SCHOOL OF ECONOMICS AND MANAGEMENT

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The Relationship between Oil Prices and Inflation – the Role of Oil Dependency

A study examining the effects of oil price shocks on inflation in the G-7 countries using a Structural Vector Autoregressive model

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Abstract

In the last decades, due to geopolitical tensions, climate change, and technological advancements, countries worldwide are becoming less dependent on oil. This thesis aims to establish if decreased oil dependence weakens the impact of oil price shocks on inflation, thus contributing to the existing literature on the oil-inflation relationship. To this end, a Structural Vector Autoregressive (SVAR) model is estimated for each of the G-7 countries. The model includes an exogenous dummy variable which captures the oil dependency of these economies. Based on this dummy variable, the sample is split into periods of oil dependence and independence, respectively. Impulse Response functions (IRFs) and Forecast Error Variance Decompositions (FEVDs) are estimated in both subsamples for each country. The results suggest that in periods of oil independency, oil price shocks induce a lower response in inflation compared to periods in which the G-7 economies are considered oil dependent. The results are policy relevant as they highlight one benefit of moving towards less oil dependency: the country's economy will remain more stable as oil prices fluctuate when becoming less dependent on oil.

Key words: Inflation, Macroeconomics, Oil-price Shocks, Structural Vector Autoregression (SVAR), time series data.

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1. Introduction

Following a near decade of highly expansionary macroeconomic policy and the more recent unconventional measures directed at combating the economic consequences of the Covid-19 pandemic, inflation is surging around the world. In 15 out of 34 Advanced Economies, the 12-month inflation through December 2021 ran above 5 percent. Such a symmetric jump in domestic inflation has not been seen for more than 20 years (Reinhart & Graf Von Luckner, 2022).

In the major western economies, inflation continues to soar. For example, in the United States (US), year-on-year Consumer Price Index (henceforth CPI) increased from 7.9 percent in February to 8.5 percent in March 2022 (Bureau of Labor Statistics, 2022). In the euro area, annual inflation measured with the Harmonised Index of Consumer Prices is expected to grow from 7.4 percent in March to 7.5 percent in April 2022 (Eurostat, 2022). Even in Japan, inflation rates above target levels are observed which is remarkable as the Bank of Japan has been struggling to reach its inflation targets over the last decades. In March, Japanese inflation hit a 26-month high, mainly driven by increases in material and energy costs (Iwamoto, 2022). Similarly, it is the cost of energy, which mainly boils down to the cost of fossil fuels, that drives inflation in the US and the euro area. When seen as one entity, the euro area is, to a large extent, dependent on fossil energy sources, and energy prices accounted for more than half of the headline inflation in February 2022 (Schnabel, 2022). In the US, prices of oil and gasoline had in March 2022 increased by 70 and 48 percent, respectively, compared to March 2021 (Bureau of Labor Statistics, 2022).

Hence, oil prices seem to be a major contributor to the current surge of inflation around the world. Further rises in this commodity are now expected as the global price of West Texas Intermediate (WTI) oil, as of April 29^{th}, is \$105 per barrel and is projected to rise to around \$113 in the second quarter of 2022 (Bloomberg, 2022; EIA, 2022a). The current economic climate and the ongoing war in Ukraine make the prediction highly uncertain (Yuksel, 2022).

The literature concerned with the impact of oil price fluctuations on the economy is extensive. The oil price makes an interesting variable in economics not only due to its notable recent transmission into US, euro area, and Japanese inflation but also as it is an important input variable in industrial production. As such, a large strand of the empirical literature is devoted to determining the impact of fluctuations in oil prices on macroeconomic variables such as real economic activity, national gasoline consumption (e.g. Lee & Cho, 2021), economic growth, unemployment (e.g. Almutairi, 2020), and external balances (e.g. Kilian, Rebucci & Spatafora, 2009). However, the impact of oil on inflation is a particularly active topic in the literature and mixed results are presented. For example, some authors find clear effects of oil prices transmitting into domestic inflation (see, for example, Barsky & Kilian 2004 and Du, Yanan & Wei, 2010), while others find that this pass-through effect is, in fact, decreasing (see for example Alvarez et al., 2011; Hooker, 2002 and Valcarcel & Wohar, 2013). In contrast, Raqif and Salim (2014) find no evidence of oil prices influencing inflation in some countries, while other studies indicate that there is short-run, but no long-run influence of oil prices on inflation (see for example: Cologni & Manera, 2008; Jiranyakul, 2015). In short, the heterogenous results stem from a multiple of reasons such as differences in countries studied, estimation techniques, data samples and frequencies.

Another dimension of the oil-inflation relationship is the recent tendencies of advanced economies shifting towards more renewable sources of energy. In 2016, the G-7 countries, which consists of Canada, Germany, France, Italy, Japan, the United Kingdom (UK), and the US, formally pledged to phase out their support for fossil fuels by 2025 (Climate Transparency, 2019). The reasons for these shifts towards more renewable energy are many, including the risks of oil-spills, fossil fuel burning induced climate-change and increased health-compromising pollution (Vohra et al., 2021). Another motivation for reducing oil-dependency is that oil oftentimes is imported from geopolitically risky countries in which conflicts may cause supply disruptions (Laura, 2016). These are all reasons for countries to restrict their oil usage, and a decline in emissions and oil intensity is already on way in many developed countries (Le Quéré et al., 2019). For example, US carbon dioxide emissions per capita fell by 19.9 percent between 2005 and 2017 (Hausfather, 2017), German household carbon dioxide output sank by around 7 percent between 2000 and 2009 (Price, 2010) and in the UK carbon dioxide emissions fell by 38 percent during the period 1990 – 2018 (Hausfather, 2019). The reductions in emissions are due to, among other things, lower fuel consumption and a cleaner energy mix (Hausfather, 2017, 2019; Price, 2010). Of course, technological advances such as exhaust filters and more effective engines also add to the reduction in carbon emissions.

However, the tendency of advanced economies reducing their emissions in favour of renewable sources of energy still indicate a reduction in the dependency on oil among these countries.

This thesis aims to contribute to the empirical oil-inflation literature by taking into account the decreasing dependence of oil in developed countries. To this end, a Structural Vector Autoregressive (SVAR) model is estimated for each of the G-7 countries using monthly data from 1980 to 2021. The (S)VAR framework is used to jointly model the oil price and inflation as a result of multiple structural shocks, which poses a more robust statistical method compared to conventional static regressions, particularly when estimating the relation between oil and inflation (see Kilian and Zhou, 2020). The G-7 countries are chosen for the analysis as they are at the forefront of technological advances while also consuming more than 30 percent of the oil produced globally. This implies that their macroeconomies would be more susceptible to oil price shocks compared to other countries (Wen, Zhang & Gong, 2021). Additionally, the environmental movement is particularly prominent in this group as these countries were all driving the formulation of the millennium goals established at the 2000 UN summit (United Nations, 2000). They are also original members of the Paris-Agreement (United Nations, 2020). This suggests that these countries should be at the forefront of replacing oil usage with more environmentally friendly energy sources, and that they will continue this endeavour in the future.

As reduced oil dependency could make domestic inflation less sensitive to fluctuations in the price of oil, differences in the transmission of oil price shocks into inflation may be expected in periods when a country is relatively more contra less dependent on oil. This leads to the formulation of the following hypothesis:

* Oil price fluctuations will have a smaller effect on inflation when counties are less oil dependent

While it may seem obvious to make the prediction that a less oil dependent economy will be less sensitive to fluctuations in oil prices, it is however worthwhile to note that simply because oil is not used to the same extent as before in the own country, it does not imply that the same is true for all trading partners and suppliers of the economy. This follows from the globalization and specialization of production that the global economy has experienced the past century where regulations and economies of scale has favoured industrial production of tradeables in developing and emerging markets around the world. Of course, as seen above, environmental, and technological advances in major western economies have led to, among other things, increases in the share of energy stemming from renewable sources and thus a decrease in oil dependence. That is, production of oil intense goods has shifted away from the richer, western, countries in favour of emerging and developing economies. It is important to keep in mind that the western countries still depend on consumption of oil intense goods on both the consumer and producer side, the difference being that some of these goods are now produced abroad. Oil price fluctuations will therefore likely continue to affect economies via for example changes in input prices and costs of transportation even though the countries themselves grow less oil dependent in conventional terms.

The thesis is structured as follows; section 2 covers previous literature and theories related to the oil-inflation relationship. Section 3 presents the data used in this thesis. In section 4 the methodology is presented, in section 5 the empirical results are found while the analysis and discussion are conducted in section 6. Section 7 concludes.

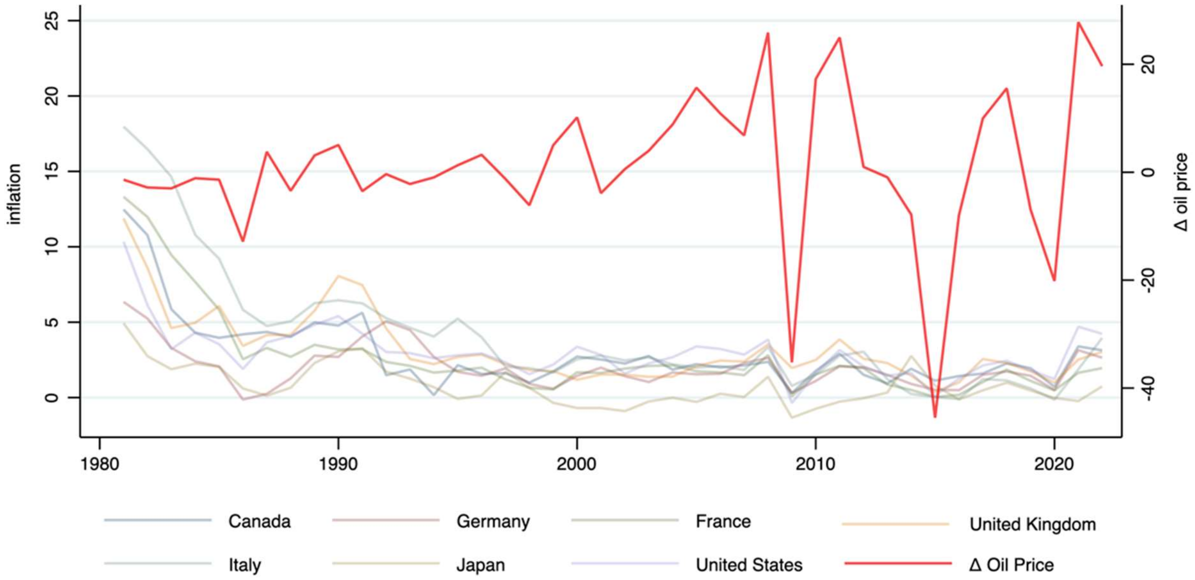
2. The Relationship between Oil and Inflation

This chapter amends with insights from the literature and a theoretical explanation to why oil prices tend to influence other macroeconomic variables. It continues in section 2.2. where the influence of oil dependency on the relationship between oil prices and inflation is accounted for. The chapter ends with a summary of the arguments presented in the form of a postulation on how the oil-inflation relationship may evolve in the future.

2.1. Why do Oil Prices Affect Macroeconomic Variables?

Graph 1. The growth rate (%) of G-7 inflation and the yearly change in oil price 1980-2020

Notes: The graph was generated using inflation data retrieved from OECD (2022a) and oil price data from the World Bank (2022).



In graph 1 above, the inflation of the G-7 countries is plotted together with the yearly change of crude oil prices. Inflation tends to be relatively high when oil prices are high and low when oil prices are low. As illustrated, the oil price fluctuates and experiences dramatic spikes and contractions throughout the years. The changes in oil prices are sometimes due to geopolitical events disrupting supply chains, as the Iran-Iraq war in 1980 which led to spiking oil prices (Ross, 2022). Changes in oil prices has also occurred due to economic downturns which depress demand, as seen following the 2008 global financial crisis. What also affects oil prices is the ability for oil producer cartels to control prices. During the global financial crisis, OPEC cut production targets by 1.7 million barrels per day which induced an increase in the price. But do oil prices lead to changes in inflation, and if so, through which channels? The following sections are devoted to answering this question.

Theory presents many frameworks regarding inflation and deflation. Commonly rereferred to in literature is the demand-pull inflation theory and the Phillips curve. In the demand-pull inflation theory, inflation arises from an excess of aggregate demand over the full-employment capacity of the economy. In this framework, rising prices can lead to inflation if people expect that the increases in prices are not temporary. The rational response in this situation is for consumers to increase consumption and spending, the same rationale applies for producers. If the general belief is that the price increase is temporary, inflation may decline as people postpone spending in favour of future consumption (Ackley, 1961). The Phillips curve describes the relationship between unemployment and inflation. According to this theory, increased demand for goods and services will induce a positive demand shock for labour. Consequently, inflation will rise slightly due to upwards pressure on wages which in turn will make the public revise their inflation expectations and wage demands. Following this upwards revision in expectations, the initial excess demand for labour will be reduced and employment falls back to the point of departure, the equilibrium unemployment rate, although with the economy at a higher rate of inflation (Fregert, 2007). Another relevant aspect regarding the oil-inflation relationship is that of market power. In uncompetitive markets characterized by dominant corporations, market power leads to higher prices (Vaitilingam, 2022). The oil market is an uncompetitive market as the Organization of the Petroleum Exporting Countries (OPEC) do exert market influence (Colgan, 2014). Therefore, the market power of oil producers may be an important mechanism through which the oil-inflation relation is affected.

There is plenty of published research aimed at untangling the relationship between oil prices and macroeconomic variables. Regarding the findings of the relation between oil prices and inflation, Zakaria, Khiam & Mahmood (2021) among others, argue that oil prices impact inflation in two ways, in an indirect way and in a direct way. Direct effects work through the demand side, when oil goods have a larger share in the consumer basket the inflation will increase directly. The indirect effect works though the supply side as it affects the cost of production. If the oil price increases, the cost of production is affected and the producer must charge a higher price to cover its new costs (Zakaria, Khiam & Mahmood, 2021).

With regards to the macroeconomy in general, Rotemberg and Woodford (1996) points out that oil shocks cause recessions because an increase in oil prices can reduce the demand for factors of production, not only for oil but also for labour and capital services. Others have argued that increases in oil prices can induce recessions because it generates reallocation of work between sectors and if this process is costly, it can generate significant contractions in value added (Castillo, Montoro & Tuesta, 2020). Note that in the terminology of Zakaria, Khiam & Mahmood, the just mentioned mechanisms which are argued to cause recessions, would all be characterized as indirect effects. A positive oil price shock would increase revenues in the oil industry but may on the other hand make the sector relatively less competitive, which can generate a reallocation of resources between sectors, a process which may be costly.

