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Hungary's inflationary exposures to global price movements

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ABSTRACT

This paper investigates Hungary's inflationary exposures to global price movements using a simple cost-push input-output price model and a database of inflation-to-output price elasticities (Global Inflation-to-Output Price Elasticity Database, GIOPED) developed on the basis of the OECD's Inter-Country Input-Output Tables. Inflation elasticities are decomposed into local, simple, and complex global value chain effects by applying Wang's decomposition scheme (Wang et al. 2017) to price movements and inflation. Our empirical analysis based on GIOPED elasticities shows that Hungary is highly exposed to global value chain price transmissions originating in Germany, Austria, and Russia; and in particular to changes in energy prices. The crude oil and natural gas price boom and the resulting energy crises caused a significant increase in consumer price levels in Hungary; however, this explains only a fraction of current inflation rates.

KEYWORDS

international price transmission, global value chains (GVCs), inflation exposures, GVC decompositions, OECD inter-country input-output tables (ICIO), global inflation-to-output price elasticity database (GIOPED)

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1. INTRODUCTION

The global economy has been extremely volatile since the beginning of the pandemic (Ahir et al. 2023) which is also reflected in inflation developments. Figure 1 shows the evolution of the price level in some European countries including Hungary (black solid line) and the European Union (EU) (black dashed line). During 2020, with the COVID lockdowns, inflation was low in most countries. In 2021, after opening, in parallel with surging demand, price levels increased all over the world (Kekarainen 2022). This was also supported by ultra loose monetary and generous fiscal policies. In 2022, the international sanctions and the reciprocal countermeasures as a result of the Russian-Ukrainian war, caused a rapid rise in energy commodity prices. According to the World Bank (2023), the price increase for commodities (food, energy, metals etc.) was above 40% in 2022 on a year-over-year basis.

According to the Eurostat, inflation peaked at around 20% in the Central-Eastern European region. Hungary experienced one of the highest consumer price increases in the European Union (see Fig. 1). This study examines how much of Hungary's outstanding 2022 inflation rates can be explained by price transmissions through global value chains (GVCs), especially the rise in crude oil and natural gas prices.

GVCs have been widely researched in the literature since the 1990s. Gereffi (1994; 1999), Porter (1998), and Kaplinsky (2000) formulated the basic theory of value chains. After the

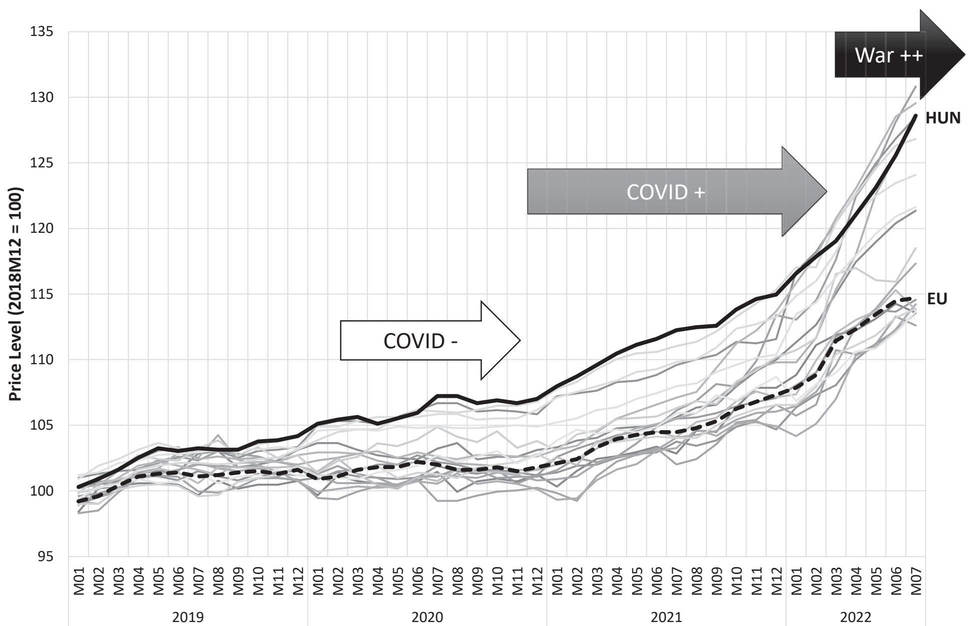

Fig. 1. The evolution of the price level (2018M12 = 100) in some European countries, the European Union (EU), and Hungary (HUN)
Source: authors, based on data from Eurostat (2022).

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construction and publication of the open access global input-output (IO) tables and databases (World Input-Output Database, WIOD, Timmer et al. 2015; OECD's Inter-Country Input-Output Tables, OECD 2021a; and the EU's Full International and Global Accounts for Research in Input-Output Analysis, FIGARO, European Union 2021; for a comparison see Gáspár, 2020 and Gáspár – Koppány 2020) intensive quantitative research began. Hungary's role and position in GVCs was analysed by Gáspár et al. (2023), Braun et al. (2020), and Koppány (2020).

Recently, with the current inflationary shocks described above, the phenomena of international interaction of prices, i.e. the global price transmission and the GVC-related determinants of inflation have come into focus. Explaining inflation within the context of global value chains, however, is still a topical and novel idea both in the international and Hungarian literature.[1] In this vein, we developed an input-output price model and inflation elasticity database (Global Inflation-to-Output Price Elasticity Database, GIOPED) to explore inflation exposures of domestic and foreign industries on the basis of the OECD's Inter-Country Input-Output Tables. For this, we defined and broke down inflation-to-output price elasticities based on the decomposition method and terminology of Wang et al. (2017). Using this approach first to an input-output price model we can distinguish transmission effects resulting from local, simple, and complex global value chains, and specific countries and industries. Based on the GIOPED, this paper aims to explore some GVC-related sources of recent record high inflation in Hungary.

The study is organised as follows. Section 2 gives an overview on the types of GVC cost-push price transmissions handled by our model, and Section 3 uses them to analyse Hungary's inflationary exposures to global price movements. Section 4 summarizes the main findings.

