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Vliv zahraničního obchodu na predikční schopnosti Phillipsovy křivky

Bakalářská práce

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Anotace

Cílem této práce je prozkoumat vliv zahraničního obchodu na predikční schopnosti Phillipsovy křivky. Nejdříve pomocí rešerše literatury prozkoumám, jaké názory zastávají různí ekonomové. Následně pomocí ekonometrických metod sestojím vlastní model založený na už existující práci. Skrze základní ukazatele následně porovnáím různé specifikace modelů, které obsahují mimo jiné proměnné pro mezinárodní obchod. Výsledky mé práce mě vedou k závěru, že význam domácích proměnných sice klesá, avšak ne nutně ve prospěch zahraničních vlivů.

Abstract

The goal of this thesis is to investigate the influence of international trade on the prediction ability of the Phillips curve. First, I will research recent literature and find out what opinions other economists have about the topic. Next, with the help of econometric methods, I will construct my own model based on an already existing one. Using basic indicators, I will compare different model specifications that include, among other variables, a variable for international trade. My findings lead me to a conclusion that the importance of domestic factors is gradually declining but not necessarily in favour of foreign factors.

Čestné prohlášení

Prohlašuji, že jsem bakalářskou práci na téma Vliv zahraničního obchodu na predikční schopnosti Phillipsovy křivky vypracoval samostatně pod vedením Mgr. Jakuba Chalmovianského a uvedl v ní všechny použité literární a jiné odborné zdroje v souladu s právními předpisy, vnitřními předpisy Masarykovy univerzity a vnitřními akty řízení Masarykovy univerzity a Ekonomicko-správní fakulty MU.

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List of abbreviations

CPI	– consumer price index
DOM	– domestic
IM	– import
IMEX	– import and export
MSPE	– mean squared prediction error
NAIRU	– Non-accelerating inflation rate of unemployment
NKPC	– New Keynesian Phillips curve
OLS	– ordinary least squares
WGDP	– world gross domestic product

1 Introduction

The Phillips curve is a very common and widely used tool of policymakers across the world ever since A. W. Phillips published his paper (1958), in which he introduced the concept. It helps them to predict inflation so they can adjust monetary and other economic policies accordingly. Although it is so popular, the whole concept went through a breakdown in the last century. This divided economists into two groups, those who support the status quo of the country-centric Phillips curve, such as Lawrence Ball or Nicola Zaniboni for example, and those who call for an augmentation using variables that would represent global factors and make the Phillips curve more globe-centric, Claudio Borio and Andrew Filardo or Serkan Cicek among others.

The goal of my thesis is to answer the question of whether international trade does have any influence on the prediction ability of the Phillips curve, mainly the short-run prediction of future inflation. To help me reach the answer I will use basic econometric methods applied to my models that are based on previous researches.

The thesis itself has the following structure. In the first chapter, I shortly discuss the history of the Phillips curve and its alleged breakdown. Then I follow up by introducing recent literature that investigates how modified models, based on the conceptual work of the original Phillips curve, perform compared to simple benchmark models and if globalisation and economic openness does influence this performance. In the second chapter, I will begin the practical part of my research using real data of the chosen economy, the United States of America. I will theoretically describe the models, variables and data used in the thesis. Finally, in the third chapter, I will try to forecast domestic inflation, compare my

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results to other researches and discuss the possible differences between them and what might cause these disparities.

2 Recent Literature

In the first chapter of my thesis, I will briefly describe the history of the Phillips curve and the breakdown that happened in the late 20th century. Next, I will summarise chosen studies that focus on the same topic, whether or not domestic inflation is affected by external pressures coming from the openness of an economy. Among these researches is also the paper of Borio and Filardo (2007) which has a crucial role in the practical part of my thesis as I used their framework as a cornerstone for my models.

2.1 The Phillips Curve

In 1958 A. W. Phillips wrote a thesis in which he noticed that there exists a correlation between unemployment and the rate of change of money wage rates (Phillips, 1958). He investigated this using data from the United Kingdom from 1861 until 1957. He assumed that a similar mechanism that works in the market of goods and services should work in the labour market as well. That is when demand rises relatively to the supply, the price should rise too and vice versa, simply put. He stated that the rate of change of money wages is influenced by a few factors, among which are also import prices, though he considers them to have any relevant effect only when they change suddenly and greatly. But even in the earliest days of the Phillips curve, international trade already had a role. He concluded that the rate of change of money wage rates can be explained by the level of unemployment and the rate of change of unemployment, except for periods with a rapid rise of import prices that would cause a wage-price spiral. This thesis became a cornerstone for many

policymakers as it helped them better understand the trade-off between inflation and unemployment so they could effectively set their economic policies, but it also faced some criticism such as lack of theoretical and structural basis. The problem being that while Phillips correctly assumed some form of correlation between unemployment and inflation, he did not hold other factors accountable, such as the underlying structural behaviour of economic agents and changes in monetary policies as Fuhrer pointed out in his work (1995). Unfortunately, Fuhrer was unable to find any evidence that the Phillips curve was not structural.

Sometime in the late 1960s, the Phillips curve began to be outperformed by simpler models and in the 1980s was deemed as not functional and not up-to-date. 1970s were very turbulent times, economic-wise. During this period, the US economy experienced stagflation, raise in both unemployment and inflation at the same time, something that goes against the fundamental trade-off between these two variables that is essential to the Phillips curve as well as something that the Keynesian school was unable to explain. To help them, economists created a so-called New Keynesian Phillips curve (NKPC) that, unlike the original curve, which was backward-looking, tried to relate the inflation process to rational future inflation expectations and proxies for real economic activity, such as the output gap. (Abbas et al., 2016).

In the 1990s inflation dynamics changed completely and instead of underestimating inflation's rate of growth, like in the previous decades, forecasting models started to overestimate it. This might be due to a more effective monetary policymaking that was more focused on targeting inflation or it could be also due to bigger global market integration. These two explanations are likely to be complementary to each other and might not be the only viable ones (Borio, Filardo, 2007). In the following

sections, I will more closely introduce both approaches and summarise findings of relevant literature, beginning with the country-centric approach.

2.2 The Country-centric Approach

In this part, I will introduce the literature that finds little to no evidence in support of using any variables for global influence as the main determinant of domestic inflation. All the advocates of the country-centric approach mostly argue that domestic inflation is determined from within through the country's monetary policy rather than influenced by global factors. They consider any foreign influences to be more corroborative than deterministic. In their opinion, inflation dynamics has gone through a breakdown, in the last century, that weakened the link between domestic factors and inflation. Although this breakdown flattened the Phillips curve, these changes cannot be attributed solely to the increasing integration of global markets and thus globalisation cannot be the correct way to resurrect the Phillips curve. In their eyes, foreign factors have mostly limited effect on domestic inflation (Kohl, 2006) and are often statistically insignificant (Ihring et al., 2010).

2.2.1 Ball (2006)

In his paper, Ball (2006) tries to determine the relationship between domestic inflation and domestic and foreign output gap. In Ball's opinion, the US economy is not a standard open economy per se because of the low total international trade to gross domestic product ratio. However, in terms of financial openness, the US economy is very globalised as its

financial integration with other countries has grown substantially since the 1990s.

First, Ball pooled annual data for 14 industrialized countries and then regressed the change in inflation on the domestic output gap, the foreign gap, and both gaps. Results of this regression show that adding the foreign slack improves the models adjusted coefficient of determination only by 0.01. The domestic output gap is highly statistically significant while foreign slack is barely significant, both have positive signs. These findings contradict the hypothesis suggesting the importance of global factors.

Instead, he offers his own two explanations for a flatter Phillips curve. The first argues that it is the lower trend inflation that is responsible. It reduced the frequency of nominal price adjustments which in return flattens the Phillips curve in sticky-price models. The other one says that the rising credibility of central banks across the world anchored inflation expectations and that dampened any movements in actual inflation.

Unlike the globalisation hypothesis, these have a theoretical basis. In the last two decades, both trend inflation and the central bank credibility have seen big changes, unlike the international trade that has changed only modestly, mostly gradually. The theory that imports would lower domestic prices, and thus inflation, is wrong in his opinion. Imports only change relative prices and inflation is affected by nominal prices, not relative. Only a sharp change in relative prices, such as oil shock, could impact domestic inflation. In his eyes, inflation is still mainly determined by domestic factors, most notably by monetary policy, and international trade has little to no effect at all.

