

The impact of Quantitative easing on the EU economy with the Augmented Synthetic Control Method

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Abstract

Following the 2008 financial crisis, the European Central Banks (ECB) implemented Quantitative Easing (QE), one of the unconventional policies. European Central Bank purchased covered bonds on a large scale in May 2009 (Duncan, G. 2009) and additionally spent 250 billion euro in 2010 and 2011 to purchase covered bonds from targeted member states through the SMP Program. This paper investigates how QE affected the GDP of the European Union through the Augmented Synthetic Control method¹. In addition to GDP, this research also investigates GDP growth, Export of services and goods, Import of services and goods, Gross capital formation, and Foreign Direct Investment. As a result of the study, this paper found that QE had a negative effect on GDP. The research results on additional selected variables also supported the above research results. However, the magnitude of negative effect comes with the enormous amount of uncertainty.

Keywords: Unconventional monetary policy, European Union, GDP, Augmented Synthetic Control Method

Chapter 1. Introduction

As the financial crisis erupted in 2007 and worsened by Lehman Brothers' bankruptcy in September 2008, major central banks implemented other steps to ease monetary policy, prevent production collapse, ensure financial stability, and combat deflation. Central banks such as the European Central Bank (ECB) and the U.S. Federal Reserve (Fed) have reduced their key interest rates to close to zero. The Bank of England (BoE) also reduced the official bank interest rate from 5.5 percent in early 2008 to 0.5 percent in March 2009. Other short-term measures have also been taken to improve the stability of the pressured financial markets.

As interest rates close to zero, some central banks came up with so-called non-standard monetary policies. To be specific, central banks initiated buying large amounts of mid- to long-term assets. This

¹ Companion software developed by the authors (Augmented Synthetic Control Method package for Python) is available at <https://github.com/Jaykim1234/Python/tree/main/The%20impact%20of%20Quantitative%20easing%20on%20the%20EU%20economy%20and%20the%20Augmented%20Synthetic%20Control%20Method>. The example of implementation can be found at <https://github.com/Jaykim1234/Python/blob/main/The%20impact%20of%20Quantitative%20easing%20on%20the%20EU%20economy%20and%20the%20Augmented%20Synthetic%20Control%20Method/Augmented%20Synthetic%20Control%20Method%20Package.pdf>. The data used in this study can be downloaded for purposes of replication.

non-standard monetary policy is called quantitative easing (QE). Because QE reduces asset returns and long-term interest rates, borrowing costs decrease and spending, output, and inflation increase. The policy was adopted by the Fed, the BoE, the ECB, the Bank of Japan (BoJ), and Sweden's Riksbank.

According to SIKLOS et al. (2020), QE in the Eurozone successfully avoided the deflationary trend of 2013-2014 and prevented the expansion of bond spreads. In addition, QE contributed to reducing the bank's lending cost (Blattner et al., 2016). However, studies have shown that the real impact of QE on GDP is modest (Gambetti & Musso, 2017). In addition, the estimated effects of QE were heterogeneous. In other words, even though previous researchers have already conducted several studies about QE, the macroeconomic effect of the policy is unclear. Therefore, this study, conducted using other methods, will assist to solve the uncertainty of the QE effect.

In addition, this study will explain the effectiveness of the quantitative tightening policy that the U.S. government is currently pursuing. Because QE takes the opposite direction of Quantitative tightening policy, understanding QE will allow for a more definite response to the future ahead.

For this purpose, this paper will investigate how QE affected the EU economy, especially GDP, using the previously unused Augmented Synthetic Control Method (ASCM). This method creates the counterfactual of the EU. The values of the dependent variables of the EU and control units are then compared to each other to estimate the effectiveness of the policy. The results suggest that QE has a negative effect on GDP, but the scale of the results is very uncertain.

The thesis is structured as follows: Chapter 2 focuses on quantitative easing in more detail; summarizes basic facts, describes potential transmission mechanisms of QE, discusses QE's drawbacks and risks, and presents review of empirical literature concerned with effects of QE. Chapter 3 deals with methodology. At first, ASCM is generally described, and then specific issues related to ASCM's application in QE are discussed. Data will also be described here. Chapter 4 deals with discussions of results. Chapter 5 presents a conclusion.

Chapter 2. Literature Review

2.1 Quantitative Easing of ECB

European Central Bank purchased covered bonds on a large scale in May 2009 (Duncan, 2009) and additionally spent 250 billion euro in 2010 and 2011 to buy covered bonds from targeted member states

through the SMP Program. However, until 2015, the ECB did not officially acknowledge that the existence of the quantitative easing policy.

In early 2015, the European Central Bank (ECB) joined central bank groups implementing unprecedented large-scale asset procurement programs. The asset purchase, also called quantitative easing (QE), greatly expanded the central bank's balance sheets. At the end of July 2015, the outright measures on the balance sheet reached 24% of the gross domestic product (GDP) for US Federal Reserve, 64% for the Bank of Japan, 21% for the Bank of England, and 5% for the ECB. (Constâncio 2015).

The ECB's QE program announced in 2015 that ECB would buy approximately €60 billion worth of assets from March 2015 to September 2016. This program amounts to about 10% of the annualized Euro area (EA) GDP. In December 2015, the ECB extended the amount of monetary procurement to €80 billion from April 2016 to March 2017 (Falagiarda & Reitz, 2015).

And after about a year or so, the ECB started buying Eurozone government bonds again in November 2019 around a rate of €20 billion. This allowed the government to borrow more and spend more on domestic investment projects. In March 2020, the ECB implemented the €750 billion Pandemic Emergency Purchase Program (PEPP) to mitigate the economic impact caused by COVID-19 crisis. The main purpose of the program was to reduce borrowing costs and increase lending in the Euro area. (Rebucci et al, 2022).

2.3 Literature Review

The macroeconomic effect of QE1 was estimated by Joyce et al (2010). They first estimated the change in asset prices and then the increase in household wealth. The effect of QE on GDP was estimated to be between 1.5% and 2.5%. They also studied inflation and employed a study with the Phillips Curve that showed that inflation would go up by about 0.75pp to 2.5pp.

The ultimate purpose of QE is to increase output and inflation. According to Williams (2013), the impact on these two variables is ultimately the most important thing. The effect of QE on the financial market is only part of the transmission. Since QE affects the economy over several years and there is no counterfactual, the effect of QE on macroeconomic variables is highly uncertain. For example, Williams (2013) suggested that estimating the macroeconomic effect on asset purchases is about twice as uncertain as the effect on conventional monetary policy.

Kapetanios et al. (2012) assumed that UK QE1 decreased medium and long-term gilt yields by about 100 bp. (This assumption is based on the estimate of Joyce et al. (2010)). They then used three versions of vector autoregression (VAR) model to analyze the macroeconomic effect of yields reduction. The resulting values varied depending on the model used and the exact specification. Real GDP rose by 1.5% and inflation rose by about 1.25% in the group of results used among models.

Bridge & Thomas (2012) estimated the effect of QE using money supply and demand framework. They estimated that the £200 billion of asset purchases would raise stock of broad money by £122 billion. In addition, the authors studied how other economic variables are affected by the money supply shock. QE1 increased real GDP by about 2% in the mid-2011s, and inflation was estimated to rise by 1pp a year later.

Pesaran & Smith (2012) and Lyonnet & Werner (2012) suggested that QE does not play a role properly. Pesaran & Smith (2012) noted that the long-term interest rate, which was reduced by 100bp by QE1, had an effect on output by about 1%, but this effect became insignificant after a year. According to Lyonnet & Werner (2012), QE is a policy that does not show any significant effect.

Churm et al. (2015) investigated QE2 and FLS. Using the Bayesian VAR model, the author estimated that QE2 increased GDP by 0.6%, and inflation by 0.6pp. A similar effect was found in the case of FLS. (FLS rose 0.8% for GDP and 0.6pp for inflation.)

Chung et al. (2012) investigates the macroeconomic impact of QE in the US economy and found a peak effect of 3% for GDP and 1pp for inflation. This result is based only on Fed's QE1 and QE2. In January 2015, the ECB's QE announcement increased by 1.1% for GDP and 40bp for inflation. (Andrade et al. 2016).

The effect of ECB's QE on GDP and inflation was investigated only in 2015-2018. Hohberger et al (2019) estimated that using the dynamic stoichiometric general equilibrium (DSGE) model, the QE policy raises GDP growth and cpi inflation in the Euro area by about 0.3 and 0.5 percent-point.

The overall EU's unconventional monetary policy was investigated by Thomas Aßhoff et al. (2021) through the Bayesian VAR method. They found that unconventional monetary policy raises inflation expectations in a short period of time. However, Aßhoff et al. (2021) observed that the rise in expected inflation did not increase GDP or realized inflation. A few months later, inflation declined, suggesting that the exposure channel was not functioning properly.

2.1 Channels of Transmission

Literatures recognize various routes in which QE affects the asset prices and the economy. The most frequently mentioned channels among several channels are portfolio balance, signaling, and liquidity channels. [Bowdler & Radia (2012) or Joyce et al. (2011).]

The first is the Portfolio balance channel. The Fed's purchase of US Treasury securities affects the supply available to private investors (Bernanke, 2010). Since Bond premia is determined by the characteristics of the asset and the investor's risk preference, Fed's purchase affect the asset's yield by the extent that the assets are not completely substitutable. Portfolio rebalancing can be performed in two ways. The first is that the Treasury Purchase affects the yields throughout the entire maturity spectrum. This effect is greater for longer duration securities, which results in a change in term premia. Second, assuming a preferred habitat theory, the effect becomes even greater where the shortage of supply is large. Preferred habitat refers to an investor preferring one Maturity length to another length. Numerous studies have produced evidence that preferred theory is valid (Doh, 2010; Gagnon et al., 2011; D'Amico and King, 2013).

The policy signaling channel is closely related to the disclosure of information on the future monetary policy. By purchasing the asset, the central bank signals the future policy direction and adjusts the expected inflation. The changed figures may adjust the real interest rates. This feature is effective in situations where normal interest rates cannot be changed. For example, when the normal interest rate is close to zero and cannot be lowered any more, the real interest rates can be lowered by increasing expected inflation. [Bowdler & Radia (2012) or Joyce et al. (2011).]

QE with the liquidity channel is considered effective only when the financial market is stressed. In general, in unstable market conditions, investors have trouble in finding buyers without a significant discount. To take this risk, investors demand a liquidity premium. Central bank interventions can reduce the liquidity premium in volatile market. The way is to let the market know that the central bank is buying an asset. Knowing their involvement, investors find it relatively easy to sell assets to central banks if necessary. This increases the market's liquidity, reduces the liquidity premium, and eventually decreases the yields. Therefore, the liquidity channel only functions when the central bank is implementing asset purchase. Additionally, the channel may not correspond well to the relatively liquid gilt market where the need for liquidity premium is low. [Bowdler & Radia (2012) or Joyce et al. (2011).]

Besides these three main channels, Joyce et al. (2011) identifies also confidence effects: if the policy improves perceived state of the economy, it may lead to higher confidence of consumers and to the increase in spending beyond direct effects of asset purchases.

Lastly, the purchase of assets from non-banks may encourage banks to provide more loans, which would then increase spending (since sellers of the assets would deposit obtained money in banks, amount of liquid assets held by banks as well as willingness of banks to lend would increase). Nevertheless, the MPC did not expect significant effect through this bank lending channel because of strained conditions in financial markets (Bank of England 2009).

2.2 Drawbacks and Risks of QE

Quantitative easing is a policy that can revive the economy in crisis situations, but risks are also inherent. According to Mortimer-Lee (2012), QE is a policy that distorts the market. QE will make investors pursue yield in a low-interest environment. This environment can lead to investors taking more risks and creating a market bubble.

Resource allocation can also be a problem. Due to QE, companies that were originally unproductive can survive due to low borrowing costs. QE can also induce unnecessary structural reforms. Because QE cause low borrowing costs, many companies can make structural unnecessary changes. In summary, QE induces the inefficient use of resources in terms of society (Gern et al. 2015).

As is admitted even by Bank of England (2012b), QE has significant distributional impact. Increase in asset prices directly benefits owners of those assets but the ownership is distributed unevenly across population, with top 5% of households holding 40% of the financial assets of the household sector in the UK (pension wealth excluded). Two main consequences follow. First consequence is social considerations: QE may contribute to higher social inequality and to potential resulting social tensions; secondly, as Bossone (2013) points out, more affluent households, which benefit from QE the most, have low propensity to consume, so likely the society will not spend much of newly acquired wealth, which undermines transmission of higher asset prices to increased spending.

Lastly, Mortimer-Lee (2012) argues that exit from conventional policies may contain set of risks. With respect to lack of experience with unconventional policies in the past, the expected effect is unclear when exactly should the exit occur (i.e. coordination of exit from QE with increases of interest rates), or how quickly should the exit be conducted. Exit at an extremely slow pace could generate substantial

inflationary pressures resulting in inflation exceeding the target; exit at an extremely fast pace could cause return of recession and deflationary pressures.

Chapter 3. Data

3.1 Data design

The annual national panel data was set in the period from 1960 to 2020. A sample of countries consists of 75 countries. The countries comprising the data are as follows.

Algeria, Argentina, Australia, Bangladesh, Belize, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Cameroon, Chad, Chile, China, Colombia, Congo, Rep., Costa Rica, Cote d'Ivoire, Dominican Republic, Ecuador, Egypt, Arab Rep., El Salvador, Eswatini, European Union, Fiji, Gabon, Gambia, Ghana, Guatemala, Guyana, Honduras, India, Indonesia, Iran, Islamic Rep., Iraq, Jamaica, Kenya, Korea, Rep., Lesotho, Madagascar, Malaysia, Mali, Mauritania, Mexico, Morocco, Nepal, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Rwanda, Senegal, Sierra Leone, Singapore, Sri Lanka, Sudan, Syrian Arab Republic, Thailand, Togo, Tunisia, Turkey, Uganda, Uruguay, Venezuela, RB, Zambia, Zimbabwe.

Although the 2008-2009 financial crisis has affected almost all countries worldwide, the amount of damage can be different by country. According to Ben-Michael et al. (2021), the damage from economic activities varies depending on the leverage rate, credit growth rate, and short-term debt rate.

It can be extremely difficult to select countries with the same leverage rate, credit growth rate, and short term. Even if countries meet the conditions, the number of samples will be very limited. And besides the three variables mentioned, it is very difficult to confirm that the damage is not affected by many other variables, such as political, geographical, and population. In other words, choosing countries to compare on specific conditions likely lead to an inaccurate comparison, which lead to biased results.

Therefore, countries were chosen randomly. Among the selected countries, countries that fall under the following two conditions were excluded. The two conditions are as follows. First is non-member of the EU. Second is that countries have not implemented QE yet.

As will be explained later in the methodology section, the Augmented Synthetic Control Method must have goodness of fitting to interpret meaningful results. That is why this research selects the large number of countries. This can also be seen in Appendix B. In Appendix B, the goodness of fitting

changes by the number of countries of the selected sample. In the case of Foreign Direct Investment, the goodness of fitting drops a lot even when only one country is excluded. Therefore, 74 countries are assumed to be the minimum number of countries required for goodness of fitting.

Despite random selection over countries, this paper still includes limitation because selecting the large number of countries could cause the upward bias. According to the IMF's definition, 152 out of 193 countries in the world are classified as developing countries. This means that most countries are developing countries. Because of these characteristics, most of the sampled countries are developing countries. Developing countries are growing faster than developed countries, so there is room for upward bias in estimating GDP changes.

The dependent variables selected to know how quantitative easing policies affect the EU's GDP are as follows. GDP (current USD). In addition to these variables, foreign direct investment (BoP, current US\$), exports of goods and services (% of GDP), and imports of goods and services (% of GDP) were selected. The reason for selecting additional variables besides GDP is that there are no unified results regarding the effect of QE on GDP. Therefore, three more additional variables closely related to GDP were selected and investigated. More details will be explained in a following sub chapter.

Since samples were taken from countries around the world, many independent variables were required to obtain goodness of fitting. However, if there are lots of independent variables, the potential multicollinearity problem threatens the research. Therefore, this paper standardizes independent variables. According to Marquardt, D. W. (1980), if the variables are standardized, the multicollinearity goes down to the level of essential multicollinearity. In addition, the used group of independent variables was different according to the selected dependent variables to reduce the multicollinearity problem as much as possible. The independent variables used for each dependent variable will be described in detail in Appendix A. The source and observations of selected variables will be described as well.

