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1 Introduction

In our dissertation thesis we analyse the dynamics of inflation applying the New Keynesian Phillips curve. Inflation is one of the key indicators of monetary policy, and its dynamics and the nature of short-run inflation have been very debated issues over the decades. Phillips (1958) initiated the discussion that has not been finished yet. The Phillips curve has been one of the central models in macroeconomics since it was published by A. W. Phillips in the paper *"The Relationship Between Unemployment and the Rate of Price Change of Money Wage Rates in the United Kingdom, 1862–19"*. He observed and documented an inverse statistical relationship between the wage inflation and the rate of unemployment over the business cycle. According to his paper, when unemployment was high, nominal wages increased slowly and when unemployment was low, nominal wages rose rapidly except for the period of volatile inflation between two world wars. Low rates of unemployment pressured the labour market to offer higher wages while higher rates of unemployment allowed employers to lower wages.

Recent theoretical advances have produced alternative views of the inflation process with crucially different implications for optimal monetary policy. The new inflation literature is built on the work of Fischer (1977), Taylor (1980) and Calvo (1983) and emphasizes the forward-looking behaviour of subjects on the market and sticky prices framework. One of the key New Keynesian models based on these assumptions is generally known as the New Keynesian Phillips curve (NKPC). The term was introduced by Roberts (1995) and empirically supported by Sbordone (2002a, 2002b), Galí and Gertler (1999) and Galí et. al (2001). Galí and Gertler (1999) also pioneered the estimation of the hybrid NKPC to capture the inflation persistence. Findings of Galí et al. encourage the use of this dynamic general equilibrium models in monetary policy analysis as they suggest that the observed dynamics of inflation can be understood with models derived from microeconomic foundations (Neiss et al., 2002).

The New Keynesian Phillips curve has two distinct features that characterize the relationship between inflation and economic activity. First, it is forward-looking character of inflation that is a consequence of the fact that firms set prices on the basis of their expectations about the future evolution of demand and cost factors. The second feature involves the link between inflation and real activity. The hybrid case of the New Keynesian Phillips curve allows a subset of firms to use the backward-looking rule of thumb to set prices and introduces the lagged inflation term to the former equation.

The final hybrid NKPC is expressed by equation

$$\pi_t = \gamma_f \, \mathbf{E}_t \, \pi_{t+1} + \gamma_b \pi_{t-1} + \lambda mc_t^r + \varepsilon_t, \tag{1}$$

where current inflation π_t is determined by inflation expectations $\mathbf{E}_t \, \pi_{t+1}$, past inflation π_{t-1} and real marginal cost mc_t^r. Coefficients of the model are functions of three structural parameters: probability of price adjustment $(1 - \theta)$, the share of forward-looking subjects on the market $(1 - \omega)$ and subjective discount factor β:

$$\begin{aligned}
\gamma_f &\equiv \theta\beta\phi^{-1} \\
\gamma_b &\equiv \omega\phi^{-1} \\
\lambda &\equiv (1 - \beta\theta)(1 - \omega)(1 - \theta)\phi^{-1} \\
\phi &\equiv \theta + \omega[1 - \theta(1 - \beta)].
\end{aligned}$$

The NKPC can not be directly estimated due to the missing data on the real marginal cost. In the literature, there are generally described two approaches where the real marginal cost is replaced by an appropriate proxy variable, real unit labour costs or output gap.

2 Goals

In our dissertation thesis we concentrate on the inflation dynamics described by the New Keynesian Phillips curve. The main goals of the thesis are:

- Comparison of the two most widely applied estimation techniques, Generalized Method of Moments (GMM) and Full Information Maximum Likelihood (FIML). Although the GMM is a popular method for the estimation of the NKPC, many papers critical to this approach have been published in the last years (Lindé, 2005, Mavroeidis, 2005 and 2006, Stock et al., 2002, Menyhért, 2008, Rudd and Whelan, 2005). Besides other issues, they also focus on the small sample bias, weak instruments and the inclusion of omitted variables in the instrument set. These results recommend the FIML over the GMM also in misspecified models. Since FIML is invariant to normalizations, it enables to estimate structural parameters as well.

- Estimation of the New Keynesian Phillips curve for the selected emerging economy and analysis of the convergence to the advanced economies.

- Collection of available literature on the hybrid case of the NKPC and analysis of its development and outputs. The empirical literature on the hybrid version of NKPC is well founded, with almost 200 papers published in the past 12 years. However, these studies do not come to similar conclusions but often go to opposite direction. Therefore we plan to employ meta-analysis (Stanley and Jarrell, 1989, Stanley, 2005, Feld and Heckemeyer, 2011) and investigate the true relationship between contemporaneous inflation and inflation expectations. The meta-analysis minimizes potential subjective contribution of authors and does not lead to the majority compromise in the presented issue. We would like to detect whether publication selection in this type of literature exists and estimate genuine effect adjusted from the publication bias. Another important goal is to identify significant characteristics of studies and authors that influence the inflation expectations term in the hybrid NKPC.

3 Results

3.1 Inflation Convergence in the Czech Republic[1]

In the presented dissertation thesis we estimate several specifications of the NKPC for the Czech Republic over period 1996–2009. We compare two estimation methods, GMM and FIML, and test their results.

