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PRICE SETTING AND PRICE STICKINESS
IN LITHUANIA

Doctoral Dissertation

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VILNIAUS UNIVERSITETAS

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KAINŲ NUSTATYMAS IR JŲ NELANKSTUMAS LIETUVOJE

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ABSTRACT

The object of dissertation research is the price setting behaviour and the associated price stickiness in Lithuania. The goal of the research is to determine the ways and the outcomes of pricing in Lithuania identifying the technological, market competition and other factors behind the price setting process. The dissertation pursues to examine incidence and sources of the price stickiness in Lithuania bringing together the findings from aggregate data and micro – firm-level – data.

To accomplish the goal of the dissertation, the research postulates a number of tasks. It strives to examine the ways and the outcomes of the price review and the price adjustment in Lithuania. It seeks to determine the frequency of price changes as the frequency of these changes represents the measure of price stickiness. The dissertation examines ten potential explanations for upward and downward price stickiness: cost-based pricing, explicit contracts, implicit contracts, menu costs, information costs, non-price competition, quality signal, coordination failure, temporary character of shocks, and price thresholds. The research looks into the price adjustment following the economic shocks. It strives to determine the role of some of the technological, market competition and other factors in shaping the price response to demand and cost shocks. Research aims to uncover asymmetries in the price response to the shocks of a different direction. Throughout the analysis particular attention is paid to the relationship between labour costs and prices.

The research shows that Lithuanian firms use the time-dependent and the state-dependent price reviewing policies, though the price reviewing practices appear to be somewhat tilted to the state-dependent pricing. Prices are found to be reviewed more frequently than they are changed. According to the survey, largest share of the firms – approximately one quarter – change the prices quarterly to half yearly, approximately one fifth of the firms change the prices once a year. Survey evidence on the frequency of price changes in part stands in line with the evidence implied by the aggregate data, which is employed under the New Keynesian Phillips Curve framework. Delayed price adjustment is found to be mostly related to the price adjustment stage rather than the price reviewing stage. The most momentous explanations for not adjusting prices upwards or downwards rest on the cost-based pricing and the explicit

contracts. The study finds an asymmetric influence of some of the price factors. In particular, the cost factors are found to be decisive in invoking the price increase rather than the price decrease. The research shows that competition is an important determinant of the pricing behaviour of firms, while the evidence on the relationship between labour costs and prices is rather mixed.

REZIUMĖ

Disertacijos tyrimo objektas yra įmonių elgsena, nustatant kainas, ir kainų nelankstumas Lietuvoje. Tyrimo tikslas yra išnagrinėti kainų peržiūros ir jų keitimo būdus bei savybes Lietuvoje ir išsiaiškinti technologinių, rinkos konkurencijos ir kitų veiksnių įtaką kainoms. Naudojant tiek agreguotus, tiek individualių įmonių duomenis, disertacijoje siekiama ištirti kainų nelankstumą ir jo priežastis Lietuvoje.

Siekiant tyrimo tikslo, disertacijoje sprendžiami keli uždaviniai. Disertacijoje analizuojami kainų peržiūros ir kainų keitimo būdai Lietuvoje. Siekiama nustatyti kainų keitimo dažnį, kuris literatūroje naudojamas kaip matas kainų nelankstumui nusakyti. Disertacija vertina dešimt galimų kainų nelankstumo didėjimo ir mažėjimo kryptimi priežasčių: sąnaudomis pagrįstą kainodarą, sudarytas sutartis, menamas sutartis, kainoraščio sąnaudas, informacijos sąnaudas, nekaininę konkurenciją, blogėjantį kokybės vertinimą, nesuderintą kitų įmonių elgseną, ekonominių šokų trumpalaikiškumą ir kainų ribas. Tyrime analizuojami kainų pasikeitimai, įvykus ekonominiams šokams. Siekiama nustatyti kai kurių technologinių, rinkos konkurencijos ir kitų veiksnių įtaką kainoms, pasikeitus paklausai ir sąnaudoms. Disertacijoje tiriama, ar kainų reakcija į skirtingos krypties ekonominius pasikeitimus yra asimetriška. Ypatingas dėmesys skiriamas nusakyti sąryšį tarp darbo sąnaudų ir kainų.

Tyrimas rodo, kad Lietuvos įmonės peržiūri kainas tiek reguliariai, tiek atsižvelgdamos į tam tikras aplinkybes. Kainų peržiūra atsižvelgiant į aplinkybes vis dėlto yra labiau paplitusi. Kainos peržiūrimos dažniau nei jos keičiamos. Remiantis apklausos duomenimis, didžiausia įmonių dalis – maždaug ketvirtadalis – keičia kainas kas ketvirtį arba kas pusmetį, maždaug penktadalis įmonių keičia kainas kartą per metus. Įmonių apklausoje nustatytas kainų keitimo dažnis iš dalies atitinka Naujosios keinsistinės Phillips'o kreivės vertinimo rezultatus. Nustatyta, kad kainas keisti delsiama dėl priežasčių, daugiausia atsirandančių ne tiek kainų peržiūros, kiek kainų keitimo etape. Svarbiausios iš šių priežasčių, sąlygojančių kainų nelankstumą didėjimo ir mažėjimo kryptimi, siejamos su sąnaudomis pagrįsta kainodara ir sudarytomis sutartimis. Tyrime nustatytas asimetriškas kai kurių veiksnių poveikis kainoms. Veiksniai, susiję su sąnaudomis, dažniau iššaukia kainų didėjimą nei

mažėjimą. Tyrimas rodo, kad konkurencija yra svarbus veiksnys, įmonėms nustatant kainas, o sąryšis tarp darbo sąnaudų ir kainų yra nevienareikšmis.

NOTATION

Symbols

Symbols used in Chapter 2:

A_t – common technological factor;

C_t – consumption;

C_t^d – consumption of domestically produced goods;

C_t^m – consumption of imported goods;

C_t^* – foreign countries' imports of domestically produced goods used for consumption;

e_t – expectation errors;

I_t – share of imported goods, used in the production, in GDP;

IM_t – imports of goods used in the production;

IM_t^* – foreign countries' imports of domestically produced goods used in the production;

j – index of firms;

K – capital;

MC_t – nominal marginal cost;

MC_t^r – real marginal cost;

N_t – labour input;

P_t – price level;

P_t^b – price level chosen by backward looking rule of thumb firms;

P_t^d – price level chosen by domestic firms;

P_t^{df} – price level chosen by domestic optimising (forward looking) firms;

P_t^f – price level chosen by optimising (forward looking) firms;

P_t^m – price level of imported goods;

P_t^* – price level chosen by firms, which adjust the prices;

S_t – labour income share or equivalently real unit labour cost;

t – time index;

u_n – natural unemployment rate;

u_t – unemployment rate;

W_t – wage level;

x_t – instruments set;

Y_t – production output;

Y_t^* – real GDP;

z – proxy of factors affecting inflation under original Phillips curve specification;

α – elasticity of substitution between labour and capital;

α_{IM} – share of imported goods used in the production;

α_N – share of labour used in the production;

β – subjective discount factor;

χ – parameter representing home bias in the consumption;

ε – price elasticity of demand and an elasticity of substitution between differentiated goods;

γ_b – reduced-form parameter in a hybrid NKPC specification;

γ_f – reduced-form parameter in a hybrid NKPC specification;

λ – reduced-form parameter in a baseline NKPC specification;

$\tilde{\lambda}$ – reduced-form parameter in a hybrid NKPC specification;

μ – price mark-up;

π_t – inflation rate;

π_t^d – inflation of domestically produced goods' prices;

θ – fraction of firms that keep prices unchanged;

ρ – elasticity of substitution between labour and imported goods;

σ – elasticity of substitution between goods produced in the home country and abroad;

τ – Lagrange multiplier;

ω – fraction of firms adjusting the prices according to the backward looking rule of thumb.

Lower case letters under "^" denote log deviations of the variables from their steady state values.

Symbols used in Chapter 3:

J_s – number of firms in the stratum s in general population;

j_s^* – number of firms in the stratum s in potential sample population;

j_s – number of firms in the stratum s in realised sample;

N_s – number of employees in the stratum s in general population;

p_s – probability that the firm in the stratum s is selected for potential sample population;

s – index of strata;

$w_{1,s}$ – factor that adjusts for unequal probability of the firm to be included in potential sample population;

$w_{2,s}$ – factor that adjusts for unequal probability of the firm to be included in realised sample, if the firm is selected for potential sample population;

$w_{3,s}$ – factor that adjusts for significance of the employment in each stratum in general population;

w_s^* – factor that adjusts for unequal probability of the firm to be included in realised sample;

w_s^{**} – factor that adjusts for unequal probability of the firm to be included in realised sample and for differences of the employment across the strata in general population.

Abbreviations

CPI – consumer price index;

EU – European Union;

GDP – gross domestic product;

GMM – generalized method of moments;

IPN – Inflation Persistence Network;

n.a. – not available;

NACE – classification of economic activities in the European Community;

NEER – nominal effective exchange rate;

NKPC – New Keynesian Phillips curve;

OECD – Organisation for Economic Co-operation and Development;

PPI – producer price index;

RFS – Russian Federation Federal State Statistics Service;

UK – the United Kingdom;

US – the United States;

WDN – Wage Dynamics Network.

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INTRODUCTION

Research motivation

Prices constitute an important mechanism in the functioning of the economy. Prices contribute to resource allocation by aiding the products to be produced to match the ones that are demanded. Prices influence the level of the aggregate output. They bring the output to be supplied to the level that is needed.

Prices play a role in the transmission of the economic shocks. Price responsiveness has the effects on the ways of the adjustment. If prices are less responsive, the adjustment is less efficient and less smooth. If prices are more responsive, the magnitude and the length the shocks affect economy is less marked.

The level of price stickiness is particularly important when adjustment is not possible through the exchange rate. When country operates in a monetary union or maintains the exchange rate fixed, like Lithuania, the economy may respond through prices or through wages or through real activity, accommodating to the unaltered exchange rate. In such setting, pricing behaviour becomes of an utmost importance in the transmission of the shocks.

This motivates to investigate the price setting and the price stickiness in greater details. It is momentous to analyse the ways of price review and price adjustment, to determine the frequency of price reviews and price changes, to discriminate the explanations for upward and downward stickiness of prices, and to interpret the price response to economic shocks.

Research problem

Various price setting practices may have different implications for the responsiveness of prices. Price setting process is typically split into the price reviewing stage and the price adjustment stage. The price review might have different characteristics. The price review may be the one where the time between reset of prices is independent from the economic shocks. This is so called the time-dependent price review. The price review may also be dependent on the specific economic

triggers. This is the state-dependent price review. All else equal, the state-dependent price review is more responsive than the time-dependent price review.

The price adjustment may also have numerous characteristics. One of the most important features is the frequency of price adjustment. This frequency represents the measure of the price stickiness. Higher frequency of price changes possibly indicates higher responsiveness of prices. Lower frequency of price adjustment possibly shows weaker reaction to the economic shocks. Although the frequency of price changes is not a perfect measure of the responsiveness of prices, it is commonly agreed that it heavily relates to the flexibility of firms in taking price decisions.

The stickiness of prices may be related to the price reviewing stage and the price adjustment stage. Firms may delay the price adjustment if the price review is costly. Firms may postpone the change in prices if the change itself is costly or the reaction of the customers or the competitors is unwelcoming. If stickiness of prices relates not only to the price reviewing stage but also to the price adjustment stage, prices are changed less often than they are reviewed.

The responsiveness of prices may differ in the face of distinct economic shocks. Response of firms may vary when demand increases and demand decreases. Response might also differ when costs go up and costs go down. The pricing following the shocks is influenced by the numerous factors, such as technology of the production, market competition, arrangements of the labour compensation and other factors. They play a role in the timing and the way the prices are adjusted making it a momentous venue for the research.

To put it all together, the research problem is centred on the features, ways and outcomes of price setting and the associated impact on price stickiness.

Object of the research

The object of the dissertation research is the price setting behaviour and the associated price stickiness in Lithuania. The dissertation investigates the price review and the price adjustment, the price response to the economic shocks, the explanations for upward and downward price stickiness, and the role of structural price setting factors in Lithuania.

Goal of the dissertation

The goal of the dissertation research is to determine the ways and the outcomes of pricing in Lithuania identifying the technological, market competition and other factors behind the price setting process. The dissertation pursues to examine the incidence and sources of the price stickiness in Lithuania bringing together the findings from aggregate data and from micro – firm-level – data.

Research tasks

To accomplish the goal of the dissertation, the research postulates the following tasks:

- to investigate the price setting practices in Lithuania from a macroeconomic perspective, using aggregate data, and from a microeconomic perspective, employing firm-level survey data;
- to examine the ways and the outcomes of price review. In particular, to investigate the incidence of time-dependent and state-dependent price review and to determine the frequency of price review;
- to determine the frequency of price changes as the frequency of these changes represents the measure of price stickiness;
- to analyse the reasons for upward and downward price stickiness. In particular, to investigate ten potential explanations for the price stickiness: cost-based pricing, explicit contracts, implicit contracts, menu costs, information costs, non-price competition, quality signal, coordination failure, temporary character of shocks, price thresholds;
- to investigate the price adjustment following the economic shocks. In particular, to determine the role of some of the technological, market competition and other factors in shaping price response to demand and cost shocks. Research aims to uncover asymmetries in price response to the shocks of a different direction;
- to examine the relationship between labour costs and prices.

Research methodology

The research investigates price setting and price stickiness in Lithuania from a macroeconomic perspective and from a microeconomic perspective. From a macroeconomic perspective, pricing is analysed using New Keynesian Phillips Curve (NKPC) framework as outlined in Galí and Gertler (1999) and Galí et al. (2001), for the closed economy case, and Leith and Malley (2007), for the open economy case. The dissertation considers a baseline and a hybrid NKPC, where in the latter case the lagged inflation is accounted for. Reduced form and structural NKPC estimates are obtained employing the generalized method of moments (GMM).

From a microeconomic perspective, research is conducted using a unique dataset obtained in ad hoc survey "On Price and Wage Setting" that was carried out in Lithuania in 2008. The dissertation employs the survey approach to analyse pricing that was introduced by Blinder (1991, 1994) and Blinder et al. (1998). The analysis draws on the experience of the euro area and non-euro area EU countries that conducted the price (and wage) setting research based on the firm-level data obtained from the surveys. Inferences are made employing comparative analysis and estimating ordered and binary probits.

Scientific novelty of the research

The dissertation puts together macroeconomic and microeconomic evidence on the price setting and the price stickiness in Lithuania. From a macroeconomic perspective, the dissertation provides reduced form and structural NKPC estimates. NKPC estimates for Lithuania are very scarce. Dabušinskas and Kulikov (2007) report reduced form and structural estimates for the hybrid NKPC in Lithuania that accounts for inflation inertia. Mihailov et al. (2010) estimates both the baseline and the hybrid NKPC, however this study provides reduced form estimates only. The dissertation complements these studies by obtaining reduced form and structural estimates for both the baseline and the hybrid NKPC.

From a microeconomic perspective, the dissertation employs a survey approach to analyse pricing in Lithuanian firms. The survey considers a broad range of firms in terms of their economic activity and their size. The survey tackles numerous aspects

of pricing, including the way of price review, the frequency of price review and adjustment, the upward and downward price stickiness, and the response to the economic shocks. This way of pricing research in Lithuania appears to be unique.

Practical importance of the research

The dissertation yields a number of results important for economic modelling and policy design in Lithuania. The conducted research provides inferences on the frequency of price adjustment and the price duration in Lithuania. The assumptions on the price duration are used in economic models where the price setting follows some staggered form. The obtained evidence on the frequency of price change and the price duration in Lithuania might be directly used in such economic models.

The dissertation considers the reasons for upward and downward price stickiness in Lithuania. These reasons include cost-based pricing, menu costs, information costs and others. Economic models often make the assumptions on the ways firms are setting prices. Some of them assume the mark-up pricing, which is associated with the cost-based pricing. A number of models make the assumptions on the menu costs and the information costs in setting prices. The obtained evidence on the role of the mentioned factors in setting prices, thus, might be accounted for in construction of such economic models.

The conducted research provides evidence on the role of some of the technological, market competition and other factors in shaping the frequency of price changes. The frequency of these changes represents the measure of price stickiness. The inferences on the role of the mentioned factors might prove to be useful in designing policies aimed at enhancing the degree of price responsiveness in Lithuania.

Defended theses of the dissertation

- Lithuanian firms use the time-dependent and the state-dependent price reviewing policies. Most of them review the prices depending on the time and in certain – state-dependent – cases. Price reviewing practices, nevertheless, are somewhat tilted to the state-dependent pricing as the

occurrence of the firms, reviewing prices only in certain cases, is more widespread than the prevalence of the firms that review the prices only regularly;

- according to the survey, the largest share of the firms – approximately one third – review the prices daily to monthly, almost one quarter of the firms review them quarterly to half yearly. Prices turn out to be reviewed more frequently than they are changed. The largest share of the firms – approximately one quarter – change the prices quarterly to half yearly, approximately one fifth of the firms change the prices once a year. This implies that stickiness of prices might occur at both the price reviewing stage and the price adjustment stage;

- survey evidence on the frequency of price changes stands in line with the evidence implied by NKPC though the NKPC estimates yield somewhat lower frequency. The estimates imply that a price duration in Lithuania stands at around 3.8-4.6 quarters;

- the most momentous explanations for the delay in price adjustment are related to the price adjustment stage. The most important reasons for not adjusting prices upwards and downwards are related to the costs that firms encounter in operational activities – cost-based pricing – and formal contracts (or, alternatively, explicit contracts) with their customers;

- some of the factors have asymmetric influence on prices. The cost factors, namely, movements in labour costs and movements in prices of raw materials or services that the firms buy, appear to be more decisive in invoking the price increase rather than the price decrease. In corroboration, survey results indicate that prices are more likely to respond to the higher cost shocks rather than to the lower cost shocks;

- operational characteristics contribute to the asymmetric price response. The non-formal contracts are found to limit price adjustment when demand goes up, but not when demand goes down. Price accommodation to different customers turns out to contribute to the response of prices to the demand decrease, but not to the demand increase;

- competition is an important determinant of the price setting. It is found out that a higher level of competition increases the likelihood of price change

following both the positive and the negative demand shocks. Greater exposure to foreign markets, which is associated with higher competition pressures, appears to be significant in lowering the likelihood of price increase in response to the intermediate input cost and wage shocks. Higher competition also turns to be significant in contributing to a more frequent change in prices;

- the research yields somewhat mixed evidence on the relationship between labour costs and prices. The survey analysis shows that a considerable share of firms would increase prices in response to the wage shock. The labour cost share appears to be an important determinant of price increase in response to this shock. Quite many firms admit that there is a link between the timing of price changes and wage changes. However, the labour cost share is not found to be significant in affecting the frequency of price changes;

- the present real marginal costs, proxied by (or largely proxied by) the labour income share, have a limited role in shaping the present inflation. Inflation is mostly governed by the inflation expectations and the inflation inertia with the influence of the expectations being stronger than that of the inertia.

