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Unravelling the Markups Changes: The Role of Price Elasticity of Demand and Concentration

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Abstract

We propose a framework identifying sources of markup changes. Our approach derives from the conjectural variation theory and highlights the role of both price elasticity and concentration in shaping the markups. We show that a decline in markups in Poland, showed by by Gradzewicz and Mućk (2024), is related to rising price elasticity of demand, while rising concentration mitigated this effect. Moreover, we document that the globalization trends, e.g. international fragmentation, increasing standardization and tighter integration with global economy, affect both price elasticity of demand and markups. We also identify factors specific to demand elasticity (product varieties and a home bias) and to markups (import content of exports).

Keywords: globalization, markups, price elasticity of demand

JEL Classification: C23, D22, D4, F61, L11

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1 Introduction

Gradzewicz and Mućk (2024) showed that monopolistic markups in the Polish economy felt in the period 2002-2016. The aim of our study is to show that the fall of markups has not been accompanied by a fall of concentration, but rather it can be attributed to a rise of the price elasticity of demand (we use the term 'demand elasticity' for short) that Polish enterprises face.

In the recent years there is a growing interest in the evolution of markups in the macroeconomic literature. It started in the US economy with the works of Barkai (2020) and De Loecker et al. (2020), both indicating a significant rise of markups of price over marginal costs (see also Caballero et al., 2017; Hall, 2018). Simultaneously, there is an evidence that in the US the rise of markups is accompanied by rising concentration – see e.g. Autor et al. (2020), Gutiérrez and Phillippon (2017) or Bajgar et al. (2019). In the European countries the evidence on markups is more scarce – Calligaris et al. (2018) or De Loecker and Eeckhout (2018) find rather heterogeneous but generally upward trends. Bajgar et al. (2019) show that in many European countries concentration also rises, although to a lesser extent than in the US.

As discussed by Syverson (2019), concentration is sometimes used as a proxy measure for markups, as a standard Cournot oligopoly model implies a positive relationship between the market concentration and the average market power. With fewer firms, each firm has less competition to take into account and more ability to raise price above marginal cost. But concentration is informative on relative revenues and includes no information on costs or profits. In many contexts concentration proves to be a bad proxy for market power as both may diverge as e.g. in the case of the monopolistic competition. A negative correlation between concentration and markups is also implied by a substitution effect in a class of models with heterogeneous firms selling differentiated goods (see e.g. Foster et al., 2008; Melitz, 2003). In these models a higher degree of substitutability implies on the one hand that a firm's residual demand becomes more elastic which lowers the price-cost margins. On the other hand, a rise in substitutability make it harder for higher-cost firms to operate and forces them to exit, leading to higher concentration. Thus, these models predict a negative correlation between market power and concentration, conditional on changes in substitution between products. Syverson (2004), among others, show that the negative correlation can be observed empirically.

Another strand of the literature trying to link concentration to markups builds on the conjectural variations models, first introduced by Bowley (1924), and is known as the Structure-Conduct-Performance (SCP) approach. It was popular till the 1970s and is extensively surveyed by Bresnahan (1989). It concentrates on estimating a conduct parameter, purported to measure the competitiveness of a market. But since the 1980s the industrial organization literature, given rising concerns on the relation between concentration and market power, forgo the approach. The example of the criticism is Corts (1999) who showed that the estimated conduct parameter need not even be positively correlated with the true measure of the elasticity-adjusted price-cost margin.

Our paper tries to re-examine the concentration-markup relationship. Our starting point is the conjectural variation theory but our contribution is to use it in a different way compared to the criticized SCP literature, in particular we do not use it to identify markups. Instead, we use the markup identification method proposed by De Loecker and Warzynski (2012) and then we utilize the relations predicted by the conjectural variation theory to identify the price elasticity of demand and to show that the changes in markups can be due to either: (1) the change in the number of symmetric firms in the given industry, or (2) the change in the price elasticity of demand. The former measures the change in the structure of the supply and the underlying market concentration, whereas the latter measures the change in the demand for products of the industry. Changes in the demand component are also indirectly related to changes in substitutability, as we are identifying the price elasticity of demand as perceived by the firm. Thus, our approach allows to empirically (and approximately) assess the role of substitution in the models in the spirit of Melitz (2003). To our knowledge this is the first attempt to identify the sources of markup changes.

On empirical grounds, we show the importance of changes in the price elasticity of demand to the development of markups in Poland. We focus on Poland because it offers an interesting and non-trivial example. Despite the rise of concentration on the aggregate level, the aggregate markups are falling (Gradzewicz and Mućk, 2024). Based on our approach we find that the decline in markups in Poland can to a large extent be attributed to the rising price elasticity of demand. One should bear in mind, that our results rest on a number of assumptions, including profit optimization under firms' market power, a constant conduct parameter, and a symmetry of firm sizes, as measured in the data.

In addition, we document extensively that a bunch of measures of industry structure affect both the price elasticity of demand and markups, but in an inverse way, as predicted by the theory. In particular, we document that changes in the price elasticity of demand and its effect on markups can to large extent be explained by the globalization trends. These include: the international fragmentation of production with an accompanying vertical specialization, increasing standardization and overall tighter integration of Poland with the global economy. However, we also identify factors that are related solely to the demand elasticities or to the markups. In particular, the price elasticity of demand is affected by two opposite effects, i.e., home bias and rising variety, both not influencing markups directly. Furthermore, our empirical analysis shows that the foreign value added at exports (an import content of exports), as a measure that affects primarily the costs of firms, affects markups directly and not via the elasticity of demand.

The rest of the paper is organized as follows. The next section presents the theoretical background, i.e., the conjectural variation theory and the resulting concentration-markup relation. Then, we discuss data sources and issues related to the identification of markups and the measurement of concentration. The next section presents the results of empirical application for Poland. It is followed by a more detailed empirical analysis indicating how the measures of industry structure affect both price elasticity of demand and markup. The final section offers some concluding remarks and comments.

2 Theoretical background

Our starting point is the conjectural variation theory (first introduced by Bowley, 1924 and surveyed extensively by Bresnahan, 1989). The derivation here follows Perry (1982) and Corts (1999). Consider a homogeneous product Q with an inverse demand function $P(Q)$ (with $P'(Q) < 0$). There are N firms in an industry, each producing q_i (so $Q = \sum_{i=1}^{N} q_i$) with a cost function $C(q_i)$. The profit of the jth firm is:

$$\Pi_j(q_j) = P\left(q_j + \sum_{i \neq j} q_i\right) \cdot q_j - C(q_j). \tag{1}$$

A firm j chooses q_j to maximize profits $\Pi_j(q_j)$. We assume that the firm formulates a conjecture about the combined output response of the other firms to a unit change in its own output level

$$\frac{d(\sum_{i \neq j} q_i)}{dq_j} = r_j, \tag{2}$$

where $-1 < r_j < N - 1$ and r_j is called a conduct parameter. This condition nests a wide range of possible market equilibria, explicitly incorporating the special cases of:

(i) the competitive equilibrium, with $r_j = -1$, so the firm expects the rest of the industry to absorb exactly its output expansion by a corresponding output reduction; as a result each firm is a price-taker;

(ii) the Cournot equilibrium (the Nash equilibrium in quantities), with $r_j = 0$, so the rival's quantities are taken as given and are not changing with the firm's decision;

(iii) collusive equilibrium, where firm j's output changes are matched by all other $N - 1$ firms, so $r_j = N - 1$; in this case the industry behaves like a single monopolist splitting total production symmetrically among all firms in the industry, so as to maximize joint profits.