3.1.1 Generalized Method of Moments

We use the following orthogonality conditions to form the baseline for the GMM estimation

$$\mathbf{E}_t\{(\pi_t - \gamma_f \, \mathbf{E}_t \, \pi_{t+1} - \gamma_b \pi_{t-1} - \lambda mc_t^r)\mathbf{z}_{t-1}\} = 0$$

where mc_t^r stands either for the output gap or real unit labour costs as a proxy variable for real marginal cost and $\mathbf{z}_t$ is a vector of instrumental variables. The analysed period is characterized by a comparably stable inflationary process which was less influenced by the reform shocks (e.g. price liberalizations) than the earlier periods. Table 1 presents the GMM and OLS estimates. We compare four different instrument sets. The first basic set includes three lags of inflation and the proxy for real marginal cost. Then we add three lags of the alternative proxy variable (set 2), the real effective exchange rate (set 3) and the interest rate (set 4). Similar instrument sets were used by Menyhért (2008) for Hungary.

The GMM results are surprisingly similar to the OLS estimates. Actually, the GMM results for the forward-looking coefficient are higher than the OLS coefficient. This is especially true if we include a parsimonious set of instruments. However, using the GMM with weak instruments often leads to an overestimation of the forward-looking coefficient and misleading sampling errors biased towards the probability limit of the OLS estimator, which may be the case also in our results.

The weak instrument problem can arise if future inflation is not sufficiently correlated with the selected instruments. To test the quality of instruments we employ several test procedures, e.g. Stock and Yogo (2002) test based on the concentration

[1] This section is based on results from the paper *Inflation Convergence and the New Keynesian Phillips Curve in the Czech Republic* elaborated in cooperation with Jarko Fidrmuc and published in Czech Economic Review (Danišková and Fidrmuc, 2011).

	λ	γ_f	γ_b	J-stat	Partial R^2	Adj.P. R^2	F-stat	S-Y 10% /30%
GAP 1	-0.016	0.613***	0.387*	3.602	0.406	0.344	7.223	11.12/5.15
	(0.032)	(0.204)	(0.204)	(0.463)				
GAP 2	-0.035	0.756***	0.244***	3.929	0.440	0.340	5.249	11.46/4.92
	(0.023)	(0.126)	(0.126)	(0.788)				
GAP 3	-0.026	0.715***	0.285***	5.646	0.633	0.537	5.698	11.52/4.75
	(0.017)	(0.073)	(0.073)	(0.844)				
GAP 4	-0.017	0.664***	0.336***	6.404	0.826	0.764	4.305	11.49/4.63
	(0.015)	(0.065)	(0.065)	(0.930)				
GAP OLS	-0.024	0.516***	0.484***					
	(0.057)	(0.132)	(0.132)					
RULC 1	-0.004	0.638***	0.362***	3.283	0.438	0.379	6.541	11.12/5.15
	(0.025)	(0.122)	(0.122)	(0.512)				
RULC 2	0.002	0.549***	0.451***	4.996	0.531	0.448	5.249	11.46/4.92
	(0.021)	(0.106)	(0.106)	(0.660)				
RULC 3	-0.008	0.652***	0.348***	6.196	0.680	0.596	5.698	11.52/4.75
	(0.018)	(0.084)	(0.084)	(0.799)				
RULC 4	0.001	0.500***	0.500***	6.770	0.848	0.793	4.305	11.49/4.63
	(0.017)	(0.066)	(0.066)	(0.914)				
RULC OLS	-0.054	0.518***	0.482***					
	(0.038)	(0.103)	(0.103)					

Estimated period: 1996q1 - 2009q2. Standard errors are reported in parentheses below the coefficient's estimates.

p-values are reported in parentheses below J statistics. * - significance at 10%, ** - significance at 5%, *** - significance at 1%.

S-Y 10% / 30% are Stock-Yogo critical values for Weak IV test statistics for maximal percentage bias.

Instrumental Variables: GAP 1 - core(1, 2, 3), gap(1,2,3); GAP 2 - core(1,2,3), gap(1,2,3), rulc(1,2,3);
GAP 3 - core(1,2,3), gap(1,2,3), rulc(1,2,3), reer(1,2,3); GAP 4 - core(1,2,3), gap(1,2,3), rulc(1,2,3), reer(1,2,3), ir(1,2,3).

Instrumental Variables: RULC 1 - core(1, 2, 3), rulc(1,2,3); RULC 2 - core(1,2,3), rulc(1,2,3), gap(1,2,3);
RULC 3 - core(1,2,3), rulc(1,2,3), gap(1,2,3), reer(1,2,3); RULC 4 - core(1,2,3), gap(1,2,3), rulc(1,2,3), reer(1,2,3), ir(1,2,3).

Table 1: GMM results for the Czech Republic

parameter. For instrument set (including a constant) $\mathbf{Z}$ and normally distributed error terms, ε_t and ν_t, the concentration parameter μ^2 is defined as

$$\mu^2 = \boldsymbol{\delta}'\mathbf{Z}'\mathbf{Z}\boldsymbol{\delta}/\sigma_\nu^2,$$

where $\boldsymbol{\delta}$ is the vector of coefficients estimated in

$$\pi_{t+1} = \mathbf{z}_t'\boldsymbol{\delta} + \nu_t.$$

With $\mu^2 \to \infty$, the GMM sampling distribution converges to the normal distribution with zero mean. However, for small values of μ^2, the distribution is nonstandard. To decide whether the instruments are weak we test $H_0 : \boldsymbol{\delta}_{nc} = \mathbf{0}$[2]. High F-statistics indicate high relevance of instrument set and higher μ^2. Their values range between 4.3 and 7.2 (see Table 1) in all specifications and they are decreasing with the number of instruments in the instrument set. There are various interpretations of these F-statistics. Stock and Yogo (2002) report critical values for a GMM bias. If F-statistics are higher than the reported critical value for 10% or 30% significance levels, the maximum bias of the GMM will be less than 10% or 30% of the OLS bias. Thus, in our estimations the GMM exceeds 10% in three cases and even 30% in one case for both proxy specifications. The conclusion is that the GMM is only partially able to improve the OLS estimates. The bias of GMM estimates is also found by Lindé (2005) and Menyhért (2008) and they recommend using the full information maximum likelihood estimator.