Structure of the dissertation

The dissertation constitutes of an introduction, four chapters and thirteen appendices. Chapter 1 introduces models and notions of the price setting and the price stickiness, it also overviews the available evidence on the research topic. The price setting and the price stickiness in a macroeconomic perspective is analysed in Chapter 2. This chapter derives the baseline and the hybrid NKPC in the closed economy and the open economy and provides NKPC estimates for Lithuania. Chapter 3 investigates the price setting and the price stickiness in a microeconomic perspective. Here the analysis exploits the data from the survey "On Price and Wage Setting" covering the issues of price review, price adjustment and price stickiness in Lithuania. General conclusions of the dissertation are provided in Chapter 4. The appendices provide the supplemental material.

Approval of research results

Results of the dissertation research are published in the refereed journals, presented in the international scientific conferences and discussed at the Faculty of Economics of Vilnius University.

CHAPTER 1.   PRICE SETTING. INCIDENCE AND SOURCES OF PRICE STICKINESS

Price setting plays a momentous role in the behaviour of the economy. Prices participate in the resource allocation by ensuring the products that are supplied are matching the ones that are demanded. Prices have an effect on the aggregate output by making the output produced to stand at the level that is needed. Prices play a distinct role in the transmission of the economic shocks. Lower degree of price responsiveness makes the economic adjustment less efficient and less smooth. On the contrary, stronger price responsiveness contributes to a lesser and a shorter impact of the shocks. The level of price stickiness is of particular importance when economic adjustment is not possible through the exchange rate. When country participates in a monetary union or maintains the exchange rate fixed, like Lithuania, the adjustment may occur either through prices or through wages or through real output. The price setting then becomes of a momentous relevance in the transmission of the shocks.

Literature distinguishes the terms the price stickiness and the price rigidity. The notion of the *price stickiness* considers the frequency of price changes. Lower frequency of price changes implies longer price duration and potentially indicates a lack of price reaction to the economic shocks. If prices change on an infrequent basis, prices are considered as sticky. Lower frequency of price changes, however, does not necessarily imply that the price adjustment is insufficient. Prices might prevail at an optimal level even if they are not changed for a protracted time. And vice versa, frequent price changes do not necessarily reflect the sufficient level of price adjustment. Following the economic shocks prices might adjust not fully and to stand at the level other than optimal. Therefore, the concept of the *price rigidity* considers the extent of price adjustment following the changes in the economic environment. If prices adjust not fully in response to the economic shocks, prices are viewed as rigid.

As mentioned, the price stickiness as such does not necessarily imply that price adjustment is not sufficient. Frequent change in prices might be not needed if there is a low degree of volatility in the economic factors that affect the costs or the price mark-ups. Such kind of stickiness of prices is sometimes called *extrinsic stickiness* so that to make a difference from the stickiness occurring due to the impediments in the

price setting (Dhyne et al., 2007). If prices are not changed frequently enough because of these impediments, stickiness of prices is then called *intrinsic stickiness*. In the latter case prices are also treated as rigid ones.

Literature uses two approaches to model the ways of pricing: a time-dependent one and a state-dependent one. The *time-dependent models* assume that the time between reset of prices is independent from the economic shocks. Such approach to pricing stands in line with evidence that the price review and the price adjustment processes are costly and some firms are opting to review and adjust the prices only in the predetermined periods and in the specific time intervals. The origins of the time-dependent models are due to Taylor (1980) and Calvo (1983) who assume the non-continuous adjustment of labour contracts and prices respectively allowing only for some share of firms to reconsider the adjustment. In these models the labour contracts and prices remain unchanged for some period of time implying that the firms are not allowed to respond to the economic shocks when they occur. The pricing under such setup might be viewed as non-optimal. Therefore the possibility of reaction to the economic shocks, when it is deemed necessary, is considered in the *state-dependent models*. The latter models were started by Barro (1972) and Sheshinski and Weiss (1977). In these models the price adjustment is non-continuous as the change in prices costs. The price duration, however, is not predetermined – it may depend on the state of the observed environment[1].

Comparing the time- and the state-dependent models, the former ones appear easier to handle, therefore the time-dependent models (especially the Calvo model) became more popular in the macroeconomic modelling. It can be shown that under certain assumptions Calvo-type restrictions allow generating the persistence in inflation and in output following the economic shocks as it is observed in the actual economy. Nevertheless, it is also known that the Calvo model yields rather limited degree of price stickiness. In the Calvo setup some firms, that are to change the prices, might not adjust significantly as they might have adjusted prices very recently. In the state-dependent models, in contrast to the Calvo model, it is mostly the firms, whose prices deviate from optimum substantially, adjust the prices. This might suggest that the prices generated by the state-dependent models respond to changes in

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[1] The time-dependent and the state-dependent models are overviewed in more details in Section 3.3.

environment somewhat more effectively compared to the prices under the Calvo model.

Available research points out a number of factors influencing the price adjustment on the aggregate level. Carvalho (2006), for instance, illustrates the importance of heterogeneity in the frequency of price changes across the economic sectors. Fast adjusting sectors change the prices first following the economic shocks, while the other sectors change the prices with some lag. In case if economic sectors possess some features of complementarity, the fast adjusting sectors might take into account the sticker price dynamics in the slow adjusting sectors. Subsequently the latter sectors make a larger impact on the general price level than their weight in the economy, implying that the price adjustment in the heterogeneous economy is slower than in the homogenous one.

Maćkowiak and Wiederholt (2009) distinguish the role of the idiosyncratic and the aggregate shocks in the price formation. In the analysed setup firms choose to what type of shocks to pay attention to when taking price decisions. If the idiosyncratic shocks are more volatile and more noteworthy, firms pay more attention to the idiosyncratic shocks and less attention to the aggregate movements in the economic environment. Such setup yields rather large adjustments of individual prices in response to the idiosyncratic shocks, while firms' reaction to the aggregate shocks stays more subdued. Such kind of pricing stands in line with evidence that the individual price changes are quite large, while the movements in the aggregate price level are rather smooth.

Literature increasingly investigates the price setting practices on a micro level. Research covers the analysis of micro data used to construct the producer and the consumer price indices (PPI and CPI respectively) as well as data obtained from the surveys of firms. Micro PPI and CPI data enables examining the size of individual price changes and their frequency, which provides indications about the stickiness of prices. Survey data, in addition to the price changes, enables investigating the price review, the firm-level explanations for responsiveness and unresponsiveness of prices, the asymmetry in price adjustment.

At the individual price level, the incidence of price changes varies at the producer and the consumer stage. Available PPI data studies for the euro area countries indicate that within a month around a fifth of the producer prices are

changed (Vermeulen et al., 2007; see Table 1). This implies that the producer price duration is close to a half of the year. The share of the consumer prices, changed within a month in the euro area countries, is somewhat lower than that of the producer prices – it stands at 15.1 percent yielding a median price duration of 10.6 months (Dhyne et al., 2006). Existing studies show that the prices at the individual level in the US are changed somewhat more frequently. Here within a month around one fourth of the consumer prices are adjusted with median price duration of 4.3-7.2 months (Bils and Klenow, 2004; Klenow and Kryvtsov, 2008). Evidence on the individual price setting practices for non-euro area EU countries is very limited. Analysis of the consumer prices in Latvia shows that within a month 28.7 percent of the consumer prices are changed, while average price duration is 3.8 months (Beņkovskis et al., 2011).

Inferences from micro PPI and CPI data to some extent corroborate with the ones from survey data. Surveys conducted, for instance, in the euro area (Fabiani et al., 2006; Druant et al., 2009), Sweden (Apel et al., 2005), the Czech Republic (Druant et al., 2009), Estonia (Dabušinskas and Randveer, 2006; Druant et al., 2009), Hungary (Druant et al., 2009), Poland (Druant et al., 2009), suggest that the prices are normally adjusted once a year. In some countries the frequency of price changes is somewhat higher: according to the surveys, the price changes in the US occur more than once a year (Blinder et al., 1998), in Canada – more than four times a year (Amirault et al., 2006), in the UK – twice a year (Hall et al., 2000).

Micro based evidence on the frequency of price adjustment broadly resembles the one obtained from the aggregate data using NKPC framework. When non-linear production technology is accounted for, existing estimates under the closed economy assumption show that the price duration in the euro area stands at 4.5-6.4 quarters (Galí et al., 2001, 2003), in the US – at 2.2-2.8 quarters (Galí et al., 2001, 2003; Leith and Malley, 2007), in Canada – at 2.9 quarters (Leith and Malley, 2007), in the UK – at 2.3 quarters (Leith and Malley, 2007), in Estonia – at 3.2 quarters (Dabušinskas and Kulikov, 2007), in Latvia – at 3.9 quarters (Dabušinskas and Kulikov, 2007)[2].

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[2] When linear production technology is assumed, estimates in the closed economy indicate that the price duration in the euro area stands at 10.0-12.8 quarters and in the US – at 5.5-5.8 quarters (Galí et al., 2001).

Under the same technology assumption in the open economy case the estimates point to the price duration of 2.5 quarters in the US (Leith and Malley, 2007), 4.2 quarters – in Canada (Leith and Malley, 2007), 3.0 quarters – in the UK (Leith and Malley, 2007), 4.0 quarters – in Estonia (Dabušinskas and Kulikov, 2007), 4.3 quarters – in Latvia (Dabušinskas and Kulikov, 2007).

Table 1. Evidence on price stickiness: cross-country comparison

	Investigated data and measure of price stickiness:				
	micro PPI data	*micro CPI data*		*firm-level survey data*	*aggregate data (NKPC framework)*
	share of prices changed within a month (percent)	*share of prices changed within a month (percent)*	*median price duration (months)*	*median frequency of price change*	*price duration (quarters)*
Canada	*n.a.*	*n.a.*	*n.a.*	*more than four times a year[a]*	*2.9[b]* *4.2[c]*
Euro area	*21.0[d]*	*15.1[e]*	*10.6[e]*	*once a year[f], [g]*	*4.5-6.4[h]* *10.0-12.8[i]*
Sweden	*n.a.*	*n.a.*	*n.a.*	*once a year[j]*	*n.a.*
UK	*n.a.*	*n.a.*	*n.a.*	*twice a year[k]*	*2.3[b]* *3.0[c]*
US	*n.a.*	*26.1[l]* *29.9[m]*	*4.3[l]* *7.2[m]*	*more than once a year[n]*	*2.4-2.8[h]* *5.5-5.8[i]* *2.2[b]* *2.5[c]*
Czech Republic	*n.a.*	*n.a.*	*n.a.*	*once a year[g]*	*n.a.*
Estonia	*n.a.*	*n.a.*	*n.a.*	*once a year[g], [o]*	*3.2[p]* *4.0[r]*
Hungary	*n.a.*	*n.a.*	*n.a.*	*once a year[g]*	*n.a.*
Latvia	*n.a.*	*28.7[s]*	*3.8[t]*	*n.a.*	*3.9[p]* *4.3[r]*
Poland	*n.a.*	*n.a.*	*n.a.*	*once a year[g]*	*n.a.*

Notes: (a) source – Amirault et al. (2006); (b) estimated under assumption of non-linear production technology; closed economy case; source – Leith and Malley (2007); (c) estimated under assumption of non-linear production technology; open economy case; source – Leith and Malley (2007); (d) covers Belgium, France, Germany, Italy, Portugal and Spain; source – Vermeulen et al. (2007); (e) covers Austria, Belgium, Finland, France, Germany, Italy, Luxembourg, the Netherlands, Portugal and Spain; source – Dhyne et al. (2006); (f) covers Austria, Belgium, France, Germany, Italy, Luxembourg, the Netherlands, Portugal and Spain; source – Fabiani et al. (2006); (g) covers Austria, Belgium, France, Greece, Ireland, Italy, the Netherlands, Portugal, Slovenia and Spain; source – Druant et al. (2009); (h) estimated under assumption of non-linear production technology; closed economy case; sources – Galí et al. (2001, 2003); (i) estimated under assumption of linear production technology; closed economy case; source – Galí et al. (2001); (j) source – Apel et al. (2005); (k) source – Hall et al. (2000); (l) source – Bils and Klenow (2004); (m) source – Klenow and Kryvtsov (2008); (n) source – Blinder et al. (1998); (o) source – Dabušinskas and Randveer (2006); (p) estimated under assumption of non-linear production technology; closed economy case; source – Dabušinskas and Kulikov (2007); (r) estimated under assumption of non-linear production technology; open economy case; source – Dabušinskas and Kulikov (2007); (s) source – Beņkovskis et al. (2011); (t) refers to average price duration; source – Beņkovskis et al. (2011); "n.a." denotes "not available".

Changes in prices exhibit different frequency in various product groups. The products at the beginning of production line – like energy and intermediate goods – seem to face more likely price adjustment, while the products closer to the final usage stage – consumption and capital goods – are characterized as the ones having less likely price adjustment (findings are available for the euro area; see Table 2). Heterogeneity of the price stickiness is also evident among the groups of consumption products. As suggested by the studies, the prices change somewhat more frequently for the consumption products of a lower technology intensity – for instance, energy and unprocessed food, and the prices change less often for the consumption products of a higher sophistication – processed food and non-energy industrial goods (existing studies include Dhyne et al. (2006) for the euro area, Bils and Klenow (2004) – for the US, Beņkovskis et al. (2011) – for Latvia). Micro CPI data indicates that the prices are considerably stickier in the services sector.

Table 2. Evidence on heterogeneity of price stickiness across product groups: cross-country comparison
(share of prices changed within a month; percent)

	Evidence from micro PPI data:					
	food	*consumption non-durable goods*	*consumption durable goods*	*energy*	*intermediate goods*	*capital goods*
Euro area[a]	27.0	11.0	10.0	72.0	22.0	9.0
	evidence from micro CPI data:					
	unprocessed food	*processed food*	*non-energy industrial goods*	*energy*	*services*	
Euro area[b]	28.3	13.7	9.2	78.0	7.1	
Latvia[c]	37.7	24.6	20.8	65.9	7.9	
	raw goods	*processed goods*				
US[d]	54.3	20.5				

Notes: (a) covers Belgium, France, Germany, Italy, Portugal and Spain; source – Vermeulen et al. (2007); (b) covers Austria, Belgium, Finland, France, Germany, Italy, Luxembourg, the Netherlands, Portugal and Spain; source – Dhyne et al. (2006); (c) source – Beņkovskis et al. (2011); (d) source – Bils and Klenow (2004).

Micro PPI and CPI data shows that the individual price changes occur both upwards and downwards. Within a month 12 percent of the producer prices are increased and 10 percent of the producer prices are decreased in the euro area (Vermeulen et al., 2007; see Table 3). Shares of the consumer prices that are adjusted

upwards and downwards are also non-negligible in the countries for which studies are available (Dhyne et al. (2006) – for the euro area, Klenow and Kryvtsov (2008) – for the US, Beņkovskis et al. (2011) – for Latvia). In all the countries the fraction of the heightened prices is somewhat higher than the proportion of the lowered prices, while the size of the average price increase is smaller than the size of the average price decrease (the latter is evident for the consumer prices only). Average hike in the consumer prices stands at around 8.2-10.3 percent and average cut in the consumer prices stands at around 9.4-11.9 percent in the examined countries.

Table 3. Evidence on incidence and size of price increases and decreases: cross-country comparison
(percent)

	Investigated data:					
	micro PPI data		*micro CPI data*			
	share of prices increased within a month	*share of prices decreased within a month*	*share of prices increased within a month*	*average price increase size*	*share of prices decreased within a month*	*average price decrease size*
Euro area	12.0[a]	10.0[a]	8.3[b]	8.2[b]	5.9[b]	10.0[b]
US	n.a.	n.a.	15.0[c]	8.9[c]	11.5[c]	9.4[c]
Latvia	n.a.	n.a.	17.8[d]	10.3[d]	11.0[d]	11.9[d]

Notes: (a) covers Belgium, France, Germany, Italy, Portugal and Spain; source – Vermeulen et al. (2007); (b) covers Austria, Belgium, Finland, France, Germany, Italy, Luxembourg, the Netherlands, Portugal and Spain; source – Dhyne et al. (2006); (c) source – Klenow and Kryvtsov (2008); (d) source – Beņkovskis et al. (2011); "n.a." denotes "not available".