2.2.2 Zaniboni (2011)

In his work, Zaniboni (2011) tries to answer two questions: whether globalisation has any effect on the long-run inflation or at least changes its short-run dynamics. He applies an NKPC to an analytical framework of two open-economy countries with sticky prices and relates domestic inflation to future inflation expectations, domestic and global gap and shocks. All variables also depend on an openness parameter that is defined as a change in the total trade to gross domestic product ratio.

His results are in direct contrast to Rogoff (2003). While Rogoff says that globalisation creates a steeper Phillips curve, Zaniboni's results show that the curve is flatter. Rogoff explains that international trade affects domestic inflation through more flexible prices. Zaniboni, on the other hand, suggests lower marginal costs' sensitivity to the domestic output to be responsible for a flatter curve.

In Zaniboni's opinion, based on his findings, globalisation does affect domestic inflation, but only at a very modest level. Domestic factors should still be considered to be the main determinant.

2.2.3 Kohl (2006)

At the very start of his research, Kohl (2006) admits that there is no clear consensus on globalisations role in inflation prediction. His goal is to add to the discussion and clarify some things. The 1990s were a significant period for international trade, countries of eastern Europe started to be more integrated while countries such as China and India emerged as important players on the global market.

Unlike other authors, he uses core inflation as the dependent variable. In the model, it is related to resource utilization, lagged inflation, changes in relative prices of food and energy, and changes in relative

import prices. He works with two channels, through which foreign factors might affect domestic inflation: changes in relative import prices and the increased demand due to global markets.

His results suggest that changes in relative import prices create some downward pressure on core domestic inflation, but since 2004 import prices have risen at approximately the same pace as core inflation, which diminishes their effect on domestic inflation. He points out that the decreasing pressure might also be caused by technological advancements and shifts in exchange rates, both of which have a substantial influence on prices.

Because of the greater demand, due to global markets, domestic producers are less able to raise prices. Rising profit margins of producers, however, suggest that this hypothesis is wrong. It might change the structure of inflation dynamics though, make inflation more sensitive to foreign demand rather than domestic. The coefficients for domestic factors (output gap, unemployment) are falling in time, which would support change in inflation dynamics. On the other hand, the coefficient for the global output gap seems to be very dependent on how the variable is defined, this fact alone implies a rather weak link to inflation.

Overall, his evidence underlines an existing effect of global integration of markets on domestic inflation dynamics. However, the magnitude of the effect is still unknown and seems to be gradual and limited.

2.2.4 Ihring et al. (2010)

In their work Ihring et al. (2010) investigate whether globalisation increased the role of international factors and at the same time decreased the role of domestic factors in the inflation process in industrial

economies. They define globalisation as an increase in the international integration of markets.

Their model puts CPI inflation on one side and lagged inflation, domestic and foreign output gap and supply shocks, including shocks in import prices, on the other. In their opinion, the inclusion of only import prices as a proxy for foreign effect is insufficient because it captures only goods and services that are actually imported into a country and not the goods and services that could be imported. They have the same reasoning as Borio and Filardo, saying that the mere threat of imported goods creates downward pressure on domestic prices (Borio, Filardo, 2007).

Regression results show that the foreign output gap coefficient is rather inconsistent, having different signs for each industrialised economy. They also tried a pooled cross-country regression in which domestic slack is always statistically significant and positive and the foreign gap is always insignificant and with a negative sign, suggesting its minimal role in defining domestic inflation. They also tested if inflation's sensitivity to domestic factors is declining and found this to be true.

Overall, their tests found very little evidence supporting the role of foreign factors in domestic inflation dynamics. Although inflation's sensitivity to the domestic gap has indeed been in decline in the past decades, there is no proof that it is due to globalisation.

2.3 The Globe-centric Approach

While authors in the previous section could not find any robust evidence that globalisation changes short-run inflation dynamics or even affects the long-run inflation, economists that are listed below have a different opinion.

The difference between the country- and globe-centric approaches is the way they look at foreign goods, the global-centric approach sees them as very close substitutes while the country-centric approach as imperfect substitutes. The globe-centric approach also implies that due to the mobility of labour, domestic wages and prices rely on supply conditions elsewhere (Borio, Filardo 2007). Almost all of the authors also agree that import prices do not sufficiently represent the global influence as they are missing important channels such as export or the effect of potentially imported goods and services. They believe that adding more elaborate variables representing the foreign effect greatly improves the forecasting ability of the Phillips curve and that these variables are gaining a more prominent role as inflation's sensitivity to domestic factors is in a steady decline.

2.3.1 Gamber, Hung (2001)

Gamber and Hung (2001) work with two hypotheses in their paper: the competing-goods effect and the foreign-slack hypothesis. The first one suggests that stronger competition forces domestic producers not to raise prices, similar to Kohl (2006), the second one says that due to international trade, domestic producers can produce more and not trigger any inflationary pressures because they use excess demand of foreign markets. They claim that globalisation will increase US inflation if foreign growth is relatively stronger but dampen US inflation if foreign growth is relatively weaker, suggesting that it is also important where these pressures are coming from and what the economic situation in the home economy is.

They test these two hypotheses on the US economy with data from the 1980s until the 1990s. Using the OLS regression, they estimated that

a positive correlation between domestic and import prices exists, supporting the competing-goods theory. In another model, they concluded that adding foreign capacity utilization makes the missing inflation, difference between actual and predicted inflation, almost disappear. Their findings suggest that the increasing globalisation and market integration changes the US inflation dynamics which allows the United States to expand without any additional inflation.

Although foreign factors became more important in predicting inflation, it does not mean that domestic pressures would be irrelevant, their influence is just dampened.

2.3.2 Borio, Filardo (2007)

In their paper, Borio and Filardo (2007) take a closer look at why policy-makers nowadays tend to overestimate inflation using current prediction methods. They consider current forecasting models to be too country-centric and propose an upgrade using a model that better reflects global connectedness.

Current forecasting models consider international factors to be exogenous and sums them up using import prices as a proxy variable, but this might not be enough. Just like Ihring et al. (2010), they argue that import prices only include imported goods and services, but the mere threat of potential import has an effect on domestic prices. Another problem that derives from using import prices as a proxy is, that it omits any effect from the export side of the trade.

As always, the real world lies somewhere between the two approaches, leaning more towards the country-centric approach in the last century. But using the so-called Scandinavian approach where the home country is a small open economy, it can be concluded that domestic

inflation is directly influenced by import. Because the home economy is unable to create any relevant pressure on the global prices, the approach suggests that under fixed exchange rate and perfect mobility of capital, it would be the foreign prices that would determine tradable prices via purchasing power parity. This approach, however, cannot be applied to the US as it is the exact opposite, a large and relatively less open economy. In smaller economies, the approach has varying degrees of success.

Models used and their findings will be discussed in greater detail in chapter 3 of this thesis, as this study is the framework of my practical part. To test the assumption that globalisation led to a lower sensitivity of inflation to domestic factors, they use an extended Phillips curve with a variable representing global slack as a weighted sum of domestic output gaps for the ten biggest trade partners. Other variables such as import and oil prices are also included. Models are used with data from both emerging and industrial markets from 1985-2005. Simply put, in their paper, inflation depends on the domestic and global output gap and other proxies (unit labour cost, oil prices, etc.) in the globe-centric approach and for the country-centric approach, they omit the global slack variable. They choose not to use lagged inflation, typical for the backward-looking Phillips curve, as it might obscure the effect of both slacks.

As I mentioned above, detailed results of their study are in chapter three of this thesis. They found that inflation's sensitivity to the domestic output gap is declining over time and on the other hand sensitivity to global slack is rising. For almost all countries the variable of global slack reduced the statistical significance of the domestic gap and domestic inflation seemed to be more positively correlated to the global output gap. This is consistent with their hypothesis of the growing importance of global factors in inflation dynamics. Proxy variables tend to improve the

performance of the forecast but do not knock out any statistical significance from the slacks. After their findings, they also implemented two other global variables, global unit labour cost gap and global wholesale price gap, to the globe-centric model to investigate whether other global factors could be taken into account. The labour cost gap turned out to be statistically insignificant, the wholesale price gap, however, proved to be a good complementary variable as it is statistically significant and doesn't reduce the statistical power from the output gaps.

Overall, their study proved that inflation dynamics changed over the years and are now more correlated with global factors. They point out that results are not robust and further research is necessary, but the study still shows that the Phillips curve needs to be augmented in one way or another.

