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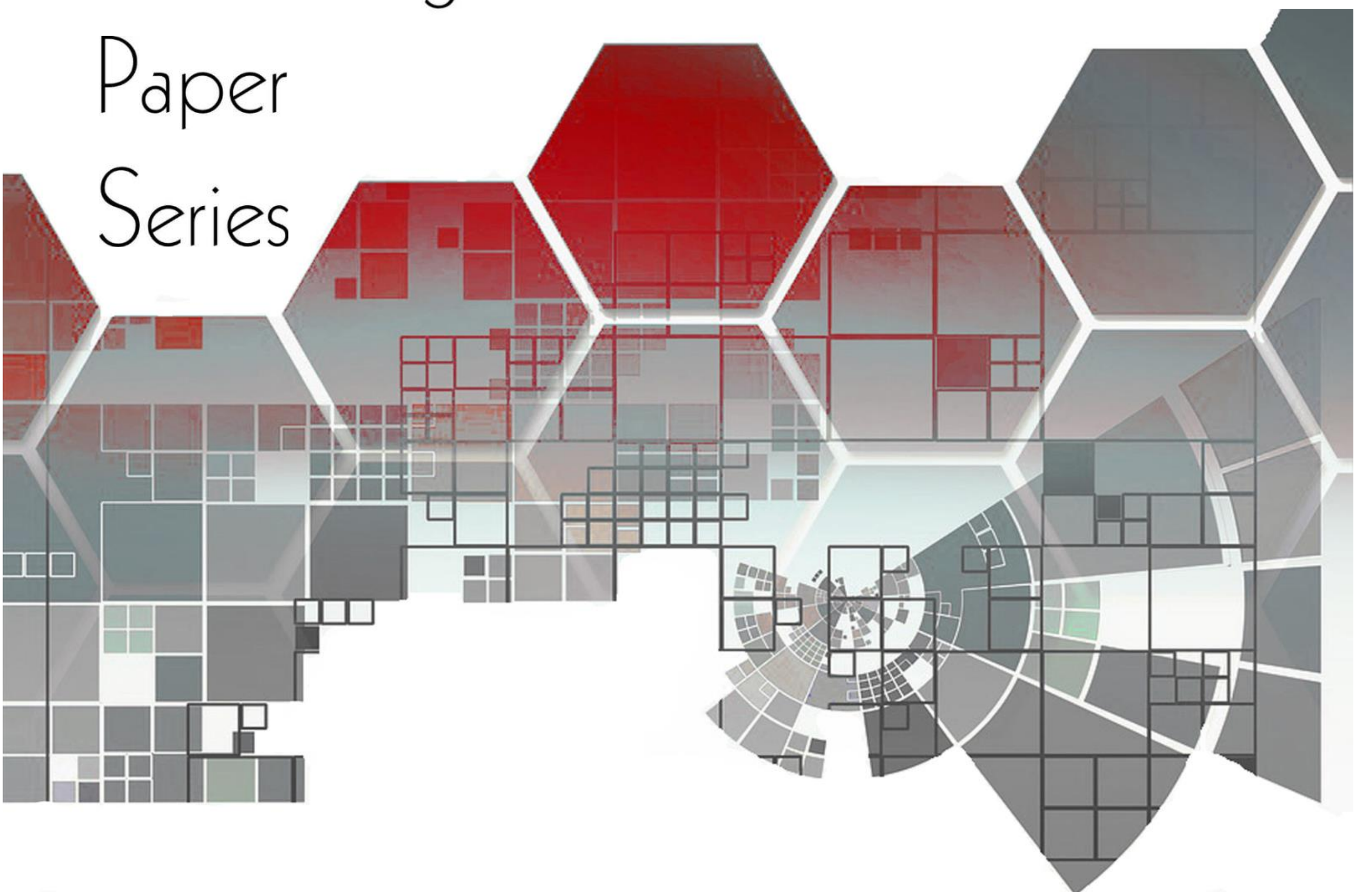

Karolina Konopczak

Modelling labour adjustments over the business cycle: evidence from non-linear ARDL model

Modelling labour adjustments over the business cycle: evidence from non-linear ARDL model

Karolina Konopczak[1]

Abstract

In this study we propose a novel approach to modelling wage and workforce adjustments in response to business cycle fluctuations, using non-linear cointegration methods. By exploring the sectoral dimension of the data we address the question of interchangeability between wage and employment adjustments. The results obtained for Polish industry show virtually no sign of a trade-off between price and quantity responses. Workforce resilience to demand fluctuations is rather matched with wage rigidity. Conversely, sectors with more flexible wages tend also to be responsive in terms of workforce.

JEL: D22, E24, E32
Keywords: Labour adjustments, Wage rigidity, Business cycles, Non-linear cointegration

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1. Introduction

Labour input adjustments play an important role in the propagation of business cycle shocks. They can be carried out by changing the price and/or the quantity of labour, i.e. wage or employment. Quantity adjustments may take place through the intensive (hours worked per employee) and/or the extensive (number of people employed) margin. Price response may concern either nominal wage or – if it is frozen - the real wage. The extent to which firms use wage and workforce adjustments in response to demand fluctuations has profound macroeconomic consequences. A mainly quantitative response to adverse business conditions, i.e. layoffs of employees, apart from inflicting social costs, may increase the depth and prolong the duration of a downturn. On the other hand, wage adjustments may help to boost international competitiveness (through a wage-based internal devaluation) and consequently support exports, contributing to the containment of negative shocks. Hence, price adjustments are often perceived as a preferable response, especially taking into account the risk of hysteresis in unemployment.

Moreover, it is also hypothesized that price and quantity adjustments of labour force are interchangeable, with either wages or employment bearing the brunt of shocks. By this logic, wage rigidity amplifies employment fluctuations, resulting in involuntary unemployment in cyclical downswings. Conversely, wage flexibility leads to employment stability, specifically facilitates employment protection in economic slack. In this vein, differential wage developments across countries during the global financial crisis are widely perceived to be one of the main reasons for divergent employment outcomes, with Germany (see i.a. Reisenbichler and Morgan 2012, Dustmann et al. 2014, Fujita and Gartner 2014) and Spain (see i.a. Gächter et al. 2018 and Doménech et al. 2018) being the most conspicuous examples of opposite results. Flexible wages are thus widely regarded as a prescription for economic stabilisation (see e.g. IMF 2010, OECD 2012, OECD 2014, IMF 2016). However, as pointed out in the Keynesian literature (see Galí 2013, Galí and Monacelli 2016) the effectiveness of downward wage adjustments in containing adverse shocks is not unconditional, and depends upon the behaviour of markups as well as macroeconomic policies being in place.

