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Meta-Analysis of the New Keynesian Phillips Curve

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Contents

List of Tables

List of Figures

Abstract

The New Keynesian Phillips Curve has become an inherent part of modern monetary policy models. It is derived from micro-founded models with rational expectations, sticky prices, and forward and backward-looking subjects on the market. Having reviewed about 200 studies, we analyze the weight of the forward-looking behavior in the hybrid New Keynesian Phillips Curve by means of meta regression. We show that selected data and method characteristics have significant impact on reported results. Moreover, we find a significant publication bias including publications in top journals, while we document no bias for the most cited studies and the most cited authors.

JEL-Classification: E31, E52, C32
Keywords: inflation, New Keynesian Phillips curve, meta-analysis, publication bias

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1 Introduction

There is hardly a more controversial issue in economics than the relationship between real activity and monetary policy, which is traditionally described as the Phillips curve (Phillips, 1958, and Samuelson and Solow, 1960). While the Phillips curve was sometimes used as an example of spurious correlation, its empirical performance also motivated intensive economic research into true causalities underlying the simple relationship between output growth and inflation. The Nobel Prize has never been awarded to William Phillips although his paper is claimed to be the most cited macroeconomics title of the past century (Sleeman, 2011). Moreover, Samuelson's and Solow's contribution to the implementation of the Phillips curve as a tool of macroeconomic analysis were not actually mentioned at the occasions of their Nobel Prize awards (1970 and 1987 respectively). In contrast to that, several Nobel Prize laureates were honored for their contributions to the critical discussion of the issue. Robert E. Lucas Jr. received his Nobel Prize in 1995, partly because he was able to explain why the Phillips curve appeared to have so much empirical support. About one decade later, the issue again received the greatest honour in economics. In 2006, Edmund S. Phelps was prized for his analysis of the determination of wages and prices, which addressed problems of information in the economy. Work on monetary policy and inflation persistence also made up a substantial part of the novel contributions by Finn E. Kydland and Edward C. Prescott, who jointly received the Nobel Prize in 2004.

The intensive discussion of the Phillips curve has become a foundation stone of the New Keynesian economics. Recent theoretical advances have produced alternative views of the inflation process with fundamentally different implications for an optimal monetary policy. The New Keynesian literature is built on the work of Fischer (1977), Taylor (1980), and Calvo (1983). Their microeconomic foundation emphasizes the forward-looking behavior of economic agents and sticky prices.

Correspondingly, one of the key neo-Keynesian concepts is generally referred to as the New Keynesian Phillips Curve (NKPC). This term was used initially by Roberts (1995). It was subsequently used widely by Sbordone (1998 and 2001), Galí and Gertler (1999), and Galí et al. (2001). The latter also pioneered the estimation of the hybrid New Keynesian Phillips Curve to capture inflation persistence.

According to the NKPC, inflation is forward-looking as a consequence of price formation. In particular, firms set prices on the basis of their expectations about the future evolution of demand and cost factors. However, inflation persistence is generally acknowledged. Therefore, the hybrid case of the New Keynesian Phillips Curve assumes that some firms use the backward looking rule to set prices. Thus, the lagged inflation term is included according to this approach. In the pure Neo-Keynesian case, the weight of lagged inflation should be zero. By contrast, inflation persistence would be mirrored by overwhelming dependence of inflation in its past values.[1] Behind these considerations,

[1] Both values are documented in the literature.

the importance of inflation inertia is likely to be determined by structural characteristics. In particular, economies characterized by structural problems and weak institutions (including for example emerging markets) are generally expected to be characterized by higher weights of inflation persistence in the NKPC than liberal markets.

The empirical literature on the hybrid version of the NKPC is well founded, with nearly 200 papers published in the past 12 years. We apply the meta-regression analysis (Rose and Stanley, 2005) in order to investigate the relationship between contemporaneous inflation and inflation expectations. We base our analysis on a collection of all studies estimating the hybrid version of the NKPC. We address the issue of whether the differences between studies can be attributed to different characteristics of data sets and methods (Stanley and Jarrell, 1989), or whether they can correspond to underlying structural differences of included economies. Moreover, we analyze possible asymmetry in the literature and relate it to the publication selection.

The paper is structured as follows. The next section introduces the concept of the hybrid NKPC. Section 3 reviews the previous empirical literature on the NKPC. Section 4 focuses on the publication bias using nearly 200 papers which we collected for our analysis. Section 5 presents statistics and meta-regression results. The last section concludes our findings.

2 The New Keynesian Phillips Curve

The NKPC is one of the key elements of New Keynesian economics. It is based on the Calvo sticky-pricing model (Calvo, 1983). The approach assumes a continuous environment of monopolistically competitive firms. These firms are identical producers of differentiated products, but they have different pricing histories. Each firm faces the same constant elasticity demand function. A fraction of firms $(1 - \theta)$ is able to adjust prices in period t, and future developments are discounted by a factor β. Generally, the pricing decision is based on a monopolistic competitor's profit maximization problem subject to the constraint of price adjustment at different time periods. Then the NKPC is derived as (Galí and Gertler, 1999)

$$\pi_t = \beta E_t \pi_{t+1} + \lambda mc_t^r + \varepsilon_t$$

with $\lambda = (1 - \theta)(1 - \theta\beta)/\theta$. Thus, inflation depends positively on the expected future inflation and real marginal costs. In particular coefficient λ depends negatively on θ and β. Therefore, inflation is less sensitive to the value of real marginal cost if the fraction of firms with constant prices, θ, is large. Full price rigidity, $\theta = 1$, implies $\lambda = 0$ and $\pi_t = \beta E_t \pi_{t+1}$. In this specific case, contemporaneous inflation is determined only by inflation expectations and the subjective discount factor.

However, Rudd and Whelan (2005) criticize the forward-looking NKPC because it does not include inflation inertia, which allow for a trade-off between economic activity and inflation in future periods. Fuhrer (1997) suggests that the pure forward-looking specification of prices is empirically unimportant in explaining inflation behavior. Moreover, price changes are caused not only by the rational expectations but also by the persistence of firms' behavior. Firms often use past information in their expectation formation. For this reason Galí and Gertler (1999) consider two types of firms with different price strategies. Firms behave in a forward-looking way with probability $(1 - \omega)$. Or they use backward looking price setting with probability ω. Thus, the hybrid NKPC introduces lagged inflation as an additional variable

$$\pi_t = \gamma_f E_t \pi_{t+1} + \gamma_b \pi_{t-1} + \lambda mc_t^r + \varepsilon_t \tag{1}$$

where the coefficients are functions of the underlying structural parameters

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

The parameter γ_b is of key importance for the shape of the NKPC. In particular, the hybrid NKPC converges to the NKPC if all firms are forward-looking ($\omega = 0$). Alternatively, empirical estimations often assume that $\gamma_f + \gamma_b = 1$, which implies no time discounting by firms. Given its economic interpretation, we concentrate on the forward looking parameter in our meta analysis.

3 Literature Review

In the last decade, the NKPC has become an intrinsic part of monetary policy models. Its major advantage over the traditional Phillips Curve is its structural interpretation, which can be used in policy analysis. Galí and Gertler (1999) created an important baseline for most future discussions and pioneered the estimation of the NKPC by GMM. The baseline model was extended by backward-looking behavior. According to their approach, real unit labour costs (RULC) are preferred to model inflation persistence, while the output gap measure yields negative coefficients and/or is insignificant. In the subsequent research, Galí et al. (2001) present the NKPC for the euro area between 1970 and 1998. The hybrid NKPC seems to fit the euro area data better than the earlier estimations for the USA. Moreover, the forward-looking component was found to be higher for the euro area than for the USA. These papers caused an intense discussion.

Galí and Gertler (1999) assume rational expectations meaning that the expected inflation term $E_t(\pi_{t+1})$ can be substituted with realized future inflation and forecasting error term.[2] Thus, equation (1) can be transformed to

$$\pi_t = \gamma_f \pi_{t+1} + \gamma_b \pi_{t-1} + \lambda mc_t^r + e_t \tag{2}$$

with $e_t = \varepsilon_t - \gamma_f \nu_t$. However, future inflation is endogenous because the error term also includes the forecasting error, ν_t. Therefore, equation (2) has to be estimated by the instrumental variables (IV) methods in order to avoid biased estimates. The instruments should include all exogenous variables available at time t, which are correlated with the endogenous explanatory variables. However, the disadvantage of IV methods is that their results can be sensitive to specification changes e.g. with respect to the proxy for real marginal costs and selected instrument sets.

The rational expectation assumption and endogeneity problems are avoided if inflation forecasts are directly used. Adam and Padula (2003) use data from the Survey of Professional Forecasters. Similarly, Paloviita (2006) uses the OECD forecasts. Henzel and Wollmershaeuser (2006) use data from ifo World Economic Survey. While Adam and Padula (2003) assume a finite number of professional forecasters that form expectations for a set of firms, Henzel and Wollmershaeuser (2006) take individual firms as individual forecasters. The latter approach makes it possible to introduce backward-looking firms into the NKPC.