2. COST-PUSH PRICE TRANSMISSIONS THROUGH GLOBAL VALUE CHAINS

The empirical results in Section 3 are based on the Global Inflation-to-Output Price Elasticity Database (GIOPED) developed in a previous project (Koppány et al. 2023a, 2023b) and presented in detail (with the model context, mathematical apparatus, user manual, and the downloadable database itself) in a companion paper (Koppány et al. 2023c).[2] In this study, we focus on the necessary background only, presenting the results supported by diagrams.

The intuition behind the concept of global inflation-to-output price elasticities stems from the fact that today final users of products (mainly households) all around the world are connected (directly and indirectly) to several producers of different countries. Direct backward linkages from final users to final producers, and additional linkages between the producers involve both domestic and foreign relations (i.e. the final and intermediate use from domestic supply and import). Starting from the nodes of final producers and going upstream (see Fig. 2),

[1]Most studies in the GVC-IO, and also in the IO literature are based on volume models. The role of price models are rather marginal. For the basics of IO price models in brief see Miller and Blair (2009) and Oosterhaven (2019). IO modelling has a long tradition in Hungary, as it has been utilised for economic planning in the 60s, 70s, and the 80s. For some price applications from these times see Bródy (1970), Szilágyi (1969), Szakolczai (1972, 1973). Since the 1990s, IO price models were undeservedly marginalised in the literature, also in Hungary. For a few exceptions see Révész (2000) and Zalai (2012).

[2]Figures 3, 9, and 10 are taken from here.

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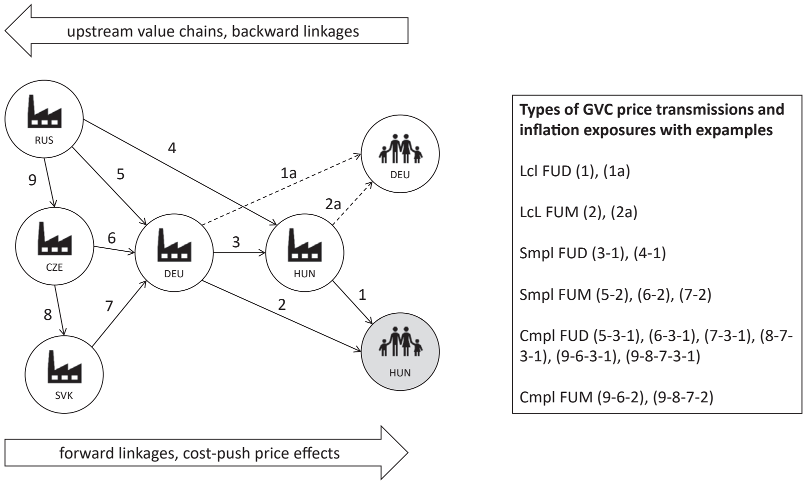

Fig. 2. Cost-push price transmissions and components of consumer inflation determination in global value chains
Source: authors.

the production network can be decomposed into three components: local, simple, and complex global value chains.[3] Local value chains involve domestic economic performance only (value added from the same country as of the producer of the final product). In simple global value chains there are just one, while in complex value chains we have multiple border-crossings (inter-country linkages) of intermediate products in addition to the numerous intra-country buyer-supplier connections.

The price effects run in the opposite direction. An increase in the price of an intermediate product causes a cost increase for the buyers, who, in turn, pass this on to their customers to avoid a decrease in value added (see point 1 of the Methodological Notes in Appendix). At the endpoints, final consumers face all original and spill-over effects transmitted by the whole global value chain as an increase in the price of their consumption bundle expressed by consumer price indices.

The pricing mechanism referred to above is the basis of the simple input-output price models, such as the one we have behind the GIOPED. What is new compared to the old theory is that (1) GIOPED connects output prices to price indices, (2) when doing this, it uses inflation-to-output price elasticities, and (3) decomposes price effects into GVC components based on a global input-output database, the OECD's Inter-Country Input-Output (ICIO) tables.[4]

[3]Basically, we follow the Wang et al. (2017) terminology with minor modifications.

[4]Based on the concept of output-to-output elasticities (Miller – Blair 2009), first we introduced and calculated output price-to-output price elasticities, which were then decomposed to six GVC components (to be defined in Fig. 2), and finally, using the corresponding consumption weights for each country, we connected price changes to consumer price level changes producing a detailed database for GVC inflation impact analyses. As far as we know, this is the first application of Wang's terminology to a global IO price model.

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Although GIOPED contains elasticities also for the producer price index (PPI) and terms of trade (ToT), here we only focus on the impact on the consumer price index (CPI), mainly from the viewpoint of Hungary (which is then called the price index country in GIOPED). The CPI inflation-to-output price elasticity expresses the percentage change in the consumer price level caused by a 1 percent exogenous change in the output price of a country-industry somewhere in the upstream value chain. For example, the elasticity of 0.018 for the Hungarian inflation to the output price of the German automotive industry means that a 1 percent increase in the price of the German automotive products, ceteris paribus, causes a 0.018 percentage point rise in the Hungarian consumer price level. Because of the linearity of the model, the causes and consequences are fully proportional (see point 2 of the Methodological Notes in Appendix), thus a five times larger (i.e. a 5%) price increase causes a 5 times larger ($5 \times 0.018 = 0.09\%$) inflationary effect. Moreover, inflation-to-output elasticities are additive, thus a simultaneous 10% exogenous price increase in the Russian energy sector, for example, for which Hungarian inflation has an elasticity of 0.033, together with the German automotive price shock in the previous example, results in a $5 \times 0.018 + 10 \times 0.033 = 0.42\%$ increase in the consumer price level in Hungary.

