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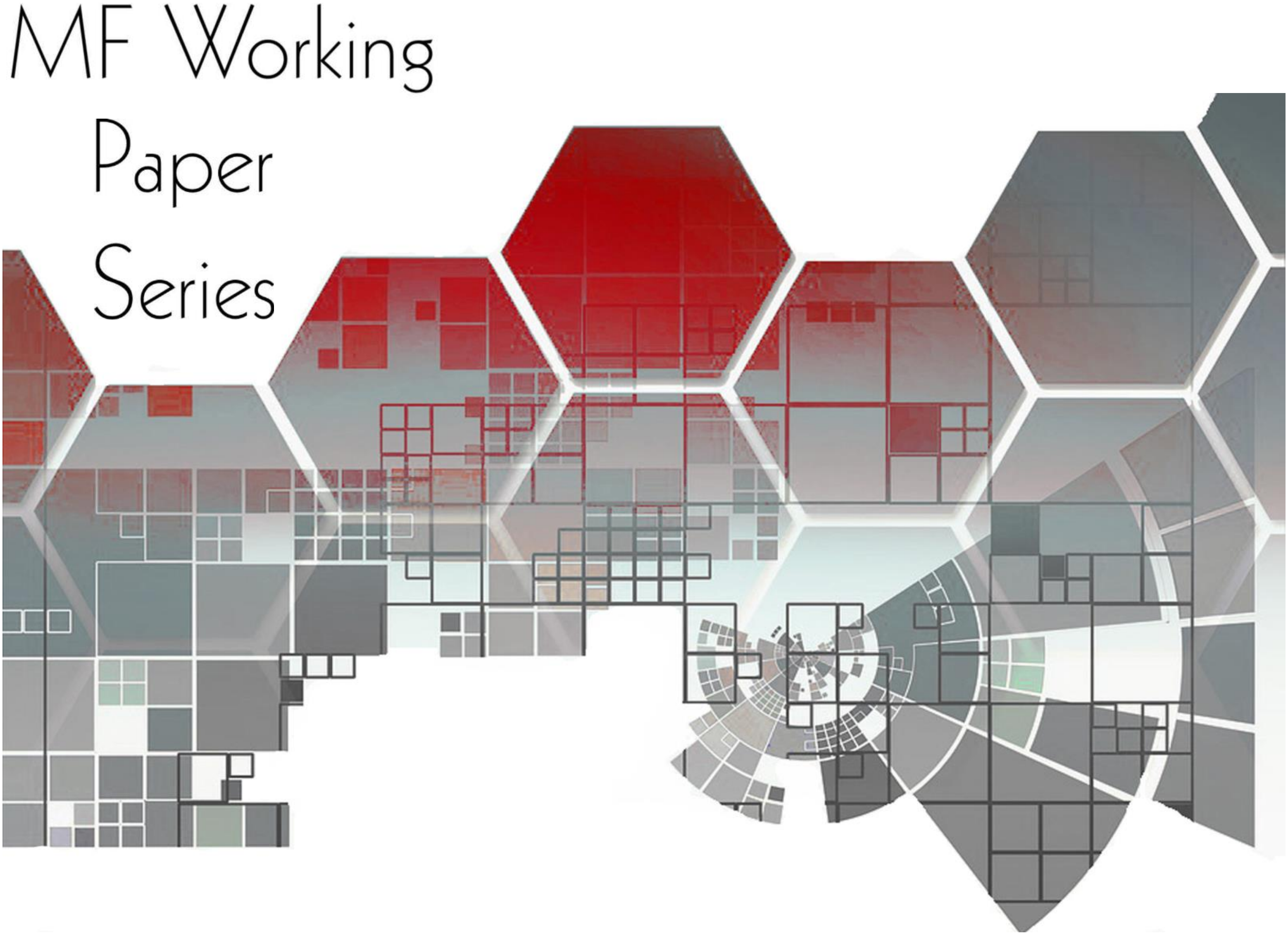

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Modelling cyclical variation in the cost pass-through: evidence from regime-dependent ARDL model

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Modelling cyclical variation in the cost pass-through: evidence from regime-dependent ARDL model