It has also been argued that the effect of oil prices on macroeconomic variables differs depending on whether the country is an oil importer or an oil exporter (Olofin & Salisu, 2017; Salisu & Isah, 2017). When a country exports oil, the increase in oil prices has the potential to increase income in the oil exporting country. This in turn may lead expenditures and investments to increase, lowering unemployment and increasing the purchasing power of the citizens. For the oil importing country, oil price increases will lead to higher production costs and the increase in producer prices will be transferred to consumer prices and this could lead to lower demand and reduced consumer spending. Lower consumption could lead to lower production and thus increased unemployment (Olofin & Salisu, 2017).

Another point of view is related to the Philips curve framework. Here, increases in oil prices can decrease purchasing power which leads to households requiring higher wages. This in turn may cause upwards revisions in wages and inflation expectation as seen above. Higher wages also lead to higher costs for the firms, which may be met with increases in prices to cover the new costs (Blanchard & Gali, 2007).

Others have looked at the effect of different types of oil price shocks on inflation. Wen, Zhang and Gong (2021) examine the G-7 countries and finds that oil price shocks affect inflation in the US more than in the rest of the G-7 countries and that each country responds differently to an oil price shock. LeBlanc and Chinn (2004) on the other hand investigate the impact of oil prices on inflation in the G-7 countries using an augmented Phillips curve framework, they find that oil price increases are likely to have only a modest effect on inflation in Europe, the U.S. and Japan.

2.2. Oil Dependency in the G-7 Countries

There are plenty of reasons for countries to restrict their oil consumption. For example, oil spills are big killers of wildlife and can cause long-lasting damage to marine ecosystems as the sites where oil is extracted disrupt ecosystems. Also, the usage of fossil fuels release heat-trapping gases into the atmosphere causing climate change (The Wilderness Society, 2021). Pollution caused by oil and gas usage is known as the "*invisible killer*" as the diseases caused by pollution is responsible for more than 13 percent of deaths in people aged 14 or older in the United States (Vohra et al., 2021). Although the origin and amount of oil imports differs from county to country, the oil consumed in the G-7 countries are in many cases imported from geopolitically risky countries. Russia, for example, is the main provider of oil in Europe (Laura, 2016).

The facts mentioned above are all reasons for countries to restrict their oil usage and various countries have already made commitments towards a less oil dependent future. For example, in 2016, the G-7 countries pledged to phase out their support for fossil fuels by 2025 (Climate Transparency, 2019). Also, France and Quebec (Canada) among other countries, states and provinces have formed the Beyond Oil and Gas Alliance (BOGA) to stop the production of fossil fuels (BOGA, 2022). More recently, countries have faced the consequences of being dependent on a geopolitically risky country as Russia invaded Ukraine, leading to increased insecurity in the world and higher oil prices. Since then, governments around Europe have made frequent announcements to increase the usage of greener sources of power, as to be less dependent on Russia (McGrath, 2022). As a result, the transition towards more climate friendly economies will likely be sped up.

Despite the initiatives to decrease the reliance on fossil fuels, including oil, oil consumption in absolute terms continue to rise in most countries and governmental support towards fossil fuels are still prevalent (Taylor, 2018). The increase in oil consumption is linked to global economic growth, which is still largely powered by the burning of fossil fuels (Quéré et al., 2022). Despite this, some studies have revealed that the oil-inflation price pass-through has declined over time because oil substitutes have become increasingly available (Bachmeier & Cha, 2011; Clark &

Terry, 2010; Katayama, 2013; LeBlanc & Chinn, 2004). It has also been shown that efforts to reduce emissions are underway in many countries, and emissions in many developed countries have decreased (Le Quéré et al., 2019). For example, US carbon dioxide emissions fell by 19.9 percent per capita between 2005 and 2017. This represents a decline of 758 million metric tons, the largest decline of any county in the world (Rapier, 2017). It has been estimated that wind-generation was responsible for 19 percent of the emission reduction, and reduced fuel consumption in homes and industry for another 12 percent (Hausfather, 2017). German household direct CO2 output sank by nearly 7 percent between 2000 and 2009. During this time period, Germany also increased its share of power from renewable sources by nearly 10 percent (Price, 2010). Another example to illustrate the move towards more climate friendly ways is France who experienced a 12.19 percent decline in CO2 emissions between 1990 and 2018 (Tapolsky, 2020). The United Kingdom has also reduced their emissions. Thanks to, among other things, a cleaner electricity mix and reduced fuel consumption the UK CO2 emissions were 38 percent lower in 2019 than they were in 1990 (Hausfather, 2019).

As mentioned in section 2.1, the responsiveness of inflation to oil price fluctuations can also be influenced by whether the country is a net importer or net exporter of oil. Other dimensions which may affect this responsiveness are the size of the economy and the nature of the shock.

The US is the world's largest economy and a leading global trader (USTR, n.d.). In 2018 the US became the world's top crude oil producer and maintained this lead throughout 2020. Despite the large production of oil in the US, the country still imports oil from other countries and was by the end of 2021 a net importer of crude oil (EIA, 2022b). Despite its significant oil production, the US rely on imports of oil as they are the largest consumer of oil in world (Worldometer, 2022). This has influenced the US economy's response to oil price shocks in the past, as it has been found that oil price shocks have a larger effect on inflation in the US compared to the rest of the G-7 countries (Wen, Zhang & Gong, 2021.

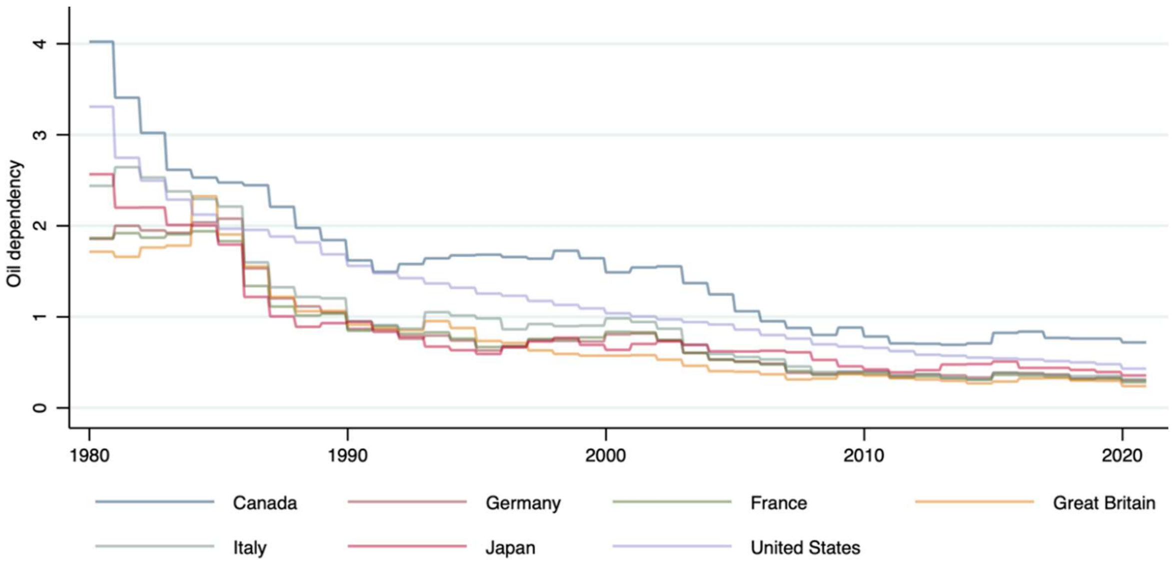
Canada on the other hand, despite producing less oil than the US, is a net oil exporter (EIA, 2022; NRCAN, 2016). This is due to, among other things, the Canadian economy not being the size of the American and thus face a lower domestic demand for oil compared to the US. Canada being a net oil exporter has influenced the economy's response to oil price shocks as the shocks have been argued to stimulate the Canadian economy through an increase in domestic aggregate demand due to the boost in oil income (Delpachitra, Hou & Cottrell, 2020). The rest of the G-7 countries do not produce anywhere near as much oil as Canada and the US[1], making them net oil importers. Like Canada, they are considered small open economies without ability to influence market conditions.

2.3. The Future of the Relationship Between Oil and Inflation - the Role of Decreased Oil Dependence

As seen in the above sections, the G-7 countries are in the process of moving towards decreasing their dependency on oil. Plotted below in graph 2 is this thesis measure of oil dependency, which has decreased for all the G-7 countries since the 1980's. This variable is defined as the oil consumption of a country divided by GDP, more information regarding this variable is found in section 3.2.

Graph 2. Oil dependency in the G-7 Countries

Notes: The graph was generated using oil consumption data from BP (2022) and GDP data from Our World in Data (2022). The variable oil dependency is generated according to section 3.2



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[1] On average in 2021, the United States produced 11.2 million barrels of crude oil per day (mb/d), Canada 4.4 mb/d, United Kingdom 0.9 mb/d, Italy 100 thousand barrels per day (tb/d), Germany 35 tb/d, France 13 tb/d and Japan 4 tb/d per day (EIA, 2021).

With the arguments of the previous section in mind, the transition into less oil dependent economies illustrated in graph 2 will likely continue in the future. This raises the question of how this movement towards a lower dependence of oil will impact the transmission of oil price fluctuations into domestic inflation. As presented in this chapter, theory provides insight on the mechanisms behind the oil-inflation relationship and the empirical literature confirm the relationship. For example, geopolitical turbulences in form of the Iranian Revolution and the Iran-Iraq war induced great disturbances in the supply of oil causing excess aggregate demand leading to higher prices, in line with the demand-pull theory presented in section 2.1. In the oil industry there are cartels that have the possibility to drive up prices. The increase in the oil prices could then be explained by cartels exercising their market power, driving up prices to increase their profits. In 2009 for example, as a response to the financial crisis which led to a decrease in demand of oil, hence a reduction in the price, OPEC decided to cut production targets by 1.7 million barrels per day to drive up prices. This is theoretically explained by the market power theory mentioned in section 2.1.

Whatever the mechanisms are, and which theory explains them, it is empirically and theoretically clear that oil price shocks have an impact on the economy. As seen above, the nature of this impact is a debated topic as mixed results are presented. For example, Valcarcel and Wohar (2013) find the pass-through of oil prices into inflation to be decreasing over time, a result which is hypothesised to be explained by, in part, an increased accessibility of substitutes to oil and changes on the global energy markets. The accessibility of substitutes to oil will make countries less dependent on oil and when countries become less oil dependent, oil constitutes a smaller share of consumption as well as a smaller share in production input. It can be argued that this will change the relationship between oil and inflation as the transmission mechanisms will likely be weakened as economies grow less oil dependent. This thesis contributes to the existing literature as it includes a measure of a country's oil dependency in the oil-inflation SVAR model. This is done in order to model the impact of oil dependency on the transmission of oil price fluctuations into inflation.

3. Data Selection

In this chapter the choices of variables for this thesis are motivated. The motivations are followed by a description of the variables included in the analysis.

3.1. Motivation Behind Choice of Variables

As mentioned previously, the exact nature of the relationship between oil and inflation is still not established in the literature, although most of the studies suggest that oil and inflation are intertwined. The direction of causality, however, has been difficult to pinpoint and results are often sensitive to sample selection and methodological approach (Bouchouev, 2021, Zakaria, Khiam & Mahmood, 2021). In contrast to most of the literature, some studies present evidence that oil prices in fact do not impact inflation in some countries (see Rafiq and Salim, 2014) or, at least, that there is no long-run influence of oil prices on inflation (see Jiranyakul, 2015).

The variables included in relevant oil-inflation literature differ across studies depending on the specific research question at hand, although there are some common and returning variables used in this type of study. Apart from measures of inflation and oil prices, these include variables capturing global demand, domestic output, the interest rate and the exchange rate. See table 1 for a compact summary of which variables that have been used in previous literature.

Table 1. Variables previously used in relevant literature

Variable	Examples of articles using the variable
Global Demand	Karim & Karim (2016), Kilian (2009), Pham & Sala (2020)
Output (GDP)	Anh et al. (2021), Bala & Alhassan (2018), Cologni & Manera (2008), Khan & Ahmed (2011), Kilian (2008)
Interest rate	Baek (2021), Cologni & Manera (2008), Jiménez-Rodriguez & Sanchez (2006), Kilian & Vigfusson (2017)
Exchange rate	Anh et al. (2021), Cologni & Manera (2008), Karim & Karim (2016), Khan & Ahmed (2011), Kilian (2008), Pham & Sala (2020)

In this body of literature, the models generally become larger when the country investigated is a small open economy compared to when only the US is of interest (compare for example Cologni & Manera 2008 or Pham & Sala (2020) to Kilian & Zhou (2020)). This typically boils down to the notion of the US being a large open economy, thus able to influence global macroeconomic conditions. Each of the G-7 countries, when considered separately, apart from the US, are arguably small enough to have no direct impact on global market conditions. This implies that these countries take global market conditions as given. Consequently, this paper will make use of variables capturing these global market conditions when modelling the oil-inflation relationship for all G-7 countries except for the US. Such variables include global demand, but also domestic interest rates and exchange rates which adjust to changes in global factors, following the modelling of for example Cologni & Manera (2008), Karim & Karim (2016) and Pham & Sala (2020).

3.2. Data Description

This thesis draws inspiration from the abovementioned papers and choose to include, apart from inflation and oil prices, data on domestic output, the interest rate, the exchange rate, and global demand. Inflation is calculated based on the Consumer Price Index (CPI). To proxy GDP, i.e. Output, the Industrial Production Index (IPI) for each of the G-7 countries is used. The IPI is an index with 2015 as the baseline year which measures output of industrial establishments. The interest rate is the country specific three-month money market rates. Following the introduction of the Euro, the interest rate of France, Italy and Germany are consequently the same. The interest rate is meant to capture monetary policy, but due to data on Japanese short-term interest rates not being reported until 1997, a monetary aggregate (M1, following Cologni & Manera, 2008) is used to capture the monetary policy stance in Japan. Also included in the model is the exchange rate, which captures international transmission effects, which is measured as the national currency unit per USD. Since the US is a large open economy, as opposed to the other G-7 countries which are regarded as small open economies, the exchange rate is suppressed from the US model. This practice is common in the literature (see for example Kilian & Zhou, 2020). The oil price is defined as an equally weighted average of the spot price of Brent, Dubai and WTI crude oil, retrieved from the World Bank (2022). The Global Economic Activity index is included to measure global demand. This index is provided by the Federal Reserve Bank of Dallas (2022) and is based on the paper published by Kilian in 2009. The data of inflation, domestic output, interest rate, M1 and exchange rate is retrieved from the OECD Database (OECD, 2022a, 2022b, 2022c, 2022d, 2022e). All variables are reported at a monthly frequency, definitions and sources are found in table 2 below.