Milani (2009) tries to replicate their work using an augmented model. It is an NKPC open-economy model that relates inflation to expectations of future inflation, domestic output gap and the global slack. Although he changed the original model a bit and simplified the global slack variable, his results still show a declining sensitivity of inflation to the domestic output gap. He also correctly notes that the foreign output gap can hardly be an exogenous variable for the USA because the American economy is often considered to be the driver of the global economy and thus influences the rest of the world.

2.3.3 Cicek (2012)

Unlike other authors, who either used a set of countries or the US for their model, Cicek (2012) explores globalisation's influence on the Turkish economy. Before 2002 inflation and output volatility in Turkey was high, but since then the volatility of inflation has lowered while output's

volatility remained relatively the same. This might be caused by a weakened link between the two. Economic openness, measured as a total trade to GDP ratio, increased from 12.5% in 1980 to 53.3% in 2007, Turkey became more globalised. In his paper, he investigates whether the use of foreign output capacity affects domestic inflation and whether inflation's sensitivity to domestic factors decreased.

To test these two hypotheses, he uses a forward-looking extended Phillips curve that relates current detrended inflation to inflation expectations, lagged inflation, current domestic output, lagged difference between the foreign and domestic output gap, change in the nominal exchange rate and dummy variables with data from 1987 to 2007. Both gaps are significant and have a positive sign, as he expected. When he changed the dependent variable to CPI inflation of tradable goods, the coefficient for foreign output gap rose, as it should. To test if the inflation's sensitivity to domestic influences fell, he used a time-varying process and the results showed that indeed the relationship between domestic inflation and the domestic output gap is now weaker.

All his findings suggest that both domestic and foreign factors are necessary to determine domestic inflation, but the domestic influence is falling as the economy is becoming more integrated into the global market.

2.3.4 Forbes (2019)

In her paper, Forbes (2019), starts by saying that the Phillips curve is not 'dead' as some economists try to argue, it only needs an overhaul. The need for implementation of global factors into the framework dates to the 1970s and the oil shocks.

She claims that the domestic slack and import prices, variables widely used in traditional country-centric models, are not enough to capture the full power of global influence and do not account for all the channels through which foreign factors affect domestic inflation. Globally the trade to gross domestic product ratio has risen sharply since the 1990s. As the share of exports to a gross domestic product increases for a given economy, demand in global markets will likely have a greater impact on national income and price setting by domestic firms. Similarly, as the share of imports to a gross domestic product increases for a given economy, domestic inflation will be more affected by the prices of imported goods simply due to their higher share in the price basket – and these imported goods prices will at least partially be determined by foreign demand conditions, foreign markups, and foreign marginal costs.

Another big change, compared to the 1990s, is that emerging markets now account for almost two-thirds of the global gross domestic product and are a primary source of demand for commodities. As a result, commodity prices are more tightly linked with emerging markets, mainly with China. These two changes combined led to greater price competition and pressure on firm markups. Due to the high mobility of labour in a more globalised world, the bargaining power of workers decreases because it is easier to use global supply chains or replace workers with foreign labour. Because the workers cannot effectively bargain for higher wages, negative pressure is created on domestic inflation.

To investigate the magnitude of global effect on inflation she uses an extended Phillips curve that explains inflation through inflation expectations, lagged inflation, both domestic and global output gap, real exchange rate, oil and commodity price and global producer price dispersion. Her output gaps are calculated using seven different calculations of

slack such as unemployment deviation from NAIRU (Non-accelerating inflation rate of unemployment), production gap and participation gap.

Her findings show for a cross-section of countries, the basic Phillips curve seems to be intact. All variables were statistically significant and all with expected signs, output gaps, inflation expectations and lagged inflation all with positive signs. The significance of the global variables suggests that the inclusion of foreign factors is appropriate. The coefficient for the domestic output gap, however, is higher than the one for the global gap, meaning that domestic slack still has a bigger effect on inflation and the global variables occur supporting factors.

Although these findings support the inclusion of global factors, they vary from country to country, some are more prone to be affected by real exchange rates while some tend to be more sensitive to domestic factors.

2.4 Summary of Recent Findings

It is quite clear that opinions on foreign factor's role in inflation prediction mostly vary. While economists agree that inflation dynamics have gone through some changes in the past decades, they cannot agree on the cause. Some see the increasing credibility of central banks as the main reason, others try to link these changes to globalisation.

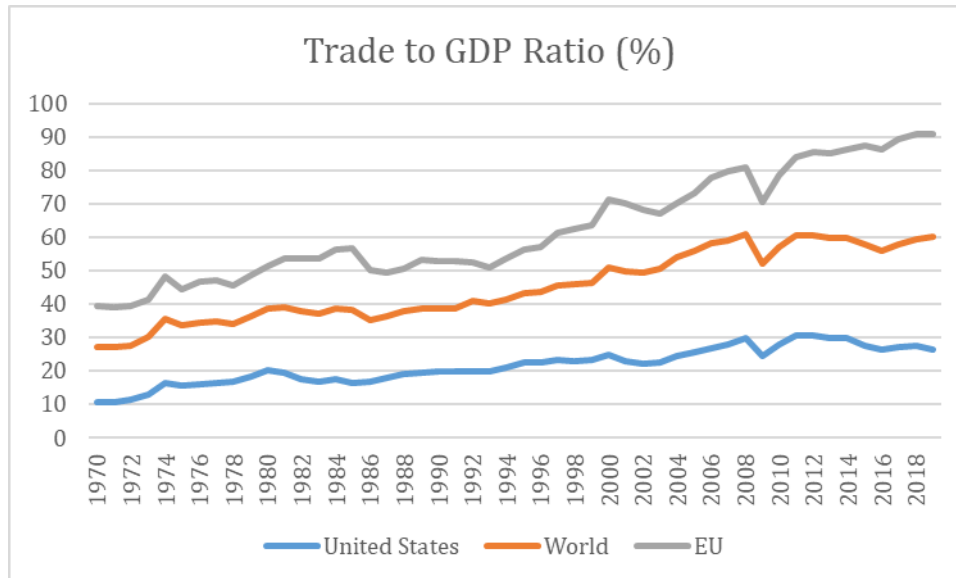
No robust evidence has been found yet in support of the globe-centric hypothesis, but that does not diminish their importance in inflation forecast. They proved to improve the forecasting ability of other models and because the inflation changes happened only recently, further research and more data are necessary.

3 Data and Model Specifications

In this chapter, I will thoroughly describe the data and variables used in this thesis, sources that I used to obtain them, and methods used to transform the raw data for the needs of my model. Next, I will introduce the different specifications of the model and detail the differences between them. Graphs for all the variables are in the appendix for better visualization (appendix A).

3.1 The Chosen Economy

I chose the United States of America to test the model mainly due to the fact of easily accessible data, rich databases and also because results can be easily compared to any recent literature. Their economy is considered to be one of the biggest in the world but rather closed. That is because of their very low international trade to gross domestic product ratio (Fig.1). Although the US is below the world average, it has the same rising trend as the rest of the world and is thus becoming more integrated with the global market. That is why it might make sense to investigate the global influence on its economy. Global factors enter the model through the GLOBAL_GAP variable, a sum of weighted domestic output gaps for the US six biggest trade partners (China, Japan, Germany, United Kingdom, Canada and Mexico), this variable will be further discussed in later sections. These six economies count for over 80% of the total trade going in and out of the United States. That should be enough to get at least a sense of whether international trade has any significant influence on domestic inflation.

Fig. 1: Trade to GDP Ratio (%)

Source: Own creation (WB, World development indicators)

3.2 Variables Used in the Model

This part of the chapter will introduce the variables that enter the model. All the transformations and calculations used to modify the data to meet the model requirements as well as sources used will be described in the upcoming part. Every variable used is in the form of a growth rate.

- INF – inflation, dependent variable, in my model defined as a difference between CPI inflation and underlying inflation (underlying inflation is described in section 2.4 of the thesis)
- OUTPUT_GAP – domestic output gap, difference between potential and real gross domestic product
- WTI_OIL – crude oil price, West Texas Intermediate, USD per barrel
- ULC – price index of unit labour cost, the average price of labour per one produced unit in the manufacturing sector

- IMP_g_s – price index of imports of goods and services
- GLOBAL_GAP – global output gap, difference between potential and real gross domestic product, calculated using domestic gaps of six biggest US trade partners representing the world, all three specifications will be discussed in the upcoming section
- EX_RATE – real broad effective exchange rate

3.3 Models

As mentioned before, I used a model developed by Borio and Filardo (2007) and modified it using a variable for the exchange rate as described in Ihring et al., 2010. The basic version of the model, with no variable for global influence, has the following form,

$$INF = \alpha + \beta_1 OUTPUT_GAP_{t-1} + \beta_2 X_{t-1} + \varepsilon_t \quad (1)$$

where X stands for the WTI_OIL, UCL and IMP_g_s variables.