A departure from the rational expectations assumption leads to a surprising result in the output gap position in the pure forward-looking NKPC formulation. While Galí and Gertler (1999) conclude that the output gap fails to be a relevant proxy, the analysis using

[2] The relationship between expected inflation and future inflation may be expressed as $\pi_{t+1} = E_t \pi_{t+1} + \nu_t$, where ν_t stands for a forecasting error with zero mean, which is not predictable using information available at time t.

survey data show that the output gap is correctly signed and significant. By contrast, Henzel and Wollmershaeuser (2006) compare their results with other similar publications and show that the forward-looking coefficient γ_f seems to be lower in an analysis based on the rational expectations assumption[3]. They explain this puzzle with non-rationalities in survey data. Overall, backward-looking behavior is more relevant according to their estimations. These findings are confirmed by Zhang et al. (2009), who use several measures of the output gap and inflation.

Alternatively, Fuhrer (2006) studied the importance of the lagged inflation term in the NKPC under the assumption of rational expectations. He showed that inflation persistence follows from the persistence of real marginal costs. By contrast, Roberts (1997) provides empirical evidence on flexible prices. Hondroyiannis et al. (2007) apply the time-varying coefficient (TVC) estimation proposed by Chang et al. (2000).[4] The TVC approach provides evidence that the high weight of lagged inflation in estimates of the NKPC might be due to the specification bias and spurious correlation.

Mavroeidis (2005 and 2007) raises two issues related to the selection of the appropriate estimation method. Firstly, weak instruments lead to an overestimation of the forward-looking coefficient (at all sample sizes and without any tendency to converge to the true value of the coefficient). Secondly, the estimations are biased if endogenous regressors are correlated with the instruments. Stock et al. (2002) provide a deeper discussion of the weak identification problem and the selection of an appropriate test procedure. Menyhért (2008) examines the problem of weak instruments related to the two stage least squares proposed by Lendvai (2005), the continuous-updating GMM estimator and the full information maximum likelihood estimator (FIML). He concludes that the FIML has superior properties in small samples.

Rudd and Whelan (2005) present one of the most critical papers about the NKPC. They criticize several issues: First, the pure forward-looking NKPC is inappropriate for monetary analysis because this specification lacks inflation inertia, hence it supports a free trade-off between output and inflation. Second, unit labour costs are shown not to be a valid proxy for the real marginal cost because they do not sufficiently follow the cyclical movements of real marginal costs. Most importantly, the GMM is not appropriate for the estimation of the hybrid NKPC because it is subject to an omitted variables problem, while potential omitted variables are included in the instrument set (and correlated with π_{t+1}). Consequently, the influence of omitted variables is captured by a proxy for $E_t\pi_{t+1}$ which leads to an overestimation of γ_f. Similarly, Rudd and Whelan (2005) argue that the lagged inflation role may be captured by the forward-looking term if inflation lags are included in the instrument set.

[3] Averages of forward-looking coefficients reported by Henzel and Wollmershaeuser (2006) are different. While the rational expectations average is 0.59, survey data generate an average of 0.4 for US.

[4] The TVC makes it possible to separate the bias-free component of each coefficient from the other components so that specification bias can be corrected.

Further Lindé (2005) adds that the GMM estimates may be severely biased in small samples and dependent on changes in monetary policy. Based on Monte Carlo simulations, he concludes that reliable estimates of the NKPC cannot be obtained by single equation methods. Therefore, he favours the FIML that performs well also under model miss-specification and non-normally distributed measurement errors.

Galí et al. (2005) review most of these critical points and conclude that the main conclusions in Galí and Gertler (1999) and Galí et al. (2001) remain intact also under alternative methods of estimation. They conclude that their estimates are robust to a variety of different econometric procedures, including the GMM estimation of the closed form as suggested by Rudd and Whelan (2005) and nonlinear instrumental variables in the spirit of Lindé (2005). They also review publications with similar results using alternative econometric approaches including Sbordone (2005), who presents the two-step minimum distance estimation procedure.

Jondeau and LeBihan (2006) compare GMM and ML specifications of the NKPC with output gap and RULC. The GMM leads to an overestimation of the forward looking coefficient in both specifications for all selected countries except Italy. Furthermore, Monte Carlo simulations presented by Fuhrer et al. (1995) show that GMM estimates are often statistically insignificant and unstable. A moderate degree of instrument relevance can lead to biased estimates in small samples. Therefore, they support the superior properties of the FIML estimator which is robust, also in miss-specified models and small samples.

Besides standard analysis for developed countries, numerous authors estimated the NKPC for emerging markets, developing and transition economies. Vašíček (2009a and 2009b) presents NKPC estimates for twelve new EU member states. His approach is based on the open economy Phillips Curve, which covers a wider range of factors than a typical analysis for closed developed economies. He recommends focussing on the post-reform period with low, one-digit inflation levels. The inflation dynamics of the NMS are found to be highly persistent with a significant forward-looking component. Inflation persistence has also been studied by Franta et al. (2007). Their results suggest that inflation persistence in the new member states is comparable to the inflation persistence of earlier member states. Danišková and Fidrmuc (2011) also confirmed that the NKPC estimated for the Czech Republic is largely similar to that of developed economies.

Other authors interested in inflation dynamics of emerging countries are Ramos-Francia and Torres (2005) who are concerned in the study of inflation dynamics in Mexico. Their results support the hybrid version of the New Keynesian Phillips curve and lagged inflation to play a key role as an inflation determinant. Patra and Kapur (2010) underline a model estimated for India. Inflation possesses persistence and validates the vertical nature of the long-run Phillips curve. Turkish inflation is studied by Saz (2011) who brings novelty in the measure of marginal costs. The forward-looking coefficient is estimated at approximately the same value as the backward-looking one.

Parsely and Popper (2009) use a large data set for Korea and employ GMM in model estimation. Zamulin and Golovan (2007) estimate the NKPC with a trade-off between inflation and exchange rate for Russia. Similarly, Boroditskaya and Whittaker (2007) compare the GMM and the FIML by using the estimation of the Russian NKPC. Inflation dynamics in South Africa are examined by Plessis and Burger (2006). Finally there are numerous authors interested in China. Mehrotra et al. (2010) use data for Chinese regions. Funke (2005) explores the relationship between inflation expectations and inflation dynamics in China. Scheibe and Vines (2005) estimate the NKPC in China with a rather low coefficient for the forward-looking behavior at 0.2.

4 Meta-Analysis

Stanley and Jarrell (1989) paved the way for the meta-analysis to economics, which is the regression analysis of regression analyses. More precisely, meta-regression analysis is a set of quantitative techniques for evaluating and combining empirical results from different studies (Rose and Stanley, 2005). In the past two decades meta-analysis has become a popular standard tool that integrates and explains the literature about some specific important parameter (Stanley, 1989). Moreover, it minimizes the potentially subjective contributions of authors. These contributions appear to be damaging in the case of literature surveys and do not help to find a general consensus on the presented issue.

Meta-analysis has already been applied in many different areas including social sciences, health sciences, marketing, education, etc. The attitude to the meta-analysis is different in these fields since they all use different models and estimation techniques, features of primary studies are also unique for every area. A possible shortcoming of the meta-regression analysis is the presence of a systematic bias across the literature. If certain views become widespread across the literature, the meta-regression analysis will not succeed in handling this pattern and identifying a true effect.

Despite its increasing use in economics, meta-regression analysis did not focus on the New Keynesian Phillips curve yet. The single exception is Carré (2008), who concentrates on the importance of the backward-looking component in inflation targeting. The database developed by Carré (2008) contains 79 papers and 891 estimates, which is significantly less than ours. Moreover, Carré (2008) does not discuss the publication bias and characteristics of the examined effect, which are important according to our results.

Since different journals are of different quality we also present the meta analysis based on publications in the top journals. In particular, we identify the top journals with rating A and A+ according to the standard rankings (see Combes and Linnemer, 2003).[5] The top 4 journals include Journal of Monetary Economics, European Economic Review, International Economic Review and Journal of International Economics. The top 7 journals extend the previous journals by Journal of Money, Credit and Banking, Journal of Applied Econometrics and Economics Letters.

4.1 Meta-Statistics

The literature on the hybrid version of the NKPC is very rich, with numerous papers published since 1999 when Galí and Gertler introduced their first paper regarding hybrid New Keynesian Phillips curve. We focus on the coefficient of expected inflation solely coming from hybrid NKPC. We do not include estimates from the pure forward-looking NKPC for two reasons. Firstly, literature has not agreed on the preferred specification. Some authors claim that purely forward-looking specification is appropriate, others tend to favour the opposite backward-looking specification. In order not to suffer from omitted

[5] We use the updated version of journal ranking according the Handelsblatt.

variable bias, we consider only the hybrid specification which includes both the lagged and future inflation. Secondly, the coefficients related to the expected inflation in hybrid and forward-looking specifications also have different theoretical interpretations. While the former is the function of underlying structural parameters with expected value between 0 and 1, the latter is equal to the discount factor with expected value close to 1. Therefore, the coefficients for the different specifications of the NKPC are not directly comparable.

