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Can supply chain disruptions explain the high inflation levels during Covid-19?

- A comparative study on the U.S., the U.K., the Euro Area & the Republic of Korea

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Abstract

In countries such as the United States and the United Kingdom, the Covid-19 pandemic has caused the highest level of inflation since several decades. Explanations are sought after and disruptions of supply chains have been labeled the cause by many politicians. However, the empirical literature regarding the topic is limited. Hence, in order to extend the literature, this paper aims to investigate whether supply chain disruptions can explain the high levels of inflation. Moreover, the possibility of a heterogeneous effect across countries is also considered in order to gain a deeper knowledge of the relationship. A local projection methodology is used on time-series data spanning from 1999 to 2022 for the United States, the United Kingdom, the Euro Area and the Republic of Korea. The results indicate a small, positive and somewhat heterogeneous effect at either horizon 0 or 1 for the United Kingdom, the Euro Area and the Republic of Korea, while the estimates remain insignificant for the United States. This result is weakened when the robustness analyses are taken into account and the conclusion is, therefore, that the effect of supply chain disruptions on inflation is positive, but small in magnitude. The following implication is that supply chain disruptions only caused a small fraction of the increases in inflation experienced during the Covid-19 crisis.

Keywords: Inflation, supply chain disruptions, local projection, impulse responses, country heterogeneity

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1. Introduction

The Covid-19 pandemic is associated with a massive upswing in inflation as inflation levels have been higher than what has been seen for decades. For instance, in March 2022, the United States reached a yearly inflation of 8.5 percent as measured by the Consumer Price Index (CPI). This is the highest yearly inflation the country has experienced in 40 years (U.S. Bureau of Labor Statistics, 2022). Similarly, the United Kingdom experienced an increase of 7.0 percent in consumer prices in March 2022 compared to the same month the previous year, which is the highest inflation the country has experienced since 1992 (Office for National Statistics, 2022). An explanation for the high levels of inflations is needed and the disruptions of supply chains has been labeled as the cause by many politicians (Ferlito, 2022).

Supply chains can be described as a value adding chain which includes all activities of all enterprises from the first component to the finished product (Sturgeon, 2001). The concept has grown in both depth and frequency during the past decades with enterprises trying to minimize costs by outsourcing parts of their production to places with comparative advantages (Nicita, Ognivtsev & Shirotori, 2013). This has led to a wide literature concerning supply chains, but breakdowns of supply chains causing inflation is a recent addition to the supply chain and inflation-determining literature, however, with little empirical papers. The theoretical explanation surrounding supply chain disruptions and their effect on inflation takes its foundation in cost-push inflation. The theoretical cost-push-based effect on inflation does not originate from the presence of supply chains themselves, but rather from the risk they impose on producers (Santacreu & LaBelle, 2022). This, as production of certain commodities has become very location-specific with the growing concept of supply chains and globalization. Semiconductors, a vital component in the production of electronic devices, is an example of such a location-specific good, as Taiwan and China produce the absolute majority of the worlds production (Santacreu & LaBelle, 2022). Hence, one large risk with the supply chain concept is that the end product heavily relies on every single part of the production operating as intended. The inclusion of many economies in the production of a single product implies that production is exposed to more potential shocks (Sodhi & Tang, 2012, p. 23). If a vital component in production, such as semiconductors, experiences a shock, the production more or less stops due to the inelastic supply that the chains impose. This is exactly what has happened during the Covid-19 pandemic with work at home policies and stimulus packages causing an increase in the demand of technological goods. These goods require semiconductors

to be produced, but China and Taiwan can only produce so many. Consequently, pressure is put on prices as demand exceeds supply, and inflation is, therefore, a theoretically plausible outcome (Santacreu and LaBelle, 2022). This example applies to many more goods and is a major reason as to why you could not buy your Playstation 5 or MacBook Pro during the pandemic!

In this paper, a Global Supply Chain Pressure Index (GSCPI) will be used as a proxy of supply chain disruptions. The GSCPI includes several components, such as delivery times, backlogs and sea shipping costs in order to measure how well supply chains are (or are not) functioning. Previous literature largely focuses on more limited measures of supply chains that only includes for instance backlogs or delivery times (see e.g., Santacreu & LaBelle 2022; or Ruch & Taskin 2022). By implementing a more dynamic measure, we believe to have a better proxy of the disruptions. Figure 1 illustrates how GSCPI has increased to extraordinary heights during the past few, Covid-characterized years. The simultaneous peak in supply chain disruptions and inflation is the reason as to why the topic has caught so much interest.

Figure 1. Global Supply Chain Pressure Index from January 1999 to January 2022.

Major supply disruptions have also been present in the past with peaks during the Korean war (1950-1953), as well as, the oil crises OPEC 1 (1973-1974) and OPEC 2 (1978-1979). The three crises have all been associated with high inflation. The Korean war caused massive destruction of industries in Korea which heavily limited supply (Lee, 2001) with increased global prices (Lans, 2018). A supply side shock also caused the rising inflation during OPEC

1 and 2 since increases in oil prices eventually led to increased prices in consumer goods. This is not surprising as oil is an essential substance (Corbett, 2013). The Covid-19 crisis is systematically different from previous crises as the shock was both supply- and demand-sided (Santacreu & LaBelle, 2022). On the one hand, supply shocks consisted of border restrictions which limited the movement and, hence, the supply of goods and services (OECD, 2020). On the other hand, demand shocks were a result of demand profiles shifting towards durable goods. This, due to stimulus packages and work from home policies (Santacreu & LaBelle, 2022). Moreover, the continuous development of supply chains over the past few decades (Nicita, Ognivtsev & Shirotori, 2013) implies that by the time of the Covid-19 crisis, supply chains had developed to be far more complex and characterized by risk than during previous crises.

The limited empirical research on the topic, in combination with the uniqueness of the disruptions experienced during the Covid-19 pandemic, has led to the following first hypothesis that this paper aims to examine:

H1: Supply chain disruptions positively affect inflation.

It is also important to note that evidence of heterogeneous effects of supply chain disruptions on inflation has been found. For instance, Santacreu and LaBelle (2022) finds evidence of this in industries within the U.S. The paper also estimates the effect to be bigger when the disruptions occur in parts of supply chains that are located in a foreign country compared to domestic disruptions. With these two findings in mind, there are reasons to expect disruptions in supply chains to affect inflation to differing degrees depending on country characteristics. Two of such characteristics are self-sufficiency and relative importance of import categories. The former is important since it demonstrates how reliant a country is on imports, and, therefore, how reliant it is on supply chains. The latter is important as supply chain disruptions hit different industries to differing extents during the pandemic. The two characteristics will be considered in the analysis in order to empirically investigate the following, second hypothesis:

H2: The effect of supply chain disruptions on inflation is heterogeneous across countries.

In order to analyze the hypotheses, this paper implements a local projection (LP) methodology with impulse response functions (IRFs) from horizon zero to twelve as the main methodology, where each additional horizon corresponds to one additional month. Monthly time series data

without gaps from January 1999 to January 2022 will be utilized for the United States (U.S.), the (U.K.), the Euro Area (EA) and the Republic of Korea (KR). The four countries/regions of interest are largely chosen based on data availability as the index is only available for a limited number of countries/regions. Given the limited choices, we opted to include countries/regions with varying degrees of self-sufficiency, measured as import share of GDP and net trade.

As a robustness analysis, an alternative impulse response methodology is conducted via a Structural Vector Autoregression (SVAR) model. The main model is also estimated with an alternative number of lags and with a country specific measurement of GSCPI, instead of a global measure as two additional tests of robustness. The result of the main regressions is an estimated positive effect of supply chain disruptions on CPI inflation. This result is significant at horizon 1 for the EA and the U.K., and at horizon 0 for KR, while no statistically significant estimations are found for the U.S. The effect of one positive unit shock in GSCPI at the significant horizons corresponds to an increase in inflation by .00108 percent, .00186 percent and .00112 percent for the EA, the U.K. and KR respectively. This positive effect at the early horizons remains throughout the robustness analysis, however, statistical significance is lost in most cases. The smallest effect is estimated for the U.S., the most self-sufficient country. This paper therefore concludes that supply chain disruptions likely have a slight positive effect on inflation and more so in countries/regions which are relatively less self-sufficient.

This paper is distributed as follows. Section two introduces the background of supply chains, while section three outlines the theoretical framework and empirical research. Section four presents the methodology, data and variables. The main result, robustness analysis, as well as, the discussion regarding the two are located in section five. The paper is, lastly, concluded in section six.

2. Supply chains background

2.1 The concept of supply chains and its development

Supply chains are defined as a value adding chain that comprises all value adding activities of all participating enterprises. This covers the logistics, information flow, and cash flow needed that leads to, and supports, the end use of products or services (Sturgeon, 2001). Supply chains can span over multiple countries and can, therefore, be referred to as global value chains. This outsourcing of production to different companies and/or different countries became a bigger part of business models in the 1980s, however it was limited to certain sectors such as textiles, electronics and clothing (Nicita, Ognivtsev & Shirotori, 2013). As the world rapidly became more globalized in the 1990s through trade liberalization with declines in the costs of cross-border transactions, technological progress, and improvements in transport management and logistics, supply chain processes continued to become more global (UNCTAD, 2011).

The choice of a company to outsource stages of its production can be explained by comparative advantages. Firms will offshore parts of its production to another country as long as the reduced production costs outweigh the costs of offshoring. Since developing countries have an ample supply of unskilled labor they often complete the low value-added labor intensive tasks of the supply chain, whereas the skill- and capital-intensive tasks are performed in advanced economies. However, the revolution in information communications technology (ICT) around the mid-1980s enabled the trade of digitized information, leading to more skill intensive tasks such as software or business process outsourcing being offshored to developing countries (Low, Nayyar & Park, 2013, p.31).

