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POOR HOUSEHOLDS AND THE WEIGHT OF INFLATION

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ABSTRACT

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Poor Households and the Weight of Inflation

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Abstract

Public opinion and the perceptions of poorer households consistently indicate that the poor are most exposed to inflation. Meanwhile, the empirical literature on income-dependent inflation inequality remains ambiguous. In this paper, we explore two different explanations for this inflation-inequality puzzle. First, we examine the role of sectorial heterogeneity in modulating the impact of cost-push shocks on households. An Input-Output analysis for 21 EU countries within the global production network shows the income-dependent impact of a price shock to be highly contingent on the sector of origin. While these findings suggest a partial explanation for the ambiguous results on inflation inequality, they do not point to a consistent overexposure of lower-income households. As a second explanation, we propose the income-weighting of price shock effects as opposed to the conventional expenditure-weighting. This approach considers the share of income allocated to consumption and thus directly affected by a change in prices. Using a utility framework, we demonstrate that under bounded rationality the decline in utility is indeed proportional to the average propensity to consume times the change in prices. Introducing these income-weights in our empirical analysis, we find lower-income households to be disproportionally affected by every sectorial price shock, fully explaining the inflation-inequality puzzle.

Keywords: Inflation, Input-output Analysis, Europe, Inequality

JEL: E31, D31, C15, C67, D90

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1. Introduction

Public opinion and the perceptions of poorer households consistently indicate that the poor are most exposed to inflation. Meanwhile, the empirical literature on the persistence, direction, and magnitude of income-dependent inflation inequality remains ambiguous. In this paper, we explore two different explanations for this inflation-inequality puzzle. First, we examine the role of sectorial heterogeneity in modulating the impact of cost-push shocks on households. An Input-Output analysis for 21 EU countries within the global production network shows the income-dependent impact of a price shock to be highly contingent on the sector of origin. While these findings suggest a partial explanation for the ambiguous results on inflation inequality, they only show lower-income households to be overexposed to inflationary pressure for some sectorial shocks. As a second explanation, we propose the income-weighting of price shock effects as opposed to the conventional expenditure-weighting. Since the poor consume a much larger share of their income than the rich, their exposure to the same shock on their consumption basket should thus also be higher. Following this argument, analyzing inflation inequality needs to consider the income-dependent propensities to consume. In a parsimonious utility framework, we demonstrate that under bounded rationality the decline in utility is indeed proportional to the average propensity to consume (APC) times the change in prices, while under rational expectations the APC does not affect the change in utility. In particular, if boundedly rational agents do not consider the effects of a shock to the aggregate price level on their future consumption, the effect of a price level change on their utility will be weighted by their individual APC. Finally, introducing these income-weights in our empirical analysis, we find lower-income households to be disproportionally affected by literally every sectorial price shock. Taken together, we suggest and empirically substantiate an explanation for the contesting results on inflation inequality and show why poorer households may indeed be overly exposed to inflation.

The paper proceeds as follows: Section 2 outlines the related literature to our study. Section 3 describes the data and model used to conduct our empirical analysis. Section 4 presents the results. Section 5 discusses the role of the APC for inflation inequality based on a utility framework. Section 6 presents the results of our empirical analysis, this time considering the income-weighting argument. Section 7 concludes with a final discussion and perspectives for further research.

2. Related Literature

Our study connects to different strands of existing literature. Most importantly, it aims to provide a partial explanation for what can be called the inflation-inequality puzzle. While unequal inflation exposure can manifest along a multitude of dimensions such as wealth (Doepke and Schneider, 2006), age (Adam and Zhu, 2016), idiosyncratic consumption or price differences (Kaplan and Schulhofer-Wohl, 2017; Strasser et al., 2023), or race (Hobijn and Lagakos, 2005), we focus on income-dependent inflation inequality of households. The existing literature on this provides inconclusive results on the existence and direction, depending on the observational period and area (Garcimartín et al., 2021). It furthermore reports low persistency of asymmetric exposure across time (Hobijn and Lagakos, 2005; Strasser et al., 2023), while again providing inconclusive results on whether or not higher inflation rates also lead to higher inflation inequality (Claeys and Guetta-Jeanrenaud, 2022; Crawford and Oldfield, 2002; Hobijn and Lagakos, 2005). Meanwhile, the perceptions of poorer households *consistently* indicate that the poor are most exposed to inflation (Easterly and Fischer, 2001; Stantcheva, 2024).

We propose two explanations for this apparent mismatch: sectorial asymmetries in price shock propagation and the consideration of affected income shares, as opposed to focusing only on expenditure shares. The first claim is motivated by foundational research from Weber et al. (2024). As their study showed for the US and subsequently was confirmed in a similar study by Ipsen et al. (2023) for the EU, a class of few sectors dominates the overall price level for consumers. The latter also provide suggestive evidence that poorer EU countries face greater exposure to volatile and rising prices, calling for a more thorough investigation of this channel. Both studies emphasize that the size of a sector or its share in final consumption may be an insufficient predictor of its actual importance in determining the price level. Often overlooked, a sector's role in the production network constitutes another key variable, as it modulates the propagation of shocks.[1] In their letter, Ipsen and Schulz (2024) build on a similar Leontief Input-Output model to uncover these production network effects for inflation inequality. They show for the same set of countries as in our study that the global production network dampens asymmetries in inflation exposure between lower- and higher-income households. Yet, in most cases, this happens at the expense of poorer households. In the present, related study, we pick up upon their work to further explore the role of sectorial asymmetries for inflation inequality, going beyond their focus on production networks. Nikiforos et al. (2024) also build upon the aforementioned Input-Output model of Weber et al. (2024) to analyze the impact of price shocks on the functional distribution of income, namely profit versus wage shares. Our study now provides the other side of this coin by showing that price shocks also asymmetrically affect households dependent on their personal income. Some parallels to our work can also be found in the analysis provided by Cucignatto et al. (2023), who try to decompose the shock propagation of the latest energy price shock for three European countries, also considering the underlying production network. Our work goes beyond this in several aspects. First, we consider shocks propagating in the global production network. Second, we analyze the relevant importance of all sector classes, not only the energy sectors. Most importantly, we focus on distributional consequences along the income distribution for a much larger set of 21 EU countries.

[1] The shortage of semi-conductors is an illustrative example, that cost a multitude worth of production relative to its input price.