Our meta-analysis includes 197 available studies, consisting of 87 working papers, 92 papers published in journals or as book chapters, 6 dissertation theses and 3 master theses. The share of published papers is 47 per cent. The search for papers was performed in the Repec database and Google Scholar. Studies in the Repec database were identified according to the keywords *"keynesian phillips curve"*. The search led to 476 results which were individually examined. The search applied in Google Scholar contained the keywords *hybrid estimation forward backward reduced "keynesian phillips curve"* with 897 results found. The relevant studies were included in the underlying database which was completed in July 2011.

The estimates are included in the database only if they originate from the hybrid version of the NKPC (closed or open economy version). We do not apply any restrictions to the proxy variable of the real marginal costs and we allow for additional inflation lags and leads. We also consider only the newest version of the study, e.g. if a dissertation thesis is published in a journal, we consider its published version instead of the original dissertation thesis. Moreover, many authors report re-estimated coefficients of Galí and Gertler (1999) for comparison with their results. We do not include the replicated coefficients in the database. Finally, we drop studies with missing information on standard errors, t-statistics or p-values.

Nevertheless, our data set covers 51 countries and three country aggregates (EU, OECD and new member states – NMS). For the majority of these we have more than five estimated values of the forward coefficient, γ_f. The largest number of estimates, which is equal to 613, is reported for the USA, while the EU follows with 165 estimates. The mean of the estimates of γ_f for different countries lies between 0.3 and 0.7 (Figure 1) with exceptions such as Japan, Sweden, Finland, etc. The median is close to the mean in most cases which suggest that estimates are symmetrically distributed.

Overall, the number of estimates available in each study ranges from 1 up to 75. The mean number of observations is 21 and the median is 15. Since the range of the estimates of the forward coefficient is quite wide we collect one preferred estimate per study in order to perform a robustness analysis of our results. In sensitivity analysis we analyze the preferred estimates according to authors' notes. If authors consider several estimates to be preferable, we compute their average. However, several studies, especially those presenting critical arguments on the estimation of the NKPC, present no result as preferable.

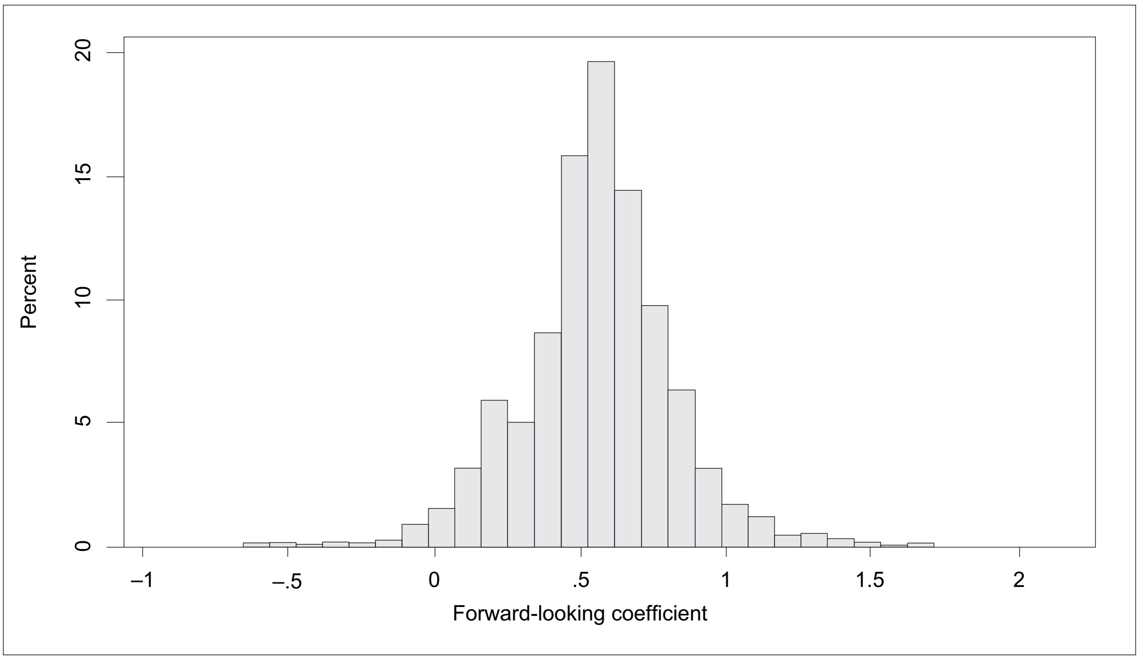

Figure 1: Distribution of estimates (excluding outliers)

The theoretical parameter γ_f is defined as the weight of forward-looking behavior and expected result should satisfy condition $0 \leqq \gamma_f \leqq 1$. Border values are also possible because some authors claim that only expected inflation causes current inflation, while other authors see the past inflation as the sole determinant of inflation dynamics. The estimated values exceed the border values of the theoretical interval. The lowest available estimate is -2.699, for the United Kingdom while the highest value of 3.590 is reported for the USA. Furthermore, 6.2 per cent of estimates are lower than zero or higher than one. Quartiles of estimates are quite close to each other. First quartile (25^{th} percentile) is equal to 0.420 while the other two are 0.562 and 0.707. A detailed description across countries is given in Table 1[6].

The development of estimates of the forward-looking parameter by years is displayed in Figure 2. The first block of figures presents the estimates published by top journals. Displayed weights are, with two exceptions, between 0 and 1 and 74 per cent of them between 0.5 and 1, thus satisfying the theoretical expectations. The second block contains estimates presented by all journals. Their variance is higher, nevertheless, 96 per cent of estimates again satisfy the assumption regarding the forward-looking coefficient, which is higher than 0.5 in more than a half of the publications. Finally, the last figure with all estimates in the third block displays the highest variance and deviation from the theoretical benchmarks.

[6] Two countries (Pakistan and New Zealand) are not included because of only one estimate being available for each.

Table 1: Meta-Statistics by Countries

country	am	ar	at	au	be	bg	br	ca	ch	cl
n	2	5	26	7	4	2	11	41	21	23
mean	0.36	0.15	0.64	0.57	0.57	0.27	0.47	0.50	0.29	0.52
p50	0.36	0.14	0.62	0.55	0.54	0.27	0.52	0.59	0.34	0.56
max	0.41	0.23	0.94	0.93	0.76	0.55	0.97	1.16	0.50	0.60
min	0.30	0.10	0.36	0.12	0.46	0.00	–0.14	–1.05	0.08	0.18
sd	0.07	0.05	0.14	0.27	0.14	0.39	0.32	0.36	0.17	0.11
skewness	0.00	1.04	0.16	–0.39	0.66	0.00	–0.36	–2.15	0.06	–2.35
kurtosis	1.00	2.80	2.25	2.23	1.84	1.00	2.50	9.73	1.22	7.30
country	cn	co	cy	cz	ee	eu	fi	fr	ge	gr
N	34	3	2	77	7	165	4	54	45	7
mean	0.24	0.53	0.60	0.57	0.39	0.51	1.24	0.64	0.60	0.50
p50	0.19	0.54	0.60	0.60	0.46	0.54	1.29	0.65	0.59	0.45
max	0.52	0.55	0.61	1.12	0.73	0.95	1.94	1.13	1.22	0.84
min	0.05	0.50	0.59	0.10	0.03	–0.30	0.42	0.19	0.18	0.30
sd	0.15	0.02	0.01	0.16	0.27	0.22	0.70	0.21	0.27	0.21
skewness	0.62	–0.55	0.00	0.33	–0.42	–1.10	–0.16	0.08	0.19	0.57
kurtosis	1.97	1.50	1.00	5.52	1.83	4.51	1.38	2.80	2.00	2.00
country	hk	hu	id	il	in	ir	it	jp	kr	lt
N	43	70	48	10	8	4	78	21	9	7
mean	0.76	0.52	0.23	0.57	0.41	1.03	0.52	0.73	0.56	0.34
p50	0.77	0.53	0.23	0.58	0.41	0.82	0.50	0.68	0.57	0.46
max	1.09	0.83	0.41	0.88	0.54	2.13	1.14	1.30	0.65	0.76
min	0.41	0.37	–0.01	0.32	0.35	0.36	–0.08	0.01	0.45	–0.31
sd	0.16	0.07	0.07	0.15	0.06	0.84	0.26	0.26	0.07	0.45
skewness	–0.27	0.85	–0.40	0.36	1.18	0.52	0.24	–0.20	–0.34	–0.70
kurtosis	2.38	6.50	6.31	3.14	3.63	1.66	2.86	4.78	1.85	1.78
country	lv	lx	ma	mt	mx	my	ne	no	pl	pt
N	7	5	3	2	17	3	7	8	43	7
mean	0.44	0.37	0.25	0.45	0.50	0.52	0.96	0.45	0.54	0.46
p50	0.55	0.44	0.24	0.45	0.57	0.52	0.63	0.67	0.56	0.47
max	0.68	1.13	0.29	0.62	0.83	0.56	2.08	0.84	1.31	0.65
min	0.12	–0.64	0.22	0.28	–0.19	0.48	0.46	–0.64	–0.66	0.31
sd	0.23	0.64	0.03	0.24	0.25	0.04	0.68	0.52	0.33	0.11
skewness	–0.42	–0.64	0.31	0.00	–1.30	0.02	0.96	–1.40	–1.22	0.36
kurtosis	1.60	2.61	1.50	1.00	4.38	1.50	2.05	3.42	7.26	2.74
country	ro	ru	si	sw	sp	tn	tu	uk	us	za
N	9	56	2	20	29	9	14	151	613	8
mean	0.41	0.42	0.31	1.06	0.56	0.57	0.62	0.61	0.60	0.84
p50	0.45	0.36	0.31	1.11	0.49	0.62	0.52	0.69	0.61	0.77
max	0.71	1.06	0.45	1.53	1.18	0.74	0.95	1.08	3.59	1.40
min	–0.17	–1.01	0.16	0.50	0.01	0.28	0.36	–2.70	–0.49	0.35
sd	0.25	0.36	0.21	0.34	0.27	0.15	0.22	0.37	0.29	0.39
skewness	–1.28	–0.92	0.00	–0.36	0.60	–0.66	0.32	–5.26	2.13	0.15
kurtosis	4.33	6.02	1.00	1.88	3.16	2.21	1.43	43.42	23.67	1.78