3.2 Reasons for additional data selection

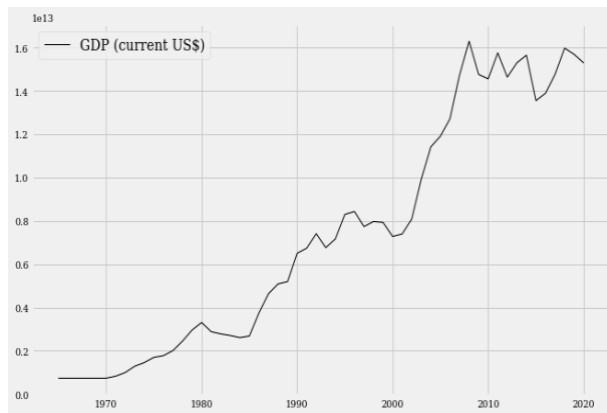


Figure 1 GDP (current US\$) of European Union



Figure 2 GDP growth (%) of European Union

Notes: The scale is 10 trillion dollars

In figure 1, the level of GDP has changed slightly since 2010, but continues to be maintained. This research notes that despite the 2008 financial crisis, the GDP did not fall or rise significantly. This suggests that the parts that make up the GDP may have undergone various changes. This fact can also be confirmed in the change in GDP growth in Figure 2.

The GDP growth in Figure 2 showed a fluctuation of about 6 to 7% in 2009. Since 2009, when QE began to be implemented, GDP growth has increased by 6% from -4% to 2%. However, such changes can also be found in the past. Between 1970 and 1980, GDP growth fell from 6% to 0%, and then rose again to about 5%. In addition, in 2020, the growth rate showed an 8% change rate from 2% to -6%. In summary, the change in GDP growth in 2009 occurred before 2012 and after 2015. Therefore, the effect of QE cannot be determined by Figure 2 alone. In addition, the trend of change in GDP growth continues to decline without any change after 2012

Therefore, this research focus on not only the overall change in GDP, but also the constituents of GDP. One of the usual methods of calculating GDP is the Expenditure Approach. Gross domestic product (GDP) consists of household final consumption expenditure, general government final consumption expenditure, gross capital formation, export of goods and service, and import of goods and services. (Zúniga-González, 2009).

Among the four variables mentioned above, this paper investigates the factors, which are directly related to economic condition: gross capital formation, export of goods and services, and import of goods and services.

Government spending and household final consumption can become larger even if economic growth does not actually occur. Government spending can be adjusted through policy changes of the government itself. For example, constructions of new buildings can increase government spending. However, there is no guarantee that this could lead to better economic growth. Additionally, according to Ghali (1997), there is no evidence that government spending is continuously related to per capita output growth.

Consumption also mainly depends on the characteristics of individual person. Consequently, this paper cannot confirm that consumption grows and decreases unconditionally by the economic growth. For example, the government's subsidy policies recently created by COVID-19 can affect the overall change in consumption of the people regardless of economic growth.



Figure 3 Gross capital formation (% of GDP) of European Union

On the other hand, Gross Capital Formation and net export have limitations in making changes only with individual policies of the country. In the case of investment, unlike the household final consumption expenditure, more time and careful choice are required. Since mid- to long-term plans are often considered in making investments, investors need to be confident that the economic situation in the future will be good. Therefore, if this study investigates gross capital formation, this study can find out in more detail whether QE contributed to economic growth and affected GDP. If the gross capital formation increases, this study interprets the phenomenon as that the economy is growing. Looking at the figure 3 above, gross capital formation continues to decline until 2012. However, gross capital formation has shown an increase since 2012. This paper assumes two factors as the reason of this increase. First one is QE. Second one is a temporary rebound because of the decrease.



Figure 4 Exports of European Union



Figure 5 Imports of European Union

Export and import are also important factors to investigate. If export and import become active, this can be interpreted that a country has become more economically active. The increase in exports is that the EU's services or products get more attractive than those of other countries, which is a good economic sign.

On the other hand, a decrease in exports can mean that there is no competitiveness among countries. At Figure 4, the export of the EU continually rises. However, investigating counterfactual without QE is necessary. Thus, this paper checked whether the increase of export was by the QE or not.

From import of goods and service status, trade surplus can be checked as well. If the import increases through QE, this paper can conclude that QE has a negative effect on GDP. From Figure 4 and Figure 5, the proportion of export and import can be seen, which allows this research to estimate the changes of net export.

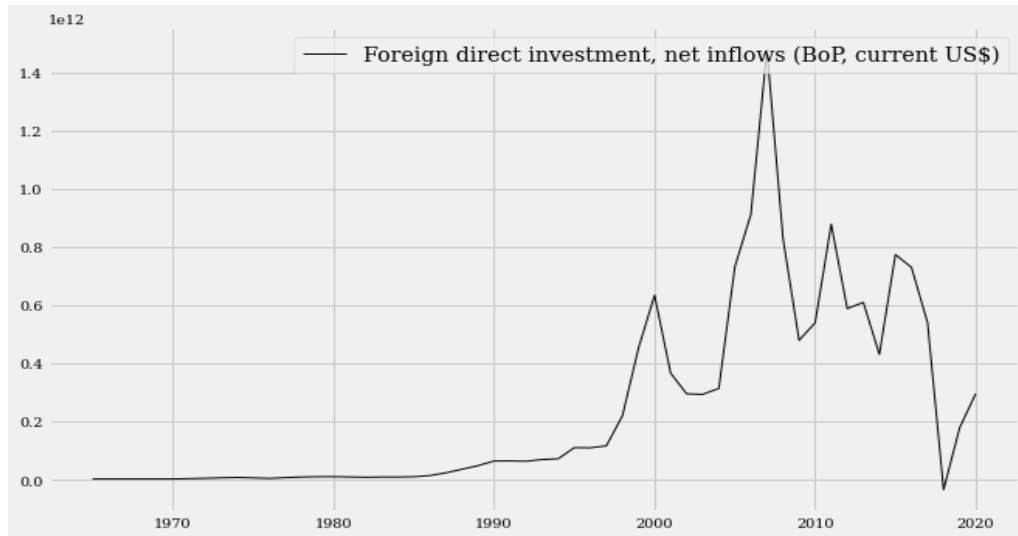


Figure 6 Foreign direct invest, net inflow of European Union

In addition, the Foreign Direct Investment (FDI) was added to determine the cause of the change in GDP. According to Sengupta & Puri (2020), FDI is closely related to GDP growth. At Figure 6, the FDI fell to the level of the 1980s again after the 2008-2009 financial crisis and then rebounded slightly. If this paper confirms whether the decline from 2011 to the present was due to QE, this paper provides better understanding about the economic effects of QE.

In Figure 1, GDP showed a trend that continued to rise overall, although GDP slowed down after 2011. In Figure 2, the volatility is not small, but continually declines. In Figure 3 and Figure 4, exports of goods and services and import of goods and services showed a continuing upward trend. Only FDI showed an inconsistent trend in Figure 5.

3.3 Descriptive statistics

Table 1

	GDP	GDP growth	Gross capital	Exports	Imports	FDI
Before						
mean	5.853	2.50	24.67	27.81	27.65	199
std	4.641	1.68	2.88	6.92	6.08	322
min	0.725	-4.34	20.63	19.36	19.69	2
25%	1.887	1.87	22.61	23.18	24.22	7
50%	5.084	2.65	23.65	25.84	26.44	36
75%	8.026	3.63	26.26	33.13	31.54	294
max	16.297	6.01	30.02	43.21	41.53	1,477

Notes: Units of variables are as follows. GDP: billion dollar, GDP growth: %, Gross capital (Gross capital formation): % of GDP, Export (Export of goods and services): % of GDP, Imports (Imports of goods and services): % of GDP, FDI (Foreign Direct Investment): trillion dollars

Table 2

	GDP	GDP growth	Gross capital	Exports	Imports	FDI
After						
mean	14,973	0.66	21.21	46.98	43.17	456,870
std	0.831	2.72	1.03	1.70	1.58	266,296
min	13.551	-5.96	19.89	44.80	41.45	(34,153)
25%	14.636	-0.03	20.31	45.69	41.94	296,059
50%	15.291	1.82	20.95	46.68	42.73	540,001
75%	15.652	2.07	22.07	48.35	44.08	609,590
max	15.978	2.81	22.93	49.34	45.90	773,435

Notes: Units of variables are as follows. GDP: billion dollar, GDP growth: %, Gross capital (Gross capital formation): % of GDP, Export (Export of goods and services): % of GDP, Imports (Imports of goods and services): % of GDP, FDI (Foreign Direct Investment): trillion dollars

From Table1 and Table 2, the effect of QE seems to be a mixed effect. The direction of change of variables was complicated. Increased variables were GDP (current US trillion \$), exports of goods and services (% of GDP), and imports of goods and services (% of GDP). The GDP average increased by about 2.55 times from \$5,853 billion dollars to \$14,973 billion dollars. Exports of goods and services (% of GDP) grew about 1.7 times from 28% to 47%, and imports of goods and services (% of GDP) grew about 1.5 times from 28% to 43%. Foreign Direct Investment grew about 2.3 times from 199 billion dollars to 456 billion dollars.

On the other hand, the GDP growth rate and Gross Capital Formation average decreased. GDP growth fell 74% from 2.5% to 0.65%. And Gross Capital formulation decreased by 16% from 25% to 21%. To recheck this downward trend, the median value was used. The same result came out. The median GDP growth rate decreased by 22% from 2.65% to 2.07%, showing the same trend. The median value of Gross Capital formation also decreased by 16% from 26.26% to 22.07%.

In summary, the effect of QE cannot be interpreted only with descriptive statistics. Although GDP increased, directions of additional variables are complicated. Exports of goods and services (% of GDP), Imports of goods and services (% of GDP), Foreign Direct Investment increased, while GDP growth (annual%) and Gross Capital formation decreased. Based on the above mixed results, the null hypothesis will be established in the next chapter.

3.4 Hypothesis

Hypothesis 1

GDP = ASCM

= QE has no effect on GDP.

This paper cannot conclude that QE is effective only with increased the values of the selected variables in Table 1 and Table 2. In Figure 1, GDP showed a trend that continually rise overall, although it slowed down after 2011. Considering that there was no change in the overall trend despite the EU's QE policy, the null hypothesis determined as that QE did not affect GDP.

Hypothesis 2

GDP growth = ASCM

= QE has no effect on GDP growth.

As in the case of GDP, this paper faces difficulty to grasp the effect of QE on GDP growth only with the descriptive statistics of Table 1 and Table 2. Although GDP has shown tremendous growth since 2009, these dramatic increases are frequent. And overall, GDP growth trend has not changed. Therefore, the null hypothesis establishes that QE did not affect GDP growth.

Hypothesis 3

Exports of goods and services (% of GDP) = ASCM

= QE has no effect on Exports of goods and services.

Export of goods and services showed the steepest decline between 1960 and 2020 and the sharpest rise from 2009 to 2011. However, the upward trend from 2009 to 2020 is similar to that from 1992 to 2008. Therefore, in terms of the overall trend, the effect of QE is not significant. Therefore, the null hypothesis determines as QE does not affect exports of goods and services.

Hypothesis 4

Imports of goods and services (% of GDP) = ASCM

= QE has no effect on Imports of goods and services.

The movement of import of goods and services in Figure 5 is quite similar to the movement of export of goods and services in Figure 4. However, the difference is that the rate of increase in import of goods and services was slower. Export of goods and services rose from 35%-point to 50%-point between 2009

and 2020. Import of goods and services, on the other hand, rose to around 45% over the same period. Therefore, this paper can judge that import of goods and services is less fluid than export of goods and services. In addition, as with exports of goods and services, the overall trend has not changed. Considering this trend, the null hypothesis was established that QE did not affect the import of goods and service.

Hypothesis 5

Gross capital formation = ASCM

= QE has no effect on Gross capital formation

In Figure 3, Gross Capital Formation has shown interesting changes since 2009. Gross Capital Formation fell by 2% again after rising by about 1% from 2009 to 2011. Then Gross Capital Formation rose again by 3% from 20% to 23%. Two scenarios can be expected for future changes.

The first possibility is that the Gross Capital Formation continually rise because of QE. The second possibility is that Gross Capital Formation continues to decline after short increase. The exact scenario cannot be known until time passes.

Although there is a possibility that Gross Capital Formation will shift to an upward trend, the null hypothesis will be set conservatively. Current data until 2020 show that the overall trend continues to decline. Therefore, the null hypothesis was also determined that QE did not affect cross capital formation.

Hypothesis 6

Foreign direct investment, net inflows (BoP, current US trillion \$) = ASCM

= QE has no effect on Foreign direct investment, net inflows

FDI was the only one of the six variables that showed a trend shift over a set period. From about 1990 to 2008, it showed a very steep rise. However, since 2008, it has fluctuated and shown a downward trend. This paper can consider that showing a falling trend did not have the effect of QE. Therefore, the null hypothesis was established that QE did not affect foreign direct investment, net flows.

Here, the ASCM is an expected figure of what it would look like without QE. In other words, ASCM is a figure that appeared in a situation where QE was not expected to affect Europe. For example, in Hypothesis 1, if the actual GDP growth is greater than ASCM, which means that GDP has grown more because of QE. Conversely, if real GDP growth are lower than ASCM, this paper can conclude that the

effect of QE had a negative effect on GDP growth. The detail of ASCM will be discussed in the Methodology section. This paper will now confirm whether the above hypotheses are valid or not. Depending on whether the hypothesis is rejected, we will check how QE affected GDP and inflation.

Chapter 4. Methodology

To know the effectiveness of Quantitative Easing, it is essential to compare EU with countries that had not used QE. Therefore, selecting the right comparison group is an important process. After selecting control units, policies can be evaluated through methods such as difference in difference. However, finding a single suitable comparison target is difficult. If EU is compared to an inappropriate country, the results can be biased.

A simple comparison between EU's GDP changes and non-EU countries without QE is unreliable to find the true QE effect. The EU and comparison groups are bound to differ in many areas, including politics, economic power, geography, and population. The most ideal comparable country would be a country that had all the same conditions as the EU except the implementation of QE. However, finding these ideal countries comes with a lot of difficulties. Ignoring these differences and conducting comparative studies will lead to biased results (Geddes 2003; George and Bennett 2005; King, Keohane, and Verba 1994).

The Augmented Synthetic Control method allows us to solve the difficulty of finding the comparative object mentioned above. Augmented Synthetic Control method is an extension of Synthetic Control method. This method contains the construction of a weighted combination of groups used as controls, in which the treatment group is included. This comparison is used to estimate what would have happened to the treatment group if the treatment group had not received the treatment. In other words, this method creates a virtual counterfactual based on the weight of the samples. Using this counterfactual, this study can eliminate the difficulty of finding a comparative group. In addition, the comparison target is also helpful in deriving accurate research results. As Abadie et al. (2010) p. 494 claim,

The idea behind the synthetic control is that a combination of units often provides a better comparison for the unit exposed to the intervention than any single unit alone.

The key to the SCM method is whether the synthetic control created through the construction of a weighted combination is like the real value during pre-treatment. If the pretreatment fitting is good, Synthetic controls are a good representation of the movements that will occur in situations where there would be no treatment during the post-treatment period (Abadie *et al.*, 2010).

However, getting a perfect or almost perfect pre-treatment fit is not always possible. Pre-treatment fit problems were frequent in the previous model, Synthetic Control Method. According to SCM's definition, the conditions for near-perfect weights are only possible when the vector of the created unit with the convex hull of control units. Pre-treatment fit may not be good when the pre-treatment period is short in SCM (Abadie et al., 2015). This can be further confirmed in Appendix B. Therefore, there are many limitations when SCM is used.

The Augmented Synthetic Control method can overcome the disadvantages of the SCM. (Ben-Michael et al., 2021) Augmented Synthetic Control method use Ridge regression to find the optimal weight of each sample. Ridge is one of the multiple regulation methods, which can increase the accuracy or interpretability of linear regression (Marquardt & Snee, 1975). Through Ridge regression, good pre-treatment fitting can be obtained even when the pre-treatment period is short.

To measure the effectiveness of QE with the Augmented Synthetic Control Method (ASCM), this study will create a fake unit or synthetic control. This process is done during the pre-treatment period. Then this paper tracks how these fake units move after treatment. During the post-treatment period, the treatment effect can be confirmed through the differences between the actual values and artificial values.

