Prices and Inflation in Global Value Chains
A global inflation-to-output price elasticity database with applications

KRISZTIÁN KOPPÁNY, PÉTER VAKHAL, PÁL PUSZTAI*

Abstract

Global value chains (GVCs) are important transmitters of product price shocks, which, in the end, will be expressed in national inflation rates. This paper deals with this phenomenon by presenting and applying an input-output model of global cost-push price transmissions using the 2021 edition of OECD Inter-Country Input-Output (ICIO) tables. Output prices are linked to several inflation rates by the concept of inflation-to-output price elasticity. Inflation elasticities are decomposed into local, simple, and complex global value chain effects and collected into the Global Inflation-to-Output Price Elasticity Database (GIOPED) published along with the paper. A step-by-step guide shows how to import data and perform quick interactive form impact analyses in Microsoft Excel. The presented GIOPED exercises reveal that local value chains are still dominant in determining inflation, although there are significant differences between countries. For Hungary, selected for an illustrative country study, inflation elasticities are higher with smaller domestic components, and exposures to current global shocks are considerable. Movements of energy commodity prices explain about a third of autumn 2022 Hungarian inflation rates.

Journal of Economic Literature (JEL) codes: C67, E31, F62.

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1. Introduction and motivations

The previous global economic crisis of 2008 had taught the central banks of the developed world a crucial lesson: household purchasing power must not diminish. In accordance with that the central banks loosened their monetary policy to a historically low level in 2020 in reaction to the pandemic. After the first shock caused by the severe and rapid spread of coronavirus infections in early 2020, lockdowns were gradually eased, and household consumption began skyrocketing. Consequently, an ongoing quantitative easing was accompanied by an increasing demand. Owing to the disturbances in the global shipping industry, a bottleneck effect developed in logistics in almost all major ports, which in turn caused shortages in almost all raw materials. This was worsened by the intense fiscal policy of all governments, intended to restart the economy and thus also boosting demand, while supply was already lower due to the aforementioned reasons. Commodity prices were depressed during the lockdowns, but after opening up, high volatility was experienced on the markets (Bourghelle et al., 2021). On 24th February 2022 Russia invaded Ukraine, which along with the international sanctions and the reciprocal countermeasures caused the rapid rise of raw material prices on the global market.

Growth requires inputs from all over the world, which are forwarded to the producers through the global value chains (GVCs). Prices of intermediate products have been rising since late 2020. It started with the price of metals (aluminium, nickel, wood etc.) that are mainly required for construction, followed by food products (oil, crops etc.) and later by beverages (coffee and tea). More recently, between 2022M1 and 2022M8, the World Bank's energy commodity price index (a weighted average of crude oil, natural gas, and coal prices) increased by more than 42%.[1] Inflation quickly escalated in the developed world through the channels of GVCs and in September 2022 the consumer price index in the OECD was 10.5% and 10.9% in the EU27.[2] The latter rose even further, to 11.5 percent, by October 2022.[3] The variation among member states is high as CPI peaked around 20% in Estonia, Latvia, Lithuania, and Hungary. Recent events in price developments highlight the fact that economies in the globalised world cannot ward off inflationary pressures whatever the source is. Industry networks are extremely dense with strong interdependencies, in which price movements are easily transmitted owing to spill-over linkages studied by Oliyide et al. (2021).

In this paper we approach international price transmission via input-output (IO) models, world IO tables and GVCs. Traditionally, most studies in the IO literature are about volume models.[4] Miller and Blair (2009) in their comprehensive book cover price models only in a few pages. Oosterhaven (2019) discusses price and quantity Leontief and Ghosh models in more detail, as dual pairs of each other, and links them in an integrated framework. Despite their background role so far, the evolution of cost-push IO price models from Leontief (1951) and the debate on Ghosh (1958) model's price interpretations (De Mesnard, 2009; Dietzenbacher, 1997) to the contemporary literature has some interesting episodes, key concepts and applications, and fortunately, it also offers opportunities to contribute.

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[1] https://www.worldbank.org/en/research/commodity-markets

[2] https://data.oecd.org/price/inflation-cpi.htm

[3] https://ec.europa.eu/eurostat/web/main/data/database

[4] IO price model-based or price-related papers (Abildgren, 2007; Bazzazan and Batey, 2003; Cabrer et al., 1998; Casler, 2011, 2013; Durand and Rioux, 1994; Folloni and Miglierina, 1994; Karasz, 1992; Kratena, 2005; Kuboniwa, 1993; Llop, 2021; Mattey, 1993; Seton, 1993) form the minority also in the leading journal of the field.

Recently, with the rise of GVCs and 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 is coming into focus. Explaining inflation within the context of global value chains, however, still seems to be a topical and novel idea. Searching the most current GVC Development Reports (ADB et al., 2021, WTO, 2019) for the keyword ‘inflation’ results in ‘no matches’. Other studies give some hints and reference points though. Przybyłiński and Gorzałczyński (2022) show the potential of input-output price model to identify mechanisms of price transmission within a country (Denmark). Although their paper is very close to our aims and motivations, they use a single country open economy model and series of national input-output tables.

The literature on international or global price transmission along the GVCs provides both theoretical and empirical studies on the topic using world IO tables, mainly the World Input-Output Database, WIOD, elaborated by Timmer et al. (2015), economic modelling (IO price models or models with at least some IO price model features or components), econometrics, or some combination of these. Llop (2021) presents a bi-regional theoretical framework decomposing total price multipliers into intra- and interregional elements with an empirical analysis of the United States and China. An econometric working paper by Forbes (2019) describes price fluctuations by changes in raw material prices, another by de Soyres and Franco (2019) investigates the relationship between inflation synchronization and trade integration and finds a strong link between inflation co-movement and GVC participation. The pass-through role of GVCs has also been revealed by Andrews et al. (2018). Al-Maadid et al. (2017) analyses the synergies between food and energy prices, while Peersman et al. (2021) utilises similar methodology to gauge the linkages between oil and food commodity prices. Wei and Xie (2018) propose a structural explanation of divergence of PPI (Producer Price Index) and CPI (Consumer Price Index) inflation measures based on a lengthening of world production chains. Auer et al. (2017) presents evidence that the expansion of cross-border trade in intermediate goods and services is an important channel of domestic inflation with results that support the hypothesis that as GVCs expand, direct and indirect competition among economies increases, making domestic inflation more sensitive to the global output gap. In another study, Auer et al. (2019) document that international input-output linkages contribute substantially to synchronizing PPI across countries. Among other findings they conclude that input-output linkages account for half the global component of the inflation measured by PPI. Another strand of the literature links imported inflation with exchange rate volatilities and price shocks generated by them (Bems and Johnson, 2017; Camatte et al., 2020, 2021). Some other papers perform a complex quantity, price, inflation, and monetary policy modelling in a global value chain context using mainly two- or three-country (or -region) small-open economy New Keynesian dynamic stochastic general equilibrium (DSGE) models (Wei and Xie, 2020; Guilloux-Nefussi, 2020; Khalil, 2022).

In this paper we do not address monetary policy issues but focus only on input price determinants of global inflation assuming stable exchange rates as our analysis is based on input-output price and inflation elasticities. The concept of elasticities in general is well-known in the IO (Angel Tarancón et al., 2008; Karasz, 1992; Maass, 1980; Mattas and Shrestha, 1991; Schnabl, 2003; Felice and Tajoli, 2021; Timmer et al., 2021) and international economics (Bems, 2014; Auer and Schoenle, 2016; Guilloux-Nefussi, 2020) literature. Based on the representation of output-to-output multipliers and elasticities in Leontief quantity model by Miller and Blair (2009) we introduce the concept of output price-to-output price elasticities and derive them in both Leontief and Ghosh cost-push price models. This leads to the traditional Leontief inverse, the elements of which can be interpreted as output price-to-output price elasticities. Then we break down output price-to-output price elasticities based on the decomposition method and terminology of Wang et al (2017) (see also UIBE Global Value Chain Indexes System – Concept Note[5]), which is compatible with both quantity and price IO models. Using this approach first to a price model we can distinguish transmission effects resulting from local, simple, and complex global value chains. Then we turn to the weight matrices that can be defined based on world IO tables to form a bridge between country-industry level index prices and price indices (inflation rates). Using them we derive IO consumer, producer, and foreign trade price indices similar to the inflation rates used in common macrostatistics, or more precisely, the elasticity indicators for these inflation measures (inflation-to-output price or price index-to-output-price elasticities). Based on the methodology discussed in the first part of the paper, we have developed an empirical inflation elasticity database using the OECD Inter-County Input-Output (ICIO) Tables edition 2021 (OECD, 2021). The rest of the paper shows the production and application of our Global Inflation to Output Price Elasticity Database (GIOPED). The local, simple, and complex global value chains components of price transmission for different inflation rates have been organized into a normalized txt database for the sake of further detailed analysis, which can be effectively processed with simple Excel pivot tables. The paper shows the steps of this with examples of possible crosstabs that can be created from the database. Beside performing a global inflation analysis, we examine and formulate economic policy conclusions from the perspective of a specific country (Hungary), which can also serve as a collection of some examples for investigations to be carried out in relation to other countries. At the end of the paper, we summarize the aim of the study, its new and novel results, and the lessons learned from the first analyses that were performed using the proposed model and database.

In brief, the paper is organized as follows: Section 2 introduces the concept of output price-to-output price elasticities and breaks them into price transmission components resulting from local, simple, and complex global value chains; Section 3 discusses the price index weights that can be defined using world IO tables; Section 4 defines inflation-to-output price elasticities; Section 5 shows the production of our empirical inflation elasticity database and Section 6 shows how to use it; Section 7 concludes. Readers and potential users are supported with appendices for technical details.

2. Input-output price models, elasticities, and decompositions

This section gives an overview of Leontief and Ghosh IO price models, introduces the concept of output price-to-output price elasticities, and offers a scheme to their GVC decomposition. By doing this, it serves as a theoretical background for the subsequent parts of the study.

2.1. Leontief and Ghosh price models

When formulating input-output (IO) price models we follow Miller and Blair (2009), Dietzenbacher (1997), and Oosterhaven (1996).[6] (For the IO basics behind the Leontief and Ghosh price models and some details of derivations see Appendix A.)

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[5] http://rigvc.uibe.edu.cn/english/D_E/database_database/index.htm

[6] For a broader overview of IO price models with extensions and national or regional applications see also Mattey (1993) aiming the ‘cumulation effect’ of prices to inflation in US, close to our motivations; Kuboniwa (1993) revealing the output and price structure of the Russian economy; Seton (1993) comparing and linking the concepts and definitions of Eastern and Western price models; Folloni and Miglierina (1994) checking different theoretical

The basic equation of the Leontief cost-push input-output price model for a closed economy is

$$\tilde{\mathbf{p}}' = \tilde{\mathbf{p}}'\mathbf{A} + \mathbf{v}'_c, \tag{1}$$

where $\tilde{\mathbf{p}}'$ denotes the row vector of index prices (measuring the relative change in output prices by indices, thus in the initial equilibrium all actual prices are set equal to 1), **A** is the matrix of direct input coefficients, and $\mathbf{v}'_c$ is the row vector of value added ratios in each productive industry.[7] Output (index) prices on the left-hand side of (1) will be set in accordance with the changes in production costs caused by price and coefficient changes of inputs (including value added) on the right-hand side.[8] Then the price changes on the left will result in further cost changes on the right. And so, the indirect price effects continue to spill over the entire downstream value chain in a forward direction.[9]

Rearranging (1) $\tilde{\mathbf{p}}' - \tilde{\mathbf{p}}'\mathbf{A} = \tilde{\mathbf{p}}'(\mathbf{I} - \mathbf{A}) = \mathbf{v}'_c$, where **I** is the identity matrix, and postmultiplying by $(\mathbf{I} - \mathbf{A})^{-1}$ leads to the following closed solution form for index prices with the Leontief inverse:

$$\tilde{\mathbf{p}}' = \mathbf{v}'_c\mathbf{L}, \tag{2}$$

where $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$. Equation (2) with the so-called price multipliers in **L** (Llop, 2021; Oosterhaven, 2019) reveals that assuming fixed quantities and production recipes, the ultimate causes of output price changes are changes in primary inputs.[10] That is, the original reason for cost-push inflation is an increase in value added without a change in intermediate input prices (i.e. without any price effect from the upstream value chain, from the suppliers).

The Ghosh model is usually formulated by

$$\mathbf{x}' = \mathbf{v}'\mathbf{G}, \tag{3}$$

where $\mathbf{x}'$ and $\mathbf{v}'$ are the row vectors of sectoral output and value added, respectively, and $\mathbf{G} = (\mathbf{I} - \mathbf{B})^{-1}$ is the Ghosh inverse with matrix **B** for the direct output coefficients. (Please note the difference between **v** (value added in million dollars or so) and $\mathbf{v}_c$ (value added coefficients, i.e. dollars of value added per dollar of output).

Assuming fixed product quantities, the Ghosh model can also be used to assess the impact of changes in primary input costs on output prices. Let $\mathbf{v}'_0$ be the vector of initial (base year)

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approaches to price formation using Italian IO tables; Cabrer at el. (1998) analysing the price variations in Spain induced by the accession to the EU, especially the introduction of value-added tax and the change in foreign trade taxes; Bazzazan and Batey (2003) investigating price effects of the hypothetical removal of energy subsidies in Iran using an extended, static and dynamic price model; Kratena (2005) combining factor demand and price equations with an import price/export demand shock simulation exercise on 1990 IO table; Abildgren (2007) developing an input-output based measure of domestic underlying inflation for Denmark, which describes annual changes in the price indices of the final demand categories as weighted averages of the annual changes in the price indices for import, net indirect taxes, gross rents and gross value added; Sharify (2013) presenting another Iranian IO price case study measuring the consequences of exogenous changes in implicit subsidies of all sectors; and Kreschner et al. (2013) analysing US economic vulnerability to peak oil using the Leontief price model.

[7] Textbook approach usually ignores net taxes on products. However, they must be included in value added vector $\mathbf{v}'$ and vector $\mathbf{v}'_c$ as value added plus net taxes on products to output ratios when working with real input-output tables and databases.

[8] Producers adopt to price changes by price adjustments only, no change in quantity supplied is assumed.

[9] In a global IO model, price effects go through the entire global value chain without interruption. Note that even though textbook approaches to price models usually apply to national (single country) tables, they hold for global settings, as well.

[10] Or in other value components excluded from **A** and **L**.

primary input costs, and $\mathbf{v}_1'$ the vector of sectoral value added after a shock. Changes in value added lead to $\mathbf{v}_1' - \mathbf{v}_0'$ direct and $\mathbf{x}_1' - \mathbf{x}_0'$ total (direct and indirect, through the entire downstream value chain) changes in the monetary value of sectoral outputs, where $\mathbf{x}_0' = \mathbf{v}_0'\mathbf{G}$ and $\mathbf{x}_1' = \mathbf{v}_1'\mathbf{G}$. To express changes in monetary value of fixed quantity outputs, i.e. output price changes in relative (index) terms one can define

$$\boldsymbol{\pi}' = \mathbf{x}_1'\hat{\mathbf{x}}_0^{-1}. \tag{4}$$

Despite the theoretical criticisms (De Mesnard, 2009),[11] equation (4) based on the Ghosh price model gives exactly the same results as the Leontief one: $\boldsymbol{\pi}' = \tilde{\mathbf{p}}_1'$, where $\tilde{\mathbf{p}}_1' = \mathbf{v}_{1,c}'\mathbf{L}$ and $\mathbf{v}_{1,c}' = \mathbf{v}_1'\hat{\mathbf{x}}_0^{-1}$. The identity of the price changes given by the two models will be clearly shown when working with price elasticities instead of index prices in the next subsection.

2.2. Output price-to-output price elasticities

Equation (2) links output prices to value added. Changes in value added as ultimate causes of price movements are harder to track than output price changes themselves.[12] It seems, therefore, that it would be useful to develop an indicator that links output prices to output prices. To get a sufficiently general, flexible, and versatile indicator, the question should be asked as follows: assuming a one percentage (1%) exogenous change in the index price of the products of a given country-industry (driven by a rise in value added or net taxes on products, i.e. by exogenous shocks, not by endogenous price changes of intermediate inputs), by what percentage does this change increase the index price of other country-industries (and of course, of the source country, too, due to repercussions) summing up all direct and indirect price effects in downstream value chains? This brings us to the concept of output price-to-output price elasticity.[13]

To develop the formula of elasticities we start with a modified version of (2):

$$\tilde{\mathbf{p}}_0' = \mathbf{i}'\hat{\mathbf{v}}_{0,c}\mathbf{L}, \tag{5}$$

where index prices for each product (each productive sector's homogenous output) are broken down into price components caused by different industries (their value added rate) in the model, and then, they (i.e. the columns of matrix $\hat{\mathbf{v}}_{0,c}\mathbf{L}$) are summed up with premultiplying by $\mathbf{i}'$.

To create a 1% direct change in output prices, we simply need to add 0.01 to the value added rates, see right-hand side of (6), while the consequences of this, including both direct and indirect spillover effects on prices, will be reflected in the elements of $\tilde{\mathbf{p}}_1'$ on the left

$$\tilde{\mathbf{p}}_1' = \mathbf{i}'\left(\hat{\mathbf{v}}_{0,c} + (0.01)\mathbf{I}\right)\mathbf{L}, \tag{6}$$

where $(0.01)\mathbf{I}$ is a matrix with 0.01s on the main diagonal and zeros everywhere else.

Subtracting (5) from (6) yields

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[11] For the debate on Ghosh price model see also Dietzenbacher (1997), Oosterhaven (1996), and de Mesnard (2001).

[12] Even if we have information on changes in value added or product taxes, they can be easily converted into direct exogenous output price changes. For instance, a 5% increase in wages in a country-industry with an initial wage to output rate of 15%, according to the cost-push pricing logic leads to a 5% · 15% = 0.75% direct output price change. Similarly, a 10% increase in net product taxes in a country-industry with an initial net product tax to output rate of 2% means a 10% · 2% = 0.2% exogenous output price shock.

[13] In an early application Karasz (1992) uses prices elasticities and decomposes price changes in model for Czechoslovakia. His concept of income and production elasticities of prices is related to our output price-to-output price elasticities; however, it is different from our approach. The case is the same with Casler's (2011, 2013) elasticities, which express technical coefficient changes caused by price variations. We assume no such changes.

$$\tilde{\mathbf{p}}_1' - \tilde{\mathbf{p}}_0' = \mathbf{i}'(0.01)\mathbf{IL}\,. \tag{7}$$

As $\tilde{\mathbf{p}}_0' = \mathbf{i}'$, we have the new index prices minus 1 on the left side, which are the relative changes in prices in a decimal form. To have them in percentages, which is common when working with elasticities, simply multiply both sides by 100. To have a full matrix of elasticities showing direct and indirect links between prices of each product (industry) pairs, leave $\mathbf{i}'$ from the right. With introducing the notation $\boldsymbol{\varepsilon}_{\tilde{\mathbf{p}}}$ for the matrix of output price-to-output price elasticities this leads to the Leontief inverse.

$$\boldsymbol{\varepsilon}_{\tilde{\mathbf{p}}} = 100\big((0.01)\mathbf{IL}\big) = \mathbf{L} \tag{8}$$

Thus, in an IO price model, **L** is the matrix of output price-to-output price elasticities, where the elements of the matrix show the percentage change in the output prices of column (*j*) industries caused by a 1% exogenous change in the output prices of the row (*i*) industries. Or, in other words, if the primary costs in industry *i* increase by 0.01$ per $ of output, then the output price p_j increases by $0.01 l_{i,j}$ $, which is $l_{i,j}$% of the actual price (=1).

The matrix of output price elasticities can also be easily derived from the Ghosh model. Starting form equation (3) for monetary changes

$$\Delta\mathbf{x}' = \Delta\mathbf{v}'\mathbf{G}\,, \tag{9}$$

assuming that direct price increases (i.e. changes in value added) are 1% of the initial monetary outputs, $\Delta\mathbf{v} = (0.01)\mathbf{x}_0$, substituting this into (9) in a diagonalised $(0.01)\hat{\mathbf{x}}_0$ form, comparing to the initial value of the output, i.e. postmultiplying by $\hat{\mathbf{x}}_0^{-1}$ to obtain relative price changes in decimals, then multiplying by 100 for a shift to percentages, and exploiting that $\hat{\mathbf{x}}\mathbf{G}\hat{\mathbf{x}}^{-1} = \mathbf{L}$, elasticity matrix results in the Leontief inverse again

$$\boldsymbol{\varepsilon}_{\pi} = 100\Big((0.01)\hat{\mathbf{x}}_0\mathbf{G}\hat{\mathbf{x}}_0^{-1}\Big) = \mathbf{L} = \boldsymbol{\varepsilon}_{\tilde{\mathbf{p}}}\,. \tag{10}$$

As $\boldsymbol{\varepsilon}_{\pi}$ and $\boldsymbol{\varepsilon}_{\tilde{\mathbf{p}}}$ are equivalent, we use only the latter notation from now.

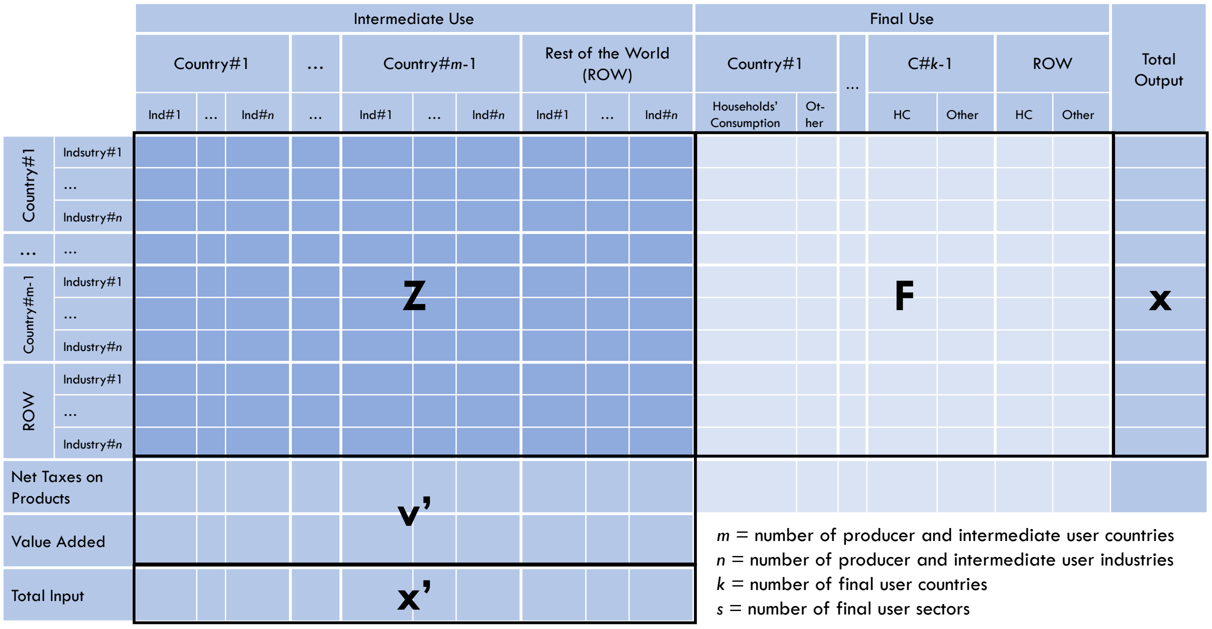
2.3. Local and global components of price elasticities

When performing global analyses with world IO tables (for an illustration see Figure 1) we use the following notations: **Z**, **A**, and **L** are $mn \times mn$ dimension block matrices, and $\mathbf{x}'$, $\mathbf{v}'$, $\mathbf{v}_c'$, and $\mathbf{i}'$ are $1 \times mn$ dimension block vectors, where *m* is the number of producer and intermediate user countries, and *n* is the number of producer and intermediate user industries.