Karolina Konopczak[1]

Abstract

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

JEL: C22, E31, E32

Keywords: Non-linear cointegration, Regime-dependence, Cost pass-through, Markup cyclicality

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1. Introduction

Wage rigidity is commonly blamed for causing unemployment in the wake of adverse shocks, thus increasing the depth and prolonging the duration of a downturn. By the same token, wage flexibility is often perceived as an absorption mechanism, with wage concessions in economic slack hypothesized to facilitate job protection, boost international competitiveness (and, hence, exports) and, consequently, contribute to the containment of negative shocks. This belief, widely held in policy circles, hinges upon a classical assumption of interchangeability between price and quantity adjustments of labour force, with either wages or employment bearing the brunt of the shock. However, as argued in the Keynesian literature (see Galí, 2013 and Galí and Monacelli, 2016) wage concessions affect labour demand and, hence, employment only insofar as 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, therefore, 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 output and, hence, employment outcomes. In such circumstances wage decreases may spur contractionary effects. It is, therefore, the interrelation between wage- and price-flexibility (rather than wage flexibility itself) that is central to the mechanism of business cycle propagation. 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.

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 and 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 and Roeger, 1995), the labour share (Bils, 1987), inventories (Bils and Kahn, 2000), advertising spending (Hall, 2012) or through adjusting average costs series (Rotemberg and Woodford, 1991 and 1999; Martins and Scarpetta, 2002; Gali et al., 2007). The results obtained for the U.S. industrial sectors using the abovementioned techniques are suggestive of both pro- (e.g. Domowitz et al., 1986 and 1988; Chirinko and Fazzari, 1994; Hall, 2012; Nekarda and Ramey, 2013) and counter-cyclicality (e.g. Bils, 1987; Rotemberg and Woodford, 1999; Bils and Kahn, 2000; Martins and Scarpetta, 2002) of markups.

Due to strong dependence on the estimation method, in this study we bypass estimating markups and propose instead 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 to capture 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 and Burstein, 2008; Hellerstein, 2008; Nakamura, 2008; Nakamura and Zerom, 2010; Gopinath et al., 2011; Goldberg and Hellerstein, 2013) identifies time-varying markups as one of the most important determinants of the pass-through variation[2]. 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 economic stabilization. Polish industry serves as an application example.

The paper is organized as follows. 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

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

the cost pass-through. Section 4 brings the empirical results. The last section concludes.

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 and 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 Rotemberg and Woodford (1992). In Stiglitz (1984), Okun (1981), Bils (1989) and Klemperer (1995) markups are predicted to rise in recessions due to lower elasticity of 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, Greenwald et al. (1984), Gottfries (1991), Chevalier and Scharfstein (1995) and Gilchrist et al. (2017) 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 and 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 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 provided 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 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 upon from the cyclical properties of demand, supply and competition. For instance, it is well established in the literature (i.a. Lee and Mukoyama, 2015; Clementi and Palazzo; 2016, Tian, 2018) that 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 under log-convex demand (and/or downward-sloping costs) into countercyclicality. The question of cyclicality of the pass-through (as well as the markup, being a key driver of the pass-through variation) is, therefore, industry-specific and ultimately an empirical one.

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 extend the non-linear cointegration analysis proposed by Shin et al. (2014), building upon Pesaran and Shin (1999) and Pesaran et al. (2001). 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^- constitute 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 zero threshold, the relation becomes asymmetric with respect to the sign, with parameter δ_1^+ capturing the long-run response of x_t to an increase in y_t, whereas δ_1^- the long-run response to a decrease.

In order to capture regime-dependence (in this case on the business cycle position), we propose an 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). Under our proposition, y_t is partitioned according to the threshold value of Δz_t (τ), 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.

Following Shin et al. (2014) the estimation of short- and long-run elasticises 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 reparametrization 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 $\beta^- = \sum_{i=0}^{q} \beta_i^-$.

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

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

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- ($\beta_i^+ = \beta_i^-$) 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 (the Davies problem, 1977). For this reason the approximate critical values should be obtained by means of a bootstrap procedure proposed in Hansen (1996, 2000).