Table 2. Description of variables

Variable	Description	Source
Inflation	Consumer Price Index, Total	OECD (2022a)
Domestic Output	Industrial Production Index, 2015 = 100	OECD (2022b)
Interest Rate	Three-month money market rates	OECD (2022c)
M1	Currency, plus overnight deposits	OECD (2022d)
Exchange Rate	National Currency Unit per USD	OECD (2022e)
World Oil Price	USD per Barrel, nominal terms	World Bank (2022)
Global Demand	Global Economic Activity Index	Federal Reserve Bank of Dallas (2022)
Oil Consumption	Thousands of Barrels Daily	BP (2020)
GDP	Domestic GDP in current USD billions	World Bank (2022)

Further, a variable called oil dependency is constructed. Oil dependency is defined in line with Rühl and Eriker (2021) as oil consumed per unit of economic output. Oil dependency defined in this way is often viewed as a good measure of the economic importance of oil in a country as it captures multiple effects; changes in preferences, technical efficiency improvements and changes in the structural composition of the economy, such as industrialization or urbanization (Rühl & Erker, 2021). In this paper, the data of GDP for all countries is retrieved from the World Bank (2022) and is measured as the GDP per country in current USD billions. The oil consumption data is acquired from BP (2020) measured in thousands of barrels daily. To calculate the resulting measure of oil dependency, the ratio of yearly oil consumption to GDP in current USD billions is computed for the full sample. Formally, oil-intensity is defined as:

$$oil\_dependency_t = \frac{Domestic\ Oil\ Consumption_t}{Domestic\ GDP_t} \qquad \text{(i)}$$

In this paper, a country is defined as relatively oil dependent whenever the variable in (i) is above its mean. Given this definition, a dummy variable called indicator is constructed as:

$$indicator_t = \begin{cases} 1\ if\ oil\_dependency_t > mean(oil\_dependency) \\ 0\ otherwise \end{cases} \qquad \text{(ii)}$$

In (ii), mean refers to a function which calculates the mean of $oil\_dependency_t$

4. Methodology

This chapter begins with a description of the Vector Autoregression (VAR) framework along with a derivation of the structural- and reduced-form representations. This is followed by a description of the empirical model, identification procedure and the resulting restrictions used. This chapter concludes with tests and adjustments of the data described in section 3.2.

4.1. Modelling Framework

Following Sims canonical 1980's paper, the VAR model has, due to its systematic way of capturing the dynamics of multiple time series, become a common tool for macro-econometric modelling (Stock & Watson, 2020). This is particularly true in the oil-inflation literature (see for example Cologni & Manera, 2008 and Kilian & Lee, 2014). Further, there are some methodological drawbacks concerning alternative, static regressions, as it has been argued that they inherently fail to account for the dynamic relationships among macroeconomic variables (Kilian & Zhou, 2020). Thus, a VAR approach is suitable for investigating the impact of oil dependency on the relationship between oil prices and inflation.

In their generic form, VAR models are n-equation and n-variable linear models where each variable is explained by its own lagged values as well as the lagged values of the other n-1 variables (Lütkepohl, 2005). Algebraically, following the pedagogical disposition of Schenk (2016), and per Lütkepohl (2005), the VAR model with exogenous variables can be written as:

$$Y_t = \sum_{k=1}^{P} A_k Y_{t-k} + \mathrm{C}\mathrm{x}_\mathrm{t} + e_t \quad (1)$$

$$\mathbb{E}(e_t e_t') = \Sigma_e \quad (2)$$

where Y_t is the vector of the endogenous variables described in section 3.2 above, A_k are coefficient matrices for $k \in \{1, \dots, p\}$, x_t the exogenous dummy variable oil dependency and C captures the effect of this variable. Note that C and x_t are scalars while e_t is a vector of regression errors. The covariance matrix of the errors is represented by Σ_e and the lag-length, p, is determined, and presented, separately for each country in section *4.3. Tests and Adjustments.*

The model in equation (1) does not allow Y_t to be contemporaneously endogenous, that is, each endogenous variable is explained only by its own lagged value and the lagged value of the other variables and not by *current* values of other variables of the model. This is arguably too restrictive and may not credibly describe economic systems (Hansen, 2022). Further, economic theory often suggests such a contemporaneous dependence among variables (Schenck, 2016), more on this in section *4.2*. To investigate matters of contemporaneous effects one imposes a certain structure on the model, thus the model becomes a *structural* VAR (SVAR). A SVAR model encompasses the more theoretically meaningful notion of contemporaneous effects.

Again, using the notation of Schenck (2016), the model in (1) can be generalized to allow for contemporaneous effects among the variables on the left-hand side:

$$AY_t = \sum_{k=1}^{p} C_k Y_{t-k} + \mathrm{Cx_t} + e_t \qquad (3)$$

$$e_t = Bu_t \qquad (4)$$

$$e_t \sim IID(\,0, \textstyle\sum_e) \qquad u_t \sim IID(\,0, \textstyle\sum_u = \mathrm{I}) \qquad (5)$$

Where the *structural* part, the contemporaneous dependence, is captured by the matrix A. C_k represents the coefficient matrices of lagged variables for $k \in \{1, \dots, p\}$ where the lag length p just as before is selected using formal selection criteria as presented in section *4.3 Tests and Adjustments.* In contrast to the reduced-form VAR in (1), the errors in (3) are generally correlated (Schenk, 2016), which is the case whenever $B \neq \mathrm{I}_n$, where I_n is the identity matrix of dimension n (the number of variables in the model). To be able to perform meaningful analysis on the model, using for example impulse response functions, the observed errors, e_t, are commonly decomposed as a linear combination of mutually orthogonal shocks, u_t, which is represented by equation (4). Note that the restriction $\sum_u = \mathrm{I}$, can be imposed without loss of generalization (Kilian, 2011; Schenk, 2016; Hansen, 2022). The potential correlation among the errors of equation (3) suggests that $\sum_e \neq \mathrm{I}$.

To be able to estimate this model, the left-hand side of the equation need to consist only of the vector of dependent variables. Solving for Y_t, assuming A is invertible, yields the reduced-form VAR and the following identities:

$$Y_t = \sum_{k=1}^{p} A_k Y_{t-k} + \mathrm{Dx_t} + \varepsilon_t \quad (6)$$

$$A_k = A^{-1} C_k \; for \; k \in \{1, \dots, p\} \quad (7)$$

$$D = A^{-1} C \quad (8)$$

$$\varepsilon_t = A^{-1} e_t = A^{-1} B u_t \quad (9)$$

$$\mathbb{E}(\varepsilon_t \varepsilon_t') = \mathbb{E}(A^{-1} e_t e_t' A^{-1\prime}) = A^{-1} B * \mathbb{E}(u_t u_t') * B' A^{-1} = A^{-1} B B' A^{-1\prime} = \Sigma_\varepsilon \quad (10)$$

In summary, the VAR model in (6) allows for simultaneous dependence among the left-hand side variables as described in (3) – (5), while excluding correlation among the errors (note that according to (5) and (9), when imposing certain structure on the model, ε_t can be decomposed as some linear combination of white noise).

4.2. Identification

The estimation procedure of the SVAR model makes use of the second moments of the variables, that is the variances, covariances, auto-covariances and the error covariance matrix Σ_ε (Schenck, 2016). From the reduced-form VAR in (6), estimates of A_i and Σ_ε are obtained. It is, however, the structural parameters that are of interest, that is matrices A and B. The problem is to recover unique estimates of the structural parameters from the reduced-form error covariance matrix, Σ_ε (Schenck, 2016). By equation (10), the estimated error covariance matrix is made from the structural matrices. However, there exist many such structural matrices that are consistent with the same observed matrix Σ_ε. In short, more information is needed to uniquely pin down A and B, this is the identification problem (Schenck, 2016).

Due to the symmetric nature of the error covariance matrix, only $\frac{n(n+1)}{2}$ unique estimates exist in Σ_ε while A and B each consists of n^2 parameters, requiring $n^2 + \frac{n(n-1)}{2}$ restrictions to be placed on A and B to recover unique parameter estimates of A and B from Σ_ε (Schenck, 2016). Following the exemplifications of Schenck (2016), A is in this thesis represented by a lower triangular matrix while B is restricted to be diagonal. This is where the previously mentioned insight from economic theory comes into play as the lower triangular form defines the contemporaneous dependence recursively among the variables. For a causal interpretation of the estimated parameter, these imposed restrictions must be identified based on economic arguments (Hansen, 2022).

These economic arguments are founded on the general notion that the G-7 countries are, excluding the US, small open economies when considered separately. As such, they are unable to affect global market conditions and consequently takes them as given. Hence, variables capturing these conditions are not allowed to be contemporaneously affected by domestic variables (excluding the US). Further, the presence of inertia follows from standard theories of nominal rigidities which implies that some macroeconomic variables respond to changes in others with a lag. For example, output is only affected by changes in variables for monetary policy with a lag, the same is true for the impact of the interest rate on inflation. Finally, it is noted that the central banks of the G-7 countries all operate under price stability-regimes where the interest rate is set depending on the value of domestic and foreign macroeconomic variables. Variables which are observed with a, at most, monthly frequency.

Under the assumptions presented below, given them being true, there is no traditional problem of endogeneity in the system which is the case with static regression on economic variables. Although founded on empirical and theoretical grounds, the imposed restrictions may however be flawed in their ability to credibly describe the economic environment related to the G-7 countries. Resultingly, if the imposed restrictions would be proven false the model will not credibly capture the dynamic of the system and hence not depict the true effect of oil dependency on the transmission of oil price shocks into inflation. Despite these potential shortcomings, the SVAR framework poses statistical advantages in modelling the dynamics of the oil-inflation relation and the imposed restrictions are theoretically and empirically well founded.

Apart from when modelling the US economy, the Structural VAR model used in this paper builds on the framework in which the separation between the foreign and domestic sector is made (see Pham & Sala, 2020). This follows from the previous discussion about the countries, when regarded separately (excluding the US), are small open economies, thus unable to influence global conditions. The foreign sector in this thesis is represented by Global Demand, proxied with a Global Economic Activity index which was introduced and clarified in Kilian (2009) and Kilian (2019), respectively, along with the global average crude oil price. Allowing global variables to affect domestic conditions is common when considering SVAR models for small open economies (see for example Karim & Karim, 2016; Ouchchikh, 2018 and Pham & Sala, 2020). The domestic sector is represented by indices tracking industrial production and consumer prices along with a domestic interest rate, and the exchange rate of national currency against the American dollar. As mentioned previously, the US differs from the remaining G-7 countries as it is considered a large open economy. The following representation of the imposed lower triangular form of A, equation (11), refers to the modelling for Canada, Germany, France, Italy, Japan, and the United Kingdom. The US, following from it being a large open economy, is modelled excluding global demand and the exchange rate. Below follows a presentation of the assumptions upon which the matrix A is structured.

$$A * Y_t = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 & 0 & 0 \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & 1 & 0 \end{bmatrix} * \begin{bmatrix} Global\ Demand_t \\ Oil\ Price_t \\ Domestic\ Output_t \\ Inflation_t \\ Interest\ Rate_t \\ Exchange\ Rate_t \end{bmatrix} \quad (11)$$

Global Economic Activity Index, which proxies *global demand* of goods (Boufateh & Saadaoui, 2021; Chen, Zhu & Li, 2020; Pham & Sala, 2020), is assumed to be exogenous to a contemporaneous shock in all other variables in the system. When considered separately, the G-7 countries excluding the US, are individually assumed to be small enough to have no direct impact on global market conditions. That is, assumption (1)[2] is in fact an exclusion restriction on the impact of oil prices on global demand. This assumption is in line with Kilian (2009) where it is argued that innovations in the real oil price will not impact real economic activity immediately, but with at least one month's lag.

[2] Assumption (X) refers to row X in matrix A. For example, assumption (2) refers to oil prices being affected contemporaneously by global demand but no other variables.

Assumption (2) is that the *oil price* in the model is being affected contemporaneously only by *global demand*, and is thus exogenous to any other variable considered in period t. The variable used to proxy global demand is the Global Economic Activity Index, following Kilian (2009), which is assumed to impact oil prices in the same period (Pham & Sala, 2020). As oil is an important input variable in the global production sector, a sudden surge of global demand should have a contemporaneous (positive) effect on the demand of inputs thus also of oil, causing, ceteris paribus, a demand driven increase in oil prices.

Output is argued to be unaffected by current innovations in monetary policy variables due to inertia, adjustment costs and planning delay, however, it is affected within the same period by shifts in oil prices as part of firm's mark-up rule (Kim & Roubini, 2000). The monetary policy variable in the model is *interest rate*, which consequently is not allowed to influence the *output* in period t. *Global Demand* is assumed to be a second determinant of time t output as firms are assumed to be able to respond within a month to an increased risk in the general economy or a sudden surge or fall in demand.

Assumption (4) is motivated by evidence from the literature suggesting that output contemporaneously affects inflation (Lee & Ni, 2002; Peersman & Smets, 2001). Inflation is also argued to be affected by GDP and the oil price (Baek, 2021; Bala & Ali, 2017; Basnet & Upadhyaya, 2015; Karim & Karim, 2016; Khan & Ahmed, 2011). In our model, GDP is proxied by IPI, and can therefore also be argued to influence inflation in period t. The interest rate does not affect inflation contemporaneously (Cologni & Manera, 2008), this since changes in the interest rate will impact macro-economic variables with a lag due to, among other things, inertia in commercial bank's ability to adjust their balance sheets.

The fifth assumption is that *interest rate* is affected by all variables except the *exchange rate*. The interest rate is set depending on the value of domestic, and foreign, macroeconomic variables. This assumption is reasonable given that the central bank can observe these variables monthly (Karim & Karim, 2016) and sets the *interest rate* as a response to changes in these variables. It is not influenced by the *exchange rate* because neither of the G-7 central banks operate under policies requiring that fluctuations in the exchange rate be met by immediate interest rate responses.

The *exchange rate* (assumption (6)) is affected by all variables (following Baek, 2021; Basnet & Upadhyaya, 2015; Jiménez-Rodríguez & Sánchez, 2006; Karim & Karim, 2016) since it is determined by the market and reacts quickly to fluctuations in other macroeconomic variables.

4.3. Tests and Adjustments

Since the (S)VAR model is a time series model, appropriate pre-processing of the series is important because of spurious results which may arise due to, for example, unaccounted for serial correlation and trends. The performed tests and adjustments necessary to avoid this are presented in this section.

4.3.1. Lag Selection

When using time series data, the choice of lag length is important to appropriately account for auto-, and cross autocorrelation in the data. Specifying a model with a lag length different from the true lag length will produce inconsistent results (Braun and Mittnik, 1993). The recommended, data-driven, way of determining the correct lag length p is by formally minimizing an information criterion (Hansen, 2022). There exists a multiple of such information criterions, which differ in the way the penalty function for including additional lags is defined. However, the Akaike Information Criterion (henceforth the AIC) tends to produce the most accurate Impulse Response Function (henceforth IRF) estimates (Ivanov & Kilian, 2007). Since this thesis will make use of IRFs when measuring the impact of an oil price shock on inflation, the lag length of the model for the difference countries will be determined based on the AIC. Further, as is common in the literature, a symmetric lag order of variables is used in this paper, meaning that the same number of lags is specified for all variables. The results from the lag length tests are presented in table 3.