3.1.2 Full Information Maximum Likelihood

The FIML estimator belongs to the class of full information methods. Specification requires a multiple-equation model formed by a complete system of simultaneous equations which are formulated for each endogenous variable.The advantage of FIML is that it is consistent also for models where the error term does not follow a normal distribution. Moreover, the FIML exploits the full information available in the complete system of simultaneous equations.

We formed the system by the NKPC equation and a vector autoregressive model (VAR) containing the endogenous variables collected in a K-dimensional vector $\mathbf{z}_t$ specified as

$$\mathbf{z}_t = \mathbf{c} + \mathbf{M}(L)\mathbf{z}_{t-1} + \mathbf{m}(L)\pi_{t-1} + \boldsymbol{\xi}_t$$

where $\mathbf{M}(L) = \mathbf{M}_0 + \mathbf{M}_1 L + \mathbf{M}_2 L^2 + \cdots + \mathbf{M}_I L^I$, $\mathbf{m}(L) = \mathbf{m}_0 + \mathbf{m}_1 L + \mathbf{m}_2 L^2 + \cdots + \mathbf{m}_I L^I$, I equals the number of lags and L is the lag operator. $\mathbf{M}_i$ and $\mathbf{m}_i$ are $K \times K$ matrices of coefficients and $\boldsymbol{\xi}_t$ is a vector of residuals. Our set of endogenous variables includes RULC, output gap and the real exchange rate. For each specification we also considered three different lag lengths.

The results for gap specification are reported in Table 2. The estimated coefficients range between 0.580 and 0.617 and they are highly significant. The output gap coeffi-

[2]The subscript nc stands for "no constant" because the constant term is not included in the null hypothesis.

cient is in nearly all cases positive but insignificant. A more encouraging result can be found for the estimated structural coefficients, which are highly significant. The share of subjects with constant prices is estimated at 0.708 to 0.898. The average duration of constant prices is calculated as $1/(1-\theta)$ and varies from 3.4 quarters to 9.8 quarters. Approximately a half of the firms are backward-looking.

The results for the RULC specification can be found in Table 3. The share of forward and backward-looking firms is similar to the output gap version. While the forward-looking component is between 0.598 and 0.617, the backward-looking component ranges from 0.381 to 0.405. Contrary to the gap specifications, λ is marginally significant and correctly signed in two models, V1L1 and V3L3, with values of 0.015 and 0.004. The structural estimates are again highly significant with average duration of

GAP	Reduced-form estimates			Structural estimates					
	λ	γ_f	γ_b	θ	ω	β	λ	γ_f	γ_b
V1L1	0.004	0.615***	0.391***	0.876***	0.556***	1.000***	0.005	0.612	0.388
	(0.007)	(0.054)	(0.055)	(0.218)	(0.118)	(0.101)			
V1L2	0.018	0.602***	0.398***	0.827***	0.406***	0.999***	0.014	0.671	0.329
	(0.011)	(0.085)	(0.072)	(0.063)	(0.024)	(0.013)			
V1L3	0.005	0.605***	0.395***	0.860***	0.564***	0.996***	0.006	0.602	0.397
	(0.009)	(0.065)	(0.065)	(0.107)	(0.122)	(0.011)			
V2L1	0.005	0.603***	0.404***	0.875***	0.545***	0.999***	0.0002	0.641	0.359
	(0.017)	(0.089)	(0.105)	(0.184)	(0.117)	(0.079)			
V2L2	0.015	0.605***	0.397*	0.802***	0.516***	0.997***	0.015	0.607	0.392
	(0.024)	(0.189)	(0.210)	(0.056)	(0.094)	(0.017)			
V2L3	0.003	0.604***	0.396***	0.898***	0.592***	0.999***	0.003	0.602	0.397
	(0.003)	(0.048)	(0.048)	(0.072)	(0.099)	(0.002)			
V3L1	0.006	0.617***	0.389***	0.862***	0.524***	0.999***	0.007	0.621	0.378
	(0.006)	(0.042)	(0.044)	(0.112)	(0.105)	(0.094)			
V3L2	0.016	0.598***	0.405***	0.708***	0.514***	0.982***	0.036	0.572	0.423
	(0.010)	(0.062)	(0.061)	(0.030)	(0.085)	(0.024)			
V3L3	−0.001	0.580***	0.419***	0.754***	0.597***	0.990***	0.003	0.612	0.388
	(0.002)	(0.035)	(0.035)	(0.000)	(0.101)	(0.002)			

Estimated period: 1996q1 - 2009q2. Standard errors are reported in parentheses below the coefficient's estimates.

VKLI stands for VAR(K) and LAG(I); $I = 1, 2, 3$; $K = 1, 2, 3$ contains the output gap and is extended with rulc and reer.