The ICT revolution shows that supply chains are not static, they can change in size, configuration or in how they are managed, controlled and coordinated. Thus, new supply chains may emerge, or some supply chains may disappear when there is no longer sufficient demand to drive the chain (MacCarthy et al., 2016). However, the use of an effective supply chain system can come with multiple advantages such as job opportunities in developing countries. For instance, a contribution to higher efficiency rates, increased quality over control, better customer relationship with better service, a faster production cycle with reduced production costs and an overall improvement in the financial performance of a company (PWC, 2020).

2.2 Supply chains and risk

Even if the use of supply chains is attractive due to its many advantages, it is not without its risks. Clearly, an increase in the number of firms or economies found in a supply chain increases the number of points for possible disruptions. Thus, making it possible for shocks to amplify throughout the chain. Another possible risk when using supply chains comes with an expansion of the length of the supply chain which can lead to a decrease in visibility and transparency, thus hindering detection and response efforts for disruptions (Sodhi & Tang, 2012, p. 7). Hence, how much risk a supply chain faces depends on the characteristics of the supply chain. One supply chain technique that faces larger risks related to demand shocks is the popular, but sensitive, just-in-time technique. This technique is one that heavily relies on speed, minimal inventories, and consistency. Thus, with this type of chain, it is difficult to compensate for disruptions which, therefore, makes the chain highly sensitive to demand shocks (Low, Nayyar & Park, 2013. p. 48).

Supply chains are, of course, not only sensitive to demand side shocks, but also to supply side shocks. Multiple historical events have been characterized by supply shocks and rising inflation, with the three-year long Korean War between 1950 and 1953 being one such event. The war caused a big supply shock in Korea, both through property and industrial facility damages. Already during the first four months of the war major industries faced large destruction ratios. The textile industry was estimated to have a destruction ratio of 70 percent, the same ratio was estimated for the chemical industry. For the agricultural machinery industry and the rubber industry it was estimated to be 40 percent and 10 percent respectively. Thus, majorly disrupting supply in both the north and the south parts of the country. At the same time, rising inflation was a big problem during, and after the war due to supply disruptions, and due to the government issuing new money to meet the demand for war expenses (Lee, 2001). Even though supply chains did not develop to become more global until the 1980's (UNCTAD, 2011), the Korean War led to increasing world market prices (Lans, 2018).

The 1970s was also characterized by supply chain failures and simultaneous high levels of inflation as the two oil crises OPEC 1 and OPEC 2 occurred. The first oil crisis took place during 1973-1974 and was a result of the U.S. supporting Israel in the Yom Kippur War. As a response, the Organization of Arab Petroleum Exporting Countries (OAPEC) stopped exporting oil to the U.S. and also reduced production to a large extent (Hammes & Wills, 2005).

The reduction resulted in almost four times higher oil prices. The U.S. experienced large economic consequences as a result of the embargo. This, as domestic oil production was limited and could not increase supply enough to meet the demand, which caused prices to rise. Since oil is such a vital substance this is not surprising and it caused large supply disruptions across multiple chains and industries. However, it should be noted that other inflation-determining forces were also at play in the U.S., such as the financing of the Vietnam war, bad crop harvests and devaluation of the Dollar, which all pushed inflation in the same direction as the oil embargo (Corbett, 2013).

The second oil crisis, OPEC 2, took place during 1978-1979, a few years after the first one, and was mainly a result of the Iranian Revolution during 1978. The revolution resulted in a new regime which made significant cuts to oil production with resulting increases in consumer prices. The CPI inflation in the U.S. rose from five percent in March 1976 to nine percent during the latter months of 1979 (Graefe, 2013). However, there were also other factors pushing up inflation during this crisis. The economy was, for instance, experiencing a boom during 1978 and was further characterized by precautionary demand increases in anticipation of future oil shortages (Kilian, 2009).

A more recent event with global impacts on supply chains is the Covid-19 pandemic. The pandemic caused disruptions across all economic sectors and industries, affecting manufacturers, distributors and the end-point consumers. The pandemic, which began in Wuhan, China, was first reported to the World Health Organization (WHO) on 31 December 2019 (WHO, 2020). China accounts for nearly 20 percent of global intermediate products, thus, the disruption of the supply of products from China has affected many foreign manufacturers causing disruptions in their supply chains. The main route for international exchange of goods is the seaports. Since they were affected by restrictions it has been challenging for importers and exporters to deliver or bring in goods across most international borders. More precisely, the lockdown measures have caused production halts, restriction in the movement of people and goods, closing of borders, logistical constraints, and all in all a slowdown of trade and business activities (PWC, 2020).

During the pandemic, some goods increased in demand as demand profiles shifted towards durable goods, rather than services, making the Covid-19 pandemic different from previous recessions (Santacreu & LaBelle, 2022). Examples of goods which increased in demand are

technological goods, cars and furniture. Two reasons for the demand shift are stimulus packages and work from home policies (Ferlito, 2022). This demand shift revealed weaknesses in the current economic structure, which is heavily based on global value chains and outsourcing parts of production to external countries. Supply chains allow for production to take place in countries with comparative advantages, but consequently creates more risk (Santacreu & LaBelle, 2022).

It is clear that the Covid-19 pandemic is a great example to display the risks of supply chains. As previously mentioned, supply chains make it possible for shocks to amplify throughout the chain as the final finished product could be sensitive to inputs from several regions (Sodhi & Tang, 2012, p. 7). More prominent risks displayed by the pandemic were caused by low vaccination rates and extensive shipping costs in important ports. This led to big disruptions for production that heavily relies on components which are more or less only produced in a small number of regions or countries, with semiconductors being one such example. The utilization of semiconductors has increased with technological advancements while the majority of the production is limited to a few countries such as China and Taiwan. A substantial increase in the demand for semiconductors caused a bottleneck-situation as supply was inelastic to changes in demand as only a set number of countries can produce semiconductors. The implication is that minor shocks to vital parts of production could have major consequences for the finished product in an economy based on supply chain production. In such a case, upwards pressure will be put on prices, which is how supply chains could cause inflation (Santacreu & LaBelle, 2022).

3. Theoretical framework and previous research

3.1 Supply chains and cost-push inflation

The theoretical explanation for how the pressure on prices coming from increased supply costs could cause inflation is known as cost-push inflation. More precisely the cost-push view on inflation describes that prices are set by costs of production, and so, prices rise when costs rise. In this framework this is the only reason for an increase in prices, and consequently, the only reason for an increase in inflation (Batten, 1981). Many political leaders around the world support the view that the rise of inflation in 2022 is a global phenomenon that is largely caused by supply chain disruptions. In the context of the pandemic, there has not only been supply

chain disruptions as the ones mentioned above, one should also consider the fact that there has been demand shocks in the form of stay-at- home orders contributing to cost-push inflation through supply chain disruptions (Ferlito, 2022).

However, it can be argued that such statements are just a way to hide the real culprit, money creation. As famously explained by Milton Friedman, a rise in inflation is generated from the excessive increase in the quantity of money compared to the increase in the quantity and the goods available for purchase. Thus, the fact that governments have implemented policies leading to government deficit spending and expansive monetary policies as a response to the Covid-19 pandemic could be another reason behind inflation (Ferlito, 2022).

3.2 Previous research

The empirical work on whether supply chain disruptions could have effects on inflation is limited, however, the Covid-19 pandemic has led to recent publications where the disruptions caused by the pandemic, and the effects on the economy is analyzed. The empirical work with a focus on supply chains is however limited to the pandemic and the 2008-2009 Great Recession.

The effect of the supply chain disruptions during the pandemic is compared to the 2008-2009 Great Recession by both Santacreu and LaBelle (2022) and Ruch and Taskin (2022). Important to note during this comparison, is the difference in the shocks. When comparing the two recessions, Ruch and Taskin (2022) find that the supply and demand shocks were larger during the Covid-19 pandemic. Specifically supply shocks were large with significant variance across sectors. This is consistent with the widely reported supply chain disruptions during the pandemic. Another difference is that it took more time for the shocks to amplify during the Great Recession as supply reacted in late 2008 with the demand shock coming through strongly by the middle of 2009. Santacreu and LaBelle (2022) explain the difference by the differing effects in backlogs due to demand. Backlogs are considered a good proxy of a situation where demand has increased to an extent such that producers cannot match it with an increase in supply and a bottle-neck situation is in effect. Thus, a lack of backlogs would mean that some of the production capacity is unused. In other words, backlogs are a proxy of how well supply can match demand, which could cause inflation in situations where supply does not keep up demand. Instead of persistent increases in backlogs during the Great Recession, the backlogs began to fade quickly during the shock. On the contrary, backlogs have constantly increased

during the entirety of the Covid-19 crisis, causing bottle-neck situations, with only the rate of increase starting to decline in June of 2021. The demand shift towards durable goods and away from services is historical in a sense that such imbalances have not been seen before. This in turn could put upwards pressure on prices which can cause inflation via the cost-push channel (Santacreu & LaBelle, 2022).

One common finding between the two above-mentioned papers is the heterogeneity between sectors during the pandemic and the Great Recession. Santacreu and LaBelle (2022) investigate the effect in the U.S. with the producer price index (PPI) as a measure of inflation with focus on backlogs and delivery times as two forces of supply chain disruptions. They find the largest effect in the automobile and the technology equipment sector. This, as semiconductors production could not keep up with demand increases. The technology equipment sector experienced huge demand increases as people started working from home and required more computers and electronics in order to do so. Moreover, fiscal stimulus packages were implemented which further increased demand. On the contrary, the pharmaceutical sector did not experience any major supply chain disruptions which is reflected in inflation within the pharmaceutical sector as PPI is relatively unaffected. At the same time the automobile and technology equipment sector experienced relatively large increases in inflation while being exposed to substantial supply chain disruptions. Ruch and Taskin (2022) instead use consumer inflation as a measure but also find heterogeneity between sectors where manufacturing, energy, and wholesale and retail trade sectors faced large disruptions. Instead, retail, grocery stores and department stores fared relatively well. Since the pandemic affected different industries to various extent, the heterogeneity between sectors regarding supply chain disruptions and the consequential effect on inflation is important to understand as this has implications for policy makers. In knowing which industries that faced the largest disruptions, politicians can target measures to those firms most impacted by current conditions (Ruch & Taskin, 2022).

