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Modelling cyclical variation in the cost pass-through: a regime-dependent approach

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Abstract. In this study a regime-dependent ARDL model is developed in order to investigate how labour costs feed through into prices conditional on the business cycle position. Its estimates enable inference on the cyclical behaviour of markups. The proposed methodology is applied to the Polish industrial sectors. The obtained estimates point to procyclicality as the prevailing pattern of markup adjustment. Thus, overall markups in the Polish industry seem to have a mitigating effect on business cycle fluctuations. The degree of procyclicality seems, however, to be positively correlated with the degree of the industry's competitiveness.

Keywords: non-linear cointegration, regime-dependence, cost pass-through, markup cyclicality
JEL: Classification: C22, E31, E32

1. Introduction

Wage rigidity is commonly thought to be the cause of unemployment in the wake of adverse shocks, thus increasing the depth and prolonging the duration of a downturn. Following the same line of thought, wage flexibility is often perceived as an absorption mechanism, with wage concessions in economic slack hypothesised to facilitate job protection, boost international competitiveness (and exports) and, consequently, contribute to the containment of negative shocks. This belief, widely held in policy-making circles, hinges upon a classical assumption of the interchangeability between price and quantity adjustments of labour force, with either wages or employment bearing the brunt of the shock. However, as argued in recent literature (see Gali, 2013 and Galí & Monacelli, 2016), wage concessions affect labour demand and, hence, employment, only if they affect prices and induce monetary policy response in the form of interest rate cuts, thus stimulating the demand for goods. The effectiveness of downward wage adjustments in containing adverse shocks is, as demonstrated, conditional upon the degree of price rigidity. In particular, if falling wages do not reduce prices, wage flexibility may have little or no effect on the output and, consequently, employment outcomes. In such circumstances wage decreases may spur contractionary effects. It is then the interrelation between the wage- and price-flexibility that is central to the mechanism of business cycle propagation, rather than the wage flexibility alone. If prices are set up as a markup over marginal costs, it is the cyclical behaviour of the markup that determines the shock-absorption capacity of wage adjustments.

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Empirical evidence on markup cyclicality is abundant, yet notoriously unrobust. Extracting the markup series is one of the most challenging empirical issues in macroeconomics (Nekarda & Ramey, 2013). Theoretically, markups can be derived by comparing prices and marginal costs. The latter, however, are not observable, leading to a number of approximations having been proposed in the literature, e.g. taking account of the evolution of the Solow residual (Hall, 1986, 1988; Roeger, 1995), the labour share (Bils, 1987), inventories (Bils & Kahn, 2000), advertising spending (Hall, 2012) or through adjusting average costs series (Galí et al., 2007; Martins & Scarpetta, 2002; Rotemberg & Woodford, 1991, 1999). The results obtained for the U.S. industrial sectors using the above-mentiond techniques are suggestive of the pro- (e.g. Chirinko & Fazzari, 1994; Domowitz et al., 1986, 1988; Hall, 2012; Nekarda & Ramey, 2013) and counter-cyclicality (e.g. Bils, 1987; Bils & Kahn, 2000; Martins & Scarpetta, 2002; Rotemberg & Woodford, 1999) of markups.

Since the conclusions on the markup behaviour depend heavily on the estimation method, in this study we bypass the estimation of markups and instead propose to investigate how labour costs feed through into prices conditional on the business cycle position. For this purpose we develop a regime-dependent ARDL model of cost pass-through, extending the asymmetric ARDL model by Shin et al. (2014). The proposed methodology does not allow for the derivation of markup series but instead enables the capture of the interrelation between wage and price adjustments over the business cycle, i.e. the degree of pass-through. Nonetheless, a large body of literature (i.a. Atkeson & Burstein, 2008; Goldberg & Hellerstein, 2013; Gopinath et al., 2010; Hellerstein, 2008; Nakamura, 2008; Nakamura & Zerom, 2010) identifies time-varying markups as one of the most important determinants of the pass-through variation.[1] Thus, the estimation results allow us to assess whether markup behaviour has a mitigating or amplifying effect on business cycle fluctuations. On this basis, conclusions can be drawn on whether wage flexibility and moderation constitute an appropriate policy prescription for the economic stabilisation. The Polish industry serves as an application example.

The paper is organised in the following way: Section 2 gives a theoretical background, Section 3 outlines the methodology employed in the study and discusses the empirical strategy, i.e. our approach to investigating business cycle dependence in the cost pass-through, and Section 4 presents the empirical results. The last section summarises our findings.