The first order condition of the firm j with respect to its own output is:

$$\frac{d\Pi_j(q_j)}{dq_j} = P\left(q_j + \sum_{i \neq j} q_i\right) + P'\left(q_j + \sum_{i \neq j} q_i\right)(1 + r_j)q_j - C'(q_j) = 0, \tag{3}$$

so that in equilibrium, each firm perceives no incentive to change its output level. When we assume that all firms are identical (let N^* be a number of symmetric firms in the industry) and they share the same conjecture about their rivals' reactions, $r_j = r$ then we can consider a symmetric equilibrium with $Q = N^* \cdot q$. Equation (3) simplifies to:

$$P(Q) + (1+r)P'(Q) \cdot \frac{Q}{N^*} - C'\left(\frac{Q}{N^*}\right) = 0 \tag{4}$$

and can be expressed as:

$$P(Q) = C'\left(\frac{Q}{N^*}\right) - \frac{1+r}{N^*}\frac{dP(Q)}{dQ} \cdot \frac{Q}{P(Q)} \cdot P(Q). \tag{5}$$

When we define the price elasticity of the demand as: $\theta \equiv -\frac{dQ(P)}{dP}\frac{P}{Q} = -\left(\frac{dP(Q)}{dQ}\right)^{-1} \cdot \frac{P}{Q}$ (note that $\theta > 0$) and assume the invertibility of the demand function, then $-\frac{dP(q)}{dQ} \cdot \frac{Q}{P} = \frac{1}{\theta}$. The price equation (4) becomes:

$$P(Q) = C'\left(\frac{Q}{N^*}\right) + \frac{1+r}{N^*}\frac{1}{\theta} \cdot P(Q). \tag{6}$$

Defining the markup μ as a price over the marginal cost (so $\mu \equiv \frac{P(Q)}{C'(\frac{Q}{N^*})}$) and dividing (6) by $C'\left(\frac{Q}{N^*}\right)$ we get the following relation:

$$\mu = 1 + \frac{1+r}{N^*}\frac{\mu}{\theta}. \tag{7}$$

It can be solved for markups:

$$\mu = \frac{1}{1 - \frac{1+r}{N_t^*\theta}} = \frac{N^*\theta}{N^*\theta - (1+r)}. \tag{8}$$

Equation (8) show that for a given conduct parameter r, the changes in markups can be due to either: (1) the change in the number of symmetric firms in the industry, or (2) the change in the price elasticity of demand.
Given N^* – the number of symmetric firms in the industry and μ – the average markup in the industry we may recover the elasticity of demand for the product of the industry as:

$$\theta = \frac{1+r}{N^*}\frac{\mu}{\mu - 1}. \tag{9}$$

One should remember, that the derivation of θ rests on a number of relatively strong assumptions, specified above, including: firms' profit optimization under market power, a constant conduct in the market, and a symmetry of firms.

In the benchmark calculations we assume additionally the Cournot equilibrium ($r = 0$, we discuss the consequences of the choice of different values of conduct parameter in the robustness section). In this case equation (9) simplifies to:

$$\theta = \frac{\mu}{N^*(\mu - 1)} = \frac{1}{N^*}\frac{\mu}{\mu - 1}. \tag{10}$$

The previous literature (see e.g. Bresnahan, 1989) used the above theory and the relation given by (7) to estimate the conduct parameter using the information on Lerner index as a proxy for markups, the number of firms in the industry and the estimates of the price elasticity of demand. However, Corts (1999) criticizes this approach and shows it is unable to estimate the conduct parameter accurately. He stressed that "the CPM estimates of market power can be seriously misleading. In fact, the conduct parameter need not even be positively correlated with the true measure of the elasticity-adjusted price-cost margin, so that some markets are deemed more competitive than a Cournot equilibrium even though the price-cost margin approximates the fully collusive joint-profit maximizing price-cost margin".
We take into account the critique of Corts (1999) and assume that in the relatively short time span we analyze the nature of competition, the conduct parameter is constant (and close to the Cournot equilibrium in the benchmark case). Moreover, different assumption on the conduct parameter r are irrelevant for our main results, provided it is a constant. As we are interested in changes, so it allow us to use relation (10) to determine the price elasticity of demand and equation (8) to perform the counterfactual analysis. The approach presented here relies on the external identification of markups and concentration, discussed in the next section.

3 Data sources and measurement

Our data cover the 15-years period (2002-2016) and come from annual financial reports and balance sheets of all Polish enterprises (excluding firms from agriculture, financial sector and some specific non-market services) employing at least 10 employees in full time equivalent. The data are collected by the Central Statistical Office (CSO). The full data is an unbalanced panel of almost 770 thousand observations—about 120 thousand firms observed for on average 6.4 years. In the last year of the analysis data cover 90% of employment and 85% of value added of the enterprise sector, as reported by the CSO. This full data is used to calculate concentration measures. However, the measurement of markups (described below) is more data-demanding and we apply carefully chosen data cleaning procedures, described in detail in Gradzewicz and Mućk (2024). The trimmed sample with which it is possible to calculate markups contains 576.4 thousand observations on 82.1 thousand firms observed for 7.02 years on average. It covers ca. 75% of both employment and value added in the enterprise sector in the last year of the analysis. The subsequent analysis is performed either at the industry level or the whole economy levels and we treat sectoral (sales-weighted) means of markups as proper measures of sectoral and economy-wide averages.

3.1 Measurement of markups

Monopolistic markups are measured on a firm-year level (indexed by i and t) using the methodology developed by De Loecker and Warzynski (2012). We use the estimates of markups from the baseline calculations presented in Gradzewicz and Mućk (2024). The identification of markups starts from the assumption of static cost minimization which gives, for any free to adjust production factor, the following relation:

$$\mu_{it} = \beta_{it}^{V} \left(\frac{p_{it}^{V} v_{it}}{p_{it} q_{it}} \right)^{-1}. \tag{11}$$

In equation (11) β_{it}^{V} stands for the production function elasticity to the variable factor V, $p_{it}^{V} v_{it}$ is the nominal cost associated with this production factor and the term in bracket is the share of nominal factor cost in total revenues.
To quantify the underlying elasticity we consider the following translog production function:

$$q_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_{ll} l_{it}^2 + \beta_{kk} k_{it}^2 + \beta_{lk} l_{it} k_{it} + \omega_{it} + \varepsilon_{it}, \tag{12}$$

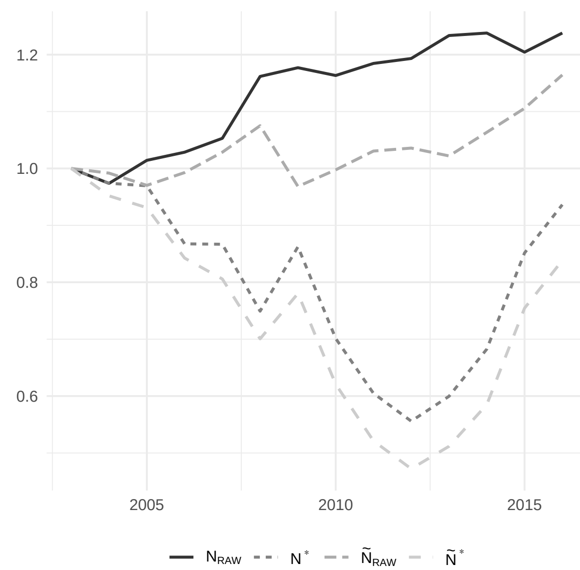
where q_{it} is the (log) value added, l_{it} is the (log) labor input, k_{it} is the (log) capital stock while ω_{it} represents the unobserved (log) productivity that simultaneously affects factor quantities. In our baseline setting, we choose the labor input as V in (11). Thus, the labor elasticity is given by:

$$\beta_{it}^{L} = \beta_l + 2\beta_{ll} l_{it} + \beta_{lk} k_{it}, \tag{13}$$

and it varies both over time and between firms.
To measure the key variables we proceed as follows. Labor input (l_{it}) is measured in full time equivalent. As value added is not directly observed in the data, we operationally define value added (q_{it}) as global output (revenues from the sale of products, including changes in inventories and the value of production for internal purposes, and profits realized on reselling of goods, and other operating revenues) less intermediate consumption (costs of materials, outsourcing and other operational costs). Capital input (k_{it}) is taken as the beginning of period book value of fixed assets: buildings, machines and vehicles. Since capital and value added are expressed in nominal terms we use a wide range of industry-level deflators from the national accounts. In particular, we use prices of value added, intermediate consumption and global output for 2-digit NACE sector. The price indices for capital (based on replacement costs) are available at 1-digit industry level for each type of assets which allows to obtain firm-specific capital deflators due to the differences in the firm-level structures of assets.
Furthermore, we use the production function identification scheme proposed by Ackerberg et al. (2015) in estimating (12), which builds on Levinsohn and Petrin

(2003) and controls for both 1) the bias due to simultaneity in productivity and factor demand and 2) for the selection bias due to firms exiting the sample. Finally, following De Loecker and Warzynski (2012) we use residuals from (12) to adjust for a lack of adequate delfator at the firm level.