In Santacreu and LaBelle (2022), an OLS regression with inflation as the dependent variable and supply chain disruptions as the explanatory one, with fixed industry effects is used to estimate the effect on PPI inflation in the U.S. The results show that production which experienced disruptions in supply chains positively affected inflation, regardless of the disruptions being domestic or foreign. However, only foreign exposure was statistically significant. The result remains the same whether delivery times or backlogs are used as a proxy

of supply chain disruption. The statistical significance increases when the explanatory variable is lagged once, which indicates a delayed effect between supply chain disruptions and inflation. The estimations generate a statistically significant result where the disruptions during the pandemic are estimated to have increased the PPI inflation in the U.S. by two percent.

Ruch and Taskin (2022) uses a different methodology, namely an LP model to identify IRFs through consecutive regression models at different horizons. This model is used to link the supply and demand sentiment shocks that are generated from earning call transcripts to economic activity. The authors use earning call transcripts of firms listed in the U.S. stock market, with headquarters in 80 countries. The results from the analysis using the IRFs from the LP model show that a shock in the demand sentiment leads to a small increase of 0.1 percentage point on inflation, with a significant effect only for the first period. For a supply sentiment shock, consumer inflation decreases significantly after about eight periods, with a peak of 0.3 percentage points. The authors suggest that the difference between the effects of demand- and supply shocks, where supply chains are largely affected, could be explained by the initial supply shock being minimized thanks to existing inventories or alternate supply channels.

Attinasi et al. (2021) also use an IRF approach to investigate the supply chain shocks of the Covid-19 pandemic on global industrial production, trade and inflation, but instead of an LP methodology, the paper implements a VAR model. To reflect strains in global production networks, the global Purchasing Managers Index suppliers' delivery times (PMI SDT) is used as a proxy for production strains since the index quantifies developments in the time required for the delivery of inputs to firms. An increase in the delivery times of suppliers across advanced economies since the end of 2020 once again confirms that there has been a widespread strain in global production networks. Furthermore, the index displays heterogeneity between advanced and emerging economies where economies like the U.S., the EA and the U.K. are much more affected than key emerging economies.

With the VAR approach, and by considering global effects, but excluding the EA, the authors find that supply chain shocks account for around one-third of the strains in global production networks. The results also suggest that supply chain disruptions have a significant effect on prices, where the effect is increasing over time. However, the IRFs of the VAR suggest that the effects on inflation dissipate in six to nine months after a one period shock. The effect is bigger

in the PPI than in the CPI. This could be explained by the fact that producers are more directly exposed to supply chain disruptions than consumers, and that rising producer prices are usually only partially passed on to consumers and/or with a lag. It is also important to note that the aggregate results hide the significant heterogeneity across countries since not all countries are affected by the supply bottlenecks to the same extent (Attinasi et al., 2021).

In all three papers, different methodologies and different measures of inflation are used. Furthermore, supply chain disruptions, or shocks, are measured differently, but even so, all three papers commonly find an effect of supply chain disruptions on inflation. Importantly, heterogeneity between sectors is noted and give important implications for policy makers. Moreover, the results could imply that the theory of cost-push inflation is also empirically relevant.

4. Methodology

4.1 Local Projection

Based on the previous research outlined in section 3.2 this paper will implement an LP model as the main econometric methodology in order to estimate IRFs from GSCPI to CPI, and will implement IRFs from a SVAR model as a part of the robustness analysis.

The local projection model for each country/region *i* in this paper is specified as the following equation (1):

$$Y_{i,t+h} = \alpha_i^h + \sum_{n=0}^{2} \theta_i^h G^h_{i,t-n} + \sum_{j=1}^{4} \phi_i^h W^h_{i,t-j} + \sum_{k=0}^{1} \sigma_i^h X^h_{i,t-k} + \varepsilon^h_{i,t+h} \quad (1)$$

Here, $h = 0, 1, ..., H$ denotes the projected horizon. $Y_{i,t+h}$ is the dependent variable presented on the left hand-side which denotes the natural log of the difference of CPI. The intercept is denoted α, GSCPI is the vector of explanatory variables and is denoted *G*, the vector with lags of the dependent variable is denoted *W*, and *X* corresponds to the vector of all other controls. Since the LP methodology is not an experimental estimation technique our estimations include five controls in addition to the dependent variable, with the purpose of accounting for the variance in inflation that is unexplained by GSCPI. The control variables are money supply, exchange rate index, unemployment, Brent spot oil price and the policy rates of central banks.

These are obtained for each of our countries/regions of interest, apart from the Brent spot oil price which remains the same for every country/region. The explanatory variables run from lag zero to the optimal lag as chosen by the Bayesian information criterion for each country/region. The last term $\varepsilon^{h}_{i,t+h}$ is the error term.

The linear LP model is obtained by estimating *H* different OLS regressions. By regressing the dependent variable at time *t+h* on the available information at time *t*, the LP method generates estimates for each forecast horizon and identifies the IRFs through the consecutive use of regressions at different horizons. The LP methodology was first introduced by Jordà (2005) and following his recommendation, this paper will implement Newey-West corrected standard errors to account for heteroscedasticity and serial correlation.

The LP method has become more popular as an alternative to IRFs from VAR models and has been implemented in papers where the objective is to analyze the effects of economic shocks (see e.g., El Herradi & Leroy, 2019; or Colavecchio & Rubene, 2020). The difference between the two is that LPs are estimated at each period of interest, as opposed to extrapolating into increasingly distant horizons from a given model in VARs. Furthermore, Jordà (2005) explains that as estimations based on a VAR model represents a global approximation to the data generating process (DGP), using LPs when conducting IRFs will make the model more robust to misspecification of the DGP. This, since the true DGP is in practice never known, thus, making fewer assumptions about the DGP is preferable. Additionally, LPs can be estimated by simple regression techniques and by using HAC robust standard errors valid inference can be obtained (Jordà, 2005).

Commonly, it is believed that SVARs are more efficient while LPs are more robust to model misspecification. More specifically, Li, Plagborg-Møller & Wolf (2021) state that LPs and VARs lie on the opposite side of the variance-bias spectrum with small bias and large variance for LPs, although this is in regards to intermediate or long forecasting horizons. However, there is earlier evidence from Brugnolini (2018) in favor of the LP model compared to the VAR when both models are misspecified. Though, he also provides evidence in favor of the IRFs from a VAR when comparing a well-specified VAR to a misspecified LP. The efficiency of LPs compared to VARs was also investigated in the initial paper by Jordá (2005) since LPs are an alternative to VAR models. He presents evidence from a Monte Carlo simulation that shows that even a correctly specified VAR when it is the true model, only is marginally more efficient

than LPs with Newey-West standard errors. This is shown to hold for a system of 6 variables, and as many as 12 lags and horizons of 24 periods.

Plagborg-Møller and Wolf (2021) state that structural VARs remain as the most popular empirical approach to impulse response estimation. They further state that the two methods are not conceptually different. Specifically, the two methods are likely to approximately agree at short horizons if the same lag length is used. But, with finite lag lengths and long horizons, the methods can give very different results. It is also pointed out that the equivalence between the two models imply that structural estimation with VARs can equally well be carried out using LPs, or the other way around (Plagborg-Møller & Wolf, 2021). SVAR models are popular because they measure and study the effect of structural economic shocks where the IRFs represent the dynamic response of the variables to economic shocks. Thus, economic interpretation is possible from the observed dynamic shocks (Gambetti, 2020).

4.2 Data

The data consists of 277 observations per country/region with a monthly frequency. The data set ranges from January in 1999 to January in 2022. The included variables are the CPI which is used as a measure of inflation, the GSCPI as a measure of supply chain disruptions, and the controls unemployment, policy rates, money supply, exchange rate index and crude oil. The variables are further specified in section 4.2.2, and information on the data sources can be found in Appendix A.

4.2.1 Country heterogeneity

To better analyze potential differences across countries/regions in the estimation results it is important to understand the differences between the chosen countries/regions in which industries that make up the largest parts of the imports. This is essential as a heterogeneous effect of supply chain disruption on inflation has been found across sectors (see e.g., Santacreu & LaBelle, 2022; or Ruch & Taskin 2022). Some of the sectors that were the most affected by supply chain disruptions during the Covid-19 pandemic were the automobile, technology equipment (Santacreu & LaBelle, 2022), manufacturing, energy, wholesale and retail trade (Santacreu & LaBelle, 2022) (Ruch & Taskin, 2022). The five most common imports for our countries/regions are presented in Table 1. Considering that some of the largest imports in all countries/regions are machinery and electrical products or electrical products, this leads to a

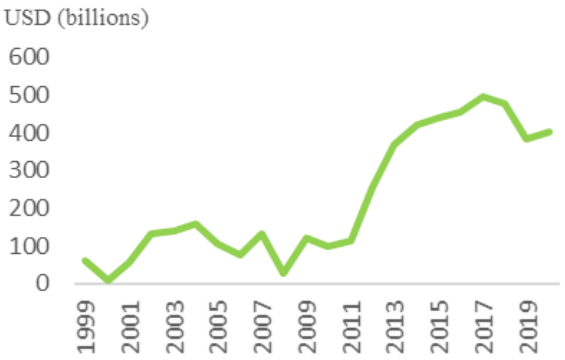
suspicion of supply chain disruptions having an effect as these industries experienced large supply chain disruptions during the Covid-19 pandemic.

Table 1. The top five imported categories for each country/region presented with the share of GDP.