Having **L** as the global matrix of output price-to-output price elasticities, we can exploit some results of GVC IO research. Wang et al. (2017) (referred to as Wang's model from now) introduces a straightforward decomposition scheme for global value added and final use. In the same vein, price changes can be decomposed to local and global value chain components. Motivated by Wang's model, we can define the following price elasticity components

$$\mathbf{L} = \mathbf{L}^D + \mathbf{L}^D\mathbf{A}^M\mathbf{L}^D + (\mathbf{L} - \mathbf{L}^D)\mathbf{A}^M\mathbf{L}^D\,, \tag{11}$$

where **L** is the global and $\mathbf{L}^D$ is the local Leontief inverse. The latter is calculated as $\mathbf{L}^D = (\mathbf{I} - \mathbf{A}^D)^{-1}$, where $\mathbf{A}^D$ is a $mn \times mn$ diagonal block matrix with entries the same as in **A** for intermediate transactions within the same countries (intra-country flows), and zeros everywhere else (for inter-country flows). For direct inter-country transactions, the $\mathbf{A}^M = \mathbf{A} - \mathbf{A}^D$ off-diagonal block matrix is used.



m = number of producer and intermediate user countries
n = number of producer and intermediate user industries
k = number of final user countries
s = number of final user sectors

Figure 1. Schematic World Input-Output Table[14]

Terms on the right-hand side of equation (11) can be interpreted as follows: $\mathbf{L}^D$ captures the components of price movements that are related to pure domestic (or local) value chains. Their final products can be used both domestically and abroad (as exports to other countries), but each stage of production for these local value chains takes place in the same country. Thus, the elements of $\mathbf{L}^D$ carry the local price effects. The next term, $\mathbf{L}^D\mathbf{A}^M\mathbf{L}^D$ is for the price transmissions through simple global value chains with only one border crossing during the production process. Finally, $(\mathbf{L}-\mathbf{L}^D)\mathbf{A}^M\mathbf{L}^D$, shows the price elasticity components that can be attributed to complex global value chains with multiple border crossings of intermediate products. For the mathematical proof of equation (11) see Appendix B.

The decomposition scheme presented above can be used for both sectoral prices and price indices. For the former, one can use equation (11) as it is. For the latter, appropriate weight matrixes should be added to the model to extend the concept of elasticities to the level of different inflation rates.

3. Defining price index weights using world input-output tables

In this section, we will look at inflation from an input-output perspective. The following paragraphs show how to calculate price indices using world input-output tables and how they can be matched to the official indicators of the standard statistical approach highlighting the most important differences.

Changes of broad price level is a headline indicator for all economies. Generally speaking, inflation is defined as the change of general price level of consumer goods and services. To gauge inflation, consumer price index (CPI) is a universally accepted measure for central banks, as an expenditure-weighted index of cost-of-living changes despite of its shortcomings. CPI has a lack of robustness, and it most likely contains measurement and weighting biases (Bryan and Cecchetti, 1993). Weights always represent the relative amount of products purchased in a fixed basket compiled by the statistical authorities. This process has received many criticism over the

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[14] ROW represents all the other countries in the world (the rest of the world).

past decades as the relation between prices and weights (the quantity purchased) is idiosyncratic and neglecting the substitution effect can lead to significant biases (Moulton, 1996). CPI covers consumer goods mostly bought by resident households only. It cannot differentiate goods purchased by residents and non-residents (for example tourists). The utilisation of CPI relies on the assumption that price level changes in the economy shall be reflected in consumer prices, thus the data collection can be conducted in a short time without unnecessary involvement of the corporate sector in the gathering.

Another way to measure inflation is through the producer price index (PPI), which defines the price level changes of goods and services produced by industry groups, primarily Mining (B), Manufacturing (C), Energy industry (D), and Water and waste management (E) (as an aggregate). PPI-type indices are also calculated for agricultural products, construction, and groups of services. PPI are widely utilised in inflation targeting of central banks, despite its volatility (Clark, 1999).

CPI and PPI should have been highly correlated; however, they tend to diverge since the 2000s. One reason could be that the common part of the two indices (that is, domestically produced consumer goods) is becoming smaller with time in the PPI basket, owing to the emergence of global value chains (Wei and Xie, 2018). Producers purchase more imported inputs, while a large part of their output is never consumed by domestic households due to the increasing international export market. Thus, domestic households are less effected by PPI volatility and the cause-and-effect relation between the two is vague (Akcay, 2011; Loupias and Sevestre, 2013). Therefore, it is worth defining and using both inflation measures when examining price transmission through global value chains using world IO tables.

PPI is usually calculated by distinguishing between PPI of total sales (a weighted average of price indices of domestic sales and export sales), PPI of domestic sales (an index calculated from net price receipts of products sold inland using base periods as weights), and PPI of export sales: an index calculated from the price receipts of products sold directly, through an agent, or in a joint venture to external trade using base periods as weights (Hungarian Central Statistical Office, HCSO, 2022).

Besides the PPI of export sales, although with different sources and methods, a price index is often calculated for trade in goods, exports and imports, for the measurement of the price level changes of the external trade. For an IO point of view, we will not distinguish now between the two types of export price indices, but in addition, we will define a price index for imported products, for the same purposes.

The structure of the CPI and the PPI is very similar as both measures are based on representative baskets that capture the weights of each product purchased/sold. Data collection of weights is generally conducted through surveys of households and producers just as the price collection. The indices are calculated as a fixed base weighted (Laspeyres) average of the price relatives of the included representative items (ILO, 2004).

With an IO table, not only a sample of representative products, but the entire macroeconomic consumption of households and the output of industries can be covered and used for generating weights, although only for broad aggregates (for the output of industries distinguished in the IO table). So, the weights in this latter case are based on an economic model (IO tables themselves are models based on several assumptions, moving away the values of cells from the underlying survey data), while in the case of official price indices, results are very close to the high-frequency (monthly) direct survey records.

Another significant difference is the use of prices. CPI is calculated using consumer prices including the most important indirect taxes (value added tax (VAT), excise duties, registration taxes for new motor cars etc.). Values for industry breakdown of household consumption in an IO table are measured at basic prices with a separate but single row for total taxes less subsidies on intermediate and final products (or separate rows for each country in some global IO tables). Thus, net taxes on final products (paid by final users) are not disaggregated to products (product groups) bought from different final producer industries (country-industries in global tables) restricting detailed analysis of final product tax changes. Ignoring this (these) row(s) (excluding them from **F**, the matrix of final use) yields to some distortions and limitations. Effects of the rates and changes in net product taxes paid by the final consumers on CPI can be modelled by adding them as an external additional information after having calculated the endogenous GVC price transmission effects. Thus, the IO-based household consumption price index will be more like the constant tax rate price index than the traditional CPI. Constant tax rate price indices are widely applied when it comes to analysis of inflation trends.

Obviously, there can also be significant differences between CPI-weights and IO-based percentage distribution of basic price consumption expenditures (weights based on **F**) across productive sectors. CPI-weights are calculated based on consumer prices containing not only net product taxes and duties, but also trade, insurance, and transportation margins. However, in an IO table, the latter are distributed to the related industries, which, in turn, can deliver extra information. Consumer price changes because of trade and transportation margins are included in product prices in the case of traditional CPI. Not in IO-based price indices, where these effects on inflation can be detected explicitly attached to trade and transport industries.

Similarly, biases may occur between official and IO-based PPI. Domestic and export sales and output of industries in IO tables (which will be used for approximating sales) are measured at basic prices. PPI, however, uses producers' prices.[15] In addition, in IO price models, technology and prices of the homogenous sectoral output are homogenous too. No distinctions can be made within the sales of an industry based on the relation of commerce.[16] Products are sold at a single, uniform price to every buyer home and abroad.[17]

In a world IO table, matrix **F** (see Figure 1) serves as the basis for the calculation of final demand weights. As **F** contains data for several final demand sectors (in addition to household final demand expenditures, there are separate columns for non-profit institutions serving households, general government final consumption, gross fixed capital formation, and in the IO database we are going to use, direct purchases abroad) for each country, weights and inflation elasticities will be calculated for all. The combination of households' consumption and direct

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[15] The basic price is essentially the producer price minus trade and transport margins, which are recorded as the basic price output of the trade and transport sectors. Other than that, there is only a slight difference between basic and producers' prices. "Basic prices are prices before taxes on products are added and subsidies on products are subtracted. Producers' prices include, in addition to basic prices, taxes less subsidies on products other than value added type taxes." International Monetary Fund, IMF (2009), pp. 22. (2.63)

[16] In realty, pricing of products can differ not only geographically (depending on countries or commercial relations), but it can also vary between partners and in time (according to short-term vs. long-term contracting decisions of firms, see Johnsen et al, 2021).

[17] This holds also for intermediate and final use of the same product. That is why it is so circumstantial to adequately address the inflationary effects of consumer price shocks due to changes in VAT on final products in IO tables, in particular with the weights determined on the basis of consumption structure at basic prices. However, effects of net product tax changes in the columns of productive country-industries (i.e. in production stages of GVCs) on basic price inflation rates can be modelled as exogenous output price changes (see footnote 12 for a simple numerical example).

purchases abroad columns allows for the construction of an IO-based HICP-type (Harmonised Index of Consumer Prices) inflation rate where weights also incorporate expenditures of foreign visitors besides those of all resident households which take place on the economic territory of the given country (domestic concept) (HCSO, 2022).

Generally, for the **F**-based weights[18] for final demand price indices (elasticities) we use the following formula

$$\mathbf{W}^{\mathbf{F}} = \mathbf{F}\left\langle \mathbf{i}'\mathbf{F} \right\rangle^{-1}, \tag{12}$$

that is, all entries in **F** are dived by the sum of the related column. For a detailed GVC analysis, with a decomposition of **F** let's define separate weight matrices for final use from domestic production and imports

$$\mathbf{W}^{\mathbf{F}^{D}} = \mathbf{F}^{D}\left\langle \mathbf{i}'\mathbf{F} \right\rangle^{-1}, \text{ and} \tag{13}$$

$$\mathbf{W}^{\mathbf{F}^{M}} = \mathbf{F}^{M}\left\langle \mathbf{i}'\mathbf{F} \right\rangle^{-1}, \tag{14}$$

where $\mathbf{F}^{D}$ and $\mathbf{F}^{M}$ are matrices with the same dimension as **F**, but have the following differences: $\mathbf{F}^{D}$ contains the final use from domestic production, while $\mathbf{F}^{M}$ from import only. In cells complying to these masking filters, we have the same entries as in **F**, and zeros everywhere else. Please note that in the weight matrices $\mathbf{W}^{\mathbf{F}^{D}}$ and $\mathbf{W}^{\mathbf{F}^{M}}$, column sums do not give 1s, only the corresponding column pairs of them, together.

Generating the weight matrix for the PPI-type IO inflation rates, a special working table is needed (see Figure 2). Here, the rows are the same as in the first quadrant of the IO table, while the columns are the PPI industry groups of each country. In this case, we have the output not the final demand in the columns. Matrix **X** contains the elements of vector **x** in a diagonalised form of the dark blocks shown in Figure 2. All other entries are zero.

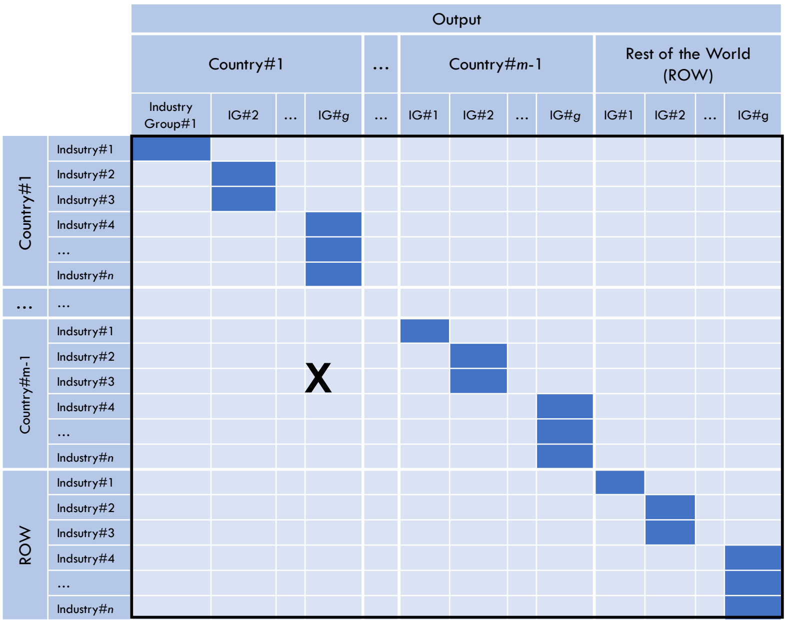

Figure 2. Working table for PPI-weights

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[18] Similar weights for final demand are used by Kuboniwa (1993) and Przybyłiński and Gorzałczyński (2022).

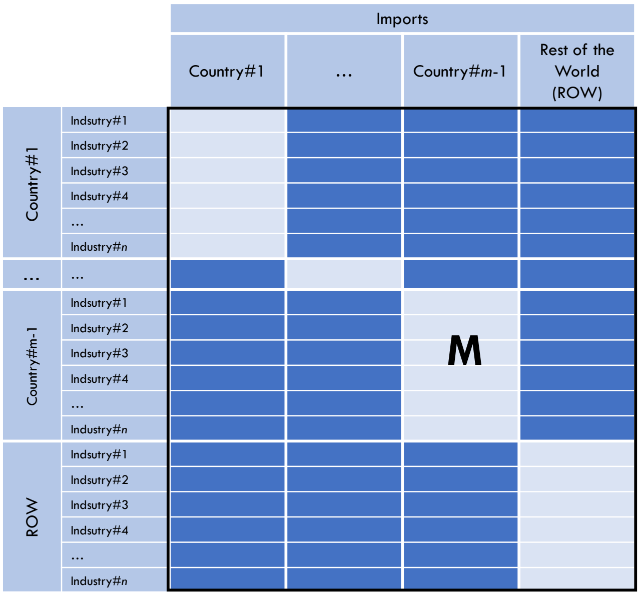

Figure 3. Working table for import price index weights

We distinguish $g=6$ industry groups (will be defined later in Subsection 5.2), so that the matrix above will be denoted by $\mathbf{X}^{6T}$ with a dimension of $mn \times mg$. Without diagonalising according to industry groups, all sectoral outputs of a country are placed in the same column. We denote this *m*-column matrix by $\mathbf{X}^{TT}$, which contains elements of $\mathbf{x}$ pertaining to column countries and row country-industries, and zeros everywhere else.[19] Both $\mathbf{X}^{6T}$ and $\mathbf{X}^{TT}$ will have a domestic and export sales version denoted by $\mathbf{X}^{6D}$, $\mathbf{X}^{6E}$, $\mathbf{X}^{TD}$, and $\mathbf{X}^{TE}$, which contain production for domestic and export (the total of intermediate and final) use only, respectively. Concatenating them, marked with $||$, yields

$$\mathbf{X}^{*} = \mathbf{X}^{6D} \,||\, \mathbf{X}^{6E} \,||\, \mathbf{X}^{6T} \,||\, \mathbf{X}^{TD} \,||\, \mathbf{X}^{TE} \,||\, \mathbf{X}^{TT}, \tag{15}$$

from which the weights for PPI-type IO price indices can be calculated analogously to (12) with the general formula

$$\mathbf{W}^{\mathbf{X}^{*}} = \mathbf{X}^{*} \left\langle \mathbf{i}'\mathbf{X}^{*} \right\rangle^{-1}. \tag{16}$$

This, of course, can be broken down into six partitions corresponding to (15) as

$$\mathbf{W}^{\mathbf{X}^{*}} = \mathbf{W}^{\mathbf{X}^{6D}} \,||\, \mathbf{W}^{\mathbf{X}^{6E}} \,||\, \mathbf{W}^{\mathbf{X}^{6T}} \,||\, \mathbf{W}^{\mathbf{X}^{TD}} \,||\, \mathbf{W}^{\mathbf{X}^{TE}} \,||\, \mathbf{W}^{\mathbf{X}^{TT}}. \tag{17}$$

Finally, the weight matrix for imports (intermediate plus final use again) is based on the following working table (see Figure 3), where we have country-industries in rows, importing countries in columns, and total imports in the cells, except in the main diagonal blocks of zeros. The weight formula is

$$\mathbf{W}^{\mathbf{M}} = \mathbf{M} \left\langle \mathbf{i}'\mathbf{M} \right\rangle^{-1}. \tag{18}$$

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[19] Thus, columns of $\mathbf{X}^{\mathrm{TT}}$ contain the output of all industries used for the calculation of the weights for overall country PPI's, while columns in $\mathbf{X}^{6\mathrm{T}}$ incorporate only the corresponding industries for PPI's of agriculture, mining and energy, manufacturing, construction, and the two groups of services to be defined later.

4. Price index elasticities and decompositions

Using the weights defined in the previous section, one can produce inflation elasticity matrices for different price indices with the following operations

$$\boldsymbol{\varepsilon}_{\tilde{\mathbf{p}}_{\mathbf{F}},\tilde{\mathbf{p}}} = \mathbf{L}\mathbf{W}^{\mathbf{F}}, \tag{19}$$

$$\boldsymbol{\varepsilon}_{\tilde{\mathbf{p}}_{\mathbf{X}},\tilde{\mathbf{p}}} = \mathbf{L}\mathbf{W}^{\mathbf{X}^*}, \tag{20}$$

$$\boldsymbol{\varepsilon}_{\tilde{\mathbf{p}}_{\mathbf{M}},\tilde{\mathbf{p}}} = \mathbf{L}\mathbf{W}^{\mathbf{M}}. \tag{21}$$

Equation (19) produces the matrix of inflation rate-to-output price elasticities for final demand price indices such as the national concept CPI-like or domestic concept HICP-like IO-price index. Since weights in $\mathbf{W}^{\mathbf{F}}$ encompass not only household consumption but all final demand sectors, price index elasticities can be calculated, for example, for general government consumption and gross fixed capital formation (investments), too. Equation (20) yields the producer price index elasticities for the predefined industry groups, both for domestic and export use, while (21) is for the import price indices.

In all cases discussed above, elements of matrices $\boldsymbol{\varepsilon}$ show the percentage point change in the price index of the related column caused by a one percent (1%) output price change in the country-industry of the related row. Since IO models are linear, the relations between changes in output prices (the causes) and inflation rates (the consequences) are proportional. Thus, a 5% output price change will result in 5 times higher percentage point change in the price index than indicated by the related elements of $\boldsymbol{\varepsilon}$.

A 1% output price change not only in a single country-industry but in any group of them will raise the inflation measure by the sum of the corresponding column elements of $\boldsymbol{\varepsilon}$. This way, one can easily calculate the impacts of 1% higher prices in a country to another countries' inflation or the consequences of a general price increase in the world market of a certain product on each countries' consumer or producer price indices or the terms of trade. Column sums of the $\boldsymbol{\varepsilon}$ matrices show the effect of a 1% overall global price increase on the related price index. So not only standalone column elements of $\boldsymbol{\varepsilon}$s are meaningful but any sum of them, as well. Moreover, with superior information on expected country-industry level exogenous price changes one can even perform quick estimates for inflationary effects (as the sum of the product of relative price changes and the corresponding elasticities).

For GVC decompositions, $\mathbf{W}^{\mathbf{F}^D}$, $\mathbf{W}^{\mathbf{F}^M}$, $\mathbf{W}^{\mathbf{M}}$ and partitions of the concatenated $\mathbf{W}^{\mathbf{X}^*}$ weight matrix provide a good service. In the case of the final demand price indices, the following six-element decomposition scheme based on (11), (13), (14), and (19) gives the most information on elasticities.

$$\begin{aligned}\boldsymbol{\varepsilon}_{\tilde{\mathbf{p}}_{\mathbf{F}},\tilde{\mathbf{p}}} = {} & \mathbf{L}^D\mathbf{W}^{\mathbf{F}^D} + \mathbf{L}^D\mathbf{W}^{\mathbf{F}^M} + \mathbf{L}^D\mathbf{A}^M\mathbf{L}^D\mathbf{W}^{\mathbf{F}^D} + \mathbf{L}^D\mathbf{A}^M\mathbf{L}^D\mathbf{W}^{\mathbf{F}^M} + \\ & + (\mathbf{L}-\mathbf{L}^D)\mathbf{A}^M\mathbf{L}^D\mathbf{W}^{\mathbf{F}^D} + (\mathbf{L}-\mathbf{L}^D)\mathbf{A}^M\mathbf{L}^D\mathbf{W}^{\mathbf{F}^M}.\end{aligned} \tag{22}$$

For a wide variety of producer price indices, a three-term formula can be developed using (11), (16), and (20)

$$\boldsymbol{\varepsilon}_{\tilde{\mathbf{p}}_{\mathbf{X}},\tilde{\mathbf{p}}} = \mathbf{L}^D\mathbf{W}^{\mathbf{X}^*} + \mathbf{L}^D\mathbf{A}^M\mathbf{L}^D\mathbf{W}^{\mathbf{X}^*} + (\mathbf{L}-\mathbf{L}^D)\mathbf{A}^M\mathbf{L}^D\mathbf{W}^{\mathbf{X}^*}. \tag{23}$$

And finally, for export and import price index elasticities the formulae based on equation (18), (21), and the previous ones are

$$\boldsymbol{\varepsilon}_{\tilde{\mathbf{p}}_{\mathbf{X}^{TE}},\tilde{\mathbf{p}}} = \mathbf{L}^D\mathbf{W}^{\mathbf{X}^{TE}} + \mathbf{L}^D\mathbf{A}^M\mathbf{L}^D\mathbf{W}^{\mathbf{X}^{TE}} + (\mathbf{L}-\mathbf{L}^D)\mathbf{A}^M\mathbf{L}^D\mathbf{W}^{\mathbf{X}^{TE}}\text{, and} \tag{24}$$

$$\boldsymbol{\varepsilon}_{\tilde{\mathbf{p}}_{\mathbf{M}},\tilde{\mathbf{p}}} = \mathbf{L}^D\mathbf{W}^{\mathbf{M}} + \mathbf{L}^D\mathbf{A}^M\mathbf{L}^D\mathbf{W}^{\mathbf{M}} + (\mathbf{L}-\mathbf{L}^D)\mathbf{A}^M\mathbf{L}^D\mathbf{W}^{\mathbf{M}}. \tag{25}$$

From (24) and (25), the matrix of approximated terms of trade[20, 21] elasticities is

$$\begin{gathered}\boldsymbol{\varepsilon}_{\tilde{\mathbf{p}}_{\mathbf{X}^{TE}},\tilde{\mathbf{p}}} - \boldsymbol{\varepsilon}_{\tilde{\mathbf{p}}_{\mathbf{M}},\tilde{\mathbf{p}}} = \mathbf{L}^D(\mathbf{W}^{\mathbf{X}^{TE}} - \mathbf{W}^{\mathbf{M}}) + \mathbf{L}^D\mathbf{A}^M\mathbf{L}^D(\mathbf{W}^{\mathbf{X}^{TE}} - \mathbf{W}^{\mathbf{M}}) + \\ +(\mathbf{L}-\mathbf{L}^D)\mathbf{A}^M\mathbf{L}^D(\mathbf{W}^{\mathbf{X}^{TE}} - \mathbf{W}^{\mathbf{M}}).\end{gathered} \tag{26}$$

Table 1, 2, and 3 summarize the meaning of terms in equations (22)-(26)[22] with notes helping the reconciliation of the categories with Wang's decomposition scheme. The main differences from Wang are the following. We categorize GVCs based on the number of subsequent production phases. No border crossings during the production process means a local value chain. With one border crossing, we have a simple, with more than one, we have a fragmented, complex GVC. Sales of final products domestically or abroad (final links in the value chains) are not a distinguishing feature in this sense. Household consumption of an imported final product, which is produced within a value chain where inputs come from inside the exporter country or abroad, up to one border crossing distance is still a simple GVC. By contrast, for Wang, because of the two border crossings in total, it is a complex value chain. Although the total number of border crossings is undoubtedly two, only one of them occurred during the production.