Exogenous price effects do not result from an increase in the price of the intermediate consumption, but the exogenous rise of the value added. The key to classifying price effects into different GVC categories is where this ultimate cause occurred, and through which channels its cost-push spill-over effects reached the final consumer. If the exogenous price change occurs in the final consumer's own country and the consequent cost-push effects do not cross the border, then this is a local price effect in the domestic final use (Lcl FUD). For Hungarian consumer inflation, this is the edge denoted by (1) in Fig. 2. The same full local price effects for the domestic final use of Germany are represented by edge (1a). The family icon denotes households, and the nodes with factories indicate productive sectors of the countries coded by HUN, DEU, RUS, CZE, SVK (for Hungary, Germany, Russia, Czechia, Slovakia, respectively).

Local price effects can also arrive through the final import channel (Lcl FUM). For Hungary it is the edge (2), for Germany (2a) in Fig. 2. In these cases of classical international trade, the exogenous price shock and the subsequent cost-push price effects are fully local, but the final product is sold to households in a different country. From the viewpoint of the latter, this is a final use from import (FUM).

In simple (Smpl) GVCs, cost-push price effects cross border only once. The final use can occur within the country where the final product was produced (finalised) (domestic final use, Smpl FUD), or in another country, from the viewpoint of which it is a final use from import (Smpl FUM) again. The walks (3-1): a price change in Germany with cost-push spill-overs to Hungary and the Hungarian final product bought by Hungarian households, and (4-1): a price change in a Russian product affecting Hungarian production costs and a price of a Hungarian final product consumed by Hungarian customers serve as examples for a Smpl FUD. (5-2), (6-2), and (7-2) illustrate Smpl FUM effects, where the final product arrives to Hungarian households from German suppliers, but the origin of the price shock is outside of Germany.

Complex (Cmpl) GVC cost-push price effects have at least one more step back to a different country in the upstream value chain. The final product can be produced domestically (final use from domestic production, FUD) or imported (FUM). For the former see (5-3-1), (6-3-1), (7-3-1), (8-7-3-1), (9-6-3-1), (9-8-7-3-1), and for the latter (9-6-2), (9-8-7-2). (9-8-7-2) means, for example, an exogenous price change in Russian energy commodities causes a price change in

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Czech power supply and coke and refined petroleum products, then a chain of cost-push effects in Czech, Slovakian, and German agriculture and the food industry, and finally, an increase in the price of ready-to-eat food imported from Germany by Hungary.

GIOPED assumes no changes in product quantities and exchange rates, no repercussions of inflation to wages (i.e. price-wage spirals) during the price adjustment process, and no changes in consumer behaviour (hence no adaption in the balance of payments). Only output price movements, their GVC transmissions and inflationary consequences are under investigation. With the six-element CPI decomposition presented above, one can analyse them in a domestic and import final use (FUD, FUM), and local, simple and complex (Lcl, Smpl, Cmpl) global value chain breakdown.

3. HUNGARY'S INFLATIONARY EXPOSURES TO GLOBAL PRICE MOVEMENTS

In this section, using GIOPED elasticities as the measure of exposure, we explore how Hungary depends on global inflationary pressures through global value chains. It is of particular interest, because (as shown in Fig. 1) in 2022 Hungary experienced one of the highest consumer price increases in the European Union. The Hungarian economy relies significantly on imported energy commodities from the Russian Federation, and positioned at the end of the downstream manufacturing global value chains, thus price increases in raw materials have a cumulated impact on Hungarian price level. At the same time, local value chains also have a significant effect on national inflation.

3.1. Hungary's relative position in the consumer inflation exposure rankings

Figure 3 shows the total inflation exposure of Hungary in 2007 and 2018, compared to the world's population weighted average. In both years, Hungary's bars are over the global one, however, the exposure slightly decreased between 2007 and 2018. At the same time, this is mainly due to the decline of domestic value chains.

Since Hungary is one of the most open countries in the world with 90% of export and 82% of import per GDP in 2020, its exposure to imported inflation is far above the global average. Our calculations show that the role of classical trade (Lcl FUM), and the simple and complex value chains in inflation-to-output price elasticities is definitely higher than in other countries of the world, and this has not changed significantly since 2007 (Fig. 3). This is mostly due to fact that the country has a lack of minerals and needs energy producing raw materials (petroleum and natural gas).

Price elasticity through the GVCs could have multiple reasons. Since regional countries share similar figures (see Figs 4–6), one could point to the monocultural industrial production which is focusing on the automotive industry and its satellite suppliers. Although a considerable amount of the world car production is concentrated in Central and Eastern Europe, other local industries not related to vehicle manufacturing are unable to really gain from it. The productivity level of the Hungarian economy is noticeably lower compared to the EU average, not to mention that some industries experienced divergence in productivity in recent pre-pandemic years (Palócz et al. 2019). Meanwhile, the labour market is extremely tight and very close to full employment (Matheika et al. 2022), which seemingly limits the formation of new production

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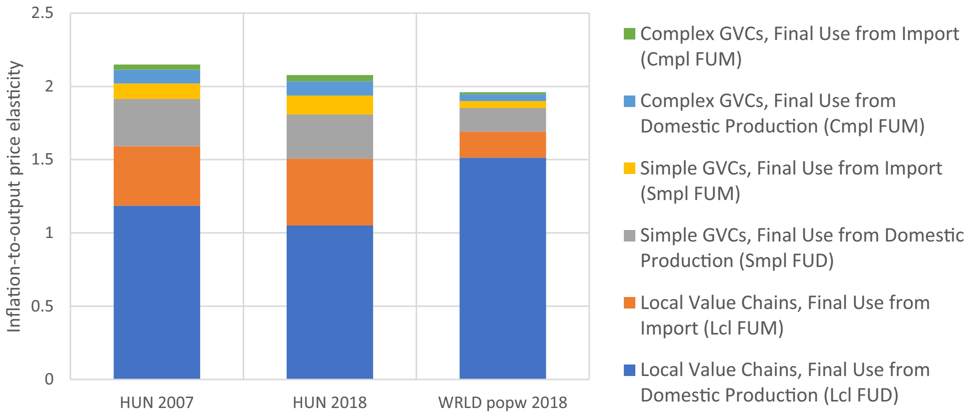

Fig. 3. Comparison of Hungarian and world average consumer price exposures to global price movements[5]
***Source*: authors.**

capacities, thus growth increasingly depends on imports. This is reinforced by the fact that the terms of trade in Hungary, just as the current account, has severely worsened since 2020.[6]

After the outbreak of the coronavirus pandemic, global value chains collapsed in the manufacturing industry and local producers could not substitute the disruptive supply, thus production was suspended for weeks in many EU member states (way before the lockdowns), which caused shortages of several industrial products. While even this alone would have been sufficient to trigger inflationary processes, shortly after the suspension of production, governments introduced lockdowns that cooled down household consumption, obviously with an inflation moderation impact. After the opening of the economies demand began to surge, thus driving prices up in many countries.