[1] It should be borne in mind that when comparing the trajectories of labour costs and prices, we do not control for other costs, in particular the cost of intermediate inputs and capital. Therefore, precisely speaking, our conclusions pertain to 'wage markups'.

2. Theoretical notes

The behaviour of markups over the business cycle is an unresolved issue in theoretical economics. Depending on the underlying assumptions, theoretical models predict different outcomes regarding markup cyclicality. The Phelps & Winter model (1970) predicts procyclicality by assuming that when firms anticipate higher demand in the future, they lower prices in order to expand their consumer base. In the Green and Porter model (1984), firms cannot observe the reason behind falling market demand and, thus, misinterpret economic slack as other firms' cheating. It is, therefore, harder to sustain collusion in recessions, which leads to procyclical markups. In the model proposed by Rotemberg and Saloner (1986), the changing ability of firms to collude is also the main driver of cyclical variation in markups, but the assumption that the benefits of cheating are proportional to the current demand renders collusion harder to sustain in economic upturns than downturns. Thus, the model predicts countercyclicality of markups. Growing competition during economic booms is also the driving force behind procyclical markups in the Rotemberg and Woodford (1992) model. In Bils (1989), Klemperer (1995), Okun (1981) and Stiglitz (1984), markups are predicted to rise in recessions due to lower price elasticity of the demand and, thus, higher pricing power of firms. Additionally, Stiglitz (1984) suggests that by lowering the markup during economic booms, incumbent firms deter others from entering the market. In turn, Chevalier and Scharfstein (1996), Gilchrist et al. (2017), Gottfries (1991) and Greenwald et al. (1984) attribute countercyclicality of markups to capital market imperfections that constrain the ability of firms to obtain external financing, especially during recessions. The subsequent liquidity squeezes force firms to raise profit margins.

The explanation to this lack of robustness in theoretical perditions can be provided by the recent advances in the pass-through literature. As derived by Weyl and Fabinger (2013), a general formula for the cost-price pass-through (ρ), applicable to a wide range of market settings (perfect competition, monopoly, symmetric imperfect competition) takes the following form:

$$\rho = \frac{1}{1 + \frac{\varepsilon_D}{\varepsilon_S} - \frac{\theta}{\varepsilon_S} + \theta\varepsilon_\theta + \frac{\theta}{\varepsilon_{ms}}}, \tag{1}$$

where:
ε_D is the elasticity of demand,
ε_S is the elasticity of supply,

ε_{ms} is the elasticity of marginal consumer surplus, measuring the curvature of demand,
θ is a conduct parameter, ranging from 0 for perfect competition to 1 for monopoly (see Genesove & Mullin, 1998),
$\varepsilon_\theta = \frac{\partial\theta}{\partial q}\frac{q}{\theta}$ is the elasticity of the conduct parameter with respect to quantity (q).

The pass-through depends, therefore, on the shape of the demand and supply curves as well as on the intensity of competition. Under perfect competition ($\theta = 0$) the pass-through rate hinges solely upon the relative slopes of demand and supply. *Ceteris paribus*, the steeper the demand curve (the less responsive the demand to changes in prices) or the flatter the supply curve (the more responsive the output to changes in prices), the higher the degree of pass-through. Under oligopolistic and monopolistic settings not only the slope, but also the curvature of the demand function plays a role. *Ceteris paribus*, the pass-through will be higher if the demand is log-convex (i.e. $\frac{1}{\varepsilon_{ms}} < 0$).

The role played by the intensity of competition in determining the pass-through rate is less straightforward, since it depends on the shape of the demand and supply functions. All else being equal, the pass-through increases with the intensity of competition, providing that the demand is log-concave and decreases in the case of log-convex demand. The impact of changing competitive conduct on firms' ability to pass through costs depends also upon the shape of the cost function. In the case of increasing returns to scale, growing intensity of competition provides cost-absorption, whereas under decreasing returns it amplifies the cost changes. Therefore, the degree of pass-through diminishes with growing competition in the case of downward sloping, while increases in the case of upward-sloping marginal costs function. Additionally, the pass-through may be dampened or amplified by the way the competitive conditions change in response to demand fluctuations (ε_θ). If higher demand leads to firm entry (i.e. strengthens competitive conduct), then the initial impact of cost hikes on prices becomes partially absorbed, ultimately resulting in a lower degree of pass-through.