Figure 1: Median, unweighted and weighted mean markups in Poland



Source: Gradzewicz and Mućk (2024).

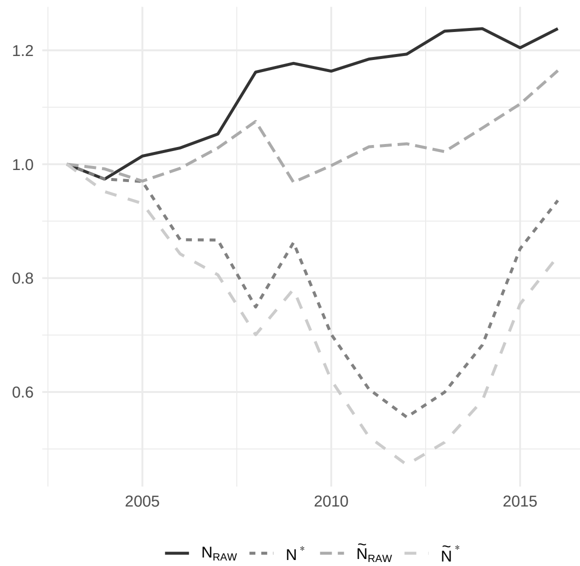
Figure 1, taken from Gradzewicz and Mućk (2024), shows the evolution of average markups in the Polish economy since 2002. It is clearly visible that the markups are on average declining. Gradzewicz and Mućk (2024) also show that the decline is robust to various adjustments in the identification scheme and we show in Section 4.2 that our main results are robust to these adjustments. Moreover, they show that the decline is also prevalent on a firm level – around 70% of enterprises experienced a fall of markup.

3.2 Measurement of concentration

The relation between markups, concentration and a price elasticity of demand described in Section 2 requires N^* – a number of symmetric firms in the industry. It can be derived as an inverse of the Herfindahl-Hirshman Index (denoted as HHI). It can be easily shown that $HHI_t = \sum_i \left(\frac{p_{it} q_{it}}{\sum_j p_{jt} q_{jt}} \right)^2$ can be expressed as

$HHI = N\sigma^2 + 1/N$, where σ^2 is the variance of the market shares of firms. When firms are symmetric then each firm has the same market share, thus $\sigma^2 = 0$ and $N^* = HHI^{-1}$.

Figure 2: Changes in raw and symmetric firm number for the total enterprise sector and firms 10+ in the period 2003-2016 (2003=1)



Note: N_{RAW} is the number of firms in our dataset, $\tilde{N}_{RAW}$ denotes the number of firms corrected by small enterprises, N is the number of symmetric firms and $\tilde{N}$ denotes the number of symmetric firms adjusted by small firms. The figure starts from 2003, limited by the data on the number of smaller firms from CSO.

We measure N^* using our full dataset (before the cleaning procedures) as there are no missing values on nominal sales, which is only needed to determine HHI. Still, the measurement of HHI in our data is biased, as the data do not include small firms, employing less than 10 persons. In order to check the severity of this source of bias we use the aggregate information provided by the Polish Central Statistical Office and correct our calculations with the number of small firms. When correcting the HHI index we assume that the total sales generated by small firms (which we observe only in the aggregate of small firms) are equally spread among them.

Figure 2 shows the evolution of a raw number of firms, both in our dataset (N_{RAW}) and with small firms included ($\tilde{N}_{RAW}$) together with the number of symmetric firms, both in our dataset (N) and corrected for small firms ($\tilde{N}$). As we focus on changes, we normalize the series with the levels in year 2002. The number of firms in the Polish economy has been rising at least since 2003. The rise is more pronounced for relatively larger firms (it is worth emphasizing that the growth of the number of firms employing 10+ is comparable to official figures). In smaller firms the crisis year of 2009 was particularly responsible for a slower cumulative growth. Figure 2 also shows that a growing firm number was accompanied by a rise of concentration, as the number of symmetric firms was on a declining tendency till 2012. Only after 2012 there was a relatively sharp rise of N^*, but still the cumulative change since 2002 is negative. Moreover, Figure A1 in the Appendix shows also that the concentration measured using the CR4 and CR20 measures (market shares of the biggest 4 and 20 firms, respectively) also increased since 2009, as suggested by a number of symmetric firms. To sum up, the comparison of the number of symmetric firms in our datset (N^*) with a proxy for a number of symmetric firms in the whole enterprise sector ($\tilde{N}^*$ in Figure 2) shows that the extent of firm concentration is underestimated in our dataset but the bias is time-invariant. In the subsequent analysis we will use a symmetric firm number from our dataset (N^*) since: 1) it is very close to a number of symmetric firms calculated for the whole enterprise sector ($\tilde{N}^*$), and 2) the data on smaller firms from the CSO do not allow for the sectoral split. Summing up, our analysis showed that the fall of markups in the Polish economy has not been accompanied by a fall of concentration.

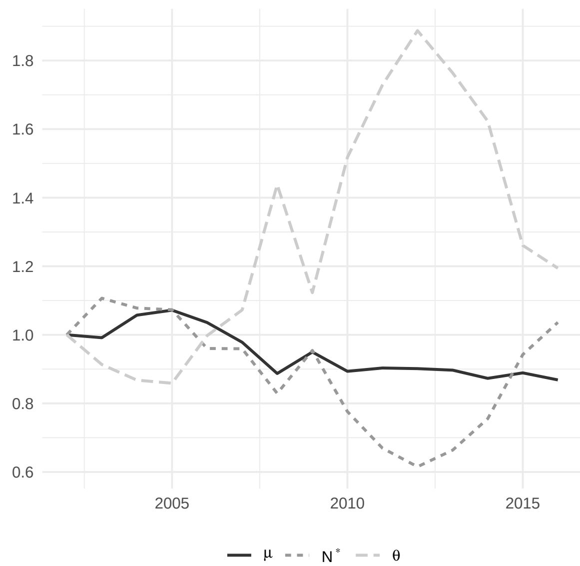
4 Empirical application

In this section we will try to assess what is the role of concentration (measured as a number of symmetric firms, discussed in Section 3.2) in shaping monopolistic markups in Poland. First, we show the evolution of the derived price elasticity of demand and then we use counterfactual analysis to assess the importance of both price elasticity of demand and concentration for the evolution of markups.

Given calculations of markups μ and a number of symmetric firms N^* we apply equation (10) to measure the price elasticity of demand θ. Figure 3 shows the results. In the initial period there was a small increase of markups, but monopoly power exhibited a longer declining tendency. The decline of markups, by almost 10% till 2008, was accompanied by a decline of a number of symmetric firms by ca. 18% and a huge increase of demand elasticity, which rose by over 40% during this period. After 2008 the decline of markups slowed down substantially, but the underlying changes in θ and N^* continued. A number of symmetric firm continued to decline even further till 2012, but then concentration decreased substantially (reflected in an increase of N^*) and in 2016 stayed on a level similar to the one observed at the beginning of the sample. Demand elasticity mirrored the development of N^* – it continued to increase till 2012 reaching a level almost 90% higher than in 2002 and then felt sharply to a level only 20% higher than in 2002.