* - significance at 10%, ** - significance at 5%, *** - significance at 1%.

Table 2: FIML estimates of the NKPC with output gap proxy

constant prices from 3 to 11 quarters.

Our preferred results are comparable to those reported for other countries of the EU. In particular, real activity is correctly signed in some specifications, but the coefficients are generally low or even insignificant. This implies that the New Keynesian Phillips curve is flat in the Czech Republic in comparison to other countries. In turn, we find a relatively high share of the inflation expectations term of about 60%. The estimated results are also similar to those obtained by other authors for the early member states of the European Union. Jondeau and LeBihan (2006) estimate the forward-looking coefficients in a RULC specification at 0.6 for the EU, 0.54 for France, USA and Italy, 0.56 for Germany and 0.71 for the UK. Thus, we can conclude that the monetary features of Czech Republic has converged to those characterized for the advanced economies.

RULC	Reduced-form estimates			Structural estimates					
	λ	γ_f	γ_b	θ	ω	β	λ	γ_f	γ_b
V1L1	0.015*	0.598***	0.403***	0.793***	0.537***	0.996***	0.015	0.594	0.404
	(0.008)	(0.035)	(0.036)	(0.105)	(0.147)	(0.010)			
V1L2	−0.000	0.616***	0.384***	0.779*	0.528**	0.993***	0.018	0.593	0.405
	(0.003)	(0.095)	(0.092)	(0.418)	(0.264)	(0.101)			
V1L3	−0.006	0.610***	0.384***	0.807***	0.584***	0.999***	0.011	0.580	0.420
	(0.035)	(0.054)	(0.048)	(0.104)	(0.113)	(0.006)			
V2L1	0.019	0.606***	0.405***	0.789***	0.513***	0.998***	0.017	0.605	0.395
	(0.016)	(0.115)	(0.036)	(0.070)	(0.094)	(0.011)			
V2L2	−0.000	0.615***	0.384***	0.775***	0.513***	0.996***	0.020	0.600	0.399
	(0.006)	(0.071)	(0.067)	(0.151)	(0.102)	(0.016)			
V2L3	−0.013	0.606***	0.381***	0.910***	0.590***	0.998***	0.002	0.605	0.394
	(0.044)	(0.056)	(0.052)	(0.107)	(0.082)	(0.004)			
V3L1	−0.000	0.613***	0.386***	0.785***	0.518***	0.997***	0.017	0.601	0.398
	(0.000)	(0.043)	(0.043)	(0.111)	(0.109)	(0.089)			
V3L2	−0.000	0.616***	0.384***	0.681***	0.458***	0.997***	0.048	0.597	0.402
	(0.003)	(0.045)	(0.045)	(0.070)	(0.096)	(0.001)			
V3L3	0.004*	0.617***	0.383***	0.807***	0.584***	0.999***	0.011	0.579	0.420
	(0.002)	(0.010)	(0.008)	(0.104)	(0.113)	(0.006)			

Estimated period: 1996q1 - 2009q2. Standard errors are reported in parentheses below the coefficient's estimates.

VKLI stands for VAR(K) and LAG(I); $I = 1, 2, 3$; $K = 1, 2, 3$ contains rulc and is extended with output gap and reer.

* - significance at 10%, ** - significance at 5%, *** - significance at 1%.

Table 3: FIML estimates of the NKPC with RULC proxy

3.2 Meta-Analysis of the New Keynesian Phillips Curve[3]

We analyse the expected inflation term γ_f of the New Keynesian Phillips curve by meta-analysis. At first we concentrate on the existence of publication selection, and then we examine characteristics that influence estimated value of the γ_f.

The publication bias expresses preference for statistically strong, significant and theoretically sound results and it is determined only by the decisions made by the editors, reviewers and researches who tend to prefer results of a specific range (Stanley, 2005, 2008). Their bias in a particular direction might be detected in the funnel plot which would reveal it unless veiled by the asymmetry from other sources. The funnel plot is a scatter diagram displaying the precision (e.g. inverse standard errors, square root of sample size, etc.) against an examined effect. If publication bias is insignificant, the funnel plot should look like an inverted funnel and the estimates should vary symmetrically around the true effect. The estimates which are close to the true effect should be characterized by the highest precision. Similarly, the less precise estimates should be located in the lower part of the chart. On the other hand, if publication selection prefers significant results then the funnel plot would be hollow and unduly wide. A visual examination of the funnel plots is often not conclusive in the detection of asymmetry. Nevertheless, it provides the first evidence of a publication selection for the journals.

For purpose of meta-analysis we collected 1899 estimates from almost 200 studies. All of them except outliers are displayed in the funnel plots in Figure 1. The lower part of the figures misses insignificant estimates especially for the top ranked journals. Furthermore, most observations are on the right hand side of the funnel plots which shows a preference for higher values of estimates. Regarding the lower blocks, they have the shape close to an inverted funnel having slightly more weight on their right hand side as well. Since funnel plot is subjective tool, we test the existence of publication selection by Funnel Asymmetry Test (FAT) and results are available in the thesis. Overall, they confirm the presence of asymmetry in NKPC literature which is related to the publication bias. The bias is even higher for top ranked journals proving that they tend to significant estimates close to expected value between 1/2 and 2/3.

Further, meta-analysis is able to answer the question about differences in estimates

[3]This section is based on results from the working paper *Meta-Analysis of the New Keynesian Phillips Curve* elaborated in cooperation with Jarko Fidrmuc (Fidrmuc and Danišková, 2012).