Given the complex and interactive way the degree of pass-through depends on its determinants, its cyclical behaviour cannot be easily inferred from the cyclical properties of demand, supply and competition. For instance, it is well established in the literature (e.g. Clementi & Palazzo, 2016; Lee & Mukoyama, 2015; Tian, 2018) that the economic expansion, leading to increasing profit opportunities in relation to entry costs, renders firm entry procyclical. Combined with counter- or acyclical firm exit, this suggests more competitive conduct in economic upturns. However, the resulting pass-through dynamics is not straightforward. In industries facing log-concave demand (and/or upward-sloping costs) this translates into procyclicality of the pass-through, whereas for sectors experiencing log-convex demand (and/or downward-sloping costs) it leads to countercyclicality. The question of cyclicality of the pass-through (as well as the markup, being the key driver of the pass-through variation[2]) is, as demonstrated, industry-specific and, ultimately, empirical.

3. Empirical framework

3.1. Regime-dependence in the ARDL model

In order to capture cyclical variation in the cost pass-through, we develop a regime-dependent ARDL model. For this purpose, we utilize and expand the non-linear cointegration analysis proposed by Shin et al. (2014), building upon Pesaran et al. (2001) and Pesaran and Shin (1999). In the 2-dimensional case, the non-linear cointegration equation takes the following form:

$$x_t = \delta_0 + \delta_1^+ y_t^+ + \delta_1^- y_t^- + \varepsilon_t, \tag{2}$$

where y_t^+ and y_t^- are partial sums of changes in y_t, so that $y_t = y_0 + y_t^+ + y_t^-$. In Shin et al. (2014), the non-linearity takes the form of asymmetry with y_t decomposed into y_t^+ and y_t^- around the threshold value of Δy_t. The threshold can be exogenously imposed (often set at zero) or endogenously determined (e.g. *via* the grid search). In the case of a zero threshold, the relation becomes asymmetric with respect to the sign of changes in y_t, with parameter δ_1^+ capturing the long-run response of x_t to an increase in y_t, and δ_1^- the long-run response to a decrease.

In order to capture regime-dependence (in this case, the dependence on the business cycle position), we propose the extension to the Shin's et al. (2014) framework by making the decomposition in y_t conditional on the behaviour of a transition variable (z_t). In this approach, y_t is partitioned according to the threshold value of $\Delta z_t(\tau)$, with partial sums defined as $y_t^- = \sum_{i=1}^{T} \Delta y_i \mathbb{I}_{\{\Delta z_i \leq \tau\}}$ and $y_t^+ = \sum_{i=1}^{T} \Delta y_i \mathbb{I}_{\{\Delta z_i > \tau\}}$, where $\mathbb{I}_{\{.\}}$ is an indicator function taking the value of one if the condition in the bracket is met, and zero otherwise.

[2] The empirical literature on the pass-through determination is almost entirely devoted to the exchange rate pass-through, in the case of which usually the non-traded costs contribute the most to its variation, followed by markup adjustments. The role of nominal rigidities ('menu costs') is universally considered negligible. Therefore, it can be hypothesised that it is markup adjustments that are the driving force in the context of the wage pass-through.

Following Shin et al. (2014), the estimation of short- and long-run elasticities as well as testing for the existence of the cointegration relationship is performed within the non-linear ARDL model:

$$x_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i x_{t-i} + \sum_{i=0}^{q} (\beta_i^+ y_{t-i}^+ + \beta_i^- y_{t-i}^-) + \vartheta_t. \tag{3}$$

After reparametrisation, the model is estimated in the unrestricted error correction form:

$$\Delta x_t = \alpha_0 + \gamma x_{t-1} + \beta^+ y_{t-1}^+ + \beta^- y_{t-1}^- + \sum_{i=1}^{p-1} \alpha_i \Delta x_{t-i} + \sum_{i=0}^{q-1} (\beta_i^+ \Delta y_{t-i}^+ + \\ + \beta_i^- \Delta y_{t-i}^-) + \vartheta_t, \tag{4}$$

where $\gamma = -(1 - \sum_{i=1}^{p} \alpha_i)$, $\beta^+ = \sum_{i=0}^{q} \beta_i^+$ and $\beta^- = \sum_{i=0}^{q} \beta_i^-$.

The existence of a long-run relationship is established using the bounds-testing approach proposed by Pesaran and Shin (1999). It involves testing the null hypothesis of $\gamma = \beta_1^+ = \beta_1^- = 0$. The framework is applicable for both I(1) and I(0) regressors. Therefore, there are two asymptotic critical values: one under the assumption that all regressors are I(1), and the other assuming their stationarity. If the test statistics falls outside the critical value bounds, the null of no level relationship can be rejected. If it falls within the bounds, the inference is inconclusive. The relevant critical values are tabulated in Pesaran et al. (2001).