Table 3. Lag order Selection

	Canada	Germany	France	Italy	Japan	United Kingdom	United States
AIC	2	4	3	3	2	3	3

Since the countries are different, the optimal lag length for the model differs across countries. Based on the AIC, the model for Canada and Japan will be specified with p = 2 while the model for the UK, US, France and Italy will have three lags while the model for Germany requires 4 lags to account for the serial correlation among the variables in the dataset.

4.3.2. Stationarity

To causally interpret and draw conclusions from Structural VAR models, it is important to make sure that the included variables are stationary. This is to avoid spurious results, that is, when statistically independent, yet non-stationary, series appear related by traditional tests (Hansen, 2022). First, the variables in the foreign block are tested for stationarity using the Augmented Dickey-Fuller (ADF) test, in which the null hypothesis is the presence of a unit root. Additionally, for all ADF tests, the results from the lag selection test dictate the number of lags included in the null hypothesis for each country and variable. The chosen significance level for determining the stationarity of the series is set at the conventional 5 percent. The results of the foreign sector are presented in table 4 below.

Table 4. Augmented Dickey-Fuller test for unit root. H0: Unit root. Foreign sector

	Global Demand	Oil Price	ΔOil Price
p-value	0.0025***	0.1819	0.0000***

*** *p<0.01, **p<0.05, * p<0.1*

As the null is rejected for Global Demand it is concluded that this variable is stationary in levels, whereas the oil price is stationary only after taking first differences. Next, in table 5, the variables of the domestic sector for all countries are tested for stationarity.

Table 5. Augmented Dickey-Fuller test for unit root. H0: Unit root. Domestic sector

Notes: Number of lags according to AIC are included in the test

Country	IPI	Inflation	Interest Rate	Exchange rate	ΔIPI	ΔInterest rate	ΔExchange rate
Canada	0.7689	0.0000***	0.1809	0.5053	0.0000***	0.0000***	0.0000***
Germany	0.6475	0.0000***	0.3055	0.4086	0.0000***	0.0000***	0.0000***
United Kingdom	0.4888	0.0000***	0.7148	0.0824	0.0000***	0.0000***	0.0000***
France	0.3647	0.0000***	0.5345	0.1510	0.0000***	0.0000***	0.0000***
Italy	0.2631	0.0000***	0.6648	0.0358**	0.0000***	0.0000***	0.0000***
Japan	0.0684*	0.0000***	0.7519	0.2587	0.0000***	0.0000***	0.0000***
United States	0.6797	0.0000***	0.0863*	N/A	0.0000***	0.0000***	0.0000***

**** p<0.01, **p<0.05, * p<0.1*

The Japanese IPI and American interest rate are significant at the 10 percent level, but as the significance level in this thesis is set at 5 percent, they are regarded as non-stationary in levels and hence differenced. Both series are stationary in first differences. The null hypothesis of a unit root is rejected for the Italian exchange rate. However, it is not the unit root itself that is important at this stage, it is the non-stationary behaviour of the series. Visual inspection of the Italian exchange rate shows clear cyclical behaviour, see Appendix 1, and consequently, the series is included in first differences where it is stationary. Resultingly, except for inflation, all variables used in the following sections are first differenced versions of the data presented in table 2.

Since a majority of the series are unit root processes in levels, they may be cointegrated which refer to a possibility of some long run relationship among the variables (Hansen, 2022). However, in the oil-inflation SVAR literature, it is often the short-run relation among variables that is of interest and models are thus commonly estimated on stationary variables, oftentimes expressed in differences, logs or log differences (see for example Kilian, 2009 and Pham & Sala, 2020). Based on this methodology, the following model and subsequent analysis will be performed on differenced series, thus disregarding the long-run relation among variables.

For clarity, the estimated equation for Canada is presented below. According to the AIC, 2 lags of the endogenous variables should be included. Based on ADF-test, all variables except for Global Demand and Inflation are included as first differences, Δ being the difference operator.

$$\begin{bmatrix} Global\ Demand_t \\ \Delta Oil\ Price_t \\ \Delta Output_t \\ Inflation_t \\ \Delta Interest\ Rate_t \\ \Delta Exchange\ Rate_t \end{bmatrix} = \begin{bmatrix} a_{1,1}^1 & \cdots & a_{1,6}^1 \\ \vdots & \ddots & \vdots \\ a_{6,1}^1 & \cdots & a_{6,6}^1 \end{bmatrix} * \begin{bmatrix} Global\ Demand_{t-1} \\ \Delta Oil\ Price_{t-1} \\ \Delta Output_{t-1} \\ Inflation_{t-1} \\ \Delta Interest\ Rate_{t-1} \\ \Delta Exchange\ Rate_{t-1} \end{bmatrix} + \begin{bmatrix} a_{1,1}^2 & \cdots & a_{1,6}^2 \\ \vdots & \ddots & \vdots \\ a_{6,1}^2 & \cdots & a_{6,6}^2 \end{bmatrix} * \begin{bmatrix} Global\ Demand_{t-2} \\ \Delta Oil\ Price_{t-2} \\ \Delta Output_{t-2} \\ Inflation_{t-2} \\ \Delta Interest\ Rate_{t-2} \\ \Delta Exchange\ Rate_{t-2} \end{bmatrix} + \begin{bmatrix} D_{1,1} & \cdots & D_{1,6} \\ \vdots & \ddots & \vdots \\ D_{6,1} & \cdots & D_{6,6} \end{bmatrix} * x_t + \begin{bmatrix} \varepsilon_{1,t} \\ \vdots \\ \varepsilon_{6,t} \end{bmatrix} \tag{12}$$

Here, $a_{i,j}^k$ is element (i,j) of $A_k = A^{-1}C_k$, see (6) and (7). Following steps (1) – (10) in section 4.1 and the imposed restrictions on A and B in 4.2, the estimated parameters of the above equation are used to recover the structural parameters. The sign and significance of the elements of the matrix D capture the effect of being in a period characterised by relative oil dependence, measured as above mean oil dependence for the period 1980-2021. If significant, the sample will be split into two based on this indicator variable to further investigate the impact of oil dependence on the transmission of oil price fluctuations into inflation.

5. Empirical Results

In this section, the model as presented in section 4 is estimated for each of the G-7 countries. The model is first run using the full sample for all countries, after which the sample is split into a period when the countries are regarded as oil dependent and oil independent, respectively. The basis of this split is the oil dependency variable as described in section *3.2*. Next, the model is estimated for each of the subsamples and impulse responses are compared to determine the effect of oil dependency on the transmission of oil price shocks onto inflation. The section is completed with a robustness analysis.

5.1. Estimation and Impulse Response Functions

The structural VAR model is estimated based on the variables, tests and adjustments presented in chapters 3 and 4. The structural coefficients themselves, that is the elements of matrices A and B from chapter 4 are not of primary interest as the analysis in the (S)VAR framework is usually performed using visual tools based on these estimated coefficients, although they are found in appendix 2. Of importance at this initial stage, however, is the sign and significance of the exogenous oil dependency variable found in table 6 below.

Table 6. Point estimates and p-values of the oil-indicator in the inflation equation (equation 12)

Country	Canada	Germany	France	Italy	Japan	United Kingdom	United States
Coefficient[3] p-value	0 .122*** (0.000)	0.111*** (0.001)	0.110*** (0.000)	0.118*** (0.000)	0.158*** (0.000)	0.258*** (0.000)	0.1037*** (0.010)

For all countries, the indicator of oil dependency is significant and positive. Since a country is defined as oil *dependent* in periods where the oil consumption, normalized by GDP, is above its mean value, this suggest a higher intercept in the equation for inflation in periods of oil dependency compared to when the economy is regarded as oil independent. To investigate this further, a sample split is proposed based on this indicator variable. In table 7 the time periods in which the country is deemed as relatively oil dependent and oil independent is presented.

[3] These coefficients are difficult to interpret quantitatively. Dummy variables are often included in the VAR framework when, as in this thesis, the is focus on the dynamics of other variables in the system (see for example Jakab & Kaponya, 2010)

The periods when a country is regarded as oil dependent independent differ among countries. What also differs is how oil dependent/independent the country is in absolute terms. The mean of the variable oil dependency when Canada is deemed as oil independent is for example 0.923 whilst the same mean for France is 0.420. This means that France, in absolute terms, consumes less oil per unit of GDP than Canada in the oil independent period, and this is also true for the oil dependent period. Therefore, the subsequent results and analysis will be in terms of relative differences within and between the G-7 economies. The periods when the G-7 countries are defined as relatively oil dependent and independent are found in table 7 below.

Table 7. Years of oil dependence/oil independence

Notes: The table was generated using data of the variable oil dependency described in section 3.2.

Countries	Oil Dependent	Mean	Oil Independent	Mean
Canada	1980-1990, 1992-1999, 2001-2002	2.221	1991, 2000, 2003-2020	0.923
Germany	1980-1991	1.701	1992-2020	0.580
France	1980-1993, 2000	1.368	1994-1999, 2001-2020	0.420
Italy	1980-1989, 1993-1995, 2000	1.306	1990-1992, 1996-1999, 2001-2020	0.483
Japan	1980-1990	1.540	1991-2020	0.530
United Kingdom	1980-1994	0.616	1995-2020	0.580
United States	1980-1996	1.87	1997-2020	0.753

After splitting the sample, the same model as before is run in both samples although excluding the exogenous variable. Each of the figures in Graph 3 depict the evolution in the inflation variable due to a one standard deviation shock in oil prices. Note that it is the average effect in the period considered that is depicted in the following IRFs.

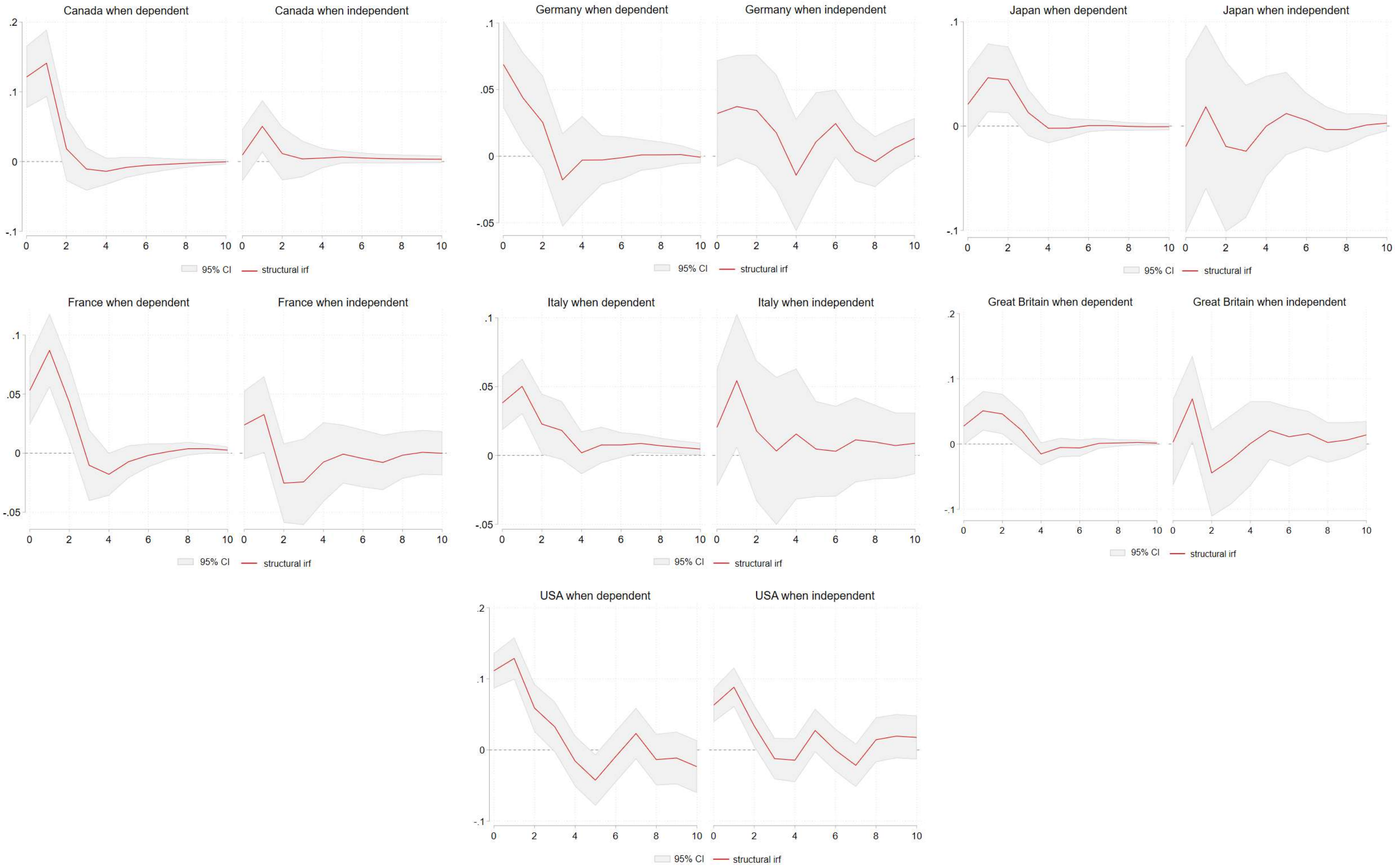
The results for Canada, presented in graph 3, suggest that Canadian inflation is affected by an oil price shock in both sample periods, however with a larger magnitude in periods when the economy is characterized as oil dependent. In periods of relative dependence on oil, a shock in oil prices immediately transmits into a 0.12 percent increase of CPI inflation which grows somewhat in the first month following the price shock. The impact of the shock lasts for approximately two months as zero is included in the 95 percent confidence interval two perio9ds after the shock was initiated. In contrast, for periods of relative oil independence, the shock in oil prices appears to have no immediate effect on the Canadian CPI inflation as the impulse is only significant for the first period following that of the shock. Here, a one standard deviation shock in oil prices transmit into a 0.05 percent increase of CPI inflation, an effect which after one period is no longer significantly different from zero. That is, peak response of inflation in the period of relative oil independence is less than half of the response of a similar shock in a period of relative dependence.

Similar to the Canadian results are those corresponding to the United States. In the US, the effect of a shock in oil prices on inflation is significant within the same period in both subsamples, although the transmission of the shock to inflation is more prominent when the economy is relatively dependent on oil. Immediately following the shock, American inflation respond with an increase of around 0.11 percent in periods of oil dependence while the response is an increase of 0.063 when independent. The effect is, regardless of subsample considered, more persistent in America than in Canada as it continues to affect inflation until the third period following the shock. Additionally, the magnitude of the response in inflation is rather similar in Canada and the US in periods of relative oil dependence. Whenever relatively oil independent, the size of the US inflation response exceeds that of the Canadian.