A number of factors affect the frequency of price adjustment. The studies show that the changes in prices feature the patterns of the state-dependent and the time-dependent behaviour. Analysis of micro PPI and CPI data suggests a positive relationship between the frequency of price increases and the level of aggregate inflation and a negative relationship between the frequency of price decreases and the level of aggregate inflation (Vermeulen et al., 2007; Dhyne et al., 2006; Beņkovskis et al., 2011; see Table 4). The evidence also indicates a relationship between the frequency of price adjustment and the sectoral inflation rate. The state-dependent pricing behaviour is similarly demonstrated by a significant role of the market competition and the changes in the demand – higher degree of market competition and hikes in the demand are positively correlated with a more frequent price adjustment. This frequency also seems to be dependent on the size of the last price change: the price adjustment is more likely the larger is the size of the preceding

price decrease, and the adjustment is less likely the larger is the size of the preceding price increase. Along with this, the studies show, the pricing process is affected by the moves in indirect taxes. The analysis indicates that the price decisions are also taken in the time-dependent way. The frequency of price adjustments exhibits some seasonality. The change in prices also depends on the time elapsed since the last price adjustment. In addition, the individual price movements are associated with some other factors, like, the structure of the costs and the price thresholds. It is found out that the higher labour costs share couples with the lower frequency of price changes, while the higher share of energy and non-energy intermediate goods in the costs couples with the higher frequency of price moves. The prices that are set at the price thresholds appear to be changed less frequently.

Table 4. Factors of individual producer and consumer price changes

Investigated data:	
micro PPI data	*micro CPI data*
factors indicating state-dependent pricing behaviour:	
aggregate inflation rate[a]	*aggregate inflation rate[b] [c]*
sectoral inflation rate[a]	*sectoral inflation rate[b]*
competition[a]	*changes in demand[c]*
-	*size of last price change[c]*
-	*indirect taxes[b] [c]*
factors indicating time-dependent pricing behaviour:	
seasonality[a]	*seasonality[b] [c]*
-	*elapsed price duration[b] [c]*
other factors:	
costs structure[a]	*price thresholds[b] [c]*

Notes: (a) evident in the case of the euro area; covers Belgium, France, Germany, Italy, Portugal and Spain; source – Vermeulen et al. (2007); (b) evident in the case of the euro area; covers Austria, Belgium, Finland, France, Germany, Italy, Luxembourg, the Netherlands, Portugal and Spain; source – Dhyne et al. (2006); (c) evident in the case of Latvia; source – Beņkovskis et al. (2011).

The research considers explanations for sticky price behaviour reported by the firms[3]. It is hypothesized that the prices may remain unchanged if there are no shifts in the underlying factors related to, for instance, operational costs. The cost-based pricing finds a support in the available survey studies (Fabiani et al. (2006) – for the euro area, Blinder et al. (1998) – for the US, Amirault et al. (2006) – for Canada, Hall et al. (2000) – for the UK, Apel et al. (2005) – for Sweden, Dabušinskas and Randveer (2006) – for Estonia; see Table 5). The surveys also point to the explicit

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[3] Explanations for the upward and downward price stickiness at the individual price level, as reported by the firms, are overviewed in more details in Section 3.5.

contracts with the customers as to another important reason to keep the prices constant instead of changing them. The prices appear to embed some stickiness due to other, less lucidly manifested, factors. As it is reported by the firms, they often view it disadvantageous to adjust the prices when this affects business relationship with their customers. Firms effectively engage into the implicit contracts committing to maintain the prices even if there are some reasons for the change. The moves in prices also seem to be discouraging if the reaction of competitors is difficult to anticipate. The coordination failure likewise plays a role in the process of the price setting.

Table 5. Price stickiness explanations reported by firms: cross-country comparison

Evidence from surveys conducted in:					
Canada[a]	*Euro area[b]*	*Sweden[c]*	*UK[d]*	*US[e]*	*Estonia[f]*
cost-based pricing;	*implicit contracts;*	*implicit contracts;*	*explicit contracts;*	*coordination failure;*	*cost-based pricing;*
consumer relations;	*explicit contracts;*	*cost-based pricing;*	*cost-based pricing;*	*cost-based pricing;*	*implicit contracts;*
explicit contracts;	*cost-based pricing;*	*explicit contracts;*	*coordination failure;*	*non-price competition;*	*explicit contracts;*
non-price competition;	*coordination failure;*	*coordination failure;*	*price thresholds;*	*implicit contracts;*	*coordination failure;*
coordination failure	*quality signal*	*countercyclical cost of finance*	*implicit contracts*	*explicit contracts*	*quality signal*

Notes: (a) source – Amirault et al. (2006); (b) covers Austria, Belgium, France, Germany, Italy, Luxembourg, the Netherlands, Portugal and Spain; source – Fabiani et al. (2006); (c) source – Apel et al. (2005); (d) source – Hall et al. (2000); (e) source – Blinder et al. (1998); (f) source – Dabušinskas and Randveer (2006); explanations are ranked according to their significance.

Evidence on the price setting and the price stickiness in Lithuania is rather limited. Literature investigates the stickiness of Lithuanian prices looking at the asymmetries in the price change distributions and examining the price duration implied by the NKPC framework.

Vetlov (2002) examines the patterns of the consumer price movements and the distribution of these movements across 92 groups of the consumer goods and services. The author computes measures of the asymmetry for price change distributions for the period of 1993-2001. The analysis indicates that the investigated distributions are skewed with price increases occurring more frequently than price decreases (positive skewness). The skewness is larger in the beginning and in the end of the analysed period, and it is lower in 1999. As the skewness remains positive for the whole examined period, this possibly suggests, as noted by the author, the incidence of the downward stickiness of the consumer prices.

Price duration in Lithuania is investigated in Dabušinskas and Kulikov (2007) employing the NKPC framework. The authors estimate the hybrid NKPC in Lithuania, accounting for inflation inertia, for the period starting from the third quarter of 1996 and ending in the fourth quarter of 2005. The study uses the labour income share or equivalently the real unit labour cost as a proxy for the real marginal cost in a closed economy as in Galí and Gertler (1999) and Galí et al. (2001). It also considers the open economy cases by allowing imported goods to be used in the consumption and in the production as in Leith and Malley (2007) and by incorporating the energy production factor. In the open economy cases real marginal cost is linked to a combination of the labour income share, the real GDP and the domestic costs/prices relative to the import prices. Assuming the non-linear production technology, the study provides estimates for the fraction of firms that keep prices unchanged – Calvo (1983) parameter in the price setting formulation – and the associated duration of prices. It is found out that the price duration in Lithuania stands at 3.4 quarters in the closed economy case, 4.1 quarters in the open economy case, where the imported goods are used in the consumption and in the production, and 6.4 quarters in the open economy case, where the energy production factor is accounted for.

A study of Mihailov et al. (2010) provides estimates for both the baseline and the hybrid NKPC in Lithuania that does not account and does account for the inflation inertia respectively. The authors investigate the closed and the open economy cases, where in the latter case the terms of trade are accounted for as in Galí and Monacelli (2005). In this study the real GDP series is used to proxy the real marginal cost. Estimates are obtained for the reduced form parameters of the NKPC. The study does not provide estimates for the structural parameters, like the fraction of firms that keep prices unchanged, thus not scrutinising the price duration.

Literature uses the Phillips curve approach to model inflation in Lithuania. Kuodis and Vetlov (2002) employs the real GDP series to obtain a proxy for the real economic activity in investigating the Lithuanian consumer price inflation. Vetlov (2004) uses a form of nominal unit labour cost in gauging the dynamics of GDP deflator. The unemployment and the industrial production series are exploited in the Lithuanian inflation analysis conducted by Masso and Staehr (2005). All these studies provide the reduced form estimates for the Phillips curve in Lithuania leaving aside

the examination of the structural parameters of the price setting, thus not touching the aspects of the price stickiness in Lithuania.

CHAPTER 2. MACROECONOMIC ANALYSIS OF PRICE SETTING AND PRICE STICKINESS: EVIDENCE FROM A PHILLIPS CURVE

2.1. Phillips curve in a historical perspective. New Keynesian Phillips curve

Looking at the very origin, Phillips (1958), working on the data of the UK, postulated a hypothesis that there exists a negative relationship between the rate of nominal wage change and the unemployment rate. Phillips noted that owing to a downward wage rigidity this relationship should not be linear. In other words, the higher and lower unemployment rate should not necessarily lead to a similar rate of the wage deceleration in the case of labour market slack and the wage acceleration in the case of labour market tightness.

The original Phillips curve relationship, linking the rate of nominal wage change to the unemployment rate, was equivalent to the negative relationship between the inflation rate and the unemployment rate owing to a wage-price spiral. The higher or lower unemployment rate leads to the lower or higher rate of the nominal wage change with subsequent implications for the price movements. The lower or higher rate of the inflation in turn affects the wage bargaining, inducing the wage-price spiral. The *original Phillips curve*, therefore, might be viewed as a negative relationship between the inflation rate and the unemployment rate

$$\pi_t = z + \lambda u_t \tag{2.1.1}$$

where π_t is the inflation rate, u_t is the unemployment rate and z is a proxy of other factors affecting the inflation. The negative link between the rate of inflation and the unemployment rate was demonstrated by Samuelson and Solow (1960) who studied the data of the US.

Later on, the economic phenomena underlying the Phillips curve was disputed by analysing the labour market imperfections. The economists Phelps (1967) and Friedman (1968) expressed their view that the Phillips curve arises due to the search and the information frictions in the labour market. Phelps and Friedman claimed that there is a negative relation between the inflation rate and the unemployment rate because of the public misperception about inflation. The Phillips curve relationship, therefore, was augmented by introducing the inflation expectations

$$\pi_t = z + \lambda u_t + \beta E\pi_t \ . \tag{2.1.2}$$

At that time the inflation expectations took the form of the naive expectations constructed as the lagged actual inflation rate. If the inflation expectations play an important role, i.e. if β approaches 1, and if they take the form of $E\pi_t = \pi_{t-1}$, then the Phillips curve relationship (2.1.2) turns into the one, which links the change in the inflation rate to the unemployment rate

$$\pi_t - \pi_{t-1} = z + \lambda u_t \ . \tag{2.1.3}$$

The relation (2.1.3) is sometimes called a *modified Phillips curve* so that to distinguish it from the original Phillips curve (2.1.1). The modified Phillips curve relationship implies that the link between the inflation rate and the unemployment rate exists only in the short run. In the long run, i.e. when the inflation rate becomes constant, the link between the inflation and the unemployment disappears, and the unemployment rate stays at the level called, as named by Phelps and Friedman, the natural unemployment rate (for graphical exposition see Figure 1).

Figure 1. Phillips curve in a short run and in a long run
(a) short run case   *(b) long run case*
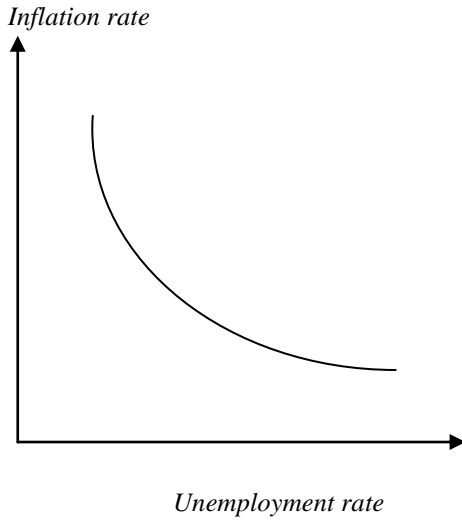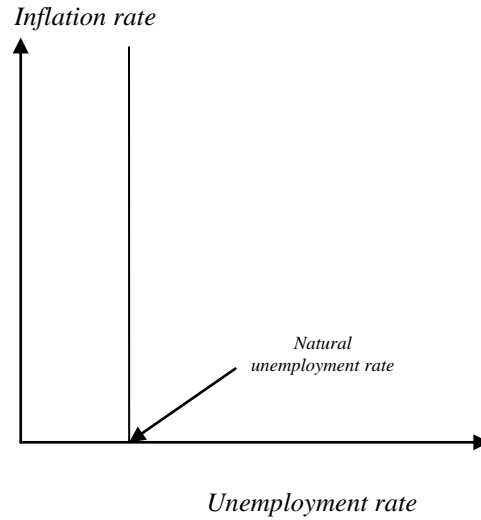
The concept of the natural unemployment rate allows interpreting the Phillips curve in one more way. In the described setting, the natural unemployment rate u_n, as suggested by (2.1.3), stands at $-\dfrac{z}{\lambda}$. Substituting the natural unemployment rate into the relation (2.1.3) renders

$$\pi_t - \pi_{t-1} = \lambda \left(\frac{z}{\lambda} + u_t \right) = \lambda (u_t - u_n). \tag{2.1.4}$$

The change in the inflation rate is, thus, viewed as dependent on the linear combination of the actual unemployment rate and the natural unemployment rate. To put it differently, the Phillips curve relationship embodies a link between the change in the inflation rate and the deviation of the actual unemployment rate from the natural one.

The modified Phillips curve (2.1.2) became empirically acknowledged in 1970s when the inflation has picked up notably. Until then the academic research and the policy analysis was mostly centred on the original Phillips curve formulation (2.1.1), which was properly describing the link between the price formation and the unemployment in the environment of rather low inflation that was prevailing at that time. In 1970s, however, the inflation has increased significantly owing to a rise in prices in the commodity markets. The heightened inflation contributed to a more important role of the inflation expectations, weakening the link between the inflation rate and the unemployment rate. The relationship between the inflation rate, the unemployment rate and the expected inflation rate has become more evident.

Expectations took an important role in the economic analysis, therefore their formulation was investigated further. It seemed appropriate to go beyond the automatic rule governing the expectations and to assume that the expectations take into account all the information that is available at the time when they are formed (see Lucas 1972). By definition, such expectations should not end up in any systematic errors as they are based on all the information available for economic agents. Hence, these expectations were named as rational ones.

In the 1980s the economic research witnessed a rise in the real business cycle analysis. Research included a construction of the general equilibrium aggregate economy models based on the neoclassical assumptions. The real business cycle analysis covered the interaction of the main real macroeconomic variables while keeping the assumption of the money neutrality. Once the money neutrality assumption was lifted up, the general equilibrium models started accounting for nominal rigidities. This gave a rise to a New Keynesian macroeconomic modelling and a formulation of the Phillips curve named the *NKPC*.

In the New Keynesian framework the nominal price setting rigidities are typically implemented by assuming the environment of monopolistic competition where the firms are producing differentiated goods. The goods are viewed as imperfect substitutes, therefore the demand for these goods hinges on their prices relative to the general price level. The price setting is typically constrained by restricting the firms to adjust their prices in a non-continuous way. A widely adopted view is to allow resetting the prices only for some share of firms and for random periods, as in Calvo (1983)[4]. This has implications for the optimal price level set by the firms, which are allowed to change the prices. In particular, firms set the prices in a way so that to maximize the discounted stream of the expected profits over the period during which the prices are to stay unchanged. Such economic setup renders the NKPC, which relates the current inflation to the current real marginal cost and to the expected next period's inflation

$$\pi_t = \lambda mc_t^r + \beta E_t \pi_{t+1} \tag{2.1.5}$$

where mc_t^r is the real marginal cost. In this setup the reduced-form parameter λ, among the other factors, depends on the structural parameter representing the share of firms that are allowed to reset the prices.

Many studies find the inflation to exhibit a significant rate of inertia. Therefore in the New Keynesian framework the Phillips curve (2.1.5) is often extended to include a term of the lagged inflation. This can be implemented, as suggested by Galí and Gertler (1999), by assuming some share of firms to follow a backward looking rule of thumb in setting their prices[5]. The NKPC then relates the current inflation to the current real marginal cost, the lagged inflation and the inflation, which is expected to prevail in the next period

$$\pi_t = \tilde{\lambda} mc_t^r + \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} \tag{2.1.6}$$

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[4] As mentioned in the previous chapter of the dissertation, an alternative view to restrict the price adjustment is to assume fixed-duration contracts as suggested by Taylor (1980).

[5] Fuhrer and Moore (1995) derives the hybrid NKPC by assuming the specific contracting schemes when employees are bargaining for wages; Christiano et al. (2005) use a framework where the prices are set every period with some of the prices set optimally and some of them adapted to the past inflation.

where $\tilde{\lambda}$, γ_b, γ_f are the reduced-form parameters that are governed, among the other factors, by such structural parameters as the share of firms that are allowed to reset the prices and the share of backward looking rule of thumb firms. The NKPC (2.1.6) can be viewed as a hybrid of the baseline NKPC (2.1.5) and a more standard Phillips curve, therefore it is often called a *hybrid NKPC*.

The hybrid NKPC was plentifully investigated starting with Galí and Gertler (1999) who documented estimates for the US. Rudd and Whelan (2006, 2007) and Sbordone (2002, 2005) also analysed US' inflation by assuming the hybrid NKPC setting. Galí et al. (2001, 2003) provided estimates of the hybrid NKPC for the euro area. All these studies worked on the closed economy specification where the real marginal cost is shown to be proxied by the labour income share or alternatively by the real unit labour cost. To account for possible open economy effects the research considered a substitution between the domestic and the imported inputs as well as a substitution between the domestically produced and the imported consumption goods (Holmberg, 2006, Leith and Malley, 2007, Rumler, 2007). Owing to the introduction of the imported goods, the real marginal cost is shown to be governed, apart from the labour income share, by the imported goods share or/and by the level of wages relative to the domestic prices and the level of import prices relative to the domestic prices.

Overall, the NKPC provides a framework to analyse inflation. This framework sets a basis to investigate the structural parameters that govern the inflation and that represent the nominal rigidities of the price setting. The NKPC constitutes an important part of the New Keynesian macroeconomic modelling by incorporating the nominal rigidities into the macroeconomic models. In contrast to the preceding Phillips curve formulations, the NKPC is based on the optimising behaviour of firms and on the pricing decisions of firms that are modelled in the inter-temporal dimension.

2.2. New Keynesian Phillips curve in a closed economy

This section of the dissertation describes the economy setup that generates the baseline and the hybrid NKPC in a closed economy. The economic framework follows Galí and Gertler (1999) and Galí et al. (2001) in reconstructing the structural

relations between the inflation, the real economic activity, the inflation expectations and, in the hybrid NKPC case, the inflation inertia.