In order to recover the long-run parameters, the restricted error correction model can be derived as follows:

$$\Delta x_t = \alpha_0 + \gamma \left(x_{t-1} + \frac{\beta^+}{\gamma} y_{t-1}^+ + \frac{\beta^-}{\gamma} y_{t-1}^- \right) + \sum_{i=1}^{p-1} \alpha_i \Delta x_{t-i} + \\ + \sum_{i=0}^{q-1} (\beta_i^+ \Delta y_{t-i}^+ + \beta_i^- \Delta y_{t-i}^-) + \vartheta_t, \tag{5}$$

where $-\frac{\beta^+}{\gamma}$ and $-\frac{\beta^-}{\gamma}$ are the long-run elasticities, δ_1^+ and δ_1^- respectively, and γ is the error correction coefficient. The symmetry in the short-run ($\beta_i^+ = \beta_i^-$) and long-run ($\delta_1^+ = \delta_1^-$) responses can be tested by applying the Wald statistics. If, however, the threshold is estimated, the statistics follows a nonstandard asymptotic distribution (Davies, 1977). For this reason, the approximate critical values should be obtained by means of a bootstrap procedure proposed in Hansen (1996, 2000).

3.2. The data

The data on the Polish industry comes from Eurostat and Statistics Poland. Unit labour cost, price and demand series were obtained from the short-term business statistics (STS) database (Eurostat). The sample covers the years 2000 through 2016 and is of quarterly frequency. The data is both seasonally- and calendar-adjusted. The Herfindahl-Hirschman index, as a measure of the industry's degree of concentration, comes from Statistics Poland (Statistical Yearbook of Industry).

Unit labour costs are defined as productivity-adjusted wages and the demand faced by the industry is proxied by its turnover (for the definition of variables see Table 1).

Table 1. Definition of variables[a]

Variable	Symbol	Definition
prices	p_t	producer price index (PPI)
unit labour costs	ulc_t	gross wages and salaries over PPI-deflated output
demand	$demand_t$	volume of sales (i.e. total turnover in industry deflated by PPI)

a All variables are in natural logarithms.
Source: Eurostat.

The sectoral coverage includes NACE rev. 2 sections B (*mining and quarrying*), C (*manufacturing*), D (*electricity, gas, steam and air conditioning*) and E (*water supply, sewerage, waste management*), i.e. the industry. The manufacturing section consists of 23 divisions (see Table 2 for basic characteristics of the sectors).

Table 2. Sectoral characteristics[a]

Sectoral classification	NACE code	Production (% of total industry)	Employment (% of total industry)	Herfindahl--Hirschman index
Manufacture of:				
food	C10	14.4	13.6	0.004
beverages	C11	2.2	0.9	0.062
tobacco	C12	0.8	0.2	0.228
textiles	C13	0.9	1.8	0.036

a Data come from Eurostat and Statistics Poland and cover the year 2015.

Table 2. Sectoral characteristics[a] (cont.)

Sectoral classification	NACE code	Production (% of total industry)	Employment (% of total industry)	Herfindahl--Hirschman index
Manufacture of (cont.):				
wearing apparel	C14	0.6	3.1	0.004
leather and related products	C15	0.4	0.9	0.066
wood, cork, straw and wicker products	C16	2.5	4.2	0.013
paper and paper products	C17	2.6	2.0	0.020
printing and reproduction	C18	1.0	1.7	0.021
coke and refined petroleum products	C19	7.9	0.5	0.367
chemicals and chemical products	C20	4.6	2.7	0.018
pharmaceutical products	C21	1.1	0.8	0.109
rubber and plastic products	C22	5.7	6.4	0.006
other non-metallic mineral products	C23	3.6	4.5	0.010
basic metals	C24	3.5	2.2	0.081
metal products	C25	6.3	10.5	0.003
computer, electronic and optical products	C26	2.8	2.1	0.061
electrical equipment	C27	3.8	3.5	0.030
machinery and equipment n.e.c.	C28	3.1	4.2	0.011
motor vehicles, trailers and semi-trailers	C29	9.1	6.0	0.028
other transport equipment	C30	1.4	1.5	0.031
furniture	C31	2.7	5.6	0.019
other products	C32	0.9	2.0	0.016
Mining and quarrying	B	4.3	5.7	0.148
Electricity, gas, steam and air conditioning	D	9.3	4.3	0.071
Water supply; sewerage, waste management	E	2.5	4.8	0.005

a Data come from Eurostat and Statistics Poland and cover the year 2015.