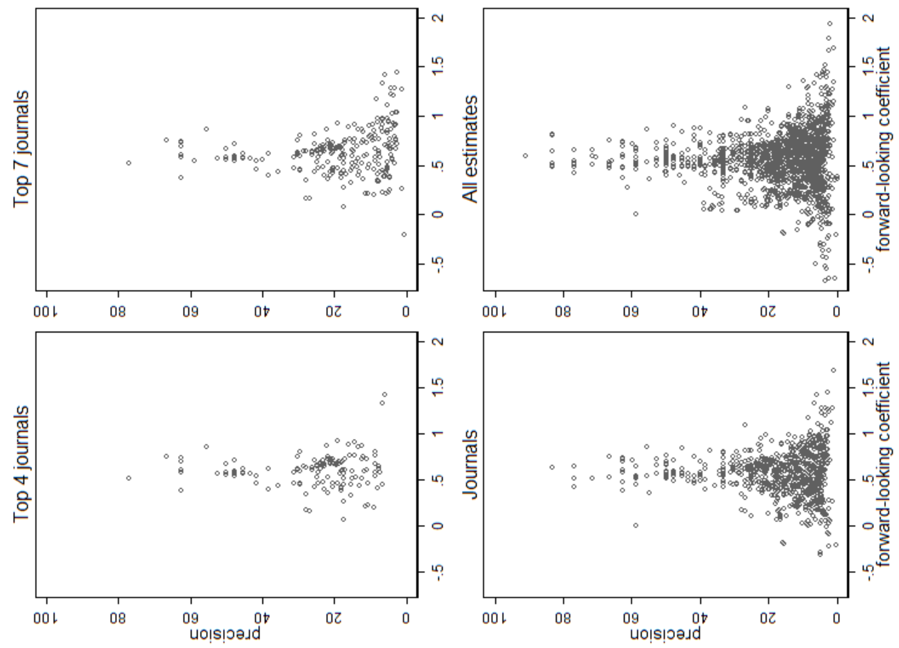

Figure 1: Funnel plots

of the same parameter. What causes estimates of γ_f to come from such a wide range and authors to come to totally opposite conclusions? After all, they do investigate similar issues, trying to employ the most appropriate tools. Using the corresponding parameter estimates for γ_f from nearly 200 studies investigating the hybrid NKPC for different countries and periods, we estimate multi-variable regression models which aim to explain the differences of the estimated coefficients:

$$\frac{\hat{\gamma}_i}{se_i} = t_i^{\gamma} = \gamma \frac{1}{se_i} + \sum_{k=1}^{K} \beta_k D_{ik} \frac{1}{se_i} + \nu_i, \tag{2}$$

where $\hat{\gamma}_i$ is the estimated share of inflation expectations term, ν_i is the error term and equation is weighted by standard errors of collected estimates. Variables D_k represent a set of K variables, which include both continuous and dummy variables and summarize information related to data definition, data structure, estimation method, publication, and included control variables, among others. Some of them are excluded from the equation (2) to avoid perfect multicollinearity. The intercept, γ, shows a value of the forward-looking coefficient, which corresponds to the benchmark characteristics.

The list of variables and their description is in Table 5. Regression results are presented in Table 4. The first three columns of Table 4 include all explanatory variables, while the next three columns exclude insignificant and highly correlated characteristics. We focus on these parsimonious specifications and the results largely confirm our expectations.

Regarding study characteristics, it seems that all of them have a significant impact on the published forward-looking coefficients. The inclusion of the demeaned year of publication appears to have significant positive impact although with different coefficients. This suggests that a trend can be identified either in publications or in analysed economies. The estimated shares of the inflation expectations term are more than 10 percentage points lower for working papers (including unpublished manuscripts) than for journal publications. Google citations appear with a positive and significant coefficient which supports earlier claims that the most cited papers report higher results.

Regarding the author's characteristics, *acaa* has negative impact on the effect which means that if at least one of the co-authors holds position in an academic institution, published estimates are lower. Among the equation characteristics, the following variables are found to determine the results. The sum restriction ($\gamma_f + \gamma_b = 1$) denoted by *beta* tends to increase the associated estimates. If a study uses real unit labour costs and output gap as a proxy variable for the real marginal cost or includes additional lags into the NKPC, the results are lower. Other proxy variables are significantly different with negative sign as well. The open economy NKPC lowers the weights of inflation expectations. This can correspond to a lower impact of inflation expectations in an open economy. Quite surprisingly, our estimates suggest that the assumption of rational expectations performs similarly as the use of survey data.

The next set of explanatory variables describes the data characteristics. The way inflation is measured is important since CPI and core inflation give significantly different results comparing to the baseline GDP deflator. It seems that GDP deflator overestimates the impact of inflation expectations. The choice of data frequency turns out to be unimportant in parsimonious specifications since monthly and annual frequency of the data are not significantly different from quarterly frequency. Finally, the range of data set expressed by the first and last year of the sample says that database starting before 1979 and ending after 2003 leads to the higher estimates.