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[20] Terms of trade is the ratio of export and import price indices, for example $1.05/1.03 = 1.0194$, which indicates an almost 2 percent improvement. Instead of the ratio, we use a differential form for an approximation using elasticities, i.e., $5-3=2$. For small values, the variation between the precise and approximated results will be insignificant in terms of our analyses.

[21] The conventional method by UN Comtrade (United Nations, 2022) to define the terms of trade uses exports fob and import cif prices from merchandise trade statistics at purchasers' prices. In the IO tables imports are expressed at cif parity, and in the global IO database we will later use (ICIO tables) international trade margins are accounted to the corresponding country-industries that provide transportation services (i.e. they are included in **Z** and **F**). Adding net taxes on products to the value of total (domestic and import) intermediate use in each column, one will have country-industry's total intermediate use at purchasers' prices. By also including sectoral gross value added, column sums give output at basic prices including trade margins. Due to this endogenous feature of international trade margins, not only **A** and **L**, but also the weight matrix for import ($\mathbf{W}^{\mathbf{M}}$) involves costs of international trade. Another favourable implication of this is that impacts of a demand-driven rise in the price of transportation services, for instance, can be modelled simply and clearly as exogenous price shocks (i.e. nominal output increases because of higher value added, profits and/or wages) in the country-industries that provide these services. Thus, from the aspect of international trade margins and cif parity imports our IO-based terms of trade calculations are consistent with the official approach. Because of the differences between purchasers' and IO basic prices, however, they are not. As in the case of CPI, we must say again that we define and use our proper IO-based, basic price terms of trade indices.

[22] Attentive readers may have noticed that the implicit price index of domestic product (GDP-deflator) is not included in any of the tables, nor is a formula given for this. This is simply because nominal value added (assuming no quantity changes) is the exogenous variable of the price models used in this study.

Table 1. Decomposition of final demand price index elasticities

Type of value chains	Origin of final products	Term in (22)	Description
Local (Lcl)	Domestic (equivalent to Wang's domestic value chains)	$\mathbf{L}^{D}\mathbf{W}^{\mathbf{F}^{D}}$	price index elasticity caused by price transmission mechanism of domestic final products produced by domestic value chains only (no border crossing, domestic final and intermediate products, and domestic value added only)
	Import (Wang's classical foreign trade)	$\mathbf{L}^{D}\mathbf{W}^{\mathbf{F}^{M}}$	price index elasticity caused by price transmission mechanism of imported final products produced by local value chains only (no border crossing during production, the only border crossing takes place when the final product is sold, imported final products, local intermediate products and value added only)
Simple Global (Smpl)	Domestic (Wang's simple GVC)	$\mathbf{L}^{D}\mathbf{A}^{M}\mathbf{L}^{D}\mathbf{W}^{\mathbf{F}^{D}}$	price index elasticity caused by price transmission mechanism of domestic final products produced by simple global value chains (one border crossing during production, no border crossing when the final product is sold, domestic final products, domestic and imported intermediate products, two countries contribute to the production of the product, domestic and imported value added, value added imported from only one country)
	Import (not indicated separately, treated as a part of complex GVCs in Wang's scheme)	$\mathbf{L}^{D}\mathbf{A}^{M}\mathbf{L}^{D}\mathbf{W}^{\mathbf{F}^{M}}$	price index elasticity caused by price transmission mechanism of imported final products produced by simple global value chains (one border crossing during production and another one when the final product is sold, imported final products, two countries contribute to the production of the product, local and imported value added, no value added generated in the final demand country)
Complex Global (Cmpl)	Domestic (a part of complex GVCs in Wang's scheme, not treated separately)	$(\mathbf{L}-\mathbf{L}^{D})\mathbf{A}^{M}\mathbf{L}^{D}\mathbf{W}^{\mathbf{F}^{D}}$	price index elasticity caused by price transmission mechanism of domestic final products produced by complex global value chains (multiple border crossing during production, no border crossing when the final product is sold, domestic final products, domestic and imported intermediate products, more than two countries contribute to the production of the product, domestic and imported value added, value added imported from more countries)
	Import (a part of complex GVCs in Wang's scheme, not treated separately)	$(\mathbf{L}-\mathbf{L}^{D})\mathbf{A}^{M}\mathbf{L}^{D}\mathbf{W}^{\mathbf{F}^{M}}$	price index elasticity caused by price transmission mechanism of imported final products produced by complex global value chains (multiple border crossing during production plus one when the final product is sold, imported final products, more than two countries contribute to the production of the product, local and imported value added, no value added generated in the final demand country)

Table 2. Decomposition of producer price index elasticities

Type of value chains	Term in (23)	Description
Local (Lcl)	$\mathbf{L}^{D}\mathbf{W}^{\mathbf{X}^{*}}$	price index elasticity of domestic, export, and total use of the output of predefined industry groups and all industries caused by price transmission mechanism of domestic final and intermediate products produced by domestic value chains only
Simple Global (Smpl)	$\mathbf{L}^{D}\mathbf{A}^{M}\mathbf{L}^{D}\mathbf{W}^{\mathbf{X}^{*}}$	price index elasticity of domestic, export, and total use of the output of predefined industry groups and all industries caused by price transmission mechanism of domestic final and intermediate products produced by simple global value chains
Complex Global (Cmpl)	$(\mathbf{L}-\mathbf{L}^{D})\mathbf{A}^{M}\mathbf{L}^{D}\mathbf{W}^{\mathbf{X}^{*}}$	price index elasticity of domestic, export, and total use of the output of predefined industry groups and all industries caused by price transmission mechanism of domestic final and intermediate products produced by complex global value chains

Table 3. Decomposition of export and import price index and terms of trade elasticities

Type of value chains	Relation	Term in (24)-(26)	Description
Local (Lcl)	Export	$\mathbf{L}^{D}\mathbf{W}^{\mathbf{X}^{TE}}$	price index elasticity of export use of the output of all industries caused by price transmission mechanism of domestic final and intermediate products produced by domestic value chains only
	Import	$\mathbf{L}^{D}\mathbf{W}^{\mathbf{M}}$	price index elasticity of import purchases of all industries and final demand sectors caused by price transmission mechanism of final and intermediate products produced by local value chains only
	Terms of Trade elasticity	$\mathbf{L}^{D}(\mathbf{W}^{\mathbf{X}^{TE}}-\mathbf{W}^{\mathbf{M}})$	terms of trade elasticity of export products by domestic, and import products by local value chains
Simple Global (Smpl)	Export	$\mathbf{L}^{D}\mathbf{A}^{M}\mathbf{L}^{D}\mathbf{W}^{\mathbf{X}^{TE}}$	price index elasticity of export use of the output of all industries caused by price transmission mechanism of domestic final and intermediate products produced by simple global value chains
	Import	$\mathbf{L}^{D}\mathbf{A}^{M}\mathbf{L}^{D}\mathbf{W}^{\mathbf{M}}$	price index elasticity of import purchases of all industries and final demand sectors caused by price transmission mechanism of final and intermediate products produced by simple value chains
	Terms of Trade elasticity	$\mathbf{L}^{D}\mathbf{A}^{M}\mathbf{L}^{D}(\mathbf{W}^{\mathbf{X}^{TE}}-\mathbf{W}^{\mathbf{M}})$	terms of trade elasticity of export and import products by simple global value chains
Complex Global (Cmpl)	Export	$(\mathbf{L}-\mathbf{L}^{D})\mathbf{A}^{M}\mathbf{L}^{D}\mathbf{W}^{\mathbf{X}^{TE}}$	price index elasticity of export use of the output of all industries caused by price transmission mechanism of domestic final and intermediate products produced by complex global value chains
	Import	$(\mathbf{L}-\mathbf{L}^{D})\mathbf{A}^{M}\mathbf{L}^{D}\mathbf{W}^{\mathbf{M}}$	price index elasticity of import purchases of all industries and final demand sectors caused by price transmission mechanism of final and intermediate products produced by complex value chains
	Terms of Trade elasticity	$(\mathbf{L}-\mathbf{L}^{D})\mathbf{A}^{M}\mathbf{L}^{D}(\mathbf{W}^{\mathbf{X}^{TE}}-\mathbf{W}^{\mathbf{M}})$	terms of trade elasticity of export and import products by complex global value chains

5. An empirical inflation elasticity database

The model calculations introduced above to build an empirical IO inflation elasticity database were performed with the recently published 2021 edition of the OECD (Organisation for Economic Co-operation and Development) Inter-Country Input-Output (ICIO) Tables (OECD, 2021).[23]

5.1. The ICIO 2021 edition

The ICIO database provides a globally balanced view of inter-country inter-industry flows of intermediate and final goods and services. The dataset was published in November 2022 and covers 66 countries (plus the rest of the world, ROW henceforth), 38 OECD member states and 28 non-member states[24] and 45 industries. These cover 93% of the world's GDP, 92% of the world's total export and 90% of total import of goods and services. The final use matrix contains household Final Consumption Expenditure (HFCE), Non-Profit Institutions Serving Households (NPISH), General Government Final Consumption (GGFC), Gross Fixed Capital Formation (GFCF), Changes in Inventories and Valuables (INVNT), and Direct Purchases Abroad by Residents (DPABR). The data are available for the period of time between 1995 and 2018 from which we selected the year of 2007 (the last year before the global financial crisis) and 2018 as the latest available data. For the country and industry coverage of ICIO 2021 edition and our inflation elasticity database see tables in Appendix C.

5.2. Model data processing

In a separate Excel workbook for each year, we have performed the calculations specified by equations (1) to (26).

We have formed a weight vector for each column of the **F** matrix, and an extra column for each country for the sum of the resident households' final consumption (HFCE) and the direct purchases abroad (DPABR) by foreign tourists in that country.

For weights determined on the basis of the output matrix **X**, the 6 sector groups listed in Table 4 have been defined (see also Appendix C). PPI-like indices can thus be defined separately for each of these industry groups in three ways: domestic, export, and total output.

Table 4. Price change industry groups

Industry group code	Industry group name and content
A	Agriculture, forestry, and fishing
BDE	Mining and quarrying; electricity, gas, steam and air conditioning supply; water supply; sewerage, waste management and remediation activities
C	Manufacturing
F	Construction
GHI	Wholesale and retail trade; repair of vehicles and motorcycles; transportation and storage; accommodation and food services activities
J-T	Other services

When decomposing **L**, the flows of semi-finished products between CN1 and CN2 and between MX1 and MX2 were assumed to be a border crossing, i.e. the two 'sub-economies' of the same countries were not merged. Consequently, in the case of China and Mexico, the Local, Simple

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[23] http://oe.cd/icio, https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm

[24] Because of their significantly different IO structures, productive industries of China and Mexico are separated into export-processing and non-export processing activities as they were two individual economies.

and Complex categories bear a different meaning in GVC decompositions: the trade between CN1 and CN2 appears in the Simple value chains. Since CN2 does not sell to CN1 or CHN, this does not cause any particular disruption to either final use or production-type inflation rates. The same holds for Mexico.

By contrast, for price index weights, product transfers between CHN, CN1 and CN2 and MEX, MX1 and MX2 (if they exist) were considered as domestic sales. This was the case with $\mathbf{W^F}$, $\mathbf{W^X}$, and $\mathbf{W^M}$ matrices, too. In the import weight matrix (for compatibility with exports), final products imported by CHN and MEX has been reclassified to CN1 and MX1.

The results of the model calculations performed in Excel workbooks have been converted to a semicolon separated normalized txt file using an Excel IO Toolkit for easier and more flexible processing (see Appendix D). The resulting Global Inflation-to-Output Price Elasticity Database (GIOPED) in text format is a part of the replication package attached to this paper.[25] We strongly encourage potential users to explore the database, which allows for a wide range of analyses.

5.3. Generating result tables

This subsection supported by Appendix E and F provides a short introductory tutorial for creating some basic pivot tables using the GIOPED. These shall serve as the basis of reports and dashboards, which support analyses of cost-push price transmission through GVCs later on, in Section 6.

Table 5 shows the fields and field contents available in the GIOPED. Using the txt database as an external data source for Pivot Tables in Microsoft Excel one can easily generate several interesting results for economic analysis. Appendix E is a tutorial on how to import the database into Excel.

Table 5. Fields and field contents in the GIOPED

Field	**Field content**	
Year	2007, 2018	
Output Price Change Country	each producer country in ICIO	
Output Price Change Industry Group	A, BDE, C, F, GHI, J-T (aggregated)	
Output Price Change Industry	each producer industry in ICIO	
GVC type	Lcl, Smpl, Cmpl (see Table 1-3)	
Price Index Final Use / Output / Import	for basic price CPI indices	FUD (final use from domestic production)
		FUM (final use from import)
	for basic price PPI indices	Dom Sls (domestic sales)
		Exp Sls (export sales)
		Tot Sls (total sales)
	for basic price import price index	Tot Imp (total import)
Price Index Country	each producer, intermediate and final user country	
Price Index Sector / Industry Group	each final user sector in the ICIO plus HFCE + DPABR, and the six aggregated industries (A, BDE, C, F, GHI, J-T)	

For some basic GVC price-inflation impact analysis we show three introductory layouts in Appendix F, which can be quickly reproduced by dragging-and-dropping pivot table fields to Filter, Rows, Columns, and Values area according to the right side of the screenshots. The first example is for a CPI elasticity analysis. The crosstab in Figure F1 shows the components of

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[25] It can be downloaded from https://doi.org/10.6084/m9.figshare.19778518.v1.

each country's consumer price index elasticity related to price transmission through local, simple, and complex global value chains assuming a 1 percent increase in output prices in all countries and industries of the world. The second one in Figure F2 is for the PPI with the same assumption on output prices. Finally, the layout presented in Figure F3 serves for a terms of trade (ToT) analysis.

5.4. Implied assumptions and limitations

When using GIOPED inflation elasticity database the implied assumptions behind the modelling framework must be borne in mind. Especially, the following assumptions are important:

(a) According to the valuation conventions applied in IO tables, output prices mean basic prices in our model. GIOPED elasticities are calculated using them. This is the most important reason (for others see Section 3) why IO-based inflation rates differ from official CPI, PPI, and ToT price indices.

(b) Products by each country-industry have a single, unique basic (dollar) price regardless of the country, industry, sector, and purpose (intermediate or final use) of the buyer.

(c) As indicated in Section 1, exchange rates are assumed to be fixed at the levels of the ICIO tables. That is why all prices are expressed implicitly in dollar when calculating relative price changes.

(d) It is assumed that wage and gross profit (value added) shares are unaffected by the output price changes considered (i.e. price transmissions have no impact on the functional income distribution). Only the nominal values of output, intermediate and final use change and evolve with price movements, the nominal gross value added and net taxes on products remain unchanged at their initial or shock level. Thus, more precisely, the value added plus net taxes on products to sectoral output ratios in real terms (measured at the initial or initial shock level prices) are exogenous and fixed. Note that exogenous output price shocks are modelled as changes in these ratios. However, after the initial shock they no longer change during the whole global price adjustment process.

(e) Any “induced” effects caused by the output price changes are disregarded. To give an example, it is assumed that the price increases are not followed by increased wage demand by the workers, and thus increased wages cannot cause cost-push price shocks again. That is, no price-wage spiral can evolve in the model.[26] Also, any income multiplier effects are ignored, for instance the effect on prices from a drop in consumer demand due to the decline in real wages (resulting from the price changes considered) is disregarded. Thus, in the GIOPED framework, the resulting inflation rates have no repercussions to the economy.

(f) Simple IO models have no time horizon. Despite the extensions developed in this paper to handle global cost-push price movements and express the resulting effects on national price levels, GIOPED is still a simple IO model mainly for comparative static analyses showing how prices and inflation rates change by the end of the whole adjustment process. Repricing decisions and times (determined by several factors, for instance the level and turnover of inventories, expectations etc.) may vary significantly between country-industries. In our model the time needed for one price adjustment round is the same for all. As inflation rates increase, repricing

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[26] ICIO tables do not decompose value added into wages and other components, thus with this database, modelling price-wage spiral would be challenging empirically.

decisions become more and more frequent and price adjustment times reduce. Recent global inflationary processes (with the use of daily pricing in some industries) entitles us to believe in the conventional wisdom that static IO models are designed for short-run impact analyses and that the "time horizon" related to the GIOPED elasticities is shorter than one year. It is more like a few months.[27] This short period of time is also consistent with not taking into consideration price-wage spiral (discussed above), for which a longer time horizon should be assumed.

(g) Currently, GIOPED is available for 2007 and 2018. The ICIO tables behind the GIOPED depict the status of the world economy in those years. The structure and inter-country, inter-industry linkages of the global economy, however, may vary in time. In particular, they might have changed significantly since 2018, because of the enormous shocks of the COVID-19 pandemic and the Russian-Ukrainian war. One must keep this in mind and be careful when performing inflation calculations for current year with 2018 GIOPED elasticities.

6. Using and analysing inflation elasticities

Now having imported data and learned how to use it with pivot tables, one can perform GVC price-inflation impact analyses. For these, the following subsections show some examples with empirical results and implications.

6.1. Analysing global inflation elasticities

In this subsection, unless otherwise indicated, we assume an exogenous worldwide price increase of 1% in all industries, and we present the effects on the inflation rates by country, expressed in percentage points.

Figure 4 shows the percentage point changes in the consumer price index of each country as a result of the general 1% price increase. The results (between 2.78 and 1.74) in descending order show that although the ratio of the domestic price transmission channel is dominant in most countries, there is no correlation between this and the total size of the inflation exposure. In the group of countries with significant domestic channels, both high and low level of total elasticity can be measured. And the same is true for the cases where local inflationary drivers

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[27] Price transmissions are widely studied in econometrics, in particular in the field of agricultural goods and manufactured food. Scholars apply sophisticated time series analysis to reveal the channels through which price movements are transmitted with special attention to the time required. The general conclusion is that the velocity of price transmission highly depends on the market structure. Price transmission on spot markets, like the commodity exchange, is swift. Price movements of raw materials (for example fertilisers) have an impact on grain futures in hours (Fernandez, 2005). At a local market level the pass through become more diverse. Models proved the existence of random effects that can be linked to the market development, infrastructure, and trade barriers. Bekkers et al (2017) showed that the average pass through takes around 1.5 months; however, there are large differences among the countries. Some markets are less protected against increasing prices, especially those which are geographically more isolated. Kim and Ward (2013) analysed the price transmission of 100 agricultural products on the US wholesale and retail trade market. They showed that price movements differ in the short and the long run, and they proved the existence of asymmetric transmission, that is the elasticity of retail price is different depending on if wholesale prices are rising or falling. (Please note that our analysis focuses on the increase of prices and the resulting inflation through GVCs. Even so, not only the effects of rising, but also falling prices could be investigated with the GIOPED elasticities. Note that our model is perfectly symmetric in this sense. We do not differentiate between the direction of change: same elasticities hold for output price increases and decreases.) Price transmission via energy prices is moderately studied; however, findings suggest that it has a significant impact on producer prices. He and Lin (2019) investigated different industries in China and found heterogeneity in the market behaviour. They concluded that energy price movements impact PPI. However the degree strongly depends on the energy intensity of the given industry. On average, the time horizon of transmission is a few months, although the standard deviation is high. Sun et al. (2019) found similar patterns in the transmission of oil prices and Chinese manufacturing industry. We can conclude that the time horizon of price transmission is short but not uniform since the products and markets are very heterogenous.

are less significant. However, with the simple and complex global supply networks of domestically produced final products, the total exposure correlates much better.

The average CPI exposure of the world economy has been defined in two ways by simple and population-weighted average. Based on the simple average of the results obtained for each country (1.99), pure domestic price effects account for 64 percent of the total elasticity. This ratio is 77 percent in the case of the population weighted average (1.96). (See the last two columns in Figure 4). The share of GVC price components decreases according to the order in the legend of the figure.