3.3. Empirical strategy

We investigate the pass-through of unit labour costs (ULC) to prices with the aim to make an inference on markup variation over the business cycle. To this end, we combine asymmetry and regime-dependence in the cointegration relation, by decomposing unit labour costs series into four partial sums conditional upon the business cycle position ('good' and 'bad' times in terms of the demand faced by the industry) and the direction of changes in the ULC:

$$ulc_t^{--} = \sum_{i=1}^{T} \Delta ulc_i \mathbb{I}_{\{\Delta demand_i \leq \tau \ \wedge \ \Delta ulc_i \leq 0\}},$$

$$ulc_t^{-+} = \sum_{i=1}^{T} \Delta ulc_i \mathbb{I}_{\{\Delta demand_i \leq \tau \ \wedge \ \Delta ulc_i > 0\}},$$

$$ulc_t^{++} = \sum_{i=1}^{T} \Delta ulc_i \mathbb{I}_{\{\Delta demand_i > \tau \ \wedge \ \Delta ulc_i \leq 0\}},$$

$$ulc_t^{+-} = \sum_{i=1}^{T} \Delta ulc_i \mathbb{I}_{\{\Delta demand_i > \tau \ \wedge \ \Delta ulc_i > 0\}}.$$

Under such specification, the cointegration equation takes the following form:

$$p_t = \delta_0 + \delta_1^{--} ulc_t^{--} + \delta_1^{-+} ulc_t^{-+} + \delta_1^{++} ulc_t^{++} + \delta_1^{+-} ulc_t^{+-} + \varepsilon_t, \tag{6}$$

where δ_1^{--} and δ_1^{-+} are the long-run responses of prices (p_t) to, respectively, falling and rising labour costs in 'bad' times, whereas δ_1^{++} and δ_1^{+-} constitute the corresponding responses in 'good' times. The error correction model correspondent to (6) can be expressed as:

$$\Delta p_t = \alpha_0 + \gamma\left(p_{t-1} - \delta_1^{--} ulc_{t-1}^{--} - \delta_1^{\mp} ulc_{t-1}^{\mp} - \delta_1^{++} ulc_{t-1}^{++} - \delta_1^{\pm} ulc_{t-1}^{\pm}\right) +$$

$$+ \sum_{i=1}^{p-1} \alpha_i \Delta p_{t-i} + \sum_{i=0}^{q-1} (\beta_i^{--} \Delta ulc_{t-i}^{--} + \beta_i^{\mp} \Delta ulc_{t-i}^{\mp} + \beta_i^{++} \Delta ulc_{t-i}^{++} + \tag{7}$$

$$+ \beta_i^{+-} \Delta ulc_{t-i}^{+-}) + \vartheta_t.$$

The threshold value for 'good' and 'bad' times (τ) is estimated by means of a grid search, so as to minimise the sum of squared residuals (Q) from (7):

$$\hat{\tau} = \underset{\tau \in D}{\operatorname{argmin}} \, \mathrm{Q}(\tau), \tag{8}$$

where the domain D of percentage changes in the demand faced by the industry is set by trimming extreme observations at the 25th and 75th percentile. The lag structure of ARDL models is established using the 'general-to-specific' approach and controlling for serial correlation of residuals.

The ARDL methodology – as a single equation approach – can produce biased estimates if variables are endogenously determined. Such endogeneity can be expected in the wage-price system. In our case, however, the sectoral structure of the data allows the unambiguous determination of the direction of causality (prices in a particular sector – unlike the overall price level – do not influence sectoral wages), which justifies the utilisation of a univariate analysis.

Table 3. Unit root tests[a]