3.2. Data

The data on Polish industry comes from Eurostat. Unit labour cost, price and demand series (for the definition of variables see Table 1) were obtained from the short-term business statistics (STS) database. The sample covers years 2000 through 2016 and is of quarterly frequency. The data is both seasonally and calendar adjusted.

Table 1: Definition of variables

Variable	Symbol	Definition
prices	p_t	producer price index (PPI)
real 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)

Notes: All variables are in natural logarithms.

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. industry. The manufacturing section is divided into 23 divisions (see Table 2 for basic characteristics of the sectors).

Table 2: Sectoral characteristics

Sectoral classification	NACE code	Production (% of total industry)	Employment (% of total industry)
Manufacture of:			
food	C10	14.4	13.6
beverages	C11	2.2	0.9
tobacco	C12	0.8	0.2
textiles	C13	0.9	1.8
wearing apparel	C14	0.6	3.1
leather and related products	C15	0.4	0.9
wood, cork, straw and wicker products	C16	2.5	4.2
paper and paper products	C17	2.6	2.0
printing and reproduction	C18	1.0	1.7
coke and refined petroleum products	C19	7.9	0.5
chemicals and chemical products	C20	4.6	2.7
pharmaceutical products	C21	1.1	0.8
rubber and plastic products	C22	5.7	6.4
other non-metallic mineral products	C23	3.6	4.5
basic metals	C24	3.5	2.2
metal products	C25	6.3	10.5
computer, electronic and optical products	C26	2.8	2.1
electrical equipment	C27	3.8	3.5
machinery and equipment n.e.c.	C28	3.1	4.2
motor vehicles, trailers and semi-trailers	C29	9.1	6.0
other transport equipment	C30	1.4	1.5

furniture	C31	2.7	5.6
other products	C32	0.9	2.0
Mining and quarrying	B	4.3	5.7
Electricity, gas, steam and air conditioning	D	9.3	4.3
Water supply; sewerage, waste management	E	2.5	4.8

Notes: Data come from Eurostat and are for the year 2015.

3.3. Empirical strategy

We investigate the pass-through of unit labour costs (ULC) to prices with an 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:

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

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

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

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

Under such specification the cointegration equation takes the following form:

$$p_t = \delta_0 + \delta_1^{--} ulc_t^{--} + \delta_1^{-+} ulc_t^{-+} + \delta_1^{++} ulc_t^{++} + \delta_1^{+-} ulc_t^{+-} + \varepsilon_t \qquad (6)$$

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:

$$\Delta p_t = \alpha_0 + \gamma(p_{t-1} - \delta_1^{--} ulc_{t-1}^{--} - \delta_1^{-+} ulc_{t-1}^{-+} - \delta_1^{++} ulc_{t-1}^{++} - \delta_1^{+-} ulc_{t-1}^{+-}) + \sum_{i=1}^{p-1} \alpha_i \Delta p_{t-i} + \sum_{i=0}^{q-1} (\beta_i^{--} \Delta ulc_{t-i}^{--} + \beta_i^{-+} \Delta ulc_{t-i}^{-+} + \beta_i^{++} \Delta ulc_{t-i}^{++} + \beta_i^{+-} \Delta ulc_{t-i}^{+-}) + \vartheta_t \qquad (7)$$

The threshold value for ‘good’ and ‘bad’ times (τ) is estimated by means of a grid search so as to minimize 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 is set by trimming extreme observations at the 15th and 85th percentile, following Hansen (1999). The lag structure of ARDL models is established using the 'general-to-specific' approach (based on the Schwarz information criterion) and controlling for serial correlation of residuals.