Computation of Augmented synthetic controls can be done using freely available software scripts that this research has written for Python. In addition, the process of using the package in this study can be confirmed.²

4.3 Robustness check

4.3.1 Placebo study

Placebo studies are a useful way to prove the results of studies with only a few samples. There are two methods of validation: placebo test in time and placebo test in space. Placebo test in time study analyzes the situation when an event moves to a different time zone. Placebo test in space analyzes the situation when an event moves to another space. For example, the in-time placebo effect assumes that the EU's

2

QE occurred in 1990s, not in 2008. And the in-space placebo test assumes that the QE of the EU occurred in other countries such as Croatia and Romania that did not implement QE. Here, the in-time placebo effect is limited in use due to a short period of selected data. Therefore, this paper selects the in-space placebo test only.

The results of the placebo study were clarified using the p-value. The denominator designated the number of sample groups. And the numerator designated the number of cases where the placebo effect is greater than the treatment effect. For example, it is assumed that the effect of QE in the EU is greater in Croatia than in the EU. If so, Croatia's placebo effect is greater than the EU's treatment effect. In this case, the numerator is added by 1. Each effect was compared to the absolute values and the effect was revealed every year.

4.2 Limiting pool of donors

As mentioned in the data section, 74 countries were selected for the survey. Comparing all 74 countries can cause difficulties in conducting detailed comparative studies. A more detailed method will be described in the next paragraph.

When comparing multiple samples, several variables must be compared. For example, let's say that the QE effect of the EU is checked through two comparative research cases. The first case is to compare only the EU and Croatia. And the second case is to compare EU, Croatia, and China. In the latter case, the remarkable point is that China is an Asian country and market policies are also different. Simply comparing several countries can lead to distorted research results. However, comparing fewer samples can undermine the reliability of the study results. This part will be explained in detail in the next paragraph.

To reduce the difficulty of the study, simply reducing the number of samples can cause problems. If the sample size decreases, the pre-treatment fit will also decrease (Abadie et al., 2015). If the pre-treatment fit is reduced, ASCM will not be able to properly represent the post QE figures. Therefore, understanding the relationship between the number of samples and the pre-treatment fit is an important point.

The method mentioned in Abadie et al. (2015) will be used to confirm correlation. The method is to reduce the number of countries in the sample one by one and see if there is a difference between the ASCM and the actual values. This result will reaffirm the benefits of having many samples.

Additionally, this method verifies the consistency of the results. If the result differs depending on the selected sample groups, this paper can conclude that this result is not significant. Therefore, limiting pool of donors will make sure that even if the number of each sample decreases, the result is equally significant.

4.3 Limitations of the Approach

Spillover effect can be a problem. ASCM should be the premise of no spillover. If the EU's QE effect spreads to countries in other samples that do not use QE, the reliability of the measurement results may be reduced. Haldane et al. (2016) mentioned two routes that QE can affect other countries. One route is for QE to reduce the value of domestic currency. This raises the value of money in other countries. This means that countries in the sample group may be affected relatively negatively in trade.

Another route is for investors to switch from gilts to other domestic assets as well as foreign assets. As a result, QE raises asset prices not only at home but also abroad. This results in economic growth not only in the EU but also in other countries. Haldane et al. (2016) cited US QE as an example. According to them, the second positive effect offsets the first negative effect. Therefore, the overall Spillover effect is expected to be positive.

This Spillover effect may cause difficulties but does not prevent the use of ASCM in this paper. First, Haldane et al. (2016) said that Spillover is mainly significant for large countries such as the US. Using ASCM to know the QE effect of US can cause a big bias. This is because the results of the countries constituting the Synthetic Control Region may be affected by the QE effect of the US. But for small countries like the EU, the Spillover problem is less serious. There may still be a bias, but that's very little.

In addition, there are limitations in estimating the exact magnitude of the effect. As mentioned in the previous method part, it is not always possible to obtain a perfect goodness of fitting during pre-treatment. Not getting the perfect goodness of fitting means that the ASCM after treatment is not completely reliable. Although the overall direction of ASCM movement after treatment can be predicted, the reliability may be reduced as to exactly how much it will move. Therefore, when the degree of goodness of fitting is not perfect, only the overall degree of movement of the ASCM can be confirmed.

Chapter 5. Result

5.1 GDP

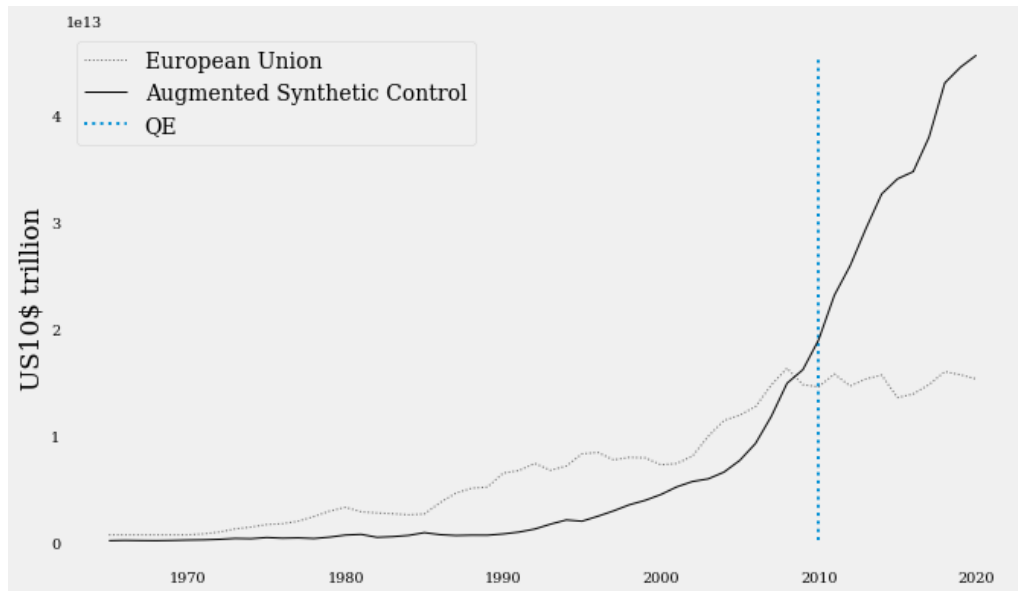


Figure 7 Trends in GDP: EU versus Synthetic EU

The graph above shows the changes in GDP in the EU and Augmented Synthetic Control (ASC). Synthetic control is a value that mimics the actual value, as explained in the methodology section earlier. This value represents a figure that predicts how GDP will move after 2011 based on the situation before the implementation of QE. In other words, ASCM indicates a post-state in which QE has not been implemented. If the actual GDP follows or is higher than ASCM, the GDP is higher or equal to the state before the 2008-2009 financial crisis. This is the basis for judging whether QE boosted economies or not.

Figure 7 shows that the ASCM has been much larger than the actual GDP since 2009. If all subsequent robust tests show that the current results are significant, this paper can judge that QE has a negative effect on GDP. However, as explained in 4.3, it is not always possible to know the magnitude of the treatment effect. Before 2009, the goodness of fitting was not perfect. This is most likely due to the limitations of Ridge regression. Also, the EU's GDP movement stopped abruptly from 2008, which did not occur between 1965 and 2007. Therefore, this research also faces difficulty to judge that Ridge regression accurately predicts movements after 2008. Therefore, it is difficult to determine the magnitude of the impact, even though it is possible to confirm whether the EU QE negatively affects GDP or not.

Table 3

year	GDP (Trillion US\$)	ASCM	Difference
2011	15.759	20.302	(4.542)
2012	14.636	23.297	(8.661)
2013	15.299	26.941	(11.641)
2014	15.652	29.475	(13.823)
2015	13.551	30.823	(17.271)
2016	13.893	30.538	(16.645)
2017	14.765	32.619	(17.853)
2018	15.978	37.650	(21.672)
2019	15.689	38.340	(22.650)
2020	15.291	40.168	(24.876)

Notes: The scale is trillion dollars

5.2 GDP growth

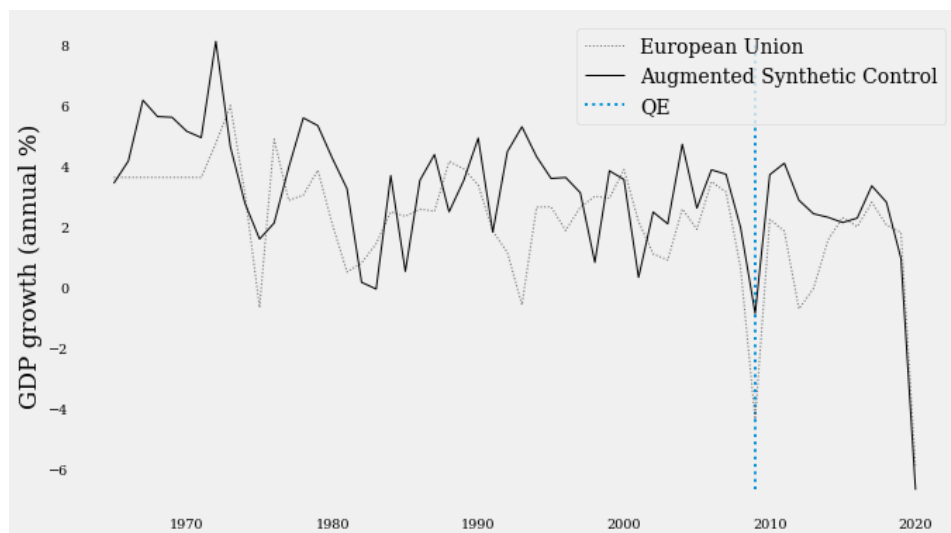


Figure 8 Trends in GDP growth: EU versus Synthetic EU

In Figure 8, the results of Figure 7 could be confirmed once again. In the movement after 2011, ASCM was higher in most years than the actual GDP growth. This can also be seen in Table 4. In all years between 2011 and 2018, ASCM was higher than the real GDP growth. This means that QE hurts GDP growth. This is consistent with the result of GDP (current trillion \$) in Figure 7.

Table 3

year	GDP growth(annual %)	ASCM	Difference
2011	1.86	4.55	-2.69
2012	-0.71	3.45	-4.16
2013	-0.03	3.03	-3.07
2014	1.58	2.71	-1.14
2015	2.31	2.36	-0.05
2016	2.01	2.61	-0.6
2017	2.81	3.64	-0.82
2018	2.07	3.01	-0.94
2019	1.82	1.02	0.8
2020	-5.96	-6.93	0.97

5.3 Exports of goods and services

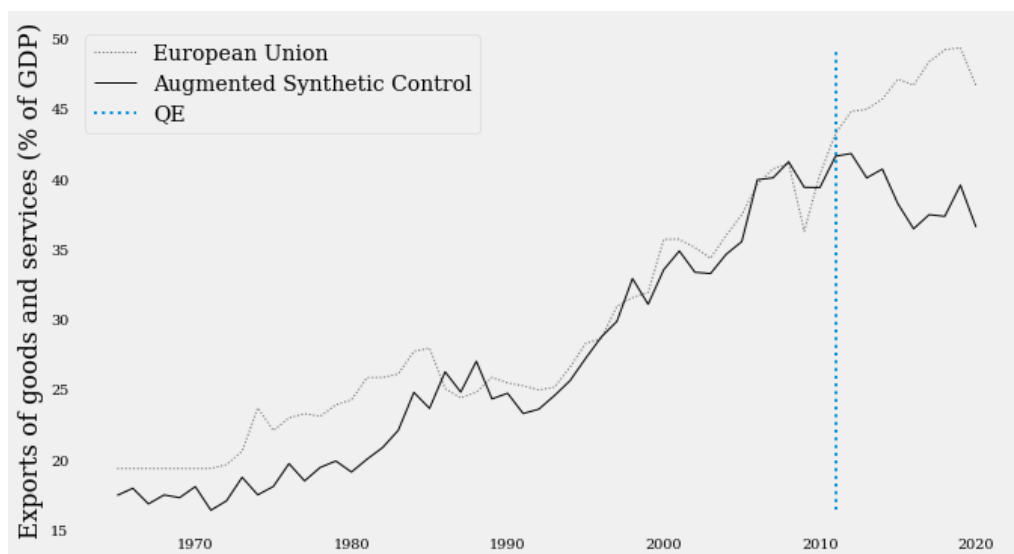


Figure 9 Trends in Exports of goods and services: EU versus Synthetic EU

Figure 9 describes the real change in exports by QE. Based on the results shown by Figure 9, this paper can confirm whether the EU is benefiting from transactions with other countries due to the QE policy. Figure 9 shows that the synthetic control value was lower than the actual export of goods and service. This means that the QE policy has increased the proportion of the trade surplus. In other words, QE contributed to the rise of GDP.

Table 4

year	Exports goods and services (% of GDP)	ASCM	Difference
2011	43.21	41.62	1.60
2012	44.80	41.81	3.00
2013	44.96	40.07	4.89
2014	45.69	40.70	4.99
2015	47.11	38.22	8.89
2016	46.68	36.45	10.24
2017	48.35	37.45	10.90
2018	49.20	37.33	11.86
2019	49.34	39.56	9.79
2020	46.65	36.57	10.08

This research utilizes Table 4 for accurate interpretation. Looking at the Difference, this paper finds that Exports goods and services were larger than ASCM. The difference becomes about 6.3 times larger from 1.6 to 10.08. If this result is significant, this paper can judge that the trade surplus from the EU's exports has increased through QE.

Imports of goods and services

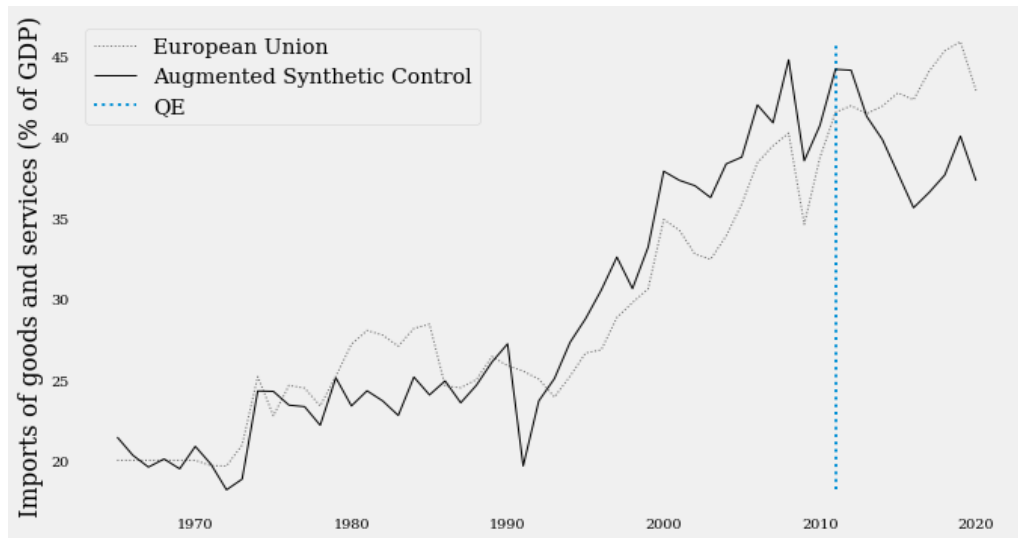


Figure 10 Trends in Imports of goods and services: EU versus Synthetic EU

Table 5

year	Imports of goods and services (% of GDP)	ASCM	Difference
2011	41.53	44.19	-2.66
2012	41.94	44.13	-2.20
2013	41.45	41.28	0.17
2014	41.91	39.86	2.06
2015	42.73	37.75	4.98
2016	42.31	35.64	6.67
2017	44.08	36.58	7.49
2018	45.33	37.66	7.66
2019	45.90	40.06	5.84
2020	42.87	37.30	5.57

In the table 5, the actual import of goods and services is larger than the virtual synthetic control effect. Although both the actual import figures and the synthetic control showed a downward trend in 2019, the synthetic control moved in the opposite direction to the actual value from 2011 to 2017. In other words, this research predicts that the import of goods and service would go down. This means that if the result value is significant, the QE policy increases the import.