Sectoral classification	Prices		Unit labour costs		Demand	
	I(1)	I(2)	I(1)	I(2)	I(1)	I(2)
Manufacturing of:						
food	−0.83	−4.26***	−0.43	−7.13***	−1.20	−6.17***
beverages	−2.31	−6.34***	−0.49	−11.32***	−2.12	−8.90***
tobacco	−1.42	−6.62***	−2.37	−3.92***	−2.55	−6.93***
textiles	−2.59	−4.84***	−1.38	−6.68***	0.83	−6.56***
wearing apparel	−0.87	−6.36***	−0.77	−5.69***	−1.83	−7.56***
leather and related products	0.09	−6.67***	−3.42	−7.35***	−0.54	−6.33***
wood, cork, straw and wicker products	−1.44	−4.71***	−1.70	−8.06***	−1.07	−7.41***
paper and paper products	−0.98	−4.98***	−1.41	−5.51***	−0.14	−6.13***
printing and reproduction	−2.11	−6.45***	−2.50	−4.28***	−0.29	−6.18***
coke and refined petroleum products	−1.70	−5.74***	−2.01	−8.22***	−2.30	−5.81***
chemicals and chemical products	−1.07	−5.20***	−1.29	−6.66***	−1.51	−6.80***
pharmaceutical products	0.92	−3.72***	−0.83	−8.59***	−1.74	−7.46***
rubber and plastic products	−1.13	−5.41***	−0.77	−6.64***	−1.55	−6.60***
other non-metallic mineral products	−2.04	−4.14***	0.09	−8.41***	−2.56	−5.75***
basic metals	−1.93	−4.72***	−2.08	−5.85***	−2.53	−4.83***
metal products	−1.96	−4.87***	−1.69	−5.92***	−1.40	−4.58***
computer, electronic and optical products	−2.52	−5.20***	−1.67	−6.13***	−2.90	−5.69***
electrical equipment	−1.44	−6.52***	−2.42	−3.13**	−2.97	−7.01***
machinery and equipment n.e.c.	−2.17	−5.07***	−0.22	−8.15***	−2.51	−8.04***
motor vehicles, trailers and semi-trailers	−2.07	−5.72***	−1.10	−5.93***	−1.04	−7.24***
other transport equipment	−0.73	−7.27***	−0.01	−9.75***	−0.74	−11.00***
furniture	−1.96	−5.06***	−1.76	−7.53***	−0.21	−7.29***
other products	−1.80	−6.40***	−2.91*	−8.96***	−1.62	−2.89**
Mining and quarrying	−1.88	−4.93***	−0.76	−5.46***	−2.05	−5.96***
Electricity, gas, steam and air conditioning	−2.37	−5.73***	−1.71	−6.76***	−1.78	−6.36***
Water supply; sewerage, waste management	−1.66	−4.14***	−2.16	−7.51***	−0.30	−6.63***

a The table presents the **ADF statistics** computed using regressions with an intercept, intercept and deterministic trend or without deterministic terms based on the visual inspection. One, two and three asterisks indicate statistical significance at the level of 10%, 5% and 1%, respectively.
Source: author's calculations.

Table 4. Estimation results[a,b,c]

Sectoral classification	Test for cointegration[a]	Test for cyclical variation[a]	$\hat{\delta}_1^{--}$	$\hat{\delta}_1^{-+}$	Symmetry: 'bad' times[a]	$\hat{\delta}_1^{+-}$	$\hat{\delta}_1^{++}$	Symmetry: 'good' times[a]
Manufacture of:								
food	48.18***	27.29***	1.36**	−0.83***	6.47**	−2.08**	2.90***	11.39***
beverages	40.18***	33.76***	0.35***	−0.08	7.08**	−0.46***	0.72***	22.18***
tobacco	48.56***	45.16***	−0.34***	0.22***	65.13***	0.54**	0.27**	1.84
textiles	18.86***	0.59	0.24	0.12	0.08	0.15	0.28	0.47
wearing apparel	13.02**	16.87***	−0.17	0.16***	13.25***	0.57***	−0.25	12.97***
leather and related products	25.95***	25.94***	0.55**	−0.36**	8.09**	−0.92***	0.95***	15.54***
wood, cork, straw and wicker products	17.30**	13.08***	−0.29*	−0.05	3.50*	0.01	0.05	0.01
paper and paper products	59.55***	53.52***	0.85***	0.24*	3.95*	−0.35**	−0.01	1.57
printing and reproduction	32.14***	12.49***	−0.52**	−0.28**	1.32	0.13	0.15	0.08
coke and refined petroleum products	24.96***	9.90**	0.56	1.39***	6.50**	0.74***	0.40**	6.50**
chemicals and chemical products	34.46***	27.34***	0.41**	0.13	3.91*	−0.42***	1.11***	33.51***
pharmaceutical products	27.55***	17.55***	0.01	−0.75	0.66	0.23*	0.67***	8.31**
rubber and plastic products	31.66***	28.09***	2.11***	0.35	4.01**	−0.60***	0.33	9.59***
other non-metallic mineral products	43.12***	31.53***	0.08	−0.40**	14.40***	−1.10**	0.39***	9.88***
basic metals	30.57***	5.88*	−0.02	−0.27**	6.42**	0.11	1.20**	0.02
metal products	45.25***	21.45***	0.85**	−0.33**	6.94**	−0.54***	−0.08	7.61**
computer, electronic and optical products	20.78***	8.36**	0.88***	0.86***	0.01	0.14	0.19	0.05
electrical equipment	31.41***	15.65***	0.53***	0.34**	12.05***	−0.02	−0.14	0.43
machinery and equipment n.e.c.	22.16***	7.36*	1.10*	−0.37	2.22*	0.01	1.05*	2.40
motor vehicles, trailers and semi-trailers	48.61***	7.19*	1.49**	0.75**	4.02*	0.00	0.14	0.25
other transport equipment	48.21***	38.09***	0.05	0.05	0.02	−0.16***	−0.05	38.07***
furniture	35.32***	26.23***	0.45***	0.18***	7.33**	−0.09**	0.18***	13.45***
other products	24.72***	11.17**	−0.20	−0.05	1.04	0.44***	0.60***	2.92*
Mining and quarrying	13.23**	8.68**	−0.40*	0.70**	9.39***	1.67***	−0.15	13.16***
Electricity, gas, steam and air conditioning	15.40**	2.49	1.08	0.17	0.67	0.12	0.91***	4.57**
Water supply; sewerage, waste management	12.23***	10.05**	1.40**	0.40***	3.34*	−0.64	1.46***	12.31***