4. Empirical findings

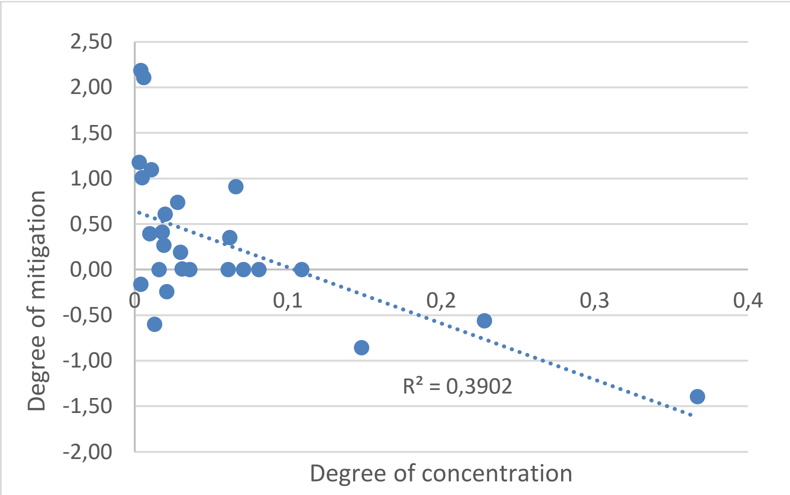
Cointegration analysis within the ARDL model as proposed by Pesaran and Shin (1999) and Pesaran et al. (2001) can be used for a mixture of I(0) and I(1) series but not for variables of higher degree of integration. For this reason the I(2)-ness of the series has to be excluded. The results of unit root 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 examined by means of the bounds test proposed by Pesaran et al. (2001) with the null hypothesis of 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 null hypothesis of symmetrical price responses to changing costs in ‘good’ and ‘bad’ times ($\hat{\delta}_1^{--} = \hat{\delta}_1^{-+} = \hat{\delta}_1^{++} = \hat{\delta}_1^{+-}$) 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, during economic booms 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 few sectors the opposite pattern can be observed, i.e. mitigating behaviour of markups during cyclical upturns and amplifying during downturns. This is especially pronounced in case of manufacturing of *tobacco*, *wearing apparel*, *coke and refined petroleum products* as well as *mining and quarrying.* In several sectors (especially in case of manufacturing of *textiles*, *computers* as well as *printing*) no clear-cut pattern of pass-through variation emerges from the estimation results.

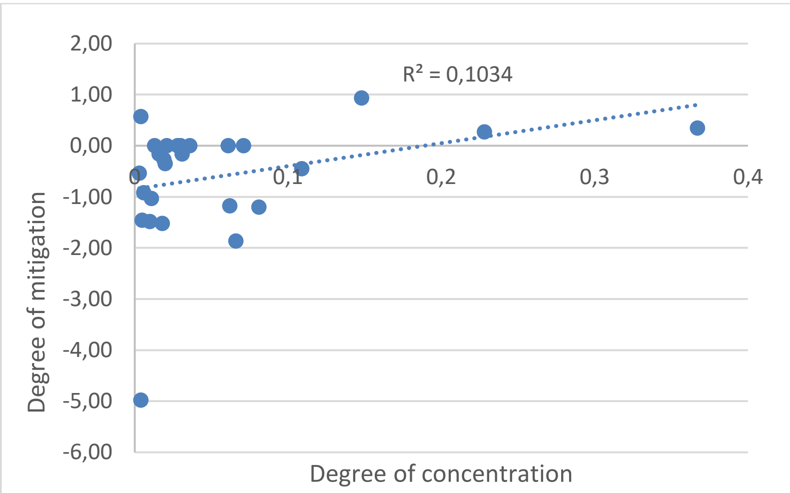
The obtained results, indicating in most sectors a mitigating impact of markups on prices in 'bad' times together with an amplifying effect in 'good' times, is suggestive of the prevalence of markup procyclicality in Polish industry. Nonetheless, the sectors are characterized by various degrees of mitigation/amplification 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 industry's degree of concentration and the adjustment pattern it exhibits (see Figure 1 and 2) with Pearson's correlation coefficient equal to 0.32 in 'good' times and -0.62 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 would be, therefore, preferable for the sake of shock-absorption in economic downturns.

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



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

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



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

Table 3: Unit root tests

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***

Notes: The *ADF statistics* was 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.