Concerning our second proposition, the role of the APC in inflation inequality, related literature is somewhat scarce. Auclert (2019) addresses the importance of differences in the propensity to consume, however, focusing on monetary policy transmission. Analysing inflation inequality in the euro area, Strasser et al. (2023) mention the propensity to consume as one aspect of consumption heterogeneity but do not explore this aspect further. Commonly, empirical analyses of inflation inequality are based on expenditure shares (see, for example, Argente and Lee, 2021; Gürer and Weichenrieder, 2020; Hobijn and Lagakos, 2005; Kaplan and Schulhofer-Wohl, 2017). While these expenditure shares capture heterogeneities in spending patterns, they do not consider the share of income used for expenditures. As poorer households consistently spend larger shares of their available income for consumption purposes, i.e. have a higher APC (Fisher et al., 2016; Eurostat, 2021a), focusing solely on expenditure shares might mask a substantial source of realized inflation inequality. This argument relates to a strand of literature that is concerned with the nexus of households' expenditure shares and income, dating back at least to Engel (1857). By now known as Engel's Law, it establishes that with increasing income, the relative income share spent on food decreases, albeit a larger absolute amount is spent. Similarly to our approach, parts of this literature indeed appear to use food's income share in several prominent papers (Engel and Kneip, 1996; Hamilton, 2001; Leser, 1963), although using food's expenditure share is still much more common (cf. Lewbel and Houthakker, 2008 for a survey). While theoretical models of Engel's law indeed suggest income-weighting (Hamilton, 2001), empirical papers typically build on expenditure shares to not confound their estimates of expenditure decisions for different goods' categories with the decision to spend or save at all (Barigozzi et al., 2012). In our parsimonious utility framework, we build on a Cobb-Douglas functional form for savings decisions, implying that optimal savings decisions are independent of the price level to address this issue. This framework allows us to interpret the expenditure- and income-weighting cases as pertaining to the utility effects of price shocks for full and boundedly rational decision-making without any confounding effect of the savings decision. We are, to the best of our knowledge, the first to provide a systematic analysis of the importance of income-dependent asymmetries in the propensity to consume for realized inflation inequality as an aggregate phenomenon not constrained to specific goods categories.

3. Empirical Strategy

In this section, we will discuss the data and model used for our empirical analysis. [2]Our global production network, the shares of final demand of a country$_c$ in sector$_i$ of country$_a$, as well as the sector-specific price shocks are based on the World Input Output Database (WIOD). It provides annual panel Input-Output data for the years 2000 to 2014 for 43 countries with 56 sectors each and covers economic activity that accounts for more than 85 percent of world GDP (Timmer et al., 2015).

To be able to analyze income-dependent inflation, we offset the final demand data of the WIOD with sector-level data on consumption by purpose

[2] Data and code are available under https://github.com/ip5490/Inflation-Inequality.

(COICOP) expenditure shares for income quintiles Q1 (low) to Q5 (high) (Eurostat, 2021c). To do so, we rely on bridging matrices (consumption by purpose to ISIC Rev. 4) provided by Cai and Vandyck (2020). This gives us the share of consumption expenditure of an income quintile_q of country_c in sector_j of country_a for 21 EU countries.[3] Note, that we still allow for price shocks to originate in any global sector and to propagate globally but will measure the impact of these shocks only for our EU country sample.

To analyze the elasticity of inflation exposure with respect to income, we use mean absolute income values for the respective income quintiles in the 21 EU countries for 2020 (Eurostat, 2021b).[4] Our final model specification used in Section 6 includes Eurostat data (2021a) on individual country-level weights for the average propensity to consume in each income quintile. Table 1 in Appendix A reports the data.

We build our empirical analysis on a Leontief price model similar to the ones used in Ipsen et al. (2023), Ipsen and Schulz (2024), Valadkhani and Mitchell (2002), and Weber et al. (2024). Core to this model is the understanding of the economy as a multitude of sectors, that are interlinked through production and trade processes and thus form a production network. Given that the linkages, their weights as well as the final demand from households are known to us, this perspective is particularly useful for analyzing the propagation of

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[3] The countries are Austria, Belgium, Bulgaria, Cyprus, Germany, Denmark, Estonia, Greece, Spain, France, Croatia, Hungary, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Poland, Romania, Slovenia and Slovakia.

[4] As we are missing the mean absolute income for the highest income quintile Q5, we use the lower limit thresholds for each quintile. The Q1 mean absolute income is corresponding to the value of the first percentile, Q2 is corresponding to the 20th percentile, up to Q5 which is corresponding to the 80th percentile. As the heterogeneity in income increases in the tail, we likely underestimate the heterogeneity in inflation inequality relative to the highest incomes.

asymmetric shocks and dependencies in an economy (Leontief, 1986; Miller and Blair, 2009). We present the full model derivation in Appendix B but rely on Figure 1 to build the intuition.

To determine the role of $sector_j$ for inflation inequality, we simulate an average price shock to this sector, computed as the mean of its yearly logarithmic price change ΔP_j from 2000 - 2014.[5]

$$\Delta P_j = \frac{1}{T} \sum_{t=t_0}^{t_1} \Delta \% P_j \tag{1}$$

The Leontief price model now assumes a linear price shock propagation downstream. Thus, the initial shock to $sector_j$ is passed through 1:1 to all its customers,[6] be that households buying final goods (*direct effect*) or other sectors buying intermediate goods from $sector_j$ (*indirect effect*). Still, at some point, this indirect effect will reach households and is counted as the indirect effect of $sector_j$.

Since expenditure shares differ substantially along income quintiles, so does the total effect (direct + indirect effect) of $sector_j$ for a given income quintile. We thus repeat this exercise for every sector in our global production network and every country-income pair. In the end, we know every direct and indirect effect of a price shock to a given sector for every income quintile in every of the 21 EU countries under consideration.

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[5] This approach accounts for the wide dispersion of price volatilities and growth in different sector classes (Weber et al., 2024).

[6] Ruling out substitution on the sector-level is undeniably an unrealistic assumption. However, as Duprez and Magermann (2018) show using a Belgium dataset, firms on average fully pass through common shocks. Arquié and Thie (2024), based on a dataset on French manufacturing firms, confirm this result for energy shocks, showing that most sectors pass-through between 90 - 110 percent of the shock. A linear shock propagation on sector-levels thus seems appropriate.

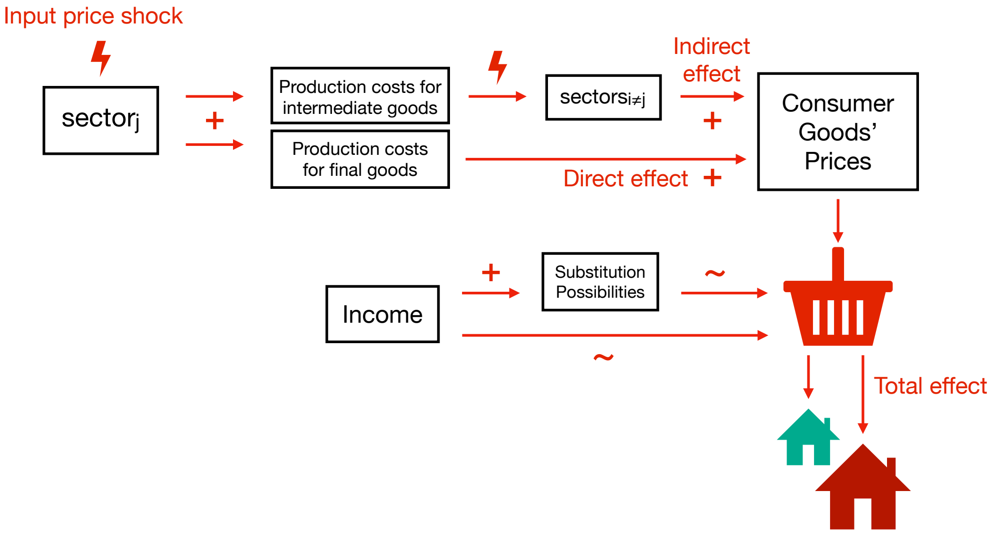

Fig. 1 Causal flow of the Input-Output price model.