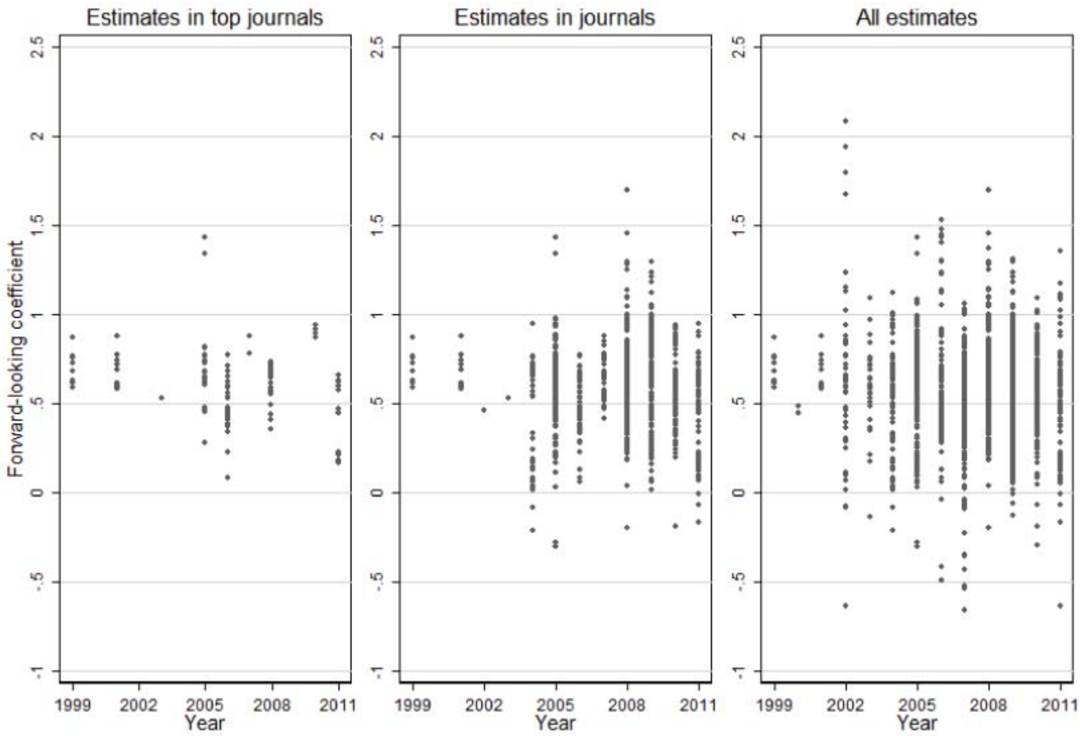

Figure 2: Evolution of estimates

The previous picture suggests the presence of some kind of selection performed by either authors or journals since almost all published estimates satisfy theoretical condition $0 \leqq \gamma_f \leqq 1$. The authors may intentionally select the results in line with general expectations and other results remain unseen in drawers. Moreover, referees or journals may act similarly since unexpected parameter values may suggest inconsistent inflation development in the long run. Correspondingly, the results different from the general expectations are rather rare in the first two categories. Moreover, the estimates published by top journals are often close to theoretical values $1/2$ and $2/3$. We address the issue of publication selection more deeply by the Funnel plot and the so called Funnel Asymmetry Test and Precision Effect Test.

4.2 Publication Bias

The publication bias expresses preference for statistically strong, significant and theoretically sound results. However, publication bias or publication selection (also referred as “file-drawer problem”) is often used also for other types of selection bias causing that the results are asymmetrically distributed around the true effect. This misinterpretation may occur if researchers test only the asymmetry of available parameters and do not analyze the sources of their asymmetry. By contrast, the publication selection is determined only by the decisions made by the editors, reviewers and researches who tend to prefer results of a specific range. 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. In such a case, a better tool for investigating this pattern would be the Galbraith plot.

However, we have to keep in mind that the funnel plot is a subjective tool for the detection of publication bias. Stanley (2005) sees its limitation in subjective interpretation of

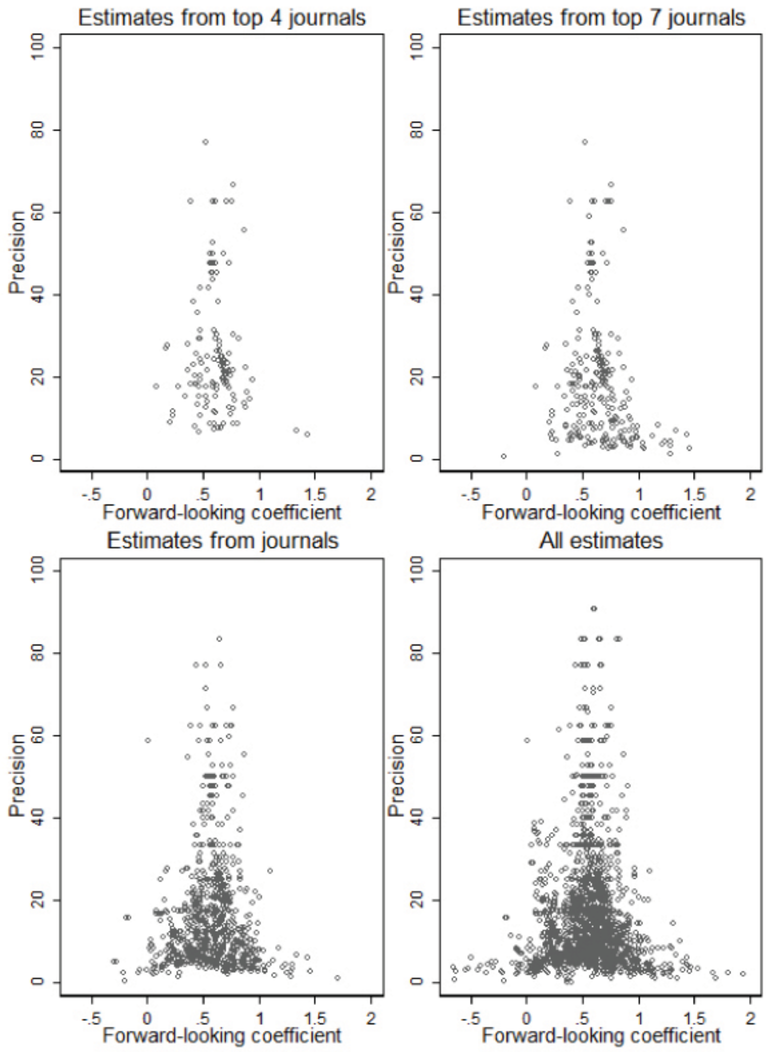

Figure 3: Funnel plots

the beholder. Moreover, he also stresses its wrong implicit assumption that a common true effect exists for all studies(it does not take into account different data sets, time periods or countries) or if not, its variation is assumed to be symmetric. Finally, Stanley (2005) mentions modelling issues including omitted variables, estimation techniques, functional forms, etc. which cause misspecification bias often wrongly attributed to the publication bias. Thus, the asymmetry presented in the funnel plot may not be the result of publication selection but rather the result of heterogeneity coming from different data sets and applied methods.