5.4 Gross capital formation

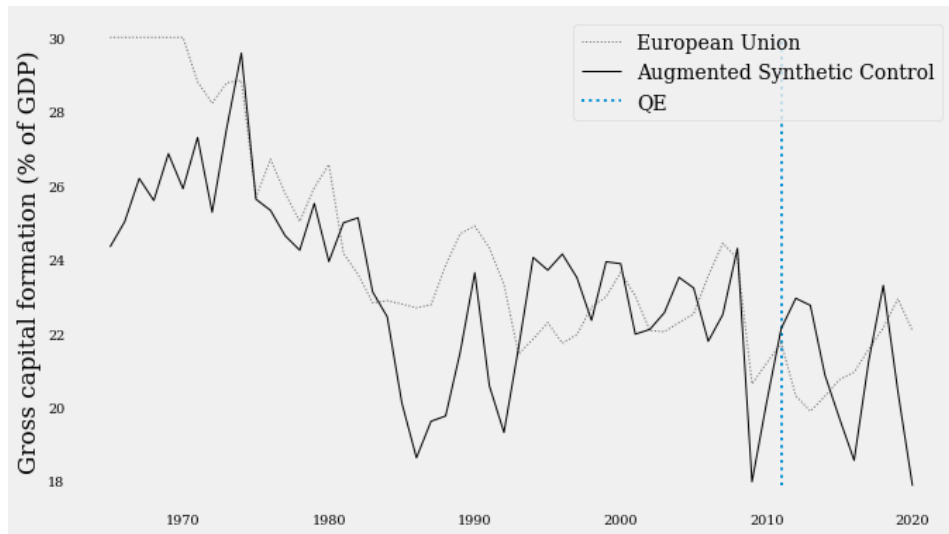


Figure 11 Trends in Gross capital formation: EU versus Synthetic EU

Figure 11 represents that the overall trend in gross capital formation. The gross capital formation of the EU shows a downward trend. Although it rose from 2012 to 2019, the overall downward trend did not change. In the same context, ASCM does not deviate significantly from the downward trend. Therefore, from the table above, QE did not have much effect on cross capital formation. However, if this paper observes each year, this paper finds that the movement is different.

Table 6

year	Gross capital formation (% of GDP)	ASCM	Difference
2011	21.74	22.13	-0.39
2012	20.31	22.95	-2.64
2013	19.89	22.76	-2.87
2014	20.29	20.87	-0.57
2015	20.74	19.69	1.06
2016	20.95	18.56	2.39
2017	21.57	21.25	0.32
2018	22.15	23.30	-1.15
2019	22.93	20.42	2.51
2020	22.07	17.87	4.20

Looking at the Difference, ASCM was larger in 2011, 2012, 2013, and 2014, and the actual value was larger in 2015, 2016, 2017, 2019, and 2020. This paper interprets the result that the direction changed continuously due to QE for each specific year. In other words, depending on the conditions of a specific year, the effect of QE can be the opposite.

5.5 Foreign Direct Investment

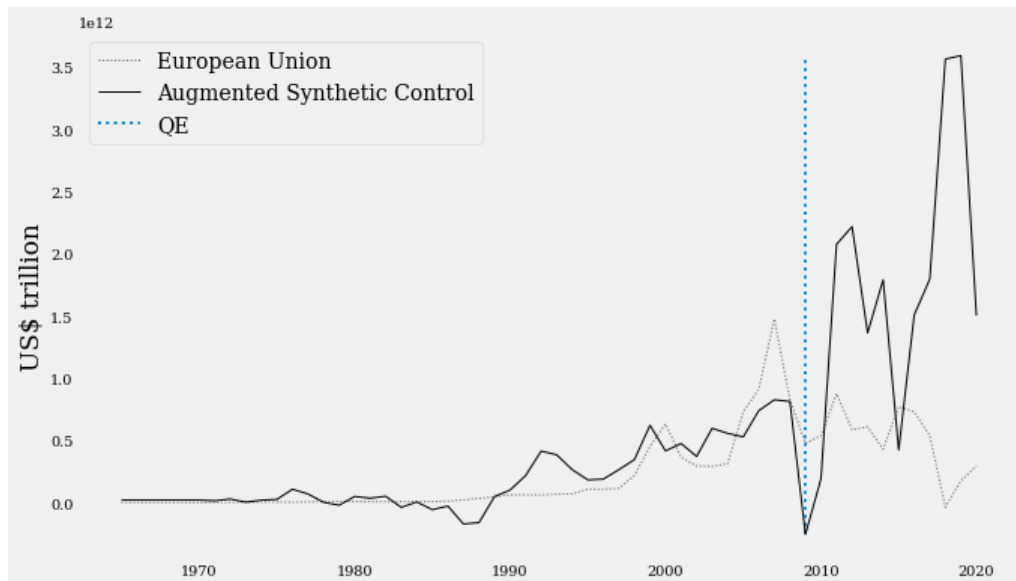


Figure 12 Trends in Foreign Direct Investment: EU versus Synthetic EU

According to the table above, FDI did not see much effect due to QE. FDI was expected to continue to rise without the fiscal crisis of 2009 in 2008. However, the FDI has decreased. Table 7 indicates that all the differences were positive except for 2018 and 2019. This research discovers that a negative correlation between QE and FDI. If QE is performed, the FDI is reduced.

Table 7

year	Foreign direct investment	ASCM	Difference
2011	877,970	316,017	561,952
2012	588,029	277,484	310,545
2013	609,590	381,159	228,431
2014	430,712	298,567	132,145
2015	773,435	284,915	488,519
2016	729,754	217,385	512,368
2017	540,001	214,748	325,253
2018	-34,153	270,330	-304,483
2019	178,399	223,567	-45,168
2020	296,059	245,654	50,404

Notes: The scale is trillion dollars

Chapter 6. Robust testing

6.1 RMSPE ratio

GDP

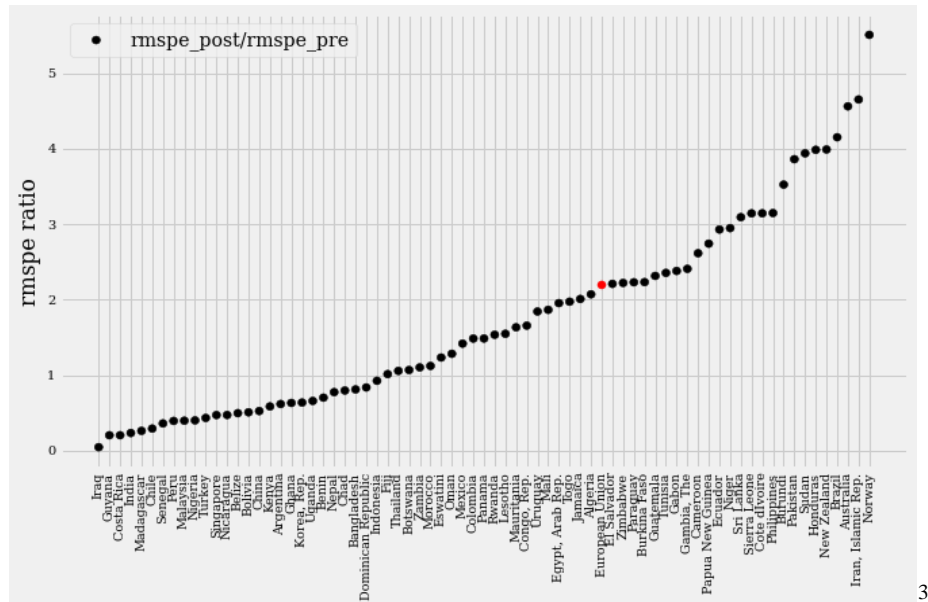
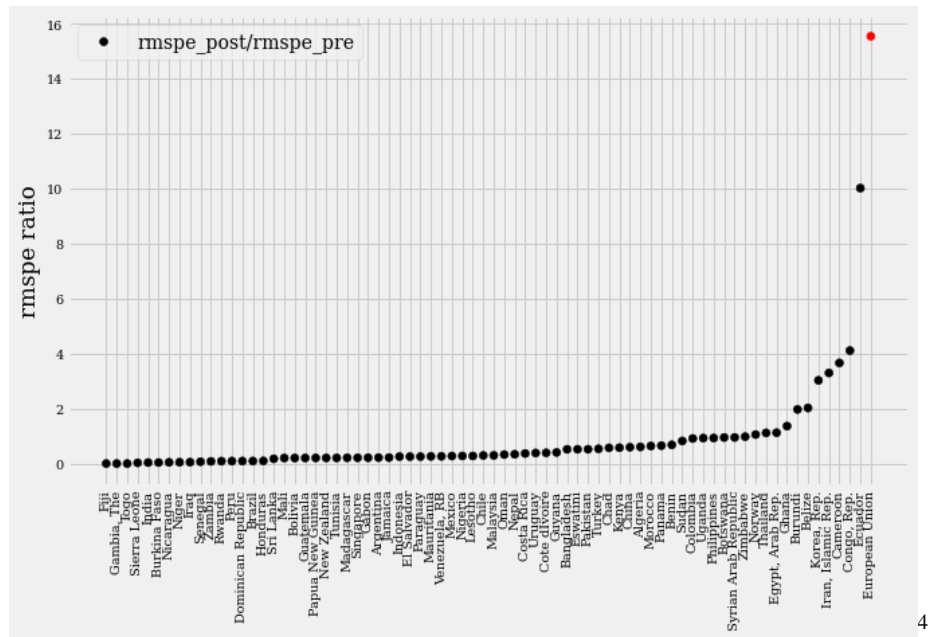


Figure 13 Ratio of Post QE RMSPE to Pre QE RMSPE: GDP (Current US\$)

Figure 13 shows the RMSPE ratio measured as of 2011. The larger this proportion is compared to other countries, the larger the deviation between synthetic control and actual values after 2011. Looking at Figure 7, the EU is included in the upper ranks, although the EU did not rank the highest. Since GDP is the sum of total national output, GDP can be affected by many variables such as political, geographical, and economic situations. Therefore, this paper cannot judge that the single policy, QE, will have a tremendous impact on GDP. Considering this limitation, the result value can be trusted.

³ The above graph excluded Venezuela, Syrian Arab Republic, and Iran for effective visualization.

GDP growth



**Figure 14 Ratio of Post QE RMSPE to Pre QE RMSPE:
GDP growth (annual %)**

In Figure 14, RMSPE ratio was the highest except for Australia which was not included for effective visualization. This confirm that the results of Figure 7 show the negative effect of QE on GDP growth. In addition, since this result is the same as the result for GDP current in Figure 12, the reliability becomes higher.

⁴ The above graph excluded Australia for effective visualization.

Export of goods and services

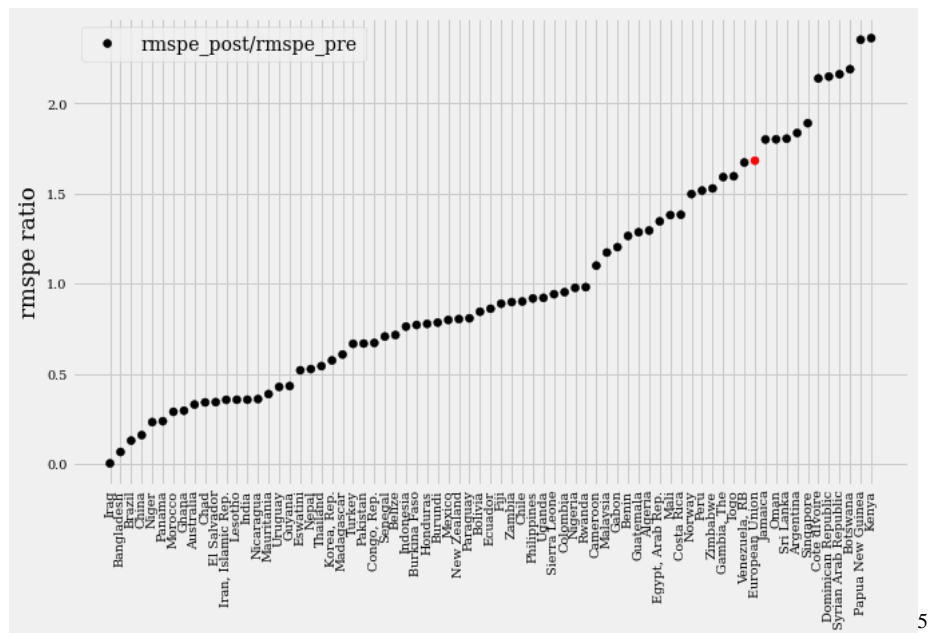


Figure 15 Ratio of Post QE RMSPE to Pre QE RMSPE:

Export of goods and services (% of GDP)

The RMSPE ratio table shows that QE's impact on export is significant. The RMSPE ratio of the EU is at the upper rank. Exports of goods and service is similar to GDP in that export can also be affected by many factors. Therefore, comparative high RMSPE ratio is sufficient to prove the QE effect is significant.

⁵ Tunisia and Sudan were excluded for effective visualization.

Import of goods and services

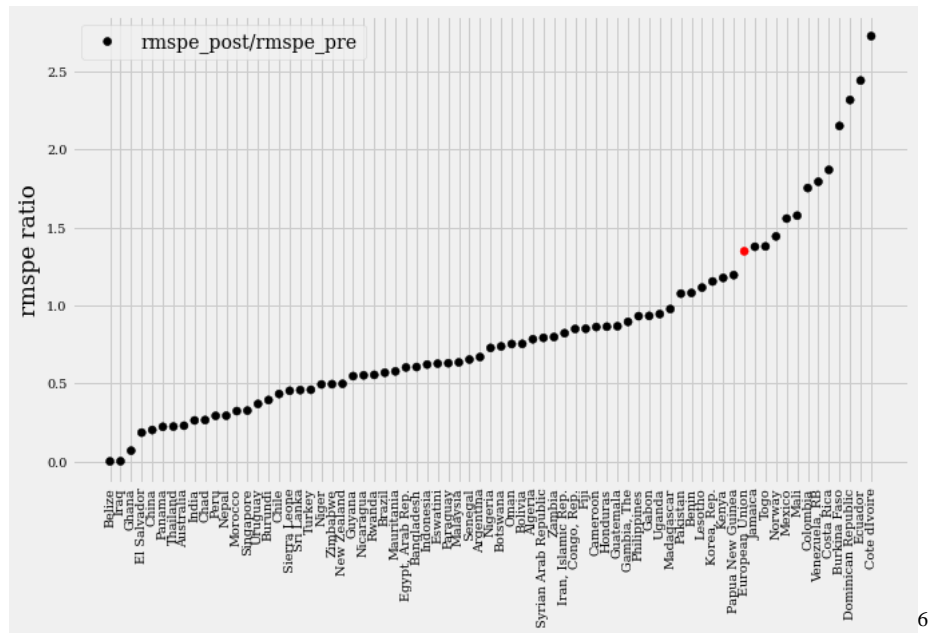


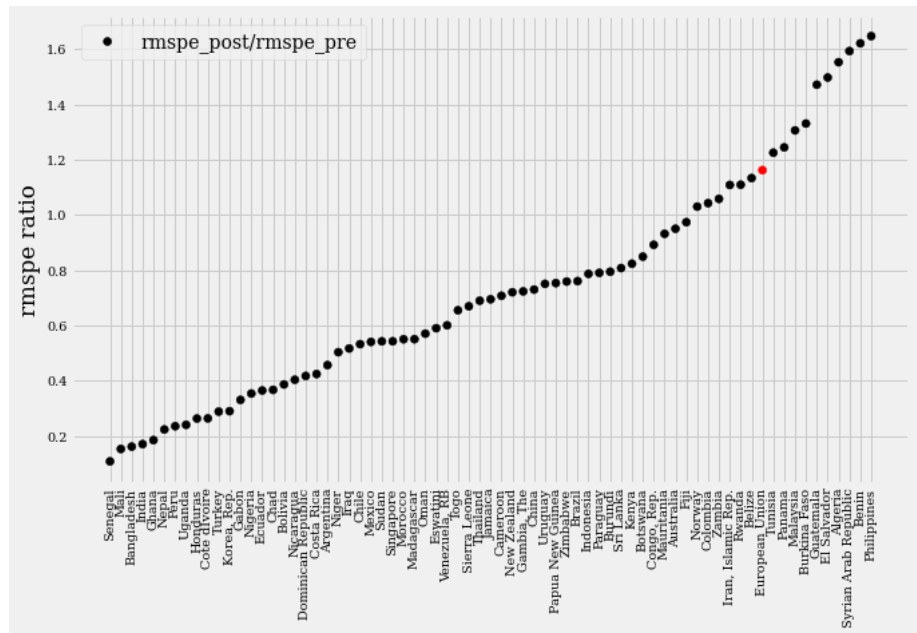
Figure 16 Ratio of Post QE RMSPE to Pre QE RMSPE:

Import of goods and services (% of GDP)

Looking at the ratio of RMSPE ratio, the EU occupies the upper middle ranks. Import is the same as export and GDP, so many variables can affect import. Therefore, the effect of QE on Import is considered as significant. Through the next placebo test, this paper will check whether the result value is significant.