Following Ipsen and Schulz (2024), we take this data to estimate how the exposure towards a sector changes with respect to income. The logarithmic effect $log(E) \in \{\text{Direct Effect, Indirect Effect, Total Effect}\}$ constitutes our dependent variable. The logarithmic average absolute income of country$_c$ quintile$_q$ is the independent variable, while δ_c is a dummy variable that accounts for country-level fixed effects. $\epsilon_{j,c,q}$ represents the error term.

$$log(E)_{j,c,q} = \beta_{0,j} + \beta_{1,j} log(Y_{c,q}) + \delta_c + \epsilon_{j,c,q} \qquad (2)$$

Each estimate will describe the percentage change in inflation exposure to a sector class, following a one percent increase in income. Negative (positive) estimates would thus indicate that exposure decreases (increases) in income. Consequently, we receive an estimate for every sector class[7] indicating

[7] A sector class corresponds to one of the 56 sectors reported in the WIOD according to the ISIC Rev. 4 classification.

whether this sector disproportionally exposes lower- or higher-income households or has a neutral effect.

4. Results for Expenditure-weighted Specification

Before turning to the results and their interpretation we need to clarify somewhat entangled concepts. Recall, that the term inflation inequality merely refers to a situation where the inflation experience of households is asymmetric along a specific dimension, in our case income. It does not tell us about the direction of this effect, that is, whether lower- or higher-income households experience higher inflation. However, to align with the intuitive understanding of inequality, we coin a price shock to a sector as an inequality increasing (decreasing) price if it disproportionally affects lower- (higher-) income households.[8] To describe the more general case of a change in inflation inequality (irrespective of the direction) we use the terms dampening or amplifying and/or explicitly refer to a change in *inflation* inequality.

Figures 2 - 4 present the estimates (points) and 95 percent confidence intervals (whiskers) for the direct, indirect, and total effects, respectively.[9] Two aspects are immediately obvious. First, most sector estimates are significantly positive, indicating that these sectors disproportionally expose higher-income households. Second, price shocks to the final goods of a sector (direct effect)

[8] This term is inspired by the idea of 'Systemically Significant Prices' put forth in Hockett and Omarova (2016) and picked up upon by Weber et al. (2024).

[9] Note, that we have less sectors in the direct effect estimates than in the indirect effect estimates, which is due to zero values in the direct effect that lead to the exclusion from our log-log regression.

lead to considerably more inflation inequality than shocks to the intermediate goods produced by a sector (indirect effect). Thus, the production network seems to distribute shocks from sectors with large income-dependent consumption differences to sectors with less heterogeneity. Substitution effects likely reinforce this situation as a stylized example shows: One might substitute away from the direct effect of a price shock in a sector. However, if this shock diffuses broadly to other sectors, the possibilities of substituting away from these indirect effects appear to be more limited. As Ipsen and Schulz (2024) point out, higher-income households seem to benefit from this redistribution: While most of the elasticity estimates for the indirect effect are still positive, they are substantially smaller than the direct effect estimates, indicating that higher-income households are *relatively* less exposed.

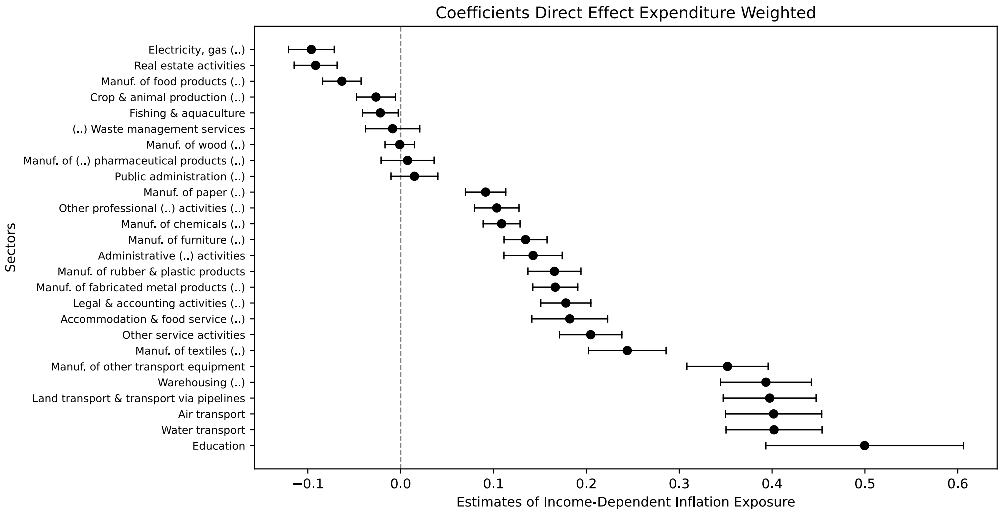

Fig. 2. Estimates of income-dependent inflation exposure for the effect of a price shock to the *final* goods produced by a sector (direct effect). Whiskers give the 95 percent confidence interval. Estimates below zero indicate Inequality Enhancing Prices, as the inflation exposure of households towards these sectors is reduced with increasing income. Positive estimates accordingly show Inequality Reducing Prices, as exposure rises with increasing income. Based on expenditure shares.

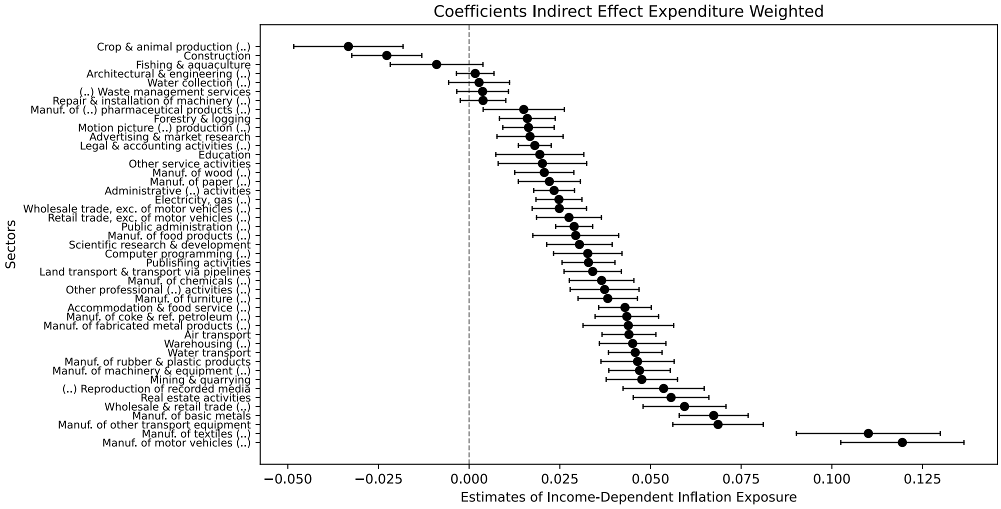

Fig. 3. Estimates and 95 percent confidence interval of income-dependent inflation exposure for the effect of a price shock to the *intermediate* goods produced by a sector (indirect effect). Based on expenditure shares.