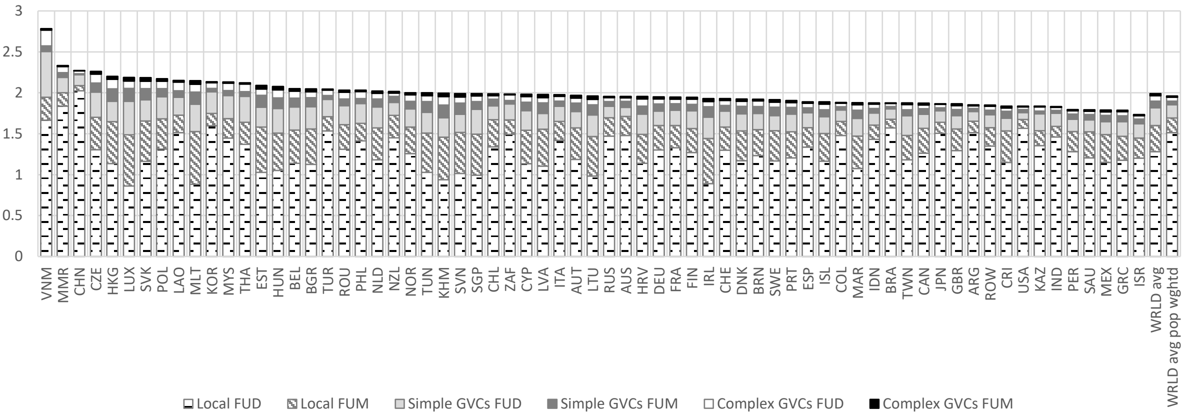

Figure 4. Basic price CPI elasticities by price index country and GVC type, 2018

Another interesting finding is that the number of countries with decreasing total inflationary exposures is higher than those with increasing ones. However, the average global fall between 2007 and 2018, due to the purely local component and the domestic products produced in simple global value chains, is negligible. For the population weighted average, the value of four (out of six) components decreased. Only variations in the price-transmission effects of imported final products produced in simple and complex GVCs increased the exposure insignificantly. However, there is still an insignificant overall fall in the value of the total inflation elasticity. These are shown in Figure 5. Figures 4 and 5 also reveal the considerable differences between countries with an increasing standard deviation of inflation elasticities from 2007 to 2018.

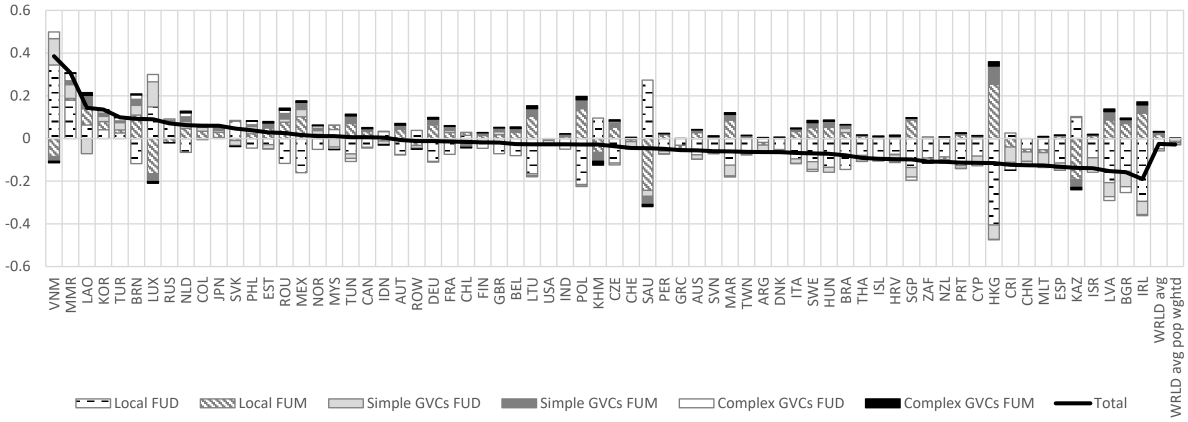

Figure 5. Change in basic price CPI elasticities by price index country and GVC type, 2018-2007

Similar proportions and changes in GVC price transmission components can be observed in the case of PPI. Based on the simple arithmetic average of the PPI elasticities of countries, purely domestic price transmission channels account for 76 percent of the total elasticity. This is 85 percent for the output-weighted average. According to the latter way of calculation, the channels of all three value chain types weakened. Total elasticity for PPI has decreased even in more countries than CPI.

As regards export and import price indices and their relationship, the most interesting results at a global level can be reached by breaking with the general assumption used so far and applying exogenous price changes only to products of certain countries or industries. Figure 6 shows the impact of a 1% increase in the price of each country's own products on terms of trade.[28] While in other countries that import these products directly or indirectly, there is a negative effect, i.e. a deterioration in the terms of trade. Figure 7 shows this on average. The exogenous price increases of products from the three leading centres of the world economy, China, the USA, and Germany, cause a fall in ToT for most countries.

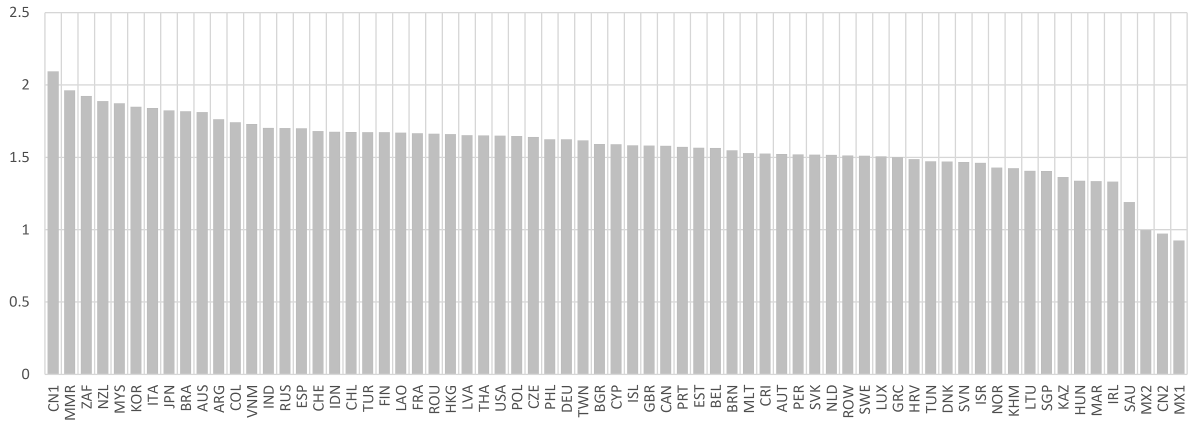

Figure 6. Basic price terms of trade elasticities to own product prices by output price change country

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[28] The order of economies in Figure 6 seems to be random in terms of size, development stage, external trade, and industry structures of economies. Yet it is apparent, there is a logical reason behind the values. The price of own products can affect export price index only through pure domestic or complex global value chains. (Through simple GVCs, they can affect another countries' product prices only.) At the same time, price of own products can affect a country's import price index through simple and complex GVCs (when exports return in the form of final or intermediate imports after one or more border crossings). From these four price transmission components, the first one, determined by local Leontief inverse, $\mathbf{L}^D$, is the dominant. As the first two effect are positive (third and fourth negative), total terms of trade effects, in the end, will obviously be positive. In the case of Hungary, for example, 1.343 + 0.004 – 0.007 – 0.001 = 1.339. Since the first factor is dominant in each country's case, we can say that the interconnectedness of own industries within each country is the crucial factor determining the order in Figure 6. Hungary is a small and open country with one of the weakest intra-country relations and domestic terms of trade price effects (see also Subsection 6.2).

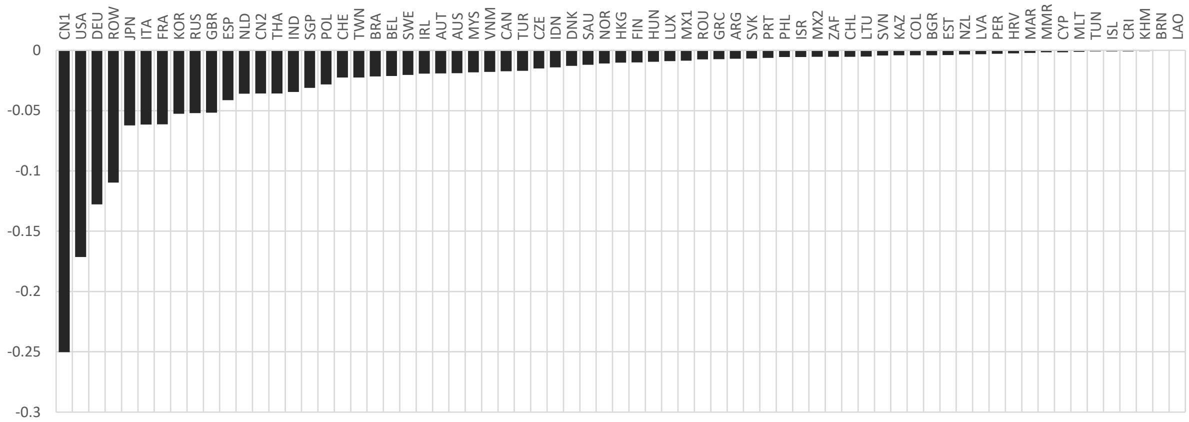

Figure 7. Average basic price terms of trade elasticities caused to other countries by output price change country

Figures 8-9 present the same by price change industry. Figure 8 clearly shows that the increase in the world price of energy products causes the greatest improvement in the ToT of countries with the highest share in their exports on the world market. There is also a significant impact of food products, financial services, automotive and electronic products.

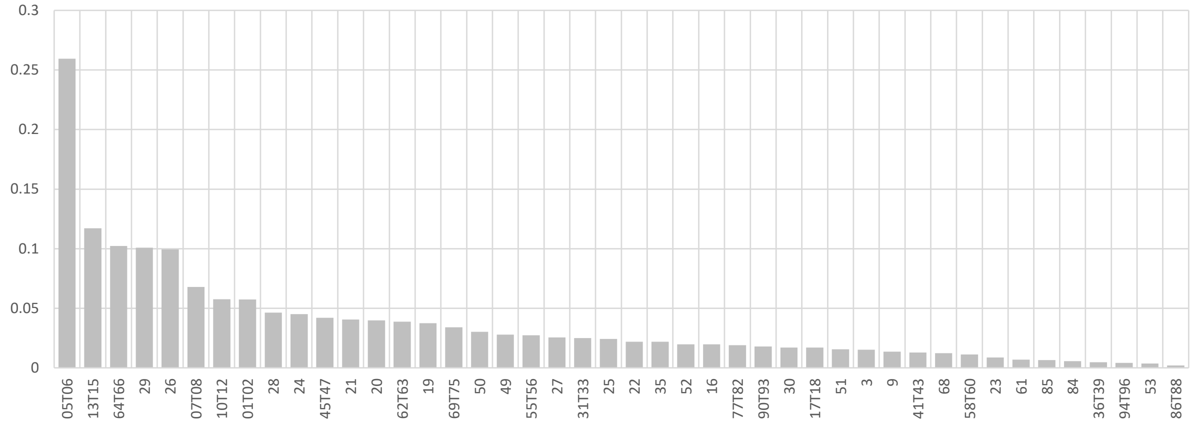

Figure 8. Average positive effects to basic price terms of trade elasticities by output price change industry

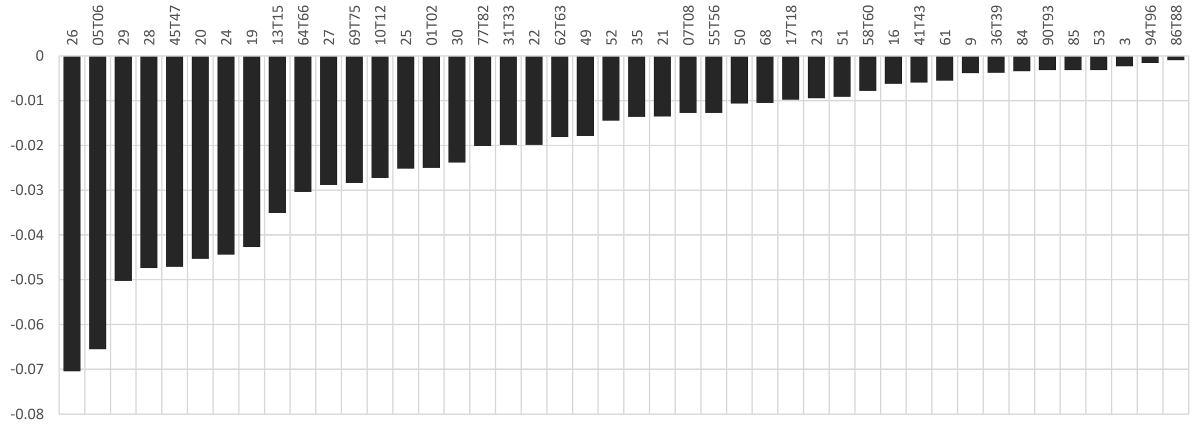

Figure 9. Average negative effects to basic price terms of trade elasticities by output price change industry

Figure 9 illustrates the average ToT-reducing effects. At first, it is somewhat surprising that the production of computer, electronic and optical products is in the first position, leaving energy sources behind them. The extremely widespread use of the sector's products (chips are now needed in almost everything) is one explanation for this, and the other is the territorial concentration of the industry, the negative consequences of which were already manifested during the coronavirus pandemic.

6.2. An illustrative country study

With the intention to present the operation and results of our proposed model for international price transmission, a small and open economy was selected. Hungary (population of 9.7 million) is one of the most opened economies in the world with 90% of export and 82% of import per GDP in 2020. Foreign trade is dominated by goods, however, the weight of services is also around 20%. The country has a lack of minerals and needs energy producing raw materials (petroleum and natural gas). In case of the latter Hungary imports 35% of petroleum and 60% of natural gas directly from Russia. However, owing to energy trade schemes in Europe the ratio of Russian direct and indirect import is likely to be much higher.[29] Hungary is deeply embedded in GVCs mainly along with the global automotive industry. The economy is integrated mostly backward, while the forward integration is smaller (Xin, 2020, p. 32). According to OECD's Trade in Value Added (TiVA) database, the domestic final demand contains foreign value added in 44% (for comparison this ratio is only 26% in Germany), while gross export incorporates foreign value added in 46%. Thus, both consumer (CPI) and producer (PPI) prices are strongly exposed to price volatilities along the GVCs.

Figure 10 helps to make a quick comparison between Hungarian and world average inflation elasticities. In addition to the fact that the Hungarian value is higher than the global average, its structure shows even more significant differences, which is a good indication of the above-average inflation exposure to GVCs. Compared to the global average of 77%, in Hungary, only 51% of CPI price elasticity is determined by purely domestic value chains. In the case of PPI, the same values are 85% and 63%, respectively. Hungarian ratios are the 8th and 6th smallest in the world (among ICIO countries).

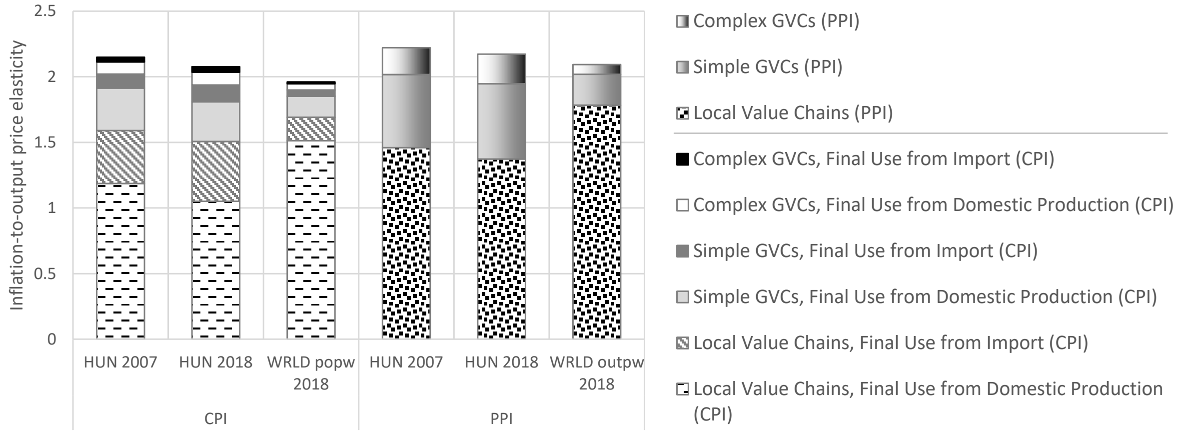

Figure 10. Comparison of Hungarian and world average basic price CPI and PPI elasticities

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[29] There are many energy hubs in Central and Eastern Europe. For example, Hungary imports a large volume of petroleum from neighbouring Austria where one of Europe's largest refineries can be found (that refines mostly Russian crude petroleum).

The data provided in the GIOPED is suitable to conduct a full country- and industrywide analysis of price transmissions. In this part we are going to show a representative example of such investigation from the viewpoint of Hungary. Our top-down method of filtering steps should be followed to save a meaningful amount of computation time when performing an inflation exposure analysis for a different country.

Step 1. First, one should pose the following research question: on which countries does the inflation rate in the country under investigation (Hungary, in our case) depend the most? To answer this question, it is again necessary to assume that prices everywhere (in all countries and industries) will increase by 1%. Obviously, the industrial structure of production and use for the price change and price index change countries, as well as for intermediate trading partners greatly influence the result. It is therefore very important which industries the effect primarily originates from. Of course, the user can freely determine any source country and industry for the change of prices, but first we focus on the global view with country-to-country relations to determine which countries are the most influential in causing high inflationary exposures. The industry level will only be examined in the second step. (In any case, the important industries that are relevant to the overall effects will dominate the results already in the first step, although these details remain hidden.)

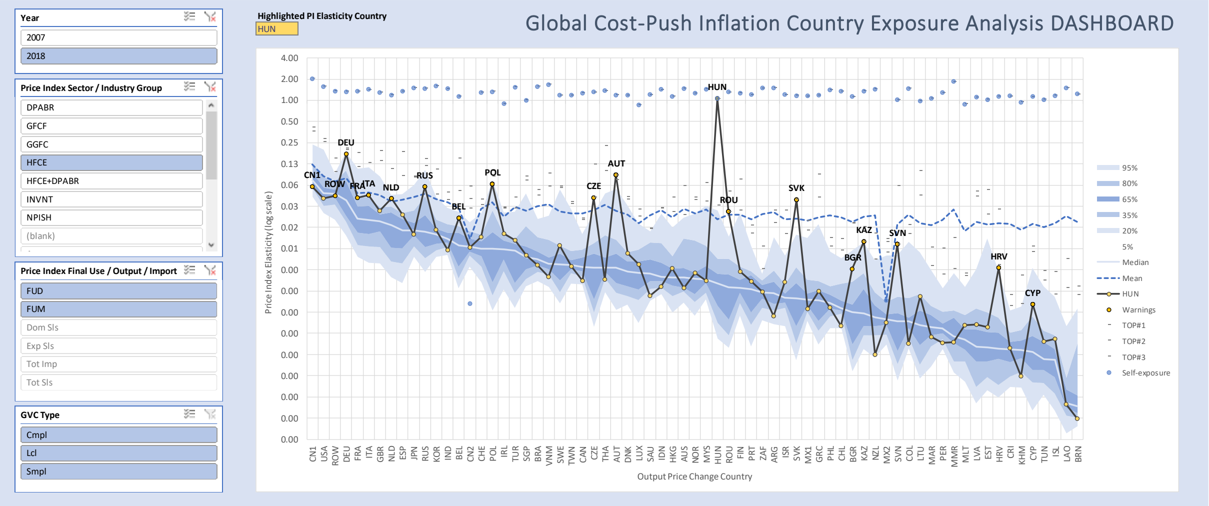
Step 2. Then, given the country ranking of Step 1, one can pick any country to check the impact of a price change in any industry. That is, having revealed the key countries of exposures, one can turn to the task of exploring the most important industries of these countries as inflation sources.

Step 3. Finally, one can also create a ranking at a country-industry level to see which industries in which countries have the largest impact on inflation. Or in other words, on which countries and industries do the producer and consumer price indices of a country depend significantly?

Of course, one can change the ‘country level first’ focus of Step 1-2 for an ‘industry level first’ approach, where the primary question is about industries in the world market that are the most important factors determining inflation in the country under investigation. Then the secondary question is which countries these dependencies come from. One can dig deeper for the effects in the price index country, as well: in the case of the CPI for the final use sectors, and in the case of the PPI for the industries that are most affected. For the latter, the bottom-level analysis is based on the output price-to-output price elasticities directly.

Now, let us check the case of Hungary according to the steps above supported by some dashboards developed for the effective analysis of the inflation elasticity database. Figure 11 depicts the global CPI elasticities. The median line represents the worldwide median inflation exposure caused by a price change country on the horizontal axis (considering both direct and indirect impacts through the GVCs). Price change countries (inflationary sources) are ordered according to that value. The shaded areas of the fan chart represent the standard deviation of exposure values. The largest impact on global inflation ‘arrives’ from China (CN1), followed by the USA, ROW, and Germany (DEU). Here, one can alter the year (currently 2007 and 2018 are included), the sector or industry group on which the global impact shall be investigated, the source of final use (from domestic production – FUD, from import – FUM), and the type of GVCs considered (local with no border crossing during the production (Lcl), simple global with one border crossing only (Smpl), and complex global with multiple border crossings (Cmpl)).

One can also highlight the inflation exposures of any country represented by the dark line with markers where labels are indicating the key dependencies that are the highest values (top 10) from the highlighted country's point of view, or even if they are smaller, they are among the top 10 dependents of the price change country on the horizontal axis.



Year
2007
2018

Price Index Sector / Industry Group
DPABR
GFCF
GGFC
HFCE
HFCE+DPABR
INVNT
NPISH
(blank)

Price Index Final Use / Output / Import
FUD
FUM
Dom Sls
Exp Sls
Tot Imp
Tot Sls

GVC Type
Cmpl
Lcl
Smpl

Highlighted PI Elasticity Country
HUN

Figure 11. Dashboard for country-to-country exposure analysis

In Figure 11 the exposure of Hungary is displayed. Apparently, every country is exposed the most to itself,[30] that is why the highest impact in the Hungarian CPI is exerted by the Hungarian economy itself. The figure also portrays this self-exposure values for each country (marked by filled circles on the top). The order of countries that the world is exposed mostly is only partly true in case of Hungary as the dark line with markers and labels suggests. To explore the exposure of any country one can check the countrywide impacts. The following plot (Figure 12) displays that for Hungary (for the sake of clarity, Hungary was removed). This is the ranking of the countries on which Hungarian inflation depends the most (i.e. the peaks of the dark line in Figure 11 in descending order).