It is assumed a continuum of firms indexed by $j \in [0,1]$ acting in a monopolistically competitive market[6]. Each firm is a monopolistic competitor producing a differentiated good Y_{jt} and selling it at time t for a nominal price P_{jt}. Each firm faces a constant-price-elasticity demand given by

$$Y_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{-\varepsilon} Y_t \qquad (2.2.1)$$

where Y_t is an aggregate production output represented by $Y_t = \left(\int_0^1 Y_{jt}^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$, P_t is an

aggregate price level $P_t = \left(\int_0^1 P_{jt}^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}$, ε is a price elasticity of demand and an elasticity of substitution between the differentiated goods. Each firm employs a production technology, which uses labour input N_{jt}, expressed as

$$Y_{jt} = A_t N_{jt}^{1-\alpha} \qquad (2.2.2)$$

where A_t denotes a common technological factor and α is an elasticity of substitution between the labour and the capital, which is kept fixed in this economy[7].

Firms set the prices in a constrained way as in Calvo (1983). In particular, every period the firm is allowed to adjust its price with the probability $1-\theta$, irrespective the fact whether the firm reset its price in the previous period. In other words, every period $1-\theta$ fraction of firms is allowed to change the price. At the same time θ fraction of firms keep the prices unchanged. The expected time that the price remains

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[6] The assumption of monopolistically competitive market can be justified by the available indications of the presence of imperfectly competitive market in Lithuania. Other than perfectly competitive market is pointed out in the survey research showing that the most common practice to set prices is to choose them according to costs and completely self-determined profit margin (mark-up pricing) as well as to engage into price discrimination (see Section 3.2.2).

[7] This production technology is equivalent to $Y_{jt} = A_t N_{jt}^{1-\alpha} K^{\alpha}$ where the capital K is fixed.

fixed, consequently, is $\dfrac{1}{1-\theta}$ [8]. θ is, thus, used to measure the stickiness of prices.

Under this setup the aggregate price level can be expressed as

$$P_t = \left((1-\theta)\left(P_t^*\right)^{1-\varepsilon} + \theta P_{t-1}^{1-\varepsilon} \right)^{\frac{1}{1-\varepsilon}} \tag{2.2.3}$$

where P_t^* is a newly set price chosen by those firms, which are allowed to adjust their prices in a period t. Log-linearization of the price index (2.2.3) around a zero-inflation steady state, as it is shown in the Appendix 1, implies that the aggregate price level evolves as a weighted average of the newly set price level $\hat{p}_t^*$ and the price level observed in the previous period $\hat{p}_{t-1}$, in particular

$$\hat{p}_t = (1-\theta)\hat{p}_t^* + \theta\hat{p}_{t-1} \tag{2.2.4}$$

where lower case letters under "^" denote log deviations of the respective variables from their steady state values[9] [10].

2.2.1. Optimal price setting under Calvo constraints

When prices are set with the restrictions, the optimal pricing involves the assessment of the expected changes in economic environment during a foreseeable future. The firm, which under the Calvo constraints is allowed to set the price at time t, picks up an optimal price P_{jt}^* so that to maximize the discounted stream of the expected future profits over the horizon during which the price is to prevail. Firm faces the profit maximization problem

$$\max_{P_{jt}^*} E_t \sum_{k=0}^{\infty} (\beta\theta)^k \left(\frac{P_{jt}^*}{P_{t+k}} Y_{jt+k} - \frac{MC_{jt+k}}{P_{t+k}} Y_{jt+k} \right)^{[11]} \tag{2.2.5}$$

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[8] To illustrate, if every quarter the firm is allowed to adjust the price with probability $\theta = 0.5$, then the implied time period, during which the price remains fixed, is 2 quarters.

[9] For a treatment of a standard log-linearization method and for a description of notation used in log-linearization see Appendix 1.

[10] In the rest of the dissertation the same notation (lower case letters under "^") for log deviations of the variables from their steady state values applies.

[11] Parameter θ (a probability that the firm is not allowed to change the price) enters the maximization problem so that to maximize the expected future profits over the period during which the price is to stay unchanged.

subject to the demand condition $Y_{jt} = \left(\dfrac{P_{jt}^*}{P_t}\right)^{-\varepsilon} Y_t$. Here β is a subjective discount

factor, MC_{jt} is a nominal marginal cost of firm j.

Substituting the demand function into the firm's maximization problem (2.2.5) and taking the first order condition with respect to P_{jt}^* results in

$$E_t \sum_{k=0}^{\infty} (\beta\theta)^k Y_{t+k} \left(\frac{1-\varepsilon}{P_{t+k}} \left(\frac{P_{jt}^*}{P_{t+k}}\right)^{-\varepsilon} + \frac{MC_{jt+k}}{P_{t+k}} \frac{\varepsilon}{P_{t+k}} \left(\frac{P_{jt}^*}{P_{t+k}}\right)^{-\varepsilon-1} \right) = 0$$

$$(1-\varepsilon)\left(P_{jt}^*\right)^{-\varepsilon} E_t \sum_{k=0}^{\infty} (\beta\theta)^k Y_{t+k} P_{t+k}^{\varepsilon-1} + \varepsilon\left(P_{jt}^*\right)^{-\varepsilon-1} E_t \sum_{k=0}^{\infty} (\beta\theta)^k Y_{t+k} MC_{jt+k} P_{t+k}^{\varepsilon-1} = 0$$

$$P_{jt}^* E_t \sum_{k=0}^{\infty} (\beta\theta)^k Y_{t+k} P_{t+k}^{\varepsilon-1} = \frac{\varepsilon}{\varepsilon-1} E_t \sum_{k=0}^{\infty} (\beta\theta)^k Y_{t+k} MC_{jt+k} P_{t+k}^{\varepsilon-1}. \qquad (2.2.6)$$

Utilizing the log-linearization rules outlined in Appendix 1, the log-linearization of the term on the left-hand side of the equation (2.2.6) results in

$$Y_{t+k} P_{t+k}^{\varepsilon-1} = Y\ P^{\varepsilon-1} \left(1 + \hat{y}_{t+k} + (\varepsilon-1)\hat{p}_{t+k}\right) \qquad (2.2.7)$$

while the log-linearization of the whole left-hand side of the equation (2.2.6) yields

$$P_j^* \left(1 + \hat{p}_{jt}^*\right) Y\ P^{\varepsilon-1} E_t \sum_{k=0}^{\infty} (\beta\theta)^k \left(1 + \hat{y}_{t+k} + (\varepsilon-1)\hat{p}_{t+k}\right) =$$

$$= P_j^* Y\ P^{\varepsilon-1} \left(\frac{1}{1-\beta\theta} + \frac{\hat{p}_{jt}^*}{1-\beta\theta} + E_t \sum_{k=0}^{\infty} (\beta\theta)^k \left(\hat{y}_{t+k} + (\varepsilon-1)\hat{p}_{t+k}\right) \right). \qquad (2.2.8)$$

The log-linearization of the term on the right-hand side of the equation (2.2.6) gives

$$Y_{t+k} MC_{jt+k} P_{t+k}^{\varepsilon-1} = Y\ MC_j P^{\varepsilon-1} \left(1 + \hat{y}_{t+k} + \hat{mc}_{jt+k} + (\varepsilon-1)\hat{p}_{t+k}\right) \qquad (2.2.9)$$

and the log-linearization of the whole right-hand side of the equation (2.2.6) results in

$$\frac{\varepsilon}{\varepsilon-1} Y\ MC_j P^{\varepsilon-1} E_t \sum_{k=0}^{\infty} (\beta\theta)^k \left(1 + \hat{y}_{t+k} + \hat{mc}_{jt+k} + (\varepsilon-1)\hat{p}_{t+k}\right) =$$

$$= \frac{\varepsilon}{\varepsilon-1} Y\ MC_j P^{\varepsilon-1} \left(\frac{1}{1-\beta\theta} + E_t \sum_{k=0}^{\infty} (\beta\theta)^k \left(\hat{y}_{t+k} + \hat{mc}_{jt+k} + (\varepsilon-1)\hat{p}_{t+k}\right) \right). \qquad (2.2.10)$$

Combining the results (2.2.8) and (2.2.10) and assuming that in a steady state

$P_j^* = P$, $P = \dfrac{\varepsilon}{\varepsilon-1} MC_j = \mu\ MC_j$ (result (A2.3) derived in Appendix 2), where μ is a

price mark-up, yields a path for a newly set price chosen by the firm under the Calvo constraints. In particular, this price is determined by the discounted stream of the

expected future nominal marginal cost of the firm, or equivalently this price is a weighted average of the current nominal marginal cost and the expected future reset price

$$\hat{p}^*_{jt} = (1-\beta\theta)E_t\sum_{k=0}^{\infty}(\beta\theta)^k m\hat{c}_{jt+k} = (1-\beta\theta)m\hat{c}_{jt} + \beta\theta E_t\hat{p}^*_{jt+1}. \tag{2.2.11}$$

The result (2.2.11) implies that in a limiting case when the prices are set in a fully flexible way, i.e. when all the firms are allowed to choose the prices in any given period $(\theta = 0)$, the prices move in line with the current nominal marginal cost[12]. Only when the price stickiness is introduced, i.e. when $\theta > 0$, the expected future developments of the nominal marginal cost obtain the weight.

2.2.2. Baseline and hybrid New Keynesian Phillips curves

The Calvo formulation of the sticky price setting and the economy setup outlined above leads to a construction of the structural relation between the inflation and the real marginal cost. This relation is obtained by making use of the above derived results ((2.2.4) and (2.2.11)) for the aggregate price level and for the newly set prices chosen by firms under the Calvo constraints.

For derivation purposes the result (2.2.11) might be rearranged. Since every firm, which is allowed to reset the price in period t, chooses the same price, the subscript j might be dropped. Additionally, nominal marginal cost $m\hat{c}_t$ can be replaced by $m\hat{c}^r_t + \hat{p}_t$ where $m\hat{c}^r_t$ is a real marginal cost. This renders the following optimal path for the level of newly set prices

$$\hat{p}^*_t = (1-\beta\theta)(m\hat{c}^r_t + \hat{p}_t) + \beta\theta E_t\hat{p}^*_{t+1}. \tag{2.2.12}$$

Defining inflation as $\hat{\pi}_t = \hat{p}_t - \hat{p}_{t-1}$ and rearranging the equation (2.2.4) yields

$$\hat{\pi}_t = (1-\theta)(\hat{p}^*_t - \hat{p}_{t-1})$$

$$\hat{p}^*_t - \hat{p}_{t-1} = \frac{\hat{\pi}_t}{1-\theta}. \tag{2.2.13}$$

Leading the equation (2.2.13) by one period and substituting it into the equation (2.2.12) results in

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[12] This compares with the optimal price setting result when prices are flexible derived in Appendix 2.

$$\hat{p}_t^* = (1 - \beta\theta)m\hat{c}_t^r + \hat{p}_t + \beta\theta \frac{E_t\hat{\pi}_{t+1}}{1-\theta} . \tag{2.2.14}$$

Substituting the result (2.2.14) into (2.2.13) gives a variant of the baseline NKPC, which relates the current inflation to the current real marginal cost and to the inflation, which is expected to prevail in the next period

$$(1 - \beta\theta)m\hat{c}_t^r + \hat{p}_t + \beta\theta \frac{E_t\hat{\pi}_{t+1}}{1-\theta} - \hat{p}_{t-1} = \frac{\hat{\pi}_t}{1-\theta}$$

$$(1-\theta)(1-\beta\theta)m\hat{c}_t^r + (1-\theta)\hat{p}_t + \beta\theta E_t\hat{\pi}_{t+1} - (1-\theta)\hat{p}_{t-1} = \hat{\pi}_t$$

$$\hat{\pi}_t = \lambda m\hat{c}_t^r + \beta E_t\hat{\pi}_{t+1} \tag{2.2.15}$$

where $\lambda = \dfrac{(1-\theta)(1-\beta\theta)}{\theta}$.

Iterating (2.2.15) results in $\hat{\pi}_t = \lambda \sum_{k=0}^{\infty} \beta^k E_t m\hat{c}_{t+k}^r$ implying that the current inflation is governed by the discounted stream of the expected future real marginal cost. Intuitively, it is justified by an assumption that the price resetting firms are forward looking and that some firms might end up without resetting their prices for a number of periods. The role of the real marginal cost, in turn, depends on λ, which is related to the structural parameter θ. Since λ is decreasing to parameter θ, higher fraction of firms, which are not allowed to reset the prices, implies more contained role of the real marginal cost in determining the inflation[13].

The baseline NKPC embodied in the result (2.2.15) relates the current inflation only to the current real marginal cost and to the foreseen inflation, which is expected to prevail in the next period. The baseline NKPC does not capture, however, the lagged inflation effects on the current inflation, which are often found as statistically significant. To account for inflation inertia Galí and Gertler (1999) suggest to assume that only a fraction of firms, which are allowed to reset their prices under the Calvo constraints, optimize their decisions as described in (2.2.12) while the rest of price resetting firms follow a backward looking rule of thumb

$$\hat{p}_t^b = \hat{p}_{t-1}^* + \hat{\pi}_{t-1} \tag{2.2.16}$$

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[13] Notice: a derivate of the expression for λ with respect to θ results in

$\dfrac{\partial\lambda}{\partial\theta} = \dfrac{\partial\left(\dfrac{(1-\theta)(1-\beta\theta)}{\theta}\right)}{\partial\theta} = \dfrac{\partial\left(\dfrac{1}{\theta}-1-\beta+\beta\theta\right)}{\partial\theta} = -\dfrac{1}{\theta^2}+\beta$; its value is non-positive for all the values of θ

and β.

where $\hat{p}_t^b$ is a price level set by the backward looking rule of thumb firms, $\hat{p}_{t-1}^*$ is a level of prices set by the firms, which were allowed to adjust their prices in the previous period (this includes both the optimizing and the rule of thumb firms).

As noted by Galí and Gertler (1999), the rule of thumb (2.2.16) possesses a few appealing features. Namely, when inflation is stationary the rule converges to the optimal price setting behaviour. The prices set by this rule are conditioned only on the information dated at $t-1$ or earlier (the backward looking feature of the rule), however indirectly the rule incorporates the information about the future developments by accounting for the newly set prices in the previous period, which were partly set by the optimizing firms.

As in the analysis above, the optimizing firms (or, in other words, the forward looking firms) set their prices according to the equation (2.2.12), which is reproduced below with a slight change in the notation. In particular, superscript * is changed into f so that to distinguish between the price level set by the optimizing firms and the price level set by all the price resetting firms

$$\hat{p}_t^f = (1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t) + \beta\theta E_t \hat{p}_{t+1}^f. \tag{2.2.17}$$

In this setup the price level of newly set prices evolves according to

$$\hat{p}_t^* = (1-\omega)\hat{p}_t^f + \omega\hat{p}_t^b \tag{2.2.18}$$

where $1-\omega$ is a fraction of firms, which reset the prices in an optimal way, ω is a fraction of firms adjusting the prices according to the backward looking rule of thumb. Notice that the equation (2.2.18) might be derived in the same way as the equation (2.2.4) (see Appendix 1).

To complete the model, one needs to notice that in the latter economy setup the aggregate price level is described as in the preceding analysis by the equation (2.2.4).

To proceed with, combine the equations (2.2.4) and (2.2.16) to get

$$\hat{p}_t^b - \hat{p}_t = \hat{p}_{t-1}^* + \hat{\pi}_{t-1} - (1-\theta)\hat{p}_t^* - \theta\hat{p}_{t-1} =$$

$$= \frac{\hat{p}_{t-1} - \theta\hat{p}_{t-2}}{1-\theta} + \hat{\pi}_{t-1} - (\hat{p}_t - \theta\hat{p}_{t-1}) - \theta\hat{p}_{t-1} =$$

$$= \frac{\hat{p}_{t-1} - \theta\hat{p}_{t-2} - \hat{p}_t + \theta\hat{p}_t}{1-\theta} + \hat{\pi}_{t-1} = \frac{\hat{p}_{t-1} - \theta\hat{p}_{t-2} + \theta\hat{p}_{t-1} - \theta\hat{p}_{t-1} - \hat{p}_t + \theta\hat{p}_t}{1-\theta} + \hat{\pi}_{t-1} =$$

$$= \frac{-\hat{\pi}_t + \theta\hat{\pi}_{t-1} + \theta\hat{\pi}_t}{1-\theta} + \hat{\pi}_{t-1} = -\hat{\pi}_t + \frac{\theta\hat{\pi}_{t-1}}{1-\theta} + \hat{\pi}_{t-1} = -\hat{\pi}_t + \frac{\hat{\pi}_{t-1}}{1-\theta}. \tag{2.2.19}$$

Combining the equations (2.2.4) and (2.2.18) yields

$$\frac{\hat{p}_t - \theta\hat{p}_{t-1}}{1-\theta} = (1-\omega)\hat{p}_t^f + \omega\hat{p}_t^b$$

$$\frac{\hat{p}_t - \theta\hat{p}_{t-1}}{1-\theta} - \hat{p}_t = (1-\omega)\hat{p}_t^f + \omega\hat{p}_t^b - \hat{p}_t$$

$$\frac{\hat{p}_t - \theta\hat{p}_{t-1} - \hat{p}_t + \theta\hat{p}_t}{1-\theta} = (1-\omega)\hat{p}_t^f + \omega\hat{p}_t^b - (1-\omega+\omega)\hat{p}_t$$

$$\frac{\theta\hat{\pi}_t}{1-\theta} = (1-\omega)(\hat{p}_t^f - \hat{p}_t) + \omega(\hat{p}_t^b - \hat{p}_t). \tag{2.2.20}$$

Rearranging the equation (2.2.20), combining with the equation (2.2.19) and leading the resulting equation by one period results in

$$(1-\omega)(\hat{p}_t^f - \hat{p}_t) = \frac{\theta\hat{\pi}_t}{1-\theta} - \omega(\hat{p}_t^b - \hat{p}_t)$$

$$\hat{p}_t^f - \hat{p}_t = \frac{\theta\hat{\pi}_t}{(1-\omega)(1-\theta)} + \frac{\omega}{1-\omega}\left(\hat{\pi}_t - \frac{\hat{\pi}_{t-1}}{1-\theta}\right)$$

$$\hat{p}_t^f = \frac{\theta+\omega(1-\theta)}{(1-\omega)(1-\theta)}\hat{\pi}_t - \frac{\omega}{(1-\omega)(1-\theta)}\hat{\pi}_{t-1} + \hat{p}_t$$

$$E_t\hat{p}_{t+1}^f = \frac{\theta+\omega(1-\theta)}{(1-\omega)(1-\theta)}E_t\hat{\pi}_{t+1} - \frac{\omega}{(1-\omega)(1-\theta)}\hat{\pi}_t + E_t\hat{p}_{t+1}. \tag{2.2.21}$$