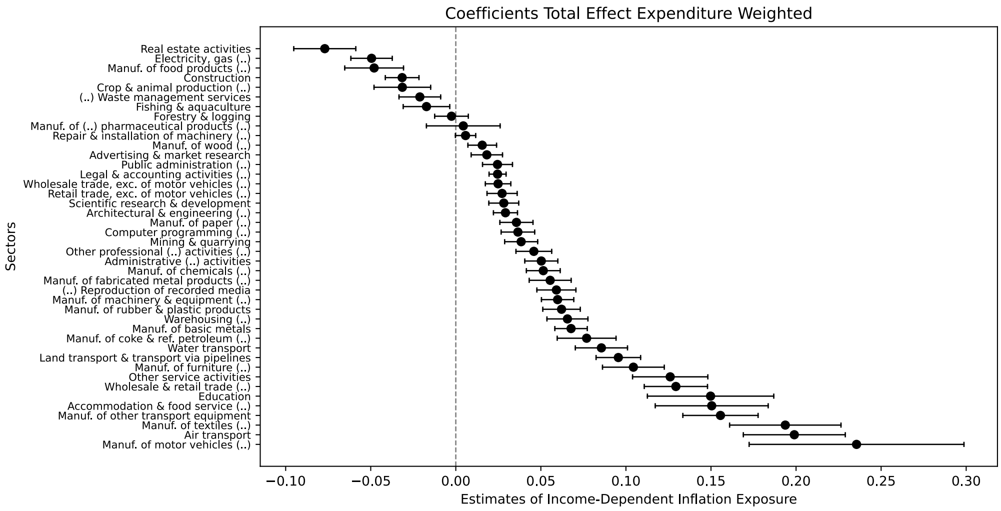

Fig. 4. Estimates and 95 percent confidence interval of income-dependent inflation exposure for the effect of a price shock to all goods produced by a sector (total effect). Based on expenditure shares.

In Figure 5 we map sectors on a four-quadrant chart. Sector classifications can be found in Appendix C. The vertical axis corresponds to the total effect estimate of a sector, indicating whether a price shock to this sector is equalizing (increasing exposure with income) or disequalizing (decreasing exposure with income). The horizontal axis shows whether the production network amplifies or dampens inflation inequality. We compute this mediating effect for each sector as

$$\text{Mediating Effect} = |\text{Dir. Effect Estimate}| - |\text{Ind. Effect Estimate}|. \quad (3)$$

If this difference is positive (negative), the production network dampens (amplifies) inflation inequality relative to the direct effect of a price shock. In other words, if positive, the production network pushes the estimate closer to the zero line – the neutral effect benchmark – relative to the direct effect. The opposite is true for a negative mediating effect.

While Figures 2 - 4 already point to significant asymmetries in the effects of price shocks, Figure 5 shows that the role of the production network in distributing these shocks is far from uniform either. In sum, our results suggest that the income-dependent inflation inequality arising from a price shock is highly contingent on the sector of origin. Thus, from a sectorial perspective, ambiguous results on inflation inequality for different periods and places are not surprising but to be expected.

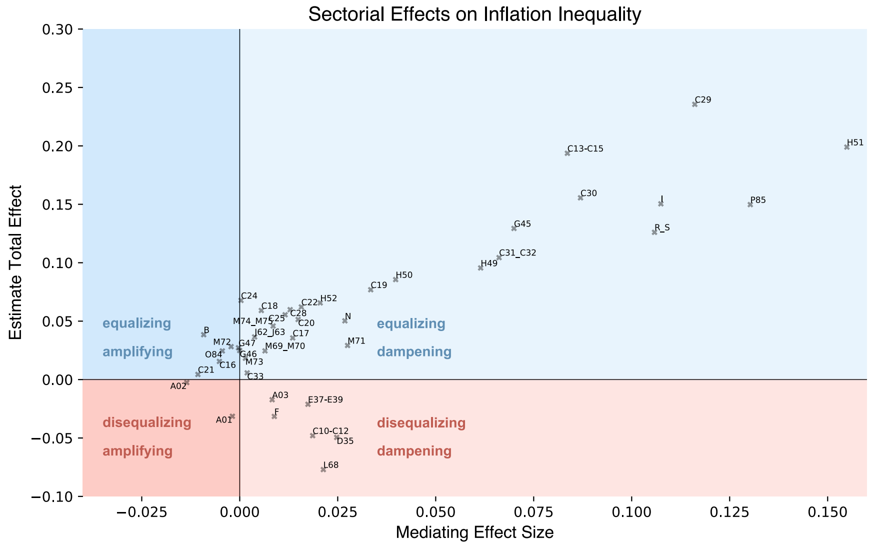

Fig. 5. Each quadrant delimits a distinct effect of a sectorial price shock on inflation inequality. The vertical axis reports the total effect estimates, where negative (positive) values indicate that a price shock is inequality enhancing (reducing). The horizontal axis reports the sum of |Total Effect Estimate| − |Indirect Effect Estimate|, where negative (positive) values indicate that the production network amplifies (dampens) inflation inequality. Sectors are labeled according to ISIC Rev. 4 classification. See Appendix C for a table with sector descriptions.

What does this mean for the actual inflation rates and inequalities at the household level? Are lower- or higher-income households more affected? Figure 6 provides an aggregate answer for our 21 countries under consideration. It shows the average mean effect of a sector in percentage points.[10] Red (inequality enhancing) and blue (inequality reducing) contrast the distributive effect of a price shock to a given sector. The darker (lighter) coloring shows the average relative effect size of the direct (indirect) effect of a price shock to a given sector. The ratio of the total effect of inequality reducing prices to inequality enhancing prices suggests an approximately equal exposure across incomes (51:49), underlining the systemic importance of a set of few sectors for the overall price level (Weber et al., 2024). Ipsen and Schulz (2024) provide a more detailed decomposition of the income-

[10] We first compute the average effect of a sector class considering sectors from all supply-countries (i.e. globally) for each income quintile of each of the 21 demand-countries. We then compute the mean of these for each sector class.

dependent effect sizes, finding the total exposure to price shocks to even tilt slightly against lower-income households.