Figures 5 and 6 show that Hungary is extremely exposed to international price fluctuations, especially through global value chains, as it is the fourth most vulnerable country in the ranking. This mostly originates from simple value chains. In other words, Hungarian final demand excessively relies on imported foreign final goods and imported intermediate products transformed into final consumer goods domestically. It is a telling result that in this respect, besides Vietnam, only very small EU member states are ahead of Hungary: Luxembourg and Malta. However, Central and Eastern European countries show a similar pattern, as both the Czech Republic and Slovakia have large exposures.

[5]Please note that Figs 3–9 show the decomposition of inflation elasticities based on ICIO 2018, not the decomposition of 2018 inflation rates. Of course, for an analysis of 2022 inflation exposures, using IO data from the year 2022 would be the best choice. Unfortunately, these data were not available at the time of writing the paper. For other reasons for choosing ICIO 2018 (not the more up-to-date FIGARO 2020, for example) see also point 3 of the Methodological Notes in Appendix.

[6]According to Oblath (2019), most EU members had improving terms of trade before 2020, while it was stagnating in Hungary. Consequently, the convergence in real income was lower than in GDP/capita measured in purchasing power parities.

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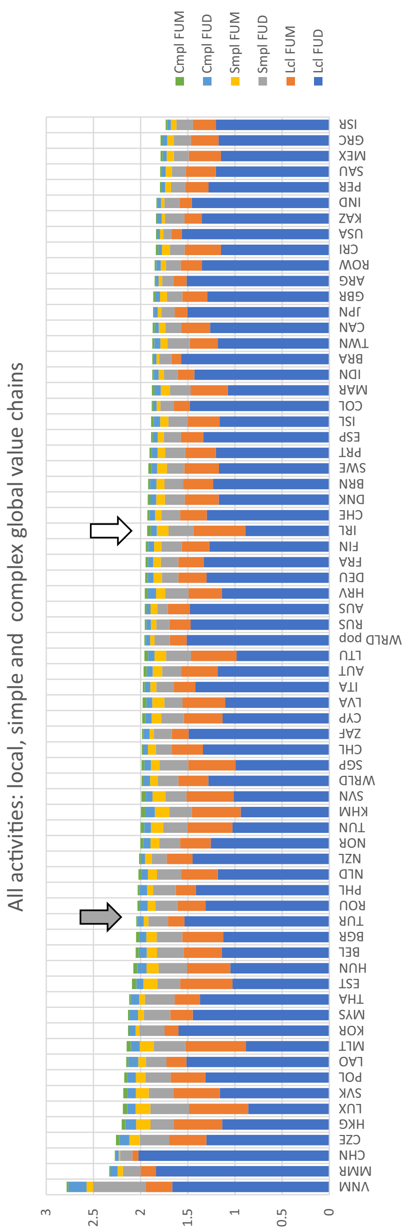

Fig. 4. Basic price CPI elasticity rankings by price index country, 2018; all activities: local, simple, and complex value chains[7]

Source: authors.

[7]Figures 4–6 reflect Hungary's changing position (grey arrow) in the ranking, relative to population weighted world average (white arrow). By excluding pure domestic price transmissions (domestic products for domestic consumption), Hungary steps ahead (Fig. 5). By including only simple and complex GVC activities, Hungarian inflation exposure becomes outstanding (Fig. 6).

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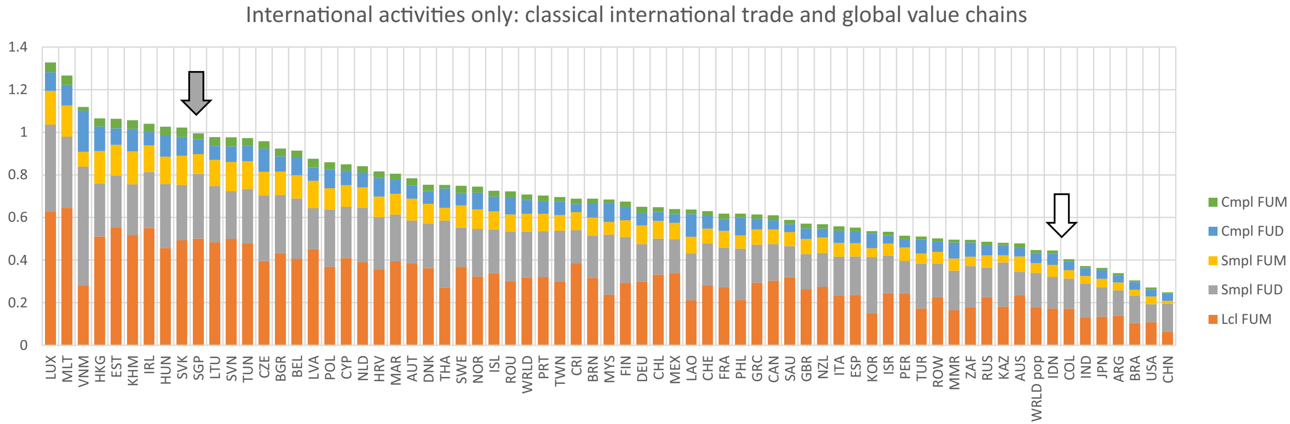

Fig. 5. Basic price CPI elasticity rankings by price index country, 2018; international activities only: classical international trade and global value chains

Source: authors.