Adding the GLOBAL_GAP variable will create three more model specifications based on the way of calculating the global gap, but generally, it will follow the formula (2).

$$INF = \alpha + \beta_1 OUTPUT_GAP_{t-1} + \beta_2 GLOBAL_GAP_{t-1} + \beta_3 X_{t-1} + \beta_4 EX_RATE_{t-1} + \varepsilon_t \quad (2)$$

3.4 Data Transformation

In this part, I will finally describe where I found my raw data, what methods I used to transform them to fit the model, and how I calculated the three different types of the GLOBAL_GAP variable. The final form of each variable is in the form of growth rate and was calculated using the formula $y = \frac{x_t - x_{t-1}}{x_{t-1}}$, unless specified otherwise. For the Hodrick-Prescott filter, I set the lambda value to 1600. Data for all the variables were in quarterly frequency except for data for the global gap weights, I used annual data to calculate them.

Data for both CPI inflation and underlying inflation were downloaded from the webpage of FRED (FRED¹). CPI inflation was found as an index with a base year of 2015, the data was then transformed into growth rate. I calculated the underlying inflation using the core inflation (index with a base year in 2012). I applied the Hodrick-Prescott filter on the growth rate and saved the smoothed series as the underlying inflation.

Data for the domestic output gap (FRED²) was downloaded as the real gross domestic product for the US in USD (base year 2012). I calculated the growth rate via logarithms and then using the Gretl software I applied the Hodrick-Prescott filter, the cyclical component is considered to represent the output gap.

Values for the WTI_OIL variable (FRED³) were obtained as USD per barrel of crude oil. First, I seasonally adjusted the data using the X-13ARIMA-SEATS and next calculated the growth rate. Data for both ULC

¹ CPALTT01USQ661S, PCEPILFE – reference codes

² GDPC1 – reference code

³ DCOILWTICO – reference code

and IMP_g_s (FRED⁴) were found as a seasonally adjusted price index (base year 2012). I transformed both into corresponding growth rates.

The GLOBAL_GAP variable was calculated the following way:

$GLOBAL_GAP_j^{Gi} = \sum_{k \in K} w_{j,k}^i Gap_k^D$, $G_i \in \{W_IMEX, W_IM, WGDP\}$, where Gap_k^D is the domestic gap of a trading partner and the weights are created using the following formulas:

$$w_k^{W_IMEX} = \frac{import_{j,k} + export_{j,k}}{total\ import_j\ and\ export_j} \quad (3)$$

$$w_k^{W_IM} = \frac{import_{j,k}}{total\ import_j} \quad (4)$$

$$w_k^{WGDP} = \frac{GDP_k}{global\ GDP} \quad (5)$$

The domestic output gap of foreign countries was calculated using data from OECD (OECD, Quarterly National Accounts) and the World Bank (data for China) (WB, Global Economic Monitor). The data was downloaded as real quarterly GDP in USD, transformed into a growth rate through logarithms and using the Hodrick-Prescott filter I gained the output gap.

Although data for all the weights were downloaded as annual, due to the unavailability of some of them in quarterly frequency, this should not make a big difference. We can assume that each weight would change only slightly between each quarter and thus would have a negligible effect on the final form of the GLOBAL_GAP variable. The same weight was used in all quarters of each year.

⁴ ULCMFG, A021RD3Q086SBEA – reference codes

Raw data for the weights W_{IM} and W_{IMEX} were found on the webpage of the United States Census Bureau (USCB) in USD, nominal and not seasonally adjusted. Data for the total volume of trade was downloaded from the FRED (FRED) page as real and seasonally adjusted values. The census data was first transformed into real using the GDP deflator (WB) and afterwards, the X-13ARIMA-SEATS was used to seasonally adjust them.

Data for the $WGDP$ weight was obtained from the FRED (FRED) and worldometer (WORLDMETER), both real values that were seasonally adjusted using the X-13ARIMA-SEATS.

I found data for the EX_RATE variable (FRED⁵) as a not seasonally adjusted index (base year 2010). This data was transformed into growth rate and to seasonally adjust them the X13-ARIMA-SEATS procedure was used.

3.5 Model Specifications

As stated above, I used four different model specifications, one with only the domestic output gap and three with a variable representing the global gap and exchange rate as well. I will now detail the differences between them.

The first model explains current inflation through the domestic output gap in the previous period and the three control variables for oil, labour and import prices. This way we almost completely ignore any influence that international trade might potentially have or in other words,

⁵ RBUSBIS – reference code

we assume that there is little to no effect on domestic inflation. Inflation relies only on how well the economy performs.

In the next model, I add two variables that introduce the global influence on domestic inflation, the global output and the effective exchange rate. In the first version of the global gap, I calculated the variable using the sum of imports and exports. That is the easiest and most obvious way to bring the international effect on inflation into the model. It also assigns bigger weights to partners with which the US competes the most in terms of trading (Borio, Filardo, 2007)

In the second version, I calculate the gap using only the import to the United States. This way I emphasize the importance of imports on inflation and the irrelevance of exports (Borio, Filardo, 2007)

The last version is made using the global GDP weight. In this model, the global gap variable has the least direct effect on inflation but is the closest equivalent to the global economy of the three versions (Borio, Filardo, 2007).

Borio and Filardo (2007) also used two other methods to calculate the weights, both used bilateral exchange rates. Due to insufficient data, I decided not to work with these weights and instead use a variable for the effective exchange rate just like Forbes did in his paper (2019).

These do not capture all the international pressures on inflation, competition from other countries other than the chosen partners for example (Borio, Filardo, 2007), but they manage to give a good idea of how international trade might affect domestic inflation through global slack.

3.6 Model and Variable Tests

Before I started the process of prediction, I tested the variables entering the models and afterwards the models themselves for all possible complications and errors. In this section I will list all the tests, their results and methods I used to mitigate the effects of problematic results. All the tests were carried out using the Gretl software.

First, I tested all the variables for correlation. The matrix (Fig. 2) shows that there is a severe case of correlation between the different versions of the global gap variables, but this is not a problem since only one is always used in a model. Correlation also appears between the price index of oil and import as well as between domestic and global gaps. This is caused mainly by their interconnection and because all the variables are crucial for the model they cannot be omitted.

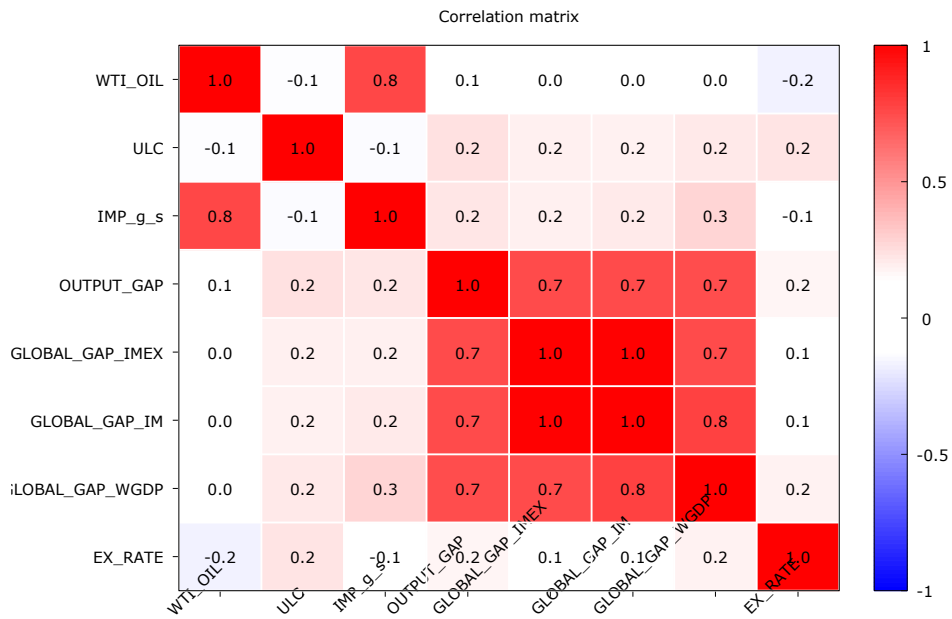
All the variables were also tested for the presence of the unit root using the Augmented Dickey-Fuller test. This was more of a formality because all the variables were transformed into growth rates. The test confirmed there was no presence of unit root and thus the data can be considered to be stationary.