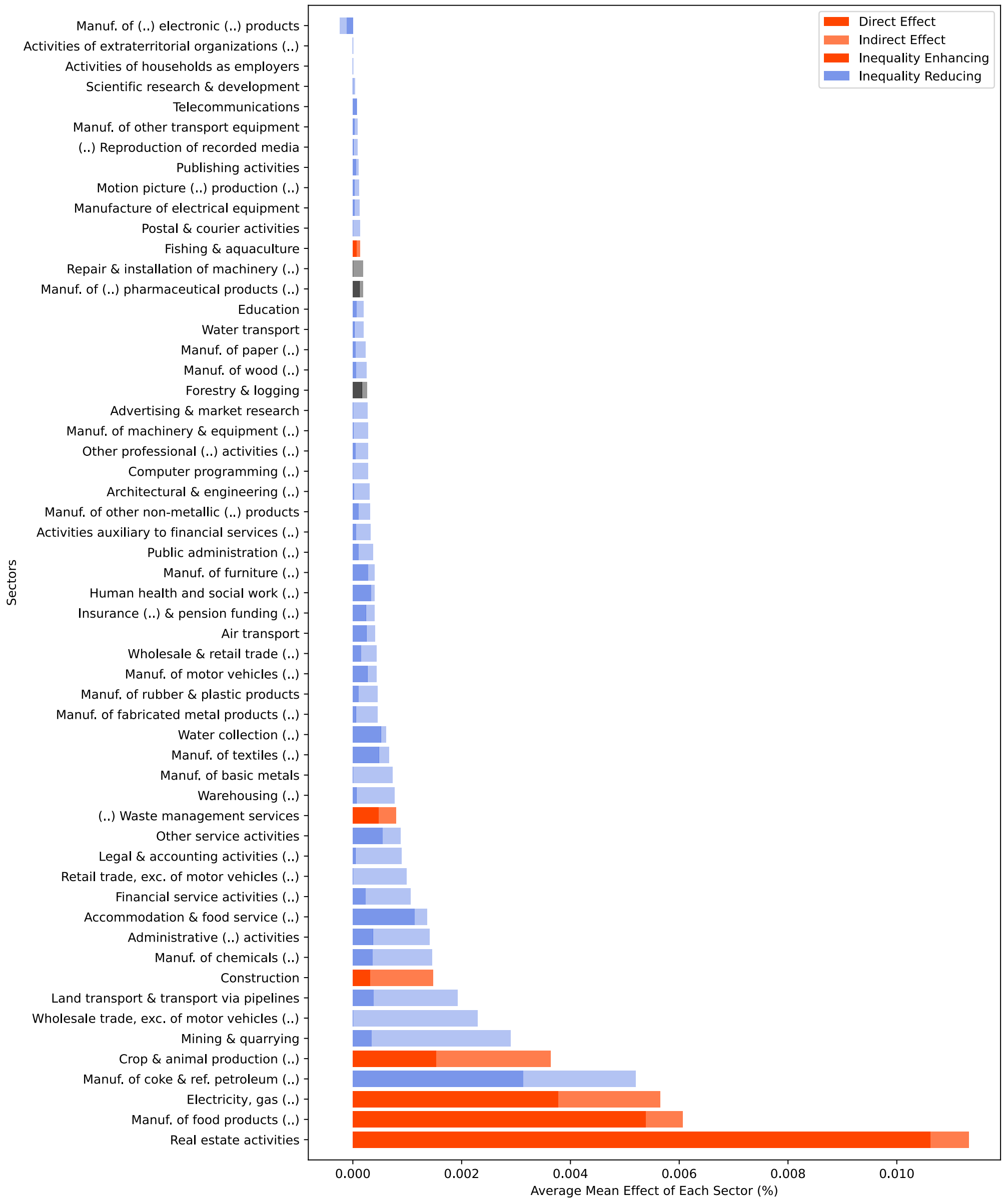

Fig. 6. Average mean direct (darker) and indirect (lighter) effect of each sector in percentage points. Red marks sectors whose total effect is inequality enhancing, blue marks inequality reducing sectors. Sectors with insignificant effect are marked in gray. Total effect ratio of Inequality Reducing Prices to Inequality Enhancing Prices suggests an approximately equal exposure across incomes (51:49).

All in all, a sectorial perspective on inflation inequality uncovers considerable heterogeneity in income-dependent inflation exposure, providing a promising explanation for ambiguous results in previous studies. It is not able, however, to substantiate the perceptions of poorer households that they are *consistently* most exposed to inflation. We discuss a second explanation for this mismatch in the following.

5. The Role of Income-weights for Inflation Inequality

Empirical studies on inflation inequality commonly base their analysis on differences in expenditures. While this approach is able to capture income-dependent heterogeneity in the consumption basket, it fails to consider the actual income that is allocated to consumption and is thus directly affected by a price change in this basket. As the propensities to consume from available income vary substantially along wealth- and income-levels, focusing solely on differences in expenditures might mask a substantial source of realized inflation inequality. In this section, we use a straightforward utility framework to show how under bounded rationality the marginal growth rate of utility is proportional to the price change times the average propensity to consume.

We assume a Cobb-Douglas type utility function with α and $(1-\alpha)$ reflecting the weights on current and expected future consumption to capture inter-temporal motives, i.e., the utility function U is given by

$$U(\gamma; Y, \alpha, p) = \left(\gamma \cdot \frac{Y}{p}\right)^{\alpha} \cdot \big((1-\gamma)Y\big)^{1-\alpha} \tag{4}$$

with γ as the average propensity to consume, Y as available current income, and p as the price level. Here, p only enters the current consumption term (left). As a consequence, agents consider the effect of the price level for their current consumption, while only considering the nominal income Y for the utility they gain out of their savings. This implies that agents act boundedly rational, since the price level will also affect their future consumption and hence, should affect the utility gained out of their savings. Indeed, a recent euro area survey data provides some evidence for this behavior, as the most common reaction to the recent inflationary surge was to modify consumption behavior, while not even half of the respondents reported adjusting their savings (Bobasu et al., 2024).

By the FOC, the optimal propensity to consume γ^* is given by,

$$\frac{\partial U}{\partial \gamma} \stackrel{!}{=} 0 \Rightarrow \gamma^* = \alpha, \tag{5}$$

which implies the canonical result that expenditures are a constant fraction of income. Optimizing gives the utility function for γ^*

$$U^*(Y, \alpha, p) = \left(\alpha \frac{Y}{p}\right)^{\alpha} \cdot \big((1-\alpha)Y\big)^{1-\alpha}. \tag{6}$$

Taking the logarithmic derivative and approximating by the discrete growth rate in utility over the discrete growth rate in the price level yields

$$\frac{d \log U^*}{d \log p} = -\frac{\alpha}{p} \approx \frac{\Delta u^*/u^*}{\Delta p/p}. \tag{7}$$

For our application case, all initial price levels are normalized to unity. This implies that we can express the marginal growth rate of utility in response to a price shock Δp as

$$\frac{\Delta u^*/u}{\Delta p} = -\alpha \Leftrightarrow -\frac{\Delta u^*}{u} = \alpha \cdot \Delta p. \tag{8}$$

Thus, if agents solely focus on the consumption effect of a change in prices, the marginal growth rate of utility is indeed proportional to the price change times the average propensity to consume. The above equation (8) nests the usual use case of expenditure weights for $\alpha = 1$. This case corresponds to a situation, where agents do not gain any utility out of savings and thus, inter-temporal motives do not matter. Within the same framework, Appendix D shows that under a full rationality assumption, the propensity to consume does not affect the reaction in utility.