Despite profound policy implications of the wage-workforce interchangeability conjecture, spurring calls for structural reforms aimed at promoting wage flexibility, surprisingly little research has verified its existence, with studies done so far subject to several limitations (Pischke 2018). In the present study, we propose a novel framework allowing to directly (albeit non-causally) address this question. First, by employing non-linear cointegration (Shin et al. 2014), allowing for both short- and long-run asymmetry in responses depending on the business cycle position, adjustment patterns in both good and bad times are estimated. Second, by conducting the analysis across a sample of countries, regions or sectors, the existence of a trade-off between price and quantity adjustments of labour force is investigated. The analysis of sectoral adjustment patterns in Polish industry serves as an application example.

The paper is organised as follows. Section 2 gives a theoretical background. Section 3 outlines the empirical strategy, i.e. the proposed approach to estimating labour market adjustments, econometric techniques employed, as well as the data used in the analysis. Section 4 presents the estimation results, allowing to address the issues of: (1) a trade-off between wage and employment adjustments, (2) a trade-off between working hours and employment adjustments, (3) an asymmetry between firms' responses to positive and negative shocks, (4) the sectoral heterogeneity in adjustment patterns. The final section concludes.

2. Theoretical notes

The relation between wage and employment developments lies at the heart of the business cycle propagation mechanism. The nature of the relationship, however, is far from being clear. In the classical model of a frictionless labour market, wages serve as an equilibrating mechanism, instantaneously adjusting to changes in the marginal product of labour, and thereby preventing involuntary unemployment. The incorporation of frictions in the search and matching model (Mortensen 1970, Phelps 1970, Pissarides 1979, Diamond 1982, Mortensen 1982, Pissarides 1985, Mortensen and Pissarides 1994) allows for involuntary unemployment, but elastic wages still act as a buffer, offsetting the impact of productivity shocks on employment. Thereby, under standard parameter values, the baseline Diamond-Mortensen-Pissarides model predicts large cyclical movements in wages that dampen employment fluctuations through both job destruction and job creation channels. However, as noted by Shimer (2005), these predictions appear to be counterfactual, which can be attributed to the existence of wage rigidities. The introduction of wage rigidity to the search and matching model (see Hall 2005, Gertler and Trigari 2006, Krause and Lubik 2006, Costain and Reiter 2008, Hall and Milgrom 2008, Elsby 2009) renders employment more susceptible to shocks and, consequently, more volatile. The classical logic (even with frictions) implies, therefore, the interchangeability between price and quantity adjustments of labour force.

From the Keynesian (and the New Keynesian) perspective, the existence of the trade-off between wage and employment adjustments hinges upon the response of aggregate demand to wage developments (Keynes 1936). Wage concessions affect labour demand and, hence, employment only insofar as they diminish prices and induce monetary policy response in the form of interest rate cuts, stimulating demand for goods and services. The role of downward wage flexibility in containing adverse shocks is, therefore, conditional upon the degree of price rigidity, as well as the monetary policy rule used by the central bank. In particular, if falling wages do not reduce prices or the central bank does not respond to reduced inflation by cutting interest rates, wage flexibility may have little or no effect on employment outcomes. Moreover, in such circumstances a wage decrease may trigger contractionary effects, suppressing purchasing power of households and increasing the real burden of debt (Eggertsson and Krugman 2012). This risk is especially pronounced in economies constrained by 'zero lower bound' on interest rate (Galí 2013) or tight fiscal conditions, where the scope for macroeconomic expansion is limited, as well as in member states of a heterogeneous currency union (Galí and Monacelli 2016).

In conclusion, wage developments affect employment through both supply and demand channels with potentially contradictory effects. From the supply-side perspective, wage moderation, resulting in lower price of labour, should boost employment. By contrast, demand-side effects of wage cuts or freezes may be ambiguous. On the one hand, lower wages are supposed to help rebuild international competitiveness, thereby stimulating exports. This outcome is, however, conditional upon the behaviour of prices (i.e. the degree of the cost pass-through) as well as international developments, since devaluation – either internal, or external – is less effective if pursued concurrently by other countries. On the other hand, lower wages may suppress domestic demand, especially if they do not fully translate into lower prices and/or if they are not offset by expansive macroeconomic policies. Therefore, in unfavourable circumstances supply-side effects of wage moderation may get stalled and demand-side effects may turn out to be negative. Taking these reservations into account, wage flexibility may not constitute a panacea for cyclical unemployment, as is commonly perceived in policy circles. The existence of a trade-off between wage and workforce adjustments in a given economy should, therefore, be subject to empirical testing.

3. Empirical strategy

In the present study, wage and workforce adjustment patterns are recovered from aggregate data using time-series techniques. Typically, the literature on shock-adjustment relies on microdata, especially from surveys (see i.a. Babecký et al., 2012; Bertola et al., 2012; Druant et al., 2012; Dias et al., 2015). This approach has an advantage of fully exploring firm-level heterogeneity in adjustment strategies but rather captures declared responses to hypothetical shocks than the actual responses to actual shocks faced by firms. Moreover, survey data provide information on the on-impact adjustments and not on the adjustment trajectories (i.e. the long-run response and the speed of adjustment) that are most relevant from the macroeconomic perspective. It should be, however, borne in mind that the time-series techniques do not capture the workforce composition adjustments. Layoffs in the wake of economic downturns tend to disproportionally affect less experienced, less educated and, hence, less paid workers, thereby influencing the average wage in a countercyclical way. This may to some extent underestimate the response of wage to business cycle fluctuations in macroeconomic data (Bils, 1985; Solon et al., 1994). This study is, however, carried out at the sectoral level and aims to explore the interchangeability between different channels of shock accommodation. Therefore, the compositional bias should not significantly affect the conclusions, provided there is a certain degree of sectoral homogeneity in its magnitude.