Table 4: Multivariate Meta-Regresion

	ME	FE	REGCL	ME	FE	REGCL	ME^{out}	FE^{out}	$REGCL^{out}$
yeardm	0.029***	0.047***	0.021*	0.030***	0.037***	0.019*	0.011***	0.011*	-0.001
	(0.004)	(0.006)	(0.011)	(0.003)	(0.004)	(0.010)	(0.004)	(0.006)	(0.007)
wp	-0.144***	-0.219***	-0.127***	-0.136***	-0.189***	-0.097**	-0.071***	-0.109***	-0.013
	(0.024)	(0.030)	(0.047)	(0.021)	(0.025)	(0.042)	(0.015)	(0.018)	(0.028)
othstudy	-0.137***	-0.186***	-0.118**	-0.102***	-0.113***	-0.088**	0.065***	0.051***	0.050*
	(0.024)	(0.031)	(0.056)	(0.018)	(0.021)	(0.041)	(0.017)	(0.020)	(0.027)
citg	0.062***	0.119***	0.066**	0.085***	0.116***	0.059***	0.026***	0.023**	0.009
	(0.014)	(0.019)	(0.029)	(0.009)	(0.012)	(0.020)	(0.008)	(0.010)	(0.011)
em	-0.146***	-0.170***	-0.101						
	(0.035)	(0.043)	(0.063)						
recfac	0.074**	0.000	-0.036						
	(0.037)	(0.053)	(0.058)						
acitr	-0.007	-0.008	0.002						
	(0.004)	(0.006)	(0.009)						
aem	0.036	0.179***	0.001						
	(0.028)	(0.038)	(0.043)						
aaca	-0.110***	-0.099***	-0.059*	-0.103***	-0.114***	-0.059**	-0.079***	-0.105***	-0.013
	(0.019)	(0.023)	(0.032)	(0.016)	(0.021)	(0.028)	(0.013)	(0.015)	(0.021)
beta	0.159***	0.156***	0.164***	0.155***	0.148***	0.158***	-0.006	-0.010	0.006
	(0.009)	(0.009)	(0.027)	(0.008)	(0.009)	(0.025)	(0.008)	(0.008)	(0.021)
gap	-0.055**	-0.035	-0.071	-0.088***	-0.085***	-0.098	-0.111***	-0.132***	-0.079**
	(0.026)	(0.030)	(0.054)	(0.025)	(0.029)	(0.061)	(0.017)	(0.019)	(0.038)
rulc	-0.142***	-0.130***	-0.146**	-0.177***	-0.184***	-0.176***	-0.050***	-0.081***	0.005
	(0.026)	(0.030)	(0.057)	(0.024)	(0.029)	(0.065)	(0.017)	(0.019)	(0.041)
othproxy	-0.149***	-0.163***	-0.072	-0.164***	-0.207***	-0.086	-0.050**	-0.086***	0.014
	(0.042)	(0.047)	(0.091)	(0.041)	(0.047)	(0.090)	(0.024)	(0.027)	(0.067)
sur	0.039	0.080**	-0.006	0.014	0.025	0.001	0.000	0.013	-0.028
	(0.028)	(0.032)	(0.052)	(0.025)	(0.028)	(0.044)	(0.015)	(0.016)	(0.035)
othexp	-0.017	0.010	-0.120						
	(0.090)	(0.096)	(0.075)						
inflag	-0.158***	-0.150***	-0.160***	-0.128***	-0.129***	-0.128***	-0.054***	-0.055***	-0.079*
	(0.029)	(0.032)	(0.052)	(0.026)	(0.028)	(0.041)	(0.016)	(0.017)	(0.046)
inflead	0.042	0.007	0.079						
	(0.064)	(0.066)	(0.088)						
infdev	-0.110***	-0.103	-0.104*	-0.084**	-0.088	-0.092*	0.001	0.007	-0.055
	(0.039)	(0.068)	(0.053)	(0.037)	(0.069)	(0.048)	(0.030)	(0.037)	(0.068)
open	-0.083***	-0.113***	-0.076**	-0.060***	-0.065***	-0.054*	-0.031**	-0.014	-0.092***
	(0.018)	(0.020)	(0.036)	(0.017)	(0.018)	(0.032)	(0.014)	(0.016)	(0.032)
firstdm	-0.004***	-0.004***	-0.005***	-0.005***	-0.004***	-0.006***	-0.002***	-0.002***	-0.000
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
lastdm	0.013***	0.011***	0.011**	0.012***	0.013***	0.010**	0.002**	0.002**	0.003
	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.004)	(0.001)	(0.001)	(0.002)

Continued on next page. . .