Empirically, as Table 1 shows, a significant share of households report APCs well over 90 percent of available income. For income-quintile one, only Cyprus reports an APC of below 100 percent. Arguably, these cash-constrained households will only be concerned with present consumption and cannot consider the effect of a change in prices on their savings. Since we are interested in why poorer households are indicated to be disproportionally affected by inflation, considering the APC seems to be well-grounded.

6. Empirical Results for Income-weighted Inflation Inequality

To empirically investigate the impact of APCs on the realization of income-dependent inflation inequality, we rerun our Input-Output analysis, this time using income-weighted expenditure shares. Therefore, we compute the share of expenditure in a given sector as a ratio of the total income as opposed to the total expenditures. We compute these for every country-income pair as

$$ex_{j,c,q} \times APC_{c,q} = \left(\frac{ex_{j,c,q}}{\sum_{j=1}^{n} ex_{j,c,q}} \right) \times \left(\frac{\sum_{j=1}^{n} ex_{j,c,q}}{\text{Income}_{c,q}} \right) = \frac{ex_{j,c,q}}{\text{Income}_{c,q}}, \tag{9}$$

with $ex_{j,c,q}$ as the average expenditures of income quintile$_q$ of country$_c$ on goods produced in sector$_j$ and $\text{Income}_{c,q}$ as the mean disposable income of quintile$_q$ of country$_c$ (see Appendix A for the country specific APCs and Eurostat (2021a) for information on the data collection. We can now replace the expenditure shares of our initial Input-Output setup with these income-weighted shares.

Figures 7 - 9 report the estimates (points) and 95 percent confidence intervals (whiskers) for the direct, indirect, and total effect, respectively. It shows that if we are to consider the differences in the APCs for inflation inequality, every sectorial price shock disproportionally affects lower-income households. The massive differences in the APCs between income groups even outweigh differences in expenditure patterns in the other direction. These findings are consistent with the indication that poorer households are consistently overexposed to inflation.

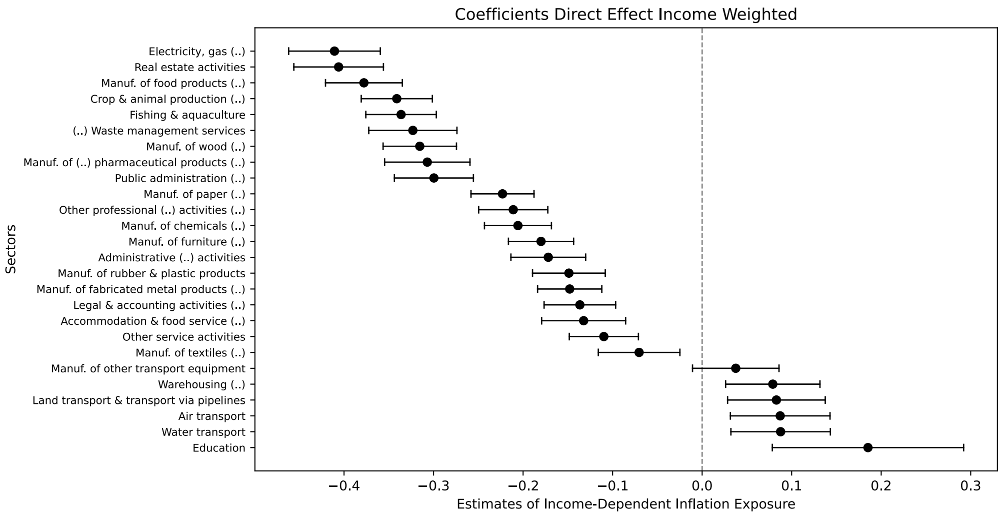

Fig. 7. Estimates of income-dependent inflation exposure for the effect of a price shock to the *final* goods produced by a sector (direct effect). Whiskers give the 95 percent confidence interval. Estimates below zero are Inequality Enhancing Prices, as the inflation exposure of households towards these sectors is reduced with increasing income. Positive estimates accordingly show Inequality Reducing Prices, as exposure rises with increasing income. Based on *income-weighted* expenditure shares.

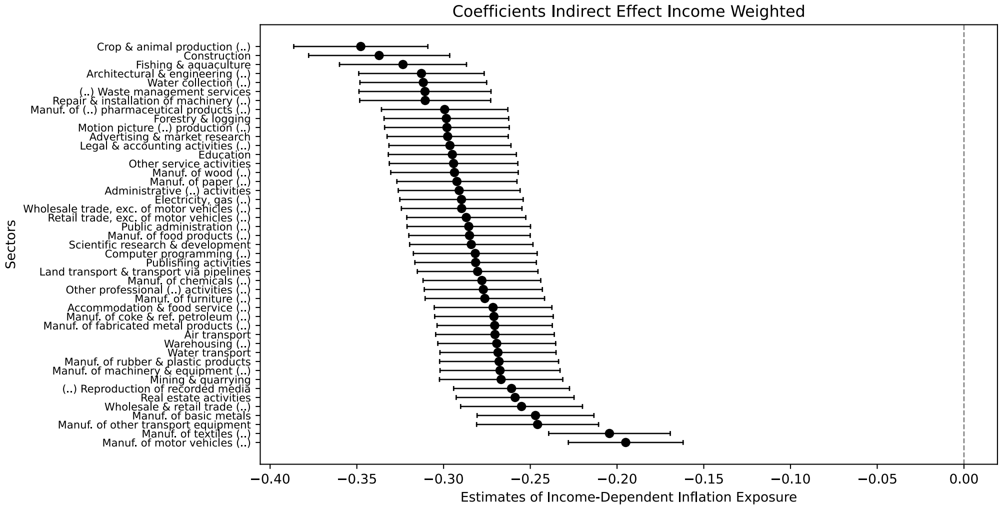

Fig. 8. Estimates and 95 percent confidence interval of income-dependent inflation exposure for the effect of a price shock to the *intermediate* goods produced by a sector (indirect effect). Based on *income-weighted* expenditure shares.

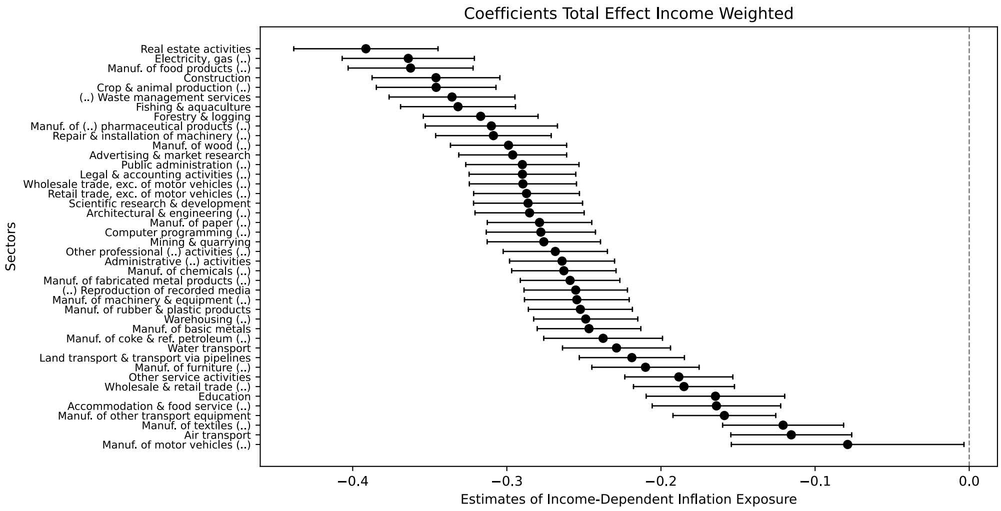

Fig. 9. Estimates and 95 percent confidence interval of income-dependent inflation exposure for the effect of a price shock to all goods produced by a sector (total effect). Based on *income-weighted* expenditure shares.