As our aim is to assess the relative importance of price elasticity of demand and concentration in the development of markups, we use equation (8) and simulate the hypothetical paths of markups μ holding either θ or N^* fixed. Figure 4 shows the results. If we do not allow for changes in concentration then the resulting path of

Figure 3: Markups, a number of symmetric firms and the demand price elasticity (2002=1)

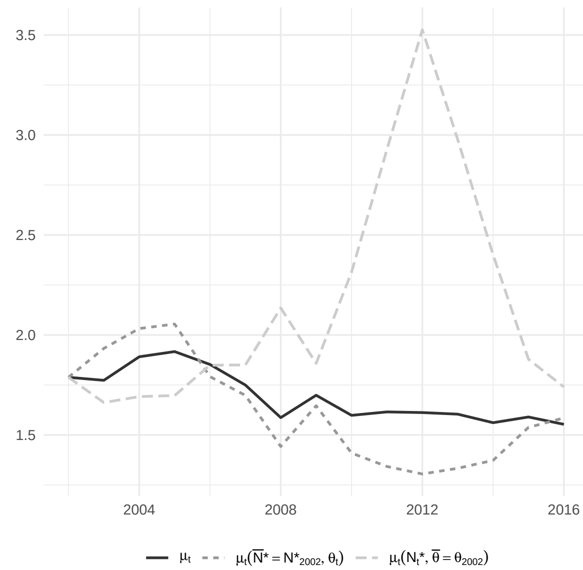


markups is very similar to the one identified in the data. Even more, absent changes in concentration the markups for most of the time would decline more than in reality. In turn, if there were no changes in demand elasticity, then the markups would actually rise substantially (especially at the beginning of 2000's) for most of the time, due to rising concentration.

The aggregation in the results for the whole economy could hide divergent underlying sectoral tendencies. Figure 5 shows it is not the case. It illustrates actual changes in markups (cumulated over the period 2002-2016) for 1-digit NACE industries, together with hypothetical cumulated changes, with either concentration or price elasticity of demand fixed. Few observations emerge. First, declines of markups prevail on an industry level, rising only in specific sectors, like mining or transportation. Second, in most industries the direction of changes in markups is associated with changing price elasticity of demand. In industries with falling markups, the fall is always (at least partially) due to a change of θ. The same is true for most cases with rising markups. Third, changes in concentration are less correlated with markups, but in industries with the greatest markup declines, it is due to both rising θ and rising concentration. The results are roughly the same with less aggregated industries the results are available upon request.

Summing up, our analysis showed that the fall of markups observed in Poland to a large extent originated in the rise of the price elasticity of demand. Rising

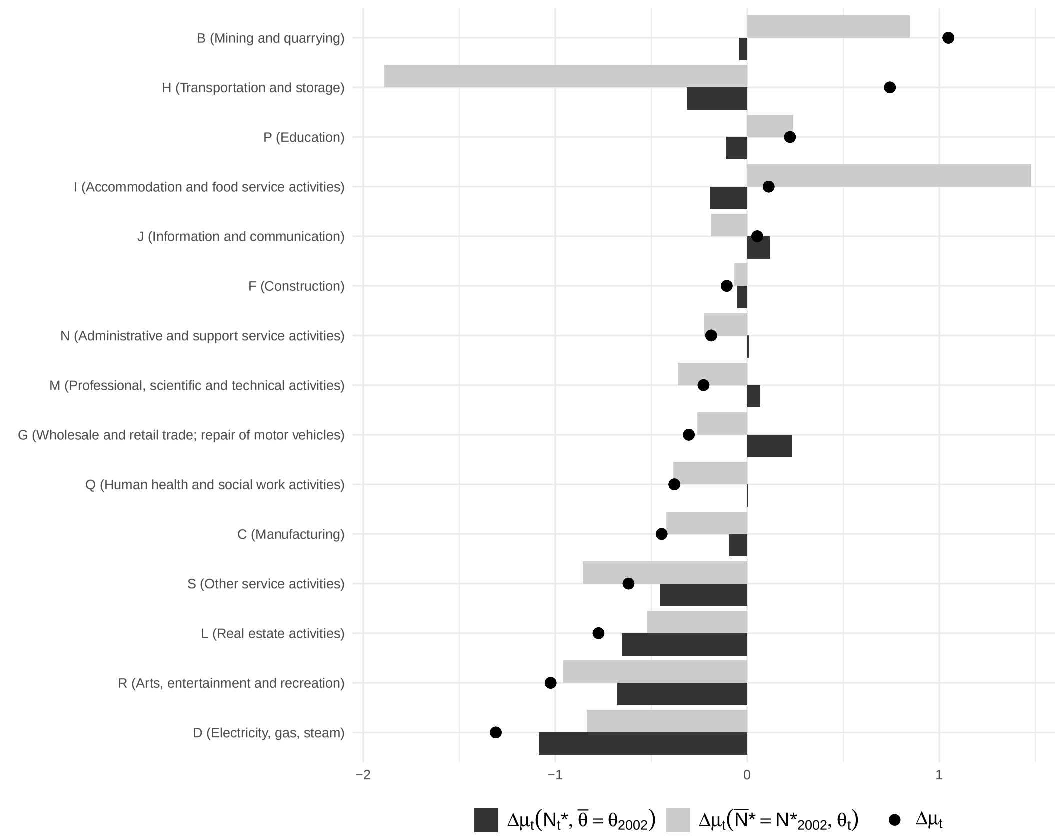
Figure 4: Counterfactual path of the markups with fixed either price elasticity of demand or concentration



Note: The series denoted by μ_t is the weighted average of markup, as measured in the data (see Figure 1). The series denoted by $\mu_t\left(\bar{N}^* = N^*_{2002}, \theta_t\right)$ is the counterfactual path of the markups with the number of symmetric firms that is fixed at the initial value, i.e., value in 2002. It measures the effect of changes in price elasticity of demand. The term $\mu_t\left(N^*_t, \bar{\theta} = \theta_{2002}\right)$ quantifies the effect of changes in concentration since the demand elasticity is fixed.

concentration was actually a counteracting factor. This observation also applies to many industries. However, the industry level analysis reveals also a substantial heterogeneity of outcomes, opening a floor for the econometric analysis. Moreover, our theoretical model does not allow to investigate the reasons for the increase in elasticity. Thus, in the next section we will use econometric techniques to gauge what structural factors affected both price elasticity of demand and markups. Beforehand, we discuss the robustness of our main results with respect to the choice of the conduct parameter r and to the alternations in the identification scheme of markups.

Figure 5: Counterfactual changes in the markups with fixed either price elasticity of demand or concentration at the industry level (2002-2016)



Note: The series denoted by $\mu_t\left(\bar{N}^* = N^*_{2002}, \theta_t\right)$ is the counterfactual change of the markups with the number of symmetric firms that is fixed at the initial value, i.e., value in 2002. It measures the effect of changes in price elasticity of demand. The term $\mu_t\left(\bar{N}^*_t, \bar{\theta} = \theta_t\right)$ quantifies the effect of changes in concentration since the demand elasticity is fixed.

4.1 Robustness check - the choice of conduct

In the baseline calculations we assumed a Cournot equlibrium, corresponding to $r = 0$. This choice seems to be restrictive, but is of limited consequence for our main results, as long as the conduct parameter is time-invariant. In our calculation method the choice of r pins down only the level of price elasticity of demand θ, as depicted on the left panel of Figure A2 in the Appendix. However, the changes in price elasticity of demand, for a given conduct r, are determined by changes in both N^* and μ, as shown in Equation (9), and are the same for different levels of conduct, as presented in the right panel of Figure A2 in the Appendix (plotting the index 2002=1). Thus, the counterfactual paths of markups μ presented in Figure 4 do not change, as long as the conduct parameter is constant.