Table 4 – Continued

	ME	FE	REGCL	ME	FE	REGCL	ME^{out}	FE^{out}	$REGCL^{out}$
month	-0.067*	-0.108**	-0.086	-0.048	-0.069	-0.077	-0.076***	-0.108***	-0.111**
	(0.037)	(0.052)	(0.054)	(0.036)	(0.052)	(0.054)	(0.024)	(0.029)	(0.056)
annual	-0.035	-0.051	-0.082						
	(0.054)	(0.100)	(0.069)						
obs	-0.002	-0.006*	0.001						
	(0.002)	(0.004)	(0.002)						
cpi	-0.135***	-0.110***	-0.146***	-0.134***	-0.124***	-0.147***	-0.085***	-0.099***	-0.055*
	(0.012)	(0.013)	(0.031)	(0.012)	(0.013)	(0.028)	(0.011)	(0.011)	(0.028)
core	-0.065***	-0.051***	-0.094**	-0.098***	-0.090***	-0.116***	0.107***	0.115***	0.053
	(0.017)	(0.019)	(0.044)	(0.016)	(0.017)	(0.040)	(0.030)	(0.033)	(0.060)
othinf	0.001	0.016	-0.018						
	(0.021)	(0.023)	(0.039)						
tsls	0.080**	0.043	0.107	0.095**	0.063	0.078	0.036	0.013	0.080
	(0.041)	(0.050)	(0.080)	(0.040)	(0.049)	(0.070)	(0.023)	(0.025)	(0.054)
like	-0.072***	-0.104***	-0.085*	-0.050***	-0.046**	-0.060	-0.053***	-0.063***	-0.059**
	(0.021)	(0.025)	(0.046)	(0.019)	(0.022)	(0.040)	(0.013)	(0.015)	(0.027)
ols	0.051*	0.020	0.092*	0.074***	0.059**	0.091	0.031**	0.020	0.062
	(0.029)	(0.031)	(0.053)	(0.027)	(0.029)	(0.055)	(0.015)	(0.016)	(0.040)
bayes	-0.142	-0.683**	-0.109	-0.085	-0.424	-0.044	0.106	-0.065	0.185***
	(0.109)	(0.311)	(0.122)	(0.101)	(0.309)	(0.083)	(0.070)	(0.159)	(0.066)
eel	0.069	0.032	0.090*	0.081	0.048	0.125**	0.001	-0.002	-0.012
	(0.083)	(0.089)	(0.051)	(0.083)	(0.091)	(0.052)	(0.044)	(0.046)	(0.023)
gse	0.206***	0.183***	0.243***	0.246***	0.242***	0.259***	-0.009	-0.020	-0.019
	(0.031)	(0.036)	(0.040)	(0.026)	(0.028)	(0.035)	(0.021)	(0.024)	(0.038)
tvc	0.059	-0.028	0.232*	0.061	-0.014	0.248*	0.009	-0.015	0.191*
	(0.152)	(0.161)	(0.130)	(0.153)	(0.164)	(0.135)	(0.081)	(0.083)	(0.103)
gel	0.047	0.041	0.068						
	(0.064)	(0.068)	(0.050)						
othmeth	0.006	0.011	-0.000						
	(0.014)	(0.014)	(0.014)						
model	0.036	0.166***	0.033						
	(0.023)	(0.032)	(0.048)						
constant	0.119	-0.021	-0.007	0.221	0.042	-0.066	0.447*	0.513***	0.175
	(0.331)	(0.221)	(0.316)	(0.314)	(0.203)	(0.324)	(0.238)	(0.126)	(0.241)
obs	1,899	1,899	1,899	1,899	1,899	1,899	1,853	1,853	1,853
R^2 adj.		0.991	0.990		0.991	0.989		0.874	0.895
n groups	197	197	197	197	197	197	194	194	194
groups	studies	studies	studies	studies	studies	studies	studies	studies	studies

Standard errors are reported in parenthesis. Upper index out stands for "without outliers".

ME - mixed-effects model, FE - fixed-effects model, OLSCL - ordinary least squares with clustered s.e.

* - significance at 10%, ** - 5%, *** - 1%.

Table 5: Description of regression variables

		mean	s.e.
Study characteristics			
yeardm	year of publication subtracted by its average; rounded average of year is 2007	0.000	2.353
jr	=1 if study is published in a journal or in a book	0.473	0.499
wp	=1 if study is working paper	0.422	0.494
othstudy	=1 if study is dissertation or master thesis, or unpublished	0.111	0.314
citg	number of study citations from Google scholar (divided by age, log)	0.808	1.041
recfac	recursive factor for working paper series and journals from Repec database	0.278	0.341
em	=1 if study is focused on emerging countries	0.270	0.444
Author characteristics			
acitr	number of citations of the most cited author from Repec (log)	3.972	2.485
awest	=1 if one or more co-authors work in developed country	0.855	0.353
aem	=1 if one or more co-authors work in developing country	0.219	0.414
acb	=1 if one or more co-authors are affiliated with a central bank	0.513	0.500
aaca	=1 if one or more co-authors are affiliated with an academic institution	0.699	0.459
Equation characteristics			
beta	=1 if the sum of forward and backward coefficient is restricted	0.330	0.470
rulc	=1 if marginal cost is proxied by real unit labour costs	0.425	0.495
unempl	=1 if marginal cost is proxied by unemployment	0.058	0.235
gap	=1 if marginal cost is proxied by output gap	0.471	0.499
othproxy	=1 if marginal cost is proxied by other variable	0.064	0.245
rat	=1 in case of assumption of rational expectations	0.735	0.442
sur	=1 in case of survey data approximation for inflation expectations	0.235	0.424
othexp	=1 in case of other types of expectations	0.034	0.181
inflag	=1 if NKPC is estimated with extra inflation lags	0.099	0.299
inflead	=1 if NKPC is estimated with extra inflation leads	0.029	0.169
infdev	=1 if inflation changes are considered instead of absolute values	0.037	0.190
closed	=1 if estimate comes from closed economy NKPC	0.787	0.410
open	=1 if estimate comes from open economy NKPC	0.213	0.410
Data characteristics			
firstdm	first year of the data subtracted by its average; rounded average first year is 1979	0.000	13.755
lastdm	last year of data subtracted by its average; rounded average last year is 2003	0.000	4.757
month	=1 in case of monthly data structure	0.092	0.289
quarter	=1 in case of quarterly data structure	0.817	0.387
annual	=1 in case of annual data structure	0.091	0.287
obs	number of years in observations	28.447	51.246
cpi	=1 if inflation is measured by cpi	0.360	0.480
gdp	=1 if inflation is measured by gdp deflator	0.483	0.500
core	=1 if inflation is measured by core inflation	0.021	0.142
othinf	=1 if inflation measured by as nfb, rpi, etc.	0.140	0.348
Method characteristics			
like	=1 if estimation method is maximum likelihood	0.086	0.280
gmm	=1 if estimation method is generalized method of moments	0.677	0.468
tsls	=1 if estimation method is two stage least squares	0.101	0.301
bayes	=1 if bayes estimation method is applied	0.005	0.072
ols	=1 if estimation method is ordinary least squares	0.074	0.261
eel	=1 if estimation method is 3S-EEL estimator	0.004	0.065
gse	=1 if estimate comes from generalized spectral estimation	0.011	0.102
tvc	=1 in case of time-varying coefficient estimation technique	0.007	0.086
gel	=1 if estimation method is generalized empirical likelihood	0.006	0.079
othmeth	=1 in case of other estimation method	0.057	0.233
model	=1 if NKPC is estimated within model	0.065	0.247

The general expectations related to the estimation methods are largely confirmed. The claims of Jondeau and LeBihan (2006), who compare the GMM and the ML specifications, are in line with our meta analysis. They report that the GMM leads to an overestimation of the forward-looking coefficient. This is clearly confirmed by meta-regression results where maximum likelihood represented by variable *like* is significantly negative. It is also expected that the results for the TSLS are more or less comparable with the GMM results, which is considered as the base category. Regarding other estimation methods (OLS, EEL, GSE and TVC) we can see a positive bias even compared to the GMM.

In our robustness analysis, we exclude outliers from all specifications. For comparison we present these results in columns whose headers are augmented by *out*. The results for nearly all variables are robust to this sensitivity test. However, some variables (e.g. sum restriction *beta*, inflation deviations *infdev*) turned out to be insignificant and other marginal variables even switched their sign (e.g. core inflation *core*, other studies *othstudy*). The impact of RULC as a proxy of real marginal cost is lower comparing to output gap and monthly frequency is significantly different from quarterly frequency with negative sign. The estimation methods TSLS and OLS are no more significant for preferred specification, which supports the critique of GMM as not dealing appropriately with the endogeneity problems. Other robustness tests are available in the dissertation thesis.

Moreover, we estimate the genuine effect for every country separately. Results confirm overwhelming differences between the countries. The meta effect is insignificant for eight countries including Japan, Brazil, China, Estonia, Norway, Latvia, Turkey and Romania. The weak results for Japan and China can be explained by deflation in these countries in some periods. In turn, Brazil and Eastern European countries were characterized by a successful disinflation process. Besides these countries it is Greece and Germany that show the lowest (while significant) shares of the forward-looking coefficient. The individual results confirm a high share of inflation expectations term in the USA and several emerging markets. The highest values are actually reported for Lithuania and Russia.

4 Summary

In the thesis we analyse monetary policy and inflation dynamics estimating the New Keynesian Phillips curve. We describe the derivation of the NKPC and the approximation of real marginal cost by different macroeconomic variables. Moreover, we review different approaches of the derivation or construction of the open economy NKPC. Finally, the theoretical part of the thesis ends with the overview of the literature developed during past twelve years since Galí and Gertler published their influential paper (Galí and Gertler, 1999).

The comparison of Generalized Method of Moments and Full Information Maximum Likelihood represents one of the main goals of the thesis. We follow approach of Menyhért (2008) and Lindé (2005) and estimate NKPC for the Czech Republic between 1996 and 2009. Our findings show that the GMM results are likely to be overestimated because GMM is not able to dispose of the significant share of OLS bias (Danišková and Fidrmuc, 2011). Moreover, the resulting estimates depend on the choice of instrumental variables. The results obtained by FIML confirm preferable status of FIML. They imply that real marginal cost is mostly unimportant in the inflation dynamics of the Czech Republic and estimates of structural parameters are comparable to those reported for other countries of the EU.

The thesis also examines the heterogeneity among estimates of the NKPC applying meta-analysis (Stanley and Jarrell, 1989, Stanley, 2005, Feld and Heckemeyer, 2011). We focus on the coefficient of the expected inflation and collect almost two hundred papers dealing with the hybrid version of the NKPC (Fidrmuc and Danišková, 2012). Our results confirm the presence of asymmetry in the NKPC literature which can be attributed to the publication bias. Top journals show even higher publication bias accepting significant estimates close to the expected value. Moreover, there is an overall positive trend in the literature concerning the NKPC.

The impact of authors' characteristics is not essential except for holding a position in an academic institution. Further, we find that characteristics of analysed studies have a significant impact on the reported results. The meta-regressions confirm that the published results are higher than results in working papers. Besides this, estimation characteristics are especially important. The GMM, which is frequently used in the earlier literature on the topic, is actually not performing statistically differently than the simple OLS in the specification clustered by studies and without outliers. This provides further empirical support for the widespread critique of the GMM method in final samples. On the other hand, likelihood estimators report lower shares of the forward-looking term. Survey measures of inflation expectations, which are also stressed in the literature, appear not to be significantly different from rational expectations.

Finally, we find significant differences between price characteristics in different countries and world regions. The role of inflation expectations is much higher for the US than it is for EU countries. The EU is also characterized by a significant heterogeneity. There is mixed evidence for emerging economies, which are often characterized by a comparably high or a comparably low weight of inflation expectations.

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