The UK, just as Canada, experiences a response in inflation within the same period as the oil price shock when relatively oil dependent, which grows over the following period. The British response is however more persistent than the Canadian and more resembles that of the American inflation as the response stays significant coming into the third period. In Britain, inflation initially jumps to 0.027 and peaks at a 0.05 percent increase one month following the shock. Turning to the period when Britain is considered relatively oil independent, the response of inflation is statistically significant in the period following the oil price shock, thus there is an effect with a lag. This suggests a similar response as in Canada. As this effect is estimated with such low precision, although statistically significant, it is considered too uncertain to base conclusions on regarding the oil-inflation relationship. The same applies to the Italian response in times of relative oil independence. Although statistically significant, the effect is measured with too much uncertainty and carries little economic significance to form conclusions based on this estimate. Thus, for the remainder of this thesis, these two estimates are considered insignificant.

Graph 3. Impulse Response Functions, main specification

Notes: The estimated ten-month evolution of inflation following a one standard deviation shock of oil prices.



The remaining European economies: Germany, France, and Italy, all show similar impulse responses. The impact of an oil price shock on inflation is insignificant when these economies are relatively independent of oil, whilst the effect is significantly positive whenever characterized as relatively dependent on oil. As with the Canadian results, the effect in inflation grows initially up to the first period following the shock in both France and Italy while it steadily decreases in Germany for periods subsequent of the shock. The shock affects Germany and Italy for two periods following the impulse while the confidence intervals stay outside zero for France into the third period. In Germany, the initial response in inflation is an 0.68 percent increase, which then decreases rather linearly over the course of two periods. The French inflation immediately responds with a 0.53 percent increase following a shock, which grows to 0.87 in one month time. The effect diminishes and dissolves coming into the third period. Of these three countries, the Italian response is of the smallest magnitude with the impact on inflation peaking at 0.05 percent.

Like the mainland European countries, the Japanese inflation does not respond to oil shocks whenever the economy is relatively independent of oil, although this estimate is very uncertain in the initial months following a shock. The evolution of the Japanese inflation response is different than that of the remaining G-7 countries as the impact of an oil price shock is first visible in the period following the shock when relatively oil dependent. This suggest that the transmission of oil price shocks into inflation is relatively sluggish in Japan compared to the other G-7 economies. When significant however, the magnitude and evolution of the inflation response is like that of the British, reaching a maximum effect of approximately 0.46 percent in the period following the shock.

5.2. Forecast Error Variance Decomposition

The IRFs in the previous section are useful for estimating how a shock in one variable affects other variables in the model. Also interesting is to investigate how important a shock in one variable is to the evolution of a response variable, compared to the other variables included in the model. That is, the question is how much of the variation in one (response) variable is due to a shock in another (impulse) variable (Lütkepohl, 2005). To investigate this, Forecast Error Variance Decomposition (FEVD) are used to measure the fraction of the total forecast error variance of an endogenous variable that is attributed to orthogonalized shocks to itself or to other endogenous variables (StataCorp, 2013). Given the purpose of the thesis, interest naturally lie in the share of the inflation forecast variance attributable to an oil price shock. The corresponding FEVDs are found in graph 4.

In contrast to the results from the impulse responses in graph 3, the general pattern with the FEVDs is that an oil price shock in period 0 transmits into an effect in inflation error variance not initially but over the course of 2 months. After these two months, the fraction stays constant for at least 10 periods for all economies except for the US where it slightly decreases after 4.

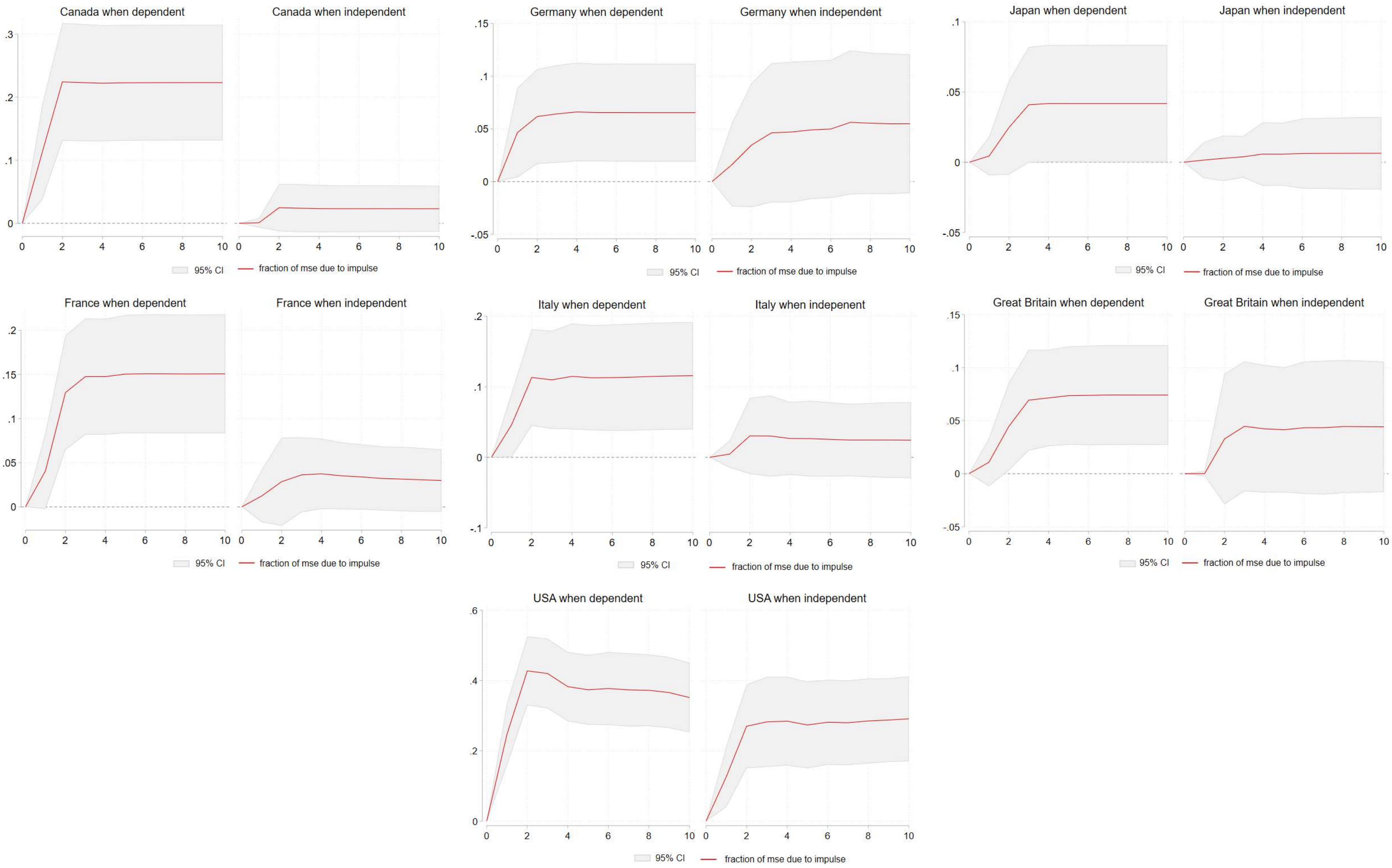
The forecast error variance decomposition of Canada is the top left figure presented in graph 4, where clear differences between time periods appear. When regarded as relatively oil dependent, the point estimate suggests that 22.4 percent of the variance of the inflation forecast error is attributed to a shock in the oil price while the corresponding number for the period of relative oil independence is not significantly different from zero. The same picture is evident for all other countries except for the US, a non-zero fraction of the forecast error variance of inflation only can be attributed to oil price shocks in periods of relative oil dependence for the G-7 countries. However, just as seen from the impulse responses of figure 3 above, the magnitude of this fraction differs among countries.

The largest fraction of inflation error variance caused by an oil price shock is found in the US, hence, since this is coherent with the results of the IRFs, the US is the G-7 economy that responds with the largest magnitude to an oil price shock. Here, around 40 and 30 percent of the error variance of inflation is due to an oil price shock in periods of relative dependence and independence of oil, respectively. Note that the fraction, in periods of relative oil dependence, peaks at 42 percent which decreases to 35 percent over the 10 periods considered. In contrast, when relatively oil independent, the fraction stays close to 30 percent for the entire 10 period duration. This is to be compared to the euro area, British and Japanese fractions which are, when oil dependent, estimated between 5 and 15 percent. Among these it is the French inflation error variance which is most vulnerable to an oil price shock with a fraction of 15.1 percent while the Italian counterpart is 11.3 percent.

Germany, Japan, and the UK are the economies in which the error variance of inflation is least suspectable to oil price shocks. The estimated fraction for the UK and Germany is between 4 and 7 percent while the Japanese is slightly below at 4.1 percent. The results for Japan should however be taken with caution as the lower bound of the confidence intervals is almost tangent to zero.

Graph 4. Forecast Error Variance Decompositions, main specification

Notes: The estimated share of inflation forecast variance due to a one standard deviation shock to the oil price.



5.3. Robustness Tests

As robustness tests, the same estimations presented above are run exchanging some variables in the model. Here, oil dependence is instead measured depending on the share of oil in the energy mix. In the second robustness test the price of oil, which originally is measured as the average oil price, is swapped for the price of brent oil specifically. And finally, CPI is substituted for the Producer Price Index (PPI). The robustness tests are run exchanging one variable from the main model at a time.

Note, however, that the same ordering among the variables as in section 4.1 applies. Since the ordering reflects the causal relation among variables which is determined by using economic reasoning (Hansen, 2022), simply changing the order of the variables in the model changes the contemporaneous dependence and so forth the causal relation. Since the ordering of variables in the original specification is theoretically and empirically founded, see section *4.2 Identification*, changing the order would impose a set of exclusion restrictions different from that suggested in the literature.

5.3.1. Determining Oil Dependency Using Share of Oil in the Energy Mix

Important to the results presented above is the variable from which the relative oil dependence and independence is determined. Therefore, as a first robustness check, an alternative variable to perform this categorisation is introduced. This new variable is defined as the share of oil in a country's energy mix, more specifically the per capita energy consumption stemming from oil in relation to the total per capita energy consumption. This data is collected from the Ritchie et al. (2020) dataset of Our World in Data.

$$alt\_oil\_dependency_t = \frac{per\ capita\ energy\ consumption\ from\ oil_t\ (kWh)}{total\ per\ capita\ energy\ consumption_t\ (kWh)}$$

In the same manner as oil dependency was previously defined (see section 3.2), the sample is split at the mean and periods of relative oil dependence are compared to those of relative oil independence. Note that performing the sample split based on this alternative variable results in a different characterization of periods which might influence the results. The point estimates of the dummy variable in the inflation equation are found in Appendix 3.

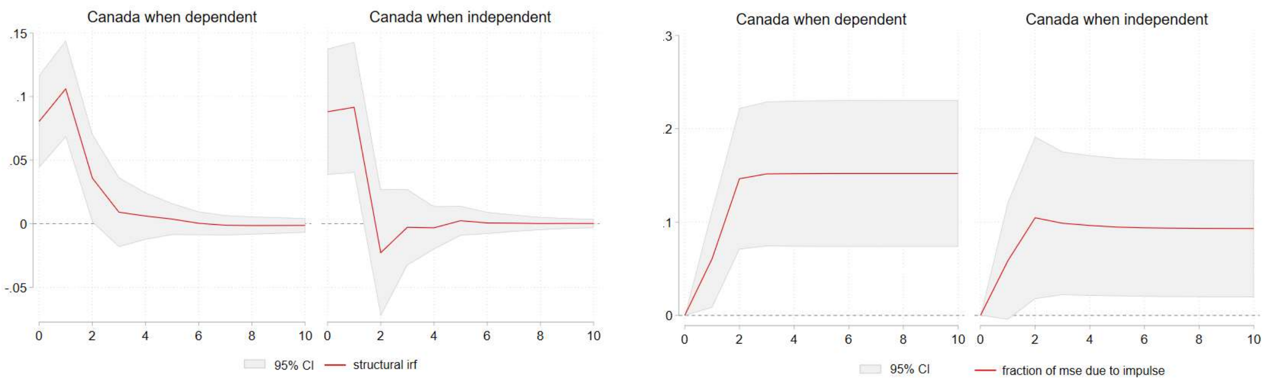
What stands out in this alternative way of defining the sample-split is the IRF and FEVD of Canada differs from the main results. The IRF in the robustness test have a significant initial effect in periods when Canada is both oil dependent and independent, compared to the main specification where oil prices affecting inflation only with a lag in periods of relative oil independence. The FEVD for Canada also differs from the main results with non-zero fractions of the inflation forecast error variance attributable to oil price shocks in both periods. This is puzzling, although can be a result of the different time periods studied in the two specifications. When dividing the sample according to share of oil in the energy mix, years classified as oil dependent include more years in during 2000-2010 period and this likely impacts the results (see Appendix 4).

Another major difference from the main results is that when relatively oil independent, the American inflation enters negative territory for one period four months after an oil price shock, see graph 5 below. Although, the negative trajectory only lasts for one month then return to insignificant territory.

With this in mind, the main results of 5.1 and 5.2 stay relatively robust to this alternative way of defining oil dependence and categorising periods as relatively dependent and independent of oil. As before, an oil price shock impacts German, French, Italian and Japanese inflation only in periods of relative oil dependence with about the same magnitude as in the main specification of the model.

Graph 5. Impulse Response Function and Forecast Error Decomposition: Canada

Notes for first figure: The estimated ten-month evolution of inflation following a one standard deviation shock of oil prices. Notes for second figure: The estimated share of inflation forecast variance due to a one standard deviation shock to the oil price.



For the remaining IRFs and FEVDs, see appendix 5 and appendix 6, respectively.

5.3.2. Replacing Average Oil Price with Brent Oil Price

As a second robustness test, an alternative price of oil is used. For the results in 5.1 and 5.2, the equally weighted average of Brent, Dubai and WTI crude oil was used, here the same specifications are run using only the price of crude Brent oil. The prices of the three different types of crude oil are of course closely related, although some authors tend to favour Brent oil, (see for example: Chancharoenchai & Ibrahim, 2013; Wang, Wu & Yang, 2014). The corresponding IRFs and FEVDs are found in appendix 7 and appendix 8, respectively.

The resulting responses in inflation to an impulse in the Brent oil price is arguably identical to the case in which the average oil price was used. Canadian, British, and American inflation are affected positively in both periods of relative oil dependence and independence, although the Canadian and British inflation respond with a month's lag. The magnitude of the response of inflation in periods of relative dependence is largest in Canada and the US. The remaining countries also show results similar to those of the main specification with a significant effect on inflation only in periods of relative oil dependence, the magnitudes of the responses are also coherent with those from the main specification.