⁶ Papua New Guinea and Kenya were excluded for effective visualization.

Gross Capital formation

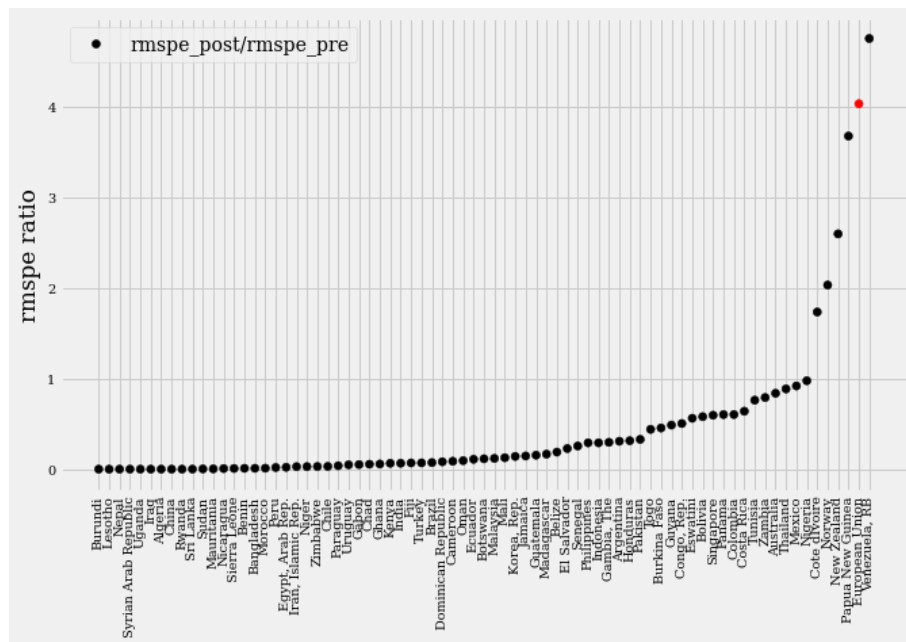


**Figure 17 Ratio of Post QE RMSPE to Pre QE RMSPE:
Gross Capital formation (% of GDP)**

The ratios of the EU are also at a comparatively high rank. Therefore, if significant results are also produced in the placebo test, this study concludes that the EU QE does affect the gross capital formation.

⁷ Four following countries were excluded in Figure 17 for effective visualization. Algeria, Syrian Arab Republic, Benin, Philippines

Foreign Direct Investment



**Figure 18 Ratio of Post QE RMSPE to Pre QE RMSPE:
Foreign direct investment, net inflows (BoP, current US\$)**

Figure 18 describes that the ratio of the EU is the second largest. This means that the synthetic control of EU is the second largest of all samples. Therefore, the reliability of the results in the Figure 22 is quite high. This research should investigate whether the Placebo study also shows consistent results.

6.2 Placebo testing

6.2.1 GDP

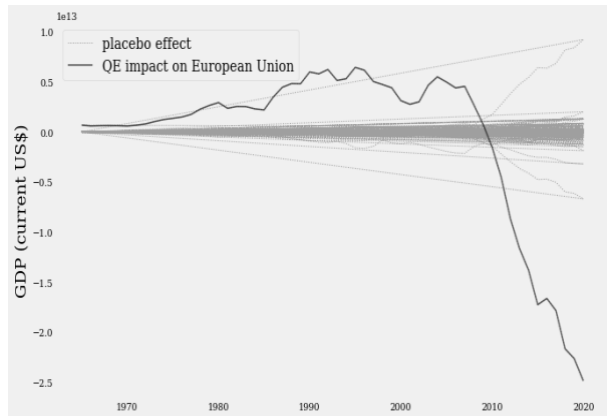


Figure 19 Placebo testing on GDP

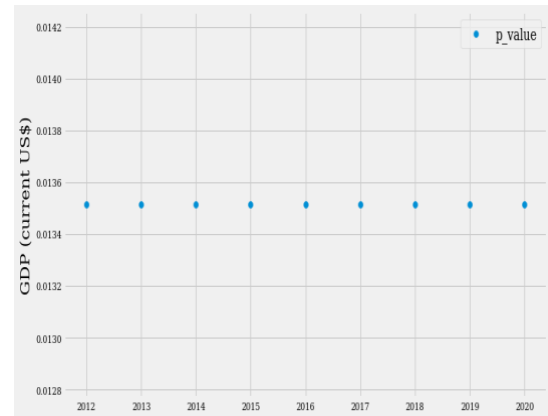


Figure 20 P-values analysis of GDP

The effect of QE was confirmed once again through the placebo test. From Figure 19, the EU synthetic control effect has drastically increased compared to those of other countries after 2011. Figure 20 shows the P-value of Figure 19. The P-value is the number of countries with a higher placebo effect divided by the total number of countries. The P-value was very low at 0.0136 for all years. This means that the synthetic control effect of the EU is very high in the sample group. In other words, if the other countries in the sample performed the same QE, the effect of the EU QE was relatively high among all sample countries. Therefore, this paper confirms once again that the results were significant.

6.2.2 GDP growth

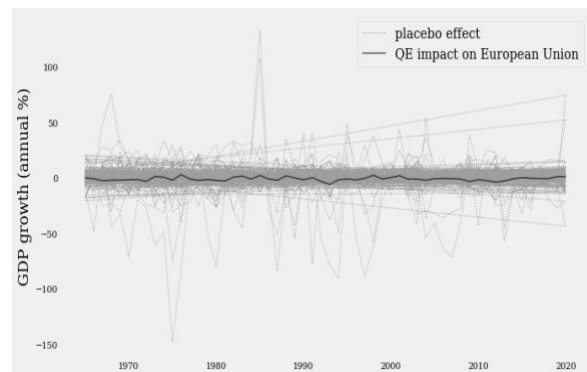


Figure 21 Placebo testing on GDP growth

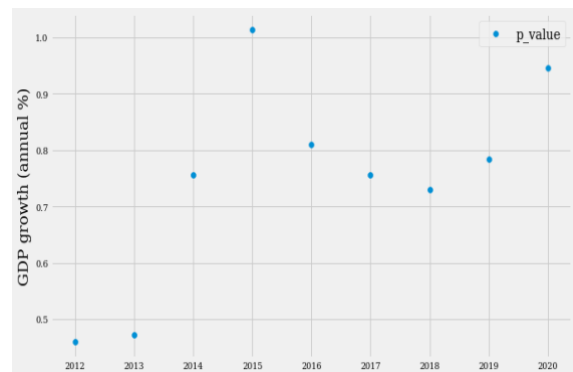


Figure 22 P-values analysis of GDP growth

Unlike the results of the previous RMSPE table, the results were not significant in the placebo test. In Figure 21, the placebo effect is not large. This could be confirmed again by the p-value in Figure 22. P-value was very high above 0.7 in all years except 2013 in 2012. Therefore, this research discovers that there is no direct relationship between QE and GDP growth.

6.2.2 Export of goods and services

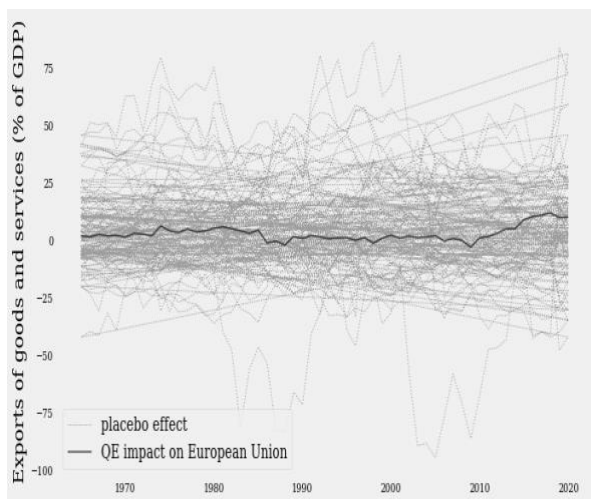


Figure 23 Placebo testing on Export

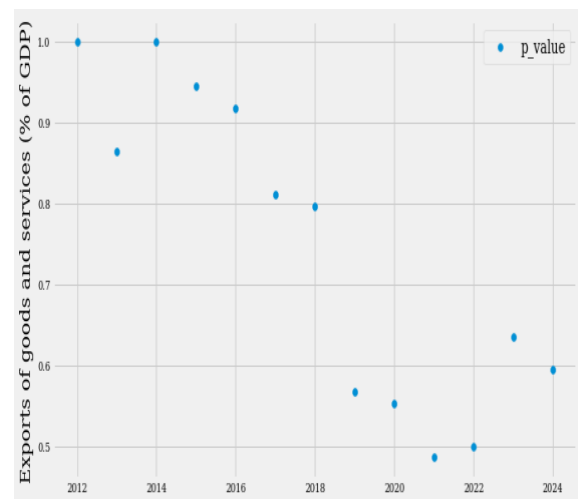


Figure 24 P-values analysis of Export

Unlike the results of the previous RMSPE table, the results were not significant in the placebo test. Figure 23 exhibits that almost all other country's synthetic control effects are greater in all years. In addition, when looking at the p-value, the smallest value was 0.5 or more, and the effect of QE was not significant in all years. Therefore, although the result was significant in the RMSPE ratio, the effect on the export of QE in the placebo test was not significant.

6.2.3 Import of goods and services

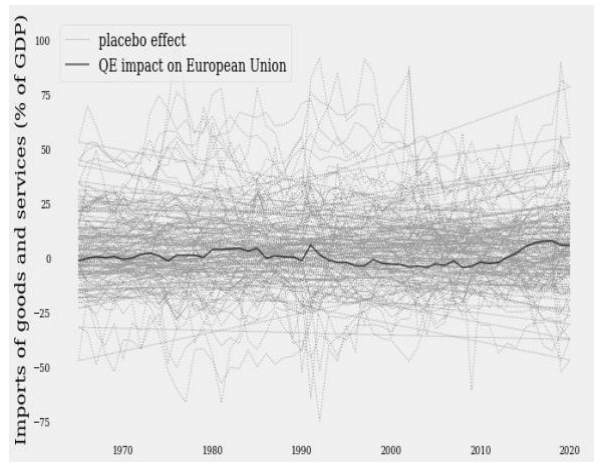


Figure 24 Placebo testing on Import

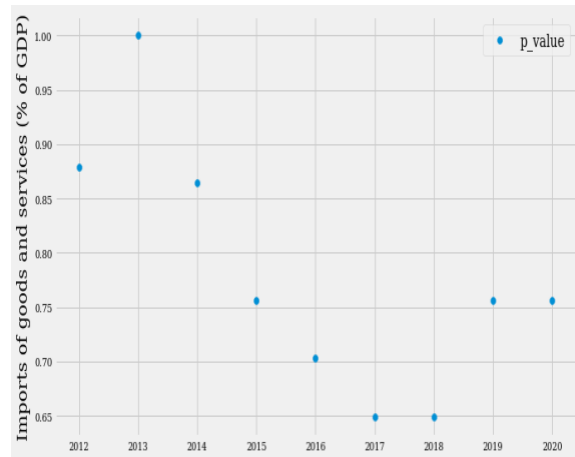


Figure 25 P-values analysis of Import

The Placebo effect shows that, like export of goods and services, QE has little effect on the import of goods and services of the EU. The same was true of the P-value table. Although the p-value has gradually decreased since 2013, the lowest value is 0.65, and the p-value is 1 in 2013, the least effective of all countries. Therefore, QE had no effect on imports in all years.

6.2.4 Gross capital formation

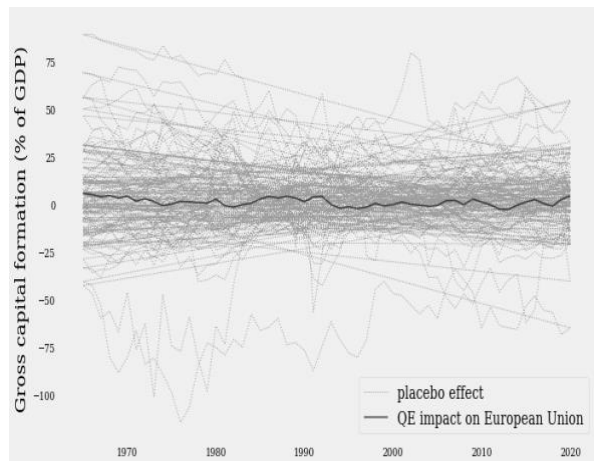


Figure 26 Placebo testing on Import

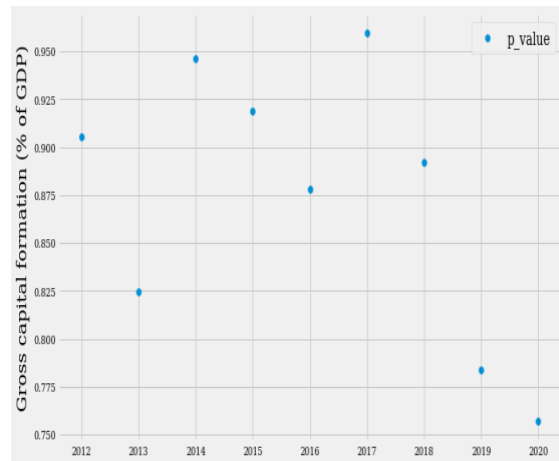


Figure 27 P-values analysis of Import

Through the Placebo investigation, the effect of QE on gross capital formation was insignificant. P-values are also 0.75 or more for all years, so the result is not significant. Therefore, QE and gross capital formation do not have much correlation.

6.2.5 Foreign direct investment

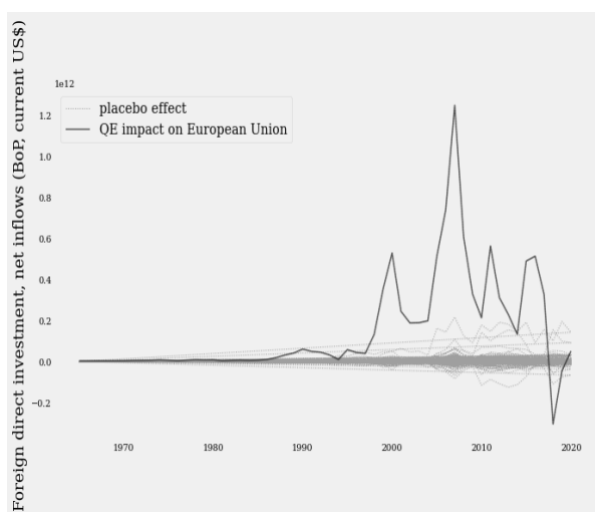


Figure 28 Placebo testing on FDI

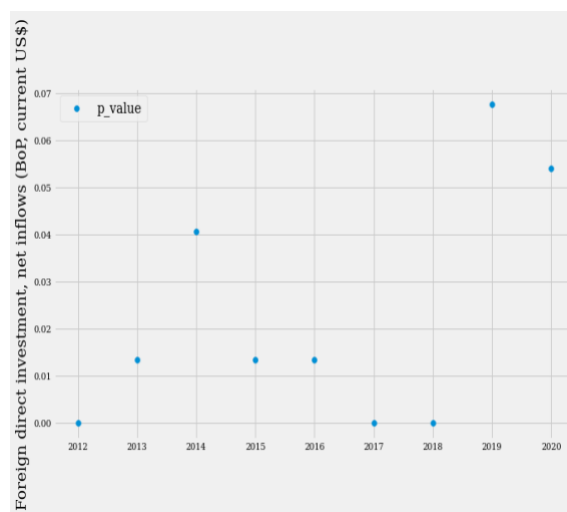


Figure 29 P-values analysis of FDI

Consistent results were also confirmed in the Placebo test. In 2012, 2017, and 2018, the p-value was zero, which means that the synthetic control effect was the largest among all samples. In other years, the P-value was very low at less than 0.07. Therefore, results of Foreign direct investment are reliable.

6.3 Limiting donor pool

Finally, this paper will check if the results change as the composition of the sample changes. If the result changes by the number of selected samples, then the result is not significant. Among the five investigated variables, only GDP current and FDI were significant after the current RMSPE ratio and placebo test. Therefore, these two variables will be further tested.

First, we will check the change in GDP. According to Appendix B, the results are as follows. In the case of GDP current, goodness of fitting has fallen since nine countries were excluded. And while excluding samples, the difference between the Augmented Synthetic Control and the GDP current was not different from before. Therefore, once again, the result value of QE was significant. And in the case of FDI, the goodness of fitting decreased even if only one sample was excluded. However, even if the goodness of fitting was reduced, the direction in which the synthetic control moved was generally similar. Therefore, this research can prove once again that the result value of FDI was also significant. In other words, FDI also decreased due to QE.