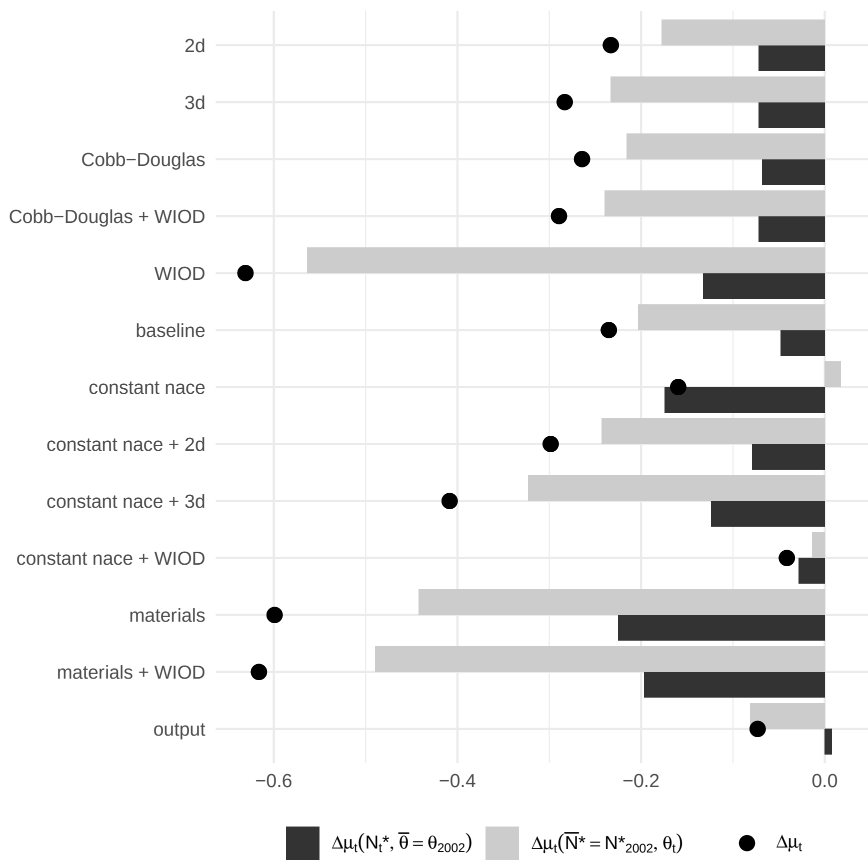
The invariance of our counterfactual paths to the choice of conduct is of course a desired property, as long as one is interested in the analysis of the sources of changes of markups or changes in the price elasticity of demand. If one seeks to determine the level of θ, then the choice of r is important and should be based on separate empirical evidence.

4.2 Robustness check – the alternative estimates of the markups

In our second robustness check we pay more attention to a sensitivity of main results to empirical strategy of measuring markups. Recall that in our baseline settings we exploited the markup estimates that are based on specific assumptions about the firm-level production function. Here we consider alternative estimates of markups that are based on a different set of assumptions related to the firm-level production function. First, we relax the assumption on homogeneity of the translog parameters across industries. There is a natural trade-off between efficiency gain from a large size of industry and heterogeneity of the production function parameters. Therefore, the production functions are estimated separately for (i) the two-digit NACE industries, (iii) three-digit NACE industries, and (iii) the industries aggregated by the WIOD classification. Second, we restrict the production function to a Cobb-Douglas. Third, we add materials as a production factor and estimate the production function for the gross output instead of the value added. In this case, we also check the robustness against using materials instead of intermediate consumption as a proxy variable. Forth, we consider also the effect of firm-level changes in NACE classification. Many firms have changed their NACE classification through their lifespan. On the one hand, it could be related to a change in nature of economic activity. On the other hand, it might lead to unexpected variations of key economic variables utilized in the estimation of production function. Thus, we construct real variables and estimate the production function holding fixed the NACE classification of the firm.

The counterfactual changes of markups (cumulated for the whole 2002-2016 period) for alternative measures of markups are depicted on the Figure 6. It is straightforward

Figure 6: Counterfactual cumulative changes in the alternative measure of markups with fixed either price elasticity of demand or concentration at the industry level (2002-2016)



Note: The series denoted by $\mu_t\left(\bar{N}^* = N^*_{2002}, \theta_t\right)$ is the counterfactual change of the markups with the number of symmetric firms that is fixed at the initial value, i.e., value in 2002. It measures the effect of changes in price elasticity of demand. The term $\mu_t\left(\bar{N}^*_t, \bar{\theta} = \theta_t\right)$ quantifies the effect of changes in concentration since the demand elasticity is fixed.
Alternative measurement of markups: *2d* – production function estimates at the two digits industry level, *3d* – production function estimates at the three digits industry level, *WIOD* – production function estimates at the WIOD aggregation industry level, *Cobb-Douglas* – the Cobb-Douglas production function estimates, *constant nace* – recalculation of real variables and production function estimation with a fixed industry classification, *output* – the production function for output (with materials as a proxy variable), *materials* – the production function with materials as a proxy variable.

to observe that there is a compelling evidence that the markups felt in the Polish economy between 2002 and 2016, irrespectively of the identification strategy. However, there is a substantial heterogeneity in the scale of decline, ranging from −0.6 (the markups estimates basing on the WIOD industries and the results using materials as a proxy variable) to −0.05 (the markups estimates corresponding to fixed NACE classification and the WIOD-level estimates of the production function). Nevertheless, in the majority of cases the fall in the price elasticity of demand was the key force pushing markups down. The cumulated changes of concentration also contributed to a decline of markups, although to a lesser extent.

5 Econometric analysis

In this section we analyze the empirical link between price elasticity of demand and its potential drivers. We also perform the analysis for markups since some of the drivers of the demand elasticity could also affect markups directly. It also allows us to indicate factors that affect solely markups or demand elasticities.

Our empirical analysis is performed on a 2-digit NACE industrial aggregation. This choice (related to the definition of a homogeneous product) is mainly data-driven. Most of the potential determinants of the price elasticity of demand and markups are measured using the World Input-Output database (WIOD, Timmer et al., 2015, explained below), which is available for a 2-digit NACE classification.

We consider here the following regression:

$$\theta_{jt} = \mathbf{x}'_{jt}\beta + \varepsilon_{jt}, \tag{14}$$

where θ_{jt} is the price elasticity of demand, $\mathbf{x}_{jt}$ is a set of explanatory variables and ε_{jt} denotes the error term which is assumed to be idiosyncratic. We also consider an analogous regression explaining the variation in markups:

$$\mu_{jt} = \mathbf{z}'_{jt}\gamma + \omega_{jt}, \tag{15}$$

where μ_{it} is the markup in the j-th industry, $\mathbf{z}_{jt}$ is a set of explanatory variables and ω_{jt} is the error term. To control for systematic differences between industries we included the industry fixed effects in all regressions. Furthermore, we also tried to account for common unobservable factors by introducing time effects in (14) and (15).

For the sake of brevity, we consider regressions explaining variation in θ as well as in μ. As it has been explained in the theoretical section, the changes in price elasticity of demand could be transmitted into changes in markups. If some factors affect both markups and demand elasticity then the signs of β and γ should be opposite. Note that if the x'_{jt} equals z'_{jt} and combining with (10) there is a non-linear negative relationship between the parameters of both regressions, i.e., $\beta = -\gamma \left(1/N^*\right)\left(\gamma x_{jt} - 1\right)^2$. We try to take into account both these considerations.

First, we use the fact, that in the range of common explanatory variables the relationship between β and γ is expected to be negative. Second, we additionally estimate a set of regressions with the second degree polynominals of explanatory variables to approximate potential non-linearities.

A key empirical problem in estimating underlying parameters of especially (14) is a substantial variation in the calculated θ_{jt}. Recalling the derivation of the price elasticity of demand (10), it is straightforward to observe that the effect of small changes in markups on θ can be extreme in industries with gross markups very close to one. This implies that the variation in some industries could be immense due to the appearance of outliers. We address this issue by applying a robust regression technique. The concept of a robust regression is to limit the importance of outlying observations. The detailed procedure is as follows. First, observations with above unitary Cook's distance, which measures the effect of omitting observation on estimation results, are excluded. Second, the weighted least squares estimator is iteratively applied with weights calculated using the residuals from the previous step.