For the purpose of characterizing labour adjustment trajectories in response to demand fluctuations both short- and long-run elasticises as well as the speed of adjustment is needed. Therefore, we employ the cointegration analysis. Since differences in firms' responses to positive and negative shocks are of particular interest, we resort to non-linear techniques and apply the non-linear ARDL model (NARDL) proposed by Shin et al. (2014), building upon a symmetric ARDL model (Pesaran and Shin 1999, Pesaran et al. 2001) to capture both long- and short-run asymmetries.

The sectoral structure of the data allowed to unambiguously determine the direction of causality, which justifies the utilisation of an univariate cointegration analysis. Therefore, for every sector covered by the analysis four equations were estimated with, respectively, nominal wage, real wage (in order to capture a response in the form of nominal wage freezes), the number of people employed and working hours per employee as the endogenous variable and the demand faced by the industry as the exogenous variable. The lag structure of NARDL models was established using the 'general-to-specific' approach (based on the Schwarz information criterion) and controlling for serial correlation of residuals. To this end the Breusch-Godfrey test for autocorrelation was applied.

3.1. Methodological notes

In the 2-dimensional case the asymmetric cointegration equation takes the following form:

$$x_t = \delta_0 + \delta_1^+ y_t^+ + \delta_1^- y_t^- + \varepsilon_t \quad (1)$$

where $y_t^+ = \sum_{i=1}^{T} \Delta y_i^+ = \sum_{i=1}^{T} \max(\Delta y_i, 0)$ and $y_t^- = \sum_{i=1}^{T} \Delta y_i^- = \sum_{i=1}^{T} \min(\Delta y_i, 0)$ constitute partial sums of positive and negative changes in y_t so that $y_t = y_0 + y_t^+ + y_t^-$. The series y_t is decomposed into y_t^+ and y_t^- around the zero threshold. Therefore, parameter δ_1^+ captures the long-run response of x_t to the increase in y_t, whereas δ_1^- the response to the decrease.

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

$$x_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i x_{t-i} + \sum_{i=0}^{q} (\beta_i^+ y_{t-i}^+ + \beta_i^- y_{t-i}^-) + \vartheta_t \quad (2)$$

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

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

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:

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

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 long-run and short-run responses can be tested by applying the Wold statistics. The existence of the asymmetric long-run relation is established using bounds-testing approach proposed by Pesaran and Shin (1999). It consists in testing the null hypothesis of $\gamma = \beta_1^+ = \beta_1^- = 0$. However, its rejection does not necessarily imply the existence of a meaningful cointegration relationship since, in the case of significant adjustment parameter and non-significant elasticities, the relationship is degenerate (see Pesaran and Shin, 1999).

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 Wold statistics fall 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).

3.2. Data

The data on Polish industry comes from Eurostat. Demand, wage, employment and working hours series (for the definition of variables see Table 1) were obtained from the short-term business statistics (STS) database. The sample covers years 2004 (from the 2nd quarter) through 2015, i.e. the post-EU accession period, and is of quarterly frequency. The data is both seasonally and calendar adjusted.

Table 1: Definition of variables

Variable	Definition
demand	sales deflated by producers' prices
nominal wage	gross wages and salaries over total hours worked
real wage	gross wages and salaries over total hours worked deflated by the HICP index
employment	number of persons employed
hours worked	total hours worked over number of persons employed

Notes: Due to lack of relevant data, in the case of *mining*, *electricity* and *water supply* demand is approximated by production series. 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 (with division *repair and installation of machinery and equipment* omitted due to lack of relevant data). Table 2 contains 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 2014.

3.3. Integration and cointegration testing

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 indicate integration of order 1 with some weak signs of stationarity (the non-stationarity null rejected at the 10% significance level) in a few cases (see Table 3). For this reason in the case of all industries and all equations we can apply the ARDL methodology.

The existence of the long-run relationship is examined by means of the test proposed by Pesaran et al. (2001) with the null hypothesis of non-significant both error correction parameter and long-run elasticities. Since all the series are difference-stationary we use the critical values for I(1) variables. In most cases the null hypothesis is rejected and the relation is non-degenerate (both 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 labour inputs and demand fluctuations (see tables 4, 5, 6 and 7). In some cases (especially working hours equations) the estimation results point to a degenerate relation, where the differenced variable of interest depends on its lagged level and not on the lagged levels of the forcing variables (see Pesaran et al. 2001). Such cases cannot be interpreted in terms of cointegration. In most cases the null hypothesis of a long-run symmetry is rejected, implying different responses (in terms of significance, magnitude or even sign) depending on the business cycle position.