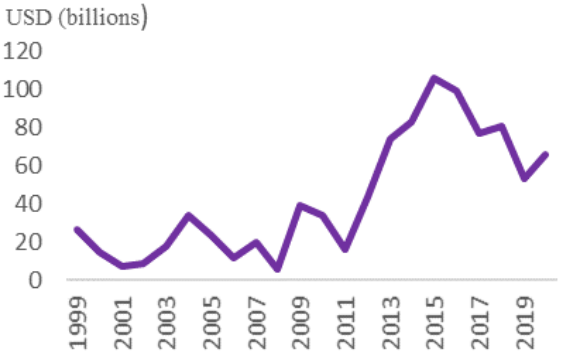
The United States	**The United Kingdom**	**The Euro Area**	**The Republic of Korea**
Electronics (20.7 %)	Pearls, precious metals, coins (12 %)	Machinery and vehicles (35.3 %)	Electrical, electronic equipment (20 %)
Transportation equipment (16.4 %)	Machinery including computers (12 %)	Other manufactured goods (25.8 %)	Mineral fuels, oils, distillation products (19 %)
Chemicals (14.1 %)	Mineral fuels including oil (10 %)	Energy products (16 %)	Machinery, nuclear reactors, boilers (12 %)
Machinery (8.8 %)	Vehicles other than railway, tramway (9.1 %)	Chemicals and chemical products (11.7 %)	Optical, photo, technical, medical apparatus (4.1 %)
Minerals and metals (8.7 %)	Electrical machinery, equipment (9 %)	Food and drinks (6.5 %)	Vehicles other than railway, tramway (3.9 %)

Sources: Eurostat, Trading Economics, United States International Trade Commission, authors own calculations.

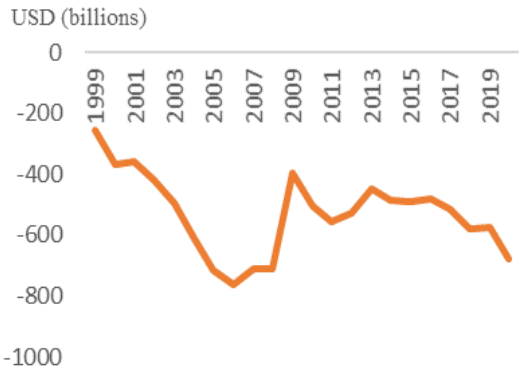
It is also relevant to consider each country's/region's import share of GDP or whether they are a net importer or net exporter. Figure 3 displays each country’s or region's import share of GDP. This can be considered an indicator of how self-sufficient the country or region is. Furthermore, Figure 2 displays whether the country or region is a net importer or net exporter of goods and services. This is relevant for the analysis since a shock to GSCPI is likely to have a larger impact on CPI in a country the more the country relies on imports, and thus, global supply chains.



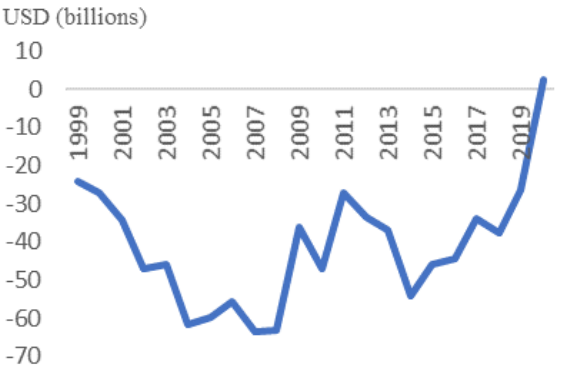
Panel 1. Net trade for the Euro Area.



Panel 2. Net trade for the Republic of Korea

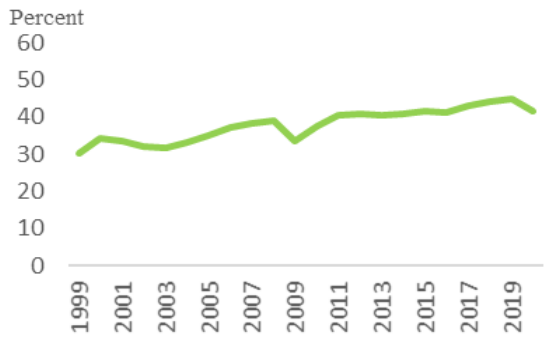


Panel 3. Net trade for the United States.

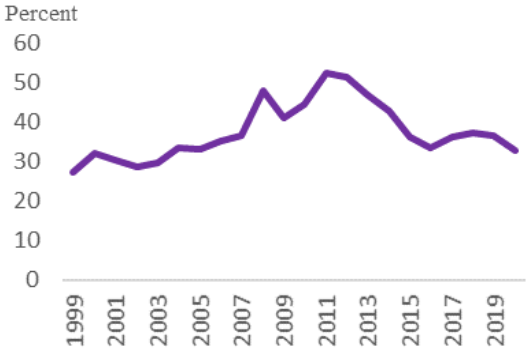


Panel 4. Net trade for the United Kingdom.

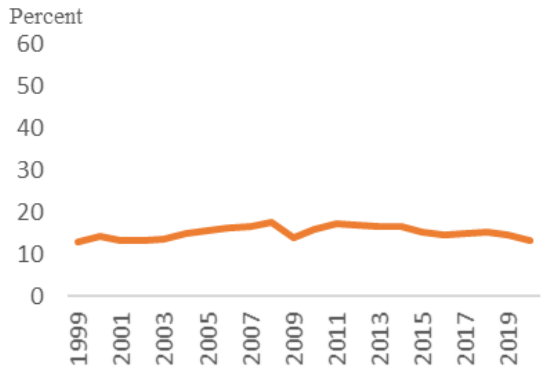
***Figure 2*. Net trade in billion USD, 1999-2020, data from the World Bank.**



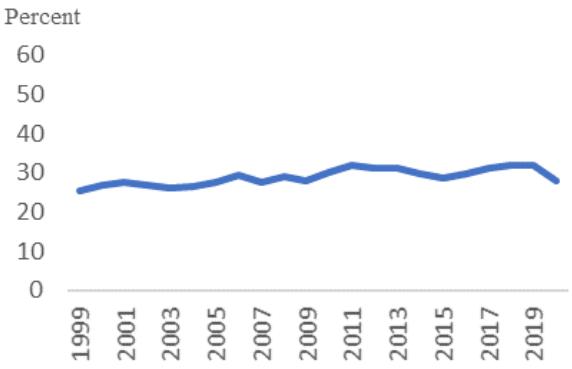
Panel 1. Import share of GDP for the Euro Area.



Panel 2. Import share of GDP.for the Korea Republic of Korea.



Panel 3. Import share of GDP for the United States.



Panel 4. Import share of GDP for the United Kingdom.

***Figure 3*. Import share of GDP, 1999-2020, Data from the World Bank.**

4.2.2 Variables

CPI is the dependent variable and the main explanatory variable is *GSCPI*. Additionally, the five controls of *unemployment*, *money supply*, *policy rate*, *exchange rate* and *Brent spot oil price* are included in order to account for variation in inflation not caused by GSCPI. All variables which do not take negative values have been log-transformed to directly arrive at the results in percentages. Moreover, stationarity is investigated by the Augmented Dickey-Fuller test which tests the null hypothesis of unit root presence. The null is rejected for every variable except for the unemployment rate in KR. Hence, first differences are taken of the non-stationary variables in order to make them stationary. Non-stationarity is a major issue as more or less all

inference and econometric approaches are meaningless without stationarity (Zou, 2019). Taking first differences accomplished the goal of making variables stationary according to the Dickey-Fuller test.

The *CPI* for our countries of interest will be used as a proxy of inflation and is, thus, the dependent variable. This paper aims to explain variation in CPI by implementing the Global Supply Chain Pressure Index (*GSCPI*) as our main explanatory variable. The GSCPI is used as a proxy of worldwide supply chain disruptions in this paper. The expected effect on inflation is positive due to an increasing index putting upward pressure on prices, which is more thoroughly outlined in section 3. The index is based on several metrics, which can be divided into two main parts. The first one has three components. Firstly, it measures the by sea shipping costs of raw material. This is done by utilizing the Baltic Dry Index (BDI), which is reported by the Baltic Exchange in London. The index is generally utilized as a proxy of the costs of moving major raw materials, such as coal or steel, by sea. It is calculated based on transportation costs of roughly twenty routes and is considered the main indicator of economic activity as the index is reflecting supply, as well as, demand for vital raw materials in production (Liu et al., 2022). Secondly, the relative frequency of container shipping in the charter market is taken into account via the Harpex Index, published by Harper Petersen which is a company within the shipbroker industry. The purpose of the Harpex Index is to be a proxy of the prices within the container shipping charter market (Smyrlis, 2021). Lastly, air transportation costs of freight are incorporated into the index. This, by utilizing U.S. data from the U.S. Bureau of Labor Statistics (BLS) in combination with airfreight costs from other continents (Benigno et al., 2022).

Manufacturing data on a national level makes up the second part of the GSCPI. The data is based on surveys from the Purchase Manager Index (PMI) which is published by the IHS Markit (Benigno et al., 2022). Senior executives within the private sector from around the world are asked questions concerning numerous economic indicators in order to measure for instance the level of inventories, inflation and unemployment. The PMI index compiles these individual measurements in order to create a proxy of the overall health of the economy (Swedbank, 2022). The GSCPI tailors the manufacturing data to a narrower supply chain perspective by focusing on economies that are largely intertwined in global supply chains, such as the U.K., the U.S. and the EA. Moreover, the GSCPI utilizes three components of the PMI in order to measure supply chain disruptions. Firstly, backlogs which correspond to the number

of undelivered orders. Secondly, delivery times and, lastly, purchased stocks as an estimation of inventory accumulation among companies (Benigno et al., 2022).

Two different alterations of GSCPI are used in the estimations. The first one is a global measure which is the same for all countries at any given time. This is used as the main explanatory variable in the main result, presented in section 5.1. Country-specific measurements of GSCPI are, on the contrary, different for each country at any given time as this measurement aims to reflect the actual experienced supply chain disruptions in a specific country. The two different GSCPI measurements are not the same due to the fact that supply chain disruptions in a particular industry impacts countries to differing extent based on the relative importance of that industry. The latter, country specific GSCPI, is used as a robustness analysis which is located in section 5.2.3.