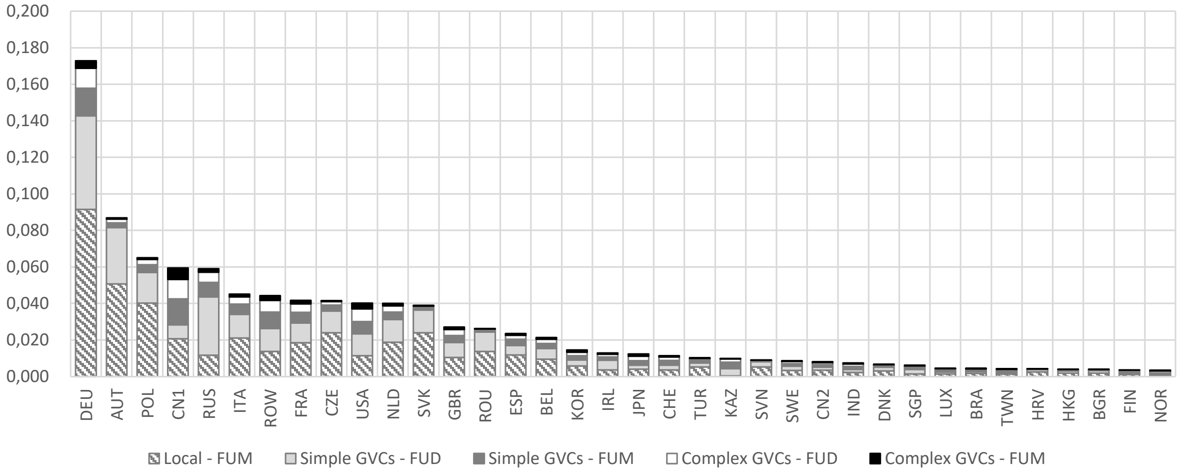


Figure 12. Country rank and GVC decomposition of basic price CPI elasticities for Hungary

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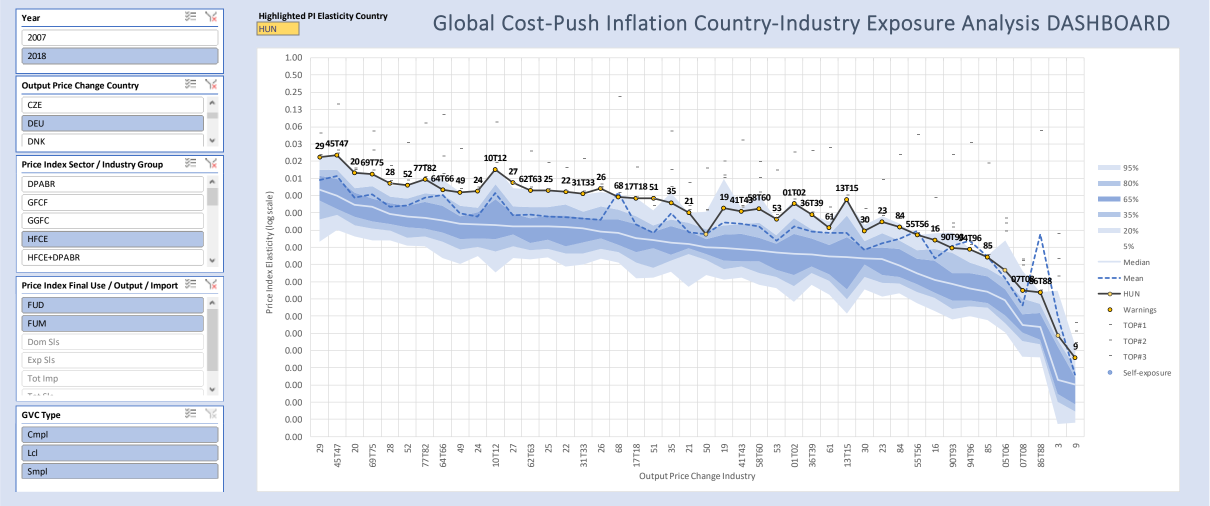
[30] Except the special export processing zones in China and Mexico, CN2 and MX2.

The Hungarian CPI is exposed mostly to the largest trading partner Germany, followed by Austria and Poland. The one and almost only energy producing materials supplier Russia is ‘only’ fourth after China (CN1). The stacked columns also depict the GVC types of the exposure. It reveals that final goods import from non-EU countries has very little impact on the Hungarian CPI as these countries mostly export intermediate goods to Hungary. At the same time, most exposures are originated from imported final goods from the EU.

Since it was revealed that the Hungarian inflation is chiefly exposed to the German price changes one can further detail this vulnerability to an industry level (Step 2) as Figure 13 represents.



Year
2007
2018

Output Price Change Country
CZE
DEU
DNK

Price Index Sector / Industry Group
DPABR
GFCF
GGFC
HFCE
HFCE+DPABR

Price Index Final Use / Output / Import
FUD
FUM
Dom Sls
Exp Sls
Tot Imp

GVC Type
Cmpl
Lcl
Smpl

Highlighted PI Elasticity Country
HUN

Figure 13. Dashboard for country-to-country-industry exposure analysis

Here, the user sees the German industries on the horizontal and the CPI elasticities on the vertical axis. The world is most exposed to the German automotive sector, followed by the wholesale and retail trade and repair of motor vehicles. For Hungary the top two are the same, but their order is reversed. This is not surprising since Hungary accommodates two large car 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 (Lcl – FUM). Hungary’s largest CPI exposure to Germany comes from the German trade sector: directly through final product import and indirectly through simple global value chains. Along with the car manufacturers, large German retail companies are also presented in Hungary. The share of German imports is high both in final consumption and investments. The shaded areas show how German industries affect all countries (the median and the mean are depicted as well). One can observe that the dark line with markers is located on the top edge of the fan chart; that is Hungarian inflation is top exposed to almost all industries of Germany.

For a bottom-level insight (Step 3) Figure 14 with the top 25 country-industry exposures of Hungarian CPI is to be considered. The highest inflation elasticity belongs to the Austrian electricity, gas, steam, and air conditioning supply sector (35). Between the German retail and automotive industry, one can find Russian mining and quarrying of energy producing products (05T06) with an outstanding simple GVC component. Since Hungary is a small open country lacking raw materials producing energy, the producers must import these inputs. Owing to geographical, political, and infrastructural[31] reasons, these products are mostly imported from Russia. This causes a significant amount of vulnerability for Hungary, which is becoming increasingly prominent due to the sanctions against Russia.

Finally, because of the high-degree energy dependence of Hungary and the results shown in Figure 14, it is worth checking the full sectoral view of inflation exposures to Austria and Russia. Figure 15 shows that global inflation exposure to Russia comes through energy goods (05T06) and coke and refined petroleum products (19). Hungary is one of the most affected countries in the world. For the Austrian industries coded by 35, 19, and 05T06 in Figure 16, this is even more true.

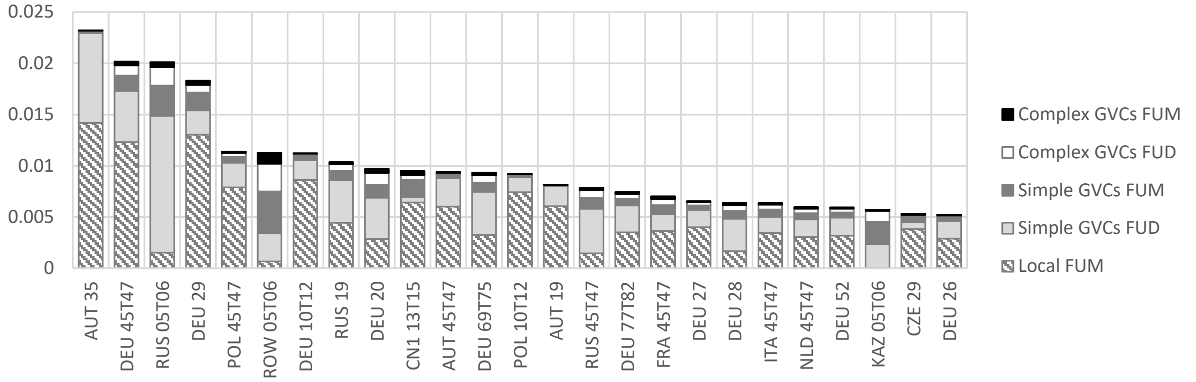


Figure 14. Top 25 country-industry exposures of Hungarian basic price CPI

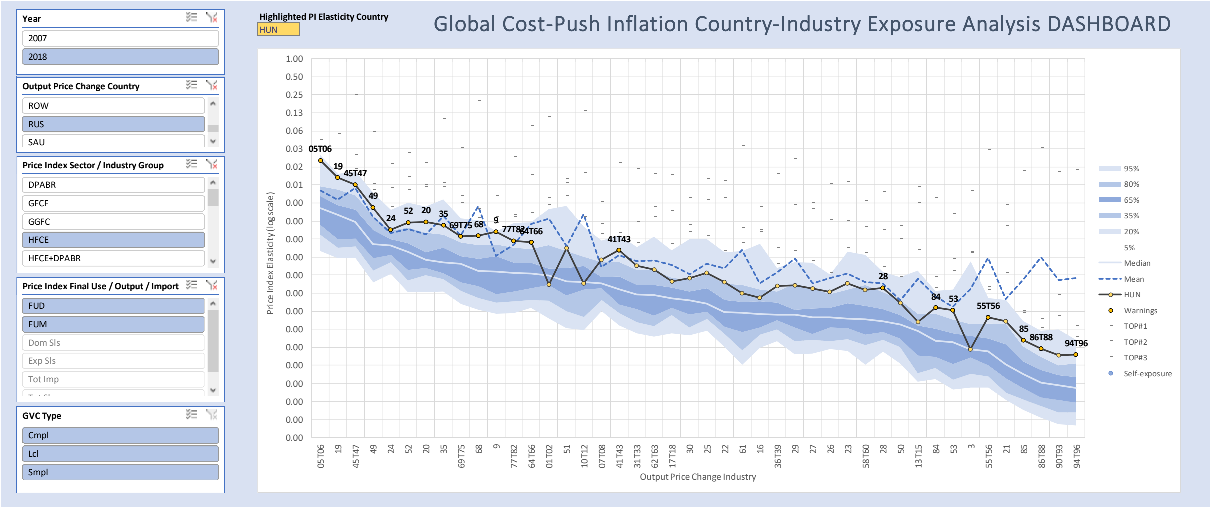

Year: 2007, 2018 (selected: 2018)
Output Price Change Country: ROW, RUS, SAU (selected: RUS)
Price Index Sector / Industry Group: DPABR, GFCF, GGFC, HFCE, HFCE+DPABR (selected: HFCE)
Price Index Final Use / Output / Import: FUD, FUM, Dom Sls, Exp Sls, Tot Imp (selected: FUD, FUM)
GVC Type: Cmpl, Lcl, Smpl (selected: Cmpl, Lcl, Smpl)
Highlighted PI Elasticity Country: HUN

Figure 15. Global and Hungarian inflation exposure to Russia

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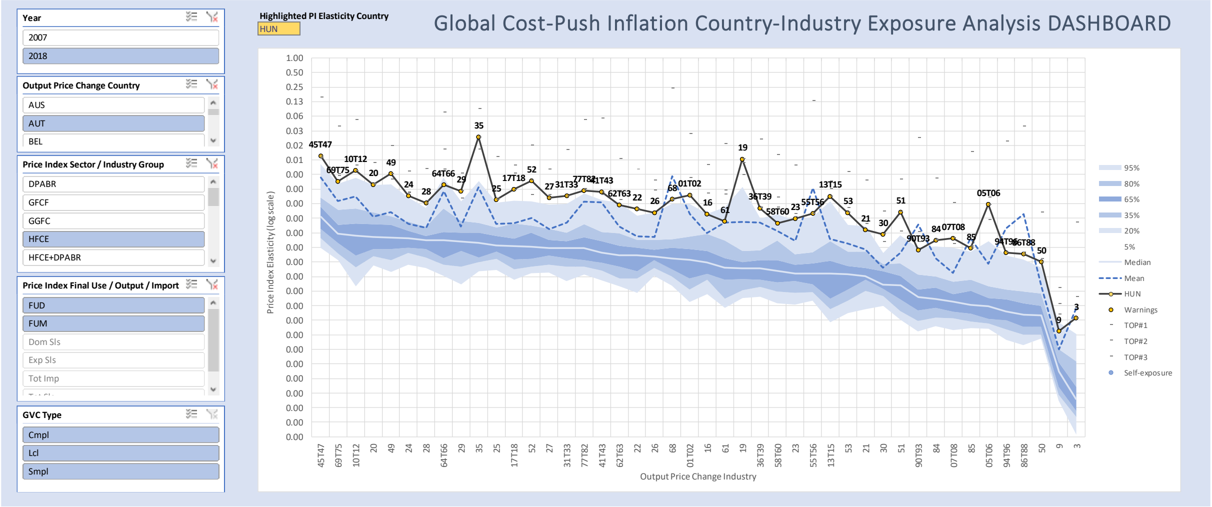
[31] In the 1960s the Soviet Union began to build the Friendship Pipeline, which is the longest and largest oil pipeline in the world, and it delivers oil from the Russian endpoint to users in Ukraine, Belarus, Poland, Hungary, Slovak Republic, the Czech Republic, Austria, and Germany.



Year
2007
2018

Output Price Change Country
AUS
AUT
BEL

Price Index Sector / Industry Group
DPABR
GFCF
GGFC
HFCE
HFCE+DPABR

Price Index Final Use / Output / Import
FUD
FUM
Dom Sls
Exp Sls
Tot Imp

GVC Type
Cmpl
Lcl
Smpl

Highlighted PI Elasticity Country
HUN

Figure 16. Global and Hungarian inflation exposure to Austria

Owing to historical and geographical reasons, it is not only Hungary that is exposed to the Russian economy; moreover, Hungary is only moderately susceptible. The Baltic countries (Lithuania, Latvia, and Estonia) are highly impacted, just as Bulgaria and Slovakia. Figure 17 depicts Hungary's relative position (Russia was removed due to clarity).

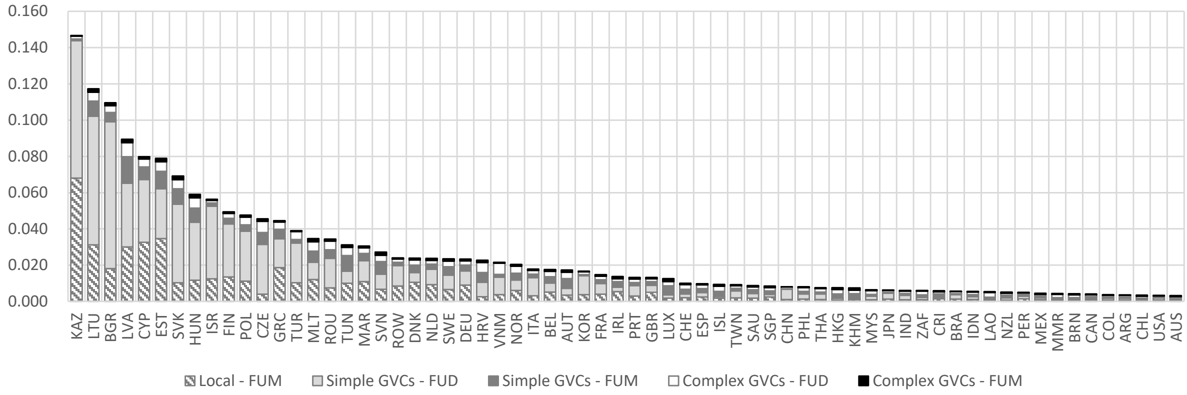


Figure 17. Rank of basic price CPI exposures to Russian output prices

Country and industry applications of producer price index and terms of trade calculations offer further opportunities to exploit the inflation elasticity database. Owing to limited space available, we cannot discuss them in this study.

6.3. Using inflation elasticities with superior information

So far, we have analysed inflation elasticities directly as they are, with a specific assumption of hypothetical 1 percent exogenous price changes. At this point, we abandon this premise. This subsection shows an exercise on how to use inflation elasticities for a quick model calculation when superior information on exogenous price changes is available. These are the movements that cannot be explained by the endogenous cost-push patterns of intermediate use. Of course, statistically documented price indices always reflect a mix of supply and demand side effects. In particular, when moving downstream in the global value chains, the separation of exogenous and endogenous price changes becomes more and more challenging and requires special research.

This problem may be less apparent in the upstream stages, for the output of agriculture and mining i.e. fewer processed products or raw materials. Price movements of energy commodities in the last two years, for example, were mainly driven by excess demand over the restricted supply. Restarting economies after COVID-19 lockdowns in 2020 and 2021, panic buying in Europe during the summer because of the Russian-Ukrainian war and the ensuing sanctions caused a boom in energy prices and raised their volatility. World Bank's 'Pink Sheet' global energy price index showed a 443% increase between 2020M04 and 2022M07.[32] There is no evidence that such a price explosion was caused by the increase of production costs i.e. cost-push patterns. Thus, it seems reasonable to assume that all the changes in the price of products by 05T06 industries (mainly crude oil and natural gas) experienced in the last few years were fully exogenous for our model framework. Nevertheless, it's still just an assumption,[33] like the example presented here is only an illustration focusing on further possibilities and ways of using inflation elasticities. With exogenous price changes different from 1 percent, one can exploit the linearity of the model. Moreover, endogenous cost-push price and inflation effects are not just proportional but also additive. This serves well when having exogenous price shocks in several country-industries.

According to the Eurostat, in October 2022, Hungary experienced the third highest inflation rate in the European Union. Motivated by this phenomenon, our research question to be answered using the GIOPED is the following: how much of Hungarian inflation can be explained by exogenous energy commodity price changes and their direct and indirect GVC transmissions?

Of course, we must be cautious and aware of the limitations and possible distortions of the model calculations. Firstly, the most updated ICIO and GIOPED data is for 2018. Obviously, it should be used as the reference year for our analysis. For the end of the investigation period 2022M07 was selected when prices were near their peak. Based on HICP monthly data (index) [table prc_hicp_midx] by Eurostat,[34] the consumer price level in Hungary increased to 129,6% (2018=100%) i.e. the change was almost 30% between 2018 and 2022M07.

Secondly, ICIO data do not reveal possible variations of global value chains in the last few years. Thus, for our analyses, 2018 structure of inter-country, inter-industry linkages, and final use must be assumed to be unchanged. However, most significant transformations have begun and will continue in the energy supply networks. As revealed in the previous subsection, Hungary is highly exposed to Russia in its upstream energy supply chains. The intention to detach from Russian crude oil and natural gas has been strengthened in Hungary as well, especially from the middle of last summer. However, this transformation cannot be immediate owing to several legal and technological reasons (long-term contracts, non-existing transport routes, technical background in related industries etc.). And even though there has been some decline in Russian imports in 2022 due to the disruption of deliveries, we cannot say that Hungary's energy supply chains were significantly restructured between 2018 and mid-2022. The

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[32] https://www.worldbank.org/en/research/commodity-markets

[33] It is important to note that in our model of inflation-to-output price elasticities, exogenous price changes always have some repercussions to the source industry (or industries) as well, causing some extra loops and overestimation of price and inflationary effects. To exclude such distortions, one can use the so-called mixed or restricted price models with some fully exogenous prices in some predefined country-industries, abandoning the general approach enforced in the GIOPED. For a development and application of a single-country mixed IO price model see Révész (2000).

[34] https://ec.europa.eu/eurostat/web/main/data/database

exposure to Russian energy is still above the EU average and if import needs do not change, this may remain the same in the future (Kovalszky et al., 2022).

Thirdly, even if the structure of global value chains remained unchanged since 2018, highly aggregated data can cause significant distortions. ICIO industry 05T06 incorporates production of coal, crude oil, and natural gas.[35] A compatible aggregate, Pink Sheet's Energy Index could be used as a global uniform indicator of output price changes in 05T06 industries, but it hides regional and sectoral differences and can lead to serious bias in results. Natural gas prices in Europe have been skyrocketing and show a hectic, extremely volatile pattern compared to US prices. Crude oil prices have been less diverse regionally and the magnitude of their boom was smaller. The share of coal is quite low globally, so for the sake of simplicity, we will dispense with this commodity in our analyses.

To be able to attach a unique output price to each 05T06 country-industry we used their 2018 ICIO table global sales structure to detect the approximate crude oil and natural gas content of output. All the sales to the industries of coke and refined petroleum products (19) have been assumed to be crude oil, and all the flows to electricity, gas, steam, and air conditioning supplies to be natural gas production (35). Then, with these two components, shares in their sum have been used as weights for composite 05T06 output prices. In the case of Russia, for example, we obtained 71.5% and 28.5% for crude oil and natural gas, respectively. For the price changes, we used globally uniform crude oil average by the Pink Sheet. It shows a 53.7% increase from 2018 to 2022M07. As for the natural gas, we distinguished between European and global prices. The change in European and global prices for the investigation period were 568.2% and 320.0%, respectively. The former was used to estimate European countries' changes in composite 05T06 prices, and the latter for others. For Russia, based on the approximate oil and gas weights by sales structure and the price movements referred to above, the calculation resulted in a $71.5\% \cdot 53.7\% + 28.5\% \cdot 568.2\% \approx 200\%$ exogenous energy price change.[36] For other 05T06 country-industries, we used the same formula with their own weights and the 53.7% oil and 568.2% (European) / 320% (non-European) gas price increases.

Having the vector of exogenous output price changes by 05T06 country-industries and the pivot table of elasticities shown in Figure 18 one can perform a simple model calculation to assess the consequences on Hungarian inflation. Column vector of row totals in Figure 18 (column H in the Excel worksheet) show the percentage change in the consumer price level in Hungary caused by a 1% price change in the 05T06 industry of the related row country. Element-by-element product of this inflation elasticity vector and the vector of estimated exogenous energy commodity price changes gives the inflationary pressures in Hungary caused by different supplier countries. These results contain all direct and indirect GVC effects. The sum of them, 8.4% expresses the total Hungarian inflation exposures to current global crude oil and natural gas prices. Figure 19 shows its breakdown by GVC types and countries. Russian (4%)

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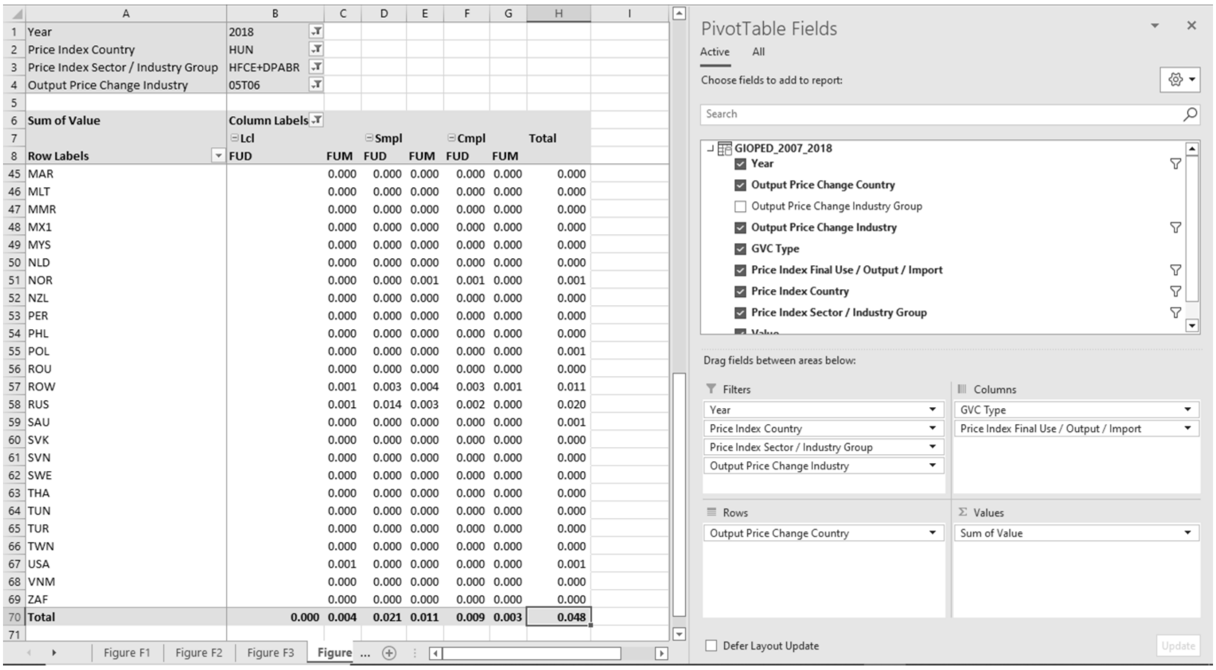
[35] Of which, 05 is coal mining. Crude oil and natural gas production belong to industry 06. It is rare even in national IO tables that 2-digit code industries are further disaggregated. As a higher level of aggregation can result in distortions, a much more reassuring solution would be obtained if all three energy products (crude oil, natural gas, coal) were broken down into separate sectors (with their own prices) in the world input-output table. Such a solution cannot be undertaken within this study.