5.3.3. Replacing Consumer Price Index with Producer Price Index

There are two main measures of inflation in the economy, Consumer Price Index (CPI) and Producer Price Index (PPI). PPI measures the rate of change in prices of products sold as they leave the producer, and the data is retrieved from OECD (2022). The PPI is often seen as an advanced indicator of price changes throughout the economy, a measure of inflation from the perspective of the producers. Therefore, as an alternative to the inflation in consumer prices, the inflation in producer prices is used as a robustness check. These results are presented in appendix 9 and appendix 10 respectively.

Here, the results differ from those of the original specification in that the impact of an oil price shock on inflation is significant in both periods for all countries, although with larger magnitude in periods of relative oil dependence and only initially for the French inflation. In general, an oil price shock yields responses in producer prices of a magnitude about two to three times larger than that of consumer prices. This magnitude is likely the reason why the impact of an oil price shock on inflation in periods of relative independence is insignificant when measuring inflation with consumer prices while significant and positive when measured as producer prices. The picture of oil prices having a larger effect in periods of relative oil dependence compared to relative oil independence remains, however.

The reason for oil prices having a larger impact on producer than consumer prices reasonably depend on the fact that the goods included in the producer basket generally holds more oil intense goods. This simply because most of the burning of fossil fuels, apart from for example transportation, happen on the producer side of the economy. Examples of this include the refinement of raw material, industrial heating and operation and the supply chains needed to ensure a steady delivery of finished products. Based on this, it seems reasonable that inflation responds more resolutely to an oil price shock when measured in producer prices compared to consumer prices.

5.3.4. Summary of Robustness Tests

Important for the analysis of the results are particularly three elements. The results should not be heavily dependent on either the choice of variable based on which the sample is split, the way inflation is measured or the included price of oil. As seen throughout the presentation of alternative ways of defining these important variables, the results of 5.1 and 5.2 are robust to substituting producer prices for consumer prices, the average oil price for the brent oil price as well as measuring oil dependency as the share of oil in the energy mix rather than the volume of oil consumed. As different ways of measuring the same thing yields coherent results, it speaks for the validity of the study.

6. Analysis and Discussion

In this chapter, the results presented in the previous chapter will be analyzed and discussed. To make the analysis as comprehendible as possible, the G-7 countries are divided into three groups based on similarities in how their inflation responds to an oil price shock. Each of the three groups will be discussed and analysed separately and the chapter ends with a subsection analysing the common trends of the countries.

As stated in chapter 1, the hypothesis of this thesis is:

* Oil price shocks will have a smaller effect on inflation when counties are less oil dependent

The previous chapters were devoted to presenting a framework in which this hypothesis could be tested. In the main results (graphs 3 and 4) it has been made clear that there is a difference in how inflation responds to an oil price shock depending on whether the country is relatively more or less oil dependent. These results are also prevalent in the alternative specifications of the model presented in the robustness analysis section, see section 5.3.

Based on the results from the IRFs and FEVDs presented in graphs 3 and 4 in section 5.1 and 5.2, respectively, three distinct groups in which the countries display similar results can be identified. The first group consists of the US as it is the only economy for which the IRFs indicate that an oil price shock has an immediate positive effect on inflation in both periods of oil dependence and independence, although of larger magnitude in periods of relative dependence. Also evident from graph 3 is that oil price shocks affect inflation more in the US compared to the rest of the G-7 countries, a result consistent with those of Wen et al. (2021). Further, the FEVDs portray the US as the only economy where the oil price is responsible for a non-zero fraction of the inflation error forecast variance in both subsamples.

From the FEVDs, no further distinction can be made, although information from the IRFs suggests further separation among the G-7 economies. As seen in graph 3 (IRFs), the Canadian inflation responds to an oil price shock with a one period lag when regarded as relatively oil independent, a feature distinct for this country. Therefore, Canada will form the second group.

The third group consists of the remaining countries which are Italy, the UK, Germany, Japan, and France where oil prices transmit into inflation only in periods of relative oil dependence according to the IRFs of graph 3. Additionally, the variance of the inflation forecast error is affected by oil price shocks only in periods of relative oil dependence for these countries.

6.1. The United States

The US economy is the largest consumer of oil in absolute terms as well as the world's largest economy, which translates into the US potentially being affected differently from an oil price shock compared to the other G-7 countries. Comparing periods of relative oil dependence and independence, smaller effects are seen when the US is regarded as independent of oil. Since the US is defined as relatively oil dependent in 1980-1996 and relatively independent between 1997-2021, it suggests that the transmission mechanism of direct and indirect effects as presented in section 2.1 has decreased over time with the oil dependency.

Direct effects work through the demand side as goods which are closely related to oil, to some extent is included in the consumer basket, these goods include for example gasoline and petrol. Indirect effects on the other hand work through the supply side of the economy, affecting producers through price increases of, among other things, inputs, energy, and heating. Thus, an oil price shock transmits into inflation fast through the direct channel as consumer goods immediately become more expensive, thus, inflation measured as CPI increases directly. This is illustrated in graph 3 (see figure for USA) as inflation responds to a shock directly. The indirect effect will hit producers right away but since few goods consumed by producers are included in the basket which is used to calculate the CPI, this effect likely influences CPI with a lag. Indeed, as seen in figure 3, US inflation continue to increase into the first month after a shock in the oil price, this is likely due to the inflation in producer prices which spills over to consumer prices. This explanation seems credible given the evolution in PPI to an oil price shock as presented in the robustness tests, here, inflation in producer prices is initially high and decreases in each subsequent period following that of a shock.

The figure for the US economy in graph 4 shows the FEVD. The FEVD for the US is remarkably similar for the period of the US being relatively oil independent compared to the period of relative oil independence. This means that oil price shocks are roughly similar in the importance to the volatility of the evolution of inflation in both time periods. Again, this could be a result of the US being the largest consumer of oil in the world. Naturally this could mean that even if the US is moving towards less oil dependent ways, the oil still constitute large share of the economy and will therefore continue to impact consumer prices.

6.2. Canada

Although district from the US, Canada is still very different from the remaining economies as the mean of oil dependency is considerably higher in Canada compared to the others (see table 7). In relative terms, Canada is more oil dependent than the US, however, the US economy consume more oil in absolute terms which may be why the results are of larger magnitude for the US than for Canada. Additionally, Canada is the only net exporter of oil among the G-7 countries, which means that Canadas economy is more vulnerable to oil price shocks. This could be because of the indirect channel through which oil prices affect inflation, as described in section 2.1. The indirect effects work through the supply side and as such, it mostly affects producers. That is, producers are directly affected in the period of the oil shock which then transmits into the demand side as firms revise prices upwards due to the new higher costs. This spill-over to consumer prices happens with a lag, which is seen in graph 3 in the results section as the Canadian CPI responds to an oil price shock first in the period following the shock. Canada experiences the largest increase in inflation following an oil price shock among the small open economies in the sample. An explanation of this may again be related to the status of Canada as a net exporter of oil. As mentioned in section 2.1., positive oil price shocks lead to an increase in income of the country which in turn increase the purchasing power of the country, as well as prices. That is, on top of the price increase occurring due to the indirect and direct effect mentioned above, Canada experiences a surge in purchasing power that further increases inflation.

The FEVD for Canada presented in graph 4 illustrates that in periods where Canada is relatively less oil dependent, oil price shocks do not explain any of the variation in inflation. When oil dependent on the other hand, after two periods, an oil price shock explains around 20% of the variance in inflation. This is in line with our hypothesis and could mean that shocks in the oil price will not influence countries inflation when they move towards more oil independent ways.

6.3. The United Kingdom, Italy, Germany, France & Japan

The remaining G-7 economies are in general different from the US and Canada in that they, in absolute terms, consume less oil per unit of GDP. This is visible in table 7 as the mean value of the variable of oil dependency is notably lower for this group of countries, both in periods when regarded as relatively dependent and independent. As an illustrative example, the Canadian mean value of oil consumption normalized by GDP is 0.923 when Canada is considered as relatively oil independent, approximately double that of every country in this third group. As such, it is reasonable that the impulse in oil prices cause a weaker response in inflation for these countries regardless of whether periods of relative oil dependence or independence are considered. This is evident from the results of the IRFs presented in graph 3, that is, inflation in the third group does not respond as forcefully to an oil price shock as Canadian or US inflation does.

A way of viewing the, compared to Canada and the US, low oil dependency is that the share of oil used for each unit of economic output is much lower in the UK, Italy, Germany, France, and Japan. Therefore, an oil price shock will naturally transmit into a lower effect on inflation simply because of the lower weights on oil goods in both the demand and supply side in group 3 compared to 1 and 2. As such, the direct and indirect effect are weaker here.

The above discussion explains why there is a difference in the magnitude of the inflation response following an oil price shock between the groups previously identified. The within group comparison among countries paints a coherent picture as the inflation in all countries considered here respond to oil price shocks whenever considered relatively oil dependent but not in periods of relative independence. That is, whenever dependent on oil, direct and indirect effects are strong enough to cause significant responses in inflation. Just as before, direct effects work through the demand side and consumer goods while indirect effects operate on the supply side, inducing higher costs for the producers. On the supply side, oil price shocks affect producer prices which over the course of a month spills over to consumer price inflation for all countries in this group except for Germany. This was unexpected but likely due to country specific characteristics. The magnitude of the inflation response also differs across the countries in this group, this is mainly explained by differences in market structure shares of oil-influenced goods imported.

6.4. Common trends

The analysis conducted in the sections above can explain the results on a country-level. Still, there are trends common to all G-7 countries visible in the results of chapter 5 which are left unexplained by the framework of direct and indirect effects. Therefore, in complement to the above analysis, mechanisms presented in the theoretical framework of section 2 are used to interpret and explain the results.

The most prominent common trend noticeable in the results presented is that an oil price shock leads to an immediate response in inflation which vanishes after 2-3 months. This could be related to the Philips curve framework presented in section 2.1 above. That is, the oil price shock is able to create the initial movement towards higher inflation along the same Philips-curve. But since this initial increase is seen to vanish after a rather short period of time, the shock is not able to induce an upwards revision in the general inflation expectations in the economy. Had this happened would there, for example, be a demand for higher wages which would provide further upwards pressure on inflation. However, as the initial positive response in inflation vanishes over the course of at most four months (see Graph 3), it implies that the economic agents of the G-7 economies regard the oil price shock as transitory. These results of only a temporary effect of oil price shocks on inflation are similar to those of for example Cologni and Manera (2008).

In most of the results presented in chapter 5 there is a difference for all countries between oil dependent and oil independent periods. This trend can be discussed in relation to the market power theory explained in section 2.1. In this section it is argued that dominant corporations operating on uncompetitive markets leads to higher prices and that the global oil market can be characterized as such a market due to the OPEC influence. However, as a results of technological advances and new oil findings, the US has over the course of the last decade become the world's largest producer of crude oil. This, in addition to Canada being a large net exporter of oil, has arguably worked towards decreasing the OPEC market power and thus their ability to control quantities and hence prices on the global oil markets. As this shift has occurred over the course of the latter part of the sample considered in this thesis, the general result that the transmission of oil price shocks into inflation has decreased over time could be seen in light of the Market Power Theory. That is, as the OPEC market power decreases, the degree of exogeneity in the price-setting of oil has arguably decreased. Since the US and Canada are such important actors on global oil markets, the global oil market is likely not as exogenous as it once was for the G-7 countries. As the terms and conditions of the oil market is now more influenced by the G-7 countries, shocks on that market will likely induce less of a response in macroeconomic variables in general, and to inflation in particular, as seen in graph 3. This claim is supported by for example Valcarcel & Wohar (2013) where it is argued that the oil-inflation pass-through varies over time with factors such as changes on the global energy markets. In that paper, the increase of Chinese oil demand is used as an example of such a change. In the context of this thesis, it is rather the increase of American and Canadian oil supply that has induced changes on the global market.

7. Conclusion

The aim of this thesis was to determine if there is a difference in the effect of an oil price shock on inflation depending on weather the country is relatively more or less oil dependent. By investigating evidence from the empirical oil-inflation literature as well as presenting theoretical arguments of determinants of inflation the hypothesis that the transmission of oil price shocks into inflation will diminish with the oil dependency of a country was formed.

In order to model the impact of oil price shocks on inflation, data on inflation, oil prices, global demand, output, exchange rates and interest rates was gathered, and a Structural Vector Autoregressive (SVAR) model was identified for each of the G-7 countries. To quantify the extent to which the G-7 countries are dependent on oil, oil dependency was measured as domestic oil consumption normalised by GDP. In this thesis, a country is regarded as relatively oil dependent in periods where the oil dependency-variable is above its mean value based on which a dummy variable capturing this distinction was defined. To empirically test the hypothesis, the dummy variable was included as an exogenous variable in the SVAR model for each of the countries. When estimating the model, the oil dependence-variable is significant and positive for all countries, which indicates a difference between the two subperiods. This was in line with the hypothesis and motivates further investigation. Based on the dummy variable, a sample split was proposed, and the SVAR model was re-estimated in each of the subsamples. Next, Impulse Response Functions (IRFs) and Forecast Error Variance Decompositions (FEVDs) were estimated and compared within and across countries.

An oil price shock is, according to the existing literature, expected to affect inflation through mechanisms operating on the demand and supply side, known as direct and indirect effects respectively. Direct effects work through the demand side as goods which are closely related to oil are included in the consumer basket, these goods include for example gasoline and petrol. Indirect effects on the other hand work through the supply side of the economy, affecting producers through price increases of inputs, energy, and heating among others. Thus, an oil price shock will likely transmit fast into inflation through the direct channel as consumer goods become more expensive right away. The effects from the supply side, the indirect effects, likely transmit into inflation measured in consumer prices with a lag as the price increases would have to spill over from the producer side onto consumer prices for CPI to respond. Thus, when countries become relatively less dependent on oil, both the mechanisms behind the direct and indirect effect should be weakened and lead to inflation being less impacted by an oil price shock. This implies that an oil price chock will have a smaller impact on inflation in the sample period where the country is classified as oil independent compared to oil dependent.

The results presented in chapter 5 is supportive of this hypothesis, there is a meaningful difference in the transmission of oil price shocks into inflation depending on the level of oil dependency in a country. For all G-7 economies, the results unanimously point to a weakened transmission of oil price shocks into inflation as the countries shift from being relatively oil dependent to relatively independent. That is, as a country rely relatively less on oil, an oil price shock yields a weaker response in inflation compared to a period in which the country is relatively more oil dependent. This may be explained using the Philips Curve framework and by noting that the results of chapter 5 suggest that the economic agents of the G-7 economies regard the oil price shock as transitory. That is, the initial increase in inflation following an oil price shock is not enough for the agents to update their inflation expectations. Also, from table 7 it is shown that the G-7 countries to a large extent is regarded as relatively oil independent in the later part of the sample period. As such, the weakened transmission of oil price shocks into inflation may also be affected by the increased influence of the US and Canada on the global oil market, and thus the decreased market power of OPEC.