a The table presents the Wald statistics. b One, two and three asterisks indicate statistical significance at the level of 10%, 5% and 1%, respectively. c Other estimation results are available on demand.

Source: author's calculations.

4. Empirical findings

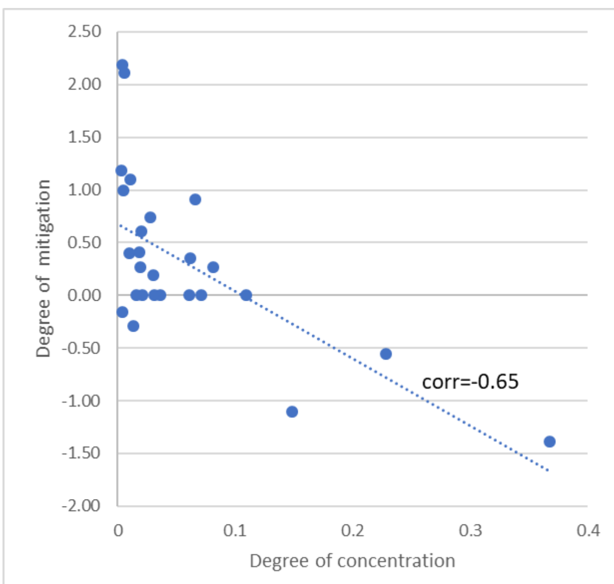
Cointegration analysis within the ARDL model as proposed by Pesaran et al. (2001) and Pesaran and Shin (1999) can be used for a mixture of $I(0)$ and $I(1)$ series, but not for variables of a higher degree of integration. For this reason, the $I(2)$-ness of the series has to be excluded. The results of unit root tests universally indicate integration of order 1 (see Table 3), allowing for the application of the ARDL methodology.

The existence of the long-run relationship is verified by means of the bounds test proposed by Pesaran et al. (2001) with the null hypothesis of the non-significant both the error correction parameter and the long-run elasticities. In all cases the null hypothesis is rejected, and in most cases the relation is non-degenerate (both the error correction parameter and at least one of the long-run elasticities is significantly different from zero), implying the existence of a meaningful long-run relationship between unit labour costs and prices (see Table 4).

In most sectors the test for cyclical variation is positive, i.e. the null hypothesis of symmetrical price responses to changing costs in 'good' and 'bad' times ($\delta_1^{--} = \delta_1^{-+} = \delta_1^{++} = \delta_1^{+-}$) is rejected (Table 4). Thus, the pass-through of unit labour costs to prices in Polish industry is conditional upon the business cycle position, implying cyclical variation in markups. In the majority of industries, the degree of pass-through in 'good' times is significantly higher in response to an increase in unit labour costs than to a decrease, suggesting an amplifying impact of markup adjustments on prices. In many sectors the elasticities of prices with respect to falling unit labour costs are even negative. Therefore, in favourable demand conditions prices are raised even in the face of falling costs, thereby increasing markups. In 'bad' times the opposite pattern seems to prevail, with decreases in unit labour costs feeding through into prices to a significantly greater extent than increases. This implies a mitigating role of markup adjustments in economic slack. Only in a few sectors the opposite pattern can be observed, i.e. a mitigating behaviour of markups during cyclical upturns and amplifying during downturns. This is especially pronounced in the case of manufacturing of *tobacco*, *coke and refined petroleum products*, as well as *mining and quarrying*, all of which are characterised by a high degree of concentration as defined by the Herfindahl-Hirschman index (see Table 2). In several sectors no clear-cut pattern of pass-through variation emerges from the estimation results.