Table 3: Unit root tests

Sectoral classification	demand		nominal wage		real wage		employment		working hours	
	I(1)	**I(2)**	**I(1)**	**I(2)**	**I(1)**	**I(2)**	**I(1)**	**I(2)**	**I(1)**	**I(2)**
Manufacture of:										
food	-1.48	**-8.53*****	-0.96	**-3.35****	-0.72	**-8.35*****	-2.23	**-5.56*****	0.76	**-2.75*****
beverages	-2.20	**-7.39*****	-0.26	**-8.18*****	-0.64	**-8.15*****	-1.17	**-4.90*****	0.80	**-13.65*****
tobacco	**-2.72***	**-7.19*****	0.42	**-6.73*****	-1.72	**-6.86*****	-0.59	**-4.76*****	-0.70	**-7.86*****
textiles	0.21	**-6.46*****	-0.16	**-3.73*****	-0.26	**-7.80*****	-1.60	**-3.00****	0.62	**-8.34*****
wearing apparel	-2.29	**-6.67*****	0.29	**-3.69*****	0.51	**-5.38*****	-0.69	**-5.58*****	1.63	**-3.15*****
leather and related products	-0.64	**-6.28*****	-0.14	**-11.91*****	0.05	**-11.36*****	-1.66	**-4.18*****	1.10	**-11.14*****
wood, cork, straw and wicker products	-1.02	**-7.50*****	-1.60	**-10.30*****	-1.08	**-9.93*****	-0.01	**-3.90*****	0.19	**-8.18*****
paper and paper products	-0.82	**-5.95*****	-0.97	**-3.47****	-0.58	**-8.87*****	-0.27	**-6.22*****	0.16	**-9.52*****
printing and reproduction	-0.26	**-5.75*****	-0.91	**-8.38*****	-0.81	**-8.42*****	1.58	**-5.78*****	-0.21	**-6.76*****
coke and refined petroleum products	-1.92	**-6.98*****	-0.79	**-11.76*****	-2.10	**-9.18*****	-1.27	**-5.16*****	0.27	**-8.34*****
chemicals and chemical products	-1.36	**-6.30*****	-0.49	**-9.36*****	-0.13	**-9.00*****	0.50	**-5.58*****	0.49	**-8.69*****
pharmaceutical products	-2.05	**-7.48*****	-0.87	**-10.99*****	-2.32	**-5.75*****	-1.93	**-4.91*****	0.61	**-12.51*****
rubber and plastic products	-1.27	**-6.01*****	**-2.63***	**-4.82*****	-1.51	**-7.53*****	-1.00	**-3.83*****	-0.84	**-8.28*****
other non-metallic mineral products	-1.39	**-7.47*****	-1.77	**-9.15*****	-1.04	**-5.22*****	**-2.96***	**-3.42****	-0.04	**-9.16*****
basic metals	**-3.02***	**-5.52*****	-1.61	**-7.27*****	-1.40	**-7.14*****	-2.21	**-4,00*****	0.15	**-8.36*****
metal products	-1.73	**-4.33****	-2.27	**-8.96*****	-2.10	**-4.89*****	-1.03	**-4.24*****	-0.61	**-12.89*****
computer, electronic and optical products	-2.09	**-5.70*****	-2.16	**-10.68*****	-1.97	**-10.33*****	**-2.80***	**-4.47*****	-1.25	**-11.55*****
electrical equipment	-1.36	**-6.67*****	**-2.59***	**-7.90*****	-2.08	**-8.13*****	-2.25	**-3.13****	-1.15	**-8.12*****
machinery and equipment n.e.c.	-2.00	**-7.43*****	-1.85	**-7.43*****	-1.40	**-7.45*****	-0.35	**-5.22*****	-0.26	**-10.22*****
motor vehicles, trailers and semi-trailers	-2.05	**-5.39*****	-2.55	**-10.56*****	-2.15	**-10.49*****	-1.57	**-3.26****	-1.24	**-10.46*****
other transport equipment	-0.41	**-7.36*****	-0.50	**-7.53*****	-0.43	**-7.47*****	-1.32	**-4.05*****	0.44	**-8.35*****
furniture	-0.78	**-6.65*****	-1.44	**-10.44*****	-0.94	**-10.22*****	-1.64	**-4.39*****	-0.23	**-7.22*****
other products	-1.53	**-6.11*****	-1.13	**-9.81*****	-0.70	**-9.80*****	-0.07	**-7.06*****	0.18	**-8.28*****
Mining and quarrying	-1.64	**-8.76*****	-1.10	**-6.27*****	-2.61*	**-4.66*****	1.23	**-4.11*****	0.25	**-6.20*****
Electricity, gas, steam and air conditioning	**-2.94***	**-7.68*****	-0.25	**-10.56*****	-0.10	**-10.34*****	0.16	**-4.93*****	0.92	**-12.29*****
Water supply; sewerage, waste management	-0.87	**-7.02****	-0.15	**-3.08****	-0.71	**-10.13*****	-0.88	**-5.15*****	0.35	**-13.20*****

Notes: The ADF statistics for *demand*, *nominal wage*, *real wage* and *employment* was computed using regressions with an intercept and for *hours worked* using regressions without deterministic terms. One, two and three asterisks indicate statistical significance at the level of 10%, 5% and 1%, respectively.

Table 4: Estimation results: the nominal wage equation

Sectoral classification	Specification (p,q)	$\hat{\gamma}$	$\hat{\delta}_1^+$	$\hat{\delta}_1^-$	$\hat{\beta}_0^+$	$\hat{\beta}_0^-$	Bounds test for cointegration	Test for LR symmetry	B-G test for autocorrelation
Manufacture of:									
food	4,2	**-0.24*** **	**0.73*** **	-0.06	-0.05	0.41	**119.07*** **	**16.20*** **	1.75
beverages	2,1	**-1.11*** **	**0.53*** **	0.10	**0.50** **	-0.09	**81.75*** **	**12.28*** **	1.17
tobacco	2,2	**-1.45*** **	**0.20*** **	0.02	-0.06	**0.52** **	**146.08*** **	**30.71*** **	0.37
textiles	2,1	**-0.57*** **	**0.45*** **	**-0.57*** **	-0.02	**-1.06*** **	**131.19*** **	**255.81*** **	0.95
wearing apparel	2,1	**-0.29*** **	**0.57*** **	**-0.59*** **	-0.04	-0.16	**166.77*** **	**11.79*** **	0.72
leather and related products	2,1	**-0.42*** **	**0.20*** **	**-0.42*** **	-0.02	-0.08	**86.07*** **	**158.44*** **	0.48
wood, cork, straw and wicker products	2,1	**-0.34***	**0.50*** **	-0.35	-0.11	0.43	**72.51*** **	**7.64*** **	0.47
paper and paper products	2,1	-0.24	0.34	-0.42	0.03	0.01	1.16	1.69	1.00
printing and reproduction	2,1	**-0.69*** **	**0.36*** **	**-1.08*** **	-0.02	**-1.25*** **	**40.37*** **	**77.46*** **	1.14
coke and refined petroleum products	2,1	**-1.00*** **	**0.42*** **	-0.03	0.30	-0.01	**86.11*** **	**42.85*** **	0.45
chemicals and chemical products	2,1	-0.04	1.63	2.06	0.02	0.02	0.95	0.27	1.34
pharmaceutical products	2,1	**-0.93*** **	**0.39*** **	**0.12** **	0.24	0.07	**87.43*** **	**33.99*** **	0.86
rubber and plastic products	5,2	-0.20	0.40	0.10	0.09	0.13	1.37	0.26	1.54
other non-metallic mineral products	2,1	**0.31*** **	**0.34*** **	-0.03	0.08	0.04	**9.46*** **	**18.64*** **	0.81
basic metals	2,5	**-0.95*** **	**1.00*** **	**0.60*** **	**0.37***	-0.19	**13.44*** **	**20.36*** **	0.63
metal products	2,5	-0.14	1.56	0.64	-0.06	0.63	1.09	0.81	1.71
computer, electronic and optical products	2,2	**-0.19***	0.14	**-0.88** **	0.17	**-0.68** **	**7.14*** **	**8.57*** **	0.85
electrical equipment	3,1	-0.28	0.35	-0.42	0.21	**-2.69***	0.69	0.36	1.38
machinery and equipment n.e.c.	2,5	**-0.84*** **	**0.62*** **	0.05	0.14	0.10	**296.93*** **	**506.49*** **	1.83
motor vehicles, trailers and semi-trailers	2,3	**-0.41*** **	**0.59*** **	**0.33** **	-0.06	**0.30***	**25.52*** **	2.82	0.61
other transport equipment	2,1	-0.20	0.19	-0.06	0.08	0.09	2.14	3.30	1.16
furniture	5,5	**-0.32*** **	**0.71***	0.24	-0.23	-0.11	**4.64***	1.37	1.82
other products	2,1	-0.08	0.53	0.81	-0.15	-0.02	1.27	0.25	0.70
Mining and quarrying	5,1	**-0.42*** **	0.24	-0.35	0.54	-0.42	**42.94** **	**8.97*** **	1.81
Electricity, gas, steam and air conditioning	2,1	**-0.31*** **	**1.06*** **	-0.41	-0.19	-0.09	**79.82*** **	**150.07*** **	0.68
Water supply; sewerage, waste management	5,4	0.02	3.64	-9.20	-0.17	0.31	0.26	0.00	**1.93***