Bearing in mind these limitations, we examine the funnel plots which are displayed in Figure 3 with precision equal to the inverse standard error. The upper two blocs present the estimates for studies published in top ranked journals, while the lower blocs display the estimates from all journals and books on the left-hand, and all estimates. The funnel plots exclude outliers in order to support the readability of the charts.

A visual examination of the funnel plots is often not conclusive in the detection of asymmetry. Nevertheless, Figure 3 provides the first evidence of a publication selection for the journals. 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 blocs, they have the shape close to an inverted funnel having slightly more weight on their right hand side as well. Finally it seems that the true effect is somewhere around 0.5 in all samples.

To test the symmetry we employ the Funnel Asymmetry Test (FAT). This test is based on the simple meta-regression of available effects and the corresponding standard errors (Card and Krueger, 1995; Ashenfelter et al., 1999)

$$\hat{\gamma}_i = \alpha se_i + \gamma + \varepsilon_i \tag{3}$$

where $\hat{\gamma}_i$ denotes the reported estimates of the forward-looking coefficient that vary around "true" effect γ and αse_i stands for the so called publication bias. If the estimates are distributed symmetrically around the true effect γ then coefficient α should not be significantly different from zero. Otherwise if there is a tendency to report certain parameter values or significant results, α would be non-zero and significant and publication bias would be proportional to standard error. In other words if a person engaged in the publication process acts in line with the publication selection (e.g. reports estimates high enough to achieve their significance) reported effects are correlated with their standard errors.

It is clear that equation (3) is heteroskedastic. Therefore it is recommended to employ inverse standard errors as weights. This means that equation (3) is divided by se_i what leads to (Stanley, 2005)

$$t_i^f = \hat{\gamma}_i / se_i = \alpha + \gamma / se_i + \nu_i \tag{4}$$

This equation puts the t-statistic of effect significance on the left-hand side and inverse standard error on its right-hand side. Following Egger (1997) the conventional t-test of hypothesis $\alpha = 0$ is a basis for the FAT and its rejection implies the presence of publication bias or more precisely said, presence of asymmetry.

Table 2 presents the results of the FAT for selected samples. Moreover, we apply two estimation methods, the mixed-effects model and OLS with clustered standard errors. According to Feld and Heckemeyer (2011) it is important to cautiously select the proper estimation method. The model choice can be based on the Q-test for unobserved heterogeneity. In our case, I^2 calculated from Q-statistics supports mixed-effects multilevel meta-analysis since the amount of between study variability is large.

The first two columns of the table contain the FAT based on published estimates in journals and books. As we can see, the coefficient α is in both cases highly significant and the presence of strong positive asymmetry is confirmed by both estimation methods. Afterwards the estimates of the true effect in the row PET show that the true effect has the value 0.461 which is 17 per cent lower than the sample average.

The next columns present the test results for the top journals. The magnitude of asymmetry increases in comparison to the results for all journals. Such results suggest even stronger publication selection and tend to prove the above mentioned claims. Moreover, we mentioned that effects from top journals were almost all from the expected interval with average value 0.602. This is in line with theoretical expectations that set the forward-looking behavior around $2/3$ which apparently affected reported effects. PET suggests genuine effect to be 0.4 which is even lower than the effect of all the journals.

Alternatively, we test the presence of asymmetry among the most cited studies and the most cited authors. If no asymmetry is detected in these categories, the evidence of asymmetry in journals attributed to the publication bias will be even stronger. According to the selected criterion for the number of citations we identified 12 studies with 80 estimates for the most cited studies and 15 studies with 102 estimates for the most cited authors.

The results of the FAT provided in Table 2 does not identify any significant publication bias for most cited studies and authors. On the other hand the true effect is significant and achieves a comparable level around 0.64 in both cases. But this result may be significantly influenced by the USA since more than half of the top cited estimates are related to the US (51 per cent in case of top cited authors and 66 per cent in case of top cited studies). We explore this issue deeper and estimate equation (4) for two sub-samples, one includes only the US estimates and the second one all other estimates. The results of both top cited

Table 2: Funnel Asymmetry and Precision Effect Test

	Journals		Top Journals		Top Cited Studies		Top Cited Authors		All estimates		US	
	ME	OLSCL	ME	OLSCL	ME	OLSCL	ME	OLSCL	ME	OLSCL	ME	OLSCL
A. Precission Effect Testand Funnel Assymetry Test												
PET	0.461***	0.476***	0.400***	0.400***	0.635***	0.676***	0.639***	0.662***	0.370***	0.375**	0.707***	0.698**
	(0.003)	(0.041)	(0.008)	(0.002)	(0.023)	(0.037)	(0.021)	(0.043)	(0.007)	(0.145)	(0.007)	(0.071)
FAT	2.668***	1.552**	5.336***	5.399***	0.086	−0.710	−0.734	−0.201	3.848***	3.584	−2.492***	−1.730
	(0.668)	(0.767)	(1.221)	(1.039)	(0.796)	(0.598)	(0.729)	(1.020)	(1.164)	(3.007)	(0.490)	(1.196)
B. Precision-effect estimate with standard error												
PEESE	0.462***	0.482***	0.406***	0.411***	0.641***	0.657***	0.626***	0.657***	0.373***	0.382***	0.699***	0.674**
	(0.004)	(0.039)	(0.008)	(0.007)	(0.018)	(0.025)	(0.017)	(0.030)	(0.006)	(0.139)	(0.008)	(0.062)
C. Model and Data Statistics of A.												
obs	899	899	143	143	80	80	102	102	1899	1899	613	613
studies	93	93	14	14	12	12	15	15	197	197	87	87
τ	0.112		0.117		0.101		0.114		0.305		0.161	
I^2	98.3%		99.4%		88.5%		87.3%		99.9%		97.1%	
Weightedmean (random/fixed)	0.462/0.4820		0.403/0.4140		0.642/0.6560		0.626/0.6560		0.373/0.3830		0.699/0.674	
Samplemean	0.5580		0.6020		0.5700		0.6520		0.5590		0.602	

Note: Standard errors are in parentheses.
* significance at 10%, ** significance at 5%, *** significance at 1%.
ME – mixed-effects model, OLSCL – OLS with clustered s.e.
Top journals – 4 top rated journals (Journal of Monetary Economics, European Economic Review, International Economic Review and Journal of International Economics.
Top cited authors: the most cited author has more than 1000 citations in Repec; Top cited studies: paper has more than 100 citations in Google Scholar.
Correlations between these categories: top journal vs. top authors = 0.30; top journal vs. top studies = 0.34; top authors vs. top studies = 0.37.
US: estimates for the USA.

specifications remain untouched. The coefficient of publication bias is insignificant in all cases and genuine effect for non-US estimates is rather lower with value around 0.55.

Thus, we conclude that citations are symmetrically distributed around the expected effect which is in line with the theory. Since the most cited authors and studies do not display any selection bias, it seems that the asymmetry found for journals and top journals may be attributed to the publication bias, although we cannot attribute it to authors, referees, or the editorial decisions. If the asymmetry of journals was not caused by the publication process, we should find it for the other categories as well. Thus, we may conclude that the publication process selects the theoretically expected and significant results. In the last two columns of Table 2, we compare the results for all countries and the US. We chose the US since this is the country for which the highest number of estimates was published. Again the weighted average is close to the expected result of 2/3. But the PET detects an even higher effect with a negative bias which points to a different tendency than the other categories. Regarding all estimates, significant estimated effect decreases to 0.37 which is almost half of the sample average. In both cases the publication selection is only confirmed for the preferred estimation method (ME).

If asymmetry is present in the literature of the NKPC, then the obtained estimated effect can be biased. Publication bias can heavily inflate estimated effect in the case that the genuine effect exists, i.e. it is different from zero. Therefore Stanley and Doucouliagos (2007) recommend replacing equation (3) with

$$\hat{\gamma}_i = se_i \lambda(c) + \gamma + \varepsilon_i \tag{5}$$

where $\lambda(c)$ is the inverse Mill's ratio, which captures distortions in the mean of observed effect. Since it is not possible to identify its values for every observation due to unavailability of unreported results, the term is approximated. One possible approximation is applied in equation (3) where we use a constant to proxy the inverse Mill's ratio. But because of the non-linearity of inverse Mill's ratio, quadratic approximation is preferable (Stanley and Doucouliagos, (2007), Feld and Heckemeyer (2011)):

$$\hat{\gamma}_i = \alpha se_i^2 + \gamma + \varepsilon_i \tag{6}$$

As before, the heteroscedasticity necessitates dividing the whole equation (6) by se_i which implies

$$t_i^f = \hat{\gamma}_i / se_i = \alpha se_i + \gamma / se_i + \nu_i \tag{7}$$

The main difference between equation (3) and (7) is in the independent variable se_i. Estimated effect corrected by the described concept is called PEESE (precision-effect estimate with standard error). Monte-Carlo simulations performed by Stanley and Doucouliagos (2007) show that PEESE reduces the potential bias of the publication selection.