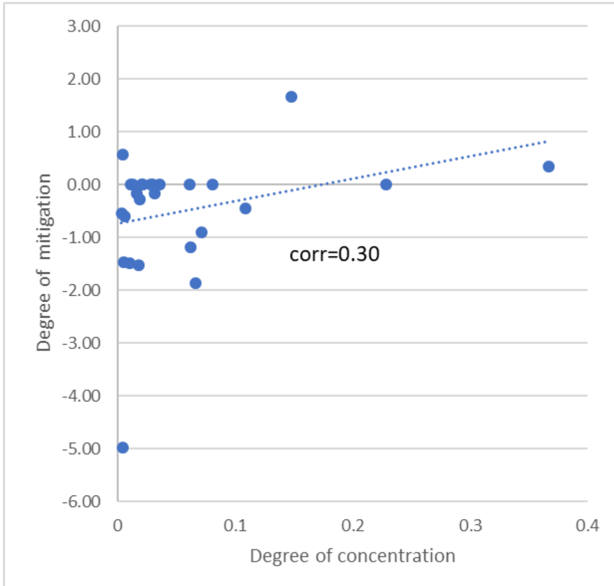
The obtained estimates, indicating in most sectors a mitigating impact of markups on prices in 'bad' times together with an amplifying effect in 'good' times, suggest the prevalence of markup procyclicality in the Polish industry. Nonetheless, the sectors are characterised by various degrees of mitigation/amplification, and some of them exhibit a different pattern of adjustment. In order to shed some light on the factors behind this heterogeneity, we tabulated each industry's degree of mitigation (defined as a difference between price response to a decrease and to an increase in costs, with non-significant differences imputed with zero) against its level of concentration (approximated by the Herfindahl-Hirschman index). There seems to be a significant, albeit moderate, relationship between the industry's degree of concentration and the adjustment pattern it exhibits (see Figure 1 and 2) with Pearson's correlation coefficient equal to 0.30 in 'good' times and −0.65 in 'bad' times (significant at the level of 0.05 and 0.01, respectively). In 'good' times, it seems that the more concentrated the industry, the more mitigation (less amplification) provided by the pass-through, i.e. the less the cost hikes feed through into prices relative to the cost drops. In 'bad' times, on the other hand, less concentrated sectors exhibit more mitigating behaviour. Higher degree of competition seems, therefore, preferable for the sake of shock-absorption in economic downturns.

Figure 1. The degree of mitigation[a] as a function of an industry's concentration[b] in 'bad' times.



a Degree of mitigation defined as a difference between price response to a decrease and to an increase in costs. b Degree of concentration is approximated by the Herfindahl–Hirschman index.
Source: author's calculations.

Figure 2. The degree of mitigation[a] as a function of an industry's concentration[b] in 'good' times



a Degree of mitigation defined as a difference between price response to a decrease and to an increase in costs. b Degree of concentration is approximated by the Herfindahl-Hirschman index.
Source: author's calculations.

5. Conclusions

This study aims at estimating a cyclical pattern in the cost pass-through. To this end, a regime-dependent framework is proposed, allowing the estimation of the pass-through parameters separately in cyclical upturns and downturns. The methodology is applied to the Polish industrial sectors.

The obtained results point to the prevalence of markup procyclicality in the Polish industry, since the impact of markups on prices is mitigating in 'bad' times and amplifying in 'good' times. In some industries, markup adjustments can be directly inferred upon, given that the response to increasing (decreasing) unit labour costs in 'bad' ('good') times entails lowering (raising) prices, reflective of negative (positive) changes in markups. In a few cases, however, the estimated pattern of adjustments is suggestive of markup counter- or acyclicality. The degree of procyclicality seems to be positively correlated with the level of competition, corroborating a large body of evidence dating back to the Domowitz et al. (1986, 1988), thus validating the proposed methodology of assessing the behaviour of markups based on the cyclicality of the cost pass-through.

Thus, in the majority of industries the estimates support the hypothesis of a mitigating effect of markups on business cycle fluctuations (markups boost prices in economic upturns and alleviate the pressure on them during downswings, thus, respectively, curbing and stimulating the demand). Polish industrial firms do not seem to take advantage of wage concessions in economic slack in order to boost their profits. In most industries wage flexibility seems, therefore, to be an appropriate policy prescription for economic stabilisation.

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