7. Conclusion

The empirical literature on income-dependent inflation inequality provides contesting results about its direction, magnitude, and persistence. Meanwhile, the perceptions of poorer households consistently indicate that they are most exposed to inflation. We propose and empirically substantiate two possible explanations for this inflation-inequality puzzle. First, we show for a set of 21 EU countries embedded in the global production network, that the income-dependent impact of a price shock is highly contingent on the sector of origin. This sectorial perspective poses a promising contester for explaining ambiguous results on inflation inequality. Conditional on the availability of data, future research could test the explanatory power of our sector-level estimates for the realized inflation-inequality in previous studies. Our results directly imply the testable hypothesis that poor households' perceptions of inflation should react the strongest, whenever inflationary pressures originate in sectors like housing and agricultural products. Monitoring sectorial prices could give policy-makers a head start in mitigating inflation and especially in preventing unnecessary hard-ship for lower-income households.

Second, we propose that income-dependent differences in the propensities to consume matter for realized inflation inequality. Focusing solely on differences in expenditures fails to consider the actual income that is allocated to consumption and thus directly affected by a price change in the consumption basket. Using a utility framework, we show that for agents who focus their concern on the consumption effect of a change in prices, the marginal growth rate of utility depends on their propensity to consume. With a substantial share of households reporting propensities to consume way beyond 90 percent of their available income, this assumption is well-grounded. To test the empirical implications, we rerun our initial Input-Output exercise under consideration of households' APCs and, in line with households' perceptions, find that every price shock disproportionally affects lower-income households. Of course, this has substantial implications, especially in times of increased inflation. However, on the upside, it culminates in a direct policy implication: How to raise the income of lower-income households?

Turning to a set of limitations: Generally speaking, the reliability of our results would profit from more current and granular data on the production network as well as consumer level. More specifically, recent research suggests that substantial differences in inflation inequality also arise from household consumption differences within industries (Jaravel, 2021; Strasser et al., 2023). As Argente and Lee (2021) show for the US, product quality substitution and changes in shopping behavior, which is more feasible for richer households, play significantly into asymmetries in the inflation experience of households as well. Hobijn and Lagakos (2005), Kaplan and Schulhofer-Wohl (2017), and Strasser et al. (2023) even document negative substitution for a significant share of households: As the price of a good rises, its relative share in the total expenditure does too, which at least for lower-income households likely results in the cutting back of other expenditures. This again reinforces the negative substitution effect. In sum, we likely underestimate the inflation exposure of lower-income households. With regard to substitution on the industry level, it is not evident that we overestimate the total propagation of shocks substantially (Duprez and Magermann, 2018). However, we certainly underestimate heterogeneity in shock propagation across sectors. A way forward might be found in Pichler et al. (2022), who estimate a modified Leontief production function to account for differences in the importance of input goods. Estimating different pass-trough rates of price shocks for individual sectors however likely introduces a high degree of ambiguity. Finally, our empirical analysis mostly neglects the wealth channel of inflation inequality (see for example Adam and Zhu, 2016; Bobasu et al., 2023; Doepke and Schneider, 2006).

Notwithstanding these limitations, our paper provides two partial explanations for a series of inconclusive results in the inflation inequality puzzle. We hope for future research to further map out their relevance for inflation inequality and its perception.

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Appendix A: Average Propensity to Consume

GEO	Q1 (%)	Q2 (%)	Q3 (%)	Q4 (%)	Q5 (%)
Austria	129.8	97.9	85	75.9	59.4
Belgium	118.9	92.1	73.8	63.3	50
Bulgaria	113.9	89.6	75	62.2	44.1
Croatia	121	107.7	88.4	80	63
Cyprus	89.3	87	86.5	82.6	65.2
Denmark	117.5	85.6	74.8	62.3	46.5
Estonia	108.3	81.9	69.9	54	45.3
France	114.1	84.9	78.7	72	55.3
Germany	143.4	91.6	84.4	77.5	63.4
Greece	168	110.4	101.5	88.6	72
Hungary	113.4	94.8	83.3	74.8	66.2
Latvia	114	88.7	78	72.4	56.9
Lithuania	110.7	82.1	69.5	51.8	39.4
Luxembourg	112.9	86.8	80.4	63.8	52.8
Malta	136.2	94.6	87.6	74.4	53.9
Netherlands	148.2	104.3	83.6	68.3	52.9
Poland	104.1	60.6	53.5	47.2	38.8
Romania	195.4	126.6	104.1	86	65.6
Slovakia	103	89.2	79.6	71.3	55
Slovenia	116.5	95.7	87	78.2	64.3
Spain	129.3	90.6	76	65.8	50.6
Mean	124.2	92.5	81.0	70.1	55.3

Table 1: Average Propensity to Consume for each income quintile in 21 EU countries for the year 2020. Based on Eurostat (2021a).

Appendix B: Leontief Price Model Derivation

We base this section on the Leontief price models used in Ipsen and Schulz (2024), Valadkhani and Mitchell (2002) and Weber et al. (2024). Equation (i) shows the model's principle case of the price P_j of sector$_j$ being a linear function of the prices of inputs $P_{i \neq j}$ times the technical coefficients a_{ij} plus the value added V_j. Since our data comprises global trade data, we need no additional import and export variables. The technical coefficients a_{ij} are computed as the ratio of value of inputs from sector$_i$ to the overall value of sector$_j$ output. With normalizing the output of sector$_j$, (i) gives the price per unit of output. A change in prices is thus to be interpreted as percentage changes.

$$P_j = a_{1j} P_1 + \ldots + a_{ij} P_i + \ldots + a_{nj} P_n + V_j \tag{i}$$

For n sectors, this becomes a system of linear equations.

$$\begin{bmatrix} P_1 \\ P_2 \\ \vdots \\ P_n \end{bmatrix} = \begin{bmatrix} a_{11} a_{21} & \cdots a_{n1} \\ a_{12} a_{22} & \cdots a_{n2} \\ \vdots \;\; \vdots \;\; \ddots & \vdots \\ a_{1n} a_{2n} & \cdots a_{nn} \end{bmatrix} \begin{bmatrix} P_1 \\ P_2 \\ \vdots \\ P_n \end{bmatrix} + \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{bmatrix} \tag{ii}$$