Additionally, the five controls of *unemployment rate*, *policy rate*, *money supply*, *exchange rate* and *Brent spot oil price* are utilized in the estimations. Unemployment has historically been able to explain inflation via the Phillips curve. The theoretical explanation of the phenomenon is that employers bid up wages in times of low unemployment with the purpose of recruiting labor in high demand from their competition, which in turn causes inflation. The result of an inverse relationship between the two variables was initially based on data from the U.K. between 1861 and 1957 (Britannica, 2022a). However, the consensus regarding the negative relationship has evaporated during more recent years (Dorn, 2020). The expected effect of unemployment on inflation is, hence, unclear in this paper.

Policy rates correspond to the interest rate at which commercial banks can loan money from central banks. It is the main monetary tool when stabilizing inflation as an increase in the policy rate is expected to dampen economic activity as loaning and investing becomes more expensive while the opportunity cost of saving becomes more lucrative. This reduces inflation as the upward pressure on prices is reduced as economic activity slows down (Britannica, 2022b). Therefore, we anticipate the effect of policy rates to have a negative impact on inflation. The policy rate of the European Central bank is called the “ECB refi rate”, while the corresponding name for the U.S., the U.K. and KR are called the “FED fund effective rate”, the “Official Bank rate” and the “Base rate” respectively.

Money supply is another potential source of inflation. A positive relationship between the two will take place if the money supply grows faster than the economy itself (ST. Louis FED, 2022).

Money supply as a measure has changed throughout time as the definition has generally been broadened due to an increasing number of payment options and, hence, different shapes of money. Measures of money are heterogeneously labeled over the world and the labels have changed at different times for different countries. We try to match the measure of money supply for our four countries of interest in order to facilitate accurate comparisons. Therefore, M2 for the U.S., M4 for the U.K. and M3 for the EA, as well as, KR are the measures of money supply. We, naturally, expect the money supply to positively affect the consumer price index.

The exchange rate operates as a control variable and is represented by a weighted index with weights depending on the relative importance of trading partners. The purpose of the control is to capture variation in inflation caused by changes the relative strength of the exchange rate. An increase in the exchange rate implies that foreign goods are cheap and an outflow of money occurs, which negatively affects inflation.

The Brent spot oil price is used in order to account for inflation caused by changes in crude oil prices, as the Brent benchmark is setting prices for over 75 % of the traded oil in the world. Oil price increases, which are heavily linked to increases in the Brent spot price, have been found to have a significant effect on CPI inflation (Elsayed et al., 2021). The effect occurs via an explicit, as well as, an implicit channel. Via the explicit channel, crude oil prices cause CPI inflation as energy prices correspond to a major part of the overall economy. Moreover, crude oil implicitly affects inflation due to it being an important raw material used in the production of plastic (Gervet, 2007), which also is a substantial component in today's economy. Therefore, increases in crude oil prices are expected to positively affect inflation.

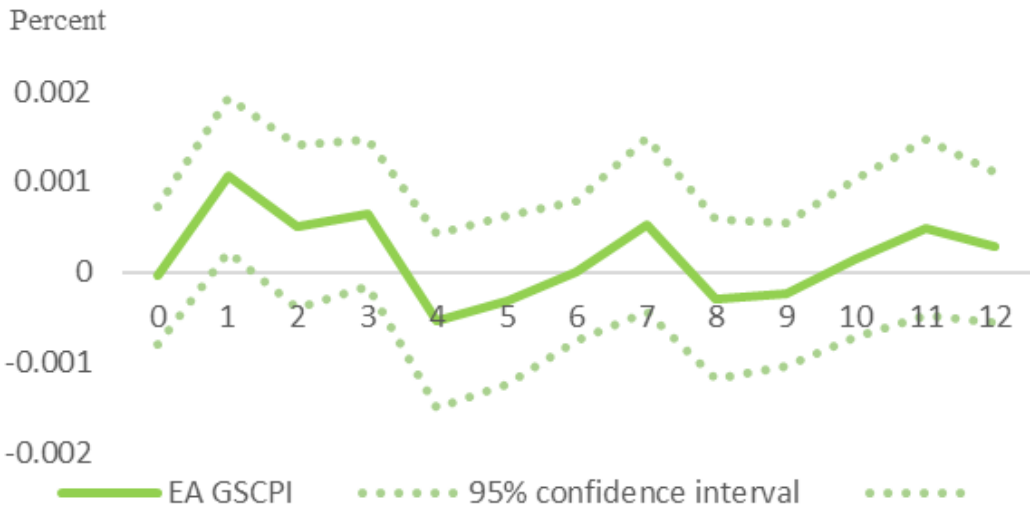
5. Empirical results

The results will be graphically illustrated with a focus on impulses from GSCPI and responses from CPI inflation, while brief discussions of the controls are implemented without illustrations. Hence, regressions are not presented in this paper and the reason for this is that the analysis for each country consists of 13 regressions due to the choice of horizon being zero to twelve which results in 52 regressions for the main result alone.

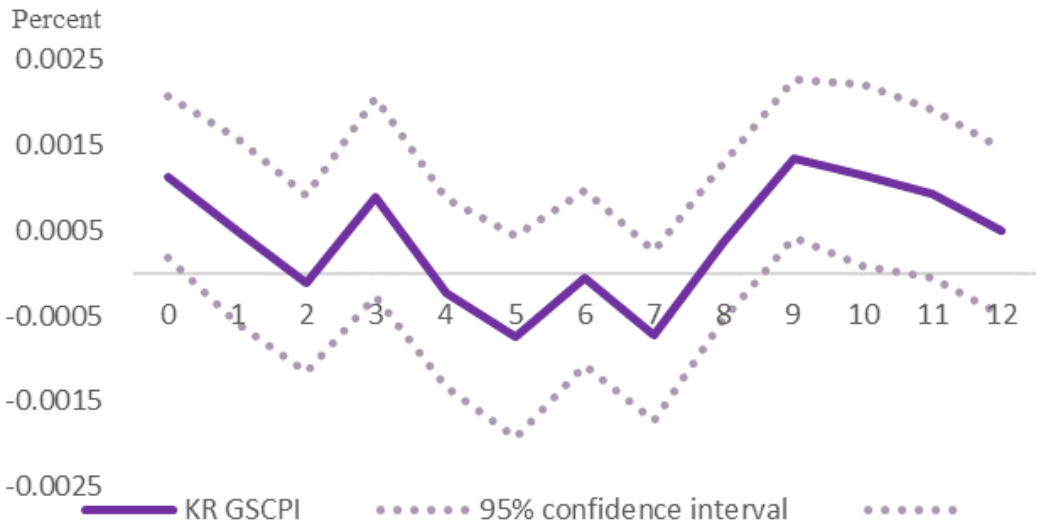
5.1 Main results: Global GSCPI

The main results of this paper are graphically illustrated by Figure 4, where the LPs of global supply chain disruptions on CPI inflation are displayed via IRFs. The direction of the estimations is mostly in line with the outlined theoretical and empirical framework as positive effects are estimated for all four countries of interest at the early horizons which then fades as the horizon increases. However, significance is only achieved at a few horizons. Firstly, the first horizon for the EA where one-unit shock in GSCPI is estimated to increase CPI inflation by .00108 percent. Secondly, the first horizon for the U.K. is also significant with a corresponding estimate of .00186 percent. Thirdly, the zero-horizon for the KR is also significantly estimated with an effect of .00112 percent per unit shock. All three estimations are significant at a sub two percent-level despite the small magnitude of the estimations. Moreover, a common positive, but mostly insignificant, pattern for the early horizons seems to exist. However, it fades around the third or fourth horizon. The effects of the later horizons mostly fluctuate closely tied to the x-axis, which corresponds to no effect with exceptions at the ninth and tenth horizons for the KR, as they indicate a negative effect. Lastly, the seventh horizon for the U.K. is positively significant.

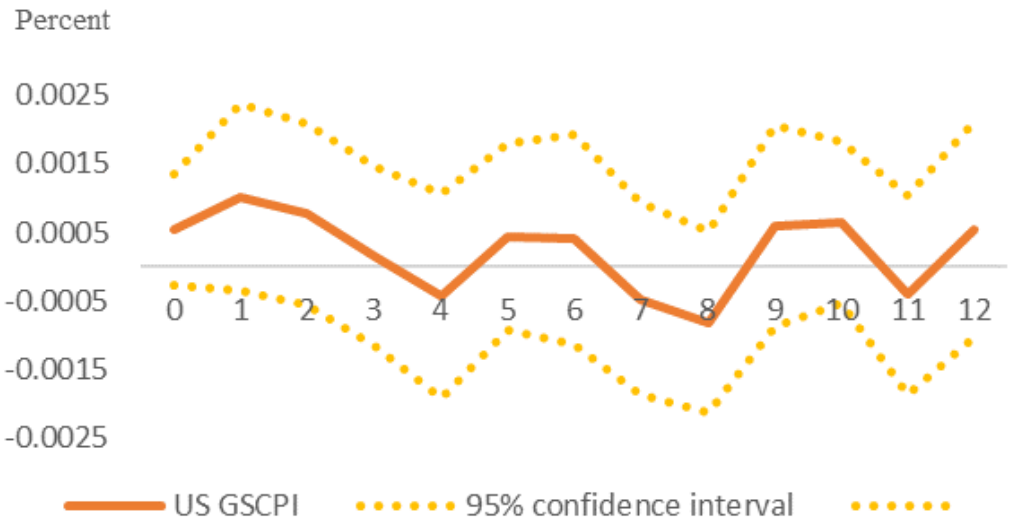
Regarding the controls, the most evident observation is the positive effect of the Brent crude oil spot price on inflation at the early horizons. The effect seems to be instant, but diminishes quickly as the variable is significant for horizon zero and one for the U.S., the U.K., and KR, while horizon one and two is significant for EA. Moreover, the absence of significance of the exchange rate is striking. Only one horizon out of the total 52 is significant, and that is in a positive direction. The policy rate behaves in a similar fashion as the exchange rate with very few significant observations over the horizons and countries. The FED funds rate seems to be the most effective policy tool in order to affect inflation with positive significance at horizon zero and one. Additionally, the estimated effect of unemployment on CPI inflation is also very low with a narrow number of significant horizon-estimates. This is not surprising and in line with recent literature which argues for a weaker relationship between the two variables (Dorn, 2020).