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

Table 5: Estimation results: the real wage equation

Sectoral classification	Specification (p,q)	$\hat{\gamma}$	$\hat{\delta}_1^+$	$\hat{\delta}_1^-$	$\hat{\beta}_0^+$	$\hat{\beta}_0^-$	Bounds test for cointegration	Test for LR symmetry	B-G test for autocorrelation
Manufacture of:									
food	4,2	**-0.26*****	0.25	0.33	0.01	0.24	**8.13*****	1.42	1.65
beverages	2,1	**-1.05*****	**0.38*****	**0.25****	**0.46****	-0.04	**18.79*****	**12.62*****	0.53
tobacco	2,1	**-1.60*****	**0.12****	0.06	-0.09	**0.52****	**36.73*****	**45.47*****	0.78
textiles	2,1	**-0.35*****	**0.37*****	-0.09	-0.06	**-0.87****	**50.71*****	**15.56*****	1.17
wearing apparel	2,1	**-0.24*****	**0.77*****	0.10	0.02	-0.13	**60.00*****	**56.90*****	0.75
leather and related products	2,1	**-0.40*****	**0.12****	**-0.22****	0.01	-0.05	**26.40*****	**46.58****	0.50
wood, cork, straw and wicker products	2,1	**-0.20***	**0.51*****	0.45	0.04	**0.35***	**24.89*****	0.10	0.59
paper and paper products	2,1	-0.14	0.28	0.18	-0.01	0.10	0.83	0.05	0.84
printing and reproduction	2,1	**-0.50*****	**0.35*****	-0.15	-0.11	-0.63	**59.87****	**5.18*****	0.84
coke and refined petroleum products	2,1	**-1.14*****	**0.39*****	0.21	0.26	0.13	**17.28*****	**5.12****	0.48
chemicals and chemical products	2,1	-0.12	0.70	0.72	0.05	0.03	1.47	0.01	0.79
pharmaceutical products	2,1	**-0.66*****	**0.16*****	**0.15****	0.10	0.08	**9.46*****	0.14	1.26
rubber and plastic products	2,1	-0.21	0.26	0.08	0.09	0.03	1.28	0.47	0.85
other non-metallic mineral products	2,1	-0.17	0.22	0.08	0.10	0.02	1.70	0.52	1.18
basic metals	2,1	**-0.29****	**0.53*****	**0.37*****	0.08	**-0.15***	**20.68*****	**6.17****	1.08
metal products	2,1	-0.13	0.31	2.04	-0.15	**1.12***	0.73	1.31	1.08
computer, electronic and optical products	2,1	-0.15	-0.37	-1.16	0.19	**-0.70***	2.37	**3.05***	0.41
electrical equipment	3,1	-0.32	0.16	-0.82	0.29	**-2.64****	3.79	0.87	1.02
machinery and equipment n.e.c.	2,3	**-0.85*****	**0.50*****	**0.26*****	0.08	0.24	**59.95*****	**29.56*****	0.27
motor vehicles, trailers and semi-trailers	2,3	**-0.40*****	**0.46****	**0.46****	-0.13	**0.39****	**13.16*****	0.01	0.38
other transport equipment	2,1	-0.19	0.23	0.15	0.11	0.08	1.29	1.23	1.04
furniture	5,5	**-0.59*****	**0.76*****	**0.73*****	0.05	0.06	**104.00*****	0.10	0.92
other products	2,1	-0.12	0.24	0.23	-0.18	-0.06	1.54	0.66	0.50
Mining and quarrying	5,2	**-0.43***	0.29	0.07	0.43	-0.32	**4.61***	0.26	**2.82***
Electricity, gas, steam and air conditioning	2,1	**-0.53*****	**0.41***	-0.45	0.11	-0.28	**4.77****	**13.79*****	0.81
Water supply; sewerage, waste management	5,4	-0.17*	0.24	-0.76	-0.05	**0.56***	**5.00****	**4.32***	0.93