Table 4: Estimation results

Sectoral classification	Test for cointegration	Test for cyclical variation	$\hat{\delta}_1^{--}$	$\hat{\delta}_1^{-+}$	Symmetry in 'bad' times	$\hat{\delta}_1^{+-}$	$\hat{\delta}_1^{++}$	Symmetry in 'good' times
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***

Notes: In the case of the long-run (LR) symmetry test the F statistics are presented. One, two and three asterisks indicate statistical significance at the level of 10%, 5% and 1%, respectively.

5. Conclusions

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

The obtained results point to the prevalence of markup procyclicality in Polish industry, since the increasing unit labour costs seem to be passed through into prices stronger in cyclical upswings than downswings, while the opposite holds in the case of falling costs. 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 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, Hubbard and Petersen studies (1986, 1988).

Thus, in the majority of industries the estimates support the hypothesis of a mitigating effect of markups on business cycle fluctuations. 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 stabilization.

References

Atkeson A., Burstein A., (2008), *Pricing-to-Market, Trade Costs, and International Relative Prices*, American Economic Review 98, 1998–2031.

Bils M., (1987), *The Cyclical Behavior of Marginal Cost and Price*, American Economic Review 77, 838–55.

Bils M., (1989), *Pricing in a Customer Market*, Quarterly Journal of Economics 104, 699-718.

Bils M., Kahn J., (2000), *What Inventory Behavior Tells Us About Business Cycles,* American Economic Review 90, 458–481.

Chevalier J.A., Sharfstein D.S., (1996), *Capital-Market Imperfections and Countercyclical Markups: Theory and Evidence*, American Economic Review 86, 703-725.

Chirinko R.S., Fazzari S.M., (1994), *Economic Fluctuations, Market Power, and Returns to Scale: Evidence from Firm-Level Data*, Journal of Applied Econometrics 9, 47–69.

Clementi G.L., Palazzo B., (2016), *Entry, Exit, Firm Dynamics, and Aggregate Fluctuations*, American Economic Journal: Macroeconomics 8, 1–41.

Davies R., (1977), *Hypothesis testing when a nuisance parameter is present only under the alternative*, Biometrika 64, 247-254.

Domowitz I., Hubbard R., Petersen B., (1986), *Business Cycles and the Relationship between Concentration and Price-Cost Margins*, The RAND Journal of Economics 17, 1–17.

Domowitz I., Hubbard R., Petersen B., (1988), *Market Structure and Cyclical Fluctuations in U.S. Manufacturing*, The Review of Economics and Statistics 70, 55-66.

Galí J., (2013), *Notes for a new guide to Keynes (I), wages, aggregate demand, and employment*, Journal of the European Economic Association 11, 973-1003.

Galí J., Gertler M., López-Salido D., (2007), *Markups, Gaps, and the Welfare Costs of Business Fluctuations*, Review of Economics and Statistics 89, 44–59.

Galí J., Monacelli T., (2016), *Understanding the Gains from Wage Flexibility: The Exchange Rate Connection*, American Economic Review 106, 3829-3868.

Genesove D., Mullin W., (1998), *Testing Static Oligopoly Models: Conduct and Cost in the sugar industry, 1890-1914*, Rand Journal of Economics 29, 355-377.

Gilchrist S., Schoenle R., Sim J., and Zakrajšek E., (2017), *Inflation Dynamics during the Financial Crisis*, American Economic Review 107, 785-823.

Goldberg P., Hellerstein R., (2013), *A structural approach to identifying the sources of local currency price stability*, The Review of Economic Studies 80, 175–210.

Gopinath G., Itskhoki O., Rigobon R., (2010), *Currency Choice and Exchange Rate Pass-Through*, American Economic Review 100, 304–36.

Gottfries N., (1991), *Customer Markets, Credit Market Imperfections and Real Price Rigidity*, Economica 58, 317-323.

Green E., Porter E., (1984), *Noncooperative Collusion under Imperfect Price Competition*, Econometrica 52, 87-100.

Greenwald B., Stiglitz J., Weiss A., (1984), *Information Imperfections in the Capital Market and Macroeconomic Fluctuations*, American Economic Review Paper and Proceedings 74, 194-99.