[36] It is worth checking this result from the side of the Hungarian import structure. Based on the share of 19 and 35 industries in total import from Russian 05T06 industry, the crude oil-natural gas shares are somewhat different, 80-20%. Using these weights, we would get a more moderate direct energy price increase (158%) from the direction of Russia. Thus, with 200%, we are probably slightly overestimating the inflationary pressures.

and non-Russian components support our previous conclusions about the regional patterns of dependencies.



Year	2018
Price Index Country	HUN
Price Index Sector / Industry Group	HFCE+DPABR
Output Price Change Industry	05T06

Sum of Value	Column Labels						
	Lcl		Smpl		Cmpl		Total
Row Labels	FUD	FUM	FUD	FUM	FUD	FUM	
MAR		0.000	0.000	0.000	0.000	0.000	0.000
MLT		0.000	0.000	0.000	0.000	0.000	0.000
MMR		0.000	0.000	0.000	0.000	0.000	0.000
MX1		0.000	0.000	0.000	0.000	0.000	0.000
MYS		0.000	0.000	0.000	0.000	0.000	0.000
NLD		0.000	0.000	0.000	0.000	0.000	0.000
NOR		0.000	0.000	0.001	0.001	0.000	0.001
NZL		0.000	0.000	0.000	0.000	0.000	0.000
PER		0.000	0.000	0.000	0.000	0.000	0.000
PHL		0.000	0.000	0.000	0.000	0.000	0.000
POL		0.000	0.000	0.000	0.000	0.000	0.001
ROU		0.000	0.000	0.000	0.000	0.000	0.000
ROW		0.001	0.003	0.004	0.003	0.001	0.011
RUS		0.001	0.014	0.003	0.002	0.000	0.020
SAU		0.000	0.000	0.000	0.000	0.000	0.001
SVK		0.000	0.000	0.000	0.000	0.000	0.000
SVN		0.000	0.000	0.000	0.000	0.000	0.000
SWE		0.000	0.000	0.000	0.000	0.000	0.000
THA		0.000	0.000	0.000	0.000	0.000	0.000
TUN		0.000	0.000	0.000	0.000	0.000	0.000
TUR		0.000	0.000	0.000	0.000	0.000	0.000
TWN		0.000	0.000	0.000	0.000	0.000	0.000
USA		0.001	0.000	0.000	0.000	0.000	0.001
VNM		0.000	0.000	0.000	0.000	0.000	0.000
ZAF		0.000	0.000	0.000	0.000	0.000	0.000
Total	**0.000**	**0.004**	**0.021**	**0.011**	**0.009**	**0.003**	**0.048**

PivotTable Fields

Choose fields to add to report:

GIOPED_2007_2018
- ☑ Year
- ☑ Output Price Change Country
- ☐ Output Price Change Industry Group
- ☑ Output Price Change Industry
- ☑ GVC Type
- ☑ Price Index Final Use / Output / Import
- ☑ Price Index Country
- ☑ Price Index Sector / Industry Group

Drag fields between areas below:

Filters: Year; Price Index Country; Price Index Sector / Industry Group; Output Price Change Industry

Columns: GVC Type; Price Index Final Use / Output / Import

Rows: Output Price Change Country

Values: Sum of Value

☐ Defer Layout Update

Figure 18. Using inflation elasticities with superior exogenous output price change information

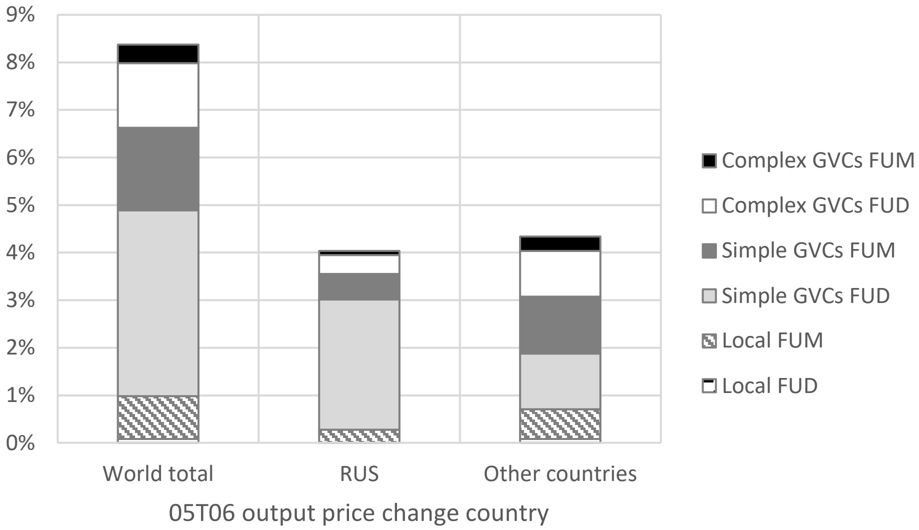


Figure 19. Pressure of global energy commodity (05T06 output) price changes through GVCs since 2018 on basic price Hungarian HICP (total direct and indirect GVC effects, 2018=100%)

Despite the possible biases indicated, it is worth comparing our results with the previously mentioned fact inflation data. The latter, of course, reflect a lot of external, internal, exogenous, and endogenous effects.[37] It is not surprising that headline inflation exceeds the one resulting solely from exogenous changes in crude oil and natural gas prices. However, it matters how

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[37] Even the rising inflation expectations and emerging price-wage spiral at a global level, which are not incorporated into our model. In Hungary, however, inflation data for 2022 have so far rather triggered a significant decline in real wages. Until mid-2022, a significant and persistent economy-wide price-wage spiral has not yet formed. In the future, however, this effect will also have to be considered.

much and, as we can see, to a considerable extent. It does so despite the fact that the Hungarian government introduced several non-conventional measures to protect consumers from inflation, e.g. regulation of household energy prices and price-caps on fuels. However, only resident private entities are (were) entitled to take advantage of price control measures with firms paying the market price. By that, the direct impact on HICP is constrained, but the indirect price transmission through the input prices could not be avoided. From August 2022, with a change in energy price regulation, households as well must pay the market price for natural gas and electricity above average consumption. For 2022 Q3 and Q4 these prices were fixed at summer 2022 peaks. It caused an approximately 3% increase in the consumer price level in autumn.[38] On 6th December 2022 the price cap on fuel was also abolished, the inflationary effects of which will be expressed lately, in the December 2022 CPI to be published in January 2023.

Government measures have not significantly affected taxes on products.[39] In this sense, results from GIOPED, ignoring final product taxes and subsidies, may be comparable to official CPI statistics. Other important factors of bias, however, must be considered. Coke and refined petroleum products (19) and food, beverages and tobacco (10T12), most affected by 05T06 price changes, have an outstanding tax rate. With a price increase in these sectors, market price inflation will be underestimated with GIOPED. As additional external information, net taxes to basic price household consumption rates by industry from Hungary’s national input-output tables by the HCSO[40] were used to estimate the bias due to non-consideration of final product taxes. Adjusting weights with tax rates resulted in a 2.4% higher, 10.8% inflationary effect of peak global energy commodity prices.

Official CPI statistics also contain several distortions, not adequately reflecting market price developments. GIOPED, on the other hand, focuses on free market price developments through cost-push channels, and cannot consider price control measures. Therefore, a significant part of the 10.8% energy price pressure indicated by our calculations does not even appear in the Hungarian inflation rate. Adding the components of market inflation suppressed by the government price control measures to the nearly 30% increase in the Hungarian price level occurring between 2018 and 2022M07, would probably result in an inflation rate several percentage points higher than the official one. To be precise, this one should be compared to the 10.8% energy price effect.

For a possible way of correction, one can use a later price level. With the changes in household energy price regulations imposed in August 2022, market movements now appear more (still partly, however) in inflation rates. Thus, using 2022M09 data is reasonable, also because, according to current research, Hungarian natural gas import prices follow Netherlands Title Transfer Facility (TTF) with a lag of about two months (Kovalszky et al., 2022). If, for the sake of simplicity, this delay is applied to crude oil import prices as well, and thus, we compare our 10.8% result with the consumer price increase of almost 37% from 2018 to 2022M09 (by the Eurostat), it can be concluded that the direct and indirect inflationary pressures (spilling over to all other sectors including food prices now being the main driver of inflation in Hungary) caused by global energy commodity prices and GVC transmissions can explain no more than a

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[38] https://www.ksh.hu/interaktiv/kaleidoszkop/kaleidoscope.html?lang=en

[39] Although excise duties on fuel had been slightly reduced, they have returned to their previous levels by phasing out the price cap.

[40] Hungarian Central Statistical Office, Dissemination Database/Economic statistics/Economic accounts/Supply and use tables, IOT, statinfo.ksh.hu/Statinfo

third of the current Hungarian inflation rate, approximately. This statement is also valid on a monthly, annual rate of change basis.

7. Summary and conclusions

Currently the world is struggling with a crisis caused by two major shocks, namely the COVID-19 pandemic and Russia's war against Ukraine. The world economy is characterised by stagnation and disruption of value chains, the loss of important sectors in the war-torn country, the effects of sanctions against Russia, product shortages and rampant commodity prices. As a result of the price transmission that runs through the global value chains, the effects of the increase in commodity prices reach final consumer expenses in a relatively short period of time, expressed by national inflation rates.

This paper dealt with this phenomenon by presenting, developing, and applying an input-output model of the global cost-push price transmission mechanism. The novelties of the study are (a) the global approach in this field, (b) the application of input-output price models on the most updated 2021 edition of Inter-Country Input-Output (ICIO) tables, (c) the connection of output prices with several inflation rates by introducing the concept of output price-to-output price and inflation-to-output price elasticities, (d) the decomposition of price transmissions into local, simple, and complex global value chain effects, and (e) the illustrated user guide to the Global Inflation-to-Output Price Elasticity Database (GIOPED) developed on the theoretical basis of the proposed framework.

Some of the first new findings that have been shown with the model are the following. On a global average, despite the spread of GVCs, local value chains are still dominant in determining inflation. Inflation exposures to value chains decreased in most countries between 2007 and 2018, although there are significant differences. For Hungary, as a small and open economy selected for an illustrative country study, inflation elasticities are higher than the global average with smaller pure domestic components. Key exposures to Austrian electricity, gas, steam and air conditioning supply, German trade and automotive industry, and Russian energy have been revealed. Global movements of energy commodity prices explain about a third of the autumn 2022 Hungarian inflation rates.

The paper has not presented detailed country and industry applications of producer price index and terms of trade calculations, which offer further opportunities to exploit the inflation elasticity database published along with the paper. Options for global and country studies, especially for other countries are still open. Diverse decomposition possibilities of GVC price transmission components might also prove to be useful both for theoretics in the field of IO and inflation modelling and practitioners in central banks. Potential users are encouraged to explore the database for further results.

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Data availability statement

The GIOPED_2007_2018_with_decimal_points.txt and GIOPED_2007_2018_with_decimal_commas.txt that supports the findings of this study are available at https://doi.org/10.6084/m9.figshare.19778518.v1.

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Xin, C. (Ed.). (2020). *CEE Countries in Europe: Toward Center or Periphery in Global Value Chains*. China-CEE Institute. https://china-cee.eu/wp-content/uploads/2020/11/PDF2019Project3.pdf

Appendices

Appendix A: Input-output basics behind the Leontief and Ghosh price models

Starting with the column-wise accounting identity of a closed-economy input-output table, where entries are recorded in monetary values, the total cost of production (including the sum of all intermediate use and value added) gives the value of output according to equation (A.1)

$$\mathbf{x}' = \mathbf{i}'\mathbf{Z} + \mathbf{v}', \tag{A.1}$$

where $\mathbf{x}'$ is the vector of output by each producing industry, $\mathbf{i}'$ is the identity (summation) vector, $\mathbf{Z}$ is the square matrix of the interindustry transactions, and $\mathbf{v}'$ is the vector of value added (the incomes of all primary inputs, regardless of type). According to conventions in matrix algebra, upper case bold letters stand for matrices, lower case bold letters represent column vectors, and apostrophes indicate transpositions, so $\mathbf{x}'$, $\mathbf{i}'$, and $\mathbf{v}'$ in (A.1) are all row vectors. Postmultiplying by $\hat{\mathbf{x}}^{-1}$, equation (A.1) can be easily converted into (A.2)

$$\mathbf{i}' = \mathbf{i}'\mathbf{A} + \mathbf{v}'_c, \tag{A.2}$$

where $\mathbf{A} = \mathbf{Z}\hat{\mathbf{x}}^{-1}$ is the matrix of direct input coefficients and $\mathbf{v}'_c = \mathbf{v}'\hat{\mathbf{x}}^{-1}$ is the vector of value added ratios in each productive industry. Hat and power exponent -1 represent matrix diagonalisation and inversion, respectively. Input coefficients calculated using monetary transactions are the same as those that are based on a unique physical measurement where physical units are the quantity of homogenous sectoral products that can be purchased for a unit of money (in world input-output tables, \$1). Thus, (A.2) shows the cost of inputs per a monetary unit of output, i.e. the cost structure of the sectoral products. The 1s in vector $\mathbf{i}'$ serve as special, base year index prices. For a most common notation of prices, (A.2) can be reformulated as

$$\tilde{\mathbf{p}}' = \tilde{\mathbf{p}}'\mathbf{A} + \mathbf{v}'_c, \tag{A.3}$$

which is the basic equation of the Leontief cost-push input-output price model (Dietzenbacher, 1997; Oosterhaven, 1996).

In the Ghosh model, not the input, but the $\mathbf{B} = \hat{\mathbf{x}}^{-1}\mathbf{Z}$ direct output coefficients are fixed. Premultiplying by $\hat{\mathbf{x}}$ yields $\hat{\mathbf{x}}\mathbf{B} = \mathbf{Z}$, and substituting with this in (A.1) leads to

$$\mathbf{x}' = \mathbf{x}'\mathbf{B} + \mathbf{v}'. \tag{A.4}$$

Rearranging (A.4), $\mathbf{x}' - \mathbf{x}'\mathbf{B} = \mathbf{x}'(\mathbf{I} - \mathbf{B}) = \mathbf{v}'$ and postmultiplying by $(\mathbf{I} - \mathbf{B})^{-1}$ gives

$$\mathbf{x}' = \mathbf{v}'\mathbf{G}, \tag{A.5}$$

where $\mathbf{G} = (\mathbf{I} - \mathbf{B})^{-1}$ is the Ghosh inverse.

Appendix B: Proof of GVC decomposition of cost-push price transmission

To prove equation (11) one can start with the price model (1) separating domestic and foreign cost-push price effects

$$\tilde{\mathbf{p}}' = \tilde{\mathbf{p}}'\mathbf{A}^D + \tilde{\mathbf{p}}'\mathbf{A}^M + \mathbf{v}'_c.$$

Subtracting $\tilde{\mathbf{p}}'\mathbf{A}^D$ from both sides and multiplying out on the left yields

$$\tilde{\mathbf{p}}'(\mathbf{I} - \mathbf{A}^D) = \tilde{\mathbf{p}}'\mathbf{A}^M + \mathbf{v}'_c.$$

Postmultiplying by $(\mathbf{I} - \mathbf{A}^D)^{-1} = \mathbf{L}^D$ leads to

$$\tilde{\mathbf{p}}' = (\tilde{\mathbf{p}}'\mathbf{A}^M + \mathbf{v}'_c)\mathbf{L}^D.$$

Now, with substituting $\tilde{\mathbf{p}}'$ for $\mathbf{v}'_c\mathbf{L}$ (based on (2)) and removing parenthesis one can get

$$\mathbf{v}'_c\mathbf{L} = \mathbf{v}'_c\mathbf{L}\mathbf{A}^M\mathbf{L}^D + \mathbf{v}'_c\mathbf{L}^D,$$

which also holds for $\hat{\mathbf{v}}_c$'s instead of $\mathbf{v}'_c$'s, ie.

$$\hat{\mathbf{v}}_c\mathbf{L} = \hat{\mathbf{v}}_c\mathbf{L}\mathbf{A}^M\mathbf{L}^D + \hat{\mathbf{v}}_c\mathbf{L}^D .$$

Premultiplying by $\hat{\mathbf{v}}_c^{-1}$

$$\hat{\mathbf{v}}_c^{-1}\mathbf{v}'_c\mathbf{L} = \hat{\mathbf{v}}_c^{-1}\mathbf{v}'_c\mathbf{L}\mathbf{A}^M\mathbf{L}^D + \hat{\mathbf{v}}_c^{-1}\mathbf{v}'_c\mathbf{L}^D ,$$

and since $\hat{\mathbf{v}}_c^{-1}\mathbf{v}'_c = \mathbf{I}$ we get

$$\mathbf{L} = \mathbf{L}\mathbf{A}^M\mathbf{L}^D + \mathbf{L}^D .$$

With subtracting local price elasticities $\mathbf{L}^D$, GVC price transmissions will remain on the right

$$\mathbf{L} - \mathbf{L}^D = \mathbf{L}\mathbf{A}^M\mathbf{L}^D .$$

Subtracting simple GVC effects, defined as $\mathbf{L}^D\mathbf{A}^M\mathbf{L}^D$ from $\mathbf{L}\mathbf{A}^M\mathbf{L}^D$, for the complex GVCs we will have

$$\mathbf{L}\mathbf{A}^M\mathbf{L}^D - \mathbf{L}^D\mathbf{A}^M\mathbf{L}^D = (\mathbf{L} - \mathbf{L}^D)\mathbf{A}^M\mathbf{L}^D .$$

Putting local, simple, and complex global value chain price elasticities into one equation we obtain the decomposition formula introduced in (11)

$$\mathbf{L} = \mathbf{L}^D + \mathbf{L}^D\mathbf{A}^M\mathbf{L}^D + (\mathbf{L} - \mathbf{L}^D)\mathbf{A}^M\mathbf{L}^D .$$

Another way of proofing is stepping backward from the equation above and showing that (11) is an identity. First, remove parenthesis on the left side to have

$$\mathbf{L} = \mathbf{L}^D + \mathbf{L}^D\mathbf{A}^M\mathbf{L}^D + \mathbf{L}\mathbf{A}^M\mathbf{L}^D - \mathbf{L}^D\mathbf{A}^M\mathbf{L}^D ,$$

$$\mathbf{L} = \mathbf{L}^D + \mathbf{L}\mathbf{A}^M\mathbf{L}^D$$

again. Premultiplying by $(\mathbf{I} - \mathbf{A})$ on both sides

$$(\mathbf{I} - \mathbf{A})\mathbf{L} = (\mathbf{I} - \mathbf{A})\mathbf{L}^D + (\mathbf{I} - \mathbf{A})\mathbf{L}\mathbf{A}^M\mathbf{L}^D .$$

Since $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$ we have the identity matrix ($\mathbf{I}$) on the left side, and on the left of the second term on the right side. Using this and substituting $\mathbf{A}$ for $\mathbf{A} = \mathbf{A}^D + \mathbf{A}^M$

$$\mathbf{I} = (\mathbf{I} - \mathbf{A}^D - \mathbf{A}^M)\mathbf{L}^D + \mathbf{A}^M\mathbf{L}^D ,$$

rearranging on the right side

$$\mathbf{I} = (\mathbf{I} - \mathbf{A}^D)\mathbf{L}^D - \mathbf{A}^M\mathbf{L}^D + \mathbf{A}^M\mathbf{L}^D ,$$

$$\mathbf{I} = (\mathbf{I} - \mathbf{A}^D)\mathbf{L}^D ,$$

and finally, since $\mathbf{L}^D = (\mathbf{I} - \mathbf{A}^D)^{-1}$ we will have the identity matrix on both sides

$$\mathbf{I} = (\mathbf{I} - \mathbf{A}^D)(\mathbf{I} - \mathbf{A}^D)^{-1} = \mathbf{I} .$$

Appendix C: Countries, industries, industry groups, and final use sectors in the ICIO 2021 edition and the GIOPED

Table C1. Country codes in the ICIO 2021 edition and the GIOPED

Code	OECD countries	Code	Non-OECD economies
AUS	Australia	ARG	Argentina
AUT	Austria	BRA	Brazil
BEL	Belgium	BRN	Brunei Darussalam
CAN	Canada	BGR	Bulgaria
CHL	Chile	KHM	Cambodia
COL	Colombia	CHN	China (People's Republic of)
CRI	Costa Rica	CN1	China - Activities excluding export processing
CZE	Czech Republic - Czechia	CN2	China - Export processing activities
DNK	Denmark	HRV	Croatia

Code	OECD countries	Code	Non-OECD economies
EST	Estonia	CYP	Cyprus
FIN	Finland	IND	India
FRA	France	IDN	Indonesia
DEU	Germany	HKG	Hong Kong, China
GRC	Greece	KAZ	Kazakhstan
HUN	Hungary	LAO	Lao People's Democratic Republic
ISL	Iceland	MYS	Malaysia
IRL	Ireland	MLT	Malta
ISR	Israel	MAR	Morocco
ITA	Italy	MMR	Myanmar
JPN	Japan	PER	Peru
KOR	Korea	PHL	Philippines
LVA	Latvia	ROU	Romania
LTU	Lithuania	RUS	Russian Federation
LUX	Luxembourg	SAU	Saudi Arabia
MEX	Mexico	SGP	Singapore
MX1	Mexico - Activities excluding Global Manufacturing	ZAF	South Africa
MX2	Mexico - Global Manufacturing activities	TWN	Chinese Taipei
NLD	Netherlands	THA	Thailand
NZL	New Zealand	TUN	Tunisia
NOR	Norway	VNM	Viet Nam
POL	Poland	ROW	Rest of the World
PRT	Portugal		
SVK	Slovak Republic		
SVN	Slovenia		
ESP	Spain		
SWE	Sweden		
CHE	Switzerland		
TUR	Turkey		
GBR	United Kingdom		
USA	United States		

