 81.5% of the euro area based on their share in 2019 GDP. The summing and averaging of the COVID, containment and stabilization for the five countries works in the same way as for the 19 countries data construction explained above.

Second, some of the nine countries apply a fixed exchange rate into certain bands towards the euro, thus the exchange rate is not completely free-floating and this may alter our results as there may be the need for monetary stabilization measures to fix the exchange rate at a certain level, even though COVID cases, containment and other stabilization measures would result in further appreciations or depreciations. To account for this, we excluded the two countries that at least to some extent fix there exchange rate from our analysis. These are Denmark and Croatia. Thus, we reestimate the model with only the remaining seven countries.

Third, our sample of non-euro area european countries consists of two different groups of countries. On the one hand there are the scandinavian countries Denmark, Iceland, Norway and Sweden who are generally viewed as highly developed countries. On the other hand we have the five eastern european countries Croatia, Czech Republic, Hungary, Poland and Romania who are among the least developed countries within the European Union. Since there may be differences between these two groups, we split-up the sample along the two country groups and reestimate the model for each group individually. Doing so allows us to identify structural differences between the two sets of countries.

Fourth, since our variables are always relative comparisons of one european country towards the very same variable of the whole euro area, changes in the exchange rate can stem from changes in the spread of the virus or containment and stabilization policies in the european country, in the euro area or both. In order to disentangle which country or area is responsible for the change in the exchange rate, we thus split-up the relative terms. Thus, we can identify whether the change in the exchange rate is primarily driven by changes in the other european country, the euro area or both. In order to make the impulse response functions comparable, we multiplied all euro area variables by minus one, so we can directly interpret the differences between euro area and other european country estimates.

4 Model

Our analysis is based on an estimated panel-VAR model. The cross-sectional dimension covers country differences to the euro area $i = 1, ..., N$, while the time dimension is $t = s+1, ..., T$. The VAR structure reflects the endogenous feedback between the state of the pandemic, the intensity of containment measures, the stance of monetary and fiscal policies and the dynamics on exchange rates. The estimated model is

$$\mathbf{A}\mathbf{y}_{it} = \mathbf{d}_i + \mathbf{F}_1\mathbf{y}_{it-1} + ... + \mathbf{F}_s\mathbf{y}_{it-q} + \varepsilon_{it}, \tag{6}$$

with q lags, where the $n \times 1$ vector $\mathbf{y}_{it}$ contains the endogenous variables. We include an $n \times 1$ vector $\mathbf{d_i}$ with country fixed-effects. The $n \times n$ matrices $\mathbf{A}$ and $\mathbf{F_1}, ..., \mathbf{F_q}$ contain the VAR coefficients. The structural shocks, which eventually drive all the endogenous variables, are collected in $\boldsymbol{\varepsilon}_{it}$ with $\boldsymbol{\varepsilon}_{it} \sim N(0, \boldsymbol{\Sigma}\boldsymbol{\Sigma}')$.

We estimate the VAR model with the following 8×1 vector of endogenous variables

$$\mathbf{y}_{it} = [Inflation_{it} \quad Cases_{it} \quad \mathbf{Contain_{it}} \quad \mathbf{Stab_{it}} \quad Exchange_{it}]' \tag{7}$$

where $\mathbf{Contain_{it}}$ is a 3×1 vector of the three containment measures and the 2×1 vector $\mathbf{Stab_{it}}$ includes the three economic stabilization measures x_{it}^{fiscal} and $x_{it}^{monetary}$. We include $q = 2$ lags of the endogenous variables. In light of the large dimension of the data set across time and across countries, the relatively large number of variables and parameters to be estimated should not be a concern.

We assume that $\mathbf{A}$ is lower-triangular such that the reduced-form model is

$$\mathbf{y}_{it} = \mathbf{c}_i + \mathbf{B}_1\mathbf{y}_{it-1} + ... + \mathbf{B}_s\mathbf{y}_{it-s} + \mathbf{A^{-1}}\boldsymbol{\Sigma}\varepsilon_{it}, \tag{8}$$

with $\boldsymbol{\varepsilon}_{it} \sim N(0, \mathbf{I}_k)$, where $\mathbf{c}_i = \mathbf{A^{-1}}\mathbf{d}_i$ and $\mathbf{B}_j = \mathbf{A^{-1}}\mathbf{F}_j$. $\boldsymbol{\Sigma}$ is an $n \times n$ matrix with standard deviations on the main diagonal.