Hall R.E., (1986), *Market Structure and Macroeconomic Fluctuations*, Brookings Papers on Economic Activity 2, 285–322.

Hall R.E., (1988), *The Relation between Price and Marginal Cost in U.S. Industry*, Journal of Political Economy 96, 921-947.

Hall R.E., (2012), *The Cyclical Response of Advertising Refutes Counter-Cyclical Profit Margins in Favor of Product Market Frictions*, National Bureau of Economic Research Working Paper 18370.

Hansen B.E., (1996), *Inference When a Nuisance Parameter Is Not Identified Under the Null Hypothesis*, Econometrica 64, 413-430.

Hansen B.E., (1999), *Threshold Effects in Non-Dynamic Panels: Estimation, Testing, and Inference*, Journal of Econometrics 93, 345-368.

Hansen B.E., (2000), *Sample Splitting and Threshold Estimation*, Econometrica 68, 575-603.

Hellerstein R., (2008), *Who bears the cost of a change in the exchange rate? Pass-through accounting for the case of beer*, Journal of International Economics 76, 14–32.

Klemperer P., (1995), *Competition when consumers have switching costs: an overview with applications to industrial organization, macroeconomics, and international trade*, Review of Economic Studies 62, 515–539.

Lee Y., Mukoyama T., (2015), *Entry and Exit of Manufacturing Plants over the Business Cycle*, European Economic Review 77, 20–27.

Martins J., Scarpetta S., (2002), *Estimation of the Cyclical Behaviour of Mark-ups,* OECD Economic Studies 1, 173-188.

Nakamura E., (2008), *Pass-Through in Retail and Wholesale*, American Economic Review 98, 430-437.

Nakamura E., Zerom D., (2010), *Accounting for incomplete pass-through*, The Review of Economic Studies 77, 1192–1230.

Nekarda Ch., Ramey A., (2013), *The Cyclical Behavior of the Price-Cost Markup*, National Bureau of Economic Research Working Paper 19099.

Okun M., (1981), *Price and Quantities: A Macroeconomic Analysis*, Oxford: Basil Blakwell.

Pesaran M.H., Shin Y., (1999), *An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis*, [in:] Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium, [ed.:] Strom S., Cambridge: Cambridge University Press.

Pesaran M.H., Shin Y., Smith R., (2001), *Bounds testing approaches to the analysis of level relationships,* Journal of Applied Econometrics 16, 289-326.

Phelps E.S., Winter S.G., (1970), *Optimal Price Policy under Atomistic Competition*, [in:] Microeconomic Foundations of Employment and Inflation, [ed.:] Phelps E.S., Norton, New York.

Roeger W., (1995), *Can imperfect competition explain the difference between primal and dual productivity measures?* Journal of Political Economy 103, 316-330.

Rotemberg J., Saloner G., (1986), *A Supergame-theoretic Model of Price Wars during Booms*, American Economic Review 76, 390-407.

Rotemberg J., Woodford M., (1991), *Markups and the Business Cycle*, NBER Macroeconomics Annual 1991, 63-129.

Rotemberg J., Woodford M., (1992), *Oligopolistic Pricing and Effects of Aggregate Demand on Economic Activity*, Journal of Political Economy 100, 1153-1205.

Rotemberg J., Woodford M., (1999), *The Cyclical Behavior of Prices and Costs*, [in:] Handbook of Macroeconomics, [ed.:] Taylor J., Woodford M., Elsevier, New York.

Shin Y., Yu B., Greenwood-Nimmo M., (2014), *Modelling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework*, [in:] Festschrift in Honor of Peter Schmidt: Econometric Methods and Applications, [ed.:] Horrace W., Sickles R., Springer, New York.

Stiglitz J., (1984), *Price Rigidities and Market Structure*, American Economic Review Paper and Proceedings 74, 350-355.

Tian C., (2018), *Firm-level entry and exit dynamics over the business cycles*, European Economic Review 102, 298-326.

Weyl E.G., Fabinger M., (2013), *Pass-Through as an Economic Tool: Principle of Incidence under Imperfect Competition*, Journal of Political Economy 121, 528-583.