To provide a systematic investigation on potential drivers of the markups and price elasticities of demand, we use a set of industry characteristics that are calculated based on the WIOD database Timmer et al. (2015). These indicators allow us to measure both the industry differences in the general features of the production function (e.g. the role of intermediates) and a different exposure of a industry to a foreign economy, measured using various characteristics. Thus, our set of regressors i.e. $\mathbf{x}_{jt}$ and $\mathbf{z}_{jt}$, includes: the share of intermediates in the gross output ($\mathcal{INT}_{jt}$), the share of directly imported final goods in the final demand of a given industry (denoted as $\mathcal{IMP}_{jt}^{\mathcal{FD}}$), the share of exports in the gross output ($\mathcal{EXP}_{jt}$). Moreover, we use indicators capturing the participation in international production fragmentation. These include: the foreign value added at export (measuring the share of imported intermediates in exports, $\mathcal{FVAX}_{jt}$) and the upstreamness index, which measures the distance to the final demand ($\mathcal{UPS}_{ij}$). All variables with the corresponding descriptive statistics are described in Table A1 in the Appendix.

5.1 Baseline regressions

We start our analysis with the linear model. Table 1 presents the results of the baseline estimation. In each two-column block we present the estimates from regression for the demand elasticities and markups, respectively. The first two blocks contain only the industry effects while the third and fourth block includes additionally time fixed effects in order to control for a potential cross-sectional dependence. The second and fourth block distinguishes additionally export intensity in final and intermediate goods.

In most cases the estimates in the markup equations have an opposite sign than in the equations for the price elasticity of demand. This suggests that a given factor

Table 1: The regression results for the price elasticity of demand and markups

	θ	μ	θ	μ	θ	μ	θ	μ
$\mathcal{IMP}^{\mathcal{FD}}_{jt}$	-0.061***	0.330*	-0.075***	0.635***	-0.052*	0.399*	-0.066**	0.827***
	(0.027)	(0.200)	(0.028)	(0.212)	(0.030)	(0.205)	(0.031)	(0.217)
$\mathcal{INT}_{jt}$	-0.200***	2.600***	-0.204***	2.792***	-0.203***	2.293***	-0.206***	2.519***
	(0.042)	(0.314)	(0.042)	(0.323)	(0.050)	(0.339)	(0.050)	(0.354)
$\mathcal{EXP}_{jt}$	0.088***	0.374**			0.090***	0.345**		
	(0.022)	(0.161)			(0.025)	(0.169)		
$\mathcal{EXP}^{\mathcal{FIN}}_{jt}$			0.134***	0.009			0.126***	-0.142
			(0.032)	(0.242)			(0.034)	(0.242)
$\mathcal{EXP}^{\mathcal{INT}}_{jt}$			0.032	0.888***			0.048	1.012***
			(0.028)	(0.215)			(0.032)	(0.229)
$\mathcal{FVAX}_{jt}$	0.268***	-5.343***	0.281***	-5.589***	0.243***	-5.350***	0.249***	-5.914***
	(0.049)	(0.368)	(0.050)	(0.378)	(0.077)	(0.520)	(0.077)	(0.546)
$\mathcal{UPS}_{jt}$	0.004	-0.135**	0.011	-0.187***	0.004	-0.130**	0.009	-0.207***
	(0.008)	(0.060)	(0.009)	(0.068)	(0.009)	(0.062)	(0.010)	(0.069)
Constant	-0.309***	1.063***	-0.311***	1.078***	-0.342***	1.485***	-0.346***	1.581***
	(0.030)	(0.222)	(0.031)	(0.236)	(0.035)	(0.241)	(0.036)	(0.253)
Observations	582	582	582	582	582	582	582	582
Industry effects	✓	✓	✓	✓	✓	✓	✓	✓
Time effects					✓	✓	✓	✓

Note: the superscripts ***, ** and * denote the rejection of null about parameters' insignificance at 1%, 5% and 10% significance level, respectively. The expressions in round brackets stand for standard errors. The detailed description of explanatory variables is delegated to Table A1.

drives price elasticity of demand and its effect is transmitted into markups in a way that is consistent with the theory we use. For instance, the estimates on intermediates share in output ($\mathcal{INT}_{jt}$) are negative in the demand elasticity regression while they are significantly positive in the regression for markups. A possible explanation of this effect refers to the product standardization. If the industry delivers more intermediates its products are probably more standardized because they need to share common features with similar intermediates produced by the other firms. Thus, the higher degree of standardization translates into lower variety pushing down demand elasticity and rising markups.

The price elasticity of demand (markups) is negatively (positively) related to the share of directly imported goods in the final demand ($\mathcal{IMP}_{jt}^{\mathcal{FD}}$). This relationship seems to be counterintuitive. From the perspective of an importing country a rising share of imported final goods in total supply of goods on the market might be perceived as an increase in variety of available goods. As a result it should move up the price elasticity of demand. However, our estimation results are inconsistent with the above intuition. A potential explanation for the negative relationship between price elasticity of demand and import content of final demand might be related to a home bias. If domestic consumers prefer purchasing domestic rather than imported goods the rising share of foreign products drives the price elasticity of demand down and domestic firms yield higher markups.

The estimation results also imply that the international fragmentation of production affects both price elasticity of demand and markups. This is captured by the estimates on the foreign value added at exports ($\mathcal{FVAX}_{jt}$), which is a a typical proxy of backward participation in Global Value Chains and it measures the import content of gross exports. Imported intermediates usually embed specific technologies that are probably not available for domestic suppliers. Thus, there are opposite signs for the estimated effects of $\mathcal{FVAX}_{jt}$ and $\mathcal{INT}_{jt}$. One possible explanation of the specific role of the imported inputs used in the export-oriented production could be fact that the imported intermediates allow to upgrade the quality of offered goods (allowing firms in a converging economy to access foreign markets). However, the usage of imported intermediates makes the exported product a closer substitute to products existing on a global market. Thus, such product gets more standardized, translating into a higher price elasticity and a decrease in markups.

So far we explained cases with the opposite signs of the underlying estimates for price elasticity of demand and markups but it is not always the case. For instance, the distance from final demand $\mathcal{UPS}_{jt}$ affects markups negatively, but it simultaneously has no effect on the price elasticity of demand. The negative estimate suggest that more distant is an industry from the final demand, the lower the markup it may charge.

More strikingly, the estimated effect of the export intensity is incoherent, i.e., it is positive for both markup and price elasticity of demand. Despite this inconsistency it can be explained as follows. On the one hand, in case of the price elasticity of demand, the positive relationship can be related to a larger variety of goods that is faced by domestic firms in foreign markets. Foreign consumers have probably a better access to a global market with more varieties. However, this effect is not transmitted into lower markups of domestic firms. On the other hand, export intensity seems to directly push the markups up. This, in turn, may be related to the export premium (see e.g. De Loecker and Warzynski, 2012). To better understand the above ambiguity we consider additional regressions, in which the export intensity is divided into: (i) exports of final goods and (ii) exports of intermediates. The estimation results suggest that the export premium is important mostly for producers of intermediates while for them the variety effect for demand elasticity is insignificant. Exporters of final goods are in turn affected only by the positive effect of varieties on the price elasticity of demand they face.

5.2 Non-linear regressions

In the next step, we consider a non-linear relationships between price elasticity of demand and the variables of interest. The previous estimation results occurs to be inconsistent because (contrary to the theoretical background discussed in the Section 2) the signs are not always opposite. Therefore, we introduce a more flexible functional form and extend our regression by introducing quadratic terms. It allows to control for a complex nature of structural factors affecting industries. Moreover, the inclusion of polynomials allows to address the possible non-linearities across variables, as predicted e.g. by equation 9.

Table 2 summarizes the extended set of the estimation results, while the implied extrema of estimated relationships are presented in Table A2 in the Appendix. It turns out that the relationship between the share of imported final goods and price elasticity of demand is U-shaped. In industries offering mostly domestic final goods the home bias plays a crucial role. When the share of imported final goods is raising the home bias effect is offset by an effect of increasing varieties. For final goods, which are mostly imported, the positive role of the variety effect is predominant in shaping demand elasticity. However, this effect is not transmitted into markups.