Chapter 7. Hypothesis testing

Overall, the results are considered and the hypotheses are tested as follows.

Hypothesis 1 testing

$GDP = ASCM$

= QE has no impact on GDP.

GDP was smaller than ASCM, so the result was a decrease in GDP due to QE. RMSPE ratio, placebo test and the limiting donor pool test confirmed that the results were significant. So null hypothesis that QE has no impact on GDP was rejected.

Interestingly, contrary to the purpose of the QE policy, GDP has rather decreased. In other words, QE has a negative correlation with GDP. The reason for this result can be the risk of the QE policy. According to Gern (2015), QE has a negative effect on resource allocation. QE keeps unproductive companies alive, which makes unnecessary structural changes. So even if QE increase stock market indexes, QE still causes a negative impact on the entire country.

This paper also considers that occurred after the QE policy ended. The first period of QE implementation was from 2009 to 2011. The implementation period of this policy may have been too short to have an impact on economy. Mortimer-Lee (2012) argued that the implementation of unconventional policies generally carries risks. He mentioned that the long implementation period of QE can cause a high inflation risk and exit at the extremely fast pace can cause recession and deflation. Therefore, the two years of QE implementation were considered as insufficient.

However, as described in 4.3, the magnitude of the treatment effect cannot be always known. Prior to 2009, the goodness of fitting was not perfect in Figure 7, possibly due to the limitations of Ridge regression. Also, the GDP movement has stopped suddenly since 2008, a move that did not appear in the pre-2008 period. This reduces the accuracy of predictability, making it more difficult to consider that Ridge Regression accurately predicts movements after 2009. Therefore, this paper cannot confirm the exact magnitude of the QE effect, even though this hypothesis test has confirmed whether the EU QE has a negative impact on GDP.

Hypothesis 2 testing

GDP growth = ASCM

= QE has no impact on GDP growth.

GDP growth was smaller than ASCM, so the result was a decrease in GDP due to QE. RMSPE ratio, confirmed that the results were significant. Unlike the results of the previous RMSPE table, the results were not significant in the placebo test. Therefore, this research could confirm that there is no direct relationship between QE and GDP growth. So null hypothesis that QE has no impact on GDP was not rejected.

However, this result does not contradict the results of QE and GDP. This study notes that most of the samples are developing countries. The necessary point is that developing countries generally have higher GDP growth potential than developed countries. Therefore, even if QE is not implemented, there is a high possibility that the placebo effect of developing countries is greater. In other words, the results of Hypothesis 2 testing do not conflict with the results of Hypothesis 1 testing.

Hypothesis 3 testing

Exports of goods and services (% of GDP) = ASCM

= QE has no effect on exports.

Exports of goods and services (% of GDP) were larger than ASCM. This means that QE increased the export production. However, RMSPE ratio, placebo test and the limiting donor pool test failed to reject the null hypothesis, thus QE and exports are not related.

The above research results are consistent with the research results of Masoud et al (2020). Masoud et al (2020) studied the correlation between US unconventional policy and EAGLE's exchange rate. As a result of the study, only one of the EAGLEs, Indonesia, was affected by QE in the United States. In other words, QE had little effect on exports of goods and services in most countries.

This result suggests that policies to increase GDP through QE are likely to fail in countries where export of goods and services occupy a high proportion.

Hypothesis 3 testing

Imports of goods and services (% of GDP) > ASCM

= QE has no effect on exports.

Import of goods and services were larger than ASCM. This means that QE increased the Imports of goods and services. However, RMSPE ratio, placebo test and the limiting donor pool test showed that the result is not significant. Therefore, this research did not reject the null hypothesis. Therefore, QE indicates no long-term association with Import of goods and services.

Through the test of hypothesis 3, the result of hypothesis 2 could be confirmed once again. Export of goods and services and import of goods and services are both affected by the exchange rate. Although Export is not completely dependent on the exchange rate, Export is still a necessary variable to predict the trade balance (Qiao, 2007). Therefore, if Hypothesis 2 is not rejected, Hypothesis 3 should not be rejected. In other words, the results of Hypothesis 2 and Hypothesis 3 testing showed that QE had no effect on both export of goods and services and import of goods and services. In other words, QE did not affect trade between countries.

Hypothesis 4 testing

Gross capital formation = ASCM

= QE has no effect on exports.

Gross capital formation was larger than ASCM in 2020. This means that QE increased the Gross capital formation. However, the overall trend of Gross capital formation was similar to that of ASCM, which shows that QE was not effective on Gross capital formation. Additionally, RMSPE ratio, placebo test and the limiting donor pool test showed that the result is not significant. Therefore, we did not reject the null hypothesis.

Gross capital formation is an indicator of how much new value has been invested. From the above results, QE is not very helpful for practical economic development. This is consistent with the results of Hypothesis 1 and Hypothesis 2 testing. Through these two testing, we found that QE had a negative effect on GDP. Therefore, with Hypothesis 4, this paper can support once again the negative effect of QE on GDP.

Hypothesis 5 testing

Foreign direct investment, net inflows (BoP, current US\$) = ASCM
= QE has no effect on Foreign direct investment, net inflows.

FDI was the only significant variable among four selected additional variables. This is also an interesting result. (Export of goods and services, import of goods and services, and the gross capital formation showed no significant results.) In other words, the result of FDI testing shows once again that QE was not helpful for the EU's economic development. Hypothesis 5 testing is also in line with the above results. According to Agrawal and Khan (2011), an increase in FDI leads to the growth of GDP. However, result showed that FDI was also reduced due to QE.

Chapter 8. Conclusion

This paper investigated whether the EU's QE was effective in GDP during the financial crisis. In addition to the change in GDP, this paper investigated elements of GDP or closely related variable. Selected variables are GDP current, GDP growth rate, Gross capital formation, Export of goods and services, Import of goods and services, and Foreign Direct Investment. Using the Augmented Synthetic Control method, this research created a counterfactual world. In other words, this study predicted the movement until 2020 based on the movement of dependent variables until 2009. As a consequence, this research could see how GDP would have moved without QE.

Interestingly, the result was the opposite of the direction of the QE policy. Because of Quantitative easing, GDP has decreased. The initial prediction was that QE would increase the GDP because QE is an economic stimulus policy, or QE would not affect the GDP because the GDP itself is a very broad variable. However, the GDP has rather gone down.

In addition, among the variables that make up the GDP, all variables that are thought to be closely related to economic growth showed insignificant QE effect after the placebo test and limitation of donor pool test. This once again showed that QE is not conducive to GDP. In addition, FDI, which is closely related to GDP, also decreased through QE.

However, since most of the samples are made up of developing countries, the scale of the negative effects of QE may be upward biased. Additionally, due to the limitations of Ridge regression, goodness of fitting was not perfect. Therefore, the exact magnitude of the QE effect could not be fully determined.

Additionally, since QE is a relatively new policy, there are extra difficulties to study the complete effect of QE on GDP. Currently, data on side effects caused by QE are insufficient. Therefore, the future research investigates again later when the QE policy becomes a commonly used policy.

References

- Abadie, A., A. Diamond, & J. Hainmueller (2010): “Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California’s Tobacco Control Program.” *Journal of the American Statistical Association* **105(490)**: pp. 493-505.
- Abadie, A., A. Diamond, & J. Hainmueller (2015): “Comparative Politics and the Synthetic Control Method.” *American Journal of Political Science* **59(2)**: pp. 495-510.
- Abhoff, S., Belke, A., & Osowski, T. (2021). Unconventional monetary policy and inflation expectations in the EUro area. *Economic Modelling*, 102, 105564.
- Agrawal, G., & Khan, M. A. (2011). Impact of FDI on GDP: A comparative study of China and India. *International Journal of Business and Management*, 6(10), 71.
- Andrade, P., J. Breckenfelder, F. De Fiore, P. Karadi, & O. Tristani (2016): “The ECB’s asset purchase programme: an early assessment.” *Working Paper Series 1956*, ECB.
- Bank of England (2009): *Minutes of the Monetary Policy Committee Meeting, 4 and 5 March 2009*.
- Bank OF England (2012b): “The distributional effects of asset purchases.” *Quarterly Bulletin* 2012 Q3.
- Berkmen, S. P., Gelos, G., Rennhack, R., & Walsh, J. P. (2012). The global financial crisis: Explaining cross-country differences in the output impact. *Journal of International Money and Finance*, 31(1), 42-59.

- BERNANKE, B. (2009): “The Crisis and the Policy Response.” Speech at the Stamp Lecture, London School of Economics, London, England, January 13.
- Ben-Michael, E., Feller, A., & Rothstein, J. (2021). The augmented synthetic control method. *Journal of the American Statistical Association*, 116(536), 1789-1803.
- Blattner, L., Farinha, L., & Nogueira, G. (2016). The effect of quantitative easing on lending conditions. Banco de Portugal Working Paper March 2016.
- Bossone, B. (2013): “Unconventional monetary policies revisited (Part I).” In W. J. Den Haan (editor), “Quantitative Easing: Evolution of economic thinking as it happened on Vox,” CEPR Press, 2016. A VoxEU.org eBook.
- Bowdler, C. & A. RADIA (2012): “Unconventional monetary policy: the assessment.” *Oxford Review of Economic Policy* 28(4): pp. 603-621.
- Chung, H., J.-P. Laforé, D. Reifschneider, & J. C. Williams (2012): “Have we Underestimated the Likelihood and Severity of Zero Lower Bound Events?” *Journal of Money, Credit and Banking* **44(1)**: pp. 47-82.
- Churm, R., M. Joyce, G. Kapetanios, & K. Theodoridis (2015): “Unconventional monetary policies and the macroeconomy: the impact of the United Kingdom’s QE2 and Funding for Lending Scheme.” *Staff Working Paper No. 542*, Bank of England.
- D’Amico, S. & T. King (2013): “Flow and stock effects of large-scale treasury purchases: Evidence on the importance of local supply.” *Journal of Financial Economics* (**108**): pp. 425-448.

- Duncan, G. (2009). European Central Bank opts for quantitative easing to lift the Eurozone. *The Times*, 8.
- ENGLAND, B. O. (2012). The distributional effects of asset purchases. Bank of England, July.
- Falagiarda, M., & Reitz, S. (2015). Announcements of ECB unconventional programs: Implications for the sovereign spreads of stressed Euro area countries. *Journal of International Money and Finance*, 53, 276-295.
- Gagnon, J., M. Raskin, J. Remache, & B. Sack (2011): "The Financial Market Effects of the Federal Reserve's Large-Scale Asset Purchases." *International Journal of Central Banking* 7(1).
- Gambetti, L., & Musso, A. (2017). The macroeconomic impact of the ECB's expanded asset purchase programme (APP).
- Gern, K. J., Jannsen, N., Kooths, S., & Wolters, M. (2015). Quantitative easing in the EUro area: Transmission channels and risks. *Intereconomics*, 50(4), 206-212.
- Ghali, K. H. (1997). Government spending and economic growth in Saudi Arabia. *Journal of Economic Development*, 22(2), 165-172.
- Haldane, A. G., M. Roberts-Sklar, T. Wieladek, & C. Young (2016): "QE: the story so far." *Staff Working Paper No. 264*, Bank of England.
- Hohberger, S., Priftis, R., & Vogel, L. (2019). The macroeconomic effects of quantitative easing in the Euro area: Evidence from an estimated DSGE model. *Journal of Economic Dynamics and Control*, 108, 103756.

- Joyce, M., M. Tong, & R. Woods (2011): "The United Kingdom's quantitative easing policy: design, operation and impact." Quarterly Bulletin 2011 Q3, Bank of England.
- Kapetanios, G., H. Mumtaz, I. Stevens, & K. Theodoridis (2012): "Assessing the economy-wide effects of quantitative easing." *Working Paper No. 443*, Bank of England.
- Lyonnet, V. & R. Werner (2012): "Lessons from the Bank of England on 'quantitative easing' and other 'unconventional' monetary policies." *International Review of Financial Analysis* **25**: pp. 94-105.
- Masoud, S., Bein, M. A., & Khalifa, W. (2020). Examining the relationship between unconventional monetary policy and exchange rate movements: Empirical evidence from United States quantitative easing. *International Journal of Finance & Economics*.
- Marquardt, D. W., & Snee, R. D. (1975). Ridge regression in practice. *The American Statistician*, 29(1), 3-20.
- Marquardt, D. W. (1980). Comment: You should standardize the predictor variables in your regression models. *Journal of the American Statistical Association*, 75(369), 87-91.
- Mortimer-Lee, P. (2012). The effects and risks of quantitative easing. *Journal of Risk Management in Financial Institutions*, 5(4), 372-389.
- Rebucci, A., Hartley, J. S., & Jiménez, D. (2022). An event study of COVID-19 central bank quantitative easing in advanced and emerging economies. In *Essays in Honor of M. Hashem Pesaran: Prediction and Macro Modeling*. Emerald Publishing Limited.

- Pesaran, **H.** & R. Smith (2012): “Counterfactual Analysis in Macroeconometrics: An Empirical Investigation into the Effects of Quantitative Easing.” *Working Paper Series*, The Rimini Centre for Economic Analysis.
- Qiao, H. (2007). Exchange rates and trade balances under the dollar standard. *Journal of Policy Modeling*, 29(5), 765-782.
- Sengupta, P., & Puri, R. (2020). Exploration of relationship between FDI and GDP: A comparison between India and its neighbouring countries. *Global Business Review*, 21(2), 473-489.
- SIKLOS, P. L., Christophe, B. L. O. T., CREEL, J., HUBERT, P., BONATTI, L., FRACASSO, A., ... & MESSORI, M. (2020). The ECB's Asset Purchase Programmes: Experience and Future Perspectives.
- Williams, J. C. (2013): “A defense of moderation in monetary policy.” *Journal of Macroeconomics* (38): pp. 137-150.
- Zúñiga-González, C. A. (2009). The Impact of the financial and Economic Crisis on Central America: An Expenditure GDP approach (No. 138-2016-2039).