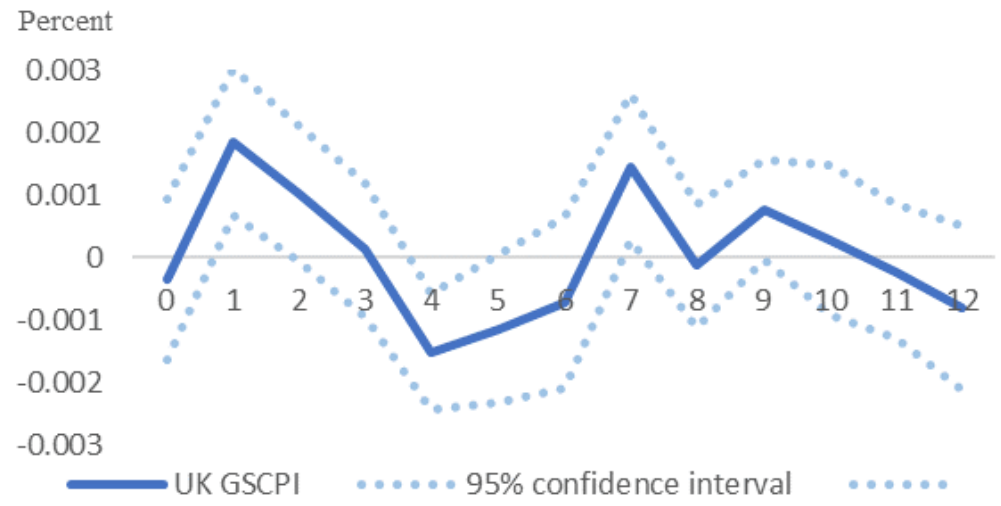
Panel 1. Response of CPI to a one unit shock to GSCPI for the Euro area.



Panel 2. Response of CPI to a one unit shock to GSCPI for the Republic of Korea.



Panel 3. Response of CPI to a one unit shock to GSCPI for the United States.



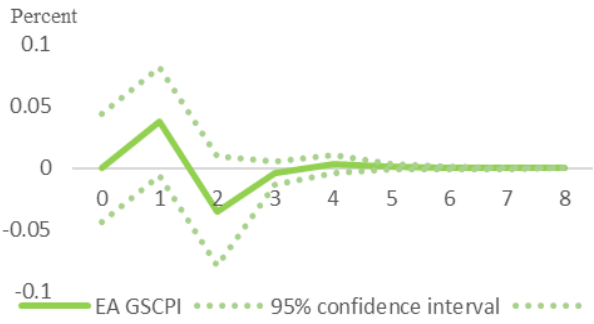
Panel 4. Response of CPI to a one unit shock to GSCPI for the United Kingdom.

Figure 4. **Main results: Impulse responses of local projections for horizon zero to twelve with a global measure of GSCPI as the main explanatory variable.**

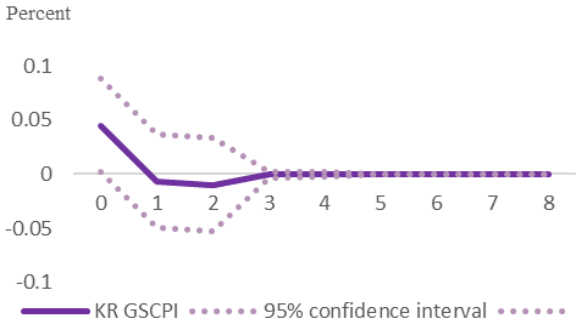
5.2 Robustness analysis

5.2.1 Structural VAR

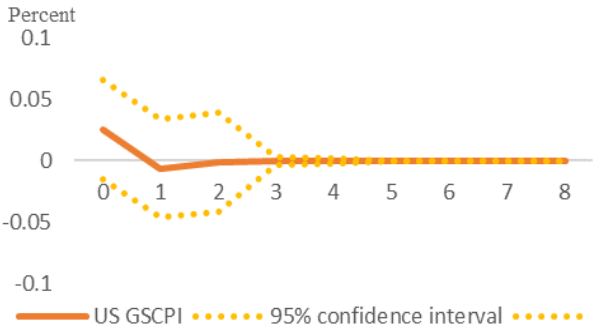
SVAR is implemented as a robustness analysis in order to analyze the IRFs with an alternative methodology. The SVAR estimations are illustrated by Figure 5 below and are essentially in line with the main result for all countries/regions, but with weaker statistical significance. However, the magnitude of the estimates at the first few horizons is generally larger. The estimated effect at the zero-horizon for the KR does for instance increase from .00112 to .0453 percent per unit shock in GSCPI. Furthermore, the zero-horizon for KR is the only significant estimate throughout the SVAR IRF result, with the implication being that the relationship between supply chain disruptions and CPI inflation is weaker than the main results suggested. Nevertheless, the direction of the result is similar at the early horizon with a weak, positive, but mostly insignificant effect. Moreover, the SVAR result converges towards zero earlier than the main result as the positive effect is mostly gone by the third horizon while the main result displays some minor effect even after that point. Yet, it should be noted that the effect is in fact not zero at horizon three and onwards. IRFs are estimated at all horizons, but the later ones are simply very close to zero with a narrow variance. The observed deviations are in line with expectations. This, as Plagborg-Møller and Wolf (2021) highlight the fact that SVAR and LP are likely to agree at shorter horizons, while deviations might occur at later horizons. Similar patterns are also observed in this paper. Concluding, the SVAR methodology indicates a less statistically significant effect at early horizons and a more or less non-existing effect at the later ones.



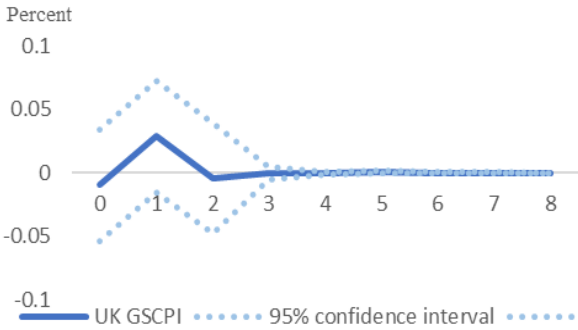
Panel 1. Response of CPI to a one unit shock to GSCPI for the Euro Area.



Panel 2. Response of CPI to a one unit shock to GSCPI for the Republic of Korea.



Panel 3. Response of CPI to a one unit shock to GSCPI for the United States.



Panel 4. Response of CPI to a one unit shock to GSCPI for the United Kingdom.

***Figure 5*. Impulse responses of SVAR estimations for horizon zero to eight with a global measure of GSCPI as the main explanatory variable.**

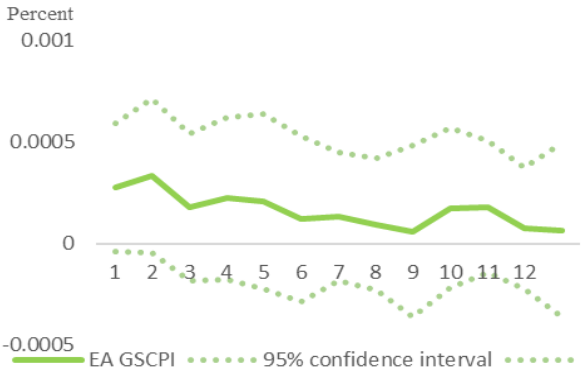
5.2.2 Country-specific GSCPI

In the following result, country specific measurements of GSCPI will be implemented as the main explanatory variable instead of the global values used in the main regression. Hence, supply chain disruptions are locally estimated and different for each country/region at any given time in order to tailor the experienced supply chain disruptions to each country. The expectation is that this should generate a stronger result since the relationship between the supply chain disruptions for a specific country has experienced should be more closely tied to

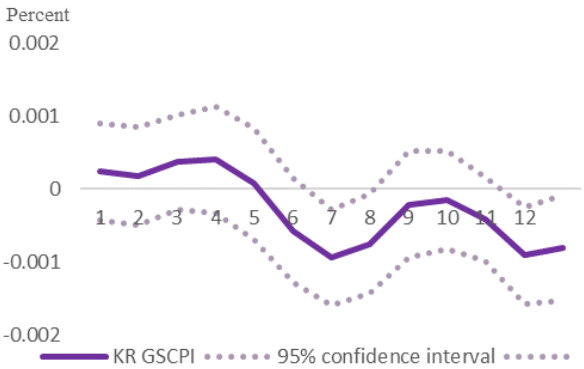
that country's specific inflation than what we expect a global measure of supply chain disruptions to be.

Changing the main explanatory variable from a global measure of supply chain disruption to a country-specific measure did not generate substantial deviations from the main results. The highlight of the main results was the positive, although to a limited extent, significant result at the early horizons. This finding is dampened, but still present, when studying the effect on CPI inflation of a positive one-unit shock in country-specific GSCPI, as is illustrated by Figure 6. All four countries/regions have positive estimates at horizon zero, one and two. However, these estimates are all insignificant. The positive, but insignificant estimate fades for the U.S. and KR, while it is more or less persistent for the EA, as well as for the U.K. The latter also has a positive and significant estimate of .000715 percent per unit shock at horizon six. KR is once again the country which deviates the most from the rest, mainly in two regards. Firstly, significant estimates are once again found at later horizons for the country. This, as GSCPI is measured to have a negative impact on CPI inflation at horizon eleven and twelve, which is in contrast to the positive significant estimates at horizon nine and ten for the country when utilizing the global measure of GSCPI. Secondly, negative, but insignificant, relationships are estimated from horizon five until, and including, horizon twelve. This is the longest span of negative estimates and it additionally includes significant estimates at horizon six and seven.