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

Table 6: Estimation results: the employment equation

Sectoral classification	**Specification (p,q)**	$\hat{\gamma}$	$\hat{\delta}_1^+$	$\hat{\delta}_1^-$	$\hat{\beta}_0^+$	$\hat{\beta}_0^-$	**Bounds test for cointegration**	**Test for LR symmetry**	**B-G test for autocorrelation**
Manufacture of:									
food	2,2	**-0.32*** **	**0.11***	0.22	0.08	0.05	**16.33*** **	**0.76**	0.86
beverages	2,1	**-0.31*** **	0.06	**0.56*** **	0.09	**0.17***	**318.46*** **	**234.89*** **	1.45
tobacco	2,1	**-0.13** **	0.17	**0.31** **	0.03	0.06	**22.55*** **	**18.26*** **	1.12
textiles	3,5	**-0.07***	0.66	**2.11** **	0.35	0.28	**19.13*** **	**12.36*** **	0.33
wearing apparel	2,2	**-0.09***	1.38	**2.41*** **	0.24	0.25	**51.21** **	**23.12*** **	0.64
leather and related products	2,1	**-0.19*** **	**0.35*** **	**0.94*** **	0.10	0.07	**7.35*** **	**10.62*** **	1.82
wood, cork, straw and wicker products	2,2	**-0.15** **	**0.43** **	**1.21** **	0.01	**0.12***	**12.96** **	**6.93*** **	0.29
paper and paper products	2,2	**-0.28*** **	**0.29*** **	0.11	**0.22*** **	0.02	**104.27*** **	6.85	0.58
printing and reproduction	2,2	**-0.32*** **	**0.54*** **	**0.75*** **	**0.18***	**0.38***	**164.27*** **	1.05	1.79
coke and refined petroleum products	2,1	**-0.15***	0.04	**0.35***	-0.03	-0.03	31.61	62.32	0.54
chemicals and chemical products	2,1	**-0.20** **	**0.22***	0.18	0.06	0.01	**5.18** **	0.75	1.02
pharmaceutical products	3,1	**-0.17** **	0.05	-0.03	0.00	0.07	**4.97** **	0.87	1.06
rubber and plastic products	2,1	**-0.18*** **	**0.68*** **	**1.09*** **	**0.14** **	**0.18** **	**112.48*** **	2.42	0.81
other non-metallic mineral products	2,1	**-0.17*** **	**0.19***	**0.29***	**0.05***	-0.02	**14.98*** **	1.51	0.39
basic metals	3,2	**-0.38*** **	**0.27*** **	**0.40*** **	**0.10** **	0.04	**150.27*** **	**7.73*** **	0.68
metal products	3,1	**-0.25*** **	**0.50*** **	**1.01*** **	**0.13** **	0.17	**202.92*** **	**2.88***	1.11
computer, electronic and optical products	2,1	**-0.11** **	**0.24***	**0.69***	0.06	**0.29** **	**4.72***	**2.81***	0.68
electrical equipment	2,3	-0.04	0.11	1.38	0.06	-0.01	2.53	0.55	1.78
machinery and equipment n.e.c.	5,1	**-0.21** **	**0.33*** **	**0.85*** **	-0.05	**0.61*** **	**112.80*** **	**40.60*** **	1.71
motor vehicles, trailers and semi-trailers	2,2	**-0.09** **	**0.69*** **	**0.90*** **	0.06	**0.13***	**13.19*** **	0.79	0.55
other transport equipment	2,1	**-0.19** **	0.24	**0.52*** **	0.06	-0.05	**15.93*** **	**22.15*** **	1.07
furniture	2,1	**-0.31*** **	**0.37*** **	**0.70*** **	**0.21*** **	**0.33*** **	**15.29*** **	**28.09*** **	1.28
other products	2,1	**-0.32*** **	0.05	**0.22** **	**0.28*** **	**0.13***	**52.62** **	**18.40*** **	0.54
Mining and quarrying	2,1	**-0.13***	-0.54	-0.07	0.13	-0.02	**22.81*** **	**15.41*** **	0.51
Electricity, gas, steam and air conditioning	2,1	-0.03	2.24	2.56	0.01	0.07	1.03	0.51	0.34
Water supply; sewerage, waste management	2,1	-0.07	0.71	0.43	**0.52*** **	0.26	2.08	0.25	0.99