Combining the result (2.2.21) with the equation (2.2.17) gives

$$\hat{p}_t^f = (1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t) + \beta\theta\frac{\theta+\omega(1-\theta)}{(1-\omega)(1-\theta)}E_t\hat{\pi}_{t+1} - \beta\theta\frac{\omega}{(1-\omega)(1-\theta)}\hat{\pi}_t + \beta\theta E_t\hat{p}_{t+1}$$

$$\hat{p}_t^f - \hat{p}_t = (1-\beta\theta)m\hat{c}_t^r - \beta\theta\hat{p}_t + \beta\theta\frac{\theta+\omega(1-\theta)}{(1-\omega)(1-\theta)}E_t\hat{\pi}_{t+1} -$$

$$- \beta\theta\frac{\omega}{(1-\omega)(1-\theta)}\hat{\pi}_t + \beta\theta E_t\hat{p}_{t+1}$$

$$\hat{p}_t^f - \hat{p}_t = (1-\beta\theta)m\hat{c}_t^r + \left(\beta\theta + \beta\theta\frac{\theta+\omega(1-\theta)}{(1-\omega)(1-\theta)}\right)E_t\hat{\pi}_{t+1} -$$

$$- \beta\theta\frac{\omega}{(1-\omega)(1-\theta)}\hat{\pi}_t. \tag{2.2.22}$$

Substituting (2.2.19) and (2.2.22) into (2.2.20) and rearranging the resulting equation yields a variant of the hybrid NKPC, which relates the current inflation to the current real marginal cost, the lagged inflation and the inflation, which is expected to prevail in the next period

$$\frac{\theta\hat{\pi}_t}{1-\theta} = (1-\omega)\left((1-\beta\theta)m\hat{c}_t^r + \left(\beta\theta + \beta\theta\frac{\theta+\omega(1-\theta)}{(1-\omega)(1-\theta)}\right)E_t\hat{\pi}_{t+1} -$$

$$-\beta\theta\frac{\omega}{(1-\omega)(1-\theta)}\hat{\pi}_t\Bigg)+\omega\Bigg(-\hat{\pi}_t+\frac{\hat{\pi}_{t-1}}{1-\theta}\Bigg)$$

$$\frac{\theta\hat{\pi}_t}{1-\theta}=(1-\omega)(1-\beta\theta)m\hat{c}_t^r+\Bigg((1-\omega)\beta\theta+\beta\theta\frac{\theta+\omega(1-\theta)}{(1-\theta)}\Bigg)E_t\hat{\pi}_{t+1}-$$

$$-\beta\theta\frac{\omega}{(1-\theta)}\hat{\pi}_t-\omega\hat{\pi}_t+\frac{\omega\hat{\pi}_{t-1}}{1-\theta}$$

$$\theta\hat{\pi}_t=(1-\omega)(1-\theta)(1-\beta\theta)m\hat{c}_t^r+((1-\omega)(1-\theta)\beta\theta+\beta\theta(\theta+\omega(1-\theta)))E_t\hat{\pi}_{t+1}-$$

$$-\omega\beta\theta\hat{\pi}_t-\omega(1-\theta)\hat{\pi}_t+\omega\hat{\pi}_{t-1}$$

$$(\theta+\omega(1-\theta(1-\beta)))\hat{\pi}_t=(1-\omega)(1-\theta)(1-\beta\theta)m\hat{c}_t^r+\beta\theta E_t\hat{\pi}_{t+1}+\omega\hat{\pi}_{t-1}$$

$$\hat{\pi}_t=\tilde{\lambda}m\hat{c}_t^r+\gamma_b\hat{\pi}_{t-1}+\gamma_f E_t\hat{\pi}_{t+1} \qquad (2.2.23)$$

where $\tilde{\lambda}=\dfrac{(1-\omega)(1-\theta)(1-\beta\theta)}{\theta+\omega(1-\theta(1-\beta))}$, $\gamma_b=\dfrac{\omega}{\theta+\omega(1-\theta(1-\beta))}$, $\gamma_f=\dfrac{\beta\theta}{\theta+\omega(1-\theta(1-\beta))}$.

The specification (2.2.23) implies that in a limiting case when all the firms, which are allowed to choose the prices, are forward looking, i.e. when $\omega=0$, the hybrid NKPC falls into the baseline model (2.2.15), which relates the current inflation only to the current real marginal cost and to the inflation, which is expected to prevail in the next period. And only when there is some fraction of firms, which reset their prices according to the backward looking rule, i.e. when $\omega>0$, the lagged inflation obtains the weight in governing the present inflation. The proportion of the rule of thumb firms affects the weight of both the lagged and the expected inflation. γ_b is increasing and γ_f is decreasing to ω, therefore higher fraction of the backward looking firms implies stronger role of the lagged inflation and weaker role of the expected inflation in determining the current inflation[14]. The impact of the fraction of

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[14] Notice: a derivate of the expression for γ_b with respect to ω results in

$$\frac{\partial\gamma_b}{\partial\omega}=\frac{\partial\left(\frac{\omega}{\theta+\omega(1-\theta(1-\beta))}\right)}{\partial w}=\frac{\partial\left(\frac{\omega}{\theta+\omega-\omega\theta+\omega\theta\beta}\right)}{\partial w}=\frac{1}{\left(\frac{\theta}{\omega}+1-\theta+\theta\beta\right)^2}\frac{\theta}{\omega^2}$$; its value is non-negative for all

the values of ω, θ and β; a derivate of the expression for γ_f with respect to ω results in

$$\frac{\partial\gamma_f}{\partial\omega}=\frac{\partial\left(\frac{\beta\theta}{\theta+\omega(1-\theta(1-\beta))}\right)}{\partial w}=\frac{\partial\left(\frac{\beta\theta}{\theta+\omega-\omega\theta+\omega\theta\beta}\right)}{\partial w}=-\frac{\beta\theta}{(\theta+\omega-\omega\theta+\omega\theta\beta)^2}(1-\theta+\theta\beta)$$; its value is non-

positive for all the values of ω, θ and β.

firms, which are not allowed to reset prices, is the opposite. γ_b is decreasing and γ_f is increasing to parameter θ, therefore if the proportion of firms, which keep their prices unchanged, is higher, the role of the lagged inflation is weaker and the role of the expected inflation is stronger[15].

2.2.3. Real marginal cost approximation

In the given closed economy, where only the labour input is used to produce the output according to the production technology (2.2.2), the total cost function under the consideration is defined as $W_t N_{jt} = W_t Y_{jt}^{\frac{1}{1-\alpha}}$. Here W_t is a nominal wage and A_t is set to 1.

The nominal marginal cost is then given by

$$MC_{jt} = \frac{\partial\left(W_t Y_{jt}^{\frac{1}{1-\alpha}}\right)}{\partial Y_{jt}} = \frac{1}{1-\alpha} W_t Y_{jt}^{\frac{1}{1-\alpha}-1} = \frac{1}{1-\alpha}\frac{W_t N_{jt}}{Y_{jt}} \qquad (2.2.24)$$

while the real marginal cost is

$$MC_{jt}^r = \frac{1}{1-\alpha}\frac{W_t N_{jt}}{P_t Y_{jt}}. \qquad (2.2.25)$$

Every firm faces the same real marginal cost, therefore the aggregate counterpart of the outcome (2.2.25) is expressed as

$$MC_t^r = \frac{1}{1-\alpha}\frac{W_t N_t}{P_t Y_t} = \frac{S_t}{1-\alpha} \qquad (2.2.26)$$

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[15] Notice: a derivate of the expression for γ_b with respect to θ results in

$\frac{\partial \gamma_b}{\partial \theta} = \frac{\partial\left(\frac{\omega}{\theta+\omega(1-\theta(1-\beta))}\right)}{\partial \theta} = \frac{\partial\left(\frac{\omega}{\theta+\omega-\omega\theta+\omega\theta\beta}\right)}{\partial \theta} = -\frac{\varpi}{(\theta+\omega-\omega\theta+\omega\theta\beta)^2}(1-\varpi+\varpi\beta)$; its value is non-

positive for all the values of ω, θ and β; a derivate of the expression for γ_f with respect to θ

results in $\frac{\partial \gamma_f}{\partial \theta} = \frac{\partial\left(\frac{\beta\theta}{\theta+\omega(1-\theta(1-\beta))}\right)}{\partial \theta} = \frac{\partial\left(\frac{\beta\theta}{\theta+\omega-\omega\theta+\omega\theta\beta}\right)}{\partial \theta} = \frac{\beta}{\left(1+\frac{\omega}{\theta}-\omega+\omega\beta\right)^2}\frac{\varpi}{\theta^2}$; its value is non-

negative for all the values of ω, θ and β.

where S_t is a labour income share or equivalently a real unit labour cost and its log-linearization yields a relation, which implies that in the given closed economy the real marginal cost moves in line with the labour income share or equivalently with the real unit labour cost

$$\hat{mc}_t^r = \hat{s}_t .$$

(2.2.27)

2.3. New Keynesian Phillips curve in an open economy

The following economy extension incorporates the open economy effects by allowing for the imported goods to be used in the consumption and in the production as in Leith and Malley (2007). It is assumed that the consumption basket is a CES aggregate

$$C_t = \left(\chi \left(C_t^d \right)^{\frac{\sigma-1}{\sigma}} + (1-\chi) \left(C_t^m \right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

(2.3.1)

where $C_t^d = \left(\int_0^1 \left(C_{jt}^d \right)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$ and $C_t^m = \left(\int_0^1 \left(C_{jt}^m \right)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$ refer to the consumption of domestically produced and imported goods respectively, χ is a parameter representing the home bias in the consumption, and σ is an elasticity of substitution between the goods produced in the home country and abroad.

The associated price indices of the domestically produced and the imported goods are given by $P_t^d = \left(\int_0^1 \left(P_{jt}^d \right)^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}$ and $P_t^m = \left(\int_0^1 \left(P_{jt}^m \right)^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}$ respectively, and the corresponding consumption price index is

$$P_t = \left(\chi^\sigma \left(P_t^d \right)^{1-\sigma} + (1-\chi)^\sigma \left(P_t^m \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} .$$

(2.3.2)

As in Leith and Malley (2007), the imported goods are viewed as a substitute for the labour in the production technology

$$Y_{jt} = \left(\alpha_N N_{jt}^{\frac{\rho-1}{\rho}} + \alpha_{IM} IM_{jt}^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}(1-\alpha)} {}^{16} \qquad (2.3.3)$$

where IM_{jt} is the imports of goods used in the production of firm j, α_N and α_{IM} are the shares of labour and imported goods respectively in the production, and ρ is an elasticity of substitution between these inputs.

Similarly as in the home country, the consumers and the firms abroad use the imported goods in the consumption and in the production, implying an additional demand for the domestic production output. The total demand for goods produced by the domestic firm j therefore is

$$Y_{jt} = \left(\frac{P_{jt}^d}{P_t^d} \right)^{-\varepsilon} Y_t = \left(\frac{P_{jt}^d}{P_t^d} \right)^{-\varepsilon} \left(C_t^d + C_t^* + IM_t^* \right) \qquad (2.3.4)$$

where C_t^* and IM_t^* represent the foreign countries' imports of domestically produced goods used for the consumption and for the production respectively.

2.3.1. Baseline and hybrid New Keynesian Phillips curves

The introduction of the imported goods into the consumption implies that the consumer prices and the domestically produced goods' prices evolve in a different way. This has an impact on the formulation of the baseline and the hybrid NKPC. In particular, since it is assumed that the firms are owned by the consumers, the nominal marginal cost of the domestic firms is deflated by the consumer prices rather than by the domestically produced goods' prices. This renders variants of the baseline and the hybrid NKPC that differ from the ones given in (2.2.15) and (2.2.23).

The baseline NKPC is derived following a procedure analogous to the one outlined in the equations (2.2.12) through (2.2.15). Deflating the nominal marginal cost of domestic firms by $\hat{p}_t$ and defining the inflation of domestically produced goods' prices as $\hat{\pi}_t^d = \hat{p}_t^d - \hat{p}_{t-1}^d$ yields the relations

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[16] This production technology is equivalent to $Y_{jt} = \left(\alpha_N N_{jt}^{\frac{\rho-1}{\rho}} + \alpha_{IM} IM_{jt}^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}(1-\alpha)} K^{\alpha}$ where the capital

K is fixed.

$$\hat{p}_t^{df} = (1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t) + \beta\theta E_t \hat{p}_{t+1}^{df}$$

$$\hat{\pi}_t^d = (1-\theta)(\hat{p}_t^{df} - \hat{p}_{t-1}^d)$$

$$\hat{p}_t^{df} = (1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t) + \beta\theta E_t\left(\frac{\hat{\pi}_{t+1}^d}{1-\theta} + \hat{p}_t^d\right)$$

$$(1-\theta)\hat{p}_t^{df} = (1-\theta)(1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t) + (1-\theta)(1-1+\beta\theta)\hat{p}_t^d + \beta\theta E_t \hat{\pi}_{t+1}^d$$

$$(1-\theta)(\hat{p}_t^{df} - \hat{p}_{t-1}^d + \hat{p}_{t-1}^d - \hat{p}_t^d) = (1-\theta)(1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t - \hat{p}_t^d) + \beta\theta E_t \hat{\pi}_{t+1}^d$$

$$\hat{\pi}_t^d - (1-\theta)\hat{\pi}_t^d = (1-\theta)(1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t - \hat{p}_t^d) + \beta\theta E_t \hat{\pi}_{t+1}^d$$

$$\hat{\pi}_t^d = \lambda(m\hat{c}_t^r + \hat{p}_t - \hat{p}_t^d) + \beta E_t \hat{\pi}_{t+1}^d \qquad (2.3.5)$$

where $\hat{p}_t^{df}$ is a price set by domestic optimizing firms, $\lambda = \dfrac{(1-\theta)(1-\beta\theta)}{\theta}$.

The baseline NKPC (2.3.5) relates the current inflation to the current real marginal cost and to the expected next period's inflation. Owing to the introduction of the imported goods, the relation (2.3.5) also includes the current consumer and the current domestically produced goods' prices. The latter prices enter the NKPC specification with the opposite signs, implying that this specification nests the baseline NKPC derived for the closed economy.

A procedure presented in the equations (2.2.16) through (2.2.23) provides a guidance for the hybrid NKPC derivation. Since in the considered open economy the nominal marginal cost is deflated by $\hat{p}_t$ rather than by $\hat{p}_t^d$, the derivation of the hybrid NKPC takes a new form starting from equation (2.2.22), which is re-derived below

$$\hat{p}_t^{df} = (1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t) + \beta\theta\frac{\theta+\omega(1-\theta)}{(1-\omega)(1-\theta)}E_t\hat{\pi}_{t+1}^d - \beta\theta\frac{\omega}{(1-\omega)(1-\theta)}\hat{\pi}_t^d + \beta\theta E_t \hat{p}_{t+1}^d$$

$$\hat{p}_t^{df} - \hat{p}_t^d = (1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t) - \hat{p}_t^d + \beta\theta\hat{p}_t^d - \beta\theta\hat{p}_t^d + \beta\theta\frac{\theta+\omega(1-\theta)}{(1-\omega)(1-\theta)}E_t\hat{\pi}_{t+1}^d -$$

$$- \beta\theta\frac{\omega}{(1-\omega)(1-\theta)}\hat{\pi}_t^d + \beta\theta E_t \hat{p}_{t+1}^d$$

$$\hat{p}_t^{df} - \hat{p}_t^d = (1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t - \hat{p}_t^d) + \left(\beta\theta + \beta\theta\frac{\theta+\omega(1-\theta)}{(1-\omega)(1-\theta)}\right)E_t\hat{\pi}_{t+1}^d -$$

$$- \beta\theta\frac{\omega}{(1-\omega)(1-\theta)}\hat{\pi}_t^d. \qquad (2.3.6)$$

The subsequent rearrangements of the equations result in the following relation for the hybrid NKPC

$$\frac{\theta\hat{\pi}_t^d}{1-\theta} = (1-\omega)\left((1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t - \hat{p}_t^d) + \left(\beta\theta + \beta\theta\frac{\theta+\omega(1-\theta)}{(1-\omega)(1-\theta)}\right)E_t\hat{\pi}_{t+1}^d - \right.$$

$$\left. - \beta\theta\frac{\omega}{(1-\omega)(1-\theta)}\hat{\pi}_t^d\right) + \omega\left(-\hat{\pi}_t^d + \frac{\hat{\pi}_{t-1}^d}{1-\theta}\right)$$

$$\frac{\theta\hat{\pi}_t^d}{1-\theta} = (1-\omega)(1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t - \hat{p}_t^d) + \left((1-\omega)\beta\theta + \beta\theta\frac{\theta+\omega(1-\theta)}{(1-\theta)}\right)E_t\hat{\pi}_{t+1}^d -$$

$$- \beta\theta\frac{\omega}{(1-\theta)}\hat{\pi}_t^d - \omega\hat{\pi}_t^d + \frac{\omega\hat{\pi}_{t-1}^d}{1-\theta}$$

$$\theta\hat{\pi}_t^d = (1-\omega)(1-\theta)(1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t - \hat{p}_t^d) +$$

$$+ ((1-\omega)(1-\theta)\beta\theta + \beta\theta(\theta+\omega(1-\theta)))E_t\hat{\pi}_{t+1}^d - \omega\beta\theta\hat{\pi}_t^d - \omega(1-\theta)\hat{\pi}_t^d + \omega\hat{\pi}_{t-1}^d$$

$$(\theta+\omega(1-\theta(1-\beta)))\hat{\pi}_t^d = (1-\omega)(1-\theta)(1-\beta\theta)(m\hat{c}_t^r + \hat{p}_t - \hat{p}_t^d) + \beta\theta E_t\hat{\pi}_{t+1}^d + \omega\pi_{t-1}^d$$

$$\hat{\pi}_t^d = \tilde{\lambda}(m\hat{c}_t^r + \hat{p}_t - \hat{p}_t^d) + \gamma_b\hat{\pi}_{t-1}^d + \gamma_f E_t\hat{\pi}_{t+1}^d \qquad (2.3.7)$$

where $\tilde{\lambda} = \dfrac{(1-\omega)(1-\theta)(1-\beta\theta)}{\theta+\omega(1-\theta(1-\beta))}$, $\gamma_b = \dfrac{\omega}{\theta+\omega(1-\theta(1-\beta))}$, $\gamma_f = \dfrac{\beta\theta}{\theta+\omega(1-\theta(1-\beta))}$.