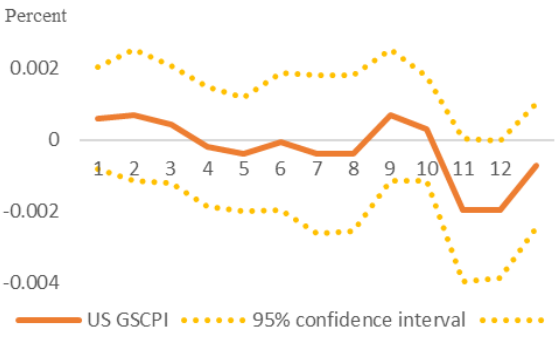
The controls are mostly in line with their corresponding measurements in the main results with the global GSCPI index. This, as Brent spot once again is the strongest predictor of CPI inflation with positive significance at early lags. Specifically, lag zero and one for the EA, the U.S. and KR, while only lag zero is significant for the U.K. Moreover, money supply within the countries also positively impacts inflation at both early and later horizons. The number of significant lags exceeds the corresponding result from the main regression. The similarity regarding the policy rate estimates between the regressions with different measures of GSCPI is significant estimates at horizon zero for the U.K. and the U.S. However, as the measure of GSCPI was altered, additional lags of money supply gained significance. The difference is most prominent for the U.S., whose tenth, eleventh and twelfth horizons now are positive at a significant level. The estimations for the unemployment, money supply and policy rate still have a more or less non-existing causal link to CPI inflation at any horizon.



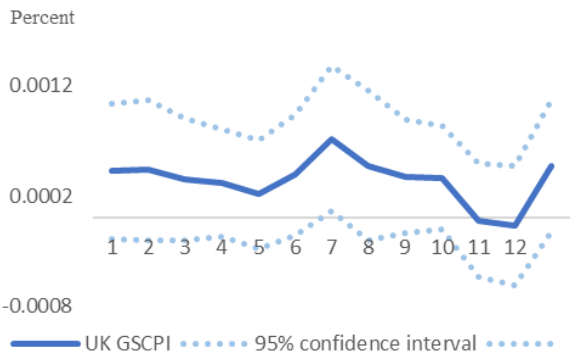
Panel 1. Response of CPI to a one unit shock to GSCPI for the Euro area.



Panel 2. Response of CPI to a one unit shock to GSCPI for the Republic of Korea.



Panel 3. Response of CPI to a one unit shock to GSCPI for the United States.



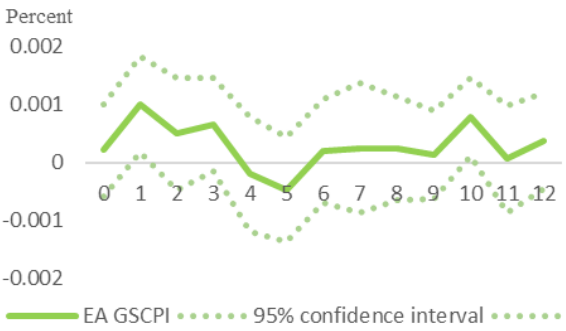
Panel 4. Response of CPI to a one unit shock to GSCPI for the United Kingdom.

Figure 6. **Impulse responses of local projection estimations for horizon zero to twelve with a global country-specific measure of GSCPI as the main explanatory variable.**

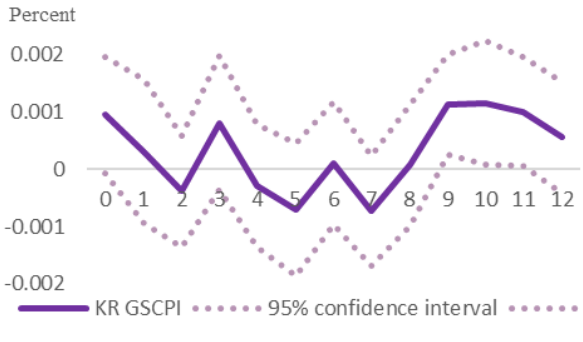
5.2.3 Additional lags

The main results are based on tailored model specifications for each country using the BIC, which resulted in differing number of lags depending on country/region. The main difference is the number of included lags on CPI and GSCPI. For instance, four lags of CPI are included for the U.K., while lagged values of CPI are not included for the EA. The approach in the main LP model is to let the data speak for itself in order to achieve an econometric depth unprecedented in the literature field of supply chain disruptions and inflation. These deviations in the model specification between the countries could potentially be explained by within-country differences of, for instance, different relative importance of certain industries, which could affect inflation at different lags. However, a robustness analysis is, nonetheless, conducted with the same lags for all four countries/regions. The choice of lag length is homogeneously three for endogenous and exogenous controls. The choice of using three lags has two reasons. Firstly, Santacreu and LaBelle (2022) finds supply chain disruptions to have a larger effect on inflation at a one-month lag of disruptions, than at zero. This paper utilizes the CPI as a measure of inflation, while Santacreu and LaBelle (2022) implements the PPI for the same purpose. Producers are likely affected by shocks earlier than consumers because of the direct link to suppliers. Hence, we choose to include three lags as opposed to only lag one since it is reasonable to suspect a delayed effect on CPI. Secondly, two lags would imply a very similar model specification as in the main results, and an almost identical model specification for the U.S. and KR specifically. Almost identical specifications make the robustness analysis redundant. Therefore, the third lag is implemented.

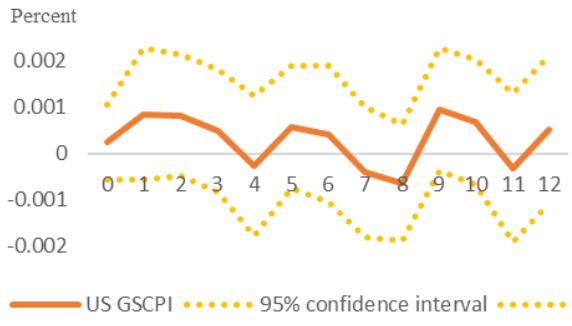
The estimations are illustrated by Figure 7. The result is almost identical to the main result. The first horizon for the EA, as well as the U.K. is significantly estimated with an effect of .00101 and .00174 respectively. The corresponding values of the main result are also significant with a magnitude of .00108 and .00186. The conclusion is that the result of the LP is robust to the number of specified lags within the model. This finding is in line with the literature on LPs as the methodology is supposed to be robust to model misspecification (see Jordà, 2005). Moreover, the minimal impact of the increased lag length on the controls suggests that they are redundant in estimation and that the effect on inflation is more immediate than suspected.



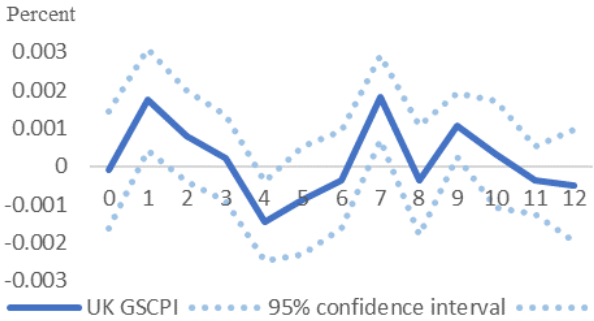
Panel 1. Response of CPI to a one unit shock to GSCPI for the Euro area.



Panel 2. Response of CPI to a one unit shock to GSCPI for the Republic of Korea.



Panel 3. Response of CPI to a one unit shock to GSCPI for the United States.



Panel 4. Response of CPI to a one unit shock to GSCPI for the United Kingdom.

Figure 7. **Impulse responses of local projection estimations for horizon zero to twelve with a global measure of GSCPI as the main explanatory variable and three lags across all variables.**

5.3 Discussion

The statistical significance is low and the magnitude of the result from the main regression with a global supply chain pressure index is small. This implies that one has to be careful with concrete conclusions regarding the effect. However, the estimated direction of the effect can still be discussed.

The results found by the LP IRFs from the main analysis is a small, positive effect of supply chain disruptions on CPI inflation at the early horizons, with a limited degree of statistical significance that varies depending on country/region. This effect then fades as the horizon increases to either two, three or four, also depending on the country/region. The effect then mostly remains insignificant and close to zero with a few exceptions. The exceptions are three positive significant estimates, one at horizon seven for the U.K. and then at horizon nine and ten for KR. When taking the U.S. and the EA into account as well, no common pattern can be observed at the later horizons for the countries/regions. This, in combination with the unlikeliness of a quite delayed effect on inflation after multiple horizons of no effect makes us question the validity of these later, significant estimates found for the U.K. and for KR. However, one possible explanation of these empirical results is particular industries having a delayed effect of supply chain disruptions on producers, and thus, an even more delayed effect on consumer prices. Goods and services that theoretically could behave like this are ones with a high elasticity of demand, which implies that demand changes drastically as a response to price increases. Therefore, producers largely have to absorb the price increase caused by supply chain disruptions. This incidence does not seem sustainable and producers could be forced to increase prices at these later horizons.

Direct comparisons to inflation effects of previous major supply disruptions such as OPEC 1, OPEC 2 and the Korean War are not possible due to the lack of econometric estimations during these crises. The lack of empirical evidence implies that the inflation experienced during these times could be partially, or fully caused by other factors than supply disruptions as discussed by Corbett (2013). He explains that chairmen of the Federal Reserve believed that many factors contributed to the rising inflation in the U.S. during OPEC 1. For instance, the devaluation of the dollar, an economic boom in previous years, financing of the Vietnam war and crop failures. However, despite the impossibility of a one-to-one comparison one would expect the effect of supply chain disruptions to have a bigger effect on inflation during recent times. The reason being that supply chains are a lot longer, more complex and risk characterized today. The small positive effect estimated in this paper is, therefore, surprising as the disruptions are expected to amplify throughout the chain and result in larger inflationary effects.