Table C2. Industry and industry group codes in the ICIO 2021 edition and the GIOPED

Code	Industry	ISIC Rev.4	Industry Group
01T02	Agriculture, hunting, forestry	01, 02	A
03	Fishing and aquaculture	03	A
05T06	Mining and quarrying, energy producing products	05, 06	BDE
07T08	Mining and quarrying, non-energy producing products	07, 08	BDE
09	Mining support service activities	09	BDE
10T12	Food products, beverages and tobacco	10, 11, 12	C
13T15	Textiles, textile products, leather and footwear	13, 14, 15	C
16	Wood and products of wood and cork	16	C
17T18	Paper products and printing	17, 18	C
19	Coke and refined petroleum products	19	C
20	Chemical and chemical products	20	C
21	Pharmaceuticals, medicinal chemical and botanical products	21	C
22	Rubber and plastics products	22	C
23	Other non-metallic mineral products	23	C
24	Basic metals	24	C
25	Fabricated metal products	25	C
26	Computer, electronic and optical equipment	26	C

Code	Industry	ISIC Rev.4	Industry Group
27	Electrical equipment	27	C
28	Machinery and equipment, nec	28	C
29	Motor vehicles, trailers and semi-trailers	29	C
30	Other transport equipment	30	C
31T33	Manufacturing nec; repair and installation of machinery and equipment	31, 32, 33	C
35	Electricity, gas, steam and air conditioning supply	35	BDE
36T39	Water supply; sewerage, waste management and remediation activities	36, 37, 38, 39	BDE
41T43	Construction	41, 42, 43	F
45T47	Wholesale and retail trade; repair of motor vehicles	45, 46, 47	GHI
49	Land transport and transport via pipelines	49	GHI
50	Water transport	50	GHI
51	Air transport	51	GHI
52	Warehousing and support activities for transportation	52	GHI
53	Postal and courier activities	53	GHI
55T56	Accommodation and food service activities	55, 56	GHI
58T60	Publishing, audiovisual and broadcasting activities	58, 59, 60	J-T
61	Telecommunications	61	J-T
62T63	IT and other information services	62, 63	J-T
64T66	Financial and insurance activities	64, 65, 66	J-T
68	Real estate activities	68	J-T
69T75	Professional, scientific and technical activities	69 to 75	J-T
77T82	Administrative and support services	77 to 82	J-T
84	Public administration and defence; compulsory social security	84	J-T
85	Education	85	J-T
86T88	Human health and social work activities	86, 87, 88	J-T
90T93	Arts, entertainment and recreation	90, 91, 92, 93	J-T
94T96	Other service activities	94,95, 96	J-T
97T98	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	97, 98	J-T

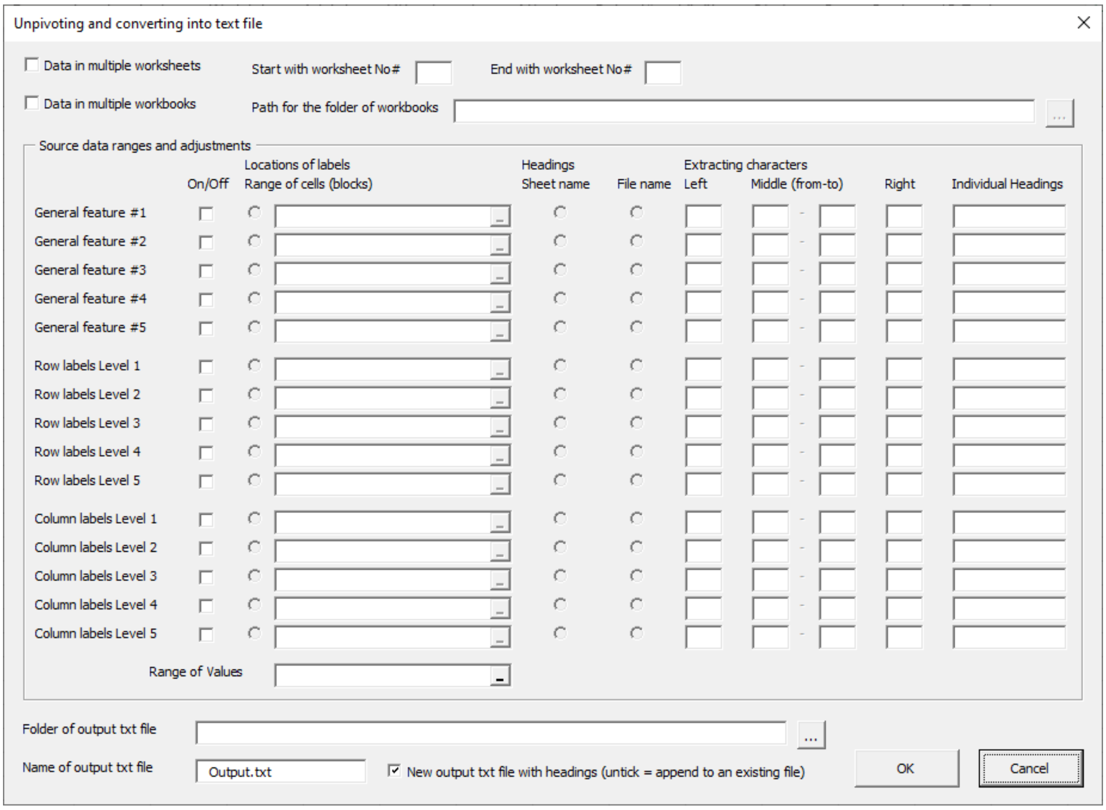
Table C3. Final use sectors in the ICIO 2021 edition and the GIOPED

Code	Final use sector
HFCE	Household Final Consumption Expenditure
NPISH	Non-Profit Institutions Serving Households
GGFC	General Government Final Consumption
GFCF	Gross Fixed Capital Formation
INVNT	Changes in Inventories and Valuables
DPABR	Direct purchases abroad by residents
HFCE+DPABR	Household Final Consumption Expenditure plus Direct purchases abroad by residents

Appendix D: Generation of the GIOPED

The semicolon separated normalized txt database of inflation elasticities (GIOPED_2007_2018_with_decimal_points.txt, GIOPED_2007_2018_with_decimal_commas.txt) was produced using a VBA program. It is a part of a versatile Excel toolkit including user functions for many IO matrix operations, as well as applications that can be used when processing the original IO tables and result matrices.

Figure D1 shows the dialog box of the unpivoting procedure used for this study. It converts a crosstab in an Excel worksheet into a txt file in the form of a normalized list. It can handle one or more worksheets in a single or multiple workbooks and offers several options for setting up txt file headers.



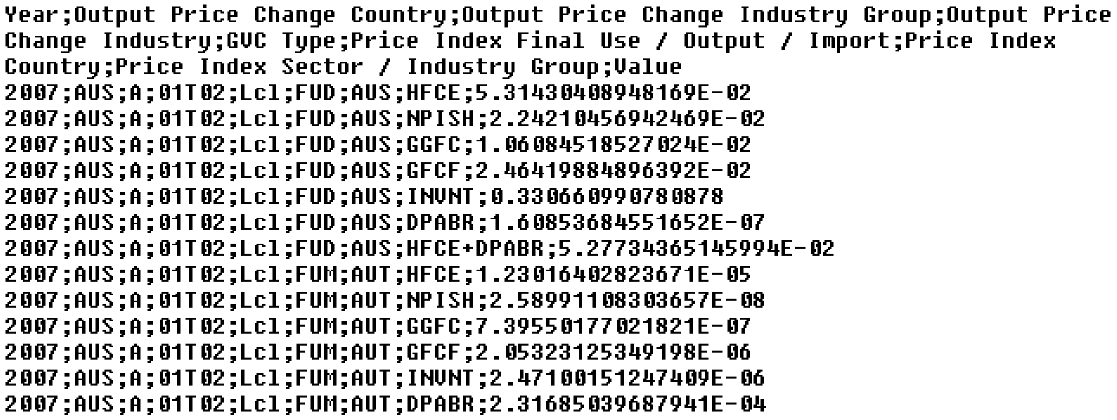
Name of output txt file: Output.txt

☑ New output txt file with headings (untick = append to an existing file)

Figure D1. Screenshot of Unpivonting and converting into text file Excel application

The application can also handle multilevel row and column ID hierarchies (up to five levels), as opposed to Excel Power Query, which can only unpivot crosstabs with one (single-level) column ID.

Unpivoting world input-output tables from a crosstab to a normalized list format results in a database that is much larger than the maximum number of rows in an Excel worksheet. By contrast, a txt file has no such size limits, and is more flexible to process (with Pivot tables). That is why inflation elasticities are stored in a text file. Figure D2 depicts an extraction from the GIOPED_2007_2018_with_decimal_points.txt.



```
Year;Output Price Change Country;Output Price Change Industry Group;Output Price
Change Industry;GVC Type;Price Index Final Use / Output / Import;Price Index
Country;Price Index Sector / Industry Group;Value
2007;AUS;A;01T02;Lcl;FUD;AUS;HFCE;5.31430408948169E-02
2007;AUS;A;01T02;Lcl;FUD;AUS;NPISH;2.24210456942469E-02
2007;AUS;A;01T02;Lcl;FUD;AUS;GGFC;1.06084518527024E-02
2007;AUS;A;01T02;Lcl;FUD;AUS;GFCF;2.46419884896392E-02
2007;AUS;A;01T02;Lcl;FUD;AUS;INVNT;0.330660990780878
2007;AUS;A;01T02;Lcl;FUD;AUS;DPABR;1.60853684551652E-07
2007;AUS;A;01T02;Lcl;FUD;AUS;HFCE+DPABR;5.27734365145994E-02
2007;AUS;A;01T02;Lcl;FUM;AUT;HFCE;1.23016402823671E-05
2007;AUS;A;01T02;Lcl;FUM;AUT;NPISH;2.58991108303657E-08
2007;AUS;A;01T02;Lcl;FUM;AUT;GGFC;7.39550177021821E-07
2007;AUS;A;01T02;Lcl;FUM;AUT;GFCF;2.05323125349198E-06
2007;AUS;A;01T02;Lcl;FUM;AUT;INVNT;2.47100151247409E-06
2007;AUS;A;01T02;Lcl;FUM;AUT;DPABR;2.31685039687941E-04
```

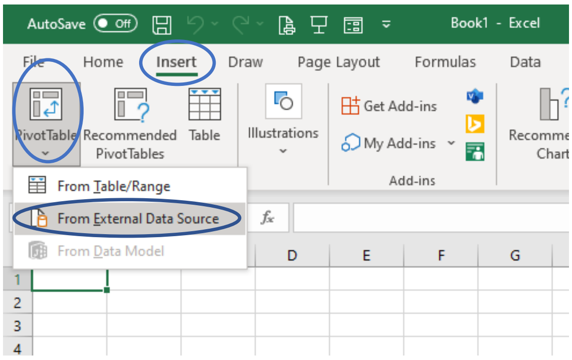
Figure D2. An extraction from the GIOPED

Appendix E: Importing the GIOPED into Microsoft Excel Pivot tables

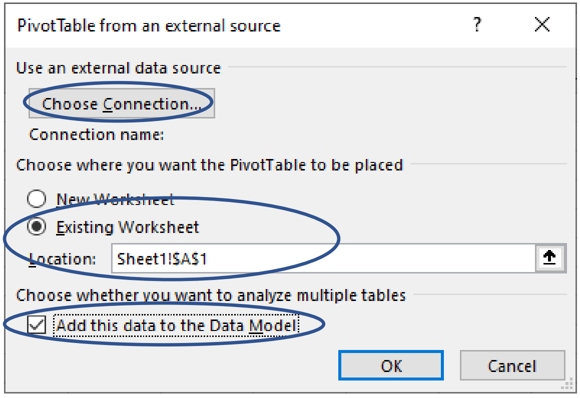
To import inflation elasticity data from GIOPED text files for pivot table analysis into Microsoft Excel 365 follow the steps shown in Figure Group E.

Figure Group E. Steps of generating a Pivot-table from the GIOPED

Step1. Insert a Pivot-table from External Data Source



Step 2. Choose location for the Pivot-table, Add data to the Data Model, and Choose Connection…



Use an external data source

Connection name:

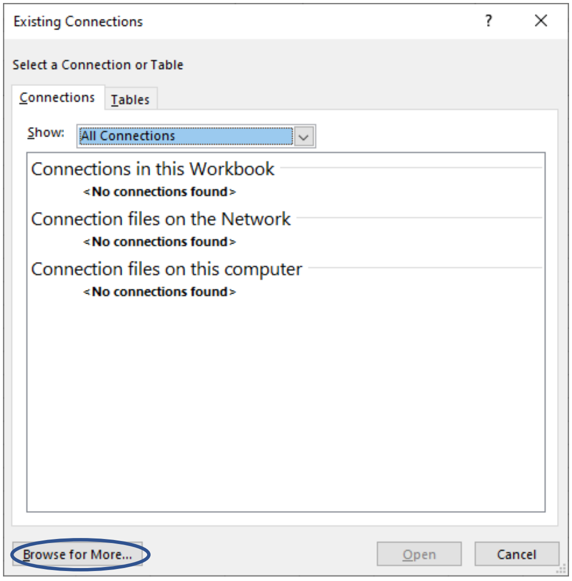
Choose where you want the PivotTable to be placed

○ New Worksheet
● Existing Worksheet
Location: Sheet1!A1

Choose whether you want to analyze multiple tables

☑ Add this data to the Data Model

Step 3. Choose connection for the external data source, Browse for More…



Select a Connection or Table

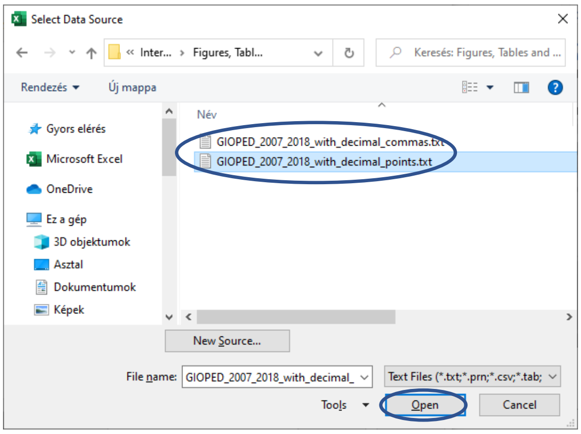
Show: All Connections

Connections in this Workbook
<No connections found>

Connection files on the Network
<No connections found>

Connection files on this computer
<No connections found>

Step 4. Select and Open GIOPED_2007_2018_with_decimal_points.txt or GIOPED_2007_2018_with_decimal_commas.txt depending on your regional settings[41]

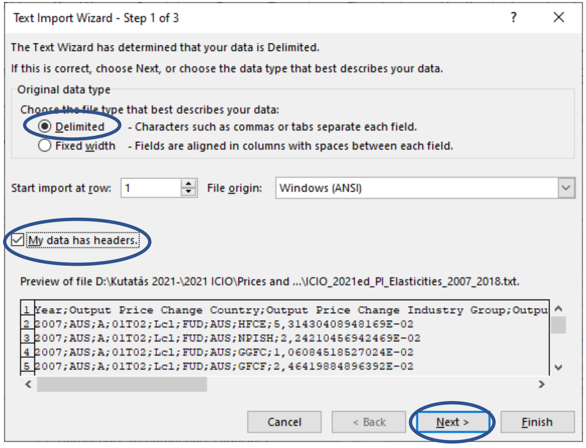


GIOPED_2007_2018_with_decimal_commas.txt
GIOPED_2007_2018_with_decimal_points.txt

File name: GIOPED_2007_2018_with_decimal_

Text Files (*.txt;*.prn;*.csv;*.tab;

Step 5. Text Import Wizard Step 1



The Text Wizard has determined that your data is Delimited.

If this is correct, choose Next, or choose the data type that best describes your data.

Original data type

Choose the file type that best describes your data:

● Delimited - Characters such as commas or tabs separate each field.
○ Fixed width - Fields are aligned in columns with spaces between each field.

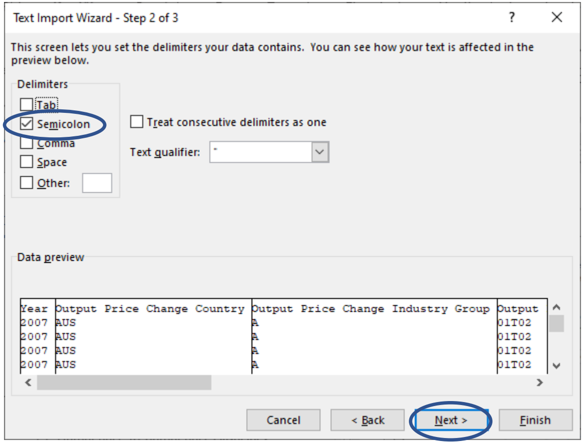
Start import at row: 1 File origin: Windows (ANSI)

☑ My data has headers.

Preview of file D:\Kutatás 2021-\2021 ICIO\Prices and ...\ICIO_2021ed_PI_Elasticities_2007_2018.txt.

```
1 Year;Output Price Change Country;Output Price Change Industry Group;Outpu
2 2007;AUS;A;01T02;Lcl;FUD;AUS;HFCE;5,31430408948169E-02
3 2007;AUS;A;01T02;Lcl;FUD;AUS;NPISH;2,24210456942469E-02
4 2007;AUS;A;01T02;Lcl;FUD;AUS;GGFC;1,06084518527024E-02
5 2007;AUS;A;01T02;Lcl;FUD;AUS;GFCF;2,46419884896392E-02
```

Step 6. Text Import Wizard Step 2



This screen lets you set the delimiters your data contains. You can see how your text is affected in the preview below.

Delimiters

☐ Tab
☑ Semicolon
☐ Comma
☐ Space
☐ Other:

☐ Treat consecutive delimiters as one

Text qualifier: "

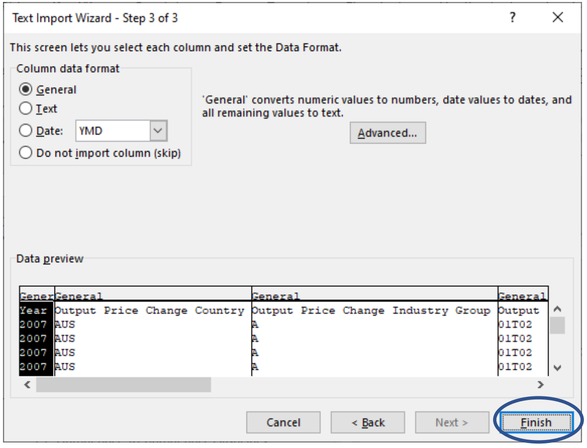
Data preview

```
Year Output Price Change Country Output Price Change Industry Group Output
2007 AUS                         A                                  01T02
2007 AUS                         A                                  01T02
2007 AUS                         A                                  01T02
2007 AUS                         A                                  01T02
```

---

[41] For some special regional settings of the operating system decimal commas are preferred than decimal points.

Step 7. Text Import Wizard Step 3 and Finish



Text Import Wizard - Step 3 of 3

This screen lets you select each column and set the Data Format.

Column data format

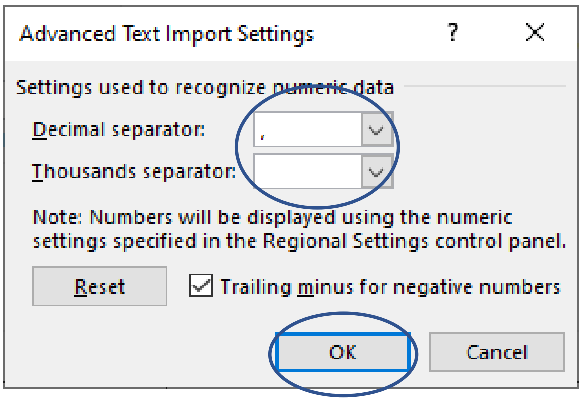
- ● General
- ○ Text
- ○ Date: YMD
- ○ Do not import column (skip)

'General' converts numeric values to numbers, date values to dates, and all remaining values to text.

Data preview

```
GenerGeneral                      General                             General
Year Output Price Change Country  Output Price Change Industry Group  Output
2007 AUS                          A                                   01T02
2007 AUS                          A                                   01T02
2007 AUS                          A                                   01T02
2007 AUS                          A                                   01T02
```

Step 7a. OPTIONAL! Settings used to recognize numeric data with decimal commas (if needed)[42]



Advanced Text Import Settings

Settings used to recognize numeric data

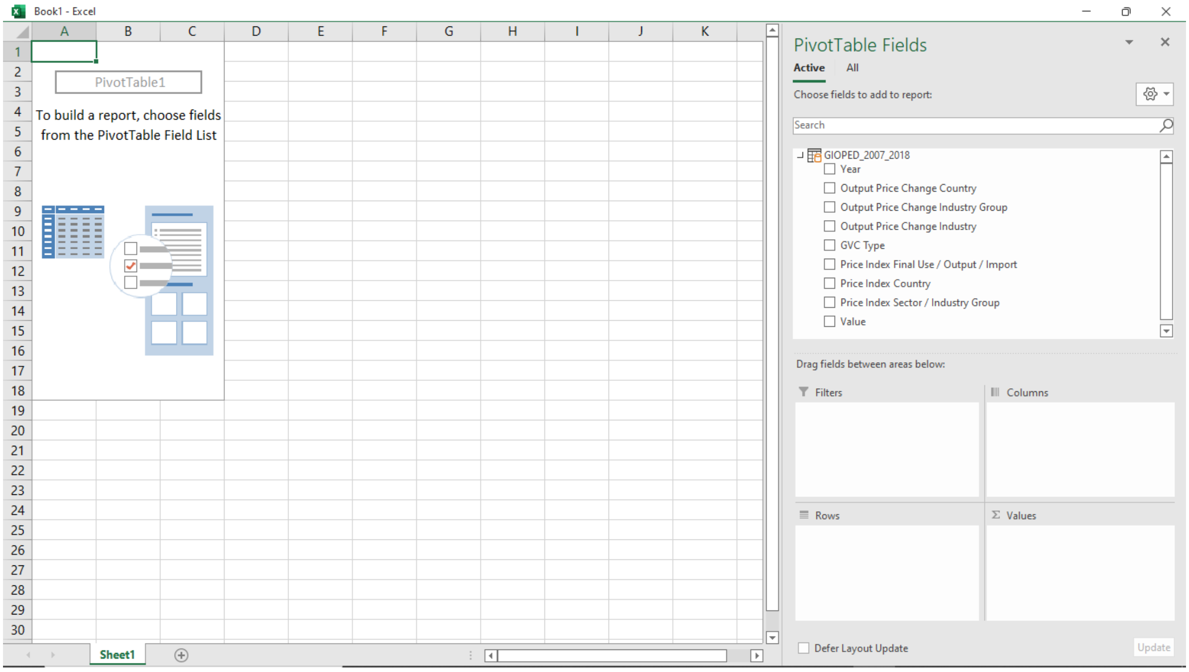
Decimal separator: ,

Thousands separator:

Note: Numbers will be displayed using the numeric settings specified in the Regional Settings control panel.