Models were first tested for heteroskedasticity using the White test. The null hypothesis, there is no heteroskedasticity, was dismissed at the 5% level of significance. Next, I used the Breusch-Pagan test for autocorrelation up to the lag order of four. The p-values were again smaller than 0.05 and the null hypothesis, there is no autocorrelation, was dismissed at the significance level of 5%. Both of these problems were solved by adjusting the models with HAC robust standard errors.

I also tested the models for the normality of residuals. The results of this test differed from model to model, some had p-values greater than

0.05 and some smaller. Due to a big enough number of observations, I used the asymptotic theory to resolve this.

Fig. 2: Correlation Matrix



Zdroj: Gretl, own computation

4 Estimation Results and Forecasting Performance

In this chapter I will first take a close look at the results of OLS estimation of the models, then describe the script used for inflation prediction and all tests that follow and lastly interpret the results and determine if any of the used models are better than the benchmark naïve prediction and in that case which one is the best for inflation prediction.

4.1 Estimation

Coefficients of the models presented in previous sections were estimated using the ordinary least squares (OLS) method. After performing all the control tests discussed in the previous chapter and adjusting the model to meet assumptions of a linear regression model, I estimated the coefficients for all model specifications for multiple periods.

The samples were as follows, a full sample from 1993:Q1 to 2017:Q4 and two smaller ones, from 1993:Q1 to 2004:Q4 and from 2005:Q1 to 2017:Q4. The goal was to see if any of the models would behave differently in different time periods. I cut the sample in half in the year 2004 for two reasons, this way I get two relatively same sample sizes while also managing to capture the time before, during and after the 2008 financial crisis in the second sample.

Let us start with the full sample results (Tab. 1). In all specifications, except for the WGDP, the OUTPUT_GAP variable is statistically significant (between 1% and 5% level of significance). Almost all variables representing the global influence are also statistically significant. The

exchange rate is significant in all three model specifications as well as both IM and IMEX versions of the global slack, all at the 5% level of significance. Only the WGDP variable is insignificant. Out of the three control variables, only the WTI_OIL shows any significance (5%-10% level of significance). In all cases, a positive correlation occurs between domestic slack and inflation, the same goes for the WTI_OIL and inflation. On the other hand, EX_RATE always lowers domestic inflation.

Tab. 1: Coefficients for the full sample OLS estimation

	DOM	IMEX	IM	WGDP
constant	0.001055***	0.001153***	0.001142***	0.001100***
OUTPUT_GAP	0.06463**	0.1312***	0.1284***	0.05661
GAP_IMEX	---	-0.1015**	---	---
GAP_IM	---	---	-0.1009**	---
GAP_WGDP	---	---	---	0.1031
EX_RATE	---	-0.05385**	-0.05370**	-0.05192**
WTI_OIL	0.01302**	0.009366*	0.009392*	0.01138*

*Source: Own computation (level of significance at 1%, 5% and 10% is ***, ** and *)*

While in the first subsample (1993:Q1-2004:Q4) many variables are significant, in the second one (2005:Q1-2017:Q4) nothing except for the EX_RATE is (Tab. 2). This might be caused by the financial crisis in 2008, as I will show later in the thesis, my models struggled to predict inflation during this period. The variable for exchange rate changes its sign from positive to negative as the models progress through time. The coefficients of the domestic gap drop in the second subsample, which implies a declining effect on inflation. The domestic gap, on the other hand, keeps its positive sign, and just like in the full sample, always raises domestic inflation.

ESTIMATION RESULTS AND FORECASTING PERFORMANCE

As I mentioned before, only the WTI_OIL variable proved to be statistically significant out of all three control variables. When I removed the IMP_g_s variable from the models, the least significant of them, it increased the importance of the oil prices even more. This might be due to a slight correlation between WTI_OIL and IMP_g_s.

The values of all coefficients might seem a little too high, but we must remember that all the variables are in growth rates, a unit change in the variable's value represents a 100% change.

Tab. 2: Coefficients for the first and second subsamples

	DOM	IMEX	IM	WGDP
Constant	0.001611***	0.001804***	0.001783***	0.001732***
	0.0006981	0.0005787	0.0005885	0.0006337
OUTPUT_GAP	0.08842***	0.1298***	0.1326***	0.1311***
	0.06143	0.1219	0.09667	0.01197
GAP_IMEX	---	-0.07130*	---	---
	---	-0.1316	---	---
GAP_IM	---	---	-0.08247*	---
	---	---	-0.07986	---
GAP_WGDP	---	---	---	-0.4056**
	---	---	---	0.1814
EX_RATE	---	0.00306	0.003338	0.01780
	---	-0.09784***	-0.09785***	-0.09510***
WTI_OIL	0.01228***	0.008832**	0.008865**	0.009740*
	0.01375	0.008912	0.009400	0.01106

Source: Own computation (level of significance at 1%, 5% and 10% is ***, ** and *), coefficients for the first subsample are in the first row and for the second one in the second row

4.2 Prediction Method and Results

In this part of my paper, I will describe the prediction method, all the tests and determinants involved as well as discuss the results of the prediction.

As a method of prediction, I used recursive estimation with expanding window, forecasting up to four quarters ahead. Forecasting starts in 2005:Q1. First, I forecast inflation in the period 2005:Q1 – 2017:Q1 using all four models and save the predicted values. In the next step, I programmed the naïve prediction, defined as the actual value from the previous quarter, as a benchmark, and calculated errors of prediction for all models including the benchmark. Then I calculated the MSPEs, mean squared prediction error, of each model so I could compare them to choose the best one and test whether they are statistically better than using a naïve prediction. To test this, I used the Diebold-Mariano test.

Now, let us look at the results themselves, this is the key part of my thesis as it contains all the necessary data to decide whether or not the globe-centric approach does have any basis. As mentioned above, to choose the best model specifications I used the MSPE. All of them are in the table below (Tab. 3). We can see that the naïve prediction makes on average bigger errors in every forecast horizon. My models have approximately the same MSPEs but on average the model specification with the smallest errors is the IMEX model. It is interesting to point out that the three-step ahead prediction has the lowest MSPEs of all, but overall, there are only very small differences between the values.

Now, I will take a closer look at the predicted inflation and interpret the results. In figures 3 – 6, you can find trajectories comparing the forecasted and actual inflation for different forecast horizons (from one up

to four quarters ahead). It is obvious that all my models are not prone to catch extreme values and fail to predict inflation near its actual values. However, they seem to forecast the trend correctly. After 2012 we can see that all models tend to predict even higher inflation than it should be and after 2014 there is a forecasting lag of about one quarter. During 2007 the WGD model in all forecasts predicts the lowest inflation and does not follow the same trajectory as the other models, but it is the only case of inconsistency.

Tab. 3: MSPEs for all models⁶

	One step	Two steps	Three steps	Four steps
domestic	4.02E-05 (0.1469)	3.82E-05 (0.0196)	3.68E-05 (0.0306)	3.75E-05 (0.0236)
IM	3.92E-05 (0.0689)	3.83E-05 (0.0128)	3.64E-05 (0.0186)	3.69E-05 (0.0104)
IMEX	3.91E-05 (0.0655)	3.81E-05 (0.0122)	3.62E-05 (0.0176)	3.67E-05 (0.0098)
WGD	4.04E-05 (0.0719)	3.99E-05 (0.0209)	3.88E-05 (0.0399)	4.00E-05 (0.0280)
naïve	6.39E-05	9.31E-05	8.64E-05	8.48E-05