This identification implies a restriction on the contemporaneous interaction of the endogenous variables. We posit that the exchange rate responds contemporaneously to all the other variables in the system. This is a plausible assumption given the instantaneous response of exchange rates to news. All other variables are assumed to respond to the exchange rates, but with a delay of at least one day. This also seems to be a fair assumption: the number of COVID cases and the containment measures should be largely independent from the exchange rate changes. Monetary and fiscal policies might respond to exchange rate changes, but a lag of one day is an innocuous assumption given the long decision processes in central bank committees, finance ministries and parliaments. Moreover, inflation rate differences are the most inertial variable and thus ordered at the beginning of the VAR model as this variable only changes once each month as the newest inflation data become available. Even though exchange rate changes as well as changes in policies are having an influence on inflation rates, this is clearly not contemporaneously but only becomes visible in inflation rates with a substantial lag.[5]

As we estimate the VAR model on a panel of exchange rates, this implies that the autoregressive coefficients are identical across exchange rates. So we assume that we obtain one set of impulse response functions summarizing the information from all exchange rates. Hence, we cannot differentiate the exchange rate response across countries. But to account for potential differences in the cross-section, a battery of different robust checks is applied, which also include sample-splits in the cross-section dimension.

5 Results

In this section, we present and discuss the results of the baseline estimation and the robustness checks as well as model extensions.

Baseline results: Starting with the baseline results, which are presented in Figure 2, we gain several insights. First, if the inflation rate differntial between one european country and the euro area increases, this tends to appreciate the Euro in line with theory. However, the effect appears to remain insignificant at a 95% level throughout. Second, if the number of COVID cases is growing stronger in the home country compared to the whole euro area this leads to a depreciation of the domestic currency. The effect tends to become significant after about five days. The maximum depreciation is reached after seven days. The reaction is rational as a more serious spread of the pandemic in one country is decreasing growth prospects, thus leading to a devaluation of the currency.

Third, the response of the exchange rate towards our containment measures appear to be positive but to a different extent. The response of the exchange rate towards closure differentials appears to be insignificant throughout. The currency of the domestic country tends to depreciate once movement restrictions are getting stricter than in the euro area. However, this effect becomes significant only after about seven days. But the reaction is rational as tougher movement restrictions

[5]However, we also checked for different orderings with respect to the inflation rate. But the results are not significantly influenced by this and available upon request.

tend to dampen growth prospects of the country applying those and thus leads to a depreciation of the currency. Finally, once a country is introducing additional health care measures, this also leads to a depreciation of the domestic currency. The effect is significant for the days three to eight after the shock appeared. This may be surprising since it could be assumed that introducing additional measures of this kind, may shorten the pandemic in time and also in the magnitude of people infected. But there is also another effect present, which is fear. Once people observe that more and more health care measures are applied, they more and more realize that the pandemic is threatening their life. Thus, they may react with e.g. going out, working or consuming less, which again dampens overall economic performance in the respective country.

Fourth, the response to our two stabilization measures differs. Once fiscal policy in the domestic country tends to be more expansionary than in the rest of the euro area this immediately leads to a appreciation of the domestic currency. The effect appears to be significant for about three days. This finding could have been expected as the fiscal stance in the remaining european countries was more favorable ahead of the crisis than in the euro area,[6] thus in line with Alberola et al. (2021) government intervention is expected to shorten the crisis and stabilize the economy, thus leading to higher growth prospects. The reverse is true with respect to monetary policy. Once monetary policy is more expansionary in the home country than the ECB this leads to a depreciation of the domestic currency. The effects is significant for a period of one to three days. The reaction is as expected as more expansionary monetary policy tends to increase inflation expectations and thus depreciate the domestic currency.

Results only five largest euro area countries: When reestimating the model defining only the five largest countries as euro area (Figure 3), there is hardly any change compared to the baseline results. This may be understandable since those five largest countries account for more than 80% of the overall economic performance in the euro area.

Results only for completely flexible exchange rates: By applying the model to cover only the seven countries with completely flexible exchange rates towards the Euro, so reestimating the model without Denmark and Croatia, we end up with the results presented in Figure 4. Again the results are almost unchanged

[6]In 2019 as the last complete year without being influenced by the COVID crisis the debt to GDP ratio of the euro area was about 84% while the average over the remaining european countries was only 47%.

to the baseline case with the one possible exception that the appreciation of the domestic currency to a more expansionary fiscal policy is now less significant. Thus, we can conclude from this analysis that the appreciation effect of fiscal policy is primarily driven Denmark, Croatia or both.

Results for geographical differences: Whether exchange rates of scandinavian and eastern european behave differently can be seen in Figure 5. There are indeed some substantial differences: First, the overall non-significance of the baseline model with respect to inflation tends to be driven by scandinavian countries. Only for eastern european countries we indeed find the expected highly significant depreciation of the domestic currency to rising inflation differentials. This effect lasts up to ten days.

Second, the highly significant impact of differences in COVID cases found in the baseline model is driven by scandinavian countries only, while this has no influence on the exchange rate of eastern european countries.

Third, exchange rates in Scandinavia and eastern Europe react differently to closure shocks. While this leads in eastern Europe to a highly significant depreciation of the domestic currency, the reverse seems to be true for scandinavian countries. But the estimates for the latter group appear to remain insignificant in all periods.