Appendix A

GDP (current US\$)

Imports of goods and services (% of GDP), Exports of goods and services (% of GDP), Adolescent fertility rate (births per 1,000 women ages 15-19), Agriculture, forestry, and fishing, value added (% of GDP), Fertility rate, total (births per woman), Foreign direct investment, net inflows (BoP, current US\$), Industry (including construction), value added (% of GDP), Inflation, GDP deflator (annual %), Life expectancy at birth, total (years), Merchandise trade (% of GDP), Mortality rate, under-5 (per 1,000 live births), Population density (people per sq. km of land area), Population, total, School enrollment, primary (% gross), Surface area (sq. km), Urban population growth (annual %)

GDP growth

Industry (including construction), Life expectancy at birth, total (years), Inflation, GDP deflator (annual %)

Gross capital formation (% of GDP)

Industry (including construction), value added (% of GDP), Adolescent fertility rate (births per 1,000 women ages 15-19), Inflation, GDP deflator (annual %), Merchandise trade (% of GDP), Agriculture, forestry, and fishing, value added (% of GDP), School enrollment, primary (% gross)

Foreign direct investment

net inflows (BoP, current US\$), Adolescent fertility rate (births per 1,000 women ages 15-19), Agriculture, forestry, and fishing, value added (% of GDP), Exports of goods and services (% of GDP), Fertility rate, total (births per woman), GDP (current US\$), GDP growth (annual %), Imports of goods and services (% of GDP), Industry (including construction), value added (% of GDP), Inflation, GDP deflator (annual %), Life expectancy at birth, total (years), Merchandise trade (% of GDP), Mortality rate, under-5 (per 1,000 live births), Population density (people per sq. km of land area), Population, total, School enrollment, primary (% gross), Surface area (sq. km), Urban population growth (annual %)

Exports of goods and services (% of GDP)

Industry (including construction), value added (% of GDP), Adolescent fertility rate (births per 1,000 women ages 15-19), Inflation, GDP deflator (annual %), Surface area (sq. km), Merchandise trade (% of GDP), Life expectancy at birth, total (years), School enrollment, primary (% gross)

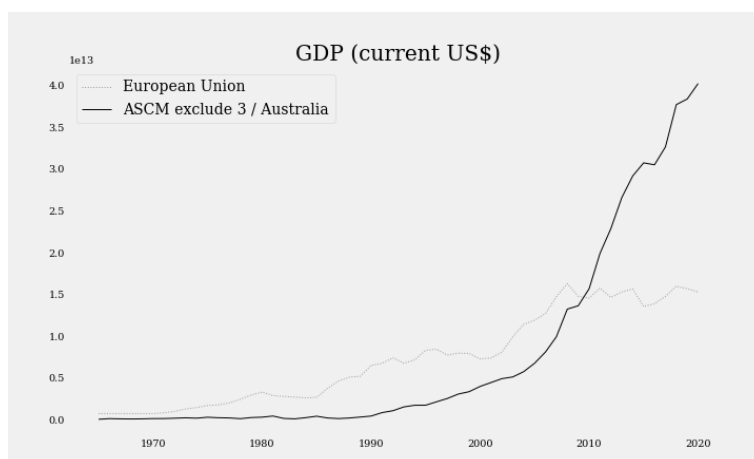
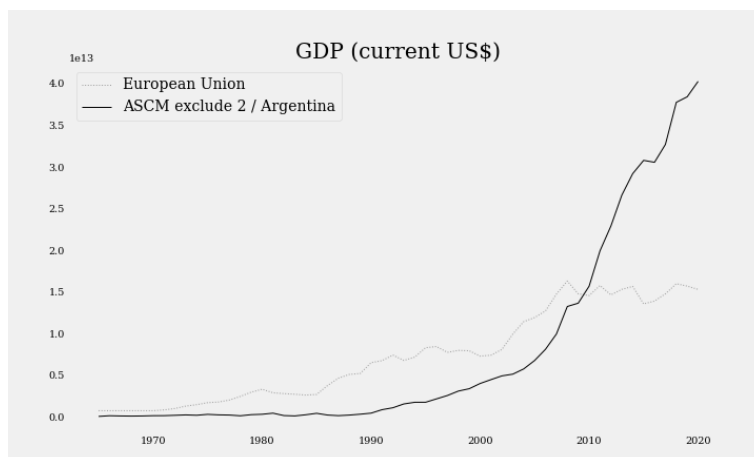
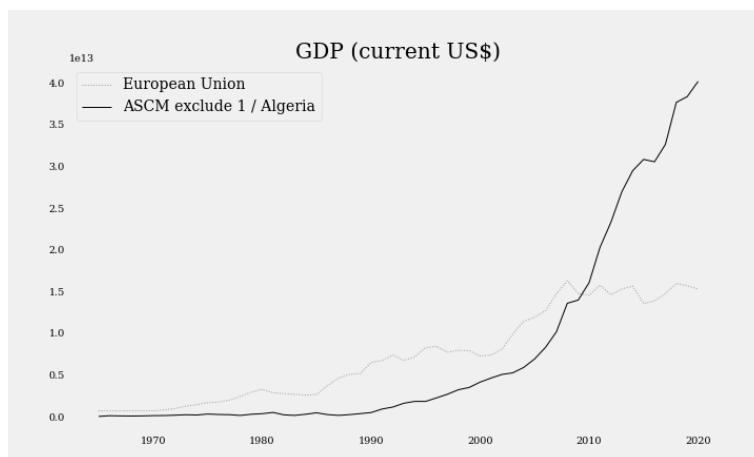
Imports of goods and services (% of GDP)

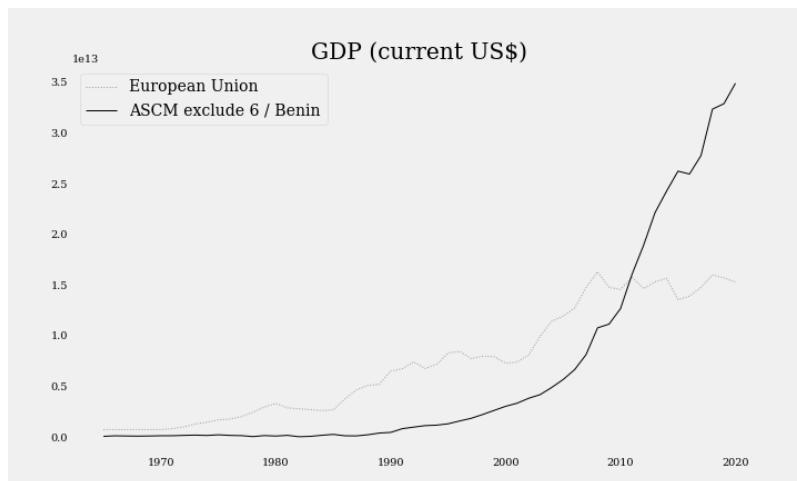
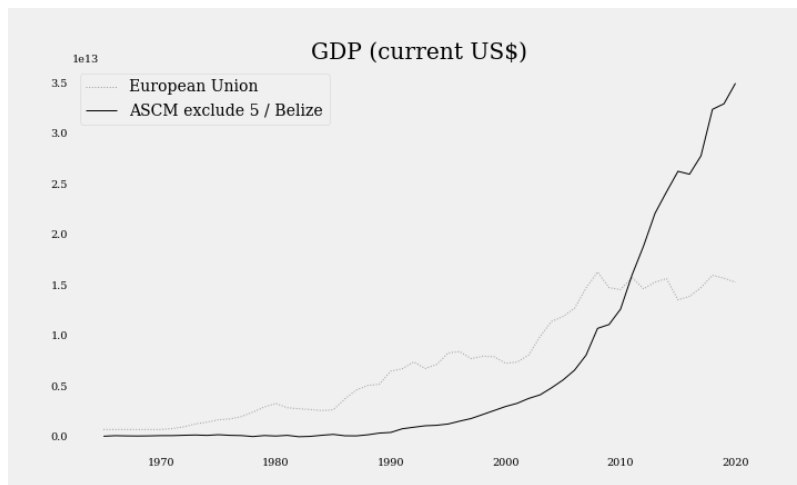
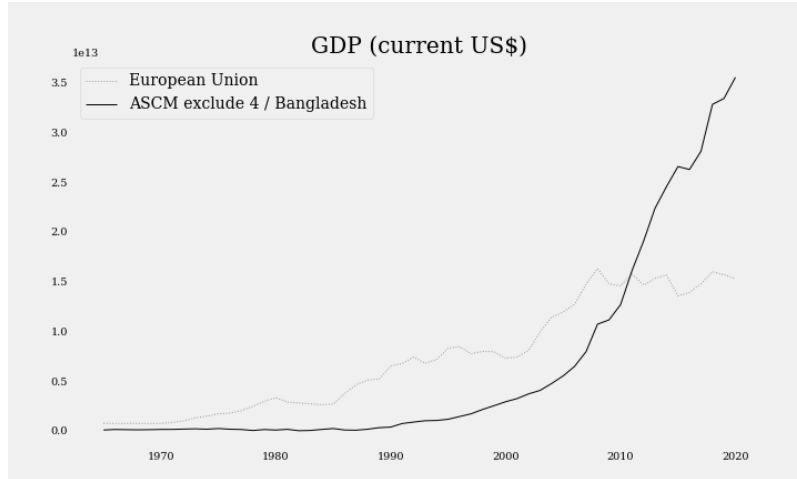
Industry (including construction), value added (% of GDP), Adolescent fertility rate (births per 1,000 women ages 15-19), Inflation, GDP deflator (annual %), Surface area (sq. km), Merchandise trade (% of GDP), Life expectancy at birth, total (years), School enrollment, primary (% gross)

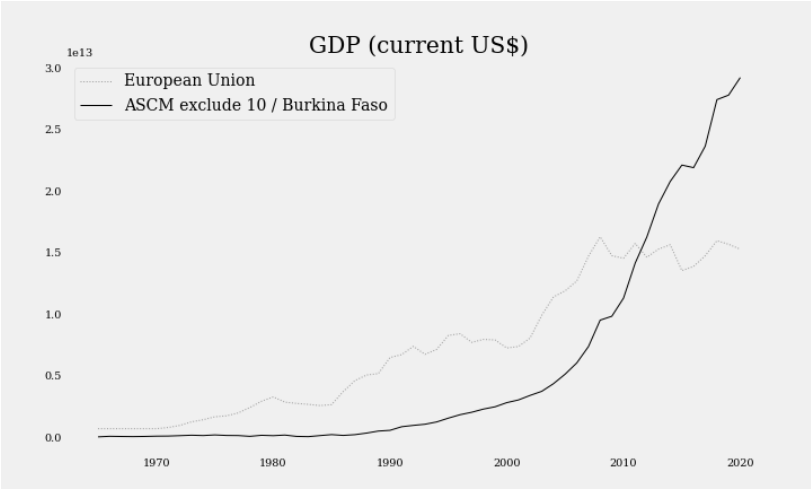
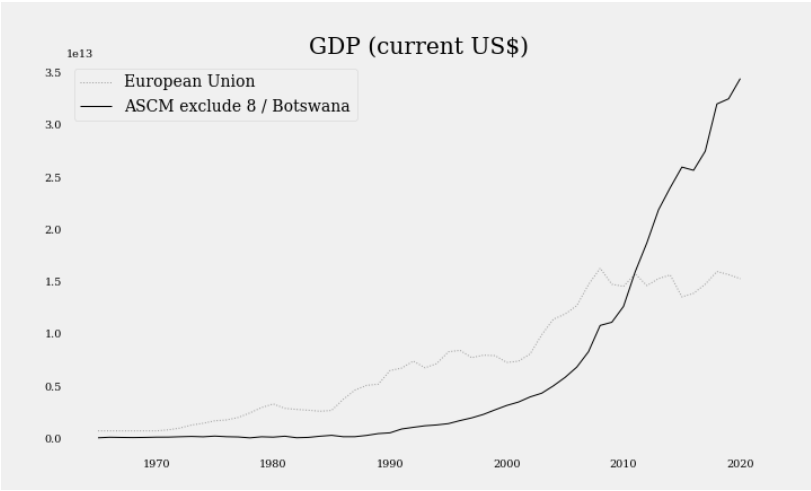
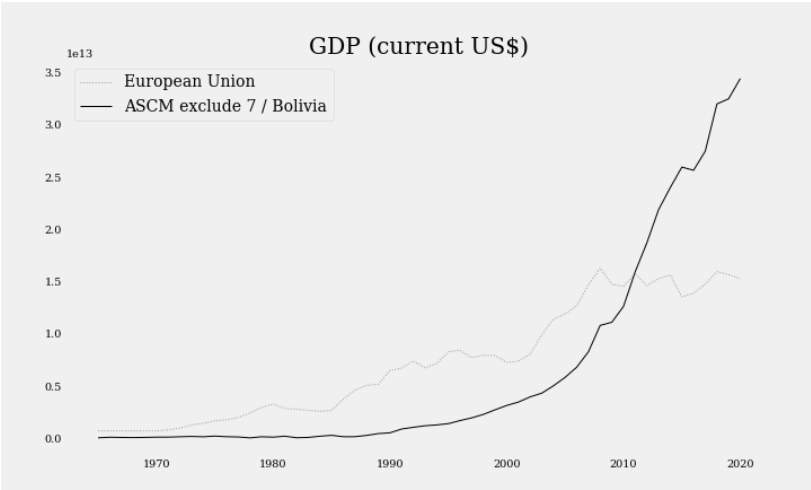
Indicator Name	Source	Observation
Adolescent fertility rate (births per 1,000 women ages 15-19)	United Nations Population Division, World Population Prospects.	4818
Exports of goods and services (% of GDP)	World Bank national accounts data, and OECD National Accounts data files.	4515
Fertility rate, total (births per woman)	(1) United Nations Population Division. World Population Prospects: 2019 Revision. (2) Census reports and other statistical publications from national statistical offices, (3) EUrostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Reprot (various years), (5) U.S. Census Bureau: International Database, and (6) Secretariat of the Pacific Community: Statistics and Demography Programme.	4818
Foreign direct investment, net inflows (BoP, current US\$)	International Monetary Fund, Balance of Payments database, supplemented by data from the United Nations Conference on Trade and Development and official national sources.	3970
GDP (current US\$)	World Bank national accounts data, and OECD National Accounts data files.	4729
GDP growth (annual %)	World Bank national accounts data, and OECD National Accounts data files.	4603
Gross capital formation (% of GDP)	World Bank national accounts data, and OECD National Accounts data files.	4362
Imports of goods and services (% of GDP)	World Bank national accounts data, and OECD National Accounts data files.	4515
Industry (including construction), value added (% of GDP)	World Bank national accounts data, and OECD National Accounts data files.	4233
Inflation, GDP deflator (annual %)	World Bank national accounts data, and OECD National Accounts data files.	4607
Life expectancy at birth, total (years)	United Nations Population Division. World Population Prospects: 2019 Revision, or derived from male and female life expectancy at birth from sources such as: Census reports and other statistical publications from national statistical offices, EUrostat: Demographic Statistics, United Nations Statistical Division. Population and Vital Statistics Report (various years), U.S. Census Bureau: International Database, and Secretariat of the Pacific Community: Statistics and Demography Programme.	4818
Merchandise trade (% of GDP)	World Trade Organization, and World Bank GDP estimates.	4727
Mortality rate, under-5 (per 1,000 live births)	Estimates developed by the UN Inter-agency Group for Child Mortality Estimation (UNICEF, WHO, World Bank, UN DESA Population Division) at www.childmortality.org .	4682
Population density (people per sq. km of land area)	Food and Agriculture Organization and World Bank population estimates.	4739
Population growth (annual %)	Derived from total population. Population source: (1) United Nations Population Division. World Population Prospects: 2019 Revision, (2) Census reports and other statistical publications from national statistical offices, (3) EUrostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Reprot (various years), (5) U.S. Census Bureau: International Database, (6) Secretariat of the Pacific Community: Statistics and Demography Programme.	4738
School enrollment, primary (% gross)	UNESCO Institute for Statistics (http://uis.unesco.org/). Data as of September 2021.	3476
Surface area (sq. km)	Food and Agriculture Organization, electronic files and web site.	4532

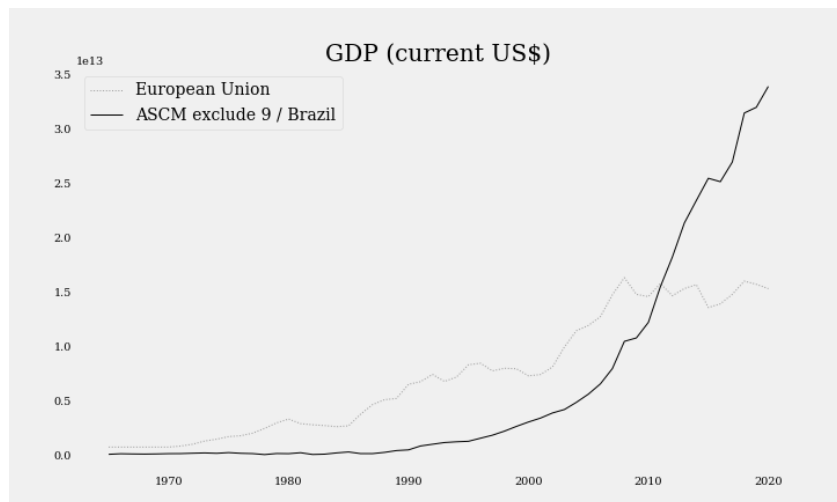
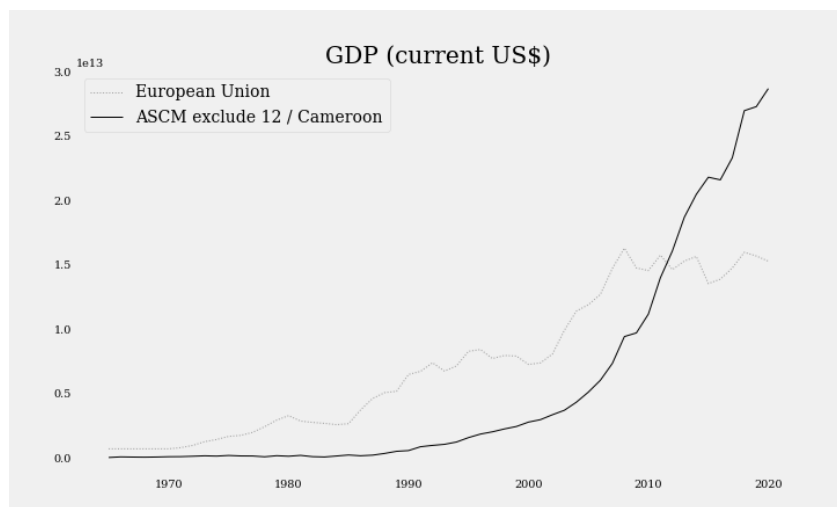
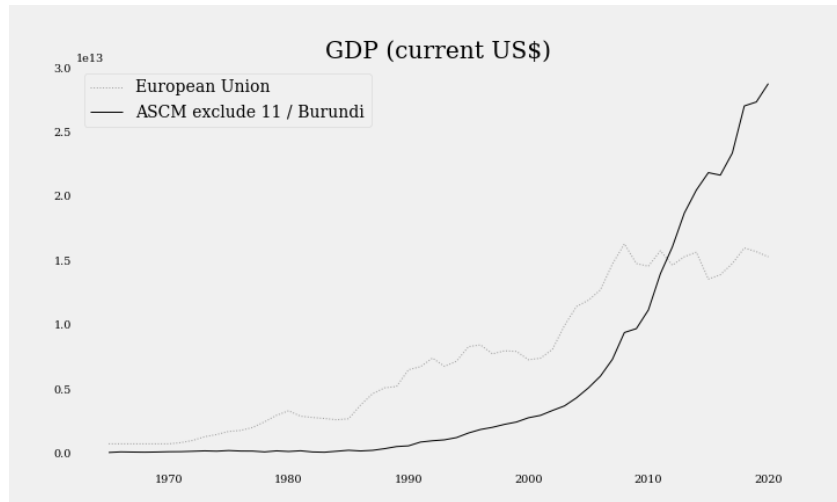
Appendix B