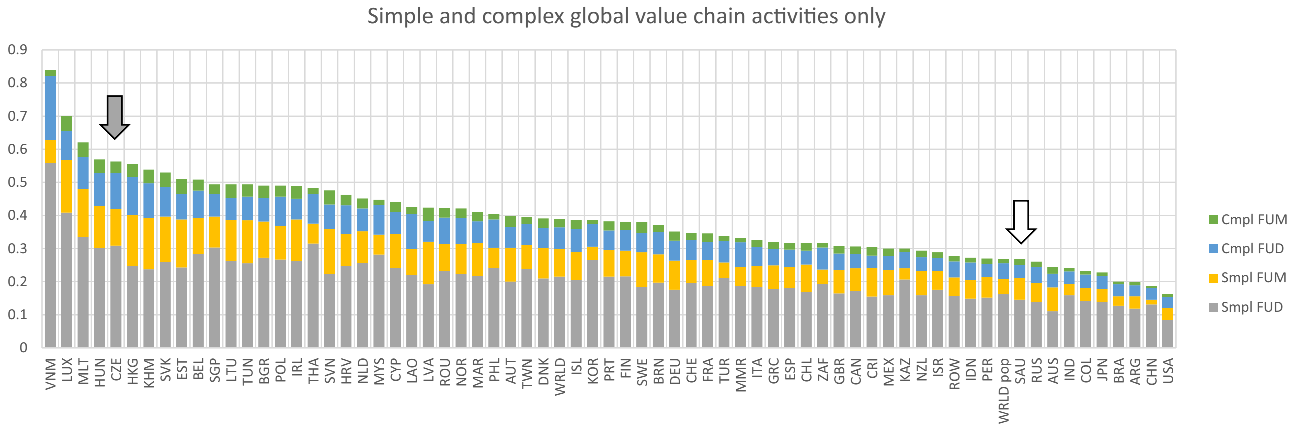

Fig. 6. Basic price CPI elasticity rankings by price index country, 2018; simple and complex global value chain activities only
Source: authors.

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The results would suggest that the import content of domestic final use is very high in Hungary, as 47% of the value of the final products used in Hungary originates from foreign value added, according to the OECD's TiVA Database (OECD 2021b). However, compared to other Central and Eastern European countries (Czechia 46%, Poland 48%, Slovakia 49%), Hungarian value cannot be considered as an outlier. The difference between these countries is the structure and concentration of dependency on GVCs.

3.2. Hungarian inflationary exposures by country and industry

In this subsection, the inflationary exposure of Hungary toward GVCs is disaggregated by country and industry. This process was conducted because the exposure and dependency are not uniformly distributed. Owing to the concentrated industrial and trade structure of the Hungarian economy, focusing on manufacturing products and the European Union, the vulnerability of the inflationary process is likely to be skewed toward particular products and import regions.

This is reinforced by Fig. 7, which reveals that Hungarian inflation is chiefly affected by German producers. The figure shows that this is especially through retail and wholesale trade including vehicle sales. Since the 1990s, there has been a permanent FDI inflow to the Hungarian retail trade industry. As a result, former Hungarian retailers lost their dominant market share and today the main players in the industry are German transnational companies (Tömöri 2015). The German exposure has two main channels in Hungary: directly through final product import and indirectly through simple global value chains. This can be explained by the different marketing conceptions of the large foreign retail trade firms operating in Hungary. While companies of German owners prefer their own (mostly German) brands, other retailers have a much wider product portfolio on the shelves (Dudás et al. 2019). As a consequence, products of German origin have a large market share in retail trade.

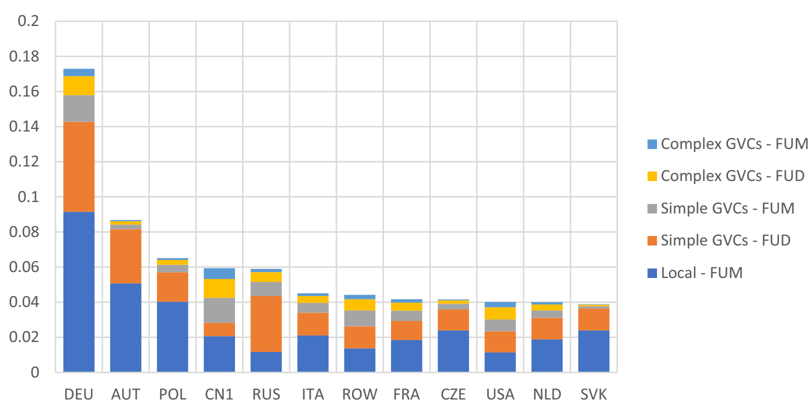

Fig. 7. Foreign country basic price CPI exposures for Hungary, 2018 (measured by inflation-to-output price elasticities)
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The exposure to Austria and the Austrian energy sector[8] is due to historical and infrastructural reasons. In the 1960s the Soviet Union began to build the Friendship Pipeline, which is the longest and largest oil pipeline in the world, delivering oil from the Russian endpoint to users in Ukraine, Belarus, Poland, Hungary, the Slovak Republic, the Czech Republic, Austria, and Germany. The Austrian endpoint is an oil refinery and a natural gas interconnector, that produces gas and fuel for household use (that is, final goods) from raw material mostly imported from Russia. That is why the complex and simple GVC channel of Austrian inflationary exposure is very narrow. It must be noted that this channel is independent from global commodity prices as it only covers the cost of refining. (See also point 3 of the Methodological Notes in Appendix.)

The exposure to the German automotive industry is not surprising, since Hungary accommodates two large manufacturing plants owned by German brands. The dominant part of the related Hungarian inflation, however, is imported directly by the final purchase of German cars.

Despite the result that Russia, with all of its industries. is only the fifth in the country ranking (Fig. 7), one can find the Russian energy sector on the top of the country-industry ranking (Fig. 8) with an outstanding simple GVC component. Since Hungary is a small open country lacking raw materials for energy production, producers must import these inputs. This causes a significant amount of vulnerability for Hungary, which is becoming increasingly prominent due to the sanctions against Russia.