The magnitude of which the oil-inflation relation has decreased, however, differs among the economies in the sample. These results are in line with previous research finding a temporary effect of innovations in the oil price on inflation (see for example Cologni & Manera, 2008; Jiranyakul, 2015).

The US is found to be the country whose inflation is most vulnerable to oil price shocks. An explanation to this is that the US is the largest economy and consumer of oil in absolute terms. Here, an innovation in the oil price causes immediate 0.11 and 0.063 percent increases in inflation in periods of relative dependence and independence, respectively. In one month´s time, the response peaks, after which it decreases and vanishes after three months. Compared to the remaining countries, the importance of oil in the American economy is so pronounced that the direct and indirect mechanisms are strong enough to generate immediate responses in inflation even when the economy is considered relatively oil independent. This result is unique to the US. The only other economy in which inflation, whenever oil independent, responds to an oil price shock is Canada, however, in this case the response is visible only after a one-month lag following the shock. The Canadian behaviour is explained by weak enough direct effects not to cause inflation, but stronger indirect effects. The indirect effects operate on the supply side of the economy, thus causing immediate effects in producer prices (as seen in the robustness analysis) which manage to spill over onto consumer prices over the course of one month. This is likely the mechanism responsible for the "one-month lag" effect seen in Canada. Although, the Canadian results may also be influenced by being the only net oil exporter in the sample.

The remaining countries display responses in inflation to oil price shocks only in periods in which they are characterised as relatively oil dependent. The inflation in all these economies respond with positive immediate effects of an oil price innovation which increases and peaks after one month in Japan, France, Italy, and the UK. Only in Germany does the initially positive response fade rather linearly. This second round effect is what is referred to above as the "one-month lag" effect. That is, the oil price shock has an impact on both the supply and demand side in the economy, inflation measured with consumer prices responds immediately while it takes one month for the effect to spill over from producer to consumer prices.

In conclusion, the dependence of oil in a country influences the transmission of oil price shocks onto inflation among the G-7 countries. Inflation, measured in consumer prices, responds more in periods of relative oil dependence compared to periods of relative oil independence. This result hold for all G-7 countries, although the magnitude with which the inflation responds to an impulse in oil prices differ. The results are mainly explained by direct and indirect effects which translates to demand and supply side responses to higher prices, respectively. In future research, it would be interesting to examine if the results differ depending on weather the oil price shock is a demand or supply shock. It would also be interesting to split the sample based on some absolute level of oil intensity, compared to the relative measure used in this thesis.

The results presented in this thesis contribute to a further understanding of the sometimes dubious and puzzling relationship between oil prices and inflation. Today, with political and technological advances paving the way for a lower dependence of oil in western economies, this relationship is arguably more important than ever. Especially in the light of the recent Russian invasion of Ukraine which caused oil prices around the world to spike, an event which also emphasises the global and political risks associated with relying on oil from geopolitically unstable regions. This could be a motive for nations to strive towards an economy less dependent on oil. In general, the results of chapter 5 and the subsequent analysis suggest that when a country transitions to a lower dependence of oil, inflation, and thus the whole economy, will become less affected by oil price shocks. It also suggests that if counties had not decreased their dependence on oil, the recent increase in oil prices would have had far larger effects on inflation and consequently, the macroeconomy in general.

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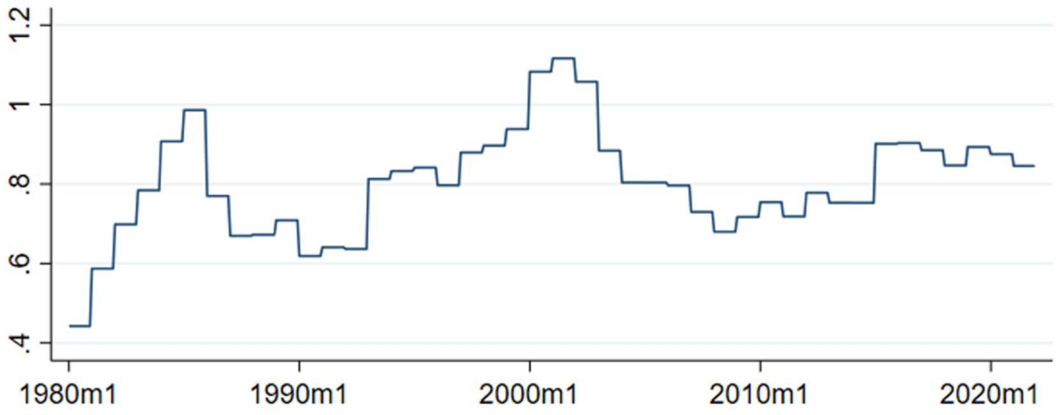
9. Appendix

Appendix 1. The Italian national currency units per USD

Notes: The graph was generated using data of the Italian exchange rate retrieved from OECD (2022e)



Appendix 2. Structural coefficients before sample split

Note 1: the lower triangular matrix proposed in chapter 4 excluding the elements on the main diagonal as they are normalized to 1

Note 2: The variables included in the US model are oil prices, output, inflation and interest rate, see chapter 4.

	Canada	**Germany**	**France**	**Italy**	**Japan**	**UK**	**US**
A21	-0.0338*** (0.107)	-0.033*** (0.010)	-0.034*** (0.011)	-0.033*** (0.011)	-0.032*** (0.011)	-0.032*** (0.012)	-0.014** (0.007)
A31	0.005 (0.003)	0.005 (0.005)	0.004 (0.005)	0.013* (0.007)	0.000318 (0.005)	-0.003 (0.005)	-0.036*** (0.003)
A32	-0.0226* (.0131)	-0.069*** (0.020)	-0.059*** (0.021)	-0.131*** (0.029)	0.017 (0.022)	0.001 (0.02)	0.066*** (0.019)
A41	-0.0001 (.001)	-0.003*** (0.001)	-0.003*** (0.000811)	-0.0000104 (0.000729)	-0.00138 (0.001133)	-0.002* (0.001)	0.012* (0.007)
A42	-0.025*** (.004)	-0.019*** (0.004)	-0.012*** (0.00329)	-0.009*** (0.003)	-0.004 (0.005)	-0.008* (0.004)	-0.151*** (0.04)
A43	-0.007 (.0141)	0.0282*** (0.009)	0.007 (0.00699)	0.008* (0.004)	0.0135 (0.01)	0.007 (0.01)	-0.168* (0.095)
A51	0.001 (.001)	-0.000196 (0.001)	-0.00094 (0.001)	-0.000463 (0.00109)	-0.00126 (0.001)	-0.001 (0.001)	N/A
A52	-0.002 (0.006)	-0.0000384 (0.003)	0.003 (0.004)	0.002 (0.005)	-0.010** (0.004)	-0.00657 (0.00308)	N/A
A53	-0.043** (0.019)	-0.002 (0.006)	-0.006 (0.001)	-0.000737 (0.00680)	0.026*** (0.009)	0.003 (0.00745)	N/A
A54	0.069 (0.059)	-0.005 (0.033)	-0.005 (0.058)	-0.016 (0.067)	0.048 (0.041)	0.0335 (0.038)	N/A
A61	0.0000628 (0.0000555)	0.0000394 (0.0000908)	0.0000348 (0.0000852)	0.0000078 (0.000069)	-0.0007 (0.013)	0.000034 (0.000037)	N/A
A62	0.000254 (0.000238)	0.0000593 (0.000378)	0.0000955 (0.000347)	0.000127 (0.000288)	0.017 (0.054)	-0.000114 (0.000147)	N/A
A63	0.000562 (0.000786)	0.000232 (0.000845)	-0.0000233 (0.000727)	-0.000332 (0.00043)	0.015 (0.111)	-0.000567 (0.000355)	N/A
A64	0.0000963 (0.00247)	-0.00302 (0.00428)	-0.004 (0.00464)	-0.006 (0.004)	-0.463 (0.510)	0.00198 (0.00181)	N/A
A65	0.000939 (0.00188)	0.00938 (0.00588)	0.002 (0.003)	0.005 (0.003)	-0.626 (0.565)	0.005** (0.00231)	N/A

Appendix 3. Point estimates and p-values of oil-mix in the inflation equation (equation 12)

Country	**Canada**	**Germany**	**France**	**Italy**	**Japan**	**United Kingdom**	**United States**
Coefficient	0.079**	0.079***	0.121***	0.087***	0.125***	0.144***	0.063**
p-value	(0.032)	(0.009)	(0.000)	(0.002)	(0.001)	(0.000)	(0.013)

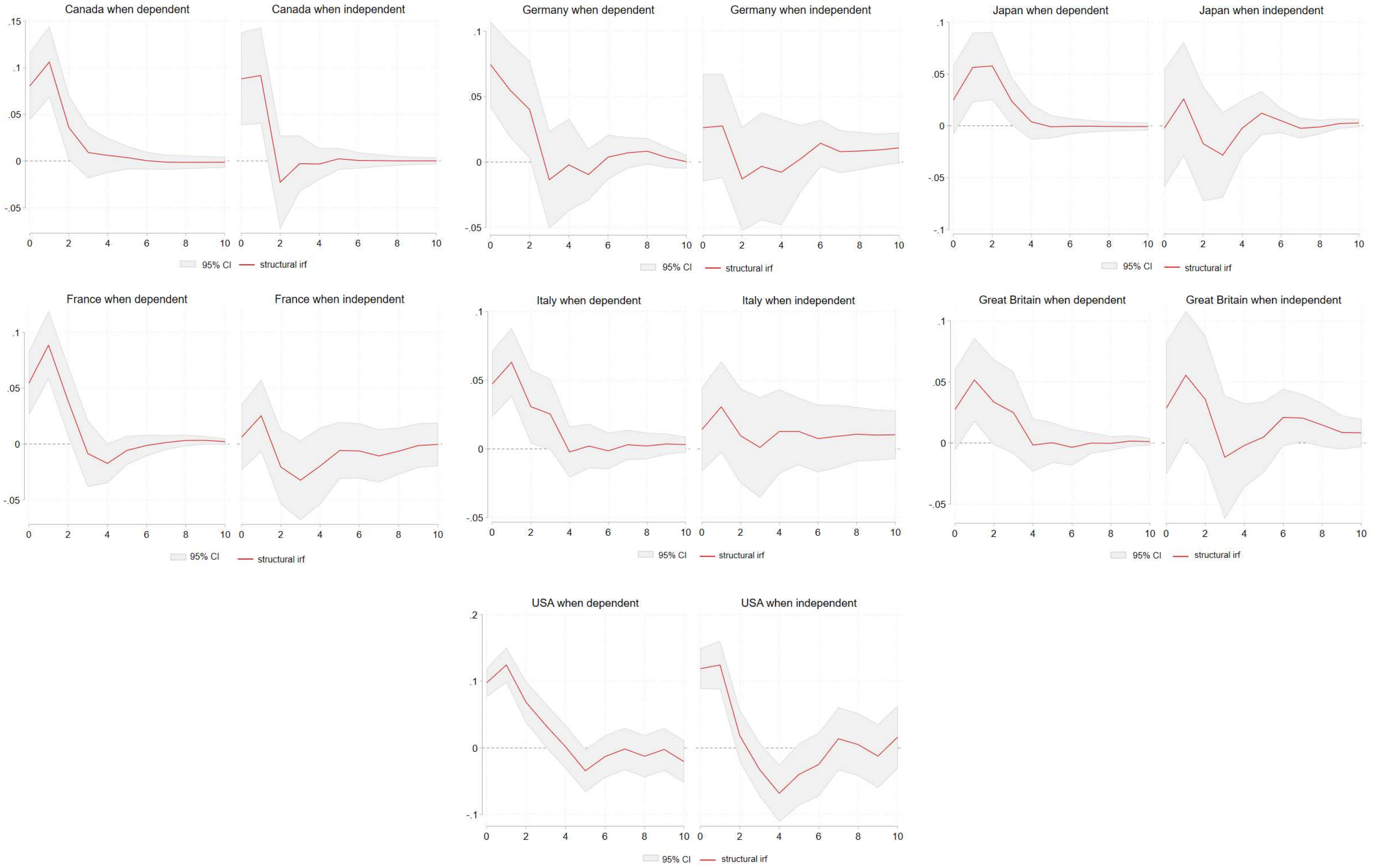
Appendix 4. Years of oil dependence/oil independence, according to share of oil in the energy mix

Notes: The table was generated using data of the variable oil dependency as described in section 5.3.1.