As in the case of the baseline NKPC, the derived hybrid NKPC (2.3.7) includes the current consumer and the current domestically produced goods' prices in addition to the other variables, which constitute the hybrid NKPC in the closed economy. The variables of prices enter the relation (2.3.7) with the opposite signs, meaning that the derived hybrid NKPC embodies the analogous relation deduced for the closed economy case.

2.3.2. Real marginal cost approximation

Given the inputs used in the production, in the considered economy the firm is minimizing its cost function $W_t N_{jt} + P_t^m IM_{jt}$ subject to the production technology constraint (2.3.3). The first order conditions with respect to N_{jt}, IM_{jt} and Lagrange multiplier τ, rendered by the firm's cost minimization problem, are

$$W_t - \tau\frac{\rho}{\rho-1}(1-\alpha)\left(\alpha_N N_{jt}^{\frac{\rho-1}{\rho}} + \alpha_{IM} IM_{jt}^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}(1-\alpha)-1}\alpha_N\frac{\rho-1}{\rho}N_{jt}^{\frac{-1}{\rho}} = 0 \qquad (2.3.8)$$

$$P_t^m - \tau\frac{\rho}{\rho-1}(1-\alpha)\left(\alpha_N N_{jt}^{\frac{\rho-1}{\rho}} + \alpha_{IM} IM_{jt}^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}(1-\alpha)-1}\alpha_{IM}\frac{\rho-1}{\rho}IM_{jt}^{\frac{-1}{\rho}} = 0 \qquad (2.3.9)$$

$$Y_{jt} = \left(\alpha_N N_{jt}^{\frac{\rho-1}{\rho}} + \alpha_{IM} IM_{jt}^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}(1-\alpha)}. \tag{2.3.10}$$

Joining the results (2.3.8) and (2.3.9) together with (2.3.10) implies a cost minimizing ratio between the labour and the imported inputs

$$\frac{W_t}{P_t^m} = \frac{\alpha_N N_{jt}^{\frac{-1}{\rho}}}{\alpha_{IM} IM_{jt}^{\frac{-1}{\rho}}}, \tag{2.3.11}$$

the labour demand equation

$$N_{jt} = \left(\frac{\alpha_{IM} W_t}{\alpha_N P_t^m} \right)^{-\rho} IM_{jt} = \left(\frac{\alpha_{IM} W_t}{\alpha_N P_t^m} \right)^{-\rho} \left(\frac{1}{\alpha_{IM}} \right)^{\frac{\rho}{\rho-1}} \left(Y_{jt}^{\frac{\rho-1}{\rho(1-\alpha)}} - \alpha_N N_{jt}^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}$$

$$N_{jt}^{\frac{\rho-1}{\rho}} = \left(\frac{\alpha_{IM} W_t}{\alpha_N P_t^m} \right)^{1-\rho} \frac{1}{\alpha_{IM}} \left(Y_{jt}^{\frac{\rho-1}{\rho(1-\alpha)}} - \alpha_N N_{jt}^{\frac{\rho-1}{\rho}} \right)$$

$$N_{jt}^{\frac{\rho-1}{\rho}} \left(1 + \left(\frac{\alpha_{IM} W_t}{\alpha_N P_t^m} \right)^{1-\rho} \frac{\alpha_N}{\alpha_{IM}} \right) = \left(\frac{\alpha_{IM} W_t}{\alpha_N P_t^m} \right)^{1-\rho} \frac{Y_{jt}^{\frac{\rho-1}{\rho(1-\alpha)}}}{\alpha_{IM}}$$

$$N_{jt}^{\frac{\rho-1}{\rho}} \left(\left(\alpha_N P_t^m \right)^{1-\rho} \alpha_{IM} + \left(\alpha_{IM} W_t \right)^{1-\rho} \alpha_N \right) = \left(\alpha_{IM} W_t \right)^{1-\rho} Y_{jt}^{\frac{\rho-1}{\rho(1-\alpha)}}$$

$$N_{jt}^{\frac{\rho-1}{\rho}} = \frac{\left(\alpha_{IM} W_t \right)^{1-\rho}}{\left(\alpha_N P_t^m \right)^{1-\rho} \alpha_{IM} + \left(\alpha_{IM} W_t \right)^{1-\rho} \alpha_N} Y_{jt}^{\frac{\rho-1}{\rho(1-\alpha)}}$$

$$N_{jt}^{\frac{\rho-1}{\rho}} = \frac{1}{\left(\frac{\alpha_N P_t^m}{\alpha_{IM} W_t} \right)^{1-\rho} \alpha_{IM} + \alpha_N} Y_{jt}^{\frac{\rho-1}{\rho(1-\alpha)}}$$

$$N_{jt} = \left(\left(\frac{\alpha_{IM} W_t}{\alpha_N P_t^m} \right)^{\rho-1} \alpha_{IM} + \alpha_N \right)^{\frac{\rho}{1-\rho}} Y_{jt}^{\frac{1}{1-\alpha}} \tag{2.3.12}$$

and the equation for the demand for the imported goods used in the production

$$IM_{jt} = \left(\frac{\alpha_{IM} W_t}{\alpha_N P_t^m} \right)^{\rho} N_{jt} = \left(\frac{\alpha_{IM} W_t}{\alpha_N P_t^m} \right)^{\rho} \left(\frac{1}{\alpha_N} \right)^{\frac{\rho}{\rho-1}} \left(Y_{jt}^{\frac{\rho-1}{\rho(1-\alpha)}} - \alpha_{IM} IM_{jt}^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}$$

$$IM_{jt}^{\frac{\rho-1}{\rho}} = \left(\frac{\alpha_{IM} W_t}{\alpha_N P_t^m} \right)^{\rho-1} \frac{1}{\alpha_N} \left(Y_{jt}^{\frac{\rho-1}{\rho(1-\alpha)}} - \alpha_{IM} IM_{jt}^{\frac{\rho-1}{\rho}} \right)$$

$$IM_{jt}^{\frac{\rho-1}{\rho}}\left(1+\left(\frac{\alpha_{IM}W_t}{\alpha_N P_t^m}\right)^{\rho-1}\frac{\alpha_{IM}}{\alpha_N}\right)=\left(\frac{\alpha_{IM}W_t}{\alpha_N P_t^m}\right)^{\rho-1}\frac{Y_{jt}^{\frac{\rho-1}{\rho(1-\alpha)}}}{\alpha_N}$$

$$IM_{jt}^{\frac{\rho-1}{\rho}}\left(\left(\alpha_N P_t^m\right)^{\rho-1}\alpha_N+\left(\alpha_{IM}W_t\right)^{\rho-1}\alpha_{IM}\right)=\left(\alpha_{IM}W_t\right)^{\rho-1}Y_{jt}^{\frac{\rho-1}{\rho(1-\alpha)}}$$

$$IM_{jt}^{\frac{\rho-1}{\rho}}=\frac{\left(\alpha_{IM}W_t\right)^{\rho-1}}{\left(\alpha_N P_t^m\right)^{\rho-1}\alpha_N+\left(\alpha_{IM}W_t\right)^{\rho-1}\alpha_{IM}}Y_{jt}^{\frac{\rho-1}{\rho(1-\alpha)}}$$

$$IM_{jt}^{\frac{\rho-1}{\rho}}=\frac{1}{\left(\frac{\alpha_N P_t^m}{\alpha_{IM}W}\right)^{\rho-1}\alpha_N+\alpha_{IM}}Y_{jt}^{\frac{\rho-1}{\rho(1-\alpha)}}$$

$$IM_{jt}=\left(\left(\frac{\alpha_{IM}W}{\alpha_N P_t^m}\right)^{1-\rho}\alpha_N+\alpha_{IM}\right)^{\frac{\rho}{1-\rho}}Y_{jt}^{\frac{1}{1-\alpha}}.\qquad(2.3.13)$$

The firm's cost function then is

$$W_t N_{jt}+P_t^m IM_{jt}=Y_{jt}^{\frac{1}{1-\alpha}}\left(W_t\left(\left(\frac{\alpha_{IM}W_t}{\alpha_N P_t^m}\right)^{\rho-1}\alpha_{IM}+\alpha_N\right)^{\frac{\rho}{1-\rho}}+\right.$$

$$\left.+P_t^{im}\left(\left(\frac{\alpha_{IM}W_t}{\alpha_N P_t^m}\right)^{1-\rho}\alpha_N+\alpha_{IM}\right)^{\frac{\rho}{1-\rho}}\right).$$

The nominal marginal cost of the firm, computed as a derivative of the cost function with respect to Y_{jt}, subsequently is

$$MC_{jt}=\frac{1}{1-\alpha}Y_{jt}^{\frac{\alpha}{1-\alpha}}\left(W_t\left(\left(\frac{\alpha_{IM}W_t}{\alpha_N P_t^m}\right)^{\rho-1}\alpha_{IM}+\alpha_N\right)^{\frac{\rho}{1-\rho}}+\right.$$

$$\left.+P_t^{im}\left(\left(\frac{\alpha_{IM}W_t}{\alpha_N P_t^m}\right)^{1-\rho}\alpha_N+\alpha_{IM}\right)^{\frac{\rho}{1-\rho}}\right)\qquad(2.3.14)$$

and the real marginal cost of the firm is

$$MC_{jt}^r=\frac{1}{1-\alpha}Y_{jt}^{\frac{\alpha}{1-\alpha}}\left(\frac{W_t}{P_t}\left(\left(\frac{\alpha_{IM}W_t}{\alpha_N P_t^m}\right)^{\rho-1}\alpha_{IM}+\alpha_N\right)^{\frac{\rho}{1-\rho}}+\right.$$

$$+\frac{P_t^m}{P_t}\left(\left(\frac{\alpha_{IM}W_t}{\alpha_N P_t^m}\right)^{1-\rho}\alpha_N+\alpha_{IM}\right)^{\frac{\rho}{1-\rho}}\right)=\frac{1}{1-\alpha}Y_{jt}^{\frac{\alpha}{1-\alpha}}MC_t^*.$$ (2.3.15)

The real marginal cost, as implied by (2.3.15), comprises of the element that is firm-specific and the element that is common across the firms. The firm-specific element reflects the firm's position on its production function, while the other element is associated with the input prices that are common for all the firms.

Employing the log-linearization rules, presented in Appendix 1, for the term MC_t^* in (2.3.15) yields a relation

$$MC^*\,m\hat{c}_t^*=\left(\frac{\rho}{1-\rho}\left(\left(\frac{\alpha_{IM}}{\alpha_N}W^{pm}\right)^{\rho-1}\alpha_{IM}+\alpha_N\right)^{\frac{\rho}{1-\rho}-1}W^p\alpha_{IM}\left(\rho-1\right)\left(\frac{\alpha_{IM}}{\alpha_N}W^{pm}\right)^{\rho-2}+\right.$$

$$+\frac{\rho}{1-\rho}\left(\left(\frac{\alpha_{IM}}{\alpha_N}W^{pm}\right)^{1-\rho}\alpha_N+\alpha_{IM}\right)^{\frac{\rho}{1-\rho}-1}P^{mp}\alpha_N\left(1-\rho\right)\left(\frac{\alpha_{IM}}{\alpha_N}W^{pm}\right)^{1-\rho}\right)W^{pm}\hat{w}_t^{pm}+$$

$$+\left(\left(\frac{\alpha_{IM}}{\alpha_N}W^{pm}\right)^{\rho-1}\alpha_{IM}+\alpha_N\right)^{\frac{\rho}{1-\rho}}W^p\hat{w}_t^p+$$

$$+\left(\left(\frac{\alpha_{IM}}{\alpha_N}W^{pm}\right)^{1-\rho}\alpha_N+\alpha_{IM}\right)^{\frac{\rho}{1-\rho}}P^{mp}\hat{p}_t^{mp}$$ (2.3.16)

where $W^{pm}=\dfrac{W}{P^m}$, $W^p=\dfrac{W}{P}$, $P^{mp}=\dfrac{P^m}{P}$.

The term, which appears in (2.3.16), might be rearranged as

$$\left(\left(\frac{\alpha_{IM}}{\alpha_N}W^{pm}\right)^{\rho-1}\alpha_{IM}+\alpha_N\right)^{\frac{\rho}{1-\rho}}=\left(\left(\frac{\alpha_{IM}}{\alpha_N}W^{pm}\right)^{\rho-1}+\frac{\alpha_N}{\alpha_{IM}}\right)^{\frac{\rho}{1-\rho}}\alpha_{IM}^{\frac{\rho}{1-\rho}}=$$

$$=\left(\left(\frac{\alpha_{IM}}{\alpha_N}W^{pm}\right)^{\rho}+W^{pm}\right)^{\frac{\rho}{1-\rho}}\left(\frac{\alpha_N}{W^{pm}}\right)^{\frac{\rho}{1-\rho}}=$$

$$=\left(\left(\frac{\alpha_{IM}}{\alpha_N}W^{pm}\right)^{\rho}P^{mp}+W^{pm}P^{mp}\right)^{\frac{\rho}{1-\rho}}\left(\frac{\alpha_N}{W^{pm}P^{mp}}\right)^{\frac{\rho}{1-\rho}}=$$

$$= \left(\left(\frac{\alpha_{IM}}{\alpha_N} W^{pm} \right)^{\rho} P^{mp} + W^p \right)^{\frac{\rho}{1-\rho}} \left(\frac{\alpha_N}{W^p} \right)^{\frac{\rho}{1-\rho}} = T \,.$$

The other term, which is also used in (2.3.16), might be rearranged as

$$\left(\left(\frac{\alpha_{IM}}{\alpha_N} W^{pm} \right)^{1-\rho} \alpha_N + \alpha_{IM} \right)^{\frac{\rho}{1-\rho}} = \left(\left(\frac{\alpha_{IM}}{\alpha_N} W^{pm} \right)^{1-\rho} + \frac{\alpha_{IM}}{\alpha_N} \right)^{\frac{\rho}{1-\rho}} \alpha_N^{\frac{\rho}{1-\rho}} =$$

$$= \left((W^{pm})^{1-\rho} + \left(\frac{\alpha_{IM}}{\alpha_N} \right)^{\rho} \right)^{\frac{\rho}{1-\rho}} \alpha_N^{\frac{\rho}{1-\rho}} \left(\frac{\alpha_{IM}}{\alpha_N} \right)^{\rho} =$$

$$= \left(W^{pm} + \left(\frac{\alpha_{IM}}{\alpha_N} W^{pm} \right)^{\rho} \right)^{\frac{\rho}{1-\rho}} \left(\frac{\alpha_N}{(W^{pm})^{\rho}} \right)^{\frac{\rho}{1-\rho}} \left(\frac{\alpha_{IM}}{\alpha_N} \right)^{\rho} =$$

$$= \left(\left(\frac{\alpha_{IM}}{\alpha_N} W^{pm} \right)^{\rho} P^{mp} + W^{pm} P^{mp} \right)^{\frac{\rho}{1-\rho}} \left(\frac{\alpha_N}{W^{pm} P^{mp}} \right)^{\frac{\rho}{1-\rho}} \left(\frac{\alpha_{IM} W^{pm}}{\alpha_N} \right)^{\rho} = T \left(\frac{\alpha_{IM} W^{pm}}{\alpha_N} \right)^{\rho} \,.$$

The relation (2.3.16) then can be viewed as

$$\left(W^p T + P^{mp} T \left(\frac{\alpha_{IM} W^{pm}}{\alpha_N} \right)^{\rho} \right) m \hat{c}_t^* = T \, W^p \hat{w}_t^p + T \left(\frac{\alpha_{IM} W^{pm}}{\alpha_N} \right)^{\rho} P^{mp} \hat{p}_t^{mp}$$

$$m \hat{c}_t^* = \frac{W^p}{W^p + P^{mp} \left(\frac{\alpha_{IM} W^{pm}}{\alpha_N} \right)^{\rho}} \hat{w}_t^p + \frac{\left(\frac{\alpha_{IM} W^{pm}}{\alpha_N} \right)^{\rho} P^{mp}}{W^p + P^{mp} \left(\frac{\alpha_{IM} W^{pm}}{\alpha_N} \right)^{\rho}} \hat{p}_t^{mp}$$

$$m \hat{c}_t^* = \frac{W^p}{W^p + P^{mp} \left(\frac{\alpha_{IM} W^{pm}}{\alpha_N} \right)^{\rho}} \left(\hat{w}_t - \hat{p}_t \right) +$$

$$+ \frac{\left(\frac{\alpha_{IM} W^{pm}}{\alpha_N} \right)^{\rho} P^{mp}}{W^p + P^{mp} \left(\frac{\alpha_{IM} W^{pm}}{\alpha_N} \right)^{\rho}} \left(\hat{p}_t^m - \hat{p}_t \right). \tag{2.3.17}$$

The whole relation (2.3.15) is then log-linearized as

$$m \hat{c}_t^r = \frac{W^p}{W^p + P^{mp} \left(\frac{\alpha_{IM} W^{pm}}{\alpha_N} \right)^{\rho}} \left(\hat{w}_t - \hat{p}_t \right) + \frac{\left(\frac{\alpha_{IM} W^{pm}}{\alpha_N} \right)^{\rho} P^{mp}}{W^p + P^{mp} \left(\frac{\alpha_{IM} W^{pm}}{\alpha_N} \right)^{\rho}} \left(\hat{p}_t^m - \hat{p}_t \right) +$$

$$+\frac{\alpha}{1-\alpha}\hat{y}_t. \tag{2.3.18}$$

Substituting the result (2.3.18) into the term in the brackets that appears in the baseline and in the hybrid NKPC formulations (2.3.5) and (2.3.7) gives

$$m\hat{c}_t^r + \hat{p}_t - \hat{p}_t^d = \frac{W^p}{W^p + P^{mp}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^\rho}\left(\hat{w}_t - \hat{p}_t\right)+$$

$$+\frac{\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^\rho P^{mp}}{W^p + P^{mp}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^\rho}\left(\hat{p}_t^m - \hat{p}_t\right)+ \hat{p}_t - \hat{p}_t^d +\frac{\alpha}{1-\alpha}\hat{y}_t =$$

$$=\frac{W^p}{W^p + P^{mp}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^\rho}\left(\hat{w}_t - \hat{p}_t^d\right)+ \frac{\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^\rho P^{mp}}{W^p + P^{mp}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^\rho}\left(\hat{p}_t^m - \hat{p}_t^d\right)+$$

$$+\frac{\alpha}{1-\alpha}\hat{y}_t. \tag{2.3.19}$$

The result (2.3.19) reflects the effects of the relative costs (prices) and the production output on the price setting behaviour of the firms. The pricing is influenced by the level of wages relative to domestic prices and the level of import prices relative to domestic prices. The shares of labour and import costs in the total costs determine the weights of both of these factors[17]. Apart from the cost factors, the pricing pattern is also influenced by the level of firms' production output.