The dependency on Russian price movements (Fig. 9) shows a regional concentration that can be explained by historical and geographical reasons. Former Soviet countries lead the ranking in the exposure (Kazakhstan, Lithuania, Latvia, Estonia etc.) followed by former

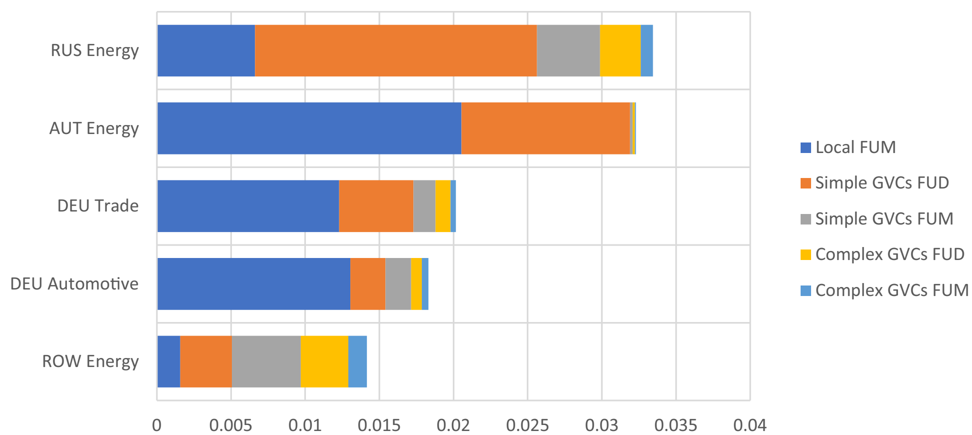

Fig. 8. Foreign country-industry basic price CPI exposures for Hungary, 2018 (measured by inflation-to-output price elasticities)
Source: authors.

[8]The energy sector is defined as the sum of ICIO industries 05T06, 09, 19, and 35 (mining and quarrying of energy producing products, mining support service activities, manufacturing of coke and refined petroleum products, and electricity, gas, steam and air conditioning supply).

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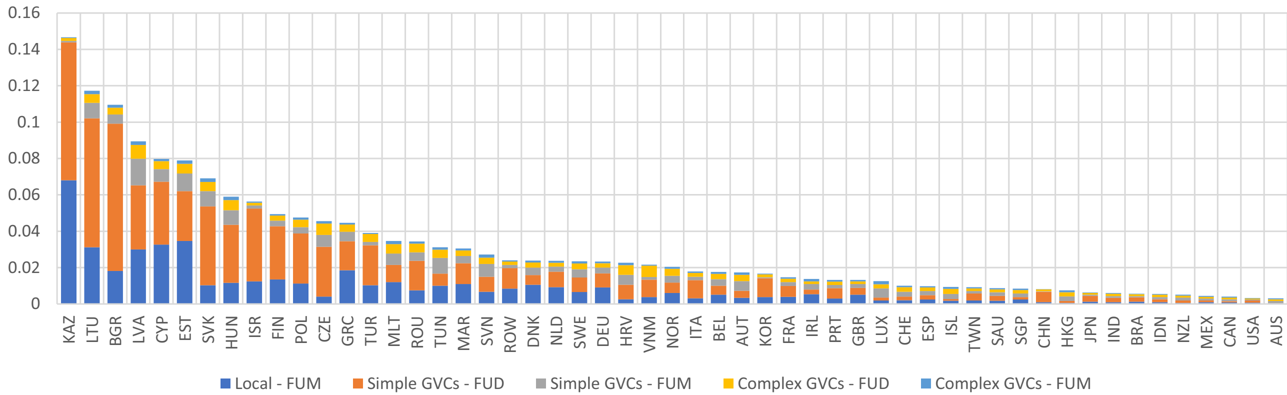

Fig. 9. Rank of basic price CPI exposures to Russian output prices, 2018 (measured by inflation-to-output price elasticities)
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Comecon countries like Bulgaria, Hungary, the Czech Republic etc. The dependency is almost exclusively due to energy carriers produced by the Russian mining and quarrying industry.

In late 2021, the price of energy began to increase owing to growing global final demand (in particular, energy commodity prices increased significantly, lifting European fuel prices to record high levels). Later in 2022, after the Russian invasion of Ukraine, gas prices surged and the service providers passed on the increase to the consumers (Kovalszky et al. 2022). Even though the inflationary exposure to Russia was high and commodity prices skyrocketed, this price increase alone would not have explained the record high inflation in Hungary and in other regional countries. Inflation expectation of the economic actors (including the central banks) also play an important role (Chernov – Mueller 2012). The concentrated inflationary exposure of the Hungarian economy calls attention to the lack of diversification and competition in industries of strategic importance. Over-reliance on a single international supplier has an adverse impact on growth inn the long term in the importer country (Jaimovich 2012). Despite the fact that multi-sourcing import is likely to have some inflationary effects, the risk of shortages or one-sided price surges can only be minimised by import diversification.[9]

3.3. Inflationary effects of the energy commodity price shock

The most pressing problem of the Hungarian economy is inflation, which is outstandingly high compared to other European countries and even in globally. There has been a lively debate between Hungarian analysts,[10] but also between the government and the central bank, as to the reasons and the start date for rising inflation. The topic is also of particular concern to the public since all Hungarians feel the negative consequences on the purchasing power of their income and savings.

The reasons may include several internal and external factors, e.g. drought (Parker 2018), weakening of exchange rates (Camatte et al. 2020, 2021), expansive fiscal policy (Szabó 2023), distortive effects of price caps (Balatoni 2022), overpricing of firms (European Commission 2023; National Bank of Hungary 2023), rising import prices, and price sensitive production sector structures (Živkov et al. 2018).