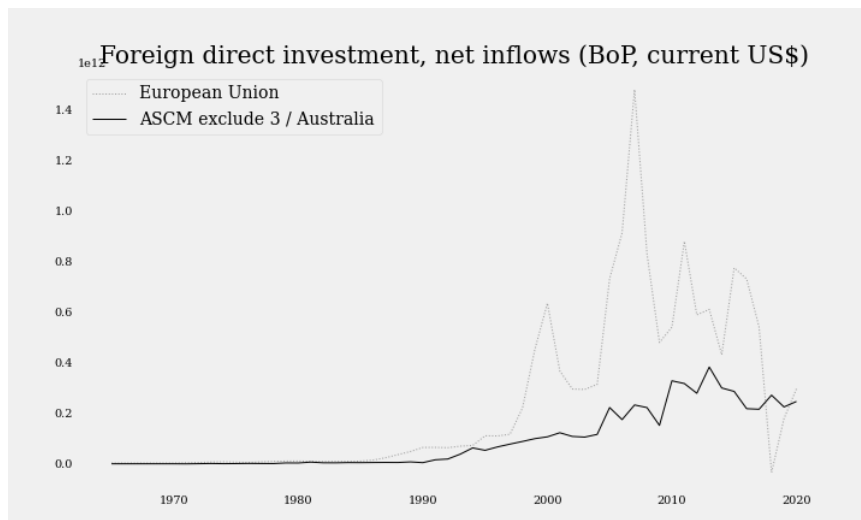
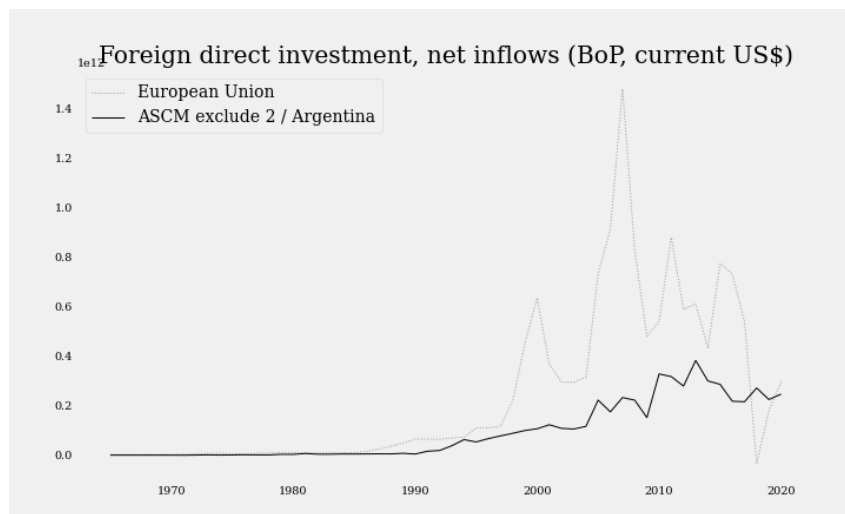
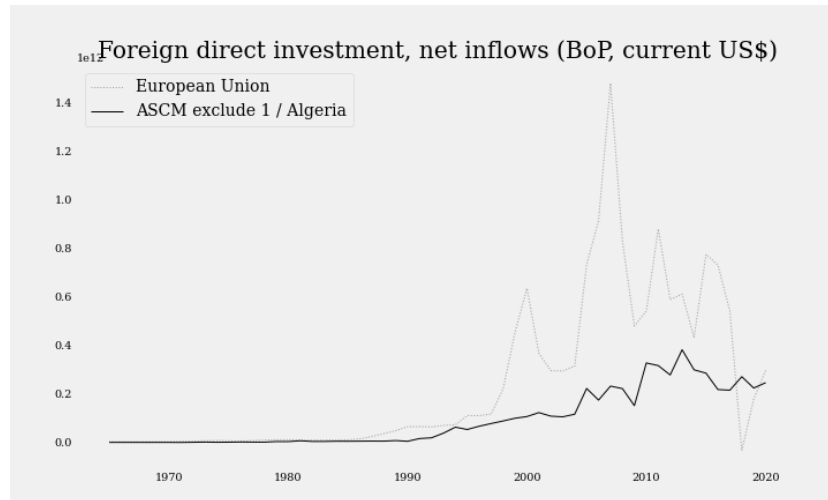
Note: The scale of GDP on y-axis is 10 trillion dollars, and that of FDI on y-axis is a trillion dollars

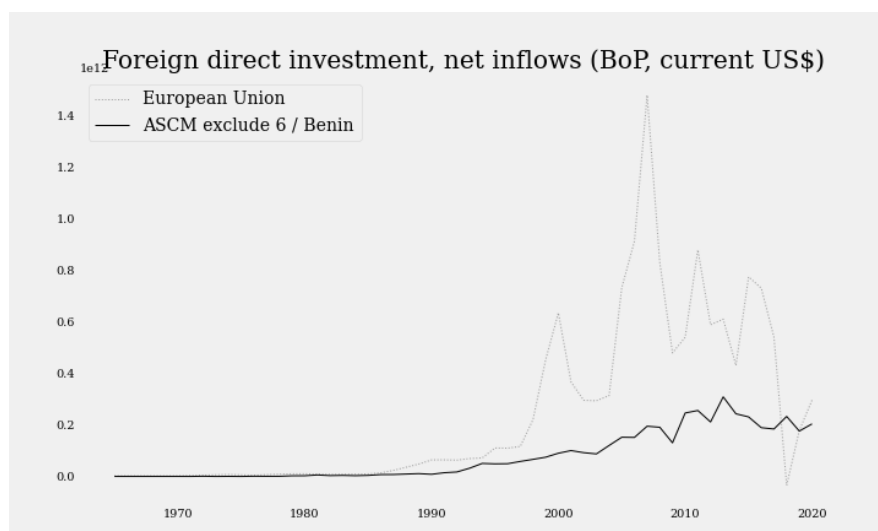
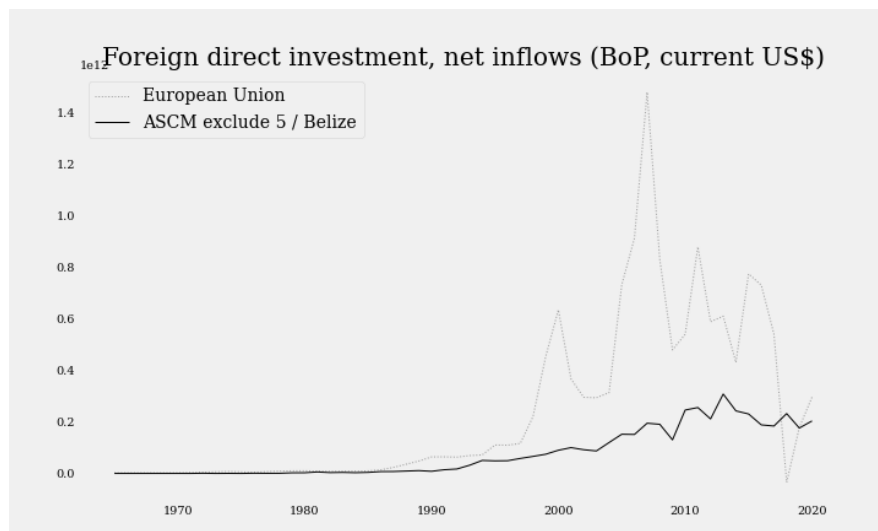
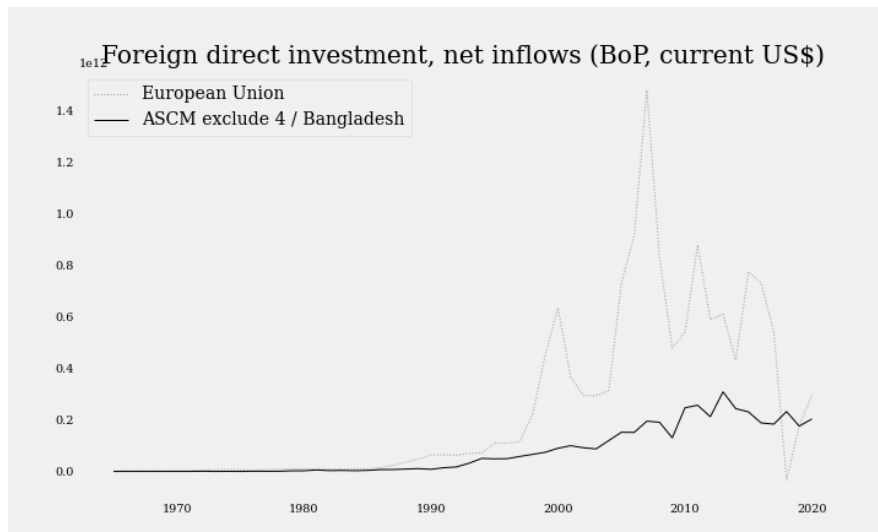


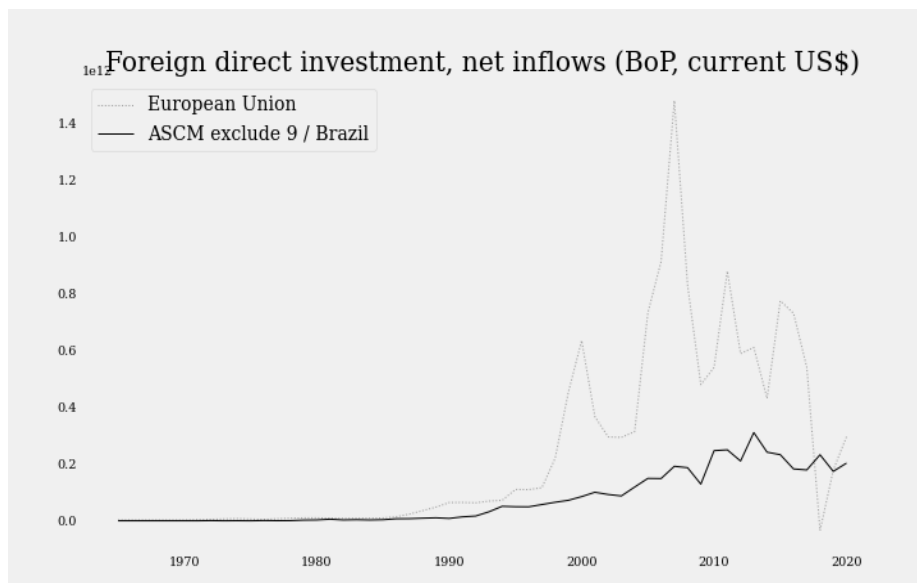
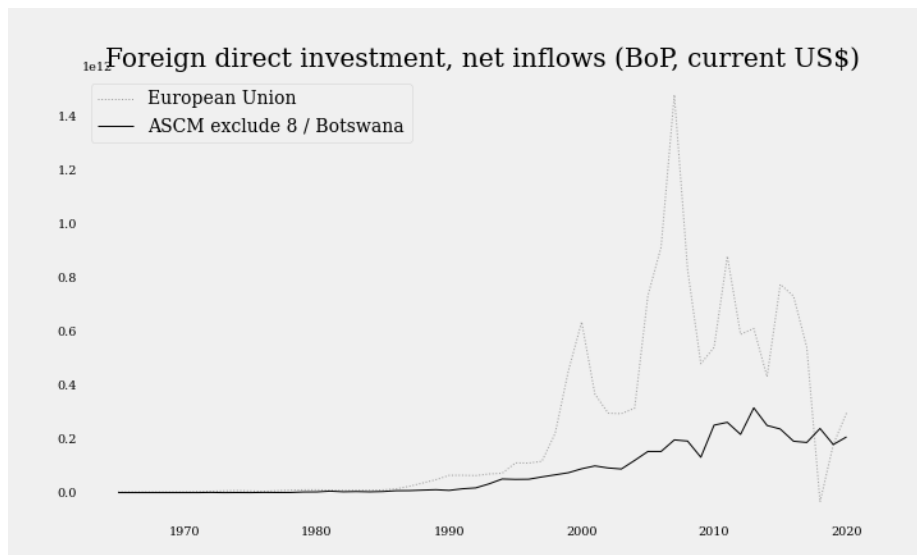
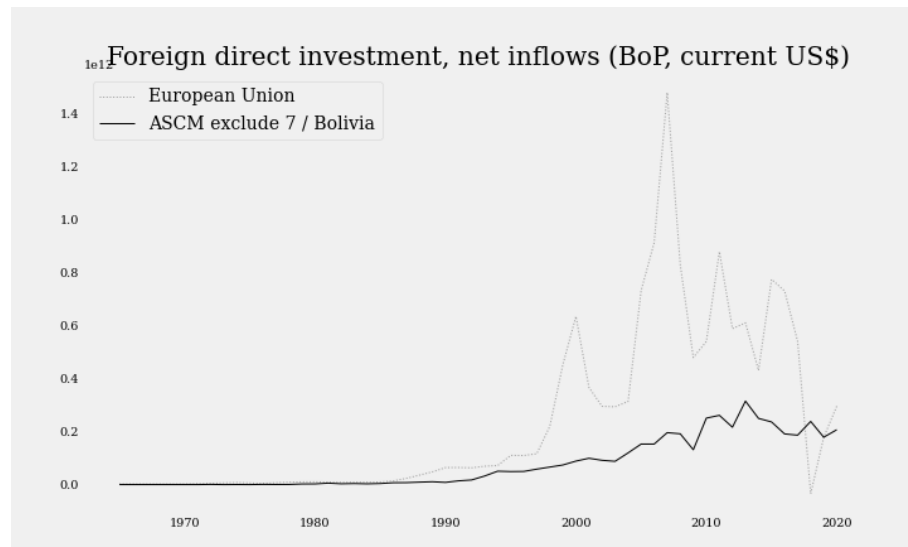




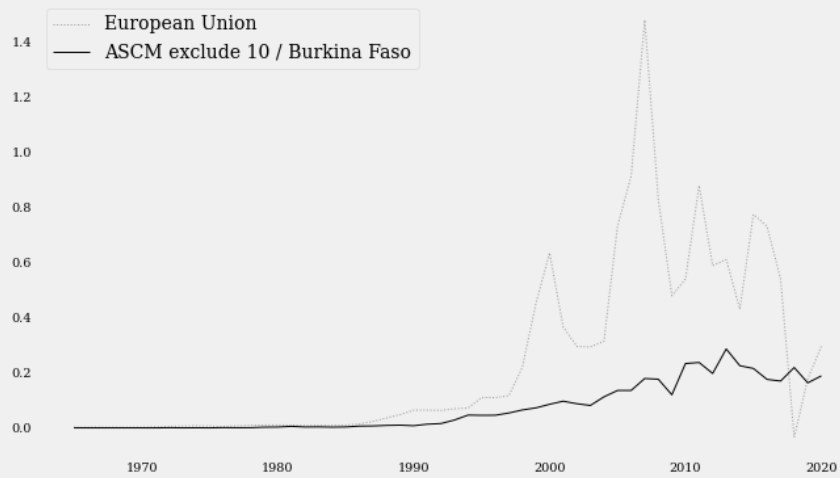








Foreign direct investment, net inflows (BoP, current US\$)



Foreign direct investment, net inflows (BoP, current US\$)