A non-linear relationship explains well some previous ambiguity in the results. Namely, the link between the export intensity and the price elasticity of demand (markup) is hump-shaped (inverted U-shaped). On the one hand, for sectors with less internationally traded goods the export expansion translates into higher price elasticity of demand since consumers at foreign markets have an access to a higher variety of available goods. As a results, a shift toward foreign sales moves up demand elasticity in such industries and triggers the fall of markups. On the other hand, as firms become more focused on foreign sales this effect is weakened. It can be related to a larger dependence of foreign consumers on these products, driving the price elasticity of demand down and markups up. Although the signs in regression explaining θ_{jt} and μ_{jt} are consistent, these effects operate through different channels

Table 2: The regression results for the price elasticity of demand and markups (quadratic relationship)

	θ	μ	θ	μ	θ	μ	θ	μ
$\mathcal{IMP}^{\mathcal{FD}}_{jt}$	-0.249***	-0.061	-0.201***	-0.074	-0.249***	0.036	-0.199***	-0.286
	(0.058)	(0.434)	(0.058)	(0.418)	(0.063)	(0.441)	(0.064)	(0.434)
${\mathcal{IMP}^{\mathcal{FD}}_{jt}}^2$	0.299***	-0.228	0.185***	-0.362	0.317***	-0.565	0.193***	-0.221
	(0.058)	(0.435)	(0.056)	(0.402)	(0.062)	(0.435)	(0.060)	(0.405)
$\mathcal{INT}_{jt}$	-0.634***	-0.407	-0.652***	0.000	-0.526***	-1.040	-0.542***	-0.249
	(0.157)	(1.176)	(0.162)	(1.162)	(0.183)	(1.284)	(0.185)	(1.258)
$\mathcal{INT}^2_{jt}$	0.457***	2.483**	0.453***	2.067**	0.391***	2.058*	0.383**	1.536
	(0.136)	(1.022)	(0.141)	(1.009)	(0.150)	(1.056)	(0.153)	(1.042)
$\mathcal{EXP}_{jt}$	0.215***	-0.536*			0.211***	-0.513*		
	(0.039)	(0.292)			(0.043)	(0.300)		
$\mathcal{EXP}^2_{jt}$	-0.241***	1.867***			-0.254***	2.192***		
	(0.049)	(0.365)			(0.053)	(0.373)		
$\mathcal{EXP}^{\mathcal{INT}}_{jt}$			0.011	-2.615***			-0.048	-1.900***
			(0.077)	(0.555)			(0.082)	(0.557)
${\mathcal{EXP}^{\mathcal{INT}}_{jt}}^2$			-0.112	7.077***			-0.038	6.143***
			(0.118)	(0.849)			(0.126)	(0.856)
$\mathcal{EXP}^{\mathcal{FIN}}_{jt}$			0.327***	1.460**			0.354***	1.347**
			(0.088)	(0.628)			(0.095)	(0.644)
${\mathcal{EXP}^{\mathcal{FIN}}_{jt}}^2$			-0.337***	-0.111			-0.377***	0.006
			(0.097)	(0.698)			(0.105)	(0.716)
$\mathcal{FVAX}_{jt}$	0.273*	0.961	0.311*	-0.986	0.078	3.367**	0.117	1.162
	(0.160)	(1.201)	(0.165)	(1.186)	(0.242)	(1.698)	(0.240)	(1.631)
$\mathcal{FVAX}^2_{jt}$	-0.028	-10.564***	-0.062	-6.451***	0.169	-12.383***	0.125	-8.148***
	(0.213)	(1.601)	(0.220)	(1.580)	(0.278)	(1.953)	(0.277)	(1.880)
$\mathcal{UPS}_{jt}$	0.205***	-1.440***	0.189***	-1.680***	0.204***	-1.611***	0.192***	-1.713***
	(0.041)	(0.309)	(0.044)	(0.318)	(0.045)	(0.314)	(0.048)	(0.329)
$\mathcal{UPS}^2_{jt}$	-0.049***	0.364***	-0.042***	0.434***	-0.049***	0.421***	-0.043***	0.448***
	(0.010)	(0.073)	(0.011)	(0.075)	(0.011)	(0.075)	(0.012)	(0.079)
Constant	-0.365***	1.689***	-0.333***	1.979***	-0.406***	1.526***	-0.370***	1.660***
	(0.050)	(0.373)	(0.051)	(0.367)	(0.054)	(0.381)	(0.055)	(0.377)
Observations	582	582	582	582	582	582	582	582
Industry effects	✓	✓	✓	✓	✓	✓	✓	✓
Time effects					✓	✓	✓	✓

Note: the superscripts ***, ** and * denote the rejection of null about parameters' insignificance at 1%, 5% and 10% significance level, respectively. The expressions in round brackets stand for standard errors. The detailed description of explanatory variables is delegated to Table A1.

(see the 3rd and 4th columns of Table 2). The price elasticity of demand is mainly linked to the exports of final goods while exports of intermediates shapes predominantly the markups.

The implied relationship between the distance from the final demand and the demand elasticity is inverted U-shaped. This suggest that firms operating in the middle stages of the production chain face higher demand elasticity. The above link is unambiguously transmitted into markups which leads to the so-called smile curve, describing a U-shaped relationship between the position in the production chains and markups (a similar effect was also described in Gradzewicz and Mućk, 2024). In addition, this empirical pattern is consistent with the smile curve hypothesis, which predicts that the gains are evenly distributed across the vertically specialized production chain. In this vein, Timmer et al. (2014) or Meng et al. (2020) show that the gains from the GVC participation are the highest for firms that are either at the beginning of the production process (e.g. R&D, design) or very close to the final use (e.g. marketing, advertising, post-sale services).

Importantly, the effect of the fragmentation of production is amplified by international integration. This is captured by the negative estimates on the squared foreign value added at exports, as well as (previously discussed) the relationship with the export intensity. Intuitively, as production becomes more vertically specialized and firms use more imported intermediates, their products become more standardized which limits their market power.

Summing up, the above estimates illustrate that the impact of structural changes is quite heterogenous among industries. Nevertheless, it is straightforward that the international fragmentation of production (international vertical specialization) has driven price elasticity of demand and this effect has been transmitted into the markups changes in a way that is consistent with the theory we use. Concurrently, there are other factors, like the interplay between home bias and the variety of goods, that are affecting price elasticity of demand, but their impact is not passed into the markups.

6 Conclusions

The aim of the article is to investigate the theoretical link and assess the empirical role that the concentration and the price elasticity of demand have on the evolution of markups. We use a dataset for Poland as it offers an interesting and non-trivial example – despite the rising concentration on the aggregate level, the aggregate markups are falling, as documented by Gradzewicz and Mućk (2024).

We utilize the conjectural variation theory (see Bresnahan, 1989) to show the relation between markups and concentration and to separate the changes in markups into two components, one related to the supply (number of symmetric firms) and one related to the demand (the price elasticity of demand). It is consistent with the excellent discussion in Syverson (2019). To the best of our knowledge it is the first attempt to show the sources of markup changes. Using a dataset for Poland we empirically show the importance of changes in the price elasticity of demand for the development of markups, both at the aggregate level and in most industries. We showed that the observed decline of markups can, to a large extent, be attributed to rising perceived price elasticity of demand. One should bear in mind, that our results rest on a number of relatively strong assumptions, including profit optimization under firms' market power, a constant conduct in the market, and a symmetry of firm sizes, as measured in the data.

We refrain from building a full demand system on top of the enterprise sector to understand the movements of price elasticity of demand. Instead we use the econometric techniques to check the significance of possible factors affecting price elasticity of demand on a sectoral level. We do not observe any direct empirical counterpart to product substitutability, but instead we use measures of changes in the structure of demand faced by production sectors. The underlying logic is as follows: if various sources of demand have different price elasticities then changes in the structure of demand should change the effective demand elasticity. We use measures related to globalization as during the period of the analysis the Polish enterprise sector was significantly influenced by the globalization forces.