☑ Trailing minus for negative numbers

Step 8. Pivot Table Drag-and-Drop editing interface



Book1 - Excel

PivotTable1

To build a report, choose fields from the PivotTable Field List

PivotTable Fields

Choose fields to add to report:

GIOPED_2007_2018

- ☐ Year
- ☐ Output Price Change Country
- ☐ Output Price Change Industry Group
- ☐ Output Price Change Industry
- ☐ GVC Type
- ☐ Price Index Final Use / Output / Import
- ☐ Price Index Country
- ☐ Price Index Sector / Industry Group
- ☐ Value

Drag fields between areas below:

☐ Defer Layout Update

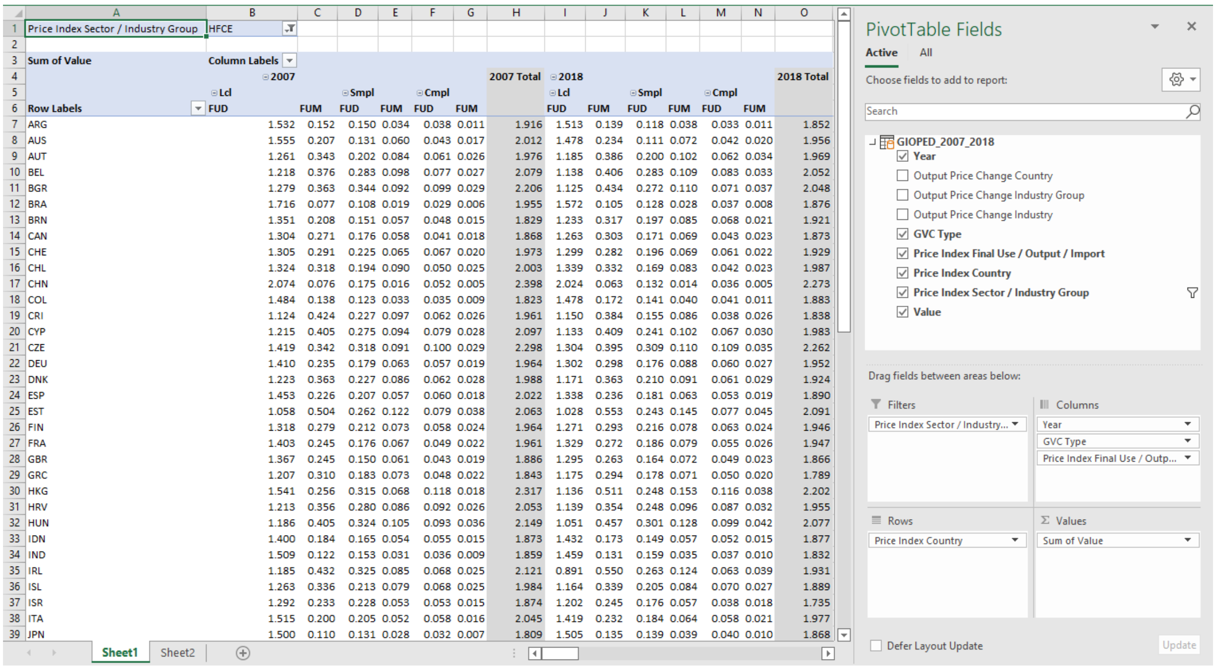
After clicking Finish button, the Pivot Table Drap-and-Drop editing interface appears (Step 8), which allows quick assemble of crosstabs to create powerful inflation impact analysis.

Please note that it is a PC resource-intensive procedure to import the txt file into the pivot table format. Loading the Data Model may take long time and needs large memory. It took around 10 minutes with a relatively recent PC environment (Core i7, RAM 128 GB, Windows 11).

---

[42] Even if the GIOPED_2007_2018_with_decimal_commas.txt has been selected in Step 4, one can ensure Excel with decimal point settings to recognize numeric data (Values) by clicking Advanced… button and performing the settings shown in Step 7a.

Appendix F: Excel pivot samples for inflation impact analyses



Price Index Sector / Industry Group: HFCE

Sum of Value | Column Labels

Row Labels	2007						2007 Total	2018						2018 Total
	Lcl		Smpl		Cmpl			Lcl		Smpl		Cmpl		
	FUD	FUM	FUD	FUM	FUD	FUM		FUD	FUM	FUD	FUM	FUD	FUM	
ARG	1.532	0.152	0.150	0.034	0.038	0.011	1.916	1.513	0.139	0.118	0.038	0.033	0.011	1.852
AUS	1.555	0.207	0.131	0.060	0.043	0.017	2.012	1.478	0.234	0.111	0.072	0.042	0.020	1.956
AUT	1.261	0.343	0.202	0.084	0.061	0.026	1.976	1.185	0.386	0.200	0.102	0.062	0.034	1.969
BEL	1.218	0.376	0.283	0.098	0.077	0.027	2.079	1.138	0.406	0.283	0.109	0.083	0.033	2.052
BGR	1.279	0.363	0.344	0.092	0.099	0.029	2.206	1.125	0.434	0.272	0.110	0.071	0.037	2.048
BRA	1.716	0.077	0.108	0.019	0.029	0.006	1.955	1.572	0.105	0.128	0.028	0.037	0.008	1.876
BRN	1.351	0.208	0.151	0.057	0.048	0.015	1.829	1.233	0.317	0.197	0.085	0.068	0.021	1.921
CAN	1.304	0.271	0.176	0.058	0.041	0.018	1.868	1.263	0.303	0.171	0.069	0.043	0.023	1.873
CHE	1.305	0.291	0.225	0.065	0.067	0.020	1.973	1.299	0.282	0.196	0.069	0.061	0.022	1.929
CHL	1.324	0.318	0.194	0.090	0.050	0.025	2.003	1.339	0.332	0.169	0.083	0.042	0.023	1.987
CHN	2.074	0.076	0.175	0.016	0.052	0.005	2.398	2.024	0.063	0.132	0.014	0.036	0.005	2.273
COL	1.484	0.138	0.123	0.033	0.035	0.009	1.823	1.478	0.172	0.141	0.040	0.041	0.011	1.883
CRI	1.124	0.424	0.227	0.097	0.062	0.026	1.961	1.150	0.384	0.155	0.086	0.038	0.026	1.838
CYP	1.215	0.405	0.275	0.094	0.079	0.028	2.097	1.133	0.409	0.241	0.102	0.067	0.030	1.983
CZE	1.419	0.342	0.318	0.091	0.100	0.029	2.298	1.304	0.395	0.309	0.110	0.109	0.035	2.262
DEU	1.410	0.235	0.179	0.063	0.057	0.019	1.964	1.302	0.298	0.176	0.088	0.060	0.027	1.952
DNK	1.223	0.363	0.227	0.086	0.062	0.028	1.988	1.171	0.363	0.210	0.091	0.061	0.029	1.924
ESP	1.453	0.226	0.207	0.057	0.060	0.018	2.022	1.338	0.236	0.181	0.063	0.053	0.019	1.890
EST	1.058	0.504	0.262	0.122	0.079	0.038	2.063	1.028	0.553	0.243	0.145	0.077	0.045	2.091
FIN	1.318	0.279	0.212	0.073	0.058	0.024	1.964	1.271	0.293	0.216	0.078	0.063	0.024	1.946
FRA	1.403	0.245	0.176	0.067	0.049	0.022	1.961	1.329	0.272	0.186	0.079	0.055	0.026	1.947
GBR	1.367	0.245	0.150	0.061	0.043	0.019	1.886	1.295	0.263	0.164	0.072	0.049	0.023	1.866
GRC	1.207	0.310	0.183	0.073	0.048	0.022	1.843	1.175	0.294	0.178	0.071	0.050	0.020	1.789
HKG	1.541	0.256	0.315	0.068	0.118	0.018	2.317	1.136	0.511	0.248	0.153	0.116	0.038	2.202
HRV	1.213	0.356	0.280	0.086	0.092	0.026	2.053	1.139	0.354	0.248	0.096	0.087	0.032	1.955
HUN	1.186	0.405	0.324	0.105	0.093	0.036	2.149	1.051	0.457	0.301	0.128	0.099	0.042	2.077
IDN	1.400	0.184	0.165	0.054	0.055	0.015	1.873	1.432	0.173	0.149	0.057	0.052	0.015	1.877
IND	1.509	0.122	0.153	0.031	0.036	0.009	1.859	1.459	0.131	0.159	0.035	0.037	0.010	1.832
IRL	1.185	0.432	0.325	0.085	0.068	0.025	2.121	0.891	0.550	0.263	0.124	0.063	0.039	1.931
ISL	1.263	0.336	0.213	0.079	0.068	0.025	1.984	1.164	0.339	0.205	0.084	0.070	0.027	1.889
ISR	1.292	0.233	0.228	0.053	0.053	0.015	1.874	1.202	0.245	0.176	0.057	0.038	0.018	1.735
ITA	1.515	0.200	0.205	0.052	0.058	0.016	2.045	1.419	0.232	0.184	0.064	0.058	0.021	1.977
JPN	1.500	0.110	0.131	0.028	0.032	0.007	1.809	1.505	0.135	0.139	0.039	0.040	0.010	1.868

PivotTable Fields

Active | All

Choose fields to add to report:

- GIOPED_2007_2018
  - ☑ Year
  - ☐ Output Price Change Country
  - ☐ Output Price Change Industry Group
  - ☐ Output Price Change Industry
  - ☑ GVC Type
  - ☑ Price Index Final Use / Output / Import
  - ☑ Price Index Country
  - ☑ Price Index Sector / Industry Group
  - ☑ Value

Drag fields between areas below:

Filters: Price Index Sector / Industry...

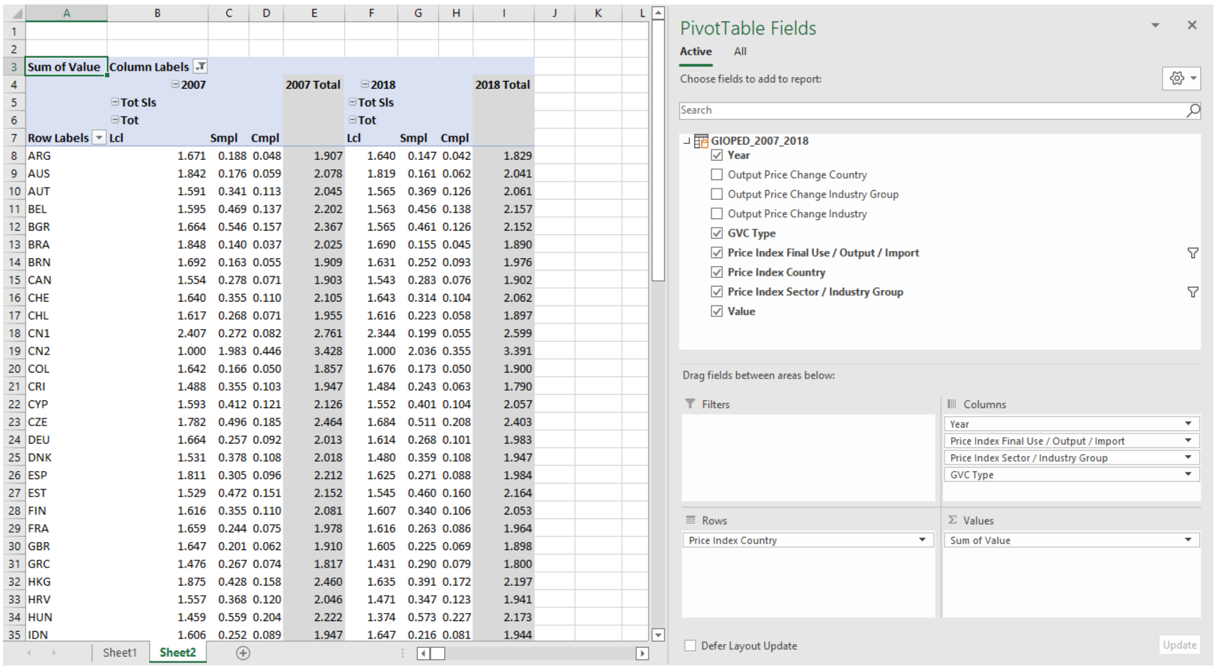
Columns: Year; GVC Type; Price Index Final Use / Outp...

Rows: Price Index Country

Values: Sum of Value

☐ Defer Layout Update

Figure F1. An Excel pivot table layout for CPI analysis



Sum of Value | Column Labels

Row Labels	2007			2007 Total	2018			2018 Total
	Tot Sls				Tot Sls			
	Tot				Tot			
	Lcl	Smpl	Cmpl		Lcl	Smpl	Cmpl	
ARG	1.671	0.188	0.048	1.907	1.640	0.147	0.042	1.829
AUS	1.842	0.176	0.059	2.078	1.819	0.161	0.062	2.041
AUT	1.591	0.341	0.113	2.045	1.565	0.369	0.126	2.061
BEL	1.595	0.469	0.137	2.202	1.563	0.456	0.138	2.157
BGR	1.664	0.546	0.157	2.367	1.565	0.461	0.126	2.152
BRA	1.848	0.140	0.037	2.025	1.690	0.155	0.045	1.890
BRN	1.692	0.163	0.055	1.909	1.631	0.252	0.093	1.976
CAN	1.554	0.278	0.071	1.903	1.543	0.283	0.076	1.902
CHE	1.640	0.355	0.110	2.105	1.643	0.314	0.104	2.062
CHL	1.617	0.268	0.071	1.955	1.616	0.223	0.058	1.897
CN1	2.407	0.272	0.082	2.761	2.344	0.199	0.055	2.599
CN2	1.000	1.983	0.446	3.428	1.000	2.036	0.355	3.391
COL	1.642	0.166	0.050	1.857	1.676	0.173	0.050	1.900
CRI	1.488	0.355	0.103	1.947	1.484	0.243	0.063	1.790
CYP	1.593	0.412	0.121	2.126	1.552	0.401	0.104	2.057
CZE	1.782	0.496	0.185	2.464	1.684	0.511	0.208	2.403
DEU	1.664	0.257	0.092	2.013	1.614	0.268	0.101	1.983
DNK	1.531	0.378	0.108	2.018	1.480	0.359	0.108	1.947
ESP	1.811	0.305	0.096	2.212	1.625	0.271	0.088	1.984
EST	1.529	0.472	0.151	2.152	1.545	0.460	0.160	2.164
FIN	1.616	0.355	0.110	2.081	1.607	0.340	0.106	2.053
FRA	1.659	0.244	0.075	1.978	1.616	0.263	0.086	1.964
GBR	1.647	0.201	0.062	1.910	1.605	0.225	0.069	1.898
GRC	1.476	0.267	0.074	1.817	1.431	0.290	0.079	1.800
HKG	1.875	0.428	0.158	2.460	1.635	0.391	0.172	2.197
HRV	1.557	0.368	0.120	2.046	1.471	0.347	0.123	1.941
HUN	1.459	0.559	0.204	2.222	1.374	0.573	0.227	2.173
IDN	1.606	0.252	0.089	1.947	1.647	0.216	0.081	1.944

PivotTable Fields

Active | All

Choose fields to add to report:

- GIOPED_2007_2018
  - ☑ Year
  - ☐ Output Price Change Country
  - ☐ Output Price Change Industry Group
  - ☐ Output Price Change Industry
  - ☑ GVC Type
  - ☑ Price Index Final Use / Output / Import
  - ☑ Price Index Country
  - ☑ Price Index Sector / Industry Group
  - ☑ Value

Drag fields between areas below:

Filters:

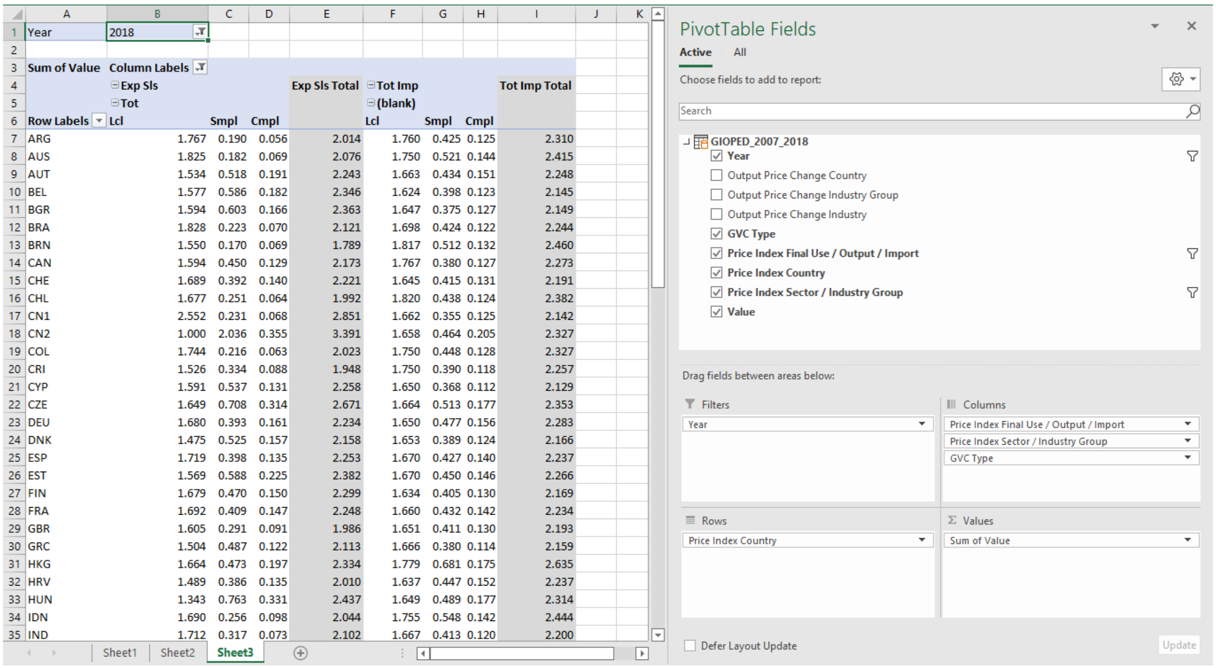
Columns: Year; Price Index Final Use / Output / Import; Price Index Sector / Industry Group; GVC Type

Rows: Price Index Country

Values: Sum of Value

☐ Defer Layout Update

Figure F2. An Excel pivot table layout for PPI analysis



	A	B	C	D	E	F	G	H	I
1	Year	2018							
2									
3	Sum of Value	Column Labels							
4		⊟ Exp Sls			Exp Sls Total	⊟ Tot Imp			Tot Imp Total
5		⊟ Tot				⊟ (blank)			
6	Row Labels	Lcl	Smpl	Cmpl		Lcl	Smpl	Cmpl	
7	ARG	1.767	0.190	0.056	2.014	1.760	0.425	0.125	2.310
8	AUS	1.825	0.182	0.069	2.076	1.750	0.521	0.144	2.415
9	AUT	1.534	0.518	0.191	2.243	1.663	0.434	0.151	2.248
10	BEL	1.577	0.586	0.182	2.346	1.624	0.398	0.123	2.145
11	BGR	1.594	0.603	0.166	2.363	1.647	0.375	0.127	2.149
12	BRA	1.828	0.223	0.070	2.121	1.698	0.424	0.122	2.244
13	BRN	1.550	0.170	0.069	1.789	1.817	0.512	0.132	2.460
14	CAN	1.594	0.450	0.129	2.173	1.767	0.380	0.127	2.273
15	CHE	1.689	0.392	0.140	2.221	1.645	0.415	0.131	2.191
16	CHL	1.677	0.251	0.064	1.992	1.820	0.438	0.124	2.382
17	CN1	2.552	0.231	0.068	2.851	1.662	0.355	0.125	2.142
18	CN2	1.000	2.036	0.355	3.391	1.658	0.464	0.205	2.327
19	COL	1.744	0.216	0.063	2.023	1.750	0.448	0.128	2.327
20	CRI	1.526	0.334	0.088	1.948	1.750	0.390	0.118	2.257
21	CYP	1.591	0.537	0.131	2.258	1.650	0.368	0.112	2.129
22	CZE	1.649	0.708	0.314	2.671	1.664	0.513	0.177	2.353
23	DEU	1.680	0.393	0.161	2.234	1.650	0.477	0.156	2.283
24	DNK	1.475	0.525	0.157	2.158	1.653	0.389	0.124	2.166
25	ESP	1.719	0.398	0.135	2.253	1.670	0.427	0.140	2.237
26	EST	1.569	0.588	0.225	2.382	1.670	0.450	0.146	2.266
27	FIN	1.679	0.470	0.150	2.299	1.634	0.405	0.130	2.169
28	FRA	1.692	0.409	0.147	2.248	1.660	0.432	0.142	2.234
29	GBR	1.605	0.291	0.091	1.986	1.651	0.411	0.130	2.193
30	GRC	1.504	0.487	0.122	2.113	1.666	0.380	0.114	2.159
31	HKG	1.664	0.473	0.197	2.334	1.779	0.681	0.175	2.635
32	HRV	1.489	0.386	0.135	2.010	1.637	0.447	0.152	2.237
33	HUN	1.343	0.763	0.331	2.437	1.649	0.489	0.177	2.314
34	IDN	1.690	0.256	0.098	2.044	1.755	0.548	0.142	2.444
35	IND	1.712	0.317	0.073	2.102	1.667	0.413	0.120	2.200

PivotTable Fields

Choose fields to add to report:

GIOPED_2007_2018
- ☑ Year
- ☐ Output Price Change Country
- ☐ Output Price Change Industry Group
- ☐ Output Price Change Industry
- ☑ GVC Type
- ☑ Price Index Final Use / Output / Import
- ☑ Price Index Country
- ☑ Price Index Sector / Industry Group
- ☑ Value

Drag fields between areas below:

Filters: Year

Columns: Price Index Final Use / Output / Import; Price Index Sector / Industry Group; GVC Type

Rows: Price Index Country

Values: Sum of Value

☐ Defer Layout Update

Figure F3. An Excel pivot table layout for ToT analysis