The estimated minor positive effect on CPI at the early horizons leads to a partial positive confirmation of the first hypothesis. Supply chain disruptions are estimated to have a minor effect on inflation, which theoretically can be explained by the disruptions causing supply to

be unable to meet demand due to bottle-neck situations. This consequence is particularly prominent if the disruptions occur at an industry with inelastic demand as explained by Santacreu and LaBelle (2022). Demand exceeding supply consequently puts upward pressure on prices due to cost of production being a determining factor of consumer prices (Batten, 1981). Moreover, the common "just-in-time" technique utilized by producers makes it rather reasonable for supply chain disruptions to have an effect on inflation at the early horizons, despite the effect having to first translate from suppliers to producers and finally to consumer prices. This, as producers have a limited inventory with the purpose of reducing storage costs and are quickly affected by limited supply (Low, Nayyar & Park, 2013, p. 48).

The positively estimated effect of supply chain disruptions on inflation is in line with the few existing econometric estimations within the field of supply chain disruptions and inflation. This, as Santacreu and LaBelle (2022) and Attinasi et al. (2021) also find positive effects. Additionally, the direction of our findings is also partially in line with Ruch and Taskin (2022) who finds a positive effect of demand shocks on inflation, but a negative one from supply shocks. However, the supply shock in their paper is positive, whereas the Covid-19 pandemic caused a negative supply shock with bottle-neck situations. The comparison is possible as supply chain disruption can be both demand-, and supply-caused, as highlighted by the Covid-19 pandemic. However, the magnitude of our result does not match any of the estimates in previous empirical publications. Santacreu and LaBelle (2022) estimated the Covid-19 pandemic to have increased inflation by 2 percent, while our estimate of .00186 per unit shock in GSCPI lies within the same positive spectrum, it is nowhere near in magnitude of previous literature. GCSPI has ranged from a lowest value of -1.59 to a largest value of 4.5 during our timespan. Moreover, GSCPI increased with roughly 4 units from the start of the Covid-19 crisis in January 2020 until our latest point of data in January 2022. Hence, this paper finds a substantially lower effect than Santacreu and LaBelle (2022), which also is reflected in the low level of significance across the board.

Previous research is very focused on the result of supply shocks/disruptions during crises, while this paper implements a general approach which includes crises, as well as, times of economic stability in the analysis. However, as shown by figure 1, the variation of the supply chain pressure index is largely located in the observations from early 2020 and onwards, with the implication being that these years have a large impact on the results. The more general approach is an explanation of the smaller estimates found in this paper.

The early and positive effect is present for all of our four countries of interest, however, the level of significance varies as the U.S. does not obtain any significant estimates, while the U.K., the EA and KR achieve significance at horizon one, one and zero respectively. Interestingly, this is in line with the findings of Santacreu and LaBelle (2022) as the paper empirically estimates exposure to foreign supply chain disruptions to have a larger positive effect on inflation than domestic supply chain disruptions. Out of the four studied countries/regions in this paper, the U.S. is the one with the by far lowest import share of GDP as illustrated by Figure 3. The implication is that the country is the most self-sufficient and, therefore, not as exposed to foreign supply chain disruptions as the other three countries/regions, even if the country has a negative net trade. Hence, the insignificant estimates of the U.S. are in line with theoretical framework and previous findings. Moreover, it implies that the answer to the second hypothesis is a possible yes. Supply chain disruptions likely have a limited heterogeneous effect on inflation across countries. This, as the U.S.'s insignificant estimates could be due to self-sufficiency, which implies that the relationship between supply chain disruption and inflation does differ between countries. However, the findings support a heterogeneous relationship, but at the same time, they do not confirm it.

As previously outlined, two industries which experienced particularly large disruptions during the Covid-19 crisis were the automobile and the electrical industry. The demand shocks in the former industry could not be matched by the same increase in supply due to the bottle-neck situation in production. Regarding the latter, work at home policies caused large demand increases in the technological sector which suppliers were unable to keep up with. As discussed in section 3, Santacreu and LaBelle (2022) found this to be true as supply chain disruptions within these sectors had the highest estimated impact on inflation. The U.S.'s largest import category is electronics, yet the estimated effect of disruptions on CPI inflation is insignificant, but once again, the U.S. is regarded as a relatively self-sufficient country. However, the EA's largest import category is machinery and vehicles and KR's corresponding category is electrical and electronic equipment. The results for the latter two countries, both with significant estimates at an early horizon, are, thus, in line with the findings of Santacreu and LaBelle (2022). Regarding the U.K., they import relatively little of these two categories with none of them breaking into the country's top three import categories. Yet, a positive significant estimate on inflation at horizon zero was found for the U.K. A possible explanation for this is the negative net trade for the U.K. illustrated by Figure 2 with the implication that they operate at a relatively low degree of self-sufficiency. Hence, supply chain disruptions could affect the

U.K. to a larger extent than more self-sufficient countries such as the U.S. Moreover, our result has the potential implication of relative self-sufficiency and independence of other countries being more important than which type of industries that dominates the import sector in order to avoid inflationary damage as a result of supply chain disruptions. This finding further strengthens the belief of the second hypothesis being true.

How robust are the above discussed results? The small, but positive effect of supply chain disruption is significant at either horizon zero or one, with the U.S. being the exception. The positive direction of these early horizons is present in all types of robustness analysis. However, the statistical significance is mostly lost when implementing IRFs for a SVAR model or when changing GSCPI to a country/region specific index. The implication of this is that the results have to be interpreted with caution. Positive estimates for all four methodologies conducted in this paper does strengthen the directional conclusion, but the robustness analysis simultaneously dampens any conclusions regarding the positive magnitude. The positive significant estimates in the main regression, at horizon seven for the U.K. and horizon nine, as well as, ten for KR are heavily weakened when the robustness analysis is accounted for, as no such effect is found. Hence, our interpretation of these significant results at later horizons is that they occur due to the nature of statistical tests as false positive conclusions are always possible and that the actual effect of supply chain disruptions on CPI inflation dies out at an earlier point in time.

6. Concluding remarks

The purpose of this paper is to contribute to the scarce empirical literature on the effect of supply chain disruptions on inflation by answering two hypotheses. Firstly, whether or not supply chain disruptions have an effect on inflation and, secondly, whether the effect is heterogeneous across countries. An LP methodology consisting of IRFs is conducted to answer the questions. The results support both hypotheses to limited extents. This, as a minor, but positive significant relationship between supply chain disruptions and inflation is found at horizon zero or one, for the EA, U.K., and KR, while estimates for the U.S. are insignificant. The significant findings could be explained by supply chains heavily relying on vital parts of production in other parts of the world. The consequences of a break in the chain are particularly impactful if supply is inelastic, which then puts upward pressure on prices, thus causing cost-push inflation. The estimated effect being significant at early horizons can be explained by the

"just-in-time" technique, where producers keep minimal stock in order to minimize storage costs. By doing so, producers are more or less immediately affected by supply shortages and, hence, have to raise prices quickly. Moreover, the effect is possibly heterogeneous across countries. This, as no effect was found for the U.S., the most self-sufficient country out of the four and, therefore, the country is less exposed to foreign disruptions in supply chains than the rest.

The weak results with little to no effect of supply chain disruptions on inflation has the implication of supply chains not being very important in an inflation determining context. Therefore, central bankers with the goal of a low and stable inflation should not prioritize inflation-fighting measures such as minimizing risks associated with supply chains. The fading of the slight positive effect as the horizon increases implies that the disruptions have no long-term effect on inflation. Hence, a way to deal with supply chain disruptions is to do nothing. Moreover, the role of central bankers varies across countries. The finding of self-sufficient countries being less affected by supply chain-disruptions in an inflation-determining context has the implication of central bankers paying some attention to supply chains in countries with a high level of import share. Central bankers in self-sufficient countries can, on the contrary, disregard supply chain disruptions as an inflation determining effect. However, a failure of supply chains could have other negative impacts than inflationary ones, these are not considered in this paper.

This paper is one of few empirical ones in the supply chain-inflation related literature. More research is very much needed, especially as the results of the present literature do not fully coincide. Additionally, both inflation and supply chain disruptions have increased since the end of the data set used in this paper. Thus, similar papers with future data would be a great addition to the literature in attempting to further understand the true nature of the relationship. This is essential as one cannot know for how long the high levels of inflation and supply chain disruptions will remain, or even to what degree they will potentially decline.

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8. Appendix A. Sources of data

Table 2. Each variable with description and source.

Variable	Description	Data source
CPI*	Consumer price index, seasonally adjusted, 2015 reference year.	ST. Louis FED
GSCPI	Global measure of supply chain disruption.	Federal Reserve Bank of New York
Country specific GSCPI*	Country specific measure of supply chain disruption.	Federal Reserve Bank of New York
Policy rate, U.K.	Official bank rate in the U.K.	Bank of England
Policy rate, U.S.	FED Funds effective rate.	ST. Louis FED
Policy rate, EA	Euro Area refi rate.	European Central Bank
Policy rate, KR	Base Rate.	Bank of International Settlements
Unemployment*	Percent, monthly frequency, seasonally adjusted.	ST. Louis FED
Exchange rate*	Represented by a weighted index, not seasonally adjusted, 2010 reference year.	ST. Louis FED
Money supply, U.K.	M4.	Bank of England
Money supply, U.S., EA and KR	M2, M3 and M4 for the U.S., the EA and KR respectively, national currency	ST. Louis FED
Brent spot oil price	Dollars per barrel, not seasonally adjusted.	ST. Louis FED
Import share of GDP**	Import of good and services, percent of GDP	World Bank
Net trade**	Export of goods and services minus imports, dollar	World Bank
Import industries**	Import category as share of total imports.	Eurostat, Trading Economics, United States International Trade Commission

* Indicates that the variable is measured at a country-level, which generates four sub variables that are used in each country's respective regressions.

** Indicates that the variable is not used in a regression context, and that it is measures at a country level.