Source: Gretl, own computation

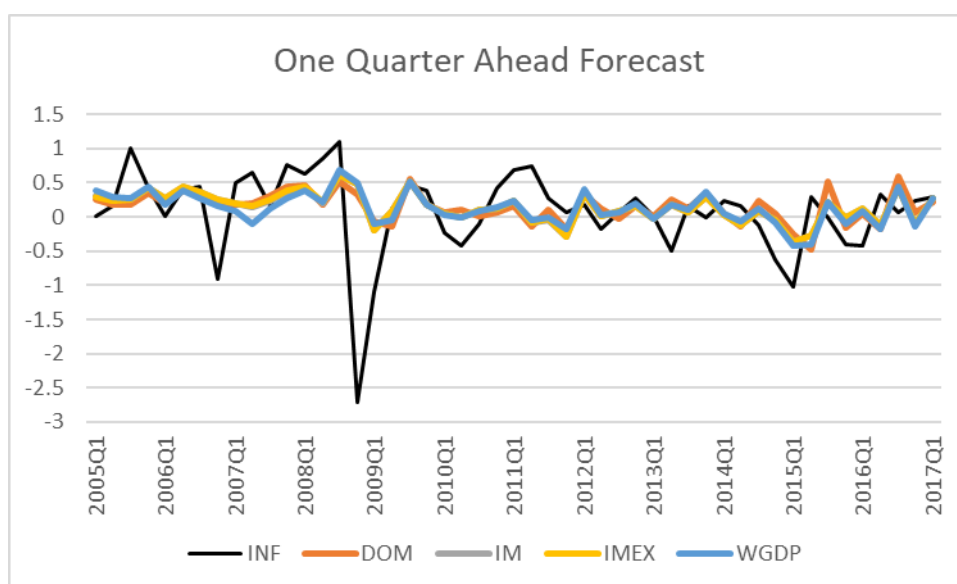
In conclusion, all model specifications can roughly predict the trend of inflation but when it comes to forecasting during an economic crisis, they start to have problems and tend to underperform. During calm times, however, all the models manage to predict inflation very close to its real values as can be seen in all graphs starting around the second quarter of 2011. Considering that all the models by far outperformed the

⁶ values in bold are not statistically more significant than naïve prediction, p-values are in parentheses

naïve prediction and that they predict the right trend we can say that all of these models are useful in real practice. However, we cannot name only one model as a clear winner. Although the IMEX specification has the lowest MSPEs, it is only by a very small margin and not enough to distinguish itself from the other model variants.

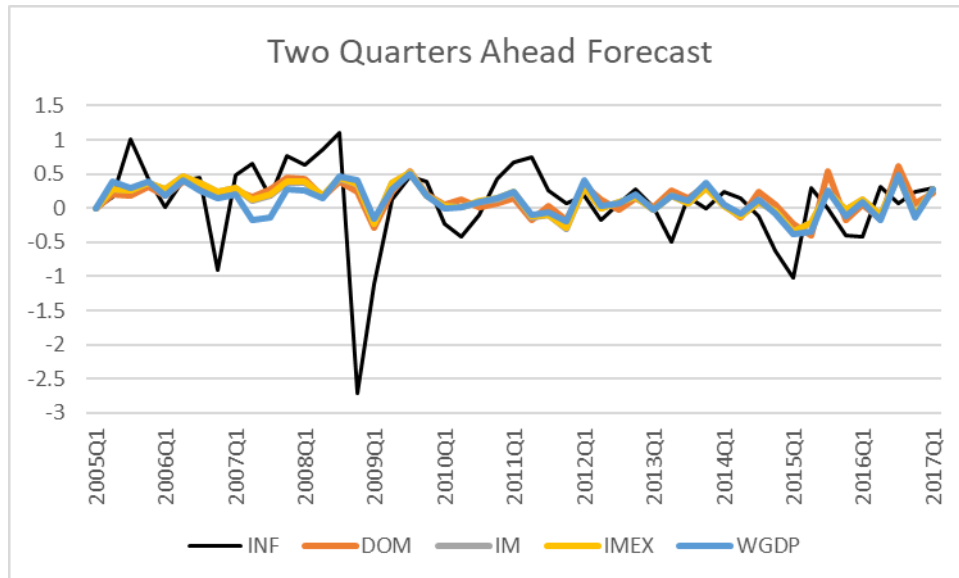
With all this information we can finally answer the main question of this paper ‘Does international trade have an impact on domestic inflation?’ and the answer is no. I did not find sufficient evidence to claim that adding a variable for global slack, in any form, improves the prediction ability of a traditional Phillips curve at least in the case of the United States in the chosen period. This however does not mean that we can rule out the option that under different circumstances, with a different economy or different variables representing the global influence the models would not outperform only the benchmark model but even the domestic-only specification. Further research is needed.

Fig. 3: One Quarter Ahead Forecast



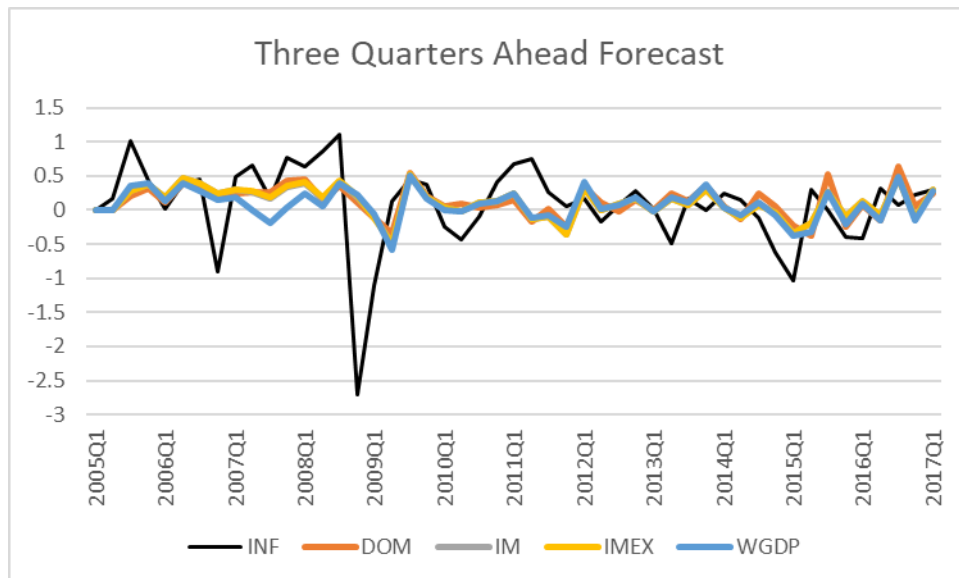
Zdroj: Own creation

Fig. 4: Two Quarters Ahead Forecast

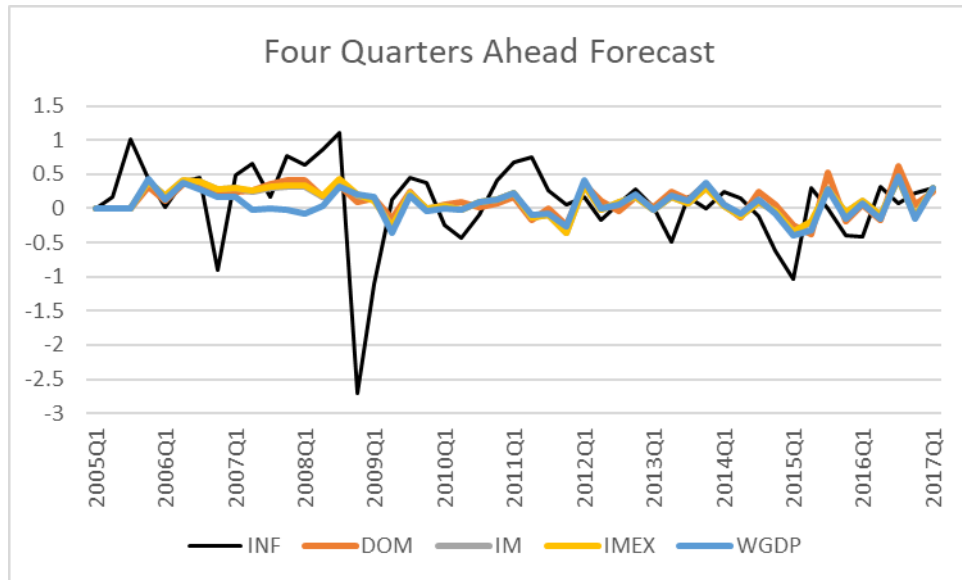


Source: Own creation

Fig. 5: Three Quarters Ahead Forecast



Source: Own creation

Fig. 6: Four Quarters Ahead Forecast

Source: Own creation

4.3 Discussion

As I said before my work is heavily inspired by Borio and Filardo (2007) and copies the main framework with a few exceptions and differences. This creates differences between the results, most notably the opposite sign for the global slack coefficient. In this part, I will try to compare my results with theirs and argue why the two might differ.