Since we showed clear evidence of the existence of genuine effect in this type of literature we estimate PEESE and report it in Table 2. If we compare rows PEESE and PET, the highest correction is in case of US estimates where effect is corrected by 3.4 per cent. Regarding all other cases, the estimated effects are very close and recommend linear relationship between the reported effects and their standard errors.

To show that our results are robust we include estimations with changed threshold values for categories top journals and top cited. We also perform FAT, PET and PEESE for the sub-sample including only preferred estimates. Results are available in Table 6 and confirm robustness of previously described findings.

4.3 Meta-Regression Analysis

Another goal of meta-analysis is to answer the question about differences in estimates 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.

The meta-regression equation is given by

$$\hat{\gamma}_i = \gamma + \sum_{k=1}^{K} \beta_k D_{ik} + \varepsilon_i \tag{8}$$

where $\hat{\gamma}_i$ is the estimated share of forward-looking behavior, D_k represents a set of K variables reflecting various characteristics of the studies, authors and models, and u_i is the error term. The intercept, γ, shows a value of forward-looking weight, which corresponds to the benchmark study characteristics. The variables D_k include both continuous and dummy variables, which summarize information related to data definition, data structure, estimation method, publication, and included control variables, among others.

In principle, the equation (8) could be estimated by ordinary least squares (OLS) methods. However, the OLS estimation does not take into account the likely heteroskedasticity of residuals. A potential way to overcome such a caveat is to use the weighted least squares (WLS) estimation, which uses the precision of each parameter estimate (measured by the inverse of their standard errors) as a weight in the regression. Through this transformation, the former intercept is estimated by the coefficient for $1/se$. Thus we get

$$\frac{\hat{\gamma}_i}{se_i} = t_i^{\gamma} = \gamma \frac{1}{se_i} + \sum_{k=1}^{K} \beta_k D_{ik} \frac{1}{se_i} + \nu_i \tag{9}$$

where the dependent variable is t-statistics for $\hat{\gamma}_i$.

As it is likely that coefficients presented in a particular study are closely related, we use the random-effect and fixed-effect linear models for the estimation of weighted meta-regression. Thus, the inclusion of unobserved effects u_s for individual studies or along other dimension of the data sample (authors, countries, etc.) controls for an error correlation within a cluster. The general estimation equation using study dimension s can be stated as

$$t_i^{\gamma} = \gamma \frac{1}{se_i} + \sum_{k=1}^{K} \beta_k D_{ik} \frac{1}{se_i} + u_s + \epsilon_i \tag{10}$$

Selected specifications are also extended by standard fixed effects for countries or regions. In our analysis we compare a mixed linear model to alternative estimation approaches including the fixed-effects model and the simple linear model with clustered standard errors.

As control variables in our meta-regressions we include information on the sample used and the characteristics of the study (for exact definitions of the control variables, see Table 5). The year of publication ($yeardm$) shows whether there is a trend in overall analysis of the NKPC. This could correspond to actual structural changes (e.g. increasing liberalization in analyzed countries), which should be associated with $yeardm$. Next, we differentiate between studies published by recognized journals (jr, which also aggregates studies published in books), working papers (wp) and other unpublished studies such as dissertation and master theses, etc. Similarly to Havránek and Iršová (2010) we also include the citation number of the study according to google scholar ($citg$), the citation index of the best author ($acitr$) according to the REPEC working paper archive, and the recursive impact factor ($recfac$) of the journal or working paper series, also according to the REPEC. Finally, the emerging economies are denoted as (em).

The next group of variables includes a dummy for authors from emerging economies (aem) and those from developed ones ($awest$). We also considered whether authors are affiliated with an academic institution ($aaca$) or a central bank (acb).

Furthermore, we include several variables describing the properties of data sets analyzed by reviewed studies. This includes information on whether estimates are based on monthly, quarterly or annual data. In addition to that we also collected the first and the last year of the sample, and the number of years in observations (obs). Inflation was most commonly defined as GDP deflator (gdp), but many studies use alternative definitions like CPI (cpi), the core inflation ($core$) or other inflation measure ($othinf$).

Equation characteristics cover definition of inflation expectations. Reviewed studies can use either realized inflation values under the assumption of rational expectations (rat), or survey data (sur). In addition to that, all estimations also include a proxy for marginal costs, which can be defined as real unit labour costs ($rulc$), output gap (gap) or unemployment ($unempl$). Further variables describe whether estimates were gained using a closed ($closed$) or open ($open$) economy version of the NKPC, number of inflation lags ($inflags$) and leads ($inflead$), and restriction of the sum of coefficients ($beta$).

Finally, the empirical literature also discussed intensively the appropriate methods of estimation as the OLS did not deal with endogeneity issues. Originally, the GMM or the two stage least squares dominated the literature, but most recent papers rather prefer maximum likelihood estimation or the Bayesian methods and experimentation with other methods mentioned in Table 5).

Due to the perfect multicollinearity, we have to exclude some characteristics. Hence, the obtained effect is related to these benchmark characteristics and the estimated coefficients are interpreted as the differences from the benchmark. Excluded control variables are jr, $unempl$, rat, $quarter$, gdp, $closed$ and gmm. Hence, the estimated effect corresponds to the effect coming from the closed economy NKPC without restricting the sum of forward and backward-looking behavior. Inflation is measured as the GDP deflator, its expectations are rational and equation is estimated with the GMM on quarterly data starting in 1979 and ending in 2003. The unemployment is considered as a proxy for real marginal costs and the final study is published in a journal. All authors of the study are from developed countries and at least one of them works in an academic institution.

Finally, the robustness test of the results was tested by excluding correlated or insignificant variables and outliers. The test of robustness does not include the estimation based on the preferred estimates because many studies do not identify a single preferred estimate. Moreover such identified estimates may not have unique characteristics described above. Therefore, if we take into account the recommended average of all preferred estimates, then we are not able attach unique characteristics to this preferred average.

4.4 Results of Meta-Regression

Almost all meta-studies enhance classical meta-analysis by including possible relevant explanatory variables as is expressed by equation (8). Feld and Heckemeyer (2011) propose a method for the selection of appropriate meta-analysis techniques. One of the main issues is the selection of the correct estimation method, which is determined by various test steps. Firstly, we check whether unobserved heterogeneity remains even after the inclusion of meta-regressors. To test sample homogeneity we use the Q-test which clearly rejects sample homogeneity. Then we perform the Breusch-Pagan LM test ($\chi^2(67) = 7010.12$,

Table 3: Multivariate Meta-Regresion

	ME	FE	OLSCL	ME	FE	OLSCL	ME^{out}	FE^{out}	$OLSCL^{out}$	ME	FE	OLSCL
yeardm	0.029***	0.047***	0.021*	0.030***	0.037***	0.019*	0.011***	0.011*	–0.001	0.020***	0.020***	0.019*
	(0.004)	(0.006)	(0.011)	(0.003)	(0.004)	(0.010)	(0.004)	(0.006)	(0.007)	(0.003)	(0.003)	(0.010)
wp	–0.144***	–0.219***	–0.127***	–0.136***	–0.189***	–0.097**	–0.071***	–0.109***	–0.013	–0.105***	–0.108***	–0.097***
	(0.024)	(0.030)	(0.047)	(0.021)	(0.025)	(0.042)	(0.015)	(0.018)	(0.028)	(0.015)	(0.015)	(0.036)
othstudy	–0.137***	–0.186***	–0.118**	–0.102***	–0.113***	–0.088**	0.065***	0.051***	0.050*	–0.087***	–0.088***	–0.088
	(0.024)	(0.031)	(0.056)	(0.018)	(0.021)	(0.041)	(0.017)	(0.020)	(0.027)	(0.014)	(0.014)	(0.057)
citg	0.062***	0.119***	0.066**	0.085***	0.116***	0.059***	0.026***	0.023**	0.009	0.056***	0.056***	0.059**
	(0.014)	(0.019)	(0.029)	(0.009)	(0.012)	(0.020)	(0.008)	(0.010)	(0.011)	(0.006)	(0.006)	(0.023)
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	–0.063***	–0.063***	–0.059**
	(0.019)	(0.023)	(0.032)	(0.016)	(0.021)	(0.028)	(0.013)	(0.015)	(0.021)	(0.012)	(0.013)	(0.026)
beta	0.159***	0.156***	0.164***	0.155***	0.148***	0.158***	–0.006	–0.010	0.006	0.154***	0.153***	0.158***
	(0.009)	(0.009)	(0.027)	(0.008)	(0.009)	(0.025)	(0.008)	(0.008)	(0.021)	(0.008)	(0.008)	(0.028)
gap	–0.055**	–0.035	–0.071	–0.088***	–0.085***	–0.098	–0.111***	–0.132***	–0.079**	–0.073***	–0.069***	–0.098**
	(0.026)	(0.030)	(0.054)	(0.025)	(0.029)	(0.061)	(0.017)	(0.019)	(0.038)	(0.020)	(0.020)	(0.039)
rulc	–0.142***	–0.130***	–0.146**	–0.177***	–0.184***	–0.176***	–0.050***	–0.081***	0.005	–0.154***	–0.150***	–0.176***
	(0.026)	(0.030)	(0.057)	(0.024)	(0.029)	(0.065)	(0.017)	(0.019)	(0.041)	(0.020)	(0.020)	(0.033)
othproxy	–0.149***	–0.163***	–0.072	–0.164***	–0.207***	–0.086	–0.050**	–0.086***	0.014	–0.062*	–0.054	–0.086
	(0.042)	(0.047)	(0.091)	(0.041)	(0.047)	(0.090)	(0.024)	(0.027)	(0.067)	(0.035)	(0.035)	(0.052)
sur	0.039	0.080**	–0.006	0.014	0.025	0.001	0.000	0.013	–0.028	–0.004	–0.004	0.001
	(0.028)	(0.032)	(0.052)	(0.025)	(0.028)	(0.044)	(0.015)	(0.016)	(0.035)	(0.019)	(0.019)	(0.040)
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*	–0.111***	–0.108***	–0.128***
	(0.029)	(0.032)	(0.052)	(0.026)	(0.028)	(0.041)	(0.016)	(0.017)	(0.046)	(0.024)	(0.024)	(0.039)