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

Table 7: Estimation results: the hours worked equation

Sectoral classification	Specification (p,q)	$\hat{\gamma}$	$\hat{\delta}_1^+$	$\hat{\delta}_1^-$	$\hat{\beta}_0^+$	$\hat{\beta}_0^-$	Bounds test for cointegration	Test for LR symmetry	B-G test for autocorrelation
Manufacture of:									
food	4,2	**-0.45*** **	-0.02	-0.20	0.18	-0.22	**8.34*** **	0.68	1.53
beverages	2,1	**-0.71*** **	**-0.15***	**-0.23***	-0.19	0.06	**6.31** **	1.51	1.34
tobacco	2,2	**-2.00*** **	**-0.08** **	**-0.05**	-0.07	-0.13	**22.54*** **	15.42	2.33
textiles	2,1	**-0.45*** **	-0.05	-0.10	0.05	**0.68** **	**6.23** **	0.28	1.83
wearing apparel	2,1	**-0.31*** **	-0.13	-0.10	0.05	0.10	**7.65*** **	0.27	1.16
leather and related products	2,1	**-0.55*** **	-0.01	-0.04	0.07	-0.03	**4.56** **	1.33	0.71
wood, cork, straw and wicker products	2,1	**-0.83*** **	0.00	-0.01	0.05	-0.05	**7.28*** **	0.02	0.50
paper and paper products	2,1	**-0.86*** **	0.04	**0.15***	-0.05	0.04	**5.64*** **	3.80	1.07
printing and reproduction	5,5	**-0.55*** **	**-0.15** **	**-0.81** **	-0.04	-0.16	**12.98** **	**3.95***	0.78
coke and refined petroleum products	2,1	**-1.01*** **	-0.10	-0.18	-0.02	-0.25	**7.15*** **	0.85	0.19
chemicals and chemical products	3,5	**-0.73*** **	-0.02	-0.04	0.05	**-0.16***	**4.58** **	0.13	0.71
pharmaceutical products	2,1	**-0.71*** **	-0.01	-0.04	-0.10	0.21	**4.50** **	**0.58*** **	1.35
rubber and plastic products	5,3	**-0.25** **	0.26	0.07	0.09	-0.03	**4.63** **	0.01	**2.07***
other non-metallic mineral products	2,2	**-0.71*** **	-0.02	-0.01	0.02	-0.02	**6.06** **	0.09	1.38
basic metals	2,1	**-1.00*** **	-0.05	-0.07	0.18	-0.01	**5.97** **	0.00	0.24
metal products	2,2	-0.42***	-0.15	-0.87	0.01	-0.52	**4.45***	0.31	1.80
computer, electronic and optical products	2,1	**-0.47*** **	-0.04	-0.03	-0.01	0.30	**6.43*** **	0.00	1.57
electrical equipment	4,1	**-0.35***	0.03	-0.15	0.02	0.72	2.97	0.01	**2.10***
machinery and equipment n.e.c.	2,3	**-0.72*** **	**-0.07*** **	**-0.13*** **	0.11	-0.08	**11.43*** **	3.64	0.72
motor vehicles, trailers and semi-trailers	3,4	**-0.92*** **	**-0.10** **	**-0.20** **	0.11	0.01	**20.72*** **	**9.36*** **	0.63
other transport equipment	2,1	**-0.56*** **	0.07	0.09	-0.01	0.04	**5.30*** **	0.61	0.75
furniture	2,1	**-1.05*** **	-0.03	-0.04	0.17	-0.13	**5.56** **	0.08	0.44
other products	2,1	**-0.57*** **	-0.01	0.00	0.16	0.03	**4.90** **	0.02	0.82
Mining and quarrying	2,1	**-1.19*** **	0.29	0.07	0.43	0.32	**8.37*** **	1.11	1.07
Electricity, gas, steam and air conditioning	3,4	**-0.46*** **	0.12	0.15	0.23	0.14	**6.79*** **	0.08	0.82
Water supply; sewerage, waste management	2,1	**-0.57*** **	0.24	-0.76	-0.05	**0.56***	**5.99** **	0.10	1.04

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

4. Empirical findings

The obtained results (see tables 4, 5, 6 and 7) suggest that firms in Polish industry respond to demand fluctuations by adjusting labour input, both its quantity and prices. There is, however, a substantial sectoral heterogeneity in terms of the adjustment patterns. In general, workforce seems to be more responsive to fluctuations than wage, especially to falling demand. Workforce adjustments take place rather through extensive than intensive margin, i.e. by adjusting the number of employees rather than hours worked per employee.

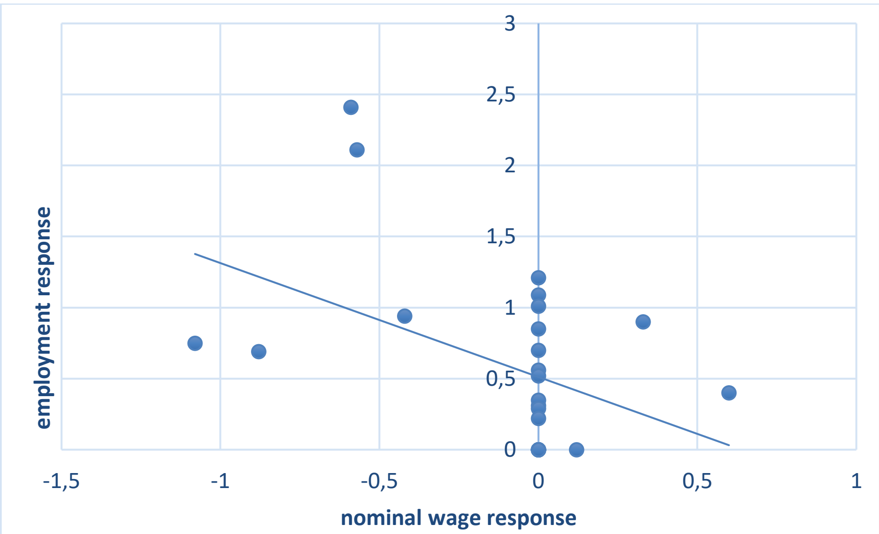
Wages respond to demand fluctuations in two thirds of the industries. In all of them nominal wages increase in cyclical upswings and in most cases (except for manufacturing of *food*) apparently above the inflation rate since real wages also rise. On the other hand, in downturns wage developments differ substantially across sectors. Only in three industries (manufacturing of *pharmaceutical products*, *basic metals* and *motor vehicles*) adjustment of nominal wages seems to be used as a cost-cutting strategy in response to falling demand. In three more (manufacturing of *beverages*, *machinery and equipment n.e.c.* and *furniture*) real wages adjust implying nominal wage freezes in economic slack. In some sectors (manufacturing of *textiles*, *wood* and *metal products* as well as *water supply*) real wages adjust on-impact but there is no evidence of a long-run response suggesting wage freezes as a transitory measure adapted by firms. In several sectors (manufacturing of *textiles*, *wearing apparel* and *leather* as well as *printing*) nominal wages increase significantly in downturns, albeit below the inflation rate (except for manufacturing of *leather*) since no increases in real wages are present, suggesting perhaps the existence of an implicit wage indexation to price developments in these sectors. Wage responses on impact are rare, but in most cases alignments are swift with the average quarterly adjustment raging from about 20 percent to even 100 percent in some cases.

Employment adjustments take place in most sectors in response to both the upturn and the downturn in demand, but responses are highly asymmetrical. In most industries the long-run elasticity with respect to negative shocks is significantly higher than with respect to positive ones, suggesting a hysteretic relationship. In some cases employment response to growing demand is even insignificant. The scale of job losses following adverse shocks varies substantially across industries with long-run elasticities with respect to falling demand ranging from less than 0.50 to over 2. In some industries workforce seems to be resilient to demand fluctuations. These are especially *mining*, *electricity* and *water supply* as well as manufacturing of *coke and refined petroleum*, i.e. industries marked by a high share of public ownership (in all cases over 40 percent public share in employment with average share of about 10 percent in industry and 2 percent in manufacturing), as well as manufacturing of *pharmaceutical products* and *electrical equipment*. In some sectors (manufacturing of *food*, *paper* and *chemicals*), workforce reacts only to upturns in demand with no sign of layoffs in downturns. The speed of the workforce adjustments seems to be slower than in the case of wage. The average quarterly adjustment ranges from less than 10 percent to 30-40 percent. On the other hand, on-impact responses seem to be more widespread than in the case of wages.