Fourth, the appreciation of the domestic exchange rate to a fiscal policy shock found in the baseline estimate, is solely driven by scandinavian countries, while there is no exchange rate response of eastern european countries in this context.

Results other european countries versus euro area: When finally looking at whether the exchange rate adjustment is driven by actions in the euro area or in the other european countries, we end up with the results in Figure 6. In fact, we find substantial differences: First, with respect to a shock in COVID cases only for the other european countries there tends to hold the depreciation of the domestic currency found in the baseline results, while the Euro would even appreciate if the pandemic spreads.

Second, the depreciation of the currency to health care measures is in the beginning solely driven by the actions in the euro area, while those in the other european countries appear to be insignificant. Both impulse responses converge only after about seven days.

Third, the initial appreciation of the currency towards fiscal policy shocks is true for both groups of countries. However, when looking at the euro area this effects turns into a depreciation after about six days and stays significant until day fourteen. This depreciation is reasonable in this context as the euro area as a whole has less fiscal space and thus after an initial euphoria on the financial markets leading to the appreciation, those realize that this may not be sustainable, thus the Euro depreciates after some time.

Fourth, while the currencies depreciate to an expansionary monetary policy shock, the effect is on impact higher in the other european countries. But for the euro area the effect tends to be more long lasting. This is also reasonable since monetary policy in other european countries was mainly done via conventional monetary policy, thus interest rate changes. For those financial markets know how to react and thus the response is immediate. The ECB, however, had to conduct unconventional monetary policies, since the zero lower bound was already reached before the crisis hit. But markets do not have the same kind of experience with those programs and therefore the response in the exchange rate comes only with a delay.

6 Conclusions

In this paper we have shown in a panel-VAR framework for nine european exchange rates that those change with the number of COVID infections, and underlying containment and stabilization measures introduced by policymakers. We have shown that the response of the exchange rate depends crucially on the type of containment measure introduced and that fiscal and monetary stimuli result in appreciation and depreciation, respectively.

In two extensions of the model we have shown that the effects are different depending on whether exchange rates to scandinavian countries or eastern european countries are investigated and that their are differences in the response if the euro area or the other european countries are adjusting their policies.

This analysis leads to a number of policy conclusions: First, the COVID pandemic has effects on the exchange rates besides containment and stabilization measures introduced. Thus, also the pure spread of the pandemic is able influence the exchange rate if the cases are about to increase stronger in one country than in the other. Even though the main goal within the crisis is certainly not to stabilize the exchange rate but to safe lives and potentially to stabilize the economy, possible unwarranted effects on the exchange rate need to be taken into account.

Second, containment measures exhibit effects on exchange rates but to a different extent. While closure measure appear to have overall no effect on the exchange rate, movement restrictions and health care adjustments tend to depreciate the currency. So i.e. countries trying to stabilize the exchange rate need to act in those cases by e.g. restrictive monetary policies to counteract this development.

Third, macroeconomic stabilization policies do have very different effects on the exchange rate. This opens up the opportunity for a unilateral policy coordination of monetary and fiscal policy accommodation which keeps the exchange rate unchanged.

Fourth, most of the exchange rate reactions are driven mainly by the policies of either euro area or the other european countries. This being said, policy coordination on an international level becomes more important. This holds i.e. for the other european countries being typically influenced more by changes in the exchange rate than euro area countries. But also the euro area countries and the ECB should take unwarranted developments for their neighbor countries into account when introducing new policy measures.