In this study, we dealt exclusively with the last two of the aforementioned external causes. The increase in the price of energy commodities has played the most significant role in rising import prices in recent years following the reopening after COVID and later the outbreak of the Russian-Ukrainian war. With the help of GIOPED, we tried to investigate the GVC spill-over effects of crude oil and natural gas prices on inflation in Hungary as follows.[11]

Given that the most recent ICIO tables underlying our inflation resilience measures refer to 2018, we examined the evolution of prices and consumer price indices (including Eurostat factual consumer price indices that include all impacts since then, as well as weighted indicators resulting from the GIOPED model that now only reflect the impact of changes in the prices of the above energy carriers) in relation to the average values for this year (2018 = 100%). According to data from the World Bank's 'Pink Sheet' (World Bank 2023), between 2018 and 2022M7, the price of crude oil increased by 54%, the global price of natural gas by 320%, and the

[9]Some Asian countries deliberately diversify their LNG import at the cost of higher inflation (Vivoda 2014).

[10]See Külgazdaság volume 67, issue 2023/1-2.

[11]For details of this investigation, see Koppány et al. (2023c).

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European gas price by 568%. In Hungary, the consumer price level increased by about 30% until 2022M7 compared to 2018 and about 37% by 2022M9. Based on our model calculations with GIOPED elasticities, approximately 8.4% of this can be explained by the increase in the price of natural gas and oil and their price transmission in global value chains (i.e. the fact that the increase in the prices of energy commodities has made all other products more expensive, both directly and indirectly, and not only in Hungary but throughout the world, with the latter also impacting the Hungarian price level). For Hungary, roughly half of the inflationary pressures caused by the energy price explosion can be linked to Russia (see Fig. 10).

If we try to eliminate the bias resulting from the fact that GIOPED inflation elasticities refer to price indices with basic prices, while Eurostat calculates HICP indicators with consumer prices, and consider the impact of net taxes on products, we get a slightly higher energy inflation effect in Hungary of 10.8%. We must compare this with the 30% by July 2022, or also consider the 2-month lag revealed by Kovalszky et al. (2022) in terms of Hungarian import energy prices, with the increase in consumer prices of 37% by September 2022 compared to 2018. However, due to the fuel price cap in force in Hungary at that time, and the modified but still valid official gas price regulation for average consumption, the market processes could not fully prevail in the actual consumer price index. Thus, even the latter higher value does not reflect the full inflationary consequences of energy price effects. GIOPED, at the same time, measures unrestricted market effects and ignores the means of official price regulation. In this sense, it can be stated that, based on our model calculations, the global energy price explosion passing through the global and Hungarian industrial structures most likely explains no more than a third of the inflation in Hungary. Presumably, other external and internal reasons also played a crucial role in the surge in inflation.

Figure 11 compares Hungary's energy-related inflation exposure at a basic price of 8.4 percent to the values of other European countries, showing that there are countries with a higher exposure than Hungary (see dark grey columns). At the same time, the price level increases in these countries (since 2018 until July 2022 = top of grey columns, or September 2022 = top of light grey columns) are well below the values in Hungary. Thus, the other external and internal reasons in Hungary referred to above must have been more significant than in other countries.

Fig. 10. Pressure of global energy commodity (05T06 output) price changes through GVCs since 2018 on basic price Hungarian HICP (total direct and indirect GVC effects, 2018 = 100%)
Source: authors.

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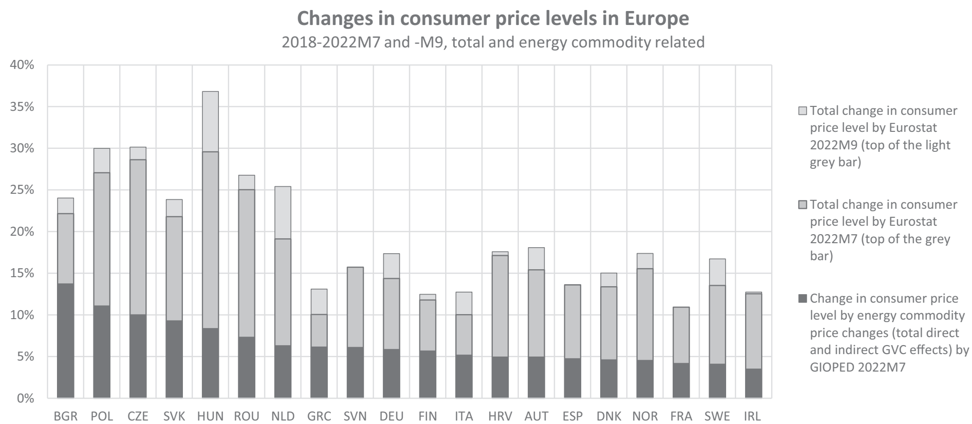

Fig. 11. Changes in consumer price levels in Europe (2018–2022M7 and 2018–2022M9, 2018 = 100%) total and energy commodity related: a comparison
Source: authors.

4. CONCLUSIONS

This paper investigated Hungary's inflationary exposures to global price movements using a model and database of inflation-to-output price elasticities developed on the basis of OECD's Inter-Country Input-Output Tables.

We revealed that the Hungarian exogenous inflation exposure is strongly concentrated to the Russian mining, Austrian energy and German trade sectors. Other countries in the region share a similar pattern; however, it is the Hungarian economy that most depends on Russian energy producing commodity supply. Still, the price movements of such commodities explain only a fraction of the record high Hungarian inflation in 2022. This is because Hungarian consumption still relies mostly on the local value chain (just as other economies), that is, other internal mechanisms have a higher impact on consumer price levels. It must also be noted that Hungarian consumers have a high exposure to the price of imported final goods.

Import diversification and import substitution policies are almost clichés in the economic literature. In the globalised world it is hard to give effect to such recommendations, because without significant increase in productivity, these processes are likely to increase inflation in those countries that do not have comparative advantages in industries highly reliant on imports. However, moderate and endogenous inflation due to lower productivity might be a tolerable risk compared to risks of security of supply (in which the price level is infinite due to shortages).