Since we want to simulate the down-stream propagation of shocks, we need to take the transpose of the technical coefficient matrix A. In matrix notation, this gives

$$P = A' P + v\,. \tag{iii}$$

As a next step, we single out the sector which we want to expose to an exogenous price shock.[11] This splits (iii) into

$$\begin{bmatrix} P_X \\ P_E \end{bmatrix} = \begin{bmatrix} A'_{XX} A'_{EX} \\ A'_{XE} A'_{EE} \end{bmatrix} \begin{bmatrix} P_X \\ P_E \end{bmatrix} + \begin{bmatrix} v_X \\ v_E \end{bmatrix} \tag{iv}$$

with P_X the price vector of the shocked sector and P_E as the price vectors of the remaining endogenous sectors. Since P_X is determined by our exogenous shock, we are only interested in

$$P_E = A'_{XE} P_X + A'_{EE} P_E + v_E\,. \tag{v}$$

$A'_{XE} P_X$ captures how the prices in the endogenous sectors depend on the price of the exogenous sector. $A'_{EE} P_E$ captures how the prices in the endogenous sectors depend on each other. If we solve for P_E, we get

$$P_E = (I - A'_{EE})^{-1} A'_{XE} P_X + (I - A'_{EE})^{-1} v_E\,. \tag{vi}$$

Assuming no substitution, the quantity of inputs remains unchanged following a change in prices. Thus, following a change in prices in the exogenous sector ΔP_x , the price change in the remaining sectors, ΔP_E , is given by

$$\Delta P_E = (I - A'_{EE})^{-1} A'_{XE} \Delta P_X\,. \tag{vii}$$

[11] Recall that we compute the price shock to sector$_j$ as its average percentage change over our period of observation.

At this point, we introduce the expenditure shares. $es_{x,q,i}$ represents the expenditure share of quintile_q of country_i in the exogenous sector_x. $es_{e,q,i}$ represents the expenditure share of quintile_q of country_i in the endogenous sector $e \neq x$. We are now able to decompose the effect of a price shock to the final goods produced by a sector into

$$\Delta\pi_{q,i,x}^{direct} = es_{x,q,i}\Delta P_x \qquad \text{(viii)}$$

and the effect of a price shock to the intermediate goods produced by a sector into

$$\Delta\pi_{q,i,x}^{indirect} = \sum_{e \neq x} es_{e,q,i}\, \Delta P_e\,. \qquad \text{(ix)}$$

The total effect of a price shock to a sector is then given by

$$\Delta\pi_{q,i,x}^{total} = es_{x,q,i}\Delta P_x + \sum_{b \neq x} es_{e,q,i}\, \Delta P_e\,. \qquad \text{(x)}$$

These direct, indirect and total price shock effects to a sector are used as the dependent variable to compute the elasticity estimates according to equation (2) in Section 3.

Appendix C: Sector Classifications

Table 2

Sector Label	Description	Sector Label	Description
A01	Crop and animal production, hunting and related service activities	C25	Manufacture of fabricated metal products, except machinery and equipment
A02	Forestry and logging	C26	Manufacture of computer, electronic and optical products
A03	Fishing and aquaculture	C27	Manufacture of electrical equipment
B	Mining and quarrying	C28	Manufacture of machinery and equipment n.e.c.
C10-C12	Manufacture of food products, beverages and tobacco products	C29	Manufacture of motor vehicles, trailers and semi-trailers
C13-C15	Manufacture of textiles, wearing apparel and leather products	C30	Manufacture of other transport equipment
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	C31/C32	Manufacture of furniture; other manufacturing
C17	Manufacture of paper and paper products	C33	Repair and installation of machinery and equipment
C18	Printing and reproduction of recorded media	D35	Electricity, gas, steam and air conditioning supply
C19	Manufacture of coke and refined petroleum products	E36	Water collection, treatment and supply
C20	Manufacture of chemicals and chemical products	E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	F	Construction
C22	Manufacture of rubber and plastic products	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
C23	Manufacture of other non-metallic mineral products	G46	Wholesale trade, except of motor vehicles and motorcycles
C24	Manufacture of basic metals	G47	Retail trade, except of motor vehicles and motorcycles

Sector Label	Description	Sector Label	Description
H49	Land transport and transport via pipelines	L68	Real estate activities
H50	Water transport	M69/ M70	Legal and accounting activities; activities of head offices; management consultancy activities
H51	Air transport	M71	Architectural and engineering activities; technical testing and analysis
H52	Warehousing and support activities for transportation	M72	Scientific research and development
H53	Postal and courier activities	M73	Advertising and market research
I	Accommodation and food service activities	M74/ M75	Other professional, scientific and technical activities; veterinary activities
J58	Publishing activities	N	Administrative and support service activities
J59/J60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	O84	Public administration and defence; compulsory social security
J61	Telecommunications	P85	Education
J62/J63	Computer programming, consultancy and related activities; information service activities	Q	Human health and social work activities
K64	Financial service activities, except insurance and pension funding	R/S	Other service activities
K65	Insurance, reinsurance and pension funding, except compulsory social security	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
K66	Activities auxiliary to financial services and insurance activities	U	Activities of extraterritorial organizations and bodies

Appendix D: Utility Maximization under Full Rationality

The utility function U is given by

$$U(\gamma; Y, \alpha, p) = \left(\gamma \cdot \frac{Y}{p}\right)^{\alpha} \cdot \left((1-\gamma)\frac{Y}{p}\right)^{1-\alpha}, \tag{i}$$

with γ as the average propensity to consume, Y as available current income, and p as the price level. In this version, p enters both the term relating to current consumption (left) and in the savings (right). Thus, in this setup, agents correctly anticipate both the consumption as well as wealth effect of a change in p.

By the FOC, we can derive the optimal average propensity to consume γ^*

$$\frac{\partial U}{\partial \gamma} \stackrel{!}{=} 0 \Rightarrow \gamma^* = \alpha\,. \tag{ii}$$

Optimizing gives the utility function for γ^*

$$U^*(Y, \alpha, p) = \left(\alpha \frac{Y}{p}\right)^{\alpha} \cdot \left((1-\alpha)\frac{Y}{p}\right)^{1-\alpha}. \tag{iii}$$

Taking the logarithmic derivative and approximating by the discrete growth rate in utility over the discrete growth rate in the price level yields

$$\frac{d \log U^*}{d \log p} = -\frac{1}{p} \approx \frac{\Delta u^*/u^*}{\Delta p/p}\,. \tag{iv}$$

Assumeíng that the initial price level is $p = 1$, than the marginal growth rate of utility is given by

$$\frac{\Delta u^*/u}{\Delta p} = -1 \Leftrightarrow -\frac{\Delta u^*}{u} = \Delta p\,. \tag{v}$$

In this case, the model suggests that if agents correctly anticipate the effect of a change in prices on their consumption *and* savings behavior, then the effect of a price shock on utility is not mediated by the average propensity to consume.

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