The first difference might occur in choosing the control variables such as oil and import prices. In their paper, Borio and Filardo (2007) did not specifically describe which indexes they used but this should have only a very small effect on the results because differences between indexes should be only marginal.

The second difference, however, might be a source of bigger deviations from Borio and Filardo's results (2007). While they used five different ways to calculate the weight for the GLOBAL_GAP variable, I used only three variations. Instead of the exchange-rate-based weights, I added a whole new variable, EX_RATE, and used it in every model specification. This way the exchange rate influenced every model not only the two with the respective weights. The reason why I decided to omit these weights is that finding data to calculate them proved to be hard and time demanding. But, as I still wanted to include the exchange rate in the model, I used Forbes' (2019) work where he used this variable, so in the end, my models are a hybrid of the two frameworks.

My chosen period and economy also differ from the original work. Borio and Filardo apply the model to multiple economies such as the United States, Euro area, Japan, and many others. For time-restraining reasons, I had to do with only the United States. I also changed the original period, they used a sample from 1985 to 2005 while I used a sample starting in 1993 and ending in 2017. This allowed me to test how well the model performed during the 2008 financial crisis.

Other than that, there were no substantial differences. Some values might also differ due to the transformation process of the dataset but again we can assume these changes to be only marginal.

First, let us compare the coefficients of the variables. The coefficient for the domestic output gap is lower in the second subsample, just like in Borio and Filardo, and thus the inflation's sensitivity to the domestic output gap is getting weaker as time progresses. As for the values they are fairly similar with and both affect inflation in the same direction, they raise it. Coefficients for the global gap variables differ, however. The biggest difference we can notice is the opposite direction they have. In my

models, the global gap variable always creates a decreasing pressure on domestic inflation, except for the WGDP specification during the full sample and first subsample. The values are also much lower in my paper and compared to the domestic slack's coefficients they are either approximately the same or lower. In Borio and Filardo's work, they were almost doubled in comparison to the domestic gap's. Coefficients of the exchange rate cannot be compared because this variable does not enter Borio and Filardo's models, not in this form at least.

In summary, while the model has almost the same structure as Borio and Filardo's, there are differences in the results due to different time samples of the data and other minor differences. The domestic slack's effect on inflation gets weaker over time in both papers and coefficients have approximately the same values. Coefficients for the global gap on the other hand not only have completely different values, but they also almost always affect inflation in opposite direction, in my case the global gap decreases domestic inflation, this corresponds with the results of Ihring et al. (2010).

5 Conclusion

My thesis' goal was to investigate the influence of international trade on the forecasting ability of the Phillips curve. To find an answer I first described the recent history of the curve and its breakdown during the last century and summarised some relevant literature that also delved into this problem. From this theoretical research, it can be easily concluded that the answer to this problem is not as clear as one might think, there is no consensus among economists about the foreign effect on domestic inflation. Although they mostly agree that the Phillips curve has become flatter in the past decades, namely since the 1990s when globalisation started to grow faster, they cannot agree on the causation.

As a result of this unsatisfactory finding, I decided to replicate the model of Borio and Filardo (2007) with the data for the United States in the last 25 years. I gathered all the raw data and using basic econometric methods I transformed them into a proper form. Next, using an OLS estimator on the linear regression model, I estimated coefficients for four different model specifications, that are both country- and globe-centric, and compared the forecasting ability of each model using MSPE. From this, I came to the conclusion that adding a variable for global slack always improves the model's forecasting ability and that inflation's sensitivity to the domestic output gap is declining. However, coefficients for the global slack have mostly opposite than expected sign (negative) and are less statistically significant than domestic slack's. Import prices also proved to be statistically insignificant in all cases, implying their inability to fully capture any global influence on domestic inflation.

Because of this, I cannot fully agree with the globe-centric hypothesis as the global influence cannot be linked to domestic inflation without

any doubt. But further research is definitely necessary as it is also clear that an augmented Phillips curve outperforms simpler models. It would be interesting to see how the model would behave with data that would better fit the Scandinavian approach, small and open economy, like the Czech Republic. The US economy is the exact opposite and considered a global driver of the economy (Milani, 2009) which might be the reasoning behind my results. As some works also concluded, the global slack coefficient acts differently for different economies and its level of openness and size might be a significant factor.

Overall, the main findings of this thesis are that the Phillips curve is still a viable tool for policymakers, it just needs to be augmented to better fit today's world. Because the whole globalisation situation and globe-centric approach are rather young, we need more time and data to fully comprehend the relation between the two. So far, we know that there is some level of correlation but not necessarily causation. Explanations such as bigger credibility of central banks or technological advancements should also be considered.

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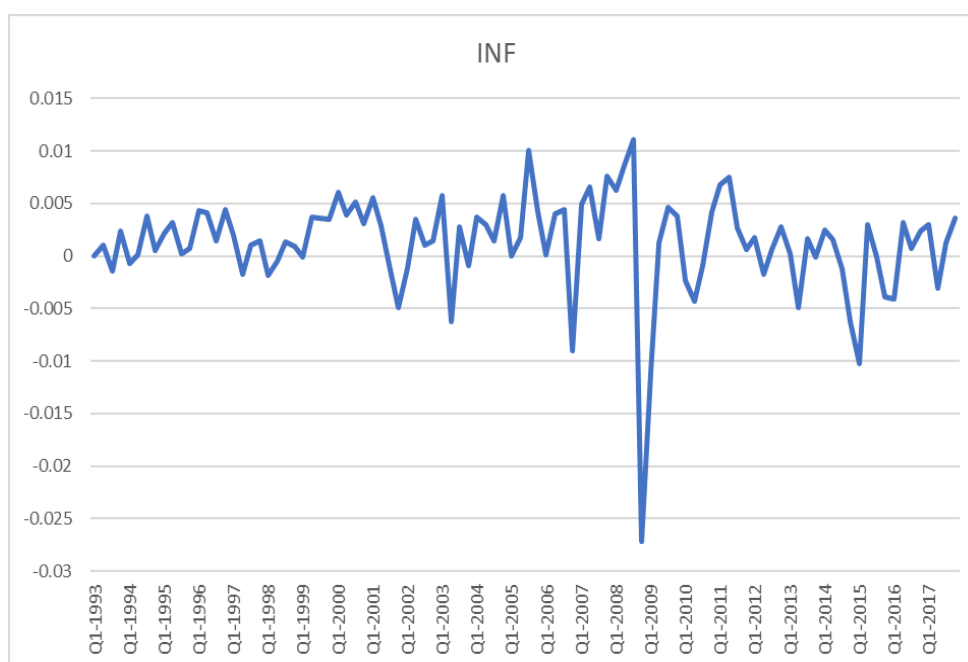
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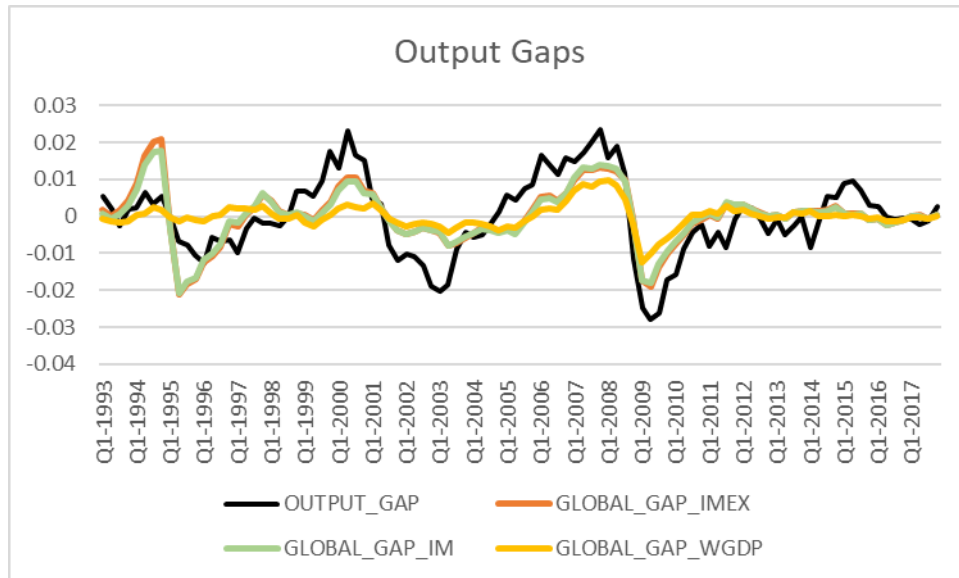
Appendix A Graphs of Variables