The study also points out the multiple factors affecting price movements in a country, of which international price transmission is only one. Exogenous international price shocks (more commonly known as imported inflation) truly have a visible impact on the inflationary process in our static model, but one must not forget that these price transmissions are not necessarily linear and additive, as consumers and balance of payments shall adapt to changes in the external inflation environment. It must also be highlighted that Hungarian consumers are only slightly affected by price fluctuations that pass through the domestic part of the GVCs, since these

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intermediate products are barely consumed later by resident households. For example, the surge of copper prices on the world market had an impact on the profitability of the local car manufacturing exporters, but only a small fraction of the total copper import was consumed directly or indirectly by Hungarian households.

The dependency on Russian energy commodity inputs has historical and infrastructural roots in Hungary; however diversification and moderation of hydrocarbon import is definitely possible and most probably preferred by the local actors of the business economy. The exposure to German retailers is also significant compared to the Russian mining industry. Still, since it occurs on a more competitive market, the vulnerability of the Hungarian inflationary process is likely to be much lower (or at least it should be, see Hungarian Competition Authority 2023).

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APPENDIX

Methodological Notes

1. In our model calculations, the vector of sectoral nominal value added is set exogenously and only prices of intermediate inputs form endogenously, being the only variable determinants of output prices. This is a very special assumption and case. When inflation is as high as nowadays, one may not assume that the producers maintain only the nominal value added and accept the resulting fall of its real (purchasing) value. In fact, there are many signs that in 2022 producers even overcompensated the cost increases in their output price, so that even their profitability has increased significantly (see European Commission 2023). Of course, one can consider various possible price formation rules, including alternative definitions of the rate of return to capital and alternative assumptions about its development. Similarly, the wage component of the value added may be assumed to be indexed fully or partly to inflation. Moreover, for an open competitive economy, one may take into account that the price of tradable products is not determined by local production costs, but capped by the domestic price of the import (the world market price of the given product converted to the domestic currency by the exchange rate and augmented by the international transportation costs and custom duties). Such a 'mixed' price model – meant to be as realistic as much as possible – was developed by Révész (2000). In this study however, we want to capture the pure price-to-price effects only, thus it intentionally excludes price-wage and price-profit spirals. To do this, we retain the special assumption described above which is

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compatible with the GIOPED. Of course, this theoretical 'cost plus original value added' type price formation rule, on the one hand, underestimates the resulting value added by not indexing them to the inflation, while on the other hand, overestimates the price effects by assuming a full and instant pass-through of the costs. Moreover, in our model, direct price changes (driven by exogenous value added changes) always have some repercussions on the source industry (or industries) as well, causing some extra loops and further increase in prices and inflation. For a more detailed description of possible sources of under- and overestimations see also Koppány et al. (2023c).

2. Constant elasticities for a linear model may seem strange at first. Elasticities, in general, describe the responsiveness of a variable A to changes in variable B. Since both changes in A and B are expressed in percentages, elasticities, which are the quotient of the previous percentage changes, are measureless metrics. Thus, price elasticities, for example, express the percentage change in the demand or supply of a product to a 1 percent change in price. Elasticities can be determined as the logarithmic derivate of the demand function. For a constant elasticity, on the one hand, the relationship between demand and prices must be exponential. For a linear demand function, on the other hand, elasticity varies from point to point.

   In this paper, however, we use the concept of elasticities for a very special case, the cost structure of products, where B is the value of a cost component, and A is the value of the product. If the price of a cost component of 0.25 (or 25%, relative to the output value) rises by 1%, ceteris paribus, the output value index (since the quantities are constant, the price index) of the product will be $0.25 \times 1.01 + 0.75 \times 1 = 1.0025$, i.e. the price of the product increases by 0.25%. Obviously, a 10% price increase in the 0.25 share cost component results in a 2.5% higher output price. That is why the shares or weights in the matrix of direct input coefficients can be seen as constant direct input price-to-output price elasticities, or since an input for an industry is the output of another one, output price-to-output price point elasticities. To involve both direct and indirect relations, elements of the Leontief inverse serve as such elasticities. For more on input-output elasticities see Miller and Blair (2009). The same holds for the weights when calculating consumer price indices based on the consumption bundles of different countries.

3. These results may seem strange at first glance in the light of the previous Hungarian GVC IO studies. Note that the variances may stem from different methods (demand side quantity models versus supply side price models), focus and database. Previous papers were based on the quantity approach and focused mainly on the automotive (Braun et al. 2020; Gáspár et al. 2023) or other specific industry (Antalóczy et al. 2019), or on the Chinese relations (Koppány 2020) and used mainly the WIOD database. This study focuses on consumer price inflation, not output or valued added, exposures of which, to some extent, can be driven by different factors, countries, and industries.

   To validate our results, we investigated and compared indicators calculated with the ICIO, WIOD, and FIGARO databases. There are significant distortions between the tables due to different basic data, classification, accounting and harmonisation methods, and adjustment techniques (Révész 2016). The divergences, for such a small economy as Hungary, in particular, at a sectoral level, can be considerable.

   In any case, our comparison shows that for a Russia-focused exposure analysis of Hungary, the ICIO database outperforms the other two being the closest to Russia's country

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share in fuels and energy based on the official import data of the Central Statistical Office of Hungary. In addition to having time series only up to 2014, for this year the WIOD delivers incompatible data for Hungary's exposure to Russian energy sectors (as was pointed out by Koppány 2021). FIGARO covers the period up to the year 2020, which is undoubtedly closer to 2022 in time; however, this year was full of lockdowns causing severe economic downturn and diverting the intra- and intercountry interindustry relations from normal (business-as-usual). For this reason and the fast recovery with an outstanding real growth in 2021, 2020 would prove to be an unfortunate base year choice, seriously violating the fixed reference year quantities assumption of the IO price model. Moreover, in FIGARO, the Russian shares in Hungarian energy import are significantly lower than the ones reflected by official data which would result in an underestimation of Hungary's Russian dependencies. Unfortunately, on the one hand, the share of the Austrian energy sector in ICIO is higher than the official one, thus it can result in an overestimation of the role of Austria in Hungarian price determinations. On the other hand, since WIOD and FIGARO deliver lower shares, they would underestimate Austria role. In the case of the trade sector the shares calculated with WIOD, ICIO, and FIGARO are quite close to each other.

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