Working hours respond significantly to demand fluctuations only in a few sectors. Except for a weak evidence for three sectors (*paper and paper products* in the long-run and *textiles* and *water supply* in the short-run) there is no sign of a decrease in the number of hours worked following a negative shock. Therefore working hours seem not to be used by firms for shock-absorption. Conversely, hours per employee tend rather to increase in downswings and decrease in upswings, which suggests that the adjustment is carried out through laying off employees and redistributing a given amount of work over rest of the staff, thereby saving productivity.

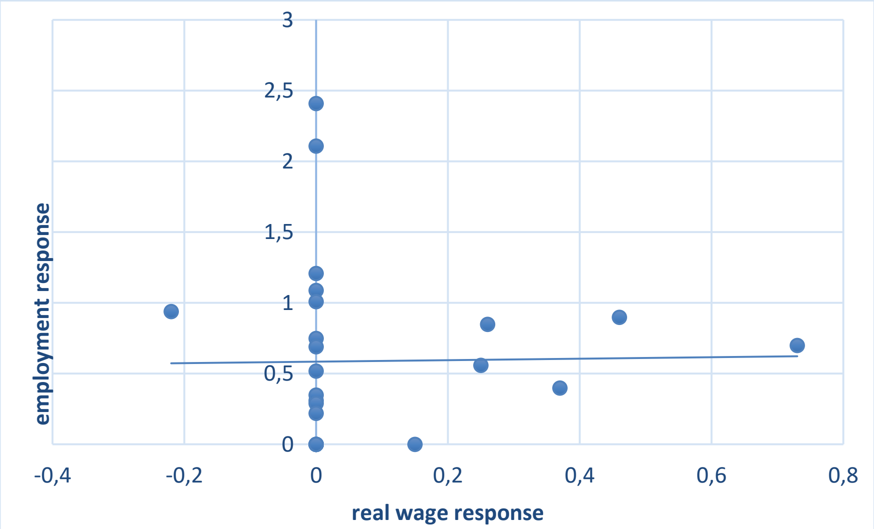
There is virtually no sign of a trade-off between wage and employment adjustments in economic slack (see Figure 1). Pearson's correlation coefficient between nominal wage and workforce responses is significantly negative (-0.44), but this result hinges upon the estimates obtained for two outlying industries (manufacturing of *textiles* and *working apparel*). Their exclusion renders the coefficient insignificant. Also wage freezes are not matched with job protection (Figure 2). Thus, wage concessions in economic downturns do not seem to cushion employment effects of shocks. Of six industries with some degree of downward wage flexibility (either in terms of nominal or real wage) only in the case of one (manufacturing of *pharmaceutical products*) employment seems to be non-responsive to falling demand. It seems rather that industries can be grouped into three categories according to their labour input adjustments in response to falling demand: (1) highly responsive in terms of both wage and workforce (manufacturing of *basic metals*, *machinery* and *motor vehicles*), (2) virtually non-responsive in terms of both wage and workforce (manufacturing of *food*, *paper*, *chemicals*, *electrical eqquippment* as well as *mining*, *electricity* and *water supply*), (3) responsive only in terms of workforce with non-responsive or even increasing wages.

Figure 1. Interrelation between nominal wage and employment responses in cyclical downturn.



Source: Own estimations.

Figure 2. Interrelation between real wage and employment responses in cyclical downturn.



Source: Own estimations.

5. Conclusions

In this study we use non-linear cointegration for the purpose of modelling labour input adjustments separately in cyclical upturns and downturns. The obtained estimates of the long- and short-run elasticities as well as the adjustment parameters allow to characterise the behaviour of wages and employment in response to both increasing and decreasing demand. Sector-level analysis makes it possible to address the question of interchangeability between different channels of shock accommodation, in particular the trade-off between price and quantity adjustments of labour input.

Firstly, the results obtained for Polish industry indicate a widespread downward wage rigidity. Only in three sectors wages seem to decrease in response to falling demand and in three more there is a sign of wage freezing. In the remaining twenty industries wages do not react to or even increase following negative shocks. Secondly, in the majority of industries workforce responds to business cycle fluctuations, but the adjustments are highly asymmetrical, i.e. significantly higher in downturns than in upturns, suggesting possible negative structural consequences. Thirdly, adjustments in hours worked are rare and -- when significant -- seem not to be an active strategy used by firms.

The estimates do not support the hypothesis of a trade-off between wage and employment adjustments. Except for one sector, employment retention in downswings seems not to be matched with wage decreases or at least freezes. It seems rather that sectors (mostly state-dominated) in which workforce is non-responsive to demand fluctuations are also marked with substantial wage rigidity. Conversely, the industries in which there are signs of at least wage moderation in economic downturns are mostly also responsive in terms of employment. Thus, Polish experiences seem not to be in line with the wage-workforce interchangeability conjecture. The degree of wage flexibility is a poor predictor of the sector's employment outcomes in economic slack, which can be the result of countercyclical markup adjustments (and hence low pass-through of wage adjustments into prices) or sectoral heterogeneity in terms of such factors as firms' financial position or foreign demand developments. In the face of these results, cutting or freezing wages in the wake of negative shocks should not be viewed as a universal policy prescription.

However, two caveats should be borne in mind. Firstly, in the aggregate-level analysis the compositional adjustment of employment cannot be taken into account, which may underestimate the degree of wage flexibility. Secondly, as argued by Pissarides (2009), wage rigidity of incumbent workers has no effect on firm's hiring agenda, since the firm begins wage bargaining anew with its new hires. Therefore, there may exist some negative correlation between wage and employment developments, but it pertains only to the job creation channel and cannot be captured at the aggregate level. Nevertheless, this effect - if present - seems to be outweighed by the functioning of the job destruction channel, showing no evidence of wage concessions being traded off for job protection.

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