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Tables

Table 1: Containment indicators

Indicator	Description	Ordinal Steps	General or Targeted Measure
Closure measures			
School closing	Closing of schools and universities	0 = No measure 1 = Recommend closing, or all schools open with alterations 2 = Require closing some levels 3 = Require closing all levels	Geographical 0 = Targeted 1 = General
Workplace closing	Closings of workplaces	0 = No measure 1 = Recommend closing, or work from home 2 = Require closing some sectors 3 = Require closing all but essential sectors	Geographical 0 = Targeted 1 = General
Cancel public events	Canceling public events	0 = No measure 1 = Recommend canceling 2 = Require canceling	Geographical 0 = Targeted 1 = General
Restrictions on gatherings	Cut-off size for bans on gatherings	0 = No restrictions 1 = Restrictions > 1000 people 2 = Restrictions 101-1000 people 3 = Restrictions 11-100 people 4 = Restrictions < 10 people	Geographical 0 = Targeted 1 = General
Movement measures			
Close public transport	Closing of public transport	0 = No measure 1 = Recommend closing or reduced volume, route, availability 2 = Require closing	Geographical 0 = Targeted 1 = General
Stay at home requirements	Orders to "shelter in place" and otherwise confine at house	0 = No measure 1 = Recommend not leaving home 2 = Require not leaving house with exceptions 3 = Require not leaving house with minimal exceptions	Geographical 0 = Targeted 1 = General
Restrictions on internal movement	Restrictions on internal movement	0 = No measure 1 = Recommend not to travel between regions and cities 2 = Internal movement restrictions in place	Geographical 0 = Targeted 1 = General
International travel controls	Restrictions on international travel	0 = No measure 1 = Screening 2 = Quarantine arrivals from high-risk regions 3 = Ban of arrivals from some regions 4 = Ban on all regions or total border closure	
Health systems measures			
Public information campaigns	Presence of public information campaigns	0 = No campaign 1 = Public officials urging caution about COVID-19 2 = Coordinated public information campaign	Geographical 0 = Targeted 1 = General
Testing policy	Testing strategies	0 = No testing policy 1 = Only to those who have symptoms and meet specific criteria 2 = Anyone with symptoms 3 = Testing for everyone	
Contact tracing	Use of measure to trace contacts	0 = No contact tracing 1 = Limited contact tracing (not for all cases) 2 = Comprehensive contact tracing (for all cases)	
Facial coverings	Policies of facial coverings outside home	0 = No policy 1 = Recommended 2 = Required in some situations 3 = Required all public places with other people present or all situations when social distancing is impossible 4 = Required outside home	Geographical 0 = Targeted 1 = General
Vaccination policy	Policies for vaccine delivery to different groups	0 = No availability 1 = Available to one of the following groups: Key workers, vulnerable groups, elderly groups 2 = Available to two of the following groups: Key workers, vulnerable groups, elderly groups 3 = Available to all of the following groups: Key workers, vulnerable groups, elderly groups 4 = Available to the three groups above plus partial additional availability 5 = Universal availability	Costs 0 = individual cost 1 = no or minimal individual costs
Protection of elderly people	Policies to protect elderly people	0 = No measure 1 = Recommended isolation, hygiene and visitor restrictions in Long Term Care Facilities (LTCF) or elderly people to stay at home 2 = Narrow restrictions for isolation, hygiene and visitor restrictions in LTCF or elderly people to stay at home 3 = Extensive restrictions for isolation, hygiene and visitor restrictions in LTCF or elderly people to stay at home	

Notes: Indicators and description based on Hale et al. (2021).

Table 2: Stabilization indicators

Indicator	Description	Measurement
Fiscal measures		
Impulse	Announcement of direct grants, tax reliefs and equity participation	Impulse as percent of national GDP 2019
Liquidity	Announcement of public loans, public guarantees public support for trade credit insurance	Liquidity as percent of national GDP 2019
Deferral	Announcement of tax deferrals, public or private moratoria	Deferral as percent of national GDP 2019
Other	Announcement of other measures of fiscal nature	Other measures as percent of national GDP 2019
Monetary measures		
Rate	Changes in the key policy rate	Change in percentage points
Refinancing	Announcement of additional and extraordinary refinancing operations	0 = No additional refinancing operation 1 = Additional refinancing operation
Purchase	Announcement of new or increases in purchase programs	Purchases as percent of national GDP 2019
Additional	Additional monetary policy measures, like e.g. changes in minimum reserve rate or changes in collateral standards	0 = No additional measures 1 = Additional measures

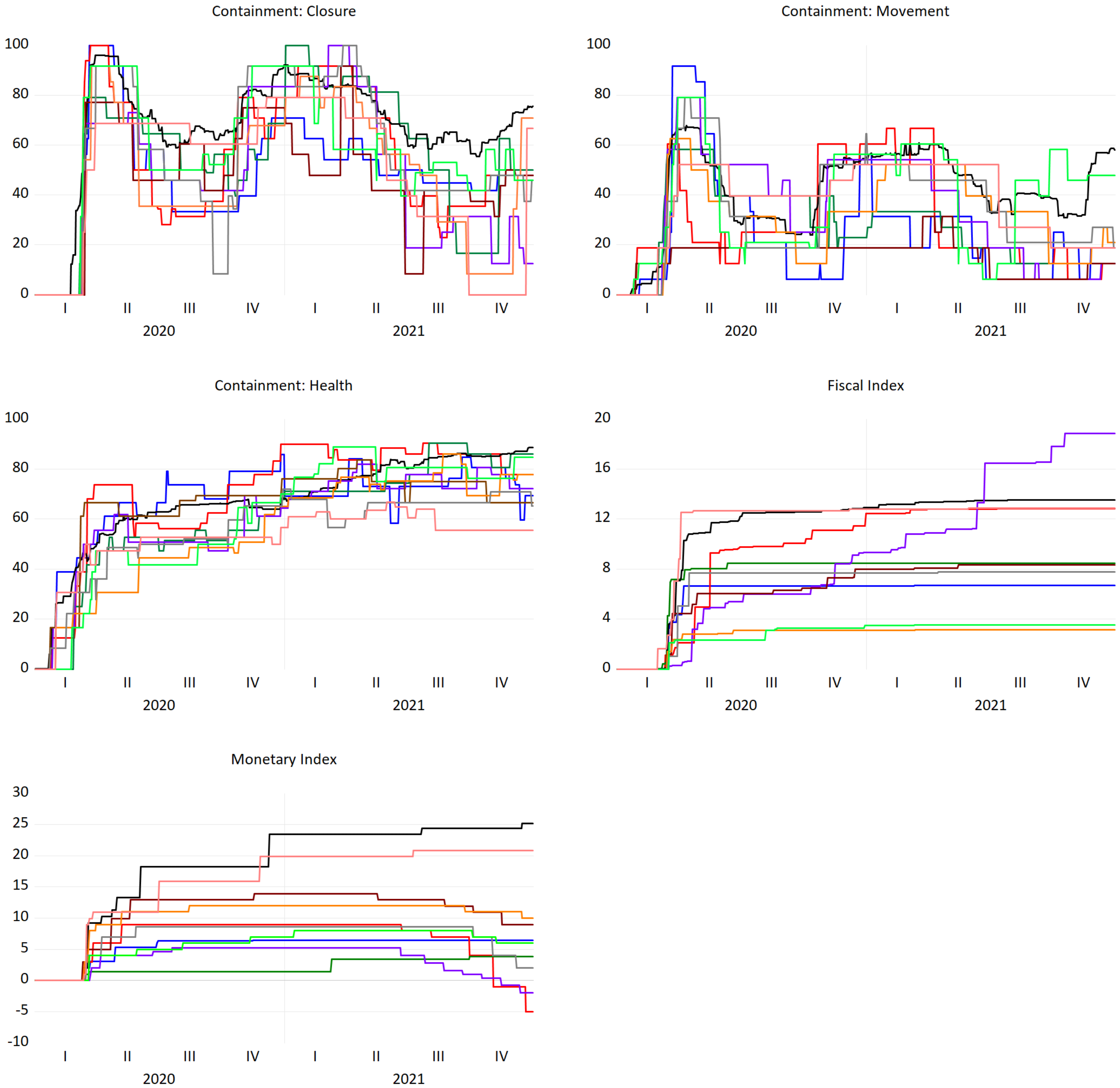
Table 3: Number of events in the sample countries

	EA	DK	SV	PO	CZ	HU	HR	RO	IC	NO	**Sum of policies**
Containment closure	255	27	14	28	34	19	24	28	21	29	505
Stricter policies	128	11	7	12	17	9	13	15	9	14	249
Laxer policies	127	16	7	16	17	10	11	13	12	15	256
Containment movement	239	18	9	18	24	20	26	32	10	17	436
Stricter policies	124	9	6	8	12	11	12	19	6	8	228
Laxer policies	115	9	3	10	12	9	14	13	4	9	208
Containment health	244	21	19	21	26	23	27	21	14	24	469
Stricter policies	175	16	13	15	17	16	17	17	10	18	333
Laxer policies	69	5	6	6	9	7	10	4	4	6	136
Sum containment policies	738	66	42	67	84	62	77	81	45	70	1410
Fiscal-events	169	8	10	5	29	38	18	7	11	8	314
Expansionary policies	169	8	10	5	29	38	18	7	11	8	314
Restrictive policies	0	0	0	0	0	0	0	0	0	0	0
Monetary-events	9	4	7	6	8	12	7	7	9	9	80
Expansionary policies	9	4	7	3	5	5	7	5	5	7	57
Restrictive policies	0	0	0	0	3	7	3	2	4	2	80
Sum stabilization policies	178	17	22	16	42	55	30	19	20	17	394

Notes: The table shows the number of policy changes for the nine European countries plus the euro area, across the different containment and stabilization policy categories.

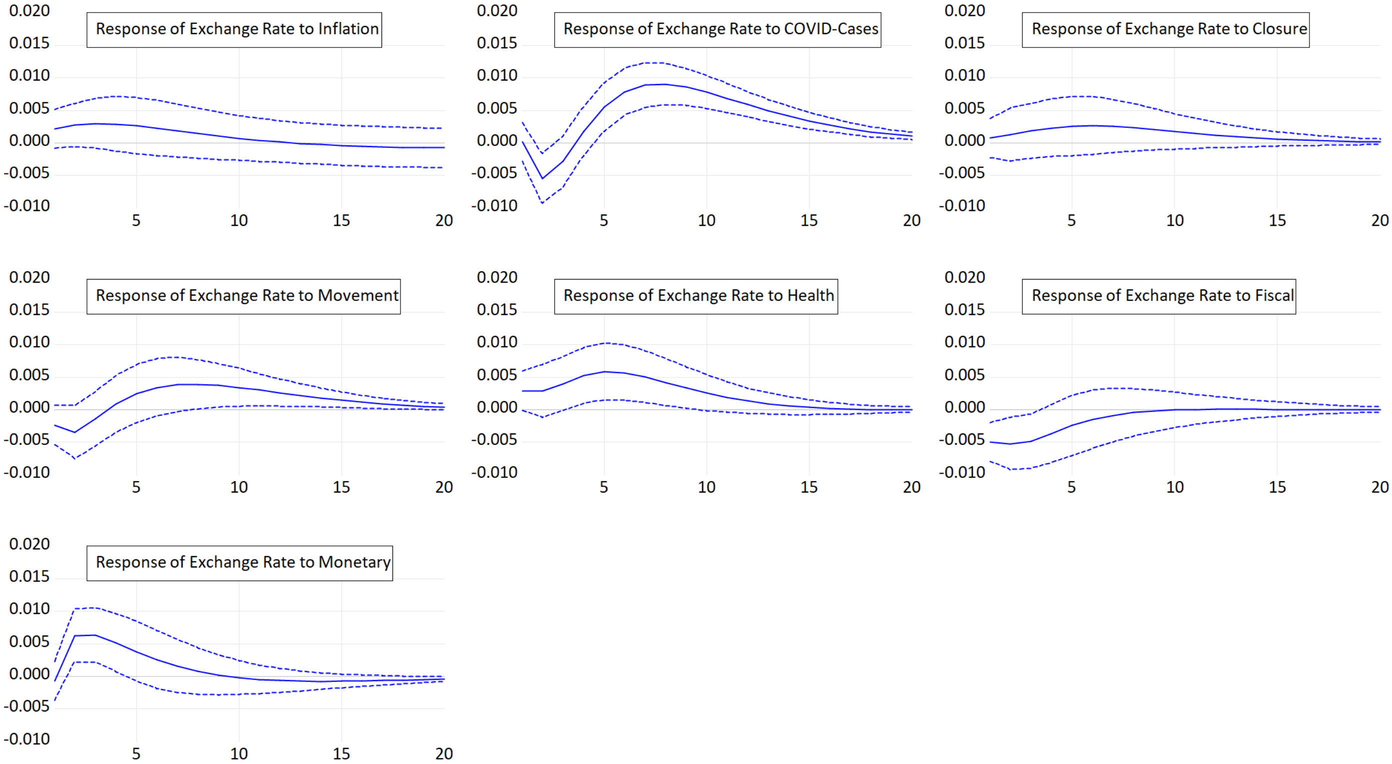
Figures

Figure 1: Containment and stabilization policies



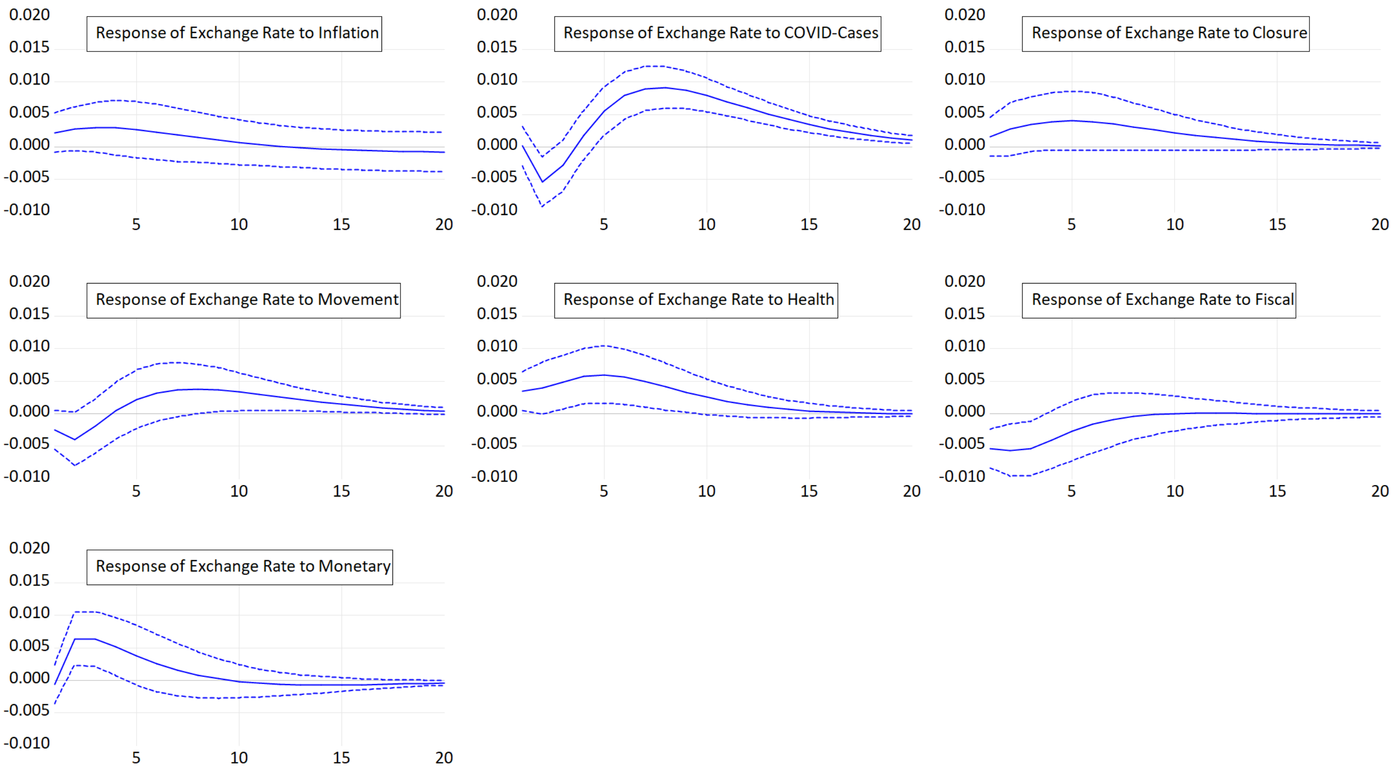
Notes: The graph shows the realizations of the three containment and two stabilization indices for the nine European countries and the euro area. Black lines = euro area, blue lines = Croatia, red lines = Czech Republic, green lines = Denmark, purple lines = Hungary, brown lines = Iceland, orange lines = Norway, grey lines = Poland, light-green lines = Romania and light-red lines = Sweden.

Figure 2: The response of exchange rates: full sample



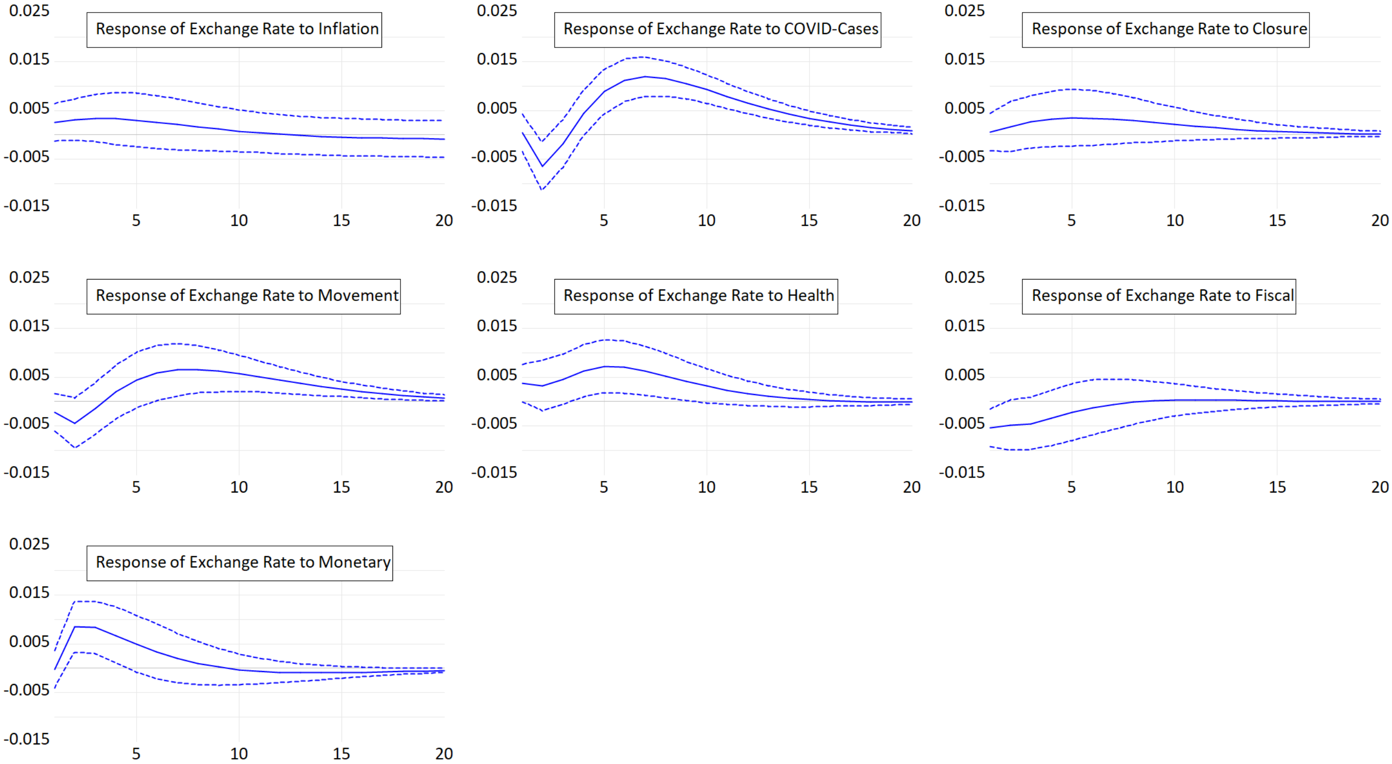
Notes: Impulse responses of exchange rates to a one standard deviation shock in price-differentials, differences in COVID cases, the three containment measures and the two areas of stabilization policies. The dashed lines indicate the 95% confidence interval.

Figure 3: The response of exchange rates: only five largest euro area countries



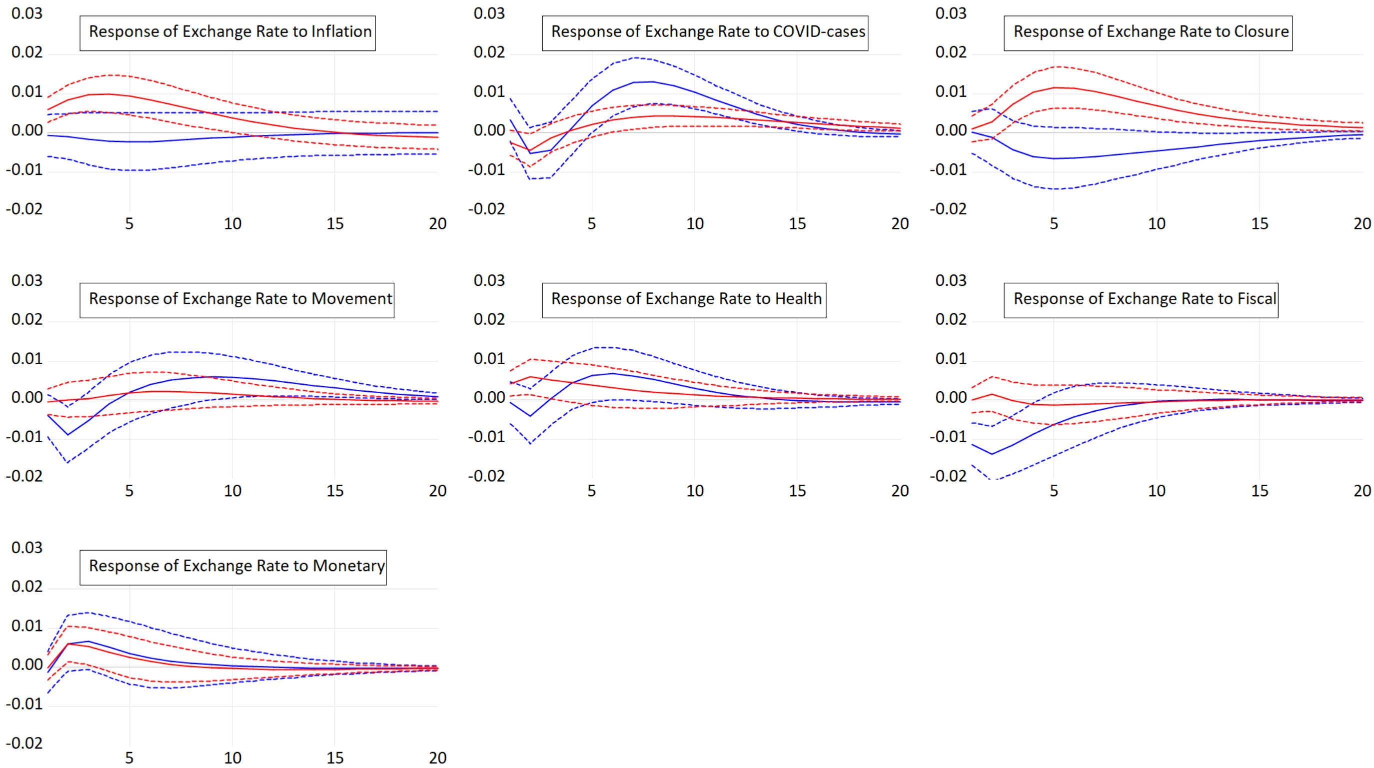
Notes: Impulse responses of exchange rates to a one standard deviation shock in price-differentials, differences in COVID cases, the three containment measures and the two areas of stabilization policies. The dashed lines indicate the 95% confidence interval.

Figure 4: The response of exchange rates: only completely flexible exchange rates



Notes: Impulse responses of exchange rates to a one standard deviation shock in price-differentials, differences in COVID cases, the three containment measures and the two areas of stabilization policies. The dashed lines indicate the 95% confidence interval.

Figure 5: The response of exchange rates: geographical differences



Notes: Impulse responses of exchange rates to a one standard deviation shock in price-differentials, differences in COVID cases, the three containment measures and the two areas of stabilization policies. The dashed lines indicate the 95% confidence interval. Blue lines indicate estimates for scandinavian countries and red lines for eastern european countries.

Figure 6: The response of exchange rates: Euro area versus other European actions

Notes: Impulse responses of exchange rates to a one standard deviation shock in price-differentials, differences in COVID cases, the three containment measures and the two areas of stabilization policies. The dashed lines indicate the 95% confidence interval. Blue lines indicate estimates other european country actions and red lines for euro area actions.