Continued on next page…

Table 3 – continued

	ME	FE	OLSCL	ME	FE	OLSCL	ME^{out}	FE^{out}	OLSCL^{out}	ME	FE	OLSCL
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	–0.077**	–0.075**	–0.092**
	(0.039)	(0.068)	(0.053)	(0.037)	(0.069)	(0.048)	(0.030)	(0.037)	(0.068)	(0.032)	(0.033)	(0.041)
open	–0.083***	–0.113***	–0.076**	–0.060***	–0.065***	–0.054*	–0.031**	–0.014	–0.092***	–0.032**	–0.025*	–0.054**
	(0.018)	(0.020)	(0.036)	(0.017)	(0.018)	(0.032)	(0.014)	(0.016)	(0.032)	(0.015)	(0.015)	(0.026)
firstdm	–0.004***	–0.004***	–0.005***	–0.005***	–0.004***	–0.006***	–0.002***	–0.002***	–0.000	–0.005***	–0.005***	–0.006***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(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	0.009***	0.008***	0.010*
	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.004)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.006)
month	–0.067*	–0.108**	–0.086	–0.048	–0.069	–0.077	–0.076***	–0.108***	–0.111**	–0.064**	–0.064**	–0.077
	(0.037)	(0.052)	(0.054)	(0.036)	(0.052)	(0.054)	(0.024)	(0.029)	(0.056)	(0.028)	(0.029)	(0.048)
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*	–0.132***	–0.128***	–0.147***
	(0.012)	(0.013)	(0.031)	(0.012)	(0.013)	(0.028)	(0.011)	(0.011)	(0.028)	(0.011)	(0.011)	(0.031)
core	–0.065***	–0.051***	–0.094**	–0.098***	–0.090***	–0.116***	0.107***	0.115***	0.053	–0.142***	–0.149***	–0.116***
	(0.017)	(0.019)	(0.044)	(0.016)	(0.017)	(0.040)	(0.030)	(0.033)	(0.060)	(0.015)	(0.015)	(0.041)
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	0.121***	0.121***	0.078
	(0.041)	(0.050)	(0.080)	(0.040)	(0.049)	(0.070)	(0.023)	(0.025)	(0.054)	(0.030)	(0.030)	(0.062)
like	–0.072***	–0.104***	–0.085*	–0.050***	–0.046**	–0.060	–0.053***	–0.063***	–0.059**	–0.069***	–0.073***	–0.060
	(0.021)	(0.025)	(0.046)	(0.019)	(0.022)	(0.040)	(0.013)	(0.015)	(0.027)	(0.016)	(0.016)	(0.038)
ols	0.051*	0.020	0.092*	0.074***	0.059**	0.091	0.031**	0.020	0.062	0.099***	0.097***	0.091***
	(0.029)	(0.031)	(0.053)	(0.027)	(0.029)	(0.055)	(0.015)	(0.016)	(0.040)	(0.025)	(0.025)	(0.028)
bayes	–0.142	–0.683**	–0.109	–0.085	–0.424	–0.044	0.106	–0.065	0.185***	–0.077	–0.083	–0.044
	(0.109)	(0.311)	(0.122)	(0.101)	(0.309)	(0.083)	(0.070)	(0.159)	(0.066)	(0.069)	(0.069)	(0.054)
eel	0.069	0.032	0.090*	0.081	0.048	0.125**	0.001	–0.002	–0.012	0.103*	0.098	0.125**
	(0.083)	(0.089)	(0.051)	(0.083)	(0.091)	(0.052)	(0.044)	(0.046)	(0.023)	(0.063)	(0.063)	(0.048)

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Table 3 – continued

	ME	FE	OLSCL	ME	FE	OLSCL	ME^{out}	FE^{out}	$OLSCL^{out}$	ME	FE	OLSCL
gse	0.206***	0.183***	0.243***	0.246***	0.242***	0.259***	–0.009	–0.020	–0.019	0.233***	0.227***	0.259*
	(0.031)	(0.036)	(0.040)	(0.026)	(0.028)	(0.035)	(0.021)	(0.024)	(0.038)	(0.024)	(0.024)	(0.139)
tvc	0.059	–0.028	0.232*	0.061	–0.014	0.248*	0.009	–0.015	0.191*	0.253*	0.253*	0.248**
	(0.152)	(0.161)	(0.130)	(0.153)	(0.164)	(0.135)	(0.081)	(0.083)	(0.103)	(0.136)	(0.137)	(0.104)
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	–0.405	–0.192	–0.066
	(0.331)	(0.221)	(0.316)	(0.314)	(0.203)	(0.324)	(0.238)	(0.126)	(0.241)	(0.513)	(0.183)	(0.339)
obs	1,899	1,899	1,899	1,899	1,899	1,899	1,853	1,853	1,853	1,899	1,899	1,899
R^2 adj.		0.991	0.990		0.991	0.989		0.874	0.895		0.991	0.989
n groups	197	197	197	197	197	197	194	194	194	55	55	55
groups	studies	studies	studies	studies	studies	studies	studies	studies	studies	countries	countries	countries

Standard errors are reported in parenthesis; out stands for "without outliers".
Estimated via mixed-effects model (ME), fixed-effects model (FE) and OLS with clustered s.e. (OLSCL).
* significance at 10%, ** 5%, *** 1%.

p-value=0.000) which indicates a presence of unobserved cluster effects. We consider study-clusters to account for the dependency within the studies. Furthermore, we test the robustness of our results with country-clusters.

As we detect the between-study heterogeneity, following Feld and Heckemeyer (2011), we use the Hausman test to determine whether these effects are not correlated with independent variables ($\chi^2(65) = 82.59$, p-value= 0.0695). Our result is not clear about the inconsistency of the random-effects regression. Since the Hausman test is not robust under heteroskedasticity, Wooldridge (2002) proposes an alternative test, which is based on the test of over-identifying restrictions. The result of this test ($\chi^2(67) = 359.70$ p-value=0.000) claims that the fixed-effects cluster-econometric model is appropriate for the final analysis. Nonetheless we report also the mixed-effects meta-regression results and the OLS with clustered standard errors in order to compare the robustness of our obtained results. The Wald test for the significance of the slope coefficients rejects the null hypothesis in all cases. Table 3 reports the results for groups of estimates and their characteristics. The estimated specification also includes coefficients of dummy variables for countries and regions which are not reported here.

The first three columns of Table 3 include all explanatory variables, while the next three columns exclude insignificant and highly correlated characteristics. We focus on these parsimonious specifications. 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 analyzed economies. The estimated shares of the forward-looking behavior are about 10 percentage points lower for working papers (including unpublished manuscripts) than for journal publications. Google citations appear with a positive and significant coefficient which is in line with earlier claims that the most cited papers report higher results.

Regarding the author's characteristic, $acaa$ has negative impact on the effect which means that if at least one of the co-authors works for an academic institution, the study finds lower coefficients. Among the equation characteristics, the following variables are found to determine the results. The sum restriction ($\gamma_f + \gamma_b = 1$), which is denoted by $beta$, tends to increase the associated estimates. On the other hand, if a study uses real unit labour costs and output gap as a proxy variable for the real marginal costs or includes additional lags into the NKPC, the results are lower. Other proxy variables are significantly different with negative sign in half of specifications. 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.