We empirically show that measures of industry structure affect both the price elasticity of demand and markups, but in an inverse way, consistently with the theory we use. Moreover, our analysis suggest that most relations are non-linear. Our econometric results indicate that the share of intermediates in gross output exhibits an U-shaped relationship with price elasticity of demand (and is predominantly negative). The share of exports in gross output exhibits mostly positive, but generally an inverted U-shaped relationship with the price elasticity of demand, reflecting the interplay of the effects of the variety and the export premium. The share of imported intermediates in exports (foreign value added at exports) exhibits an inverted U-shaped relationship, but only with markups. This is expected, because it is a factor affecting firms' costs and not the demand. Moreover, the price elasticity of demand seems to be an invered U-shaped function of the distance to the final demand and a U-shaped function of the share of directly imported final goods in the final demand. Our results indicate that the globalization has a non-trivial and highly non-linear effect on the production sectors of the economy.

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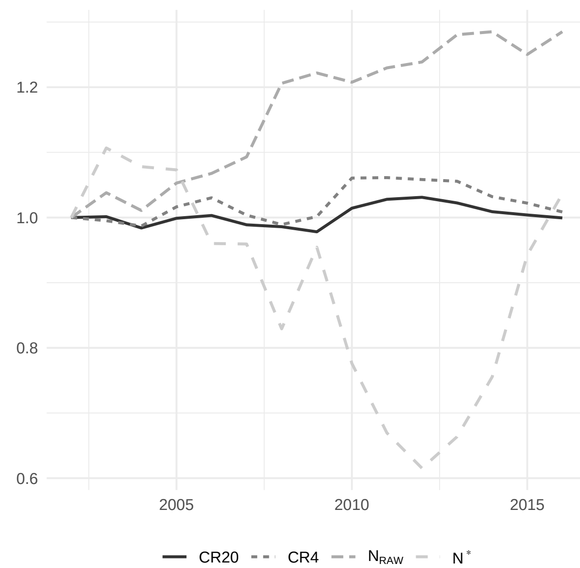
A Additional figures and tables

Figure A1: Changes in the concentration in the Polish economy (2002=1)



Note: CR20 and CR4 - market shares of 20 and 4 firms with the largest sales, respectively, calculated for each 3-digit NACE industries separately and averaged across industries using sales as weights, expressed as an index 2000 = 1. N_{raw} - a number of firms in the dataset. N^* - a number of symmetric firms in the dataset.

Figure A2: Price elasticity of demand (θ) for different values of conduct (r), right panel - levels of θ, left panel - index 2002=1

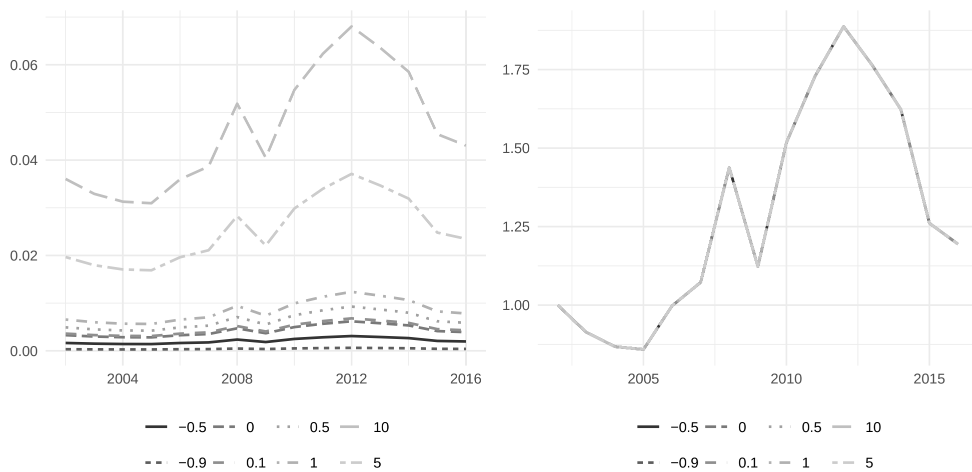


Table A1: Description and descriptive statistics of the explanatory variables

Description of explanatory variables	
$\mathcal{IMP}^{\mathcal{FD}}_{jt}$	the share of directly imported final goods in final demand of a given industry
$\mathcal{INT}_{jt}$	the share of intermediates in gross output
$\mathcal{EXP}_{jt}$	the share of exports in gross output
$\mathcal{EXP}^{\mathcal{FIN}}_{jt}$	the share of exports of final goods in gross output
$\mathcal{EXP}^{\mathcal{INT}}_{jt}$	the share of exports of intermediates in gross output
$\mathcal{FVAX}_{jt}$	the foreign value added at export calculated with using the method proposed by Wang et al. (2013)
$\mathcal{UPS}_{it}$	the upstreamness index which measures the distance of a given industry from final demand calculated using the method proposed by (Antras et al., 2012)

Descriptive statistics							
	mean	max	min	p25	p5	p75	p95
$\mathcal{IMP}^{\mathcal{FD}}_{jt}$	0.238	0.978	0.002	0.022	0.004	0.408	0.850
$\mathcal{INT}_{jt}$	0.540	0.847	0.193	0.431	0.298	0.655	0.773
$\mathcal{EXP}_{jt}$	0.266	0.940	0.003	0.066	0.006	0.417	0.782
$\mathcal{EXP}^{\mathcal{FIN}}_{jt}$	0.106	0.766	0.000	0.010	0.002	0.113	0.473
$\mathcal{EXP}^{\mathcal{INT}}_{jt}$	0.160	0.594	0.001	0.040	0.003	0.279	0.441
$\mathcal{FVAX}_{jt}$	0.204	0.565	0.048	0.123	0.083	0.273	0.401
$\mathcal{UPS}_{jt}$	2.324	3.523	1.111	1.841	1.250	2.706	3.321

Table A2: The implied extrema

	θ	μ	θ	μ	θ	μ	θ	μ
$\mathcal{IMP}_{jt}^{\mathcal{FD}}$	0.418***	-0.134	0.546***	-0.102	0.392***	0.032	0.514***	-0.648
	(0.051)	(1.179)	(0.090)	(0.676)	(0.055)	(0.370)	(0.093)	(2.085)
$\mathcal{INT}_{jt}$	0.694***	0.082	0.720***	-0.000	0.672***	0.253	0.707***	0.081
	(0.069)	(0.205)	(0.075)	(0.281)	(0.087)	(0.195)	(0.097)	(0.358)
$\mathcal{EXP}_{jt}$	0.446***	0.144**			0.414***	0.117**		
	(0.052)	(0.058)			(0.053)	(0.054)		
$\mathcal{EXP}_{jt}^{\mathcal{INT}}$			0.049	0.185***			-0.639	0.155***
			(0.301)	(0.022)			(3.133)	(0.028)
$\mathcal{EXP}_{jt}^{\mathcal{FIN}}$			0.486***	6.569			0.469***	-108.146
			(0.067)	(38.816)			(0.062)	(12,483.011)
$\mathcal{FVAX}_{jt}$	4.805	0.046	2.505	-0.076	-0.231	0.136***	-0.467	0.071
	(33.482)	(0.050)	(7.667)	(0.110)	(1.086)	(0.049)	(1.963)	(0.085)
$\mathcal{UPS}_{jt}$	2.089***	1.979***	2.242***	1.934***	2.062***	1.913***	2.228***	1.911***
	(0.088)	(0.090)	(0.122)	(0.082)	(0.099)	(0.084)	(0.134)	(0.083)
Observations	582	582	582	582	582	582	582	582
Industry effects	✓	✓	✓	✓	✓	✓	✓	✓
Time effects					✓	✓	✓	✓

Note: The implied extrema base on estimation results that are reported in Table 2. The superscripts ***, ** and * denote the rejection of null about parameters' insignificance at 1%, 5% and 10% significance level, respectively. The expressions in round brackets stand for standard errors which are calculated using delta method. The detailed description of explanatory variables is delegated to Table A1.