In contrast to the real marginal cost measure used in the closed economy, the relation (2.3.19) does not incorporate a proxy for labour income share. To make results more comparable, the outcome (2.3.19) is, therefore, rearranged further.

One needs to notice that because of the imports, the firms' production output in (2.3.19) does not correspond to the GDP. When the imported inputs are used in the production, the firms' real production output is

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[17] Notice that owing to the optimal solution to cost minimisation problem, the following holds

$$\frac{\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^\rho P^{mp}}{W^p + P^{mp}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^\rho} = \frac{1}{W^{pm}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{-\rho}+1} = \frac{1}{\frac{W\,N}{P^m IM}+1} = \frac{P^m IM}{P^m IM + W\,N}.$$

$$Y_t = Y_t^* + \frac{P_t^m IM_t}{P_t^d} \tag{2.3.20}$$

where Y_t^* is real GDP.

The log-linearization and further positioning of (2.3.20) gives

$$Y \ \hat{y}_t = Y^* \hat{y}_t^* + \frac{IM}{P^d} P^m \hat{p}_t^m + \frac{P^m}{P^d} IM \ i\hat{m}_t - \frac{P \ IM}{\left(P^d\right)^2} P^d \hat{p}_t^d$$

$$\left(Y^* + \frac{P^m IM}{P^d}\right) P^d \hat{y}_t = P^d Y^* \hat{y}_t^* + IM \ P^m \hat{p}_t^m + P^m IM \ i\hat{m}_t - P \ IM \ \hat{p}_t^d$$

$$\left(P^d Y^* + P^m IM\right)\hat{y}_t = P^d Y^* \hat{y}_t^* + P^m IM\left(i\hat{m}_t + \hat{p}_t^m - \hat{p}_t^d\right)$$

$$\left(P^d Y^* + P^m IM\right)\hat{y}_t - P^m IM \frac{1}{1-\alpha}\hat{y}_t =$$

$$= P^d Y^* \hat{y}_t^* + P^m IM\left(i\hat{m}_t + \hat{p}_t^m - \hat{p}_t^d\right) - P^m IM \frac{1}{1-\alpha}\hat{y}_t$$

$$\hat{y}_t = \frac{P^d Y^*}{P^d Y^* + \left(1 - \dfrac{1}{1-\alpha}\right)P^m IM}\hat{y}_t^* +$$

$$+ \frac{P^m IM}{P^d Y^* + \left(1 - \dfrac{1}{1-\alpha}\right)P^m IM}\left(i\hat{m}_t - \frac{1}{1-\alpha}\hat{y}_t + \hat{p}_t^m - \hat{p}_t^d\right). \tag{2.3.21}$$

For the subsequent derivation purposes, the log-linearization of the production function (2.3.3) and the log-linearization of the cost minimizing ratio between the labour and the imported inputs (2.3.11) yields

$$Y \ \hat{y}_t = \frac{\rho}{\rho-1}(1-\alpha)\left(\alpha_N N^{\frac{\rho-1}{\rho}} + \alpha_{IM} IM^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}(1-\alpha)-1} \frac{\rho-1}{\rho}\alpha_N N^{\frac{\rho-1}{\rho}-1} N \ \hat{n}_t +$$

$$+ \frac{\rho}{\rho-1}(1-\alpha)\left(\alpha_N N^{\frac{\rho-1}{\rho}} + \alpha_{IM} IM^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}(1-\alpha)-1} \frac{\rho-1}{\rho}\alpha_{IM} IM^{\frac{\rho-1}{\rho}-1} IM \ i\hat{m}_t$$

$$\hat{y}_t = (1-\alpha)\left(\alpha_N N^{\frac{\rho-1}{\rho}} + \alpha_{IM} IM^{\frac{\rho-1}{\rho}}\right)^{-1} \alpha_N N^{\frac{\rho-1}{\rho}} \hat{n}_t +$$

$$+ (1-\alpha)\left(\alpha_N N^{\frac{\rho-1}{\rho}} + \alpha_{IM} IM^{\frac{\rho-1}{\rho}}\right)^{-1} \alpha_{IM} IM^{\frac{\rho-1}{\rho}} i\hat{m}_t$$

$$\frac{1}{1-\alpha}\hat{y}_t = \left(\alpha_N N^{\frac{\rho-1}{\rho}} + \alpha_{IM} IM^{\frac{\rho-1}{\rho}}\right)^{-1}\left(\alpha_N N^{\frac{\rho-1}{\rho}}\hat{n}_t + \alpha_{IM} IM^{\frac{\rho-1}{\rho}}\hat{im}_t\right)$$

$$\frac{1}{1-\alpha}\hat{y}_t = \left(\alpha_N N^{\frac{\rho-1}{\rho}} + \alpha_{IM} IM^{\frac{\rho-1}{\rho}}\right)^{-1}\left(\alpha_N N^{\frac{\rho-1}{\rho}}(\hat{im}_t - \rho\hat{w}_t^{pm}) + \alpha_{IM} IM^{\frac{\rho-1}{\rho}}\hat{im}_t\right)$$

$$\hat{im}_t - \frac{1}{1-\alpha}\hat{y}_t = \hat{im}_t - \frac{\alpha_N N^{\frac{\rho-1}{\rho}}(\hat{im}_t - \rho\hat{w}_t^{pm}) + \alpha_{IM} IM^{\frac{\rho-1}{\rho}}\hat{im}_t}{\alpha_N N^{\frac{\rho-1}{\rho}} + \alpha_{IM} IM^{\frac{\rho-1}{\rho}}}$$

$$\hat{im}_t - \frac{1}{1-\alpha}\hat{y}_t = \frac{\alpha_N N^{\frac{\rho-1}{\rho}}\rho}{\alpha_N N^{\frac{\rho-1}{\rho}} + \alpha_{IM} IM^{\frac{\rho-1}{\rho}}}\hat{w}_t^{pm}$$

$$\hat{im}_t - \frac{1}{1-\alpha}\hat{y}_t = \frac{\alpha_N\rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}}{\alpha_N\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho} + \alpha_{IM}}\hat{w}_t^{pm}. \tag{2.3.22}$$

Substituting (2.3.21) and (2.3.22) into (2.3.19) and further positioning implies a relation between the term in the brackets, which appears in the baseline and in the hybrid NKPC formulations (2.3.5) and (2.3.7), and the real GDP, the level of wages, the level of import prices and the level of domestic prices

$$\hat{mc}_t^r + \hat{p}_t - \hat{p}_t^d = \frac{W^p}{W^p + P^{mp}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{\rho}}\left(\hat{w}_t - \hat{p}_t^d\right) +$$

$$+ \frac{\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{\rho}P^{mp}}{W^p + P^{mp}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{\rho}}\left(\hat{p}_t^m - \hat{p}_t^d\right) + \frac{\alpha}{1-\alpha}\left(\frac{P^d Y^*}{P^d Y^* + \left(1 - \frac{1}{1-\alpha}\right)P^m IM}\hat{y}_t^* + \right.$$

$$\left. + \frac{P^m IM}{P^d Y^* + \left(1 - \frac{1}{1-\alpha}\right)P^m IM}\left(\frac{\alpha_N\rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}}{\alpha_N\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho} + \alpha_{IM}}\hat{w}_t^{pm} + \hat{p}_t^m - \hat{p}_t^d\right)\right) =$$

$$
= \frac{\alpha}{1-\alpha} \frac{P^d Y^*}{P^d Y^* + \left(1 - \frac{1}{1-\alpha}\right) P^m IM} \hat{y}_t^* + \left(\frac{W^p}{W^p + P^{mp} \left(\frac{\alpha_{IM} W^{pm}}{\alpha_N}\right)^\rho} + \right.
$$

$$
+ \frac{\alpha}{1-\alpha} \frac{P^m IM}{P^d Y^* + \left(1 - \frac{1}{1-\alpha}\right) P^m IM} \frac{\alpha_N \rho \left(W^{pm} \frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}}{\alpha_N \left(W^{pm} \frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho} + \alpha_{IM}} \left. \right) \hat{w}_t +
$$

$$
+ \left(\frac{\left(\frac{\alpha_{IM} W^{pm}}{\alpha_N}\right)^\rho P^{mp}}{W^p + P^{mp} \left(\frac{\alpha_{IM} W^{pm}}{\alpha_N}\right)^\rho} - \frac{\alpha}{1-\alpha} \frac{P^m IM}{P^d Y^* + \left(1 - \frac{1}{1-\alpha}\right) P^m IM} \right.
$$

$$
\frac{\alpha_N \rho \left(W^{pm} \frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}}{\alpha_N \left(W^{pm} \frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho} + \alpha_{IM}} + \frac{\alpha}{1-\alpha} \frac{P^m IM}{P^d Y^* + \left(1 - \frac{1}{1-\alpha}\right) P^m IM} \left. \right) \hat{p}_t^m +
$$

$$
+ \left(-1 - \frac{\alpha}{1-\alpha} \frac{P^m IM}{P^d Y^* + \left(1 - \frac{1}{1-\alpha}\right) P^m IM} \right) \hat{p}_t^d . \tag{2.3.23}
$$

Utilising the result (2.3.22) and the log-linearized cost minimizing ratio between the labour and the imported inputs (2.3.11) gives a relation to be used in the subsequent derivations

$$
i\hat{m}_t - \frac{1}{1-\alpha} \hat{y}_t = \frac{\alpha_N \rho \left(W^{pm} \frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}}{\alpha_N \left(W^{pm} \frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho} + \alpha_{IM}} \hat{w}_t^{pm}
$$

$$
\hat{n}_t + \rho \hat{w}_t^{pm} - \frac{1}{1-\alpha} \hat{y}_t = \frac{\alpha_N \rho \left(W^{pm} \frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}}{\alpha_N \left(W^{pm} \frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho} + \alpha_{IM}} \hat{w}_t^{pm}
$$

$$\hat{n}_t = \frac{1}{1-\alpha}\hat{y}_t + \left(\frac{\alpha_N \rho \left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho} - \alpha_N \rho \left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho} - \alpha_{IM}\rho}{\alpha_N \left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho} + \alpha_{IM}} \right)\hat{w}_t^{pm} = \frac{1}{1-\alpha}\hat{y}_t -$$

$$- \frac{\alpha_{IM}\rho}{\alpha_N\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}+\alpha_{IM}}\hat{w}_t^{pm} = \frac{1}{1-\alpha}\hat{y}_t - \frac{\alpha_{IM}\rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}{\alpha_N + \alpha_{IM}\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}\hat{w}_t^{pm}. \quad (2.3.24)$$

Substituting (2.3.24), (2.3.21) and (2.3.22) into a labour income share defining equation $\hat{s}_t = \hat{w}_t + \hat{n}_t - \hat{p}_t^d - \hat{y}_t^*$ results in a relation between this share and the variables used in (2.3.23), i.e. the real GDP, the level of wages, the level of import prices and the level of domestic prices

$$\hat{s}_t = \hat{w}_t + \frac{1}{1-\alpha}\hat{y}_t - \frac{\alpha_{IM}\rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}{\alpha_N + \alpha_{IM}\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}\hat{w}_t^{pm} - \hat{p}_t^d - \hat{y}_t^* =$$

$$= \hat{w}_t + \frac{1}{1-\alpha}\left(\frac{P^dY^*}{P^dY^* + \left(1-\frac{1}{1-\alpha}\right)P^mIM}\hat{y}_t^* + \frac{P^mIM}{P^dY^* + \left(1-\frac{1}{1-\alpha}\right)P^mIM}\right.$$

$$\left(\frac{\alpha_N\rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}}{\alpha_N\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}+\alpha_{IM}}\hat{w}_t^{pm}+\hat{p}_t^m-\hat{p}_t^d\right)\right) - \frac{\alpha_{IM}\rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}{\alpha_N + \alpha_{IM}\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}\hat{w}_t^{pm} -$$

$$- \hat{p}_t^d - \hat{y}_t^* = \left(\frac{1}{1-\alpha}-1\right)\frac{P^dY^* + P^mIM}{P^dY^* + \left(1-\frac{1}{1-\alpha}\right)P^mIM}\hat{y}_t^* + \left(1 + \frac{1}{1-\alpha}\right.$$

$$\frac{P^mIM}{P^dY^* + \left(1-\frac{1}{1-\alpha}\right)P^mIM}\frac{\alpha_N\rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}}{\alpha_N\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}+\alpha_{IM}} - \frac{\alpha_{IM}\rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}{\alpha_N + \alpha_{IM}\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}\right)\hat{w}_t +$$

$$
+\left(-\frac{1}{1-\alpha}\frac{P^m IM}{P^d Y^* +\left(1-\frac{1}{1-\alpha}\right)P^m IM}\frac{\alpha_N \rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}}{\alpha_N\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}+\alpha_{IM}}+\right.
$$

$$
\left.+\frac{1}{1-\alpha}\frac{P^m IM}{P^d Y^* +\left(1-\frac{1}{1-\alpha}\right)P^m IM}+\frac{\alpha_{IM}\rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}{\alpha_N+\alpha_{IM}\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}\right)\hat{p}_t^m +
$$

$$
+\left(-\frac{1}{1-\alpha}\frac{P^m IM}{P^d Y^* +\left(1-\frac{1}{1-\alpha}\right)P^m IM}-1\right)\hat{p}_t^d. \qquad (2.3.25)
$$

Finally, combining (2.3.25) with (2.3.23) yields

$$
m\hat{c}_t^r + \hat{p}_t - \hat{p}_t^d = \hat{s}_t - \frac{\alpha}{1-\alpha}\frac{P^m IM}{P^d Y^* +\left(1-\frac{1}{1-\alpha}\right)P^m IM}\hat{y}_t^* -
$$

$$
-\left(1+\frac{P^m IM}{P^d Y^* +\left(1-\frac{1}{1-\alpha}\right)P^m IM}\frac{\alpha_N \rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}}{\alpha_N\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}+\alpha_{IM}}-\right.
$$

$$
\left.-\frac{\alpha_{IM}\rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}{\alpha_N+\alpha_{IM}\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}-\frac{W^p}{W^p+P^{mp}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{\rho}}\right)\hat{w}_t -
$$

$$
-\left(-\frac{P^m IM}{P^d Y^* +\left(1-\frac{1}{1-\alpha}\right)P^m IM}\frac{\alpha_N \rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}}{\alpha_N\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}+\alpha_{IM}}+\right.
$$

$$
\left.+\frac{P^m IM}{P^d Y^* +\left(1-\frac{1}{1-\alpha}\right)P^m IM}+\frac{\alpha_{IM}\rho\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}{\alpha_N+\alpha_{IM}\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}-\right.
$$

$$-\frac{\left(\dfrac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^\rho P^{mp}}{W^p + P^{mp}\left(\dfrac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^\rho}\hat{p}_t^m - \left(-\frac{P^m IM}{P^d Y^* + \left(1-\dfrac{1}{1-\alpha}\right)P^m IM}\right)\hat{p}_t^d =$$

$$= \hat{s}_t - \frac{\alpha}{1-\alpha}\frac{P^m IM}{P^d Y^* + \left(1-\dfrac{1}{1-\alpha}\right)P^m IM}\hat{y}_t^* -$$

$$-\left(\frac{P^m IM}{P^d Y^* + \left(1-\dfrac{1}{1-\alpha}\right)P^m IM}\frac{\alpha_N \rho\left(W^{pm}\dfrac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}}{\alpha_N\left(W^{pm}\dfrac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}+\alpha_{IM}}-\right.$$

$$\left.-\frac{\alpha_{IM}\rho\left(W^{pm}\dfrac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}{\alpha_N+\alpha_{IM}\left(W^{pm}\dfrac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}}+\frac{\left(\dfrac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^\rho P^{mp}}{W^p+P^{mp}\left(\dfrac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^\rho}\right)\left(\hat{w}_t-\hat{p}_t^m\right)+$$

$$+\frac{P^m IM}{P^d Y^* + \left(1-\dfrac{1}{1-\alpha}\right)P^m IM}\left(\hat{p}_t^d-\hat{p}_t^m\right)=\hat{s}_t-\frac{\alpha}{1-\alpha}\frac{\dfrac{P^m IM}{P^d Y^*}}{1-\dfrac{\alpha}{1-\alpha}\dfrac{P^m IM}{P^d Y^*}}\hat{y}_t^*-$$