Table 4: Meta Regression by Individual Countries

Country		effect	s.e.	obs
Austria	at	0.474***	0.012	26
Australia	au	0.522***	0.087	7
Brazil	br	0.140	0.194	11
Canada	ca	0.496***	0.037	41
Swiss	ch	0.538***	0.092	21
Chile	cl	0.597***	0.033	23
China	cn	0.048	0.055	34
Czech Republic	cz	0.560***	0.013	77
Estonia	ee	0.430	0.264	7
EMU/EU	eu	0.486***	0.015	165
France	fr	0.604***	0.011	54
Germany	ge	0.308***	0.004	45
Greece	gr	0.253***	0.093	7
Hong Kong	hk	0.593***	0.060	43
Hungary	hu	0.633***	0.001	70
Israel	il	0.360***	0.024	48
India	in	0.581***	0.027	10
Italy	it	0.480***	0.003	78
Japan	jp	0.008	0.006	21
Korea	kr	0.617***	0.041	9
Lithuania	lt	0.131***	0.129	7
Latvia	lv	–0.080	0.269	7
Mexico	mx	0.533***	0.007	17
Netherland	ne	0.509***	0.096	7
Norway	no	0.091	0.458	8
OECD	oecd	0.584***	0.028	26
Poland	pl	0.667***	0.035	43
Portugal	pt	0.422***	0.042	7
Romania	ro	–0.174	0.304	9
Russia	ru	0.945***	0.067	56
Slovak Republic	sk	0.334***	0.008	18
Spain	sp	0.449***	0.035	29
Sweden	sw	0.434***	0.029	20
Tunisia	tn	0.682***	0.097	9
Turkey	tu	0.145	0.089	14
United Kingdom	uk	0.441***	0.009	151
USA	us	0.698***	0.007	613

Note: Standard erros are in parentheses.
*significance at 10%, **significance at 5%, ***significance at 1%. Estimated with random-effects model for individual countries with more than 6 estimates.

The next set of explanatory variables describes the data characteristics. The way inflation was 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 important as well since quarterly data lead to significantly lower effects. Finally, the range of data set expressed by the first and last year[7] of the sample says that database starting before 1979 and ending after 2003 leads to the higher estimates. The monthly frequency of the data is significantly different from quarterly frequency, while annual seems to produce similar results.

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 behavior. This is clearly confirmed by meta-regression results where maximum likelihood represented by variable $like$ is significantly negative. It is also often 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 following the approach proposed by Hadi (1992, 1994) with p-value of 1 per cent. For comparison we present these results in columns whose headers are augmented by out. The results for all nearly variables are robust to this sensitivity test. However, some variables (e.g. sum restriction $beta$, inflation deviations $infdev$) turned out to be insignificant and some even switched their sign (e.g. core inflation $core$, other studies $othstudy$). The impact of RULC as a proxy of real marginal costs lowered comparing to output gap. The estimation methods TSLS and OLS are no more significant for preferred method, which supports the critique of GMM as not dealing appropriately with the endogeneity problems.

The last three columns of Table 3 contain the specifications with standard errors clustered by countries. Despite of this, the results are largely comparable to the previous results.

Moreover, we estimate the genuine effect for every country separately. We only include countries with five or more estimates. Table 4 reports the results, which 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 forward-looking firms. The individual results confirm a high share of forward-looking firms in the USA and in several emerging markets. The highest values are actually reported for Lithuania and Russia.

[7] Note that $lastdm$ is not correlated with year of the study, because studies also contain estimates for different historical sub-samples.

5 Conclusions

The Phillips curve represents one of the most critically discussed issues in economics. Several Nobel Prizes were awarded for theoretical contributions to the discussion. Similarly, we identified nearly 200 empirical papers estimating the hybrid version of the new New Keynesian Phillips Curve, which assumes both forward and backward-looking firms. We present a meta-analysis of the forward-looking component, which can be associated with structural characteristics of the economies analyzed.

Our results confirm the presence of asymmetry in this type of literature which can be attributed to the publication bias. Top journals show even higher publication bias accepting significant estimates close to expected value. There is an overall positive trend in the literature concerning the NKPC. Impact of authors' characteristics is not essential except for holding a position in an academic institution.

Moreover, we find that characteristics of analyzed studies have a significant impact on the reported results. The meta-regressions confirms that the published results are higher than results in working papers. Besides this, estimation characteristics are especially important. The GMM, which was frequently used in the earlier literature on the topic, was actually not performing statistically differently than the simple OLS in specification without outliers, which provides further empirical support for the widespread critique of the GMM method in final samples. On the other hand, likelihood estimators recommended by most recent studies report lower shares of forward-looking firms. Survey measures of inflation expectations, which are also stressed in the recent literature, appear not to be significantly different from rational expectations.

Finally, we find significant differences in price formation 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 significant heterogeneity. There is mixed evidence for the emerging economies, which are often characterized by a comparably high or a comparably low weight of inflation expectations.

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Appendix

Table 5: Categories describing forward looking behaviour in MRA

Category	Description	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 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, 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 series and journals from Repec	0.278	0.341
em	=1 if study is focused on emerging countries	0.269	0.444
Author characteristics			
acitr	number citations of the moct cited author from repec (log)	3.972	2.485
awest	=1 if one or more coauthors are engaged in developed country	0.854	0.353
aem	=1 if one or more coauthors are engaged in developing country	0.220	0.414
acb	=1 if one or more coauthors work for central bank	0.513	0.500
aaca	=1 if one or more of the authors work for academic institution	0.699	0.459
Equation characteristics			
beta	=1 if sum of forward and backward coefficient is restricted	0.330	0.470
rulc	=1 if marginal costs are proxied by rulc	0.425	0.495
unempl	=1 if marginal costs are proxied by unemployment	0.058	0.235
gap	=1 if marginal costs are proxied by output gap	0.471	0.499
othproxy	=1 if marginal costs are 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 use for inflation expectations' term	0.235	0.424
othexp	=1 in case of other type 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	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

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Table 5 – continued

Category	Description	mean	s.e.
lastdm	last year of data subtracted by its average; rounded average last year is 2003	0.000	4.757
month	=1 if data structure is monthly	0.092	0.289
quarter	=1 if data structure is quarterly	0.817	0.387
annual	=1 if data structure is annual	0.091	0.287
obs	number of years in observations	28.447	51.246
cpi	=1 if inflation is defined as cpi	0.360	0.480
gdp	=1 if inflation is defined as gdp	0.483	0.500
core	=1 if inflation is defined as core inflation	0.021	0.142
othinf	=1 if inflation is defined 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 gmm	0.677	0.468
tsls	=1 if estimation method is tsls	0.101	0.301
bayes	=1 if estimation method is bayes	0.005	0.072
ols	=1 if estimation method is ols	0.074	0.261
eel	=1 if estimation method is eel	0.004	0.065
gse	=1 if estimation method is gse	0.011	0.102
tvc	=1 if estimation method is tvc	0.007	0.086
gel	=1 if estimation method is gel	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

Table 6: Robusteness check of FAT and PET

	Top Journals		Top Cited Studies		Top Cited Authors		Journals preferred		All preferred	
	ME	OLSCL	ME	OLSCL	ME	OLSCL	ME	OLSCL	ME	OLSCL
A. Precission Effect Test and Funnel Assymetry Test										
PET	0.402***	0.404***	0.632***	0.678***	0.632***	0.659***	0.479***	0.485***	0.155***	0.155
	(0.006)	(0.006)	(0.022)	(0.036)	(0.020)	(0.044)	(0.004)	(0.006)	(0.013)	(0.118)
FAT	4.467***	4.037***	−0.311	−1.066	−0.518	−0.189	2.022***	1.191***	8.821***	8.870***
	(0.866)	(0.824)	(0.704)	(0.570)	(0.647)	(0.924)	(0.511)	(0.437)	(2.247)	(2.637)
B. Precision-effect estimate with standard error										
PEESE	0.404***	0.417***	0.626***	0.647***	0.622***	0.652***	0.481***	0.489***	0.165***	0.165
	(0.006)	(0.012)	(0.017)	(0.027)	(0.016)	(0.029)	(0.004)	(0.008)	(0.013)	(0.120)
C. Model and Data Statistics of A.										
obs	262	262	97	97	124	124	160	160	343	343
studies	25	25	16	16	17	17	88	88	181	181
τ	0.120		0.106		0.112		0.131		0.330	
I^2	98.9%		88.4%		85.9%		95.5%		99.9%	
Sample mean		0.621		0.541		0.653		0.538		0.539

Note: Standard erros are in parentheses.
* significance at 10%, **significance at 5%, ***significance at 1%.
ME – mixed-effects model, OLSCL – OLS with clustered s.e.
Top journals – 7 top rated journals (previous + Journal of Money, Credit and Banking, Journal of Applied Econometrics and Economics Letters.
Top cited authors: more than 800 citations in Repec; Top cited studies: more than 80 citations in Google Scholar.
Correlations between these categories: top journal vs. top authors = 0.43; top journal vs. top studies = 0.48; top authors vs. top studies = 0.51.
Preferred stands for one estimate per each study which is marked as preferred by author of the study.
In case of more such estimates, their average is considered. Studies critical to the NKPC does not have any preferred estimate.