Fig. 7: Graph of the INF variable



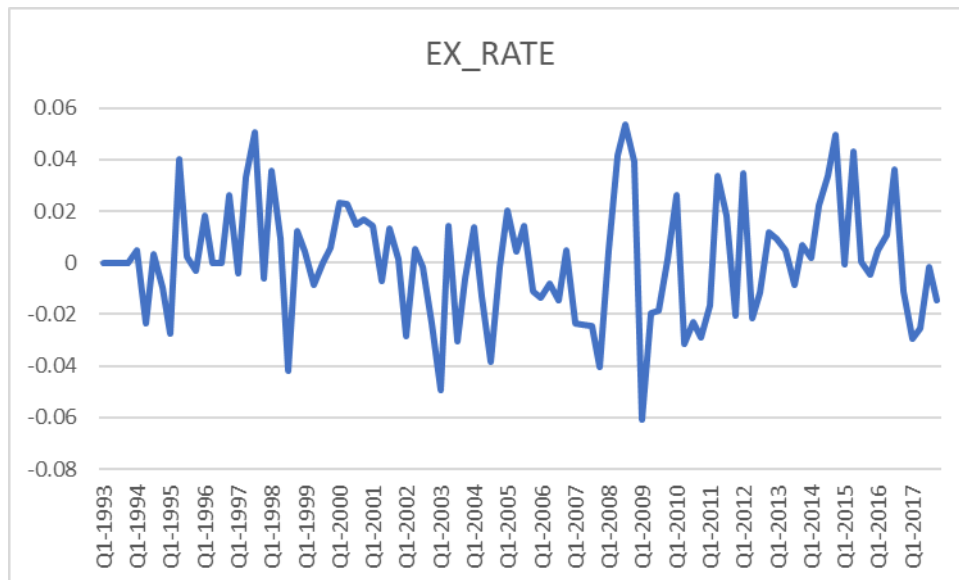
Source: Own computation

Fig. 8: Graph of the domestic and global output gaps



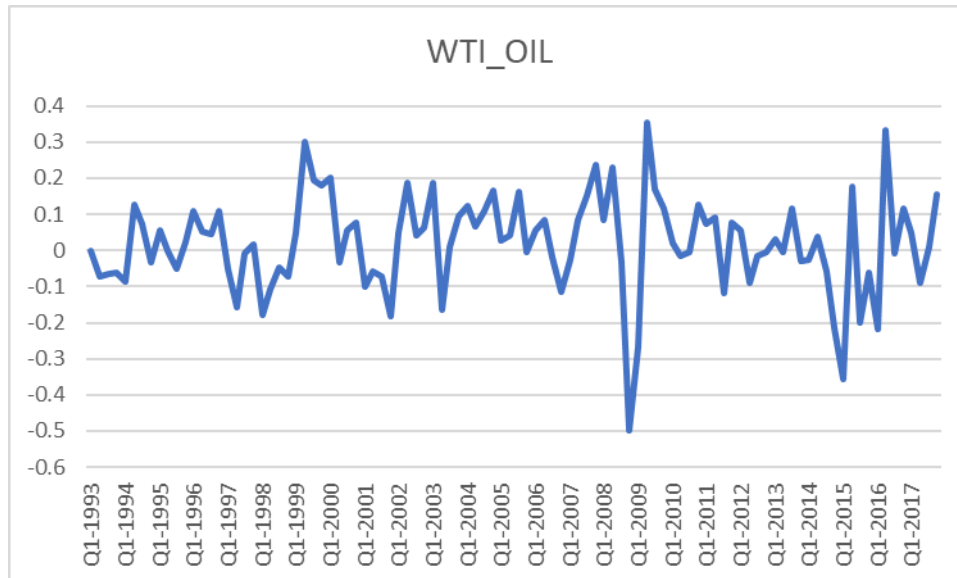
Source: Own computation

Fig. 9: Graph of the EX_RATE variable



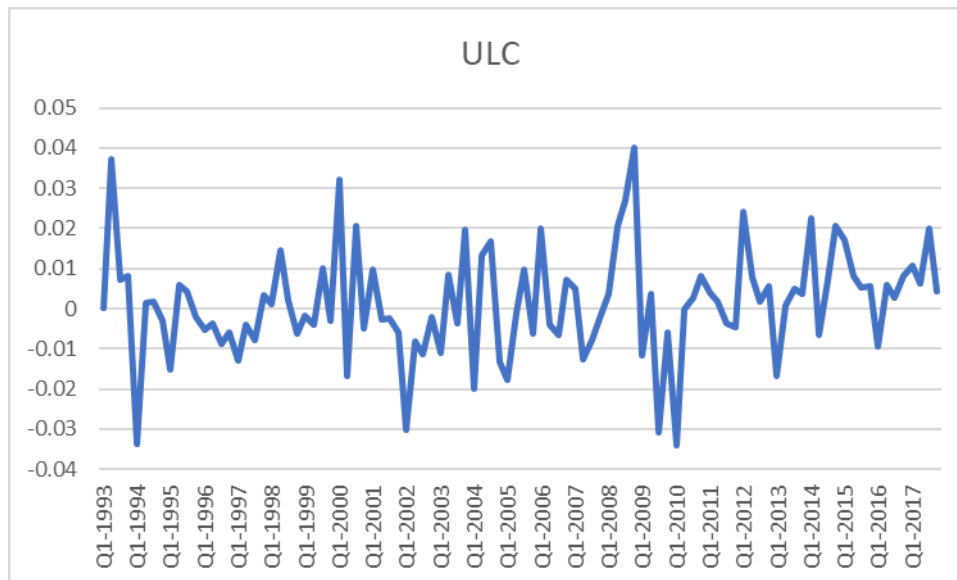
Source: Own computation

Fig. 10: Graph of the WTI_OIL variable



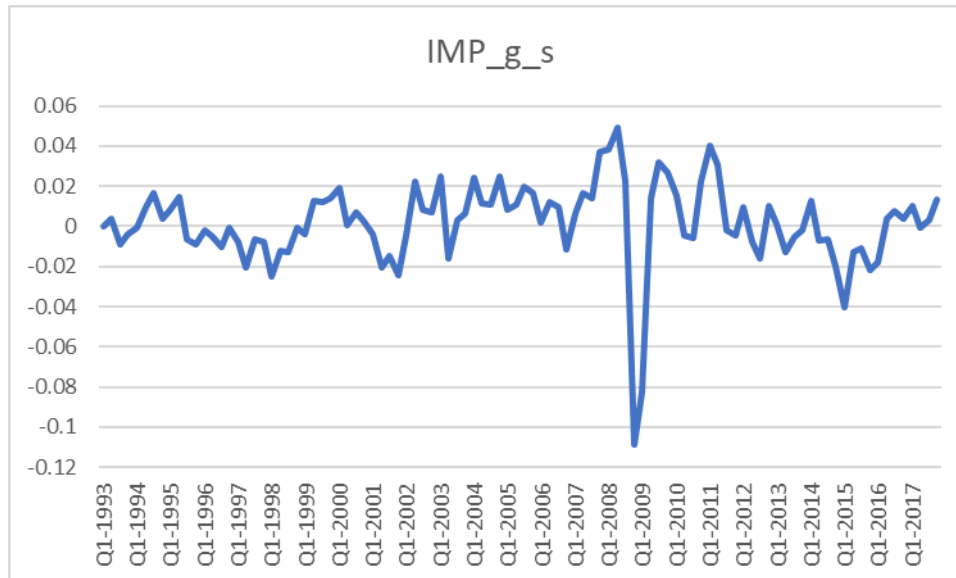
Source: Own computation

Fig. 11: Graph of the ULC variable



Source: Own computation

Fig. 12: Graph of the IMP_g_s variable



Source: Own computation

Appendix B Diebold-Mariano Test Results

Tab. 4: Diebold-Mariano test comparing global specifications to the domestic model, p-values

	One Step	Two Steps	Three Steps	Four Steps
IM	0.0841	0.6201	0.3054	0.1870
IMEX	0.0707	0.5486	0.2487	0.1445
WGDP	0.3278	0.7452	0.6393	0.6086

Source: Own computation

Appendix C Electronic Appendix

You will find both the dataset and Gretl script used in an electronic appendix.