$$-\left(\rho\frac{\dfrac{P^m IM}{P^d Y^*}}{1-\dfrac{\alpha}{1-\alpha}\dfrac{P^m IM}{P^d Y^*}}\frac{\dfrac{WN}{P^d Y^*}}{\dfrac{WN}{P^d Y^*}+\dfrac{P^m IM}{P^d Y^*}}-(\rho-1)\frac{\dfrac{P^m IM}{P^d Y^*}}{\dfrac{WN}{P^d Y^*}+\dfrac{P^m IM}{P^d Y^*}}\right)\left(\hat{w}_t-\hat{p}_t^m\right)+$$

$$+\frac{\dfrac{P^m IM}{P^d Y^*}}{1-\dfrac{\alpha}{1-\alpha}\dfrac{P^m IM}{P^d Y^*}}\left(\hat{p}_t^d-\hat{p}_t^m\right)=\hat{s}_t-\frac{\alpha}{1-\alpha}\frac{I}{1-\dfrac{\alpha}{1-\alpha}I}\hat{y}_t^*-$$

$$-\left(\rho\frac{I}{1-\dfrac{\alpha}{1-\alpha}I}\frac{S}{S+I}-(\rho-1)\frac{I}{S+I}\right)\left(\hat{w}_t-\hat{p}_t^m\right)+\frac{I}{1-\dfrac{\alpha}{1-\alpha}I}\left(\hat{p}_t^d-\hat{p}_t^m\right) \qquad (2.3.26)$$

where the following relations are used in the derivation

$$\frac{\alpha_N\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}}{\alpha_N\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{1-\rho}+\alpha_{IM}} = \frac{1}{1+\frac{\alpha_{IM}}{\alpha_N}\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}} = \frac{W^p}{W^p+W^p\frac{\alpha_{IM}}{\alpha_N}\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}} =$$

$$=\frac{W^p}{W^p+W^p\frac{P}{P^m}\frac{P^m}{P}\frac{\alpha_{IM}}{\alpha_N}\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho-1}} = \frac{W^p}{W^p+\frac{P^m}{P}\left(W^{pm}\frac{\alpha_{IM}}{\alpha_N}\right)^{\rho}} = \frac{W}{W+P^m\frac{IM}{N}} =$$

$$=\frac{\frac{W N}{P^d Y^*}}{\frac{W N}{P^d Y^*}+\frac{P^m IM}{P^d Y^*}} = \frac{S}{S+I}, \tag{2.3.27}$$

$$\frac{\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{\rho}P^{mp}}{W^p+P^{mp}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{\rho}} = \frac{\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{\rho-1}}{W^{pm}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{-1}+\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{\rho-1}} =$$

$$=\frac{\alpha_{IM}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{\rho-1}}{\alpha_N+\alpha_{IM}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{\rho-1}}, \tag{2.3.28}$$

and

$$\frac{\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{\rho}P^{mp}}{W^p+P^{mp}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{\rho}} = \frac{1}{W^{pm}\left(\frac{\alpha_{IM}W^{pm}}{\alpha_N}\right)^{-\rho}+1} = \frac{1}{\frac{W}{P^m}\frac{N}{IM}+1} = \frac{\frac{P^m IM}{P^d Y^*}}{\frac{W N}{P^d Y^*}+\frac{P^m IM}{P^d Y^*}} =$$

$$=\frac{I}{S+I}. \tag{2.3.29}$$

Here I is a share of the imported goods, used in the production, in GDP.

Owing to the undertaken rearrangements, the outcome (2.3.26), which is thereafter referred to the open economy real marginal cost measure, distinguishes the impact of the labour income share on the pricing pattern of domestic firms. In addition to the labour income share, the price setting behaviour appears to be influenced by the GDP and by the relative costs (prices). Pricing is now affected by the level of wages relative to import prices and the level of domestic prices relative to import prices. The specification of the open economy real marginal cost measure

encompasses the closed economy case. Once the imported goods are not considered, i.e. when $I = 0$, the open economy real marginal cost measure (2.3.26) falls into the respective proxy in the closed economy.

2.4. Empirical evidence

The baseline and the hybrid NKPC are estimated by undertaking an assumption of rational expectations of the firms, which reset the prices in a forward looking way[18]. The forward looking firms use all the information available at time t so that all the expectation errors $e_{t+1} = \hat{\pi}_{t+1} - E_t \hat{\pi}_{t+1}$ are not correlated with the information used at the time when prices are reset. If firms use the information represented by the vector of variables x_t, under the rational expectations this vector is orthogonal to the NKPC formulations (2.2.15), (2.2.23), (2.3.5) and (2.3.7) yielding

$$E_t\left(\left(\hat{\pi}_t - \lambda m\hat{c}_t^r - \beta\hat{\pi}_{t+1}\right)x_t\right) = 0, \tag{2.4.1}$$

$$E_t\left(\left(\hat{\pi}_t - \tilde{\lambda} m\hat{c}_t^r - \gamma_b\hat{\pi}_{t-1} - \gamma_f\hat{\pi}_{t+1}\right)x_t\right) = 0, \tag{2.4.2}$$

$$E_t\left(\left(\hat{\pi}_t^d - \lambda\left(m\hat{c}_t^r + \hat{p}_t - \hat{p}_t^d\right) - \beta\hat{\pi}_{t+1}^d\right)x_t\right) = 0 \tag{2.4.3}$$

and

$$E_t\left(\left(\hat{\pi}_t^d - \tilde{\lambda}\left(m\hat{c}_t^r + \hat{p}_t - \hat{p}_t^d\right) - \gamma_b\hat{\pi}_{t-1}^d - \gamma_f\hat{\pi}_{t+1}^d\right)x_t\right) = 0. \tag{2.4.4}$$

The assumption of the rational expectations, thus, gives a rise to the orthogonality conditions (2.4.1), (2.4.2), (2.4.3) and (2.4.4), implying that the baseline and the hybrid NKPC can be estimated employing the GMM.

The baseline and the hybrid NKPC are estimated using quarterly data disseminated by the Bank of Lithuania, Bloomberg Professional, Eurostat, Organisation for Economic Co-operation and Development (OECD) and Russian Federation Federal State Statistics Service (RFS). The data used in estimations is seasonally adjusted except for one variable representing the nominal effective exchange rate (NEER) of Lithuanian litas. Estimations are performed for the period starting from the fourth quarter of 1998 up to the fourth quarter of 2010.

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[18] The assumption of rational expectations is to some extent supported by the survey research. The forward looking approach to set prices is reflected in rather substantial importance of the prospects of inflation and/or other macroeconomic variables in inducing the upward and the downward change in prices (see Section 3.6.2).

The variable of the quarterly inflation is constructed as a logarithmic difference of GDP deflator. The estimations are undertaken using a demeaned inflation series. This serves as a proxy for the inflation's deviation from its steady state value. This variable is shown in Figure 2.

Figure 2. Deviation of inflation and real marginal cost from their respective steady state values

(a) inflation and closed economy real marginal cost
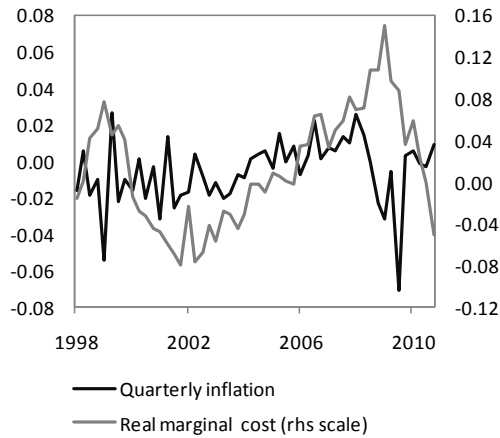
(b) inflation and open economy real marginal cost
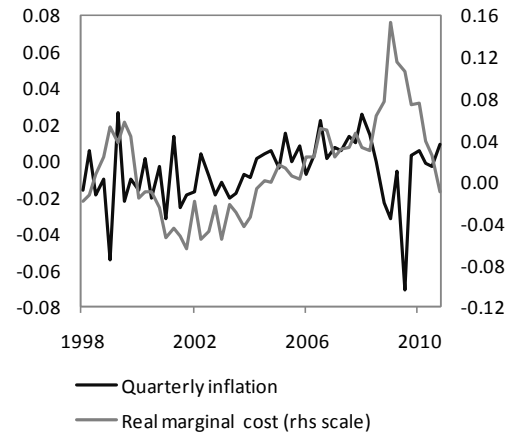
(c) closed economy and open economy real marginal cost
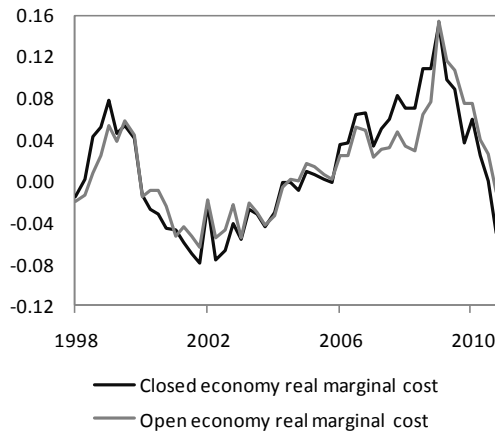
Notes: quarterly inflation is calculated as a logarithmic GDP deflator difference; real marginal cost in a closed economy is proxied by labour income share; real marginal cost in an open economy is proxied by a combination of labour income share, real GDP and relative costs/prices; in an open economy case price mark-up is set to 1.2, elasticity of substitution between labour and imported goods is set to 0.5.
Sources: Eurostat and author's calculations.

In the case of closed economy, the real marginal cost is proxied by the labour income share (a ratio of compensation of employees over nominal GDP) following equation (2.2.27). Its deviation from a steady state value is computed by taking a logarithmic difference between the labour income share and its sample average.

In the open economy the real marginal cost variable is constructed as a combination of the labour income share, the real GDP and the relative costs/prices (formulation (2.3.26)). Deviations of the real GDP, the wage level, the import price level and the domestic price level are computed as logarithmic differences between these variables and their respective smoothened counterparts. The latter ones are derived applying the Hodrick-Prescott filter. The level of wages is calculated as a ratio of compensation of employees over the number of employees. The import price level of the imported intermediate goods is not available in the national accounts, therefore the import deflator is used instead.

The open economy real marginal cost computation also includes the steady state values of the labour income share and the imported intermediate goods share in the nominal GDP. The values of the imported intermediate goods are not provided in the national accounts. As a proxy for these values the available data from the external trade statistics is used[19]. As shown in Figure 3, the imported intermediate goods share in the nominal GDP exhibited an upward trend during the considered period. Therefore, the time-varying imported intermediate goods share as well as the time-varying labour income share is used in the construction of the open economy real marginal cost measure.

The production technology parameter α is obtained by rearranging the steady state aggregate counterpart of the marginal cost formulation (2.3.14) into

$$MC = \frac{1}{1-\alpha} Y^{\frac{\alpha}{1-\alpha}} \frac{1}{Y^{\frac{1}{1-\alpha}}} \left(W\,N + P^m IM\right) = \frac{1}{1-\alpha} \frac{1}{Y} \left(W\,N + P^m IM\right) =$$

$$= \frac{1}{1-\alpha} \frac{P^d}{P^d Y^* + P^m IM} \left(W\,N + P^m IM\right) = \frac{P^d}{1-\alpha} \frac{S+I}{1+I}. \tag{2.4.5}$$

---

[19] The relevant data is sourced from the external trade statistics classified according to the Broad Economic Categories. The categories assigned to the intermediate goods are: (111) primary food and beverages (mainly for industry); (121) processed food and beverages (mainly for industry); (21) primary industrial supplies not specified elsewhere; (22) processed industrial supplies not specified elsewhere; (31) primary fuels and lubricants; (322) processed fuels and lubricants (other than motor spirit); (42) parts and accessories of capital goods (except transport equipment); (53) parts and accessories of transport equipment.

The outcome (2.4.5) together with the steady state relation for price mark-up in the open economy $\mu = \dfrac{\varepsilon}{\varepsilon - 1} = \dfrac{P^d}{MC^r P}$ (the result (A3.3) derived in Appendix 3) then yields

$$\alpha = 1 - \frac{P^d}{MC^r P} \frac{S+I}{1+I} = 1 - \frac{\varepsilon}{\varepsilon - 1} \frac{S+I}{1+I} = 1 - \mu \frac{S+I}{1+I}. \qquad (2.4.6)$$

To compute α, as it is common in the analogous studies (Galí et al., 2001; Leith and Malley, 2007; Rumler, 2007), the price mark-up μ is assumed to be fixed. The studies show that the mark-up estimates range rather widely (Basu and Fernald, 1997; Rotemberg and Woodford, 1993). As a baseline case, mark-up μ is often set to 1.1, while alternative mark-up values are used in the robustness analysis. Since the dissertation considers the economy in transition, somewhat higher mark-up value is assumed. The value of μ is set to 1.2. In the computation of α the time-varying labour income share and the time-varying imported intermediate goods share is used.

Figure 3. Logarithms of labour income share and intermediate goods imports share
(a) labour income share   *(b) intermediate goods imports share*

Notes: labour income share and intermediate goods imports share are computed as ratios of compensation of employees and intermediate goods imports respectively over nominal GDP.
Sources: Eurostat and author's calculations.

Similarly as in Leith and Malley (2007) and Rumler (2007), the value of the elasticity of substitution between the labour and the imported goods is also assumed to be fixed. The estimates of this elasticity are rarely found as statistically significant. This might be related to, as pointed out by Leith and Malley (2007), difficulties to substitute the labour and the imported goods on a frequent basis. The NKPC estimates are affected only to a minor extent by the choice of the value of the

elasticity of considered substitution as shown by Leith and Malley (2007) who estimate the models by setting ρ to 1 (effectively imposing the Cobb-Douglas production function formulation) and by setting ρ to 0 (effectively imposing the Leontief production function formulation). The NKPC for Lithuania are estimated by setting ρ to 0.5 – the value falling in between the substitution values that impose the special cases of the production function.

The closed economy and the open economy real marginal cost measures are compared in Figure 2. These measures move quite close to each other largely driven by the labour income share variation. In a short run, however, some differences in the dynamics of these measures are apparent.

The fixed values of the mark-up μ and the elasticity of substitution between labour and imported goods ρ affect the computation of the open economy real marginal cost measure and, thus, the estimates (both the reduced-form and the structural estimates) of the open economy baseline and hybrid NKPC. Apart from setting the values of μ and ρ, the structural parameters of the closed economy and the open economy hybrid NKPC are estimated by fixing the discount factor value. This leaves only two structural parameters to be estimated, namely, the fraction of firms that keep prices unchanged θ and the fraction of firms that adjust prices according to the backward looking rule of thumb ω. In estimating the structural parameters of the hybrid NKPC the discount factor value is set to 0.95.

Following the rational expectations formulation, the NKPC estimations can be carried out using the instruments dated at time t or earlier. The complete information dated at time t, however, might not be available at the moment when the firms are building up their expectations. Therefore all the estimations are performed by using the lagged variables as the instruments.

Analysis considers a number of candidate instruments. Apart from the variables of general price inflation and real marginal cost, analysis employs the variables of real GDP, unemployment rate, wage inflation, trading partners' real GDP, trading partners' inflation, import price inflation, oil price inflation in the US dollars and in Lithuanian litas and NEER inflation (the latter group of variables is shown in Figure 4 in Appendix 4). The variables representing the trading partners' real GDP and trading partners' inflation are based on the real GDP and GDP deflator data of nineteen countries accounting for more than 85 percent of foreign trade in goods of

Lithuania[20]. Similarly as the variable of general price inflation, the variables of wage inflation, trading partners' inflation, import price inflation, oil price inflation in the US dollars and in Lithuanian litas and NEER inflation are computed as logarithmic differences of wage level, trading partners' GDP deflator, import deflator, oil price level in the US dollars and in Lithuanian litas and NEER level respectively. All the variables used as the instruments represent the deviations from their respective steady state values. The estimations are performed using the demeaned series of all the mentioned inflation variables. Deviations of real GDP of Lithuania and trading partners from their respective steady state values are computed as the differences between the levels of real GDP and their smoothened counterparts that are obtained by using the Hodrick-Prescott filter. The proxy for the deviation of the unemployment rate from its steady state value is also calculated in a latter way.

All the variables that are used in estimations are tested to determine whether they embody a feature of stationarity. To investigate this issue three types of tests are carried out – the Augmented Dickey-Fuller test, the Dickey-Fuller GLS test and the Phillips-Perron test. In all of these tests the null hypothesis states that the variable is not stationary. As shown in Appendix 5, results of the tests are not uniform. The null hypothesis is rejected in all of the tests for the variables of inflation – the general price inflation, the wage inflation, the trading partners' inflation, the import price inflation, the oil price inflation in the US dollars and in Lithuanian litas and the NEER inflation. The considered hypothesis is rejected in some tests of the variables of the real marginal costs (derived for both the closed economy and the open economy), the real GDP of Lithuania and trading partners and the unemployment rate. All the examined variables, at least in some tests, are not concluded as non-stationary, implying that all these variables embody some form of stationarity.

To test the appropriateness of the instruments, the test of the over-identifying restrictions is applied. The model is over-identified if the number of orthogonality

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[20] These countries include: Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Italy, Latvia, the Netherlands, Norway, Poland, Russia, Spain, Sweden, the UK and the US. Real GDP and GDP deflators of these countries are weighted according to the weights of these countries in imports and exports of goods of Lithuania. The weights are based on four-quarter moving averages of foreign trade in goods of Lithuania with respective countries.

conditions is larger than the number of parameters to be estimated, which is the case in the considered NKPC models. J-statistic is used to determine whether the set of instruments, used in the estimations, is adequate. The null hypothesis states that the set of the instruments is valