Charles University

Faculty of Social Sciences
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MASTER'S THESIS

Macroeconomic consequences of Covid–19 and the role of stabilization policies

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Declaration of Authorship

The author hereby declares that he compiled this thesis independently; using only the listed resources and literature, and the thesis has not been used to obtain a different or the same degree.

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Opava, 31st August 2023 Tomáš Karhánek

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Abstract

The thesis applies panel data analyses supported by vast stream of empirical literature with aim to capture and quantify effects of the monetary and fiscal stabilization policies on the macroeconomic indicators during COVID-19 pandemic, while also comparing effects of UMP and CMP monetary regimes. The results show that both the monetary and fiscal stabilization policies had positive and statistically significant impact on the real GDP growth. On the other hand, the effect of the stabilization policies did not have significant effect on the inflation during 2020-2021. The thesis also presents a small subsample of forecasting utilizing properties of VECM and comparing recovery paths of 3 European countries with different monetary regimes. We also conclude that there is no significant difference between monetary regimes utilizing UMP or CMP in terms of effectivity of the GDP growth stimulus and recovery paths of the macroeconomic indicators. Furthermore, we have concluded that the GDP sectoral composition played an important role in the economic impact on the country as countries with larger share of services suffered larger decrease of the real GDP and countries with large industrial sector faced higher inflation due to supply chain disturbtion.

JEL Classification	E52, E31, E470, H51, H68, H61
Keywords	Covid-19, economic locdowns, monetary policy, fiscal expansion
Title	Macroeconomic consequences of Covid–19 and the role of stabilization policies

Abstrakt

Diplomová práce aplikuje analýzu panelových dat a kombinuje ji s několika proudy empirické literatury s cílem zachytit efekt monetárních a fiskálních stabilizačních politik a jejich vliv na vývoj makroekonomických veličin během pandemie COVIDu-19. Zároveň také chceme porovnat vliv konvečních monetárních nástrojů s těmi nekonvenčními. Výsledky regrese nám ukazují, že stimul fiskální i monetární politiky byl poszitivní a statisticky signifikantní pro vývoj růstu reálného HDP. Na druhou stranu, nebyl odhalen žádný efekt na růst inflace ani u jedné z politik v letech 2020-2021. Diplomová práce také obsahuje zachycení efektů alternativní metodologií za použití vektorového modelu korekce chyb na příkladu 3 Evropských zemí kterů reprezentují různé měnové režimy. Naše analýza neodhalila žádný signifikantní rozdíl mezi efektem konvečnch a nekonvečních měnových nástrojů na podporu růstu ekonomiky a rychlostí návratu k trendu růstu. Nakonec jsme také z modelu zjistili, že sektorové složení HDP hraje důležitý vliv na to, jak moc byly ekonomiky zasaženy. Ekonomiky s větším podílem služeb utrpěly větší pokles HDP, zatímco ekonomiky s větším zastoupením průmyslu utrpěly navýšení inflace z důvodu narušení dodavatelských řetězců.

Klasifikace	E52, E31, E470, H51, H68, H61
Klíčová slova	Covid-19, uzavírky ekonomiky, měnová politika, fiskální politika
Název práce	Makroekonomické dopady Covidu-19 a role stabilizační politiky

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Master's Thesis Proposal

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Proposed Topic:

Macroeconomic consequences of Covid–19 and the role of stabilisation policies

Motivation:

COVID-19 pandemic has been an unprecedented crisis that has caused a global economic turmoil and interrupted growth following recovery from the Great Recession. Global GDP has fallen from 2,6% growth rate in 2019 to -3,3% in 2020 (The World Bank Data). The main driver of the recession has been a negative supply shock due to distortion of the global supply chains and reduction of production due to epidemic spread or anti-epidemic bylaws limiting mobility of the labour force. The overall effect on the individual countries varies not only because of different severity of the epidemic or bylaws, but also through stabilization policies applied, both monetary and fiscal, and several other indicators that will be subject to research in this thesis such as, GDP structure based on sectors and general macroeconomic indicators.

On the other hand, current forecasts show a steeper recovery path than it was in case of the Great Recession (STATISTA; O'Neill 2022). However, path of the recovery for the specific states is also subject to already mentioned indicators, not only in the scope of speed of the recovery, but also the level reached during recovery, which might be lower than the pre-pandemic state as a result of restructuring of the economy (e.g. shift from services to machinery industry). This is concerning countries that relied heavily on tourism or countries with overheating economies which are partially a result of extensive expansionary stabilization policies that have attempted to boost aggregate demand.

There are multiple papers being published on the topic of consequences of COVID-19 each week; however my main focus is going to be to find a link between stabilization policies applied and mitigation of negative economic impacts and perform comparative cross-sectional research among individual countries and regions to determine whether specific actions of government or central banks yield positive robust results.

Hypotheses:

1. Hypothesis #1: Countries with large agriculture sector suffered smaller GDP decline compared to others.
2. Hypothesis #2: Country's debt to GDP ratio before COVID-19 epidemic has no significant effect on GDP growth.
3. Hypothesis #3: There is no general cross-sectional difference in significance of a positive effect on GDP between conventional and unconventional monetary policies.

Methodology:

In this thesis, I work with panel data to perform cross-sectional analysis of influential factors on GDP and its development. The main focus is period of 1Q2020-1Q2022 for sample of 30 states across the globe that could be divided into groups based on regions. I included representatives from America, Europe and Asia. I will include lagged variables into the model, for that reason I extend the dataset beyond COVID-19 period and work with data from 1Q2018. I am planning to work with monthly data, if available; alternatively I shall use quarterly dataset.

As already mentioned, response variable is GDP growth of individual countries and as explanatory variables I include general macroeconomic indicators (Inflation, Unemployment rate etc.), proxies to capture effects of monetary (shadow rates) and fiscal policy (deficit caused by additional transfers and government spending), index presenting severity of the anti-pandemic measures (stringency index introduced by the Oxford University) and proxy variables representing industry structure from the point of view of GDP contribution. To control for model uncertainty, I implement Bayesian model averaging.

As the data source, OECD, World Bank and Eurostat will be used. I shall use the standard procedures while working with panel data, therefore searching for the best model from available models: pooled OLS, Fixed Effects and Random effects. Analysis will be performed using R software in Jupyter notebook. Finally, I will implement VAR model to forecast the recovery path of GDP to allow us to compare speed and slope of the recovery paths and possible future development. The hypothesis will be tested at 95% confidence level based on the coefficients of the regressions.

Expected Contribution:

I will perform a quantitative research of significant determinants of GDP volatility and level during COVID-19 pandemic and its forecasted recovery path to pre-epidemic levels taking into account the trend before the pandemic. The main contribution of the thesis is to show whether current stabilization policies, which are mostly designed to counteract demand shocks are effective and sufficient tool when encountering a supply shock, sometimes in situation when economy is at ZLB and that industry mix is an important factor to take into the account when applying those policies.

Outline:

1. Introduction, motivation: Main motivation is to investigate effectivity of stabilization policies on GDP during crisis, while also controlling for severity of local anti-epidemic bylaws and industry mix of a country
2. Literature review: I mention research standards in existing literature on forecasting

GDP development and estimation of individual effects using panel data
3. Data: Explaining source of data, its extent and characteristics.
4. Methods: I will present methods implemented and associated assumptions of VAR and panel data models (Pooled OLS, random effects, fixed effects), while also performing associated tests. Performing Bayesian model averaging.
5. Results: Presenting results of the regression and forecast, as well as all associated tests.
6. Conclusion: Concluding remarks and main outtakes from findings.

Core Bibliography:

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1 Introduction

The COVID-19 pandemic has been unprecedented worldwide crisis, which has caused major long lasting effects in the economies across globe. The worldwide official death as per the official WHO database is nearing 7 million people with more than 768 million cases of infection over the course of 3,5 years since the pandemic started. The epidemic has been the greatest excess loss of life since the Second World War. In terms of economic impact the crisis, that ironically did not have any economic fundamentals, caused the largest economic year to year drop in the history of mankind. The global real GDP growth rate has fallen from 2,6% in 2019 to -3,3% in 2020 as per the World Bank database. Several economists are in retrospective state that the COVID-19 pandemic was the true ending of the Great Moderation.

The impact on the economies around the world was heterogeneous not only due to severity of the epidemic but especially due to anti-epidemic bylaws that have limited mobility of the workforce and capital not only across borders but also within the countries themselves as workplaces were temporarily closed down, curfews were implemented and social distancing was ordered.

On the other hand, stabilization policies were implemented both the monetary and fiscal ones that also varied not only in terms of size but also quality and timely distribution of the support.

The main aim of this thesis and its main contributional potential to the econometric empirical literature will be able to estimation of the effects that the stabilization policies had on the macroeconomic indicators. In order to do so we will see implementations of metrics accounting for different monetary policy regimes and synthetic proxies combining properties of several variables.

Current studies show that, even though the drop in the economic activity has been larger than during the Great Financial Crisis, the recovery paths were in some cases much steeper and faster, reaching the pre-pandemic levels of GDP in the second half of 2021. However, such case was not for all the countries, several countries in the

Eurozone, to be more specific countries that were heavily hit by the Solvency Crisis in previous years have been struggling to get even to the real GDP levels prior to the GFC. For example Italy that has been first hit by the GFC, followed by the Solvency crisis and necessary public debt restrictions and now hit by COVID-19 and as the country in the Mediterranean Region large portion of its GDP comes from the tourism, which has suffered the largest setback out of all the economic sectors.

Therefore, it is important to see they path that would the future development of macroeconomic indicators follow, discounting the uncertainty effect alongside with worsening of the energy crisis in Europe caused in 2022 by the Russian invasion of Ukraine. Therefore, the thesis deals with time period ending in the first quarter of 2022 for the panel data analysis and last quarter of the 2021 for the forecasting through VAR methodology.

2 Literature Review

The thesis builds up upon the empirical work published on subject of stabilization policies during crisis, which encompasses both monetary and fiscal policy. We also briefly refer to the literature written on a topic of comparing the macroeconomic variables development during current pandemic and the great financial crisis (2007-2009) and stabilization policy actions of
the governments and central banks. However, as mentioned by Hofmann et al.(2021) every crisis is unique in its nature and lessons learned during the GFC by the central banks are not necessarily applicable in the setting of COVID-19 as it concerns contagion of people and not financial markets, therefore the initiation of the crisis does not have an economic foundation. Lastly, the writer visits the literature concerning the modelling part of the work, that being panel data analysis and its tools (Pooled OLS, FE, RE) and VAR modelling approaches and their utilization for the forecasting part of the thesis.

2.1 Monetary policy

Starting with the literature and empirical findings regarding the monetary policy, the contribution of the thesis is inspired by the work of Brzoza-Brzezina et al.(2022) and their research on finding the optimal response of monetary policy during COVID-19 pandemic. Their work is primarily focused on simulating different scenarios of monetary policy behaviour under variety of containment policies issued by government ranging from laissez-faire approach to full lockdown. Before going deeper into findings in the paper, it is necessary to understand few assumptions the authors make.

The authors assume 3 channels through which agents in economy can be infected, those are: during consumption, during work and during leisure time. Probability to get infected for the individual channels is then parametrized through empirical findings. The authors also suggest that the agents do not internalize their actions' impact on the state of pandemic. Based on those assumptions they build a model to simulate effects of integrated policies on welfare and death toll, and trade off dilemma that central bank faces between these two variables.

The simulations yield several interesting results that are useful for purposes of this thesis.

If the monetary policy reacts to the turmoil in the economy as if it was caused by a standard recession in a business cycle, the results will be suboptimal regardless of the setting of containment policy.

The authors present the optimal approach being conditional on the implemented containment policies; in a situation of serious containment policies the monetary policy should be expansionary with respect to the ongoing crisis. In other words, the expansionary trends should not overpower the containment policy in terms of incentive/disincentive such action would have on the consumption channel. This corresponds to the actual responses of the central banks during the crisis.

The other scenario suggests that if there were no containment measures issued by a government, the optimal monetary policy is a contractionary one; in order to reduce the death toll the central bank must sacrifice some of the economic welfare. However, this scenario is rather a hypothetical one as the main aim of the central bank is to maintain price stability. Besides exposing central bank to this moral dilemma, the authors found out that the monetary policy alone is not enough to make a significant difference in terms of death toll; however it can be very effective in terms of improving welfare. We will be able to see how we can utilize the findings of this paper later when compared to estimates of macroeconomic indicators' development in time and their influential factors but also against recovery path forecasted by the VAR model, as both the thesis and the paper utilize it.

On the other hand, the paper simplifies fiscal policy to simple transfers by government, but the thesis explores both sides and it is thus necessary to include transfers by the government as well as its debt into the model.

Furthermore, Hoffman points out limitations that central banks face in choosing optimal monetary policy reaction. Among most important obstacles he mentions deterioration of the ability of large portion of the developed economies' Central banks to utilize conventional tools to fight neither demand nor supply negative shock due to interest rates facing zero lower bound. These forces central banks to implement unconventional monetary policies such as quantitative easing that bypass ZLB limitations and should stimulate economic growth. Yet providing the growth incentive is not the main goal of any central bank, as already mentioned in the Brzezina et al. paper, the main goal of the central bank should at first be ensuring price stability, which as we will see later in the thesis was not always the case. On top of providing boost to consumption, the central banks actions were acting in the same direction as were the government policies. This large stimulus to the economy combined with the fact that crisis did not have basis in economic fundamentals and the business cycle was in its expansion phase (based on World GDP development) lead to the largest year to year grow in World GDP that took place in the recovery phase of the crisis, which was 10,5 Trillion USD, comparatively the recovery following the great financial crisis, which had its base in economic fundamentals was about 7,5 Trillion USD year to year.

Some economists, such as Gita Gopinath from IMF (2022), believe that it was Covid-19 crisis and not the GFC that was the true end of the Great Moderation Era. Their reasoning is based on the surge of inflation around the globe in 2022. Gopinath mentions in her paper that monetary policy will need to restructure its policy framework for the horizon of at least next 5 year as most advanced economies were "overheating" during years following the GFC. It will also be necessary to change the perception of the Phillips curve currently used in the framework and associated strategies that considered flat Phillips curve almost as an assumption when implementing policies. Deviation from the flat PC during recovery from Covid-19 crisis compared to recovery from other downturns since 1990 is captured by graph showing quarterly development of inflation and percentage deviation from GDP trend. Unemployment from the traditional PC is here substituted by output following the same logic as in New Keynesian PC. It is also necessary to investigate if the crisis, despite its nature being a temporary negative supply shock, has not materialized in permanent change in the level of natural real interest rate. The paper also mentions that there exist risks associated with possible de-anchoring of the inflation expectations. This could pose a threat as at the moment most of the central banks (eg. CNB, FED, ECB and more) are using modified New Keynesian DSGE models to forecast essential macroeconomic variables, but more importantly optimal monetary policy, specifically desirable way how to set nominal interest rate. As we know from Galí (2008) the fundamental building blocks of DSGE model are three equations: NK IS curve, NK Phillip's Curve and Monetary rule (let us assume forward looking Taylor rule for this particular case). Then, de-anchoring of the expectations in the future inflation development would lead to upward pressures on the inflation and corresponding increase in optimal nominal interest rate which then affects the level of output and the cycle repeats. This scenario could possibly lead to long-term shift in the interest rate equilibrium, that could cause issues related to amount of liquidity available for all market agents. To be able to fully understand the actions that lead to this moment we need to understand fiscal policy responses to the crisis.

2.2 Fiscal Policy

As for the fiscal policy contribution towards stabilizing the situation, governments worldwide have initiated support programs for companies and households to mitigate the damages caused to economy by the pandemic and containment policies. Lacey et al. (2021) have released their paper focused on reviewing applied fiscal stabilization policies and their impacts which tests individual policy actions as well as the entire packages based on several characteristics that are discussed in the next paragraph. Nonetheless, the authors make it abundantly clear that reducing fiscal policy effects to mere changes in government budget deficits and money transfers does not have a necessary representative power to capture fiscal policies in reality or in a model.

The authors build up upon timely-targeted-temporary model to determine rankings and scores of the individual countries with respect to their policies. They do so based on 9 characteristics of policies adopted. Those categories are: targetability, speed, abuse resistance, cost recoverability, predictability and cost control, reversibility, scalability, administrative complexity and resilience to health measures. Country can be scored on a scale from 0-1 in each of the categories based on underlying properties for each category.

The writer plans to utilize this score, by giving equal weight to each category therefore creating Meta score for country representing overall quality of fiscal policy, however this will cover only the qualitative side of the fiscal policy.

Consequentially, the government support and relieve actions have put a large strain on the government budget, whose initial state when entering the crisis at the beginning of 2020 could play an important role as suggested in the special series on Covid-19 published by IMF dedicated to Sovereign debt management by Breuer et al. (2020). The paper builds on experience gained from the sovereign debt crisis in Europe 2009-2010. They provide guidelines to governments how to ensure access to short-term liquidity while facing increasing borrowing costs, distortion of revenue streams and increasing expenditures. One of the key elements of managing the debt is proper communication between fiscal and monetary policy authority. This reflects in choices of the government funding through debt instruments, specifically government bonds. IMF suggest that in times of inflationary pressures the central banks will have to answer by increasing the nominal interest rate making thus borrowing in the economy more expensive for all participants. To counteract the government can act in 2 ways. If we drop the assumption that all market agents have the same information about the future development we could argue based on theory presented in paper by Cole et al. (2021), who present asymmetry of information in market for government bonds. Their example can be altered to fit our case and thus government knowing about possible adverse development in inflation and thus interest rates can perform large issuance of long term government bonds to secure its funding for the economic downturn for lower than market interest rate. However, this theory and its potential effect is the weaker the more independent the central bank is, as the independence is correlated with good communication with public and publishing predictions about the future Mas et al. (2020).

The other way of acting is the only one that IMF sees as moral and correct approach. Facing increasing costs of borrowing the government should restructure its bond funding profile and skew it towards short-term bonds (one or two year maturity) while reducing number of issued long-term ones (five to thirty years maturity). It is also advised to increase frequency of the bond auctions. Such actions provide incentive for the market agents to purchase the bonds and at the same time shield government from certain risks associated with long-term bonds. According to Eidam (2020) the rollover risk for short-term bonds is lower than the risk associated with long-term bonds and it is desirable for the government in such situations to try to rollover as many debt instruments as possible. In the times of turmoil the investors in the market show sign of behaviour known as “flight to quality” this behaviour has been observed during the subprime mortgage crisis as documented by Longstaff (2010) and also during Covid-19 crisis where empirical results show shifts from stocks to bonds Papadamou et al. (2021). Furthermore, the empirical results show not only shifts between types of assets but also variation in investment on the cross-country scale. Specifically, flight of capital from emerging and developing economies towards advanced economies. To make government bonds more attractive EMDE economies raise the yield rate on the bonds to compensate for the default risk perceived by the investors. The investors are also more likely to purchase short-term bonds Omeir et al. (2022) rather than long-term bonds. This behaviour is beneficial for both the investors who shield themselves against majority of the default risk associated with long-term investment and the government who protects itself against interest rate risk associated with bonds with longer maturity.

The behaviour in the bond market allows us to observe countries with fiscal policy responses working at their limits by observing development of yield curves and structure of bonds traded based on their maturity. There have been sightings of inversed yield curves, described by Yue Kan (2022), that under normal circumstances could predict upcoming recession, but Kan argues that flat or inverse yield curves are results of behavioural pattern mentioned above.

To address the issue that has been already mentioned in the part dedicated to the monetary policy we have to investigate effects that fiscal stabilization policies had on the economy.
It is true that partial responsibility to such inflation development can be related to the war in Ukraine and associated energy crisis due to rising prices of electricity, natural gas and oil.

Nonetheless, the effect of the stimulus to the economy have not been negligible on their own, thus contributing significantly to the excess inflation in the post-crisis period as revealed by De Soyres et al. (2022). The paper they published also reveals that fiscal stimulus had cross country impact, a spillover effect. In the paper they show example of US fiscal stimulus contributing to increase in inflation in the USA by 2.5 percentage points while also increasing inflation in the UK by 0.5 percentage points. The empirical findings suggest that inside country inflationary pressures are significantly driven by large fiscal policies to support consumption in the country. The external inflationary pressures can be explained by implementation of large fiscal policy package to boost economy in a country B that has substantial international trade with country A. In other words, if country A has large portions of its exports to country B and country B gets fiscal stimulus with impact on demand (consumption), without any effect on supply (production), the price of domestic goods goes up and consumers will seek substitutes through imports from country A thus resulting in the spill over effect on inflation in country A.

The paper also shows disproportion between consumption and production during Covid-19 when using pre-crisis time as baseline. Most advanced economies reached the largest drop in the GDP in Q2 of 2020. However, at this point the consumption levels were only about 7% lower than in the pre-crisis times while production side suffered 20% decrease. It is also revealed that multiple countries fiscal support programs were much larger than what was estimated by IMF as an adequate fiscal policy response (e.g. USA deviation from estimated optimal support was + 18.5%).

Therefore, it is necessary to take into account initial state of sovereign debt, size of the fiscal support, yield curve dynamics for different maturities and exposure to the international trade.

2.3 Modelling Literature

Based on the nature of the research we conduct in the thesis, panel data analysis is the closest to ideal tool to achieve our goals. The fundamental framework is based on Wooldridge (2012), Baltagi (2005) and Eom, Lee and Xu (2007). Even though, the estimation process is discussed more in detail in the methodology part of the thesis, the stream of the stream of the literature we want to follow is dedicated mostly to fixed effects part of the panel data analysis. Before making this step it is necessary to test that the fixed effects method is the most efficient consistent method through the tests specified in the methodology section. If this holds, we will then implement least squares dummy variables model to capture the unobserved fixed effects and display them.

The literature related to the forecasting part of the empirical work relies on mostly on VECM approach as we want to maintain as much variance in the variables as possible, and do not wish to lose long trends that can contribute towards smoother recovery in the post-pandemic times. We take inspiration from forecasting using VECM in the paper published by David et al. (2020).

3 DATA

I have compiled a complex dataset containing 68 variables, some of which are purely of scaling nature or lagged versions of other variables (used only as weights or exchange rates transforming variables into new ones). The dataset is an unbalanced panel as it contains variables which were gathered only partially because their availability was found too poor to provide robust explanatory strength, or were abandoned in favour of alternative variable which had empirical backing in existing literature and was deemed superior. The source of the data is the OECD database, the World Bank, Statista, Eurostat and FRED. There are few exceptions in case of obtaining Central Banks Balance sheet sizes and interest rates, which were obtained from the official Central bank websites[1].

The other alternative source of data had to be implemented in case of accounting for the unconventional monetary policies through shadow rates, which is mentioned later on. The time period of the data for the first part of the empirical work is the period of 4Q2019-1Q2022. On the other hand, the time horizon of the data used for the forecasting part of the thesis is going to be extended based on the availability of the data for individual countries, but for most countries it is period of 1995-2021. This time window thus encompasses long term trends in the development of macroeconomic indicators, their reactions to stochastic shocks and the recovery paths they follow. The data ends in December 2021 to make the forecasting free of the possible distortion caused by war in Ukraine, which enhanced the ongoing energy crisis and inflationary pressures, as well as increased uncertainty on the financial markets around the World. The main goal of the thesis is to estimate effects of the individual central banks and governments responding to the pandemic and forecast recovery paths while taking into account economic disruption caused by restricting policies on mobility of capital and workforce across borders but also inside individual

[1] Example for Riskbank (Swedish central bank) available through weekly reports: https://www.riksbank.se/en-gb/statistics/riksbanks-balance-sheet/the-riksbanks-assets-and-liabilities-the-weekly-report/

countries. The main focus is on the actions taken inside the economies as any outside shock irrelevant to the pandemic could cause bias in the results. As for the cross-sectional part of data, we have selected sample of 30 countries, with good data coverage across the world, representing America, Europe, Asia, Africa and Oceania. It is important to understand, besides the economic variables also cultural differences between countries and their industry composition differences.

The macroeconomic indicators we perform the estimation upon are: yearly growth of real GDP and quarterly inflation. The real GDP growth is calculated from real GDP index in domestic currency using 2015 as base year for both the GDP deflator and constant prices.

I have decided to use domestic currency instead of quarterly USD recalculation for the reasons that most of the GDP contribution comes from within the economy, our sample contains countries that have suffered massive depreciation of currency combined with inflation spikes and to be able to control for both of them simultaneously without causing bias in the regression we would have to work with nominal GDP growth rather than the real one. That being said, we have implemented an independent variable capturing majority of the exchange rate effect on the real GDP growth, which is mentioned later on.

Our second dependent variable, quarterly inflation, is calculated from the quarterly headline consumer price index obtained from the World Bank database of inflation by Ha et al. (2021). We decided for alternative difference series, while GDP growth was seasonally differenced series, the inflation series is produced by implementing first differences. The first reason behind this decision lies in consultation of a book by Chatfield and Xing (2019) on time series analysis in R and ensuring stationarity of the inflation series, while also profiting from the properties of the FD, which acts as a high pass filter, meaning that it amplifies high frequency determinants in the inflation, which seems to be the determining factor in the inflation development in the recent times as shown in Bobeica and Hartwig (2023). The second reason is the fact that the inflation series is produced from already seasonally adjusted data, which Baltagi (2005) suggests could cause bias in the regression.

In the thesis we present three main independent variables that we pay special attention to as they are representatives of the monetary and fiscal policy actions during COVID-19.

In order to capture monetary policy effects, we have implemented a metric that is commonly known as shadow rates. Standard monetary policy rates are bound by zero-lower bound, more specifically effective zero lower bound as during recovery phase following the GFC and the Solvency crisis in Eurozone several central banks have lowered their policy rates below zero for deposits (for example the ECB has maintained its deposit rate at negative nominal values from June 2014 until July 2022 when the inflationary pressures around the world started to materialize). As already mentioned in the literature review, as the interest rates start nearing the effective lower bound, the risk of falling into liquidity trap increases, therefore central banks facing such scenario opt to implement unconventional monetary policies. The most commonly known UMP is quantitative easing. This leads us back to shadow rates which are allowing us to quantify effects of unconventional monetary policies. There are several ways how to estimate shadow rates, one of the mainstream estimates are Wu-Xia shadow rates, whose estimates they provide on their website[2] quantifying UMP actions of the Bank of England, the Federal Reserve Board and the European Central Bank.

Their approach as mentioned in Wu-Xia (2016) is based on model which follows VAR(1) process and is based on three latent variables, which include reaction of bond prices to policy announcements and shifts in the balance sheet of the central bank.

On the other hand, alternative approach proposed by Krippner (2020) works with decomposing yield curves into two components, that being a shadow yield curve that has no lower bound on its own and "physical currency option effect". The currency option effect is hypothetical option where people consider holding currency over keeping their money on the bank accounts that are running negative interest rates, thus putting pressure on the banking sector to increase the deposit rates. This currency option also provides a certain limit to how negative can the shadow rate

[2] Available at: https://www.atlantafed.org/cqer/research/wu-xia-shadow-federal-funds-rate

become. In the space between these curves lies the actual yield curve up to the point where yield curve equals the currency option alternative. As the yield curve continues to grow the shadow rate yield curve will asymptotically converge towards it.

The main benefit of the Krippner estimation method over the Wu-Xia method is that it works with multiple longer term rates (combination of 3 and 6 month yield curves) and its development is more robust to shocks. It also produces robust results even in the times when the conventional monetary policies are applied making its usage very seamless over longer periods of time. Lastly, Krippner also publishes much wider dataset[3] of the shadow rates across essentially all countries implementing UMP in last 20 years.

For all the above mentioned reasons, we have decided to use estimates published by Krippner as the measure of monetary policy actions.

As for the fiscal policy variable, the situation is slightly more complicated. As already mentioned in the literature the sole increase of fiscal deficit does not correctly capture the magnitude of the fiscal actions. Therefore for the purpose of this thesis we had to create a new synthetic variable which is referred to as an effective fiscal measure.

The effective fiscal measure is based on the work done by IMF and World Bank Group as it utilizes and combines size, quality and time distribution of the fiscal measures.

As for the quality, we utilize work performed by Lacey et al. (2021) who have created a complex rating system of fiscal measures applied as a response to COVID-19. As once mentioned in the literature review, the rating consists of 9 categories and in each category the rating can be in the interval of 0-1, therefore the maximal attainable rating overall would be 9 (the highest achieved rating was 7,5 by Israel). This rating would act as our weight for the fiscal stimulus.

The size of the fiscal actions performed by individual countries is measured in share of GDP in 2020. The data for this metric are available from the IMF website, where

[3] Available at: https://www.ljkmfa.com/visitors/

one can download the dataset. The dataset divides fiscal actions into two subcategories, those are: above the line measures (e.g. deferred revenues from taxes and extra spending in health sector) and liquidity support (e.g. provision of guarantees and loans). However, we are interested in the overall effect of the fiscal measures and leave the research of the effect of the individual subcategories for possible future research.

Lastly, time distribution of the fiscal policies requires more detailed research of the individual policies, their budgets and durations. Luckily IMF maintains a database with such information which is publicly available. Furthermore, we discuss paper published by Fiscal Policy and Sustainable Development Unit (MTI) of the World Bank Group (2021) and Deb et al. (2021) both of which have already performed research in this field. The data shows that majority of the entire COVID-19 measures has been dedicated to first half of the 2020 when the infection numbers and deaths per infected in most countries were not at their peak yet. This will be important piece of information as we are going to return to it.

By combining all three above mentioned metrics we obtain our time series variable capturing development of the fiscal support for the economy in terms of cumulative percentage of 2020 GDP over time.

The last important metric that will help us understand development in the macroeconomic indicators during the crisis is the Oxford lockdown stringency index which is a metric developed by Mathieu et al. (2020) and has become widely used in the research papers such as quiet recent paper by Gagnon et al. (2023).

The stringency index is a metric on a scale from 0-100 based on 9 response indicators among which are school closures, workplace closures, travel bans, curfews and quarantine rules associated with positive COVID-19 test or contact with COVID-19 positive person. There are 3 different types of stringency index; we are going to work with the weighted index. The weighted index captures the difference between restrictions applied for vaccinated population compared to non-vaccinated one, using ratio of vaccinated people in the population as a weight, thus the index has been decreasing throughout 2021, even though the restrictions were not being necessarily loosened, but rather because the vaccinated population ratio has been steadily increasing. Importance of using this metric instead of amount of infected or deceased people from methodological perspective is discussed in more detail in the variables section.

The other important time series that we have available include nominal GDP growth, central bank balance sheet growth, real GDP per capita denominated in USD, real broad effective exchange rate, quarterly central government debt to real GDP ratio, current account deficit/surplus in terms of GDP ratio human capital index and amount of infected and deceased people due to COVID-19, unemployment rate and lags of the above mentioned variables.

Real broad effective exchange rate follows same principles as real exchange rate, that being taking into account purchase power parity as well as nominal exchange rate. The broad rate does the same process but for up to 16 different exchange rates that are then represented as weighted averages based on the contribution to the total size of balance of payments. In other words the bilateral real exchange rate is the more important the larger amount of trade and financial transfers happen between the two countries.

Human capital index is a metric maintained by the World Bank[4] measures work productivity based on education and health (life expectancy, infant mortality).

All data are seasonally and calendar adjusted provided in the quarterly frequency using weighted average method in case of converting monthly time series into quarterly frequency. The dataset is too vast to display summary statistics for the data and given the short time variable and large cross-sectional dataset it is questionable how relevant would such information be. The data are available in the digital attachment alongside the R code.

[4] Available at: https://datacatalog.worldbank.org/search/dataset/0037712/World-Development-Indicators

For the forecasting part of the thesis we take analogical variables, or exactly the same variables as we use in the FE regression. We are going to construct a monetary VAR in which we order the variables based on the empirics and decreasing order of exogeneity as presented in the table:

Table 3.1: VAR model time series

time series API	Time series	Freq
namq_10_gdp	real GDP in chain linked volume of 2015 EURO, seasonally adjusted, mil. EURO	Q
M.I15.CP00.CZ	HICP index with base year of 2015, not seasonally adjusted, index of 100	M
Q.IRT_M3.CZ	Average 3M short term interest rate seasonally adjusted, in %	Q
SRR (in attached excel sheet)	Shadow rates estimated by Krippner (replaces the 3M IR if incase of QE) in %	Q
Q.GD.S13.PC_GDP.CZ	Central government debt to real GDP ratio, easonally adjusted, in %	Q
RBXXBIS (from FRED)	Real Broad Effectie Exchange Rate, index, not seasonally adjusted	M

We have discussed the ordering logic of the variables with paper by Carlstorm et al. (2009).

3.1 Hypotheses

In this section we present the hypotheses that are to be tested in the thesis and reasoning of their selection.

1) There is no general cross-sectional significant difference on change in GDP growth between conventional and unconventional monetary policies

The conventional monetary policies are captured via 3-month interest rate in the model and the unconventional policies enter the model through shadow interest rates estimated by Krippner. Alternative scenario to capture unconventional policies would then be to compare expansions/contractions of the central bank balance sheet. We run regression on the group of countries which have implemented quantitative easing and which have not and compare the results.

2) Fiscal stimulus actions have had a significant effect on the economic growth, but also led to increase in inflation.

As already mentioned in the data part of the thesis, we measure fiscal stimulus through cumulative effective fiscal measures. We suggest that these measures had a significant impact, which has been already shown in several streams of research literature for individual countries (e.g. Bartolomeo et al. (2021) for the case of Italy), but also for entire groups of countries as shown in Deb et al. (2021), who performed the research by separating countries on advanced economies and emerging economies.

However, following the recent inflation spikes around the glove, the economists have gone back to research the fiscal measures applied during COVID-19 and determine how severe this pro-inflationary shock has been compared to monetary policy actions. De Soyres et al. (2022) have published in their paper that advanced economies have "overshot" their projected fiscal spending in terms of GDP ratio on average more than the emerging economies and provided thus fundamentals to the 2022 inflation hikes. The emerging markets then inherited the inflation through spillover effect.

3.2 Variables

In the data section we have already quiet detail discussed what is reasoning behind choice and implementation of the individual variables. Therefore, in this section we can see the selected variables that appear in the final model specifications. As we can see we have omitted several variables that did not make the final cut. Among which are most noticeable metrics for infected and deceased people due to Covid-19 infection. The reasoning behind this decision lies partially in already mentioned Gagnon et al. paper that has arrived to the same conclusion as we had that the infected metric is highly endogenous variable in terms of explaining economic growth, but also it fails the Granger-causality test, due to nature of the behaviour the variable has. Essentially, the amount of people infected outgrows even vaccination rate during 2021, but its effect diminishes over time as the world gets used to the virus. As for the ratio of deceased per infected variable we arrive to multicollinearity concerns with the stringency index across the 10 quarter period. In the Gagnon paper, the aim was to show different contribution of the individual effects in each year and compare it to the entire duration of the pandemic. The results of the regression show that the deaths are only statistically significant for 2020 and have no Granger-causality to GDP growth for 2021 or 2020-2021 period. Because we are interested in the effect of variable across the entire time period, we have decided to omit it from the regression assuming that it will not lead to any estimation bias.

We can see that we kept the current account variable, however we cannot use it in the real GDP growth estimation as per Yurdakul end Ucar (2015) and Özer et al. (2018) that show Granger-causality relationship between current account and GDP growth only in the direction from GDP growth to current account deficit, which is further confirmed by impulse response function from VAR model and variance decomposition of forecast errors. Nonetheless, we will present the reasons behind incorporating is as a determinant of the inflation in the Variables section.

As for the rest of the variables, we can see their overview in the Table 1 respectively Table 2, along with their short description and units they are measured in.

specification of the model GDP growth is then our dependent variable. The independent variables consist of

Table 3.2: Variables selected for the panel analysis

Dependent Variable	Description
GDP_growth_y	Real GDP growth rate y-o-y
Inflation_q	HCPI growth rate q-o-q

Independent Variable	Description
IR	deposit interest rate/shadow interest rate in case of UMP
UR	Uneployment rate
effective_fiscal_measures	effective fiscal measures specificied as per DATA
GDP_growth	nominal GDP growth q-o-q
Real_exchange_rate_change	q-o-q change in the Broad real effective exchange rate
services	Percentage contribution of services sector to GDP
Agri	Percentage contribution of agriculture sector to GDP
Stringency_id	Oxford containment policy index
REAL_GDP_per_capita_USD	Real GDP per capita with quaterly USD conversion
Gov_debt_q	Central government debt to GDP ratio; in %
CA_gdp	Current account balance to GDP ratio; in %
XXXXX_lag	lagged variable of the original series

4 Methodology

Methodology in the thesis can be separated into two parts. First part is focused on estimating key factors influencing GDP development during the pandemic using panel data of the individual countries. The second part is dedicated to forecasting the recovery paths and future development in the economies using VAR model.

Consulting Wooldridge book, the amount of observations we are provided should be sufficient, as good practise is to maintain 10 observations per variable included in the model, we also discuss Mark Steel (2019) and possible model uncertainty, which could be solved using Bayesian model averaging technique, but it is not our case as the amount of variables in our case is below the recommended threshold. We are working with a short, or sometimes called micro, panel of data and are interested in the cross sectional behaviour in the individual points of time rather than in longitudinal behaviour, which the time dimension is too short to produce consistent results anyway. In such case, Baltagi recommends using panel data analysis consisting of pooled OLS, fixed effects and random effects over panel VAR, furthermore he recommends using one-way individual effects regression, given that we reject OLS as inconsistent estimator.

As the modelling software for both parts of the methodology we have chosen R software as it provides us in its library with packages that we can use to streamline the modelling process and perform tests that are necessary to prove consistency and efficiency of the estimators.

4.1 Panel Data Analysis

Firstly, we design model to estimate real GDP growth. The baseline model we work with is:

$$GDP\_growth\_y = IR + IR\_lagQ4 + effective\_fiscal\_measures + Stringency\_id$$
$$+ \log(REAL\_GDP\_per\_capita\_USD) + Service + Agri$$
$$+ GDP\_growth\_lag\_y$$

The real GDP growth baseline model contains monetary policy rate as well as its fourth lag. In this setting we can expect that *IR* might not be significant for all countries in the dataset, but might be significant for a sub-sample of the countries. The expectation is that the relationship is inverse as suggested by the economic theory (lowering of the interest rate promotes consumption through upward shift in the propensity to consume) and literature (e.g. Bosworth (2014)). We do not expect the explanatory power to be significant for the entire sample because it usually takes economy several quarters to fully react to the change in the interest rates. However, in the case of countries performing UMP actions, specifically QE, the effect might come to effect faster depending on what assets the central bank are purchasing in their asset purchase programs.

The asset purchase programs (APP) vary in their extension and structure, our shadow interest rate is able to capture only the general shifts in the balance sheets, but not necessarily the speed in which the additional money transits into the economy. In the paper by Pegoraro and Motagna (2021) they mention different speeds of transition depending on the type of assets purchased. The general thought behind is that in the times of low interest rates the companies tend to invest more as it is cheaper to finance such investments through loans or issuance of commercial papers, the transmission of the money into the economy through the purchase of commercial papers is suggested to be faster compared to purchase of government bonds or covered bonds issued by financial institutions, which in turn have to lend the money out to corporations to push it through the transmission mechanism. In case the central bank's QE is in its majority consisting of government bonds, it might happen that the entire effect of the UMP in our regression will be consumed by the effective fiscal measures. On the other hand, we have to acknowledge the fact that the main aim of the central bank is not to promote growth, but to promote price stability, thus attempting to reach inflation target in times that the inflation is decreasing or is stagnating below the said target. Despite the fact we now understand that the effect of the UMP might not manifest in the regression, omitting the variable is likely to cause omitted variable bias. Thus, we include it in the model.

Following from the monetary policy rate at time *t*, the fourth lag of the interest rate follows up on the logic of long term setting of the monetary policy and the time which it takes to materialize. That time is being estimated somewhere between 2 and 6 quarters depending on current economic setting and other variables. Therefore we have opted to implement the median suggested by the literature, which is four quarter lag. Based on empirical results in the literature mentioned earlier in the thesis, the variable should be statistically significant in terms of explaining real GDP growth across the whole sample, unless the countries utilizing UMP had started performing such actions before the start of our observed time period and their proportion in the sample is dominant. This could be our case as the ratio of the countries utilizing QE or other form of UMP is 19:11 in favour of QE, most of which is due to high representation of the countries from the Eurozone that have implemented EURO and their monetary policy is being centrally control from the ECB. Nonetheless, we can expect this variable to be significant for at least the CMP countries.

As mentioned earlier, the effective fiscal measures is a proxy variable for fiscal COVID-19 policy actions in response to the pandemic. Based on all the empirical literature and counterfactual analysis of different countries this variable must have a positive significant effect on the real GDP growth regardless of circumstances across all countries in the sample.

Stringency index, as already mentioned in the paper by Gagnom, represents the restrictions on the economy, thus slowing down the growth rate. The stringency index is the main and only representative variable of the non-economic effects of the COVID-19 as the model does not contain any proxy variable for the amount of infected or deceased people due to reasons mentioned in the variable section.

Nonetheless, the empirical literature working with the metric (e.g. Demiralp et al. (2022)) suggests that the variable has very good properties capturing the true effect on the economy and accounting for the vaccinated proportion of the population as well as reacting quiet elastically to spikes in amounts of seriously ill patients and rising numbers of deaths that could cause overload of the health sector. Thus we believe it captures the same or better explanatory portion of variance in the model that any transformation of deaths or infected time series would.

Moving onto the real GDP per capita in USD variable, it is a perfect proxy variable for multiple metrics we would like to get into the model, while reducing the amount of variables included and possible multicollinearity issues to zero. The variable is denominated in the USD currency, therefore it allows pass-through of the real exchange rate properties.
The relationship between GDP per capita and real exchange rate is investigated in the working paper series by the ECB conducted by Habib et al. (2016). We can expect that there exists a direct one way relationship from the exchange rate to the real GDP per capita. The paper presents robust results showing that a real appreciation of currency significantly reduces GPD per capita and vice versa. In case there is a possible endogeneity concern we can control for this relationship by adding instrumental variables.

Furthermore, the variable allows us to control for the size of the economy as we suspect that larger economies suffered larger turmoil during the initial COVID-19 wave, but were able to recover faster and resume their economic growth. We can expect this effect to be significant as shown in the Gagnon paper, where we can draw an analogy from the fact that the GDP growth in the initial stages of the pandemic dropped significantly more in the advanced economies as a reaction to increases in death, however this effect diminished and became insignificant come the end of 2020 and the AEs returned on their pre-pandemic growth paths, or even exceeding them. It is also possible that larger economies have richer GDP composition that is able to better absorb the shocks.

The composition of GDP leads us to the last two variables in our model. In the paper published by the ECB (Meinen et al. (2021)) is an interesting research which studies heterogeneous effect across economies based on the cultural differences, economic background and sectoral composition of GDP. The results of the research show that there is a significant negative effect of the entire service sector on the GDP growth as the services have suffered the most out of all 3 sectors. It was not only due to closing of most services such as restaurants and imposed social distancing, but also due to banks suffering from loan revenues as governments stepped in and provided loans and guarantees for better interest rates to companies than what the commercial banks offered. The companies themselves also decreased their borrowings compared to normal times with similar interest rates as they suffered from workplace closures, decrease in demand after services or inability to provide certain services.

On the other hand, there is no clear general effect of agriculture sector across the sample size. It is suggested that countries with higher contribution of the agriculture sector were more resistant to COVID-19 effects on the GDP growth, on the other hand those countries do not display a large economic growth in real numbers in normal times, and thus the overall effect of the contribution of the agriculture sector to GDP growth is not significant. We have decided to include the variable despite the not promising results from the paper, because when controlling for the multicollinearity of the base model when including an industry, the variable displayed high VIF. It was caused by controlling for both industry and service variable at the same time which resulted in a linear relation between them as they usually complemented each other towards similar proportion of the economy. The agriculture portion of the GDP is compared to them quiet small and for its proportions a lot more volatile, therefore there is no linear relationship with the services variable.

Last but not least, the final variable in the model is the lagged GDP growth variable. Adding lagged dependent variable is a good practise in panel data from the methodological perspective, as it would cause bias in the results if the lagged variable was a significant determinant of the dependent variable development and was omitted. Empirically for example Gagnon also included lagged GDP growth variable in his model, which has come back as statistically significant over both years of the pandemic.

Even though, there is a dedication in the literature to the initial government debt levels before the crisis and capacity of human capital index to capture quality of the health care in the economy, that could possibly result in higher amount of COVID-19 tests performed and more flexible reaction of the restrictions to the current situation as well as less likely overload of the health care system, the variables have not been included into the model for the reasons that they are not time varying thus they would have been absorb by the fixed effects of the individual countries anyway as we at this stage can already predict that we will most likely perform the first part of the methodological work using fixed effects model. Unfortunately, that is the drawback of using such models.

The second base model which helps us estimate quarterly inflation determinants is as follows:

$$Inflation\_q = IR\_lagQ4 + UR + GDP\_growth + CA\_gdp + Industry$$
$$+ effective\_fiscal\_measures + Gov\_debt\_q + Inflation\_q\_lag$$

Once again we present the fourth lag of the interest rate into the model, this time without the presence of its non-lagged variant. The reasoning behind is that it does not matter if the monetary policy is conventional or unconventional, the time period between the shift in the interest rate and effect on the inflation is estimated to be between 4 to 6 quarters as per empirical studies in the monetary policy field. We utilize the existence of the 4Q lag variable in the dataset and use it in the model. The issue of including the non-lagged variable lies in the issue which is referred to as a "price puzzle". It is discussed in the paper by Dejan (2010), which utilizes VAR model to estimate effect on the inflation, but the principle is the same, that is: at time *t*, the monetary policy shock shows on the impulse response function for inflation as a positive effect. The empirical works justify this behaviour by the fact that monetary policy is in often times reactive rather than proactive, therefore the increase in interest rates happens in reaction to inflation rise. Due to this behaviour inflation keeps rising several periods after the interest rates have been increased due to its momentum and the time the interest rate needs to pass through the monetary transmission mechanism. Eventually, the interest rate effect materializes and the inflation starts to decrease in the already mentioned time horizon.

Next variable that enters the inflation model is the unemployment rate. The economic theory suggests that there is an inverse relationship between inflation and unemployment depicted by the Phillips curve. The long run Phillips curve is depicted as a vertical line intersecting the natural unemployment rate on the horizontal axis. Prior to the pandemic times, there were economists pointing out a flattening of the Philips curve as several countries experienced low rates of unemployment and low rates of inflation

Engemann (2020). It would seem that the recent inflation hikes have ended this debate and the flattening period returning We can take a look at one of the many empirical works on the topic of the relationship of the UR and inflation to confirm the existence of the inverse relationship in the real world. The paper written by Sasongko and Huruta (2019) not only empirically confirms the economic theory about the inverse relationship, but also shows one way causality from the unemployment to inflation rate. In other words there is a casual relationship that rise in the UR causes lowering of the inflation.

Going forward, we have included a nominal GDP growth in the model. Relationship between GDP growth and inflation has always been a subject to discussion, however our inclusion of the nominal GDP growth here stands on the assumption that we are interested only in the short term relationship, which has been empirically proven in the paper by Jayathiileke et al. (2013) as to be unidirectional and positive from the economic growth to the inflation tested by Granger causality test.

Next variable in the model is the current account balance ratio to GDP growth. As it is necessary to account for the exchange rate effect as well for the effect of imported inflation through the international channel we can control for the current account balance in this model as it exhibits properties of both dimensions. The empirical work by Alawin and Qqaily (2017) shows that there is a causal relationship between current account and inflation. However, this relationship is not stable over the time horizon as in the short run an increase in the current account deficit leads to higher inflation, the long run effect is positive and leads to decrease in inflation. Similarly to nominal GDP growth we assume that the dynamics we investigate are short run ones due to nature of our dataset and the aim of the thesis.

Continuing, we add the industry variable. Once again referring to Meinen et al. paper we suspect that due to the previously mentioned heterogeneity of the pandemic impact on different countries due to their GDP composition in terms of economic growth, there is also a possible explanatory power in the sectorial variables to explain inflation movement. As mentioned in the literature part of the thesis there is a fundamental believe that a major contributing factor to the current inflation hikes was the negative supply shock caused by distortion of the supply chains. The industries could not get access to the materials and were being limited by restrictions imposed upon the workplace discipline. The idea behind adding the industry portion of GDP into the model is that the countries with larger industrial sectors have is subject to the larger inflationary pressures in time of the supply chain distortions.

The penultimate independent variable in the model is the fiscal policy proxy: effective fiscal measures. Similarly to the monetary policy proxy, we cannot omit its presence in the model, especially because one of the hypotheses we are seeking an answer to is whether the fiscal policy stimulus started to significantly influence the inflation already during the COVID-19 pandemic. The logic behind such behaviour would be the fact that the stimulus has affected the demand side of the equilibrium while keeping the supply side almost untouched. We therefore expect a positive significant relationship between the fiscal stabilization policies and inflation rate.

Lastly, we add quarterly central government debt to GDP ratio variable. We have done so in reaction to the stream of literature that is concerned with possible link between fiscal deficit and inflation. The paper published by Banerjee et al. (2022) from BIS quantifies this concern in the research study. The outcome of the study that has been conducted over four decades upon 21 AEs provides interesting results for this thesis. It shows that there is a significant unidirectional effect from the fiscal deficit to inflation, however the strength of this effect varies based on the monetary policy regimes that the countries have. The regimes where the central bank has very relaxed approach to lending to the public sector, such as in case of quantitative easing and purchasing the government bonds, the effect is much stronger compared to regimes where the central bank is much stricter with regards to public debt. This finding will be interesting to test upon our sub samples. Therefore, we expect a positive relationship between increase in the government debt and increase in the inflation rate, while also expecting the size of the effect to be higher for the countries implementing QE.

The model also contains the lagged dependent variable for the same methodological reasons as mentioned in the real GDP growth model.

4.1.1 Pooled OLS

Pooled OLS assumes that there is no heterogeneity on cross-sectional level or across the time dimensions. We implement a poolability test.

4.1.2 Test of Poolability

There is an assumption for the Pooled OLS that requires stability of coefficients across the cross-sections. To test this, there exists a poolability test. In fact, there are two versions of this test:

a) stronger
b) weaker

The stronger version takes Pooled OLS model as a restricted model and compares it with a regular OLS regression for each cross-section. Formally stated it looks like this:

Restricted model:

$$GDP\_growth = \beta_0 + \beta_k X_k + u_k$$

,where k = 1,..,NT (N is country ID and T stands for year) and X_k stands for control variables in the model

Unrestricted model:

$$GDP\_growth_{i,t} = \beta_{0,i} + \beta_{n,i}X_{i,t} + u_{i,t}$$

,where i = 1,...,N and $X_{i,t}$are control variables at time t.

The null hypothesis for this test is stability of the coefficients.

Test statistics is then defined as:

$$F = \frac{RRSS - URSS}{URSS} * \frac{N(T-K-1)}{(N-1)(K+1)}$$

,where RRSS is the residual sum of squared of the restricted model, URSS is the RSS of the unrestricted model, K number of coefficients and N number of observations. F follows F distribution.

As for the weaker version, restricted model is replaced with FE model. Specifically, with its LDSV variant (least square dummy variable) it contains a dummy variable for every cross-section (for every country in our case). Formally written as:

Restricted model:

$$ln(GDP_{i,t}) = \beta_0 + \beta_i X_{i,t} + \beta_l Country_1 + \cdots + \beta_{l+30} Country_{30} + u_{i,t}$$

The null hypothesis stays the same as in case we used Pooled OLS.

The test statistics is now defined as

$$F = \frac{RRSS - URSS}{URSS} * \frac{N(T - K - 1)}{(N - 1)(K)}$$

4.1.3 Fixed Effects

Fixed effects model assumes that there is an existence of a hidden heterogeneity which is correlated with the error term. Formally, there is a disturbance defined as: $u_{i,t} = \eta_i + \mu_{i,t}$

,where i = 1,..,N; t = 1,...T, and η_i is the unobserved fixed effect that in LSDV model is captured by β_l, where l depends on the amount of control variables in the model. In other words, it captures the coefficients of dummy variables for the individual countries

4.1.4 Fixed Effects Test

The underlying thought of this test is to see whether the individual effects are significant or not, hence we state our null hypothesis that the coefficients of the dummy variables are not significantly different from 0.

Formally, it is stated that the restricted model in this case is Pooled OLS and the unrestricted one is FE model.

The test statistics is then:

$$F = \frac{RRSS - URSS}{URSS} * \frac{N(T - 1) - K}{(N - 1)}$$

4.1.5 Random Effects

Similarly to the FE model, RE assumes that heterogeneity is hidden, but unlike FE it assumes that it is uncorrelated with the error term. In other words, it assumes that both η_i and $\mu_{i,t}$ are random, from this property it takes its name - Random effects.

4.1.6 Random Effects Test

Testing of random effects is comparing RE model to FE model to determine which one is consistent and more efficient if possible. For this there exists a test called *Hausman's specification test*. It tests the underlying property of the RE model that explanatory variables are uncorrelated with the disturbance term.

This property stands as the null hypothesis for this test.

Under the null hypothesis, both methods are consistent, but RE is preferred to FE since it is more efficient. If the null hypothesis is rejected, FE is preferred to RE as RE is no longer a consistent estimator.

Test statistics for this test is formally defined as:

$$H = (\hat{\beta}_{FE} - \hat{\beta}_{RE})^T \left(var(\hat{\beta}_{FE}) - var(\hat{\beta}_{RE})\right)^{-1} (\hat{\beta}_{FE} - \hat{\beta}_{RE})$$

, where H follows asymptotically a chi-square distribution with K_{FE} degrees of freedom (amount of coefficients in the FE model).

Furthermore, it is necessary to control for several properties in order to ensure consistency and efficiency of the regression results.

Firstly we control for stationarity of the time series in the data and we do so through unit root testing. Consulting Baltagi, there is somewhat loose assumption about requirement for stationarity for micro panels as the tests are usually producing results that are heavily influenced by the longitude of the series. Luckily, there exists a panel unit root test designed for these situations which is built on the principle of augmented Dickey-Fuller test but is able to account for short panels. To perform these tests for all variables of our interest we use function *purtest()* from the package *plm*, we have concluded that there is no presence of a unit root in the panel data, thereafter we can conclude that the panel is stationary.

The test output is attached in the Appendix and named as panel stationarity test

The next step is to test multicollinearity in our base models, we have already performed multicollinearity testing when constructing the original models to confirm several empirical findings from the mentioned papers. We perform the multicollinearity test using *vif()* function, which provides us with an output in terms of variance inflation factors. Consulting the documentation of the R package *car* in order to correctly interpret the output, we are referred to the paper by Fox and Monette (1992), who have designed the VIF and according to their paper the threshold values are 1 for no multicollinearity, 5 for mediocre multicollinearity and 10 for severe multicollinearity (corresponding to 95% correlation). Based on this information our output suggests that there is multicollinearity in our model among our variables.

As the next step we can visually investigate a possible heterogeneity in the data, which would signify rejection of the pooled OLS model before we implement any tests.

Investigating the Figures 1) and 2) we can see that there will be country specific heterogeneity for the GPD growth, but it is not so certain for the case of the inflation rate.

To determine whether there is hidden heterogeneity present in the model or not we construct fixed effects models, one for each dependent variable and perform the weak poolability test, which either rules out the pooled OLS models to be inconsistent or does not reject inconsistency.

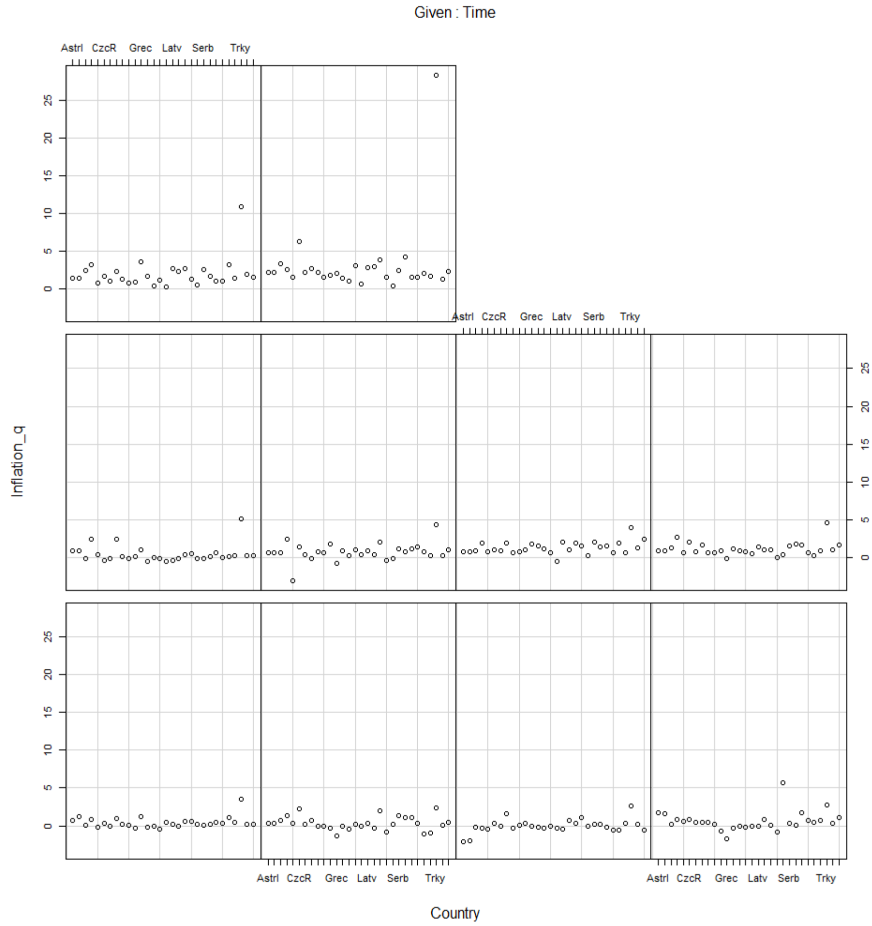
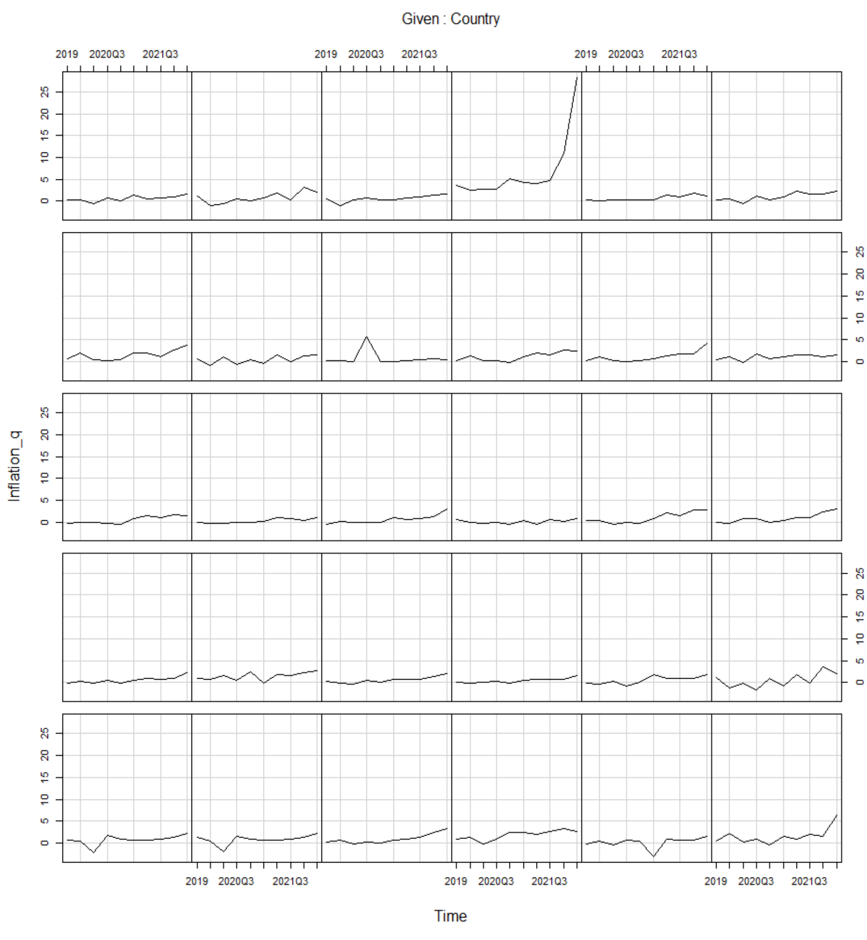


Figure 4.1: Inflation distribution across countries and time



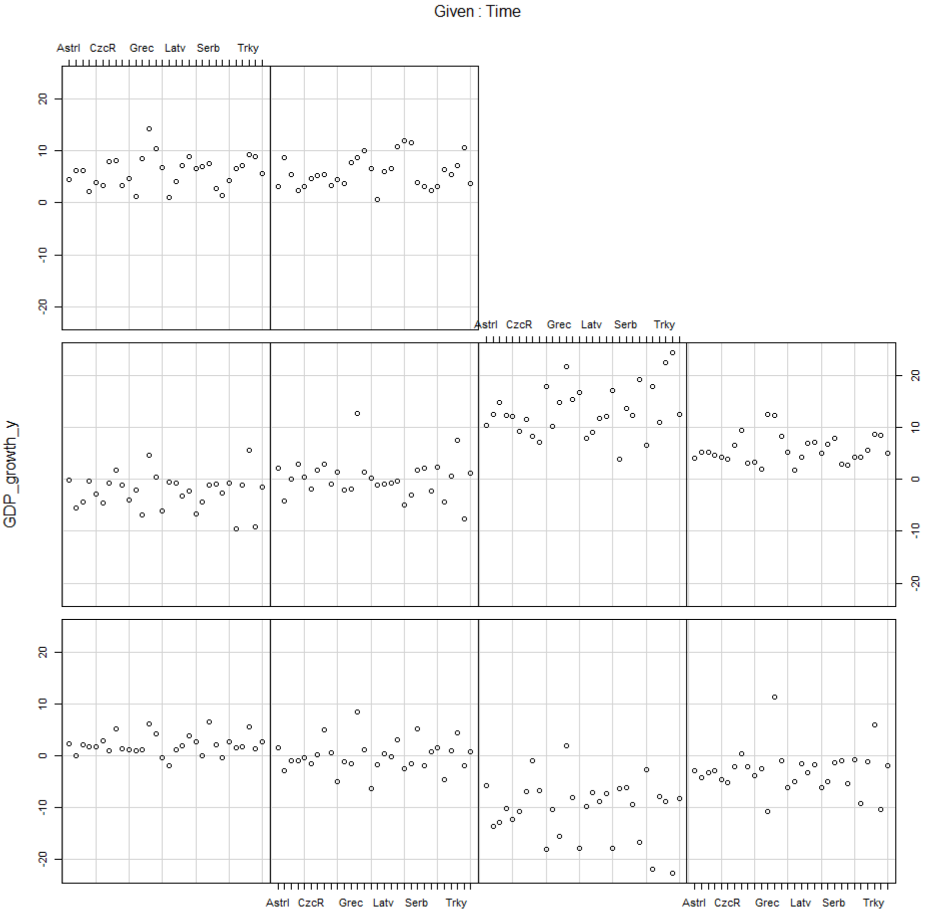
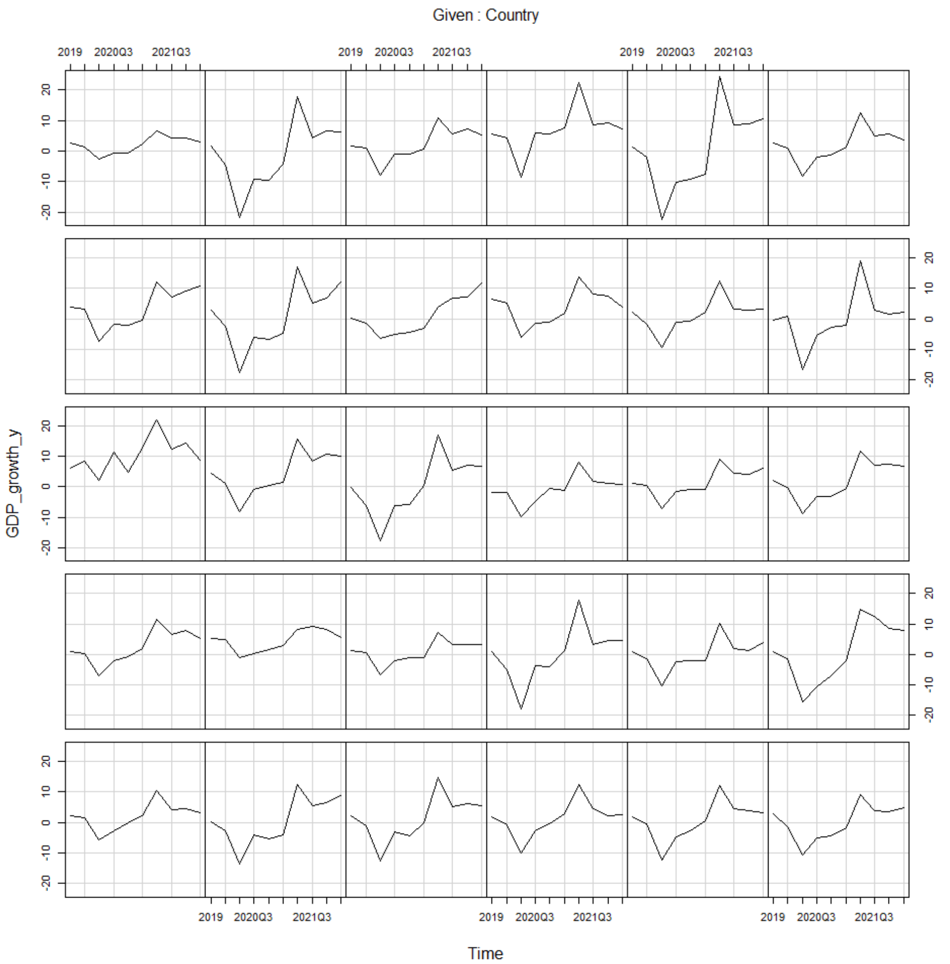


Figure 4.2 Real GDP growth distribution across countries and time



Before we can conduct the test it is important to confirm that the fixed effects in the model are significant and of which nature they are. The fixed effects can be either within time, within group or two-ways effects. In other words it is important to see where the fixed effects manifest. The function to help us determine it is *plmtest()* that determines whether there are significant fixed effects or not. The results show us that the inflation model contains significant fixed effects only within the time dimension. On the other hand, the real GDP growth rate has all of the effects significant in both categories simultaneously. However, the goodness of fit of the two-ways model compared to the within group model is significantly worse. After consulting R forum and Baltagi book it is possible to approach the issue as continuing estimating only using the within group estimation, given the fact that for micro panels the two-ways effect test may provide incorrect results due to short time period.

Now we perform the weak poolability test, the results are provided in the Appendix designated as WP test. Based on the results of the *test* we can state that Pooled OLS is not going to be an appropriate method to use for this model estimation as it is inconsistent estimator.

This leads us to the point where we need to determine whether the random effects estimator will be more efficient estimator or will be inconsistent.

We specify random effects model and implement Durbin-Wu-Hausman test using *phtest()* function. The results tell us that the random effects model is inconsistent estimator and we need to stays with the fixed effects one.

4.1.7 Endogeneity Control

Now we need to address possible endogeneity issues. The most common way how to deal with the endogeneity is to use instrumental variables, those are variables that are correlated with the independent variable X and have no direct effect on the dependent variable and are uncorrelated with the error term. As per empirical literature implementing IV in the models and Wooldridge book the most commonly used instrumental variables are lags of the original endogenous variable, which guarantees good correlation with the endogenous variable. To determine which variables should be controlled for endogeneity and which not lies mostly in empirics and economic theory, but there exist tools that can help us determine if controlling for certain variable is appropriate or not.

In the case of the fixed effects with instrumental variables we utilize function *feols()* . It allows for adding instrumental variables, separation of the endogenous variables from the rest for cleaner look and most importantly is equipped with diagnostics tool containing tests that will help us determine appropriateness of our endogenous variables and corresponding IVs.

The *feols()* function provides us with weak instrumental variables test for each endogenous variable, Hausman specification test and Sargan test. The weak instrument test tells us whether the IV we have selected to control for endogeneity of the regressor is sufficient in terms of correlation with the regressor. The null hypothesis is that the instrument is weak, alternative hypothesis that it is not weak. The real adequacy of the IV choice comes down to the researches judgement at the end of day. The Hausman specification test in the panel model tells us whether the variables we suspect to be endogenous are truly endogenous, it is the last resort in case we have decided to control for endogeneity a regressor that is in reality exogenous. The Hausman test essentialy tells us at its null hypothesis that there is no significant difference in the estimate performed by the model assuming full exogeneity and our designed model with IV controls. In case we are not able to reject the null hypothesis, it is required we perform the regression in the original model without any IVs as both estimators would be consistent but the model assuming pure exogeneity of its independent variable would be more efficient.

On the other hand, the function also contains Sargan test metric. The Sargan test works essentialy as an opposite bound to the Hausman test as it tells us whether we are imposing too strong restrictions on the model. In other words, we are adding too strong or too many instrumental variables into the model, also referred to as overidentifying of restrictions. The Sargan test is only applicable if such situation arises. The entire function works on the basis of 2SLS estimation process.

Utilizing information from the tests in the model, economic theory and empirical literature we have imposed restrictions in the form of instrumental variables in our two models in order to control for endogeneity in some of its predictor variables.

The model has now obtained the form where the independent variables in the first row formula are all exogenous variables and the dependent variable with its lag.

The left hand side of the formula in the second row are all variables from the original model we have decided to control for possible endogeneity and the right hand side of the formula are the corresponding instrumental variables.

GDP_growth_y ~ GDP_growth_lag_y + Stringency_id + effective_fiscal_measures + services | IR + IR_lagQ4 + log(REAL_GDP_per_capita_USD) + Agri ~ log(REAL_GDP_per_capita_lag) + IR_lag + IR_lagQ5 + Agri_lag |

As we can see we control for both interest rates, which is based on the empirical precedent, for the Real GDP per capita which was mentioned in the variables section of the thesis that if the endogeneity concerns arise we will control for them as it encompasses exchange rate influences as well as population growth and due to the fact that it is Real metric we also have to account for the development of inflation, specifically GDP deflator. The last but not least is the agriculture variable as we are suspicious it might be correlated with the industry variable. The Sargan test showed overidentification issue when including the service lag variable to control for service as an endogenous variable. Furthermore, the Hausman test has improved in the current specification compared to the one with restriction imposed on the service variable, which leads us to believe that this is the correct specification. Lastly, the adjusted goodness of fit has also improved in this specification.

The other model contains significantly less endogenous variables as the Hausman test failed to reject consistency of the estimation when we attempted to add any other variable as endogenous. Therefore the restricted model has the following form:

Inflation_q ~ Inflation_q_lag + UR + GDP_growth + effective_fiscal_measures + CA_gdp + Industry + Gov_debt_q | IR_lagQ4 ~ IR_lagQ5 |

The technical output with the test results is in the Appendix, here we present the coefficients with SE an p-values.

Table 4.3.: Feols output from the GDP growth restricted model

	Estimate <dbl>	Std. Error <dbl>	t value <dbl>	Pr(>|t|) <chr>	<fctr>
fit_IR_lagQ4	0.040079	0.030191	1.327498	0.217030	
Inflation_q_lag	0.659256	0.435269	1.514596	0.164175	
UR	-0.011767	0.006431	-1.829861	0.100518	
GDP_growth	0.149145	0.052908	2.818926	0.020082	*
effective_fiscal_measures	0.014159	0.019269	0.734796	0.481170	
CA_gdp	-0.017446	0.011426	-1.526888	0.161135	
Industry	0.033021	0.013927	2.370921	0.041846	*
Gov_debt_q	-0.001260	0.002451	-0.514199	0.619500	

Table 4.4: Feols output from the quarterly inflation restricted model

	Estimate <dbl>	Std. Error <dbl>	t value <dbl>	Pr(>|t|) <chr>	<fctr>
fit_IR	-0.564750	0.232341	-2.430691	2.1486e-02	*
fit_IR_lagQ4	-0.447847	0.347284	-1.289571	2.0739e-01	
fit_log(REAL_GDP_per_capita_USD)	30.772725	8.227396	3.740275	8.0591e-04	***
fit_Agri	-2.414005	2.908625	-0.829947	4.1335e-01	
GDP_growth_lag_y	0.158628	0.041105	3.859126	5.8568e-04	***
Stringency_id	-0.087425	0.016427	-5.322125	1.0363e-05	***
effective_fiscal_measures	0.446676	0.092568	4.825404	4.1206e-05	***
services	-1.171026	0.221987	-5.275210	1.1805e-05	***

The function *feols()* have served us well allowing us to perform the FE regression with the individual effects for the GDP grow using group clustered SE and also perform the FE regression with the time effects for the inflation using forcing the regression to use clustered SE based on Time variable.

4.1.8 Heteroskedasticity, Autocorrelation and cross-sectional dependence

Nonetheless, we are still far away from drawing any robust conclusions. It is now necessary to address three more issues that this regression might face. We will need to perform series of tests that R allows us to do through the *plm* package, however it is first necessary to transform the object into the plm class, using function *plm()* which allows for specification of instrumental variables, but is not equipped with diagnostics tools unlike the previous function.

Before we start conducting the remaining tests, we split the original data set into two, using implementation of quantitative easing as the metric. The new data panels are skewed towards the countries which have implemented the QE in ratio 19:11. Thus we now have 6 (3 for the inflation specification and 3 for the GDP growth specification) models being regressed over different country samples, which could potentially lead to interesting findings of key differences in the effectivity of the stabilization policies.

First, it is necessary to test for presence of heteroscedasticity. That is nothing else than testing that the variance of the fitted variables and variance of the residuals remains constant over time. We test for this using Breusch-Pagan test through *bptest()* function in R.

As the results of the B-P test can be found in the Appendix, we can see that we have rejected the null hypothesis in all cases, therefore there is heteroscedasticity present and it is necessary to control for it.

Moving on we have to check for serial correlation, sometimes referred to as autocorrelation in the data. Autocorrelation is the degree of correlation of an independent variable with its own lag. We can test for the serial correlation using Breusch-Godfrey/Wooldridge test in the R using function *pbgtest().* The null hypothesis states that there is no serial correlation, while the alternative hypothesis is that there is a serial correlation in idiosyncratic errors. The results are once again available in the Appendix, but we can notice a significant difference between the 2 models as all of the GDP models reject the null hypothesis, testing thus positive for the presence of autocorrelation in the models. On the other hand, 2 out of 3 specifications of the inflation model do not reject the null hypothesis at 95% confidence level, but only for 90% confidence level. The last model which runs the regression over the countries that have not implemented QE has rejected the null hypothesis at 95%confidence level. Given the circumstances and how close the p-value was to 95% level we assume there is serial correlation in all 3 cases and we have to control for it.

The last but not least, we have to perform the cross sectional dependence test. The literature on the cross sectional dependence in the empirical data shows that there is a link to spillover effects as investigated in Elhorst et al. (2021). However, the aim of the thesis is to control for within the country specific effects and a potential future research could then investigate this link. Nonetheless, we aim to first test for the cross sectional dependence in our model and control for it if necessary. To do so we implement function *pcdtest ()* and consult De Hoyos et al. (2006) as well as the R package documentation for setting appropriate parameters in the function. At the end we decide to implement Pesaran's CD test as it is the most appropriate test in our situation. It allows for both within individual and within time effect models and is quiet robust to short panels compared to the alternatives as demonstrated in the paper by Pesaran (2004).

The results of the test are once again presented in the Appendix. The null hypothesis of the test is that there is no cross-sectional dependence, while the alternative hypothesis states that there is a cross-sectional present in the model. Similarly to the serial correlation tests, the Pesaran's CD test has rejected the null hypothesis for all 3 GDP growth models but only for 1 inflation model. However, this time the p-values are significantly larger and the null hypothesis cannot be rejected at any commonly used confidence level.

To summarize this part, we have to control for heteroscedasticity in case of all the models as well as for the autocorrelation. The PCD test has shown that we need to control for cross-sectional dependence in case of 4 out of 6 models presented.

To control for these flaws in the models we need to implement robust standard errors. Consulting Baltagi, documentation to *vcov()* function and the econometric forum on the Researchgate website[5], it has been suggested that there are 2 primary approaches how to control for all 3 metrics in the panel data. If the panel had properties where the time dimension is larger than the cross-sectional dimension it would be wise to use FGLS estimator to obtain robust results. However, our panel is large in cross-section and short longitudinally, therefore panel corrected standard errors are recommended as the adequate tool to provide us with robust estimates. There are several types of PCSE based errors, however not all are adequate for the short panel of this proportion as for example Beck and Katz (1995) PCSE based error provide consistent and efficient results only up to 1/3 ratio of T/N.

Given the fact that we are just on the edge of this ratio, we should seek for alternative that is robust even for smaller ratios. We are referred to work of Driscoll and Kraay (1998) that have proposed standard errors that are based on work of Arellano (1987) extending his work onto cross-sectional and cross-serial correlation. The two models which have not rejected cross-sectional dependence are treated with the Arellano robust standard errors, which are robust to heteroscedasticity and serial correlation using *vcov()* function. As for the remaining 4 models, we implement Driscoll and Kray robust errors which are sometimes called SCC error (spatial correlation consistent). Fortunately, there exists a function *vcovSCC()* which is a direct implementation of the SCC method into the already existing R function. The estimates after implementing the robust standard errors are discussed in the results part of the thesis.

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[5] Discussion at :https://www.researchgate.net/post/How_can_I_solve_the_cross-sectional_dependence_and_heteroscedasticity_in_the_model_of_fixed_effects

4.2 Supplemental Methodology

To provide additional view into the behaviour of the macroeconomic indicators, we have decided to enrich our methodology for a forecasting method that will be able to show us the future development paths in the post-covid times. As this is purely supplemental methodology we will not go into the extreme details as with the panel analysis.

We implement vector error correction model (VECM) due to its ability to produce robust impulse-response functions and forecasts while processing non-stationary data at levels. This allows us to maintain the important variance low frequency information in the data. It is due to the fact that for VECM to work consistently even with non-stationary is sufficient to prove that there exists cointegration among the variables. To set up the model we have discussed the econometrics textbooks and papers by Kuschnig and Vashold (2021), Fernández et al. (2007) and Pox et al. (2016) which discusses the limitations of the VAR and the underlying time series and offering VECM as an alternative to forecast without need to difference the existing series.

4.2.1 VECM

To test for presence of cointegration among the time series we use Johansen procedure. Johansen test for cointegration presence exists either in trace form or eigenvalue form. We apply both for robustness purposes and investigate the output of the function *ca.jo(),* from *urca* package, which performs the test for us. The the null hypothesis represents the fact that number of cointegrating vectors is $\leq R$, where R sequentially increases and represents the number of cointegration vectors and alternative hypothesis is $\leq R+1$. The first non-rejection of the null hypothesis becomes the estimate of the number of vectors. VECM requires at least 1 cointegration vector in order to work.

We then proceed to estimate the VECM with including both constant and trend as the deterministic trends and generate IRF. The responses generated through VECM are looking quite similar to the responses generated through VAR, but they seem to align more with our economic intuition.

The general form of VECM can be defined as: $\Delta \boldsymbol{x}_t = \boldsymbol{\Pi} \boldsymbol{x}_{t-1} + \sum_{i=1}^{p-1} \boldsymbol{\Phi}_i^* \Delta \boldsymbol{x}_{t-i} + \epsilon_t$

, where exists an error correction term: $x_t = x_{t-1} + \Delta x_t$

$\prod$ then stands for the rank of matrix, which we estimate using the Johansen process, while $\boldsymbol{\Phi}$ is a characteristic polynomial which $\prod$ is a function of.

5 Results

Looking at the regression results we can state that all our models are overall significant as per F-test. Furthermore, they display strong adjusted goodness-of-fit, to be more specific the adjusted R^2 is for the general real GDP growth model on whole sample 0,507; for the subsample of QE countries 0,596; and for the subsample of no-QE countries 0,472.

The quarterly inflation model displays slightly lower adjusted R^2, nonetheless still very positive numbers. That being: 0,436 for the general quarterly inflation model on the whole sample; 0,332 on the QE countries subsample; and on the no-QE countries subsample 0,441.

The outputs with overall significance F-test and R^2 can be seen in the appendix as the output of the robust standard errors regression does not print out the diagnostic metrics. Nonetheless, the coefficient of the individual effects remains the same, what changes is their statistical significance.

5.1 VECM results

In this section we can see the impulse-response functions and forecasts for 3 selected European with different monetary regimes as a demonstration of the methodology.

At first we take a look at Sweden. Riksbank (Swedish central bank) has been conducting UMP since 2014. Sweden is part of the European Union but it has not adopted EURO and thus has an independent monetary policy and own currency.

Constructing a regular VAR model and then performing Johansen test shows us that in case of Sweden we have 3 significant cointegration vectors that are to be included to construct the error correction term of VECM.

We are interested in the IRF of the last 3 variables on the real GDP and inflation and also on the interaction between inflation and GDP.

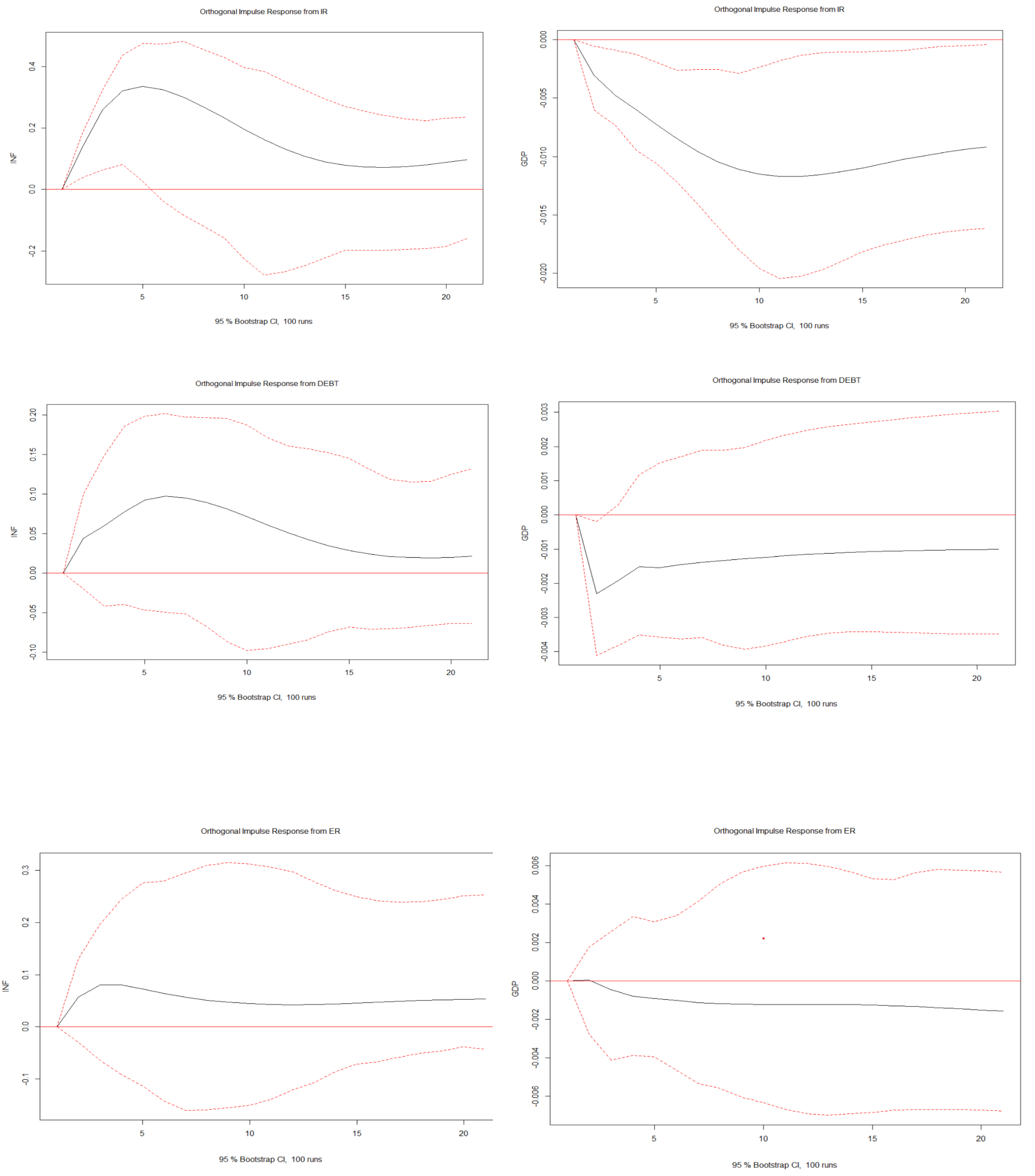

Figure 5.1: IRF – VECM – Sweden

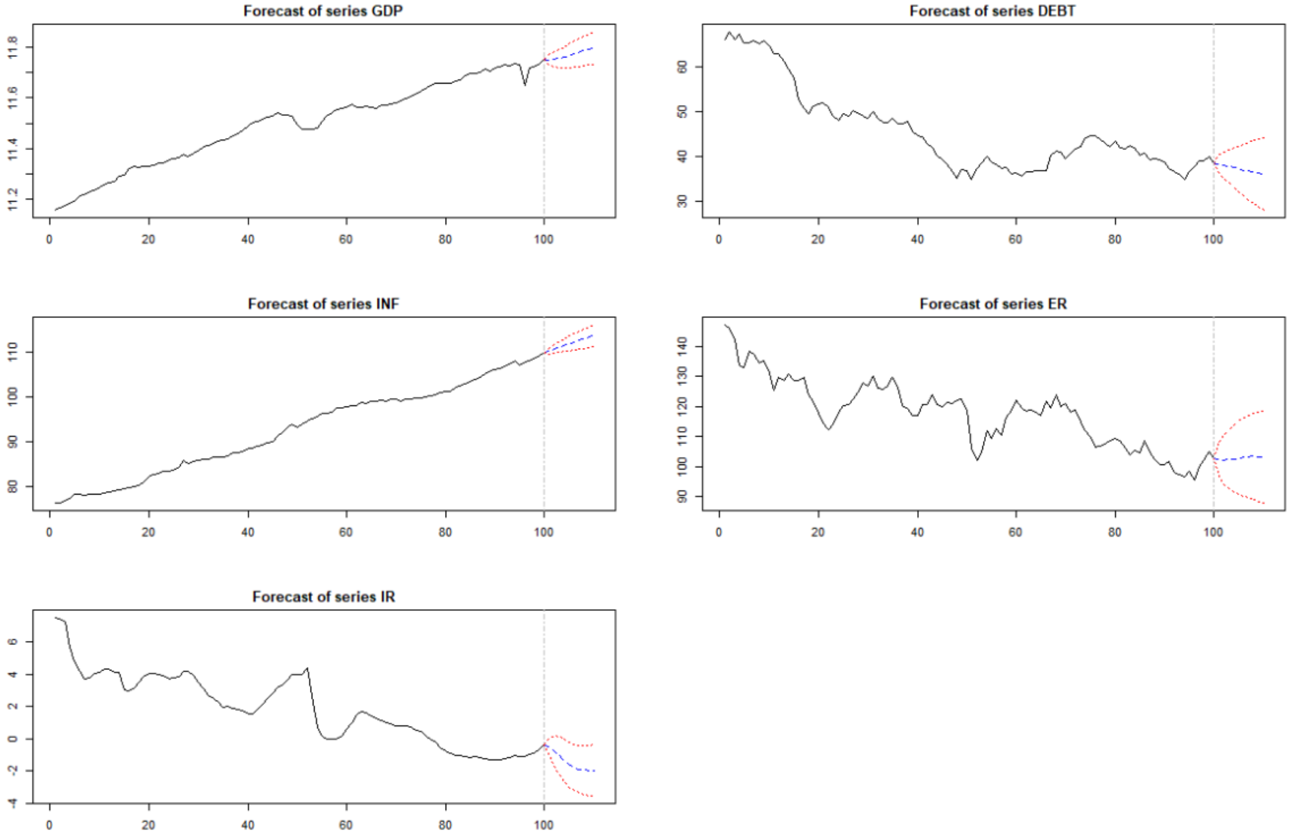

Figure 5.2: VECM – forecast – Sweden

As we can see the VECM produces IRFs that are mostly not statistically different from 0 effects for 95% CL, however we can see that there is a significant effect in term of monetary policy shock on the GDP which gradually decreases until the tenth period after the shock and then slowly starts converging back to 0.

The direction of the effects is mostly as expected and the forecast for the future looks like stabilizing towards the pre-pandemic trend levels.

Next country we will run our monetary VAR on is Italy. Italy as mentioned in the introduction of the thesis has been struggling to recover on its original real GDP levels since the GFC. The monetary policy in Italy is the common currency area, as Italy has adopted EURO and is thus part of the Eurozone, which performs centralized monetary policy and has been performing UMP since the end of the Solvency crisis during similar time as Sweden.

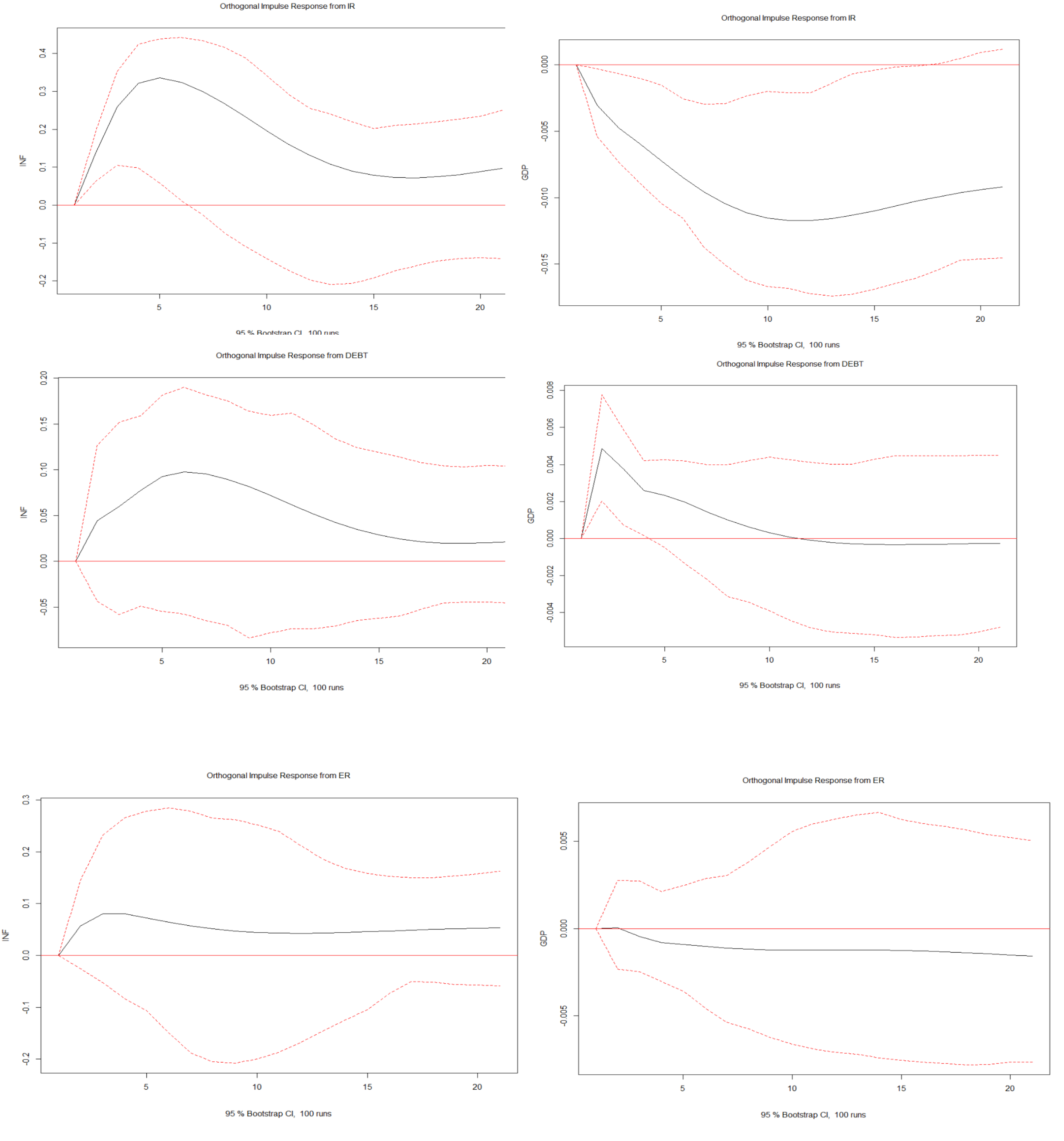

Figure 5.3: IRF – VECM – Italy

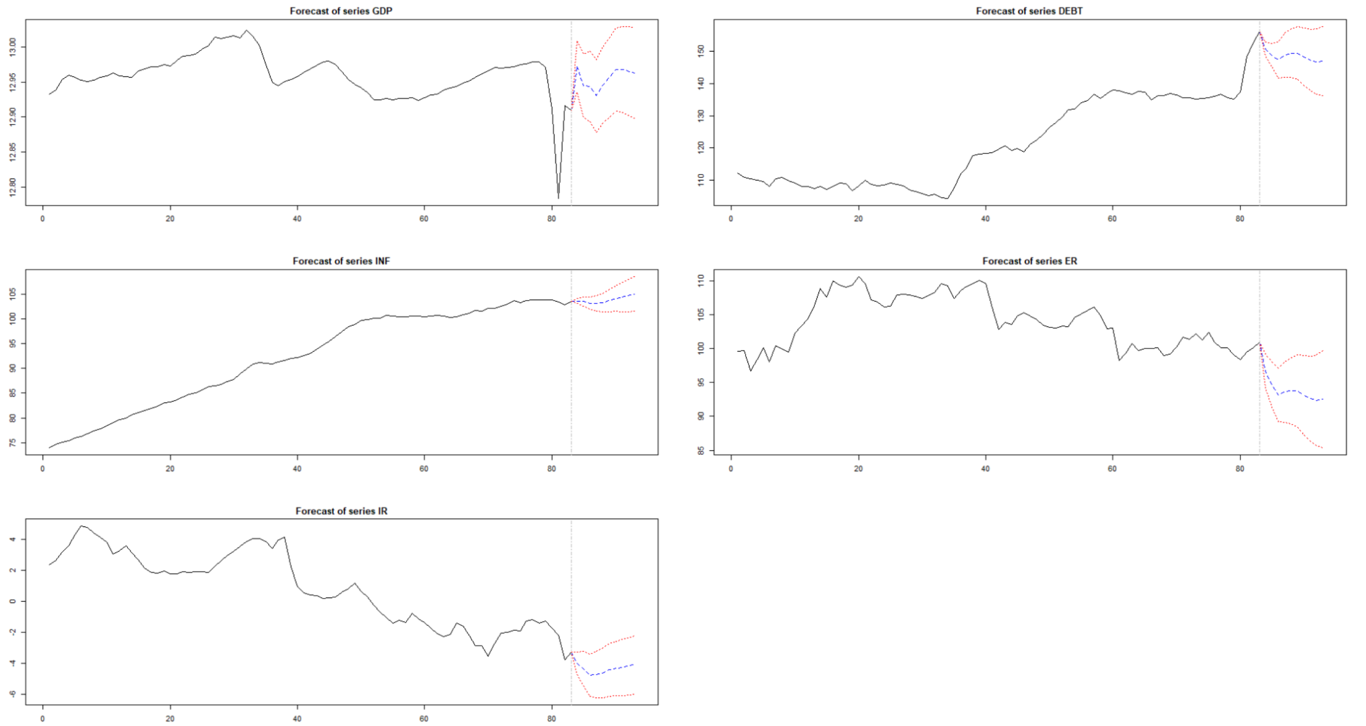

Figure 5.4: VECM – forecast – Italy

The IRF look almost identical with the only exception of the raction to fiscal debt shock where we can that economy is boosted by such shock temporatily for few period before converging back to zero. The forecasted development paths are slightly different, the GDP predicts to suffer short decrease before return back to the prepandemic level, it is expected and increase of the interest rates possible to react to the predicted rise in inflation and the real exchange rate is forecasted to stagnate or decrease.

The last but not least, we have the Czech Republic. The country has independent monetary policy with stable currency and has not been conducting quantitative easing as its nominal deposit rate has been held above 0. On the other hand, the central bank was performing exchange rate intervention between 2014 and 2017. The Johansen test tells us to include 4 cointegration vectors into VECM.

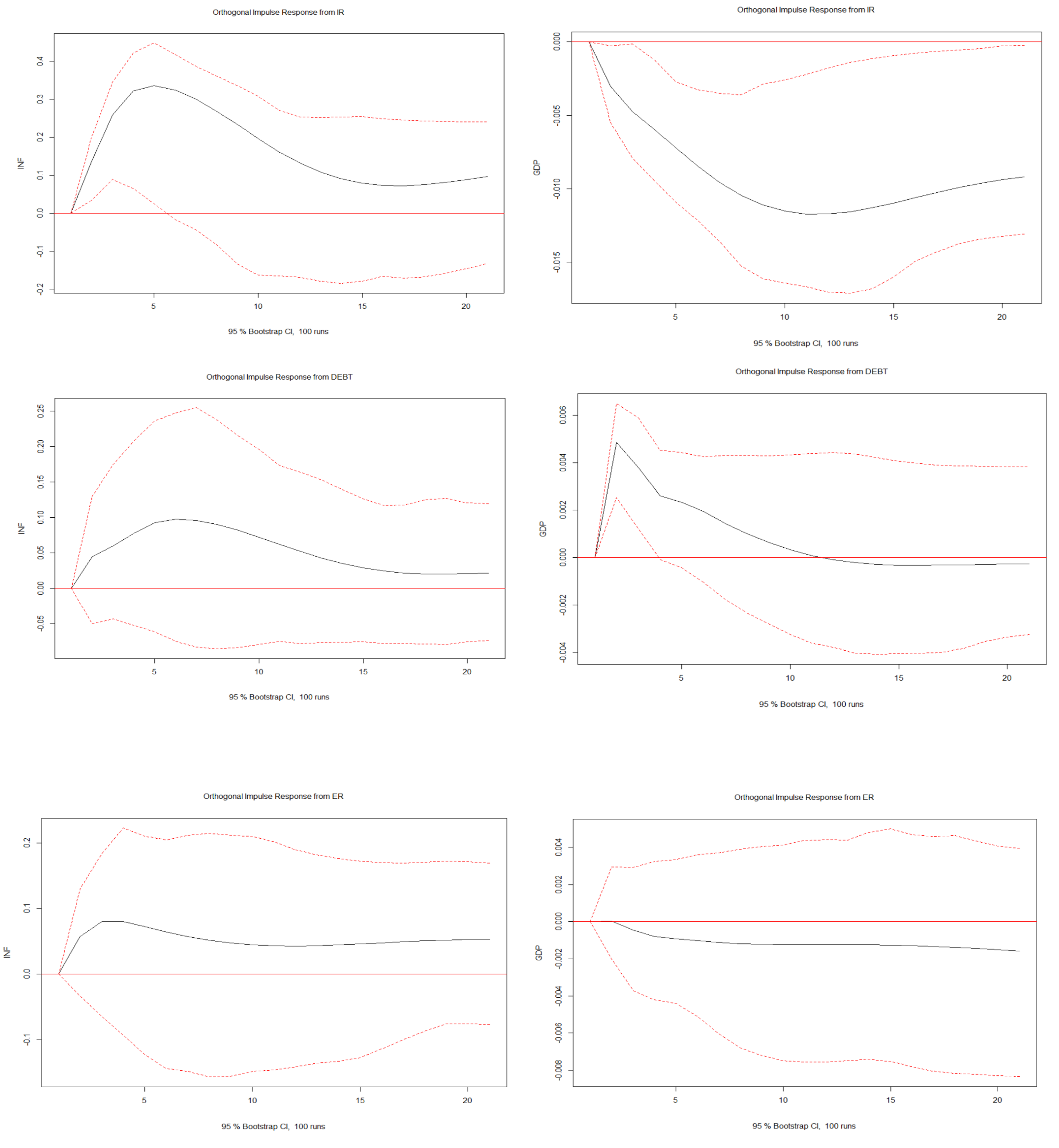

Figure 5.5: IRF – VECM – Czech Republic

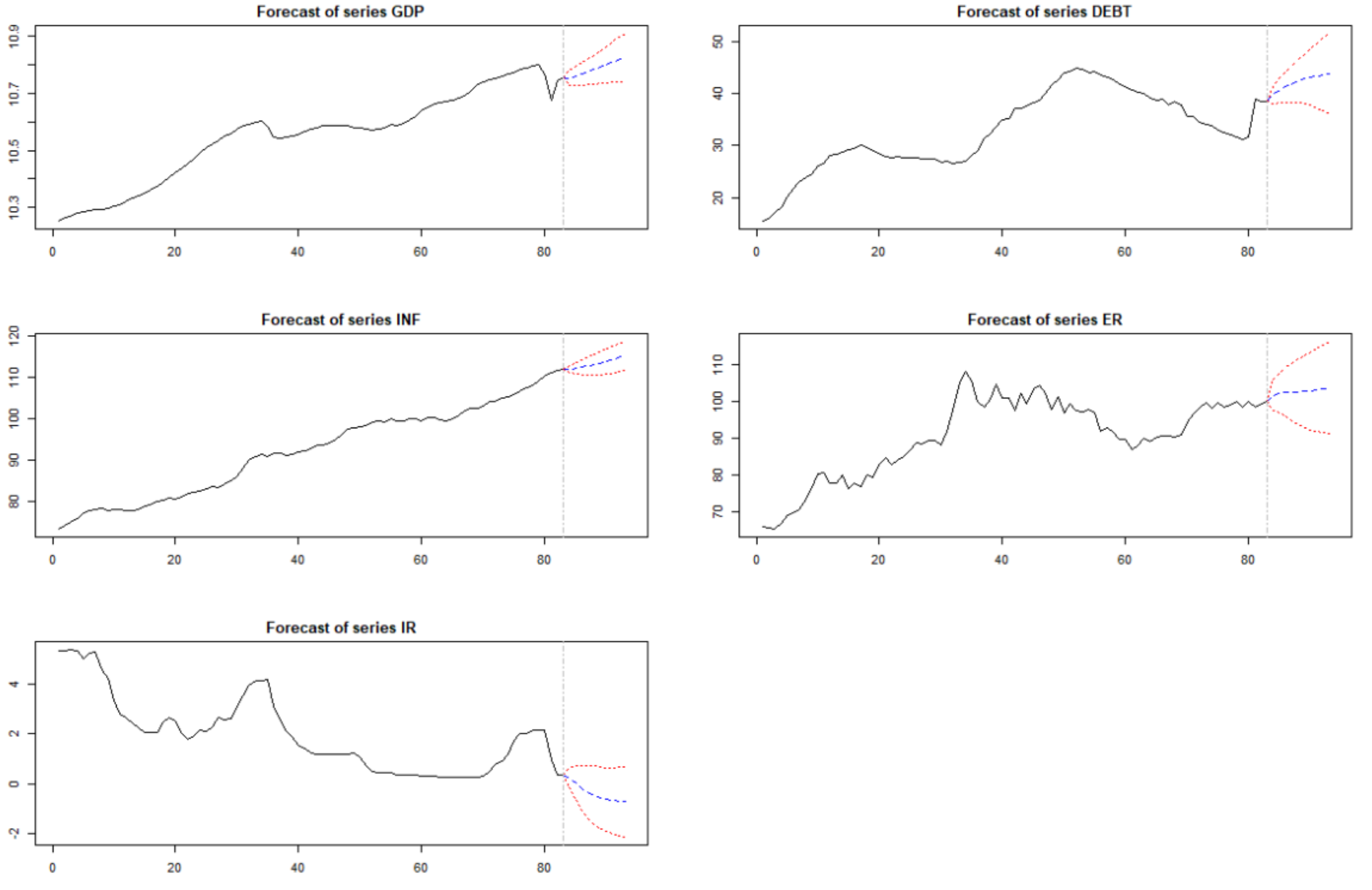

Figure 5.6: VECM – forecast – Italy

The IRF are one again almost identical to the IRFs of Italy, differatiating from each other only in the size of the effects. However, forecast of the future development resembles forecast for Sweden rather than Italy, which can be result of Italy's more volatile macroeconomic indicators. It would seem so that there is no significant difference in terms IRFs between independent CMP monetary policies, centralized UMP monetary systems and independent central bank performing UMP. This supports our findings from the fixed effects model, which will be mentioned in the results section dedicated to them.

5.2 Real GDP growth model

```
t test of coefficients:

                             Estimate Std. Error t value  Pr(>|t|)    
GDP_growth_lag_y             0.158628   0.044454  3.5684 0.0004270 ***
IR                          -0.564750   0.295147 -1.9135 0.0567800 .  
IR_lagQ4                    -0.447847   0.386528 -1.1586 0.2476572    
effective_fiscal_measures    0.446676   0.119383  3.7415 0.0002247 ***
Stringency_id               -0.087425   0.022546 -3.8776 0.0001334 ***
log(REAL_GDP_per_capita_USD) 30.772725 10.400560  2.9588 0.0033713 ** 
services                    -1.171026   0.251869 -4.6493 5.284e-06 ***
Agri                        -2.414005   3.145041 -0.7676 0.4434402    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Table 5.1: Real GDP growth FE with IV and robust SE

In the Table we can see output of the GDP growth regression after applying the SCC standard errors. We can see that the lagged dependent variable has a statistically significant effect on the GDP growth at time t, which could be explained as a certain momentum of the economy, given that the interpretation tells us that 1% increase in the GDP growth lagged period increases the GDP growth at time t by 0,158%. Moving onto the interest rate, here we can see that the IR is statistically significant at 90% confidence level and has the expected direction of the effect. We could interpret this as the effect of the UMPs promoting the growth at the same period, however we should wait with this statement until we analyse the other 2 specifications of the model. IR lagged by 4 quarters suggests that there is no statistical significance of the midterm monetary policy setting on the GDP growth for the entire sample. On the other hand, we can see that the fiscal stabilization policies are statistically significant and have desirable direction of their effect.

The interpretation is as follows: by increasing effective fiscal measures by 1% of the 2020 GDP we stimulate the economic growth by 0,447%, or alternatively slow-down its fall by that amount. The next important variable in our model is stringency index which is statistically significant as well and has the expected direction of its effect. Increase in the stringency index by 1 leads to decrease in the real economic growth by 0,09%. The next independent variable is the logarithmic transformation of the real GDP per capita denominated in the USD. This effect is significant and it is important to understand that it is level-log relationship between dependent and independent variable, therefore the interpretation of the relationship is that 1% increase in the real GDP per capita in USD results in 0,31% increase in the real GDP growth.

Moving onto the economic sectoral composition variables, first we discuss the effect which services contribution to the country's GDP has on the real growth. As we can see the relationship is negative as expected and statistically significant, which means that the countries with larger service sectors suffered larger GDP growth falls, to be specific increasing the services sector contribution to GDP by 1% results in 1,17% real GDP growth fall. On the other hand, the agriculture variable is statistically not significant. It is important to understand that the interpretation of the sectoral contributions is based also on the size of the sector in the economy, as it is level-level relationship with the dependent variable. Therefore the coefficients for the agricultural sectors are larger because 1% increase in the agriculture is for some countries 80% increase compared to its current level.

```
t test of coefficients:

                              Estimate Std. Error t value  Pr(>|t|)    
GDP_growth_lag_y              0.153800   0.030700  5.0098 1.405e-06 ***
IR                           -1.055234   0.515032 -2.0489   0.04208 *  
IR_lagQ4                      1.578356   0.926574  1.7034   0.09039 .  
effective_fiscal_measures     0.345752   0.059548  5.8062 3.253e-08 ***
Stringency_id                -0.080679   0.016877 -4.7803 3.885e-06 ***
log(REAL_GDP_per_capita_USD) 57.729215   9.026142  6.3958 1.617e-09 ***
services                     -0.674522   0.354930 -1.9004   0.05914 .  
Agri                         -3.398158  14.260365 -0.2383   0.81195    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Table 5.2: Real GDP growth FE with IV and robust SE on QE countries

Next we discuss the real GDP growth model regression on the subsample of QE countries from the table above. As the interpretation of the effects is now clear, we will comment only on the interesting differences between the whole sample model and this one. The explanatory effect of the lagged dependent variable is very similar to the original model, however the IR at the time t has become significant at 95% confidence level and its effect is almost doubled compared to the general sample. It would suggest that the UMP that are captured by decrease of shadow rates by 1% cause the real GDP growth to rise by 1,06%. On the other hand we have the fourth lag of the shadow rates with the opposite sign than expected, which can be explained by the fact that the countries were performing QE before the pandemic has started and the GDP growth fall, which came as an exogenous shock manifested itself here as an opposite effect. Nonetheless, the relationship is not statistically significant at 95% confidence level and almost not significant even at 90% CL, therefore we do not need to worry too much about it. The fiscal stabilization policies in the QE countries are at about ¾ of the effect that the whole sample regression showed us. This slight decrease might be cause be increasing explanatory power of the monetary stabilization policies in those countries. The effect of stringency index is very similar as in the prior regression and the effect of real GDP per capita has increased to almost double the size. This might be caused by the fact that all of the QE countries are advanced economies and therefore their real GDP per capita is larger, and as shown in the empirical literature the stronger economies showed a stronger swing in fall and recovery in terms of economic growth. The last but not least we have the services variable, which has become insignificant at 95% CL.

```
t test of coefficients:

                            Estimate Std. Error t value  Pr(>|t|)    
GDP_growth_lag_y             0.07586    0.12094  0.6273 0.5320593    
IR                          -0.60154    0.36473 -1.6493 0.1025327    
IR_lagQ4                    -0.98129    0.29476 -3.3291 0.0012593 ** 
effective_fiscal_measures    0.48700    0.15459  3.1503 0.0022079 ** 
Stringency_id               -0.10558    0.02790 -3.7842 0.0002759 ***
log(REAL_GDP_per_capita_USD) 19.88145   6.31644  3.1476 0.0022262 ** 
services                    -0.64761    0.61411 -1.0546 0.2944209    
Agri                        -1.77763    1.85866 -0.9564 0.3414024    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Table 5.3: Real GDP growth FE with IV and robust SE on no QE countries

The last GDP growth model shows us effects in the countries that have not implemented QE. We can immediately see that the lagged dependent variable has become statistically insignificant determinant of the growth, furthermore the current setting of the interest rate is also insignificant as expected in the empirical literature. On the other hand,, the fourth lag of the interest rate shows significance at 95% CL with a correct direction of the effect, which has been expected. In terms of the size of the effect we can state that it is very similar to the size of the effect of the UMP in the previous model. We could possible state that there is no significant difference between the effects, except that the timing for the CMP must be aiming 4 periods forward. Effective fiscal measures are of similar size as for the general model, similarly then with the stringency index and lower size of the real GDP per capita index can be explained by the fact that in this sample we have countries with on average lower GDP per capita and also countries that have suffered massive currency depreciation to USD such as Turkey. The services sector has become completely statistically insignificant, possibly due to the more variety between the countries in this sub sample.

5.3 Inflation Model

```
t test of coefficients:

                          Estimate Std. Error t value  Pr(>|t|)    
Inflation_q_lag          0.6592563  0.0944034  6.9834 2.070e-11 ***
UR                      -0.0117673  0.0167007 -0.7046   0.48164    
effective_fiscal_measures 0.0141590  0.0174476  0.8115   0.41775    
IR_lagQ4                 0.0400791  0.0227785  1.7595   0.07957 .  
GDP_growth               0.1491451  0.0219083  6.8077 5.961e-11 ***
CA_gdp                  -0.0174465  0.0133547 -1.3064   0.19248    
Industry                 0.0330210  0.0137605  2.3997   0.01706 *  
Gov_debt_q              -0.0012601  0.0020689 -0.6090   0.54298    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Table 5.4: Inflation FE with IV and robust SE

Moving onto the inflation models, we can see from the first glance that there is fewer significant determinants. The variance in the inflation seems to be primarily explained by the inflation from the previous period and nominal GDP growth. The regression tells us that 1% increase in the nominal GDP growth causes inflation to rise by 0,15% while the 1% increase in the inflation in the previous period causes the current inflation rise by 0,66% ceteris paribus. On the other hand we confirm our suspicion that the disturbance of the supply chains has manifested through the industry sectoral GDP contribution. Even though, the effect is rather small in size it is significant at 95% CL. 1% increase in industrial contribution to the GDP increases inflation by 0,03%. In other words, countries with larger industrial sector suffer larger inflation due to imbalance in the equilibrium on the domestic market.

```
t test of coefficients:

                           Estimate Std. Error t value  Pr(>|t|)    
Inflation_q_lag          -0.0621670  0.1314228 -0.4730   0.63682    
UR                       -0.1485252  0.0367470 -4.0418 8.158e-05 ***
effective_fiscal_measures  0.0919456  0.0173631  5.2955 3.793e-07 ***
IR_lagQ4                  0.1469300  0.0946733  1.5520   0.12261    
GDP_growth                0.0331925  0.0155982  2.1280   0.03484 *  
CA_gdp                   -0.0068064  0.0128670 -0.5290   0.59754    
Industry                  0.1840485  0.0833803  2.2073   0.02869 *  
Gov_debt_q               -0.0439353  0.0169394 -2.5937   0.01036 *  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Table 5.5: Inflation FE with IV and robust SE on QE countries

Now we discuss results of the inflation regression ran on the countries that implemented QE. We can see that statistical significance of the lagged dependent variable has vanished and several new determinants gained explanatory power for this sub sample. Firstly, we can see manifestation of the Phillip’s curve in the unemployment and its inverse relationship with inflation, which is significant for 99% CL and shows that an increase in the UR causes inflation to fall by 0,15%. The effective fiscal stimulus has also become statistically significant in this sample as we suggested in our hypothesis and variable choice discussion. The effect of increasing the fiscal stimulus by 1% of the 2020 GDP causes inflation to rise by 0,09%. The fourth lag of the interest in this situation is statistically insignificant. The nominal GDP growth effect has weekend to about 20% of its original size, but still remains statistically significant at 95% CL. Similarly to the previous model, the industrial proportion to GDP in the economy remains significant and positive. Unlike in the previous model, there is a significant relationship between quarterly public debt and inflation, however in a direction which we have not expected. Empirical literature offers an explanation of this phenomenon. In the countries where the CBs are performing the QE, are the nominal interest rates near or below zero, therefore there are situations where government bond coupon are extremely low, sometimes zero. This results in a phenomenon where government is able to pay of their debts upon which it has higher interests (foreign currencies, fixed interest etc.) using new debt which in turn supplies less amount of money into the economy, through the low interest on the new debts. However, this relationship has only short run character and requires specific setting of the countries.

```
t test of coefficients:

                          Estimate Std. Error t value  Pr(>|t|)    
Inflation_q_lag           0.955600   0.188426  5.0715 2.069e-06 ***
UR                        0.033860   0.158897  0.2131 0.8317300    
effective_fiscal_measures -0.059850  0.055028 -1.0876 0.2796309    
IR_lagQ4                 -0.164069   0.105486 -1.5554 0.1233312    
GDP_growth                0.112010   0.027876  4.0181 0.0001207 ***
CA_gdp                   -0.115101   0.064895 -1.7736 0.0794667 .  
Industry                  0.926103   0.283492  3.2668 0.0015349 ** 
Gov_debt_q                0.044426   0.064381  0.6900 0.4919244    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Table 5.5: Inflation FE with IV and robust SE on no QE countries

The last regression we discuss is the inflation regression ran on the countries that have not implemented QE. We can see return to the trend from the original sample, significant effects of dependent variable lag and nominal GDP growth and industry. On the other hand, we have a new statistically significant variable here, which is only significant at 90% CL but is worth mentioning as it confirms the empirical finding of Alawin and Qqaily about the short run relationship between current account deficit and inflation, meaning that increase in the current account deficit results in higher inflation in the short run. Numerically is this relationship interpreted as 1% increase in the current account deficit leads to 0,12% increase in inflation.

6 Conclusion

After conducting an extensive research across several streams of literature both theoretical and empirical we can conclude that the effect that COVID-19 pandemic had on all the countries across the globe has been definitely heterogeneous. Based on our findings around 50% of the variance in terms of real GDP growth can be explained by the country fixed effects, such as human capital, strength of institutions, population density, if the country had previous experience with such restrictions as in the case of East Asian countries and so on. Around 60% of the variance in the quarterly inflation can be explained by the time fixed effects, such as global indicators and trends at the individual time periods rather than specifics of the individual countries. In order to be able to confirm our stated hypothesis we interpret the results of the regressions.

Starting with the first hypothesis, there is no significant difference between effects of the conventional and unconventional monetary stabilization policies on the economic growth. We have found out that the effects capturing the actions of UMP and CMP policies for their respective samples have almost identical size of their effect, the difference comes obviously from the fact that the countries with QE are more agile in terms of time with providing of such stimulus as their action is being significant already at time t, whereas the actions of the CMPs take the standard time of 4 quarters to go through the transmission mechanism in order to reach a similar effect. However, when performing the regression over the entire sample neither effect has come back as statistically significant at our determined confidence level of 95%. Therefore the answer to the first hypothesis is that the countries under CMP regimes can achieve the same effects of the monetary stabilization policies as the countries under UMP regimes, but with lag of 1 year, therefore such actions must be performed at timely matter, or reactionary with expected delay of the materialization of the stimulus.

The second hypothesis states that the fiscal stabilization policies have had significant positive effect on the real economic growth but also led to increase in inflation. We can answer the first part of the hypothesis by looking at the effective fiscal measures determinant variable in the real GDP growth model. We can confidently state that the fiscal stabilization policies were indeed statistically significant in terms of increasing the real GDP growth, or alternatively reducing severity of its fall. The second part of the hypothesis can be answered only partially, as we can see evidence of this statement being true in the AEs whose central banks have implemented QE. We are certain that this effect is exogenous and not correlated with the UMP as we attempted to control the variable for endogeneity, using several different metrics representing the UMP as an instrumental variable, but all have failed to reject the Hausman test or the Weak instruments test. Based on this fact we assume that the fiscal stabilization policies are truly exogenous fiscal interventions. There is however no such relationship significant for the regression on the CMP countries or the entire sample. Therefore, the answer to the hypothesis is partial as we can only state that the fiscal stimulus in the AEs economies practicing UMP has contributed towards the increase in inflation.

The third hypothesis is dedicated to the GDP composition by sectors and the role it played during the crisis. We have predicted that the GDP sectoral composition has played a significant role in terms of explaining the fall of GDP and rise in inflation. Similarly to the second hypothesis, the answer to this one is not completely clear. We can see that in the regression of the economic growth on the entire sample the predictor capturing services representation in the economy is statistically significant and negative, which is the effect we expected based on the literature and restriction applied especially heavily on the tourism sector. However the effect dissipates once we do the same regression on either of the sub samples. We can say that overall the effect is globally statistically significant and its explanatory power diminishes in the specific sub samples due to nature of countries contained in the sub samples. As for the second part of the hypothesis, we suspected a relationship between industry sector and inflation due to disruption of supply chains which have impacted the industrial productions the heaviest. We can state that in case of industries the relationship holds across the entire country sample as well as both separate subsamples. The size of its effect varies but remains in the same direction across all 3 models, thus supporting our initial statement about the supply chain disruption. Unfortunately, we are unable to capture effect that services or agriculture have in terms of inflation as we had to remove the variables due to multicollinearity issue and worsening of the fit of the model by including the variables.

At the end we can state that both the monetary and fiscal stabilization policies significantly helped to restart the economic growth in the recovery phase following the pandemic and slowed down the fall during the second quarter. However, their contribution towards laying down the fundamentals for the recent inflation crisis is not so clear as the model suggest a fixed effects in time to hold majority of the explanatory power in that domain. It is possible it has been the spillover effects that transmitted certain inflationary pressures through the international trade channel as several countries implemented asset purchase programs that have driven up artificially the price of bonds and commercial papers. It is also possible that the inflation crisis has been just coincidence of several factors lining up at the wrong time such as beginning of energy crisis pre-COVID-19 times, increased money supply in the economies and uncertainty in the World following the Russian invasion to Ukraine. Several research studies attempting to capture contribution of the individual factors are being currently conducted and we will all hopefully soon see what the real cause was and how to prevent it from happening again.

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Appendix: Panel data tests

Table A.1: Panel Unit Root test

```
        Maddala-Wu Unit-Root Test (ex. var.: None)

data:  GDP_growth_y ~ 0
chisq = 137.21, df = 60, p-value = 5.557e-08
alternative hypothesis: stationarity

        Maddala-Wu Unit-Root Test (ex. var.: Individual Intercepts and Trend)

data:  Inflation_q ~ trend
chisq = 697.36, df = 60, p-value < 2.2e-16
alternative hypothesis: stationarity

        Maddala-Wu Unit-Root Test (ex. var.: None)

data:  effective_fiscal_measures ~ 0
chisq = 111.51, df = 60, p-value = 6.093e-05
alternative hypothesis: stationarity

        Maddala-Wu Unit-Root Test (ex. var.: Individual Intercepts)

data:  IR ~ 1
chisq = 471.03, df = 60, p-value < 2.2e-16
alternative hypothesis: stationarity

        Maddala-Wu Unit-Root Test (ex. var.: Individual Intercepts and Trend)

data:  IR_lagQ4 ~ trend
chisq = 970.16, df = 60, p-value < 2.2e-16
alternative hypothesis: stationarity

        Maddala-Wu Unit-Root Test (ex. var.: Individual Intercepts)

data:  UR ~ 1
chisq = 339.09, df = 60, p-value < 2.2e-16
alternative hypothesis: stationarity

        Maddala-Wu Unit-Root Test (ex. var.: Individual Intercepts)

data:  REAL_GDP_per_capita_USD ~ 1
chisq = 376.85, df = 60, p-value < 2.2e-16
alternative hypothesis: stationarity

        Maddala-Wu Unit-Root Test (ex. var.: Individual Intercepts)

data:  Gov_debt_q ~ 1
chisq = 429.89, df = 60, p-value < 2.2e-16
alternative hypothesis: stationarity

        Maddala-Wu Unit-Root Test (ex. var.: None)

data:  CA_gdp ~ 0
chisq = 113.75, df = 60, p-value = 3.479e-05
alternative hypothesis: stationarity

        Maddala-Wu Unit-Root Test (ex. var.: None)

data:  GDP_growth ~ 0
chisq = 434.98, df = 60, p-value < 2.2e-16
alternative hypothesis: stationarity

        Maddala-Wu Unit-Root Test (ex. var.: Individual Intercepts)

data:  Stringency_id ~ 1
chisq = 408.15, df = 60, p-value < 2.2e-16
alternative hypothesis: stationarity

        Maddala-Wu Unit-Root Test (ex. var.: Individual Intercepts)

data:  Agri ~ 1
chisq = 212.91, df = 60, p-value < 2.2e-16
alternative hypothesis: stationarity

        Maddala-Wu Unit-Root Test (ex. var.: Individual Intercepts)

data:  Industry ~ 1
chisq = 134.72, df = 60, p-value = 1.146e-07
alternative hypothesis: stationarity

        Maddala-Wu Unit-Root Test (ex. var.: Individual Intercepts)

data:  services ~ 1
chisq = 99.444, df = 60, p-value = 0.001037
alternative hypothesis: stationarity
```

Table A.2: VIF multicollinearity test for GDP growth model

```
GDP_growth_lag_y                    IR_lagQ4                   Agri     effective_fiscal_measures
        1.261029                    4.249617               3.787006                      1.350218
   Stringency_id                    services                     IR log(REAL_GDP_per_capita_USD)
        1.261843                    1.172478               4.668357                      4.030806
```

Table A.3: VIF multicollinearity test for inflation model

```
Inflation_q_lag                        UR effective_fiscal_measures                 IR_lagQ4
       1.505594                  1.313019                  1.496345                 1.529390
     GDP_growth                    CA_gdp                  Industry               Gov_debt_q
       1.108698                  1.157964                  1.258726                 1.483840
```

Table A.4: Weak poolability tests

```
        F test for twoways effects

data:  GDP_growth_y ~ IR_lagQ4 + Agri + effective_fiscal_measures +  ...
F = 27.37, df1 = 37, df2 = 254, p-value < 2.2e-16
alternative hypothesis: significant effects

        F test for time effects

data:  Inflation_q ~ Inflation_q_lag + UR + effective_fiscal_measures +  ...
F = 3.7741, df1 = 9, df2 = 282, p-value = 0.0001655
alternative hypothesis: significant effects
```

Table A.5: Hausman test (FE vs RE)

```
        Hausman Test

data:  GDP_growth_y ~ IR_lagQ4 + Agri + effective_fiscal_measures +  ...
chisq = 391.26, df = 7, p-value < 2.2e-16
alternative hypothesis: one model is inconsistent

        Hausman Test

data:  Inflation_q ~ Inflation_q_lag + UR + effective_fiscal_measures +  ...
chisq = 25.127, df = 8, p-value = 0.00148
alternative hypothesis: one model is inconsistent
```

Table A.6: feols instrumental variable test for inflation

```
TSLS estimation, Dep. Var.: Inflation_q, Endo.: IR_lagQ4, Instr.: IR_lagQ5
Second stage: Dep. Var.: Inflation_q
Observations: 300
Fixed-effects: Time: 10
Standard-errors: Clustered (Time)
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
RMSE: 1.34986     Adj. R2: 0.540807
                Within R2: 0.468113
F-test (1st stage), IR_lagQ4: stat = 7,038.8    , p < 2.2e-16, on 1 and 291 DoF.
                  Wu-Hausman: stat =     4.4527, p = 0.03573, on 1 and 281 DoF.
```

Table A.7: feols instrumental variable test for Real GDP growth

```
TSLS estimation, Dep. Var.: GDP_growth_y, Endo.: IR, IR_lagQ4, log(REAL_GDP_per_capita_USD), Agri, Instr.: log(REAL_GDP_per_capita_lag), IR_lag, IR_lagQ5, Agri_lag
Second stage: Dep. Var.: GDP_growth_y
Observations: 300
Fixed-effects: Country: 30
Standard-errors: Clustered (Country)
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
RMSE: 4.42548     Adj. R2: 0.558844
                Within R2: 0.567315
F-test (1st stage), IR                          : stat =  91.0    , p < 2.2e-16 , on 4 and 291 DoF.
F-test (1st stage), IR_lagQ4                    : stat = 470.3    , p < 2.2e-16 , on 4 and 291 DoF.
F-test (1st stage), log(REAL_GDP_per_capita_USD): stat = 154.2    , p < 2.2e-16 , on 4 and 291 DoF.
F-test (1st stage), Agri                        : stat =  74.6    , p < 2.2e-16 , on 4 and 291 DoF.
                                      Wu-Hausman: stat =   7.09455, p = 1.964e-5, on 4 and 258 DoF.
```

Table A.7: B-P Heteroskedasticity test (GDPgrowth, GDP growth_QE, GDP growth_noQE, inflation, inflation_QE, inflation_noQE)

```
	Breusch-Pagan test

data:  fixed_effects_IV_exp
BP = 97.742, df = 12, p-value = 1.539e-15


	Breusch-Pagan test

data:  fixed_effects_IV_exp_noQE
BP = 53.544, df = 12, p-value = 3.296e-07


	Breusch-Pagan test

data:  fixed_effects_IV_exp_QE
BP = 73.528, df = 12, p-value = 6.966e-11


	Breusch-Pagan test

data:  fixed_effects_IV_inf_alt
BP = 1864, df = 9, p-value < 2.2e-16


	Breusch-Pagan test

data:  fixed_effects_IV_inf_alt_QE
BP = 21.233, df = 9, p-value = 0.01166


	Breusch-Pagan test

data:  fixed_effects_IV_inf_alt_noQE
BP = 541.3, df = 9, p-value < 2.2e-16
```

Table A.8: Wooldridge serial correlation test (GDPgrowth, GDP growth_QE, GDP growth_noQE, inflation, inflation_QE, inflation_noQE)

```
        Breusch-Godfrey/Wooldridge test for serial correlation in panel models

data:  GDP_growth_y ~ GDP_growth_lag_y + IR + IR_lagQ4 + effective_fiscal_measures +  ...
chisq = 96.641, df = 10, p-value = 2.556e-16
alternative hypothesis: serial correlation in idiosyncratic errors

        Breusch-Godfrey/Wooldridge test for serial correlation in panel models

data:  GDP_growth_y ~ GDP_growth_lag_y + IR + IR_lagQ4 + effective_fiscal_measures +  ...
chisq = 67.132, df = 10, p-value = 1.582e-10
alternative hypothesis: serial correlation in idiosyncratic errors

        Breusch-Godfrey/Wooldridge test for serial correlation in panel models

data:  GDP_growth_y ~ GDP_growth_lag_y + IR + IR_lagQ4 + effective_fiscal_measures +  ...
chisq = 34.52, df = 10, p-value = 0.0001508
alternative hypothesis: serial correlation in idiosyncratic errors

        Breusch-Godfrey/Wooldridge test for serial correlation in panel models

data:  Inflation_q ~ Inflation_q_lag + UR + effective_fiscal_measures +  ...
chisq = 17.318, df = 10, p-value = 0.06763
alternative hypothesis: serial correlation in idiosyncratic errors

        Breusch-Godfrey/Wooldridge test for serial correlation in panel models

data:  Inflation_q ~ Inflation_q_lag + UR + effective_fiscal_measures +  ...
chisq = 17.251, df = 10, p-value = 0.06899
alternative hypothesis: serial correlation in idiosyncratic errors

        Breusch-Godfrey/Wooldridge test for serial correlation in panel models

data:  Inflation_q ~ Inflation_q_lag + UR + effective_fiscal_measures +  ...
chisq = 28.974, df = 10, p-value = 0.001258
alternative hypothesis: serial correlation in idiosyncratic errors
```

Table A.9: PCD test for cross-sectional dependence (GDPgrowth, GDP growth_QE, GDP growth_noQE, inflation, inflation_QE, inflation_noQE)

```
        Pesaran CD test for cross-sectional dependence in panels

data:  GDP_growth_y ~ GDP_growth_lag_y + IR + IR_lagQ4 + effective_fiscal_measures +     Stringency_id +
log(REAL_GDP_per_capita_USD) + services +     Agri | Agri_lag + IR_lag + log(REAL_GDP_per_capita_lag) +
effective_fiscal_measures + services + IR_lagQ5 + Stringency_id +     GDP_growth_lag_y
z = 36.422, p-value < 2.2e-16
alternative hypothesis: cross-sectional dependence


        Pesaran CD test for cross-sectional dependence in panels

data:  GDP_growth_y ~ GDP_growth_lag_y + IR + IR_lagQ4 + effective_fiscal_measures +     Stringency_id +
log(REAL_GDP_per_capita_USD) + services +     Agri | Agri_lag + IR_lag + log(REAL_GDP_per_capita_lag) +
effective_fiscal_measures + services + IR_lagQ5 + Stringency_id +     GDP_growth_lag_y
z = 26.138, p-value < 2.2e-16
alternative hypothesis: cross-sectional dependence


        Pesaran CD test for cross-sectional dependence in panels

data:  GDP_growth_y ~ GDP_growth_lag_y + IR + IR_lagQ4 + effective_fiscal_measures +     Stringency_id +
log(REAL_GDP_per_capita_USD) + services +     Agri | Agri_lag + IR_lag + log(REAL_GDP_per_capita_lag) +
effective_fiscal_measures + services + IR_lagQ5 + Stringency_id +     GDP_growth_lag_y
z = 8.9769, p-value < 2.2e-16
alternative hypothesis: cross-sectional dependence


        Pesaran CD test for cross-sectional dependence in panels

data:  Inflation_q ~ Inflation_q_lag + UR + effective_fiscal_measures +     IR_lagQ4 + GDP_growth + CA_gdp + Industry +
Gov_debt_q |     GDP_growth + UR + effective_fiscal_measures + Industry +         IR_lagQ5 + CA_gdp + Inflation_q_lag +
Gov_debt_q
z = 0.39082, p-value = 0.6959
alternative hypothesis: cross-sectional dependence


        Pesaran CD test for cross-sectional dependence in panels

data:  Inflation_q ~ Inflation_q_lag + UR + effective_fiscal_measures +     IR_lagQ4 + GDP_growth + CA_gdp + Industry +
Gov_debt_q |     GDP_growth + UR + effective_fiscal_measures + Industry +         IR_lagQ5 + CA_gdp + Inflation_q_lag +
Gov_debt_q
z = 5.1265, p-value = 2.952e-07
alternative hypothesis: cross-sectional dependence


        Pesaran CD test for cross-sectional dependence in panels

data:  Inflation_q ~ Inflation_q_lag + UR + effective_fiscal_measures +     IR_lagQ4 + GDP_growth + CA_gdp + Industry +
Gov_debt_q |     GDP_growth + UR + effective_fiscal_measures + Industry +         IR_lagQ5 + CA_gdp + Inflation_q_lag +
Gov_debt_q
z = 0.19469, p-value = 0.8456
alternative hypothesis: cross-sectional dependence
```