Countries	Oil Dependent	Mean	Oil Independent	Mean
Canada	1980-1984, 1989, 2003-2007, 2009-2012, 2019	0.350	1985-1988, 1990-2002, 2007-2008, 2013-2018, 2020	0.32
Germany	1980-1982, 1986, 1991-2003,	0.48	1982-1985, 1987-1990, 2004-2020	0.359
France	1980-1993, 1998	0.34	1994-1997, 1999-2020	0.35
Italy	1980-2002	0.603	2003-2020	0.429
Japan	1980-1999	0.57	2000-2020	0.451
United Kingdom	1980-1982, 1984-1985, 1988-1995, 2015-2019, 2021	0.34	1983, 1986-1987, 1996-2014, 2020	0.368
United States	1980-1990, 2001, 2003-2007	0.396	1991-2000, 2002, 2008-2020	0.396

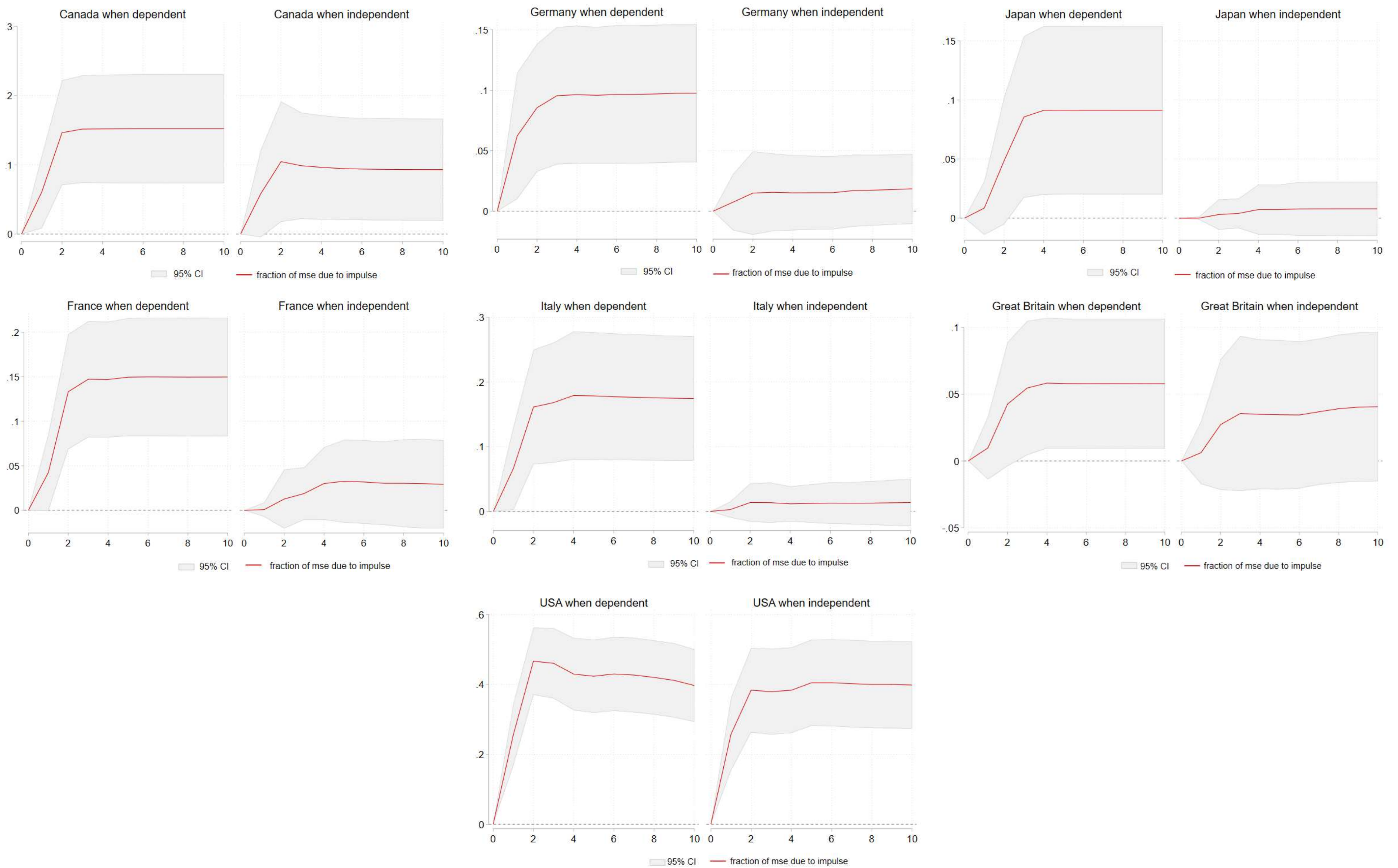
Appendix 5. Impulse Response Functions, sample divided according to the share of oil in the energy mix

Notes: The estimated ten-month evolution of inflation following a one standard deviation shock of oil prices.



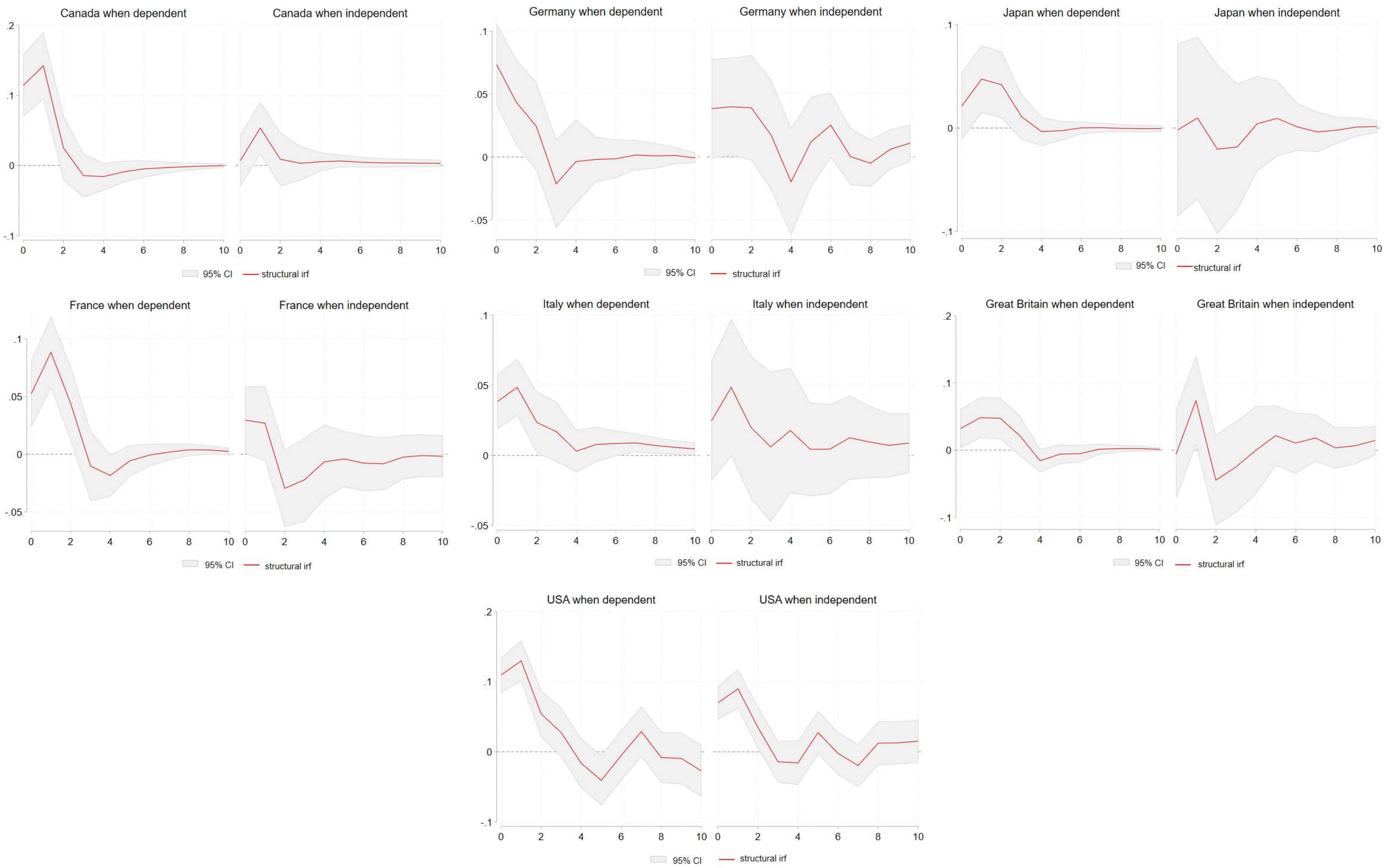
Appendix 6. Forecast Error Variance Decompositions, sample divided according to the share of oil in the energy mix

Notes: The share of inflation forecast variance due to a one standard deviation shock to the oil price.



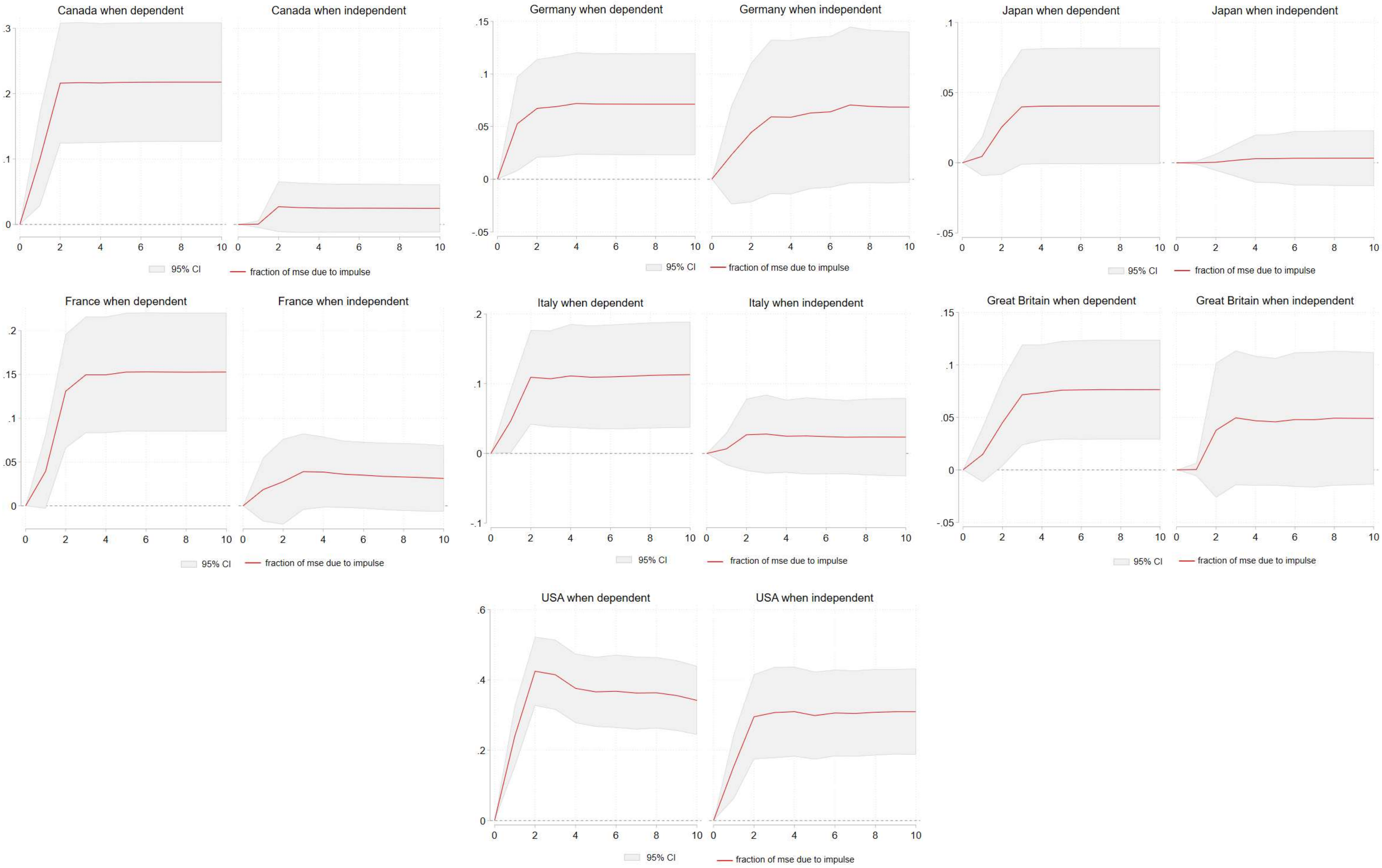
Appendix 7. Impulse Response Functions, average oil price replaced with Brent oil price

Notes: The estimated ten-month evolution of inflation following a one standard deviation shock of oil prices.



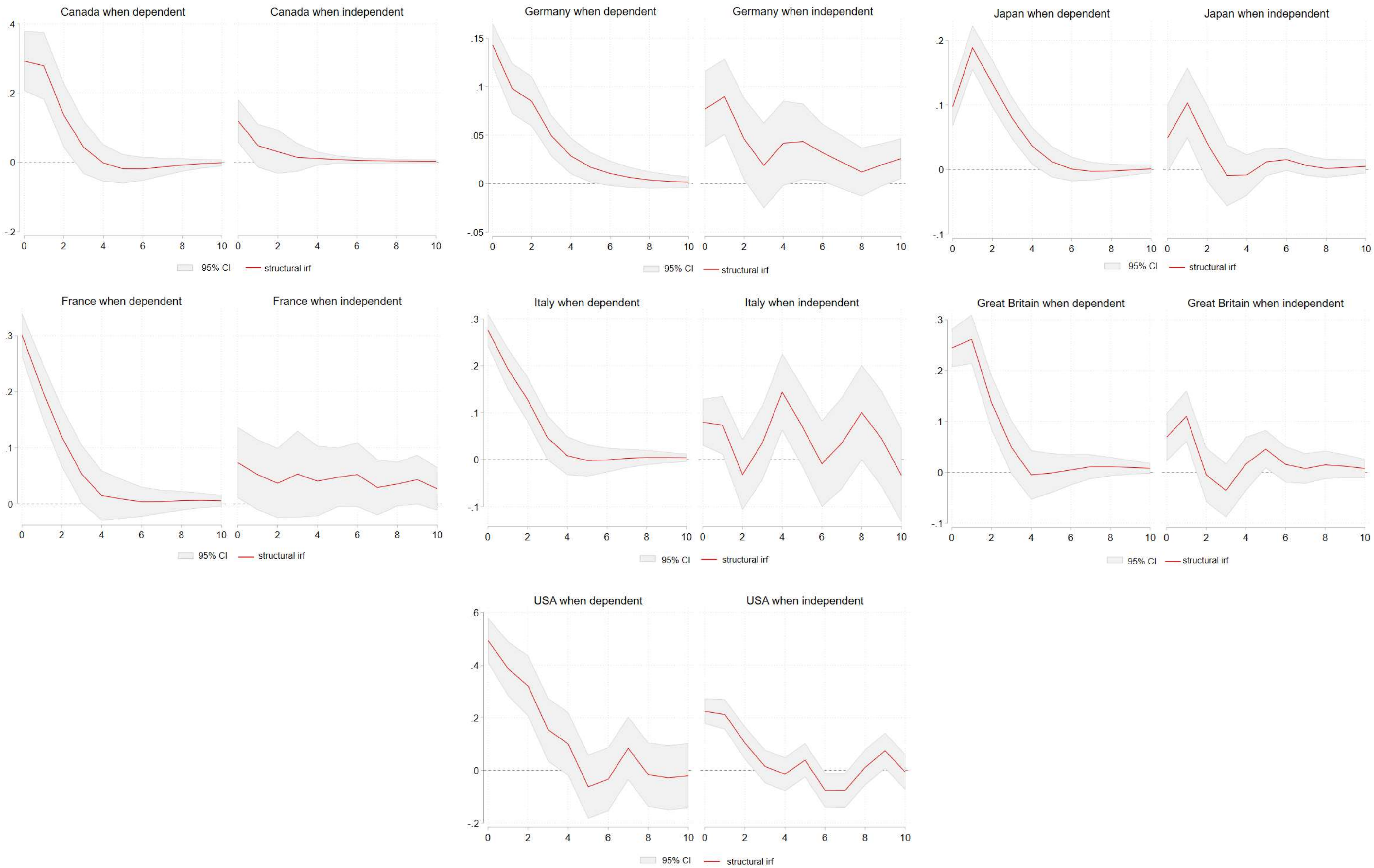
Appendix 8. Forecast Error Variance Decompositions, average oil price replaced with Brent oil price

Notes: The share of inflation forecast variance due to a one standard deviation shock to the oil price.



Appendix 9. Impulse Response Functions, CPI replaced with PPI

Notes: The estimated ten-month evolution of inflation following a one standard deviation shock of oil prices.



Appendix 10. Forecast Error Variance Decompositions, CPI replaced with PPI

Notes: The share of inflation forecast variance due to a one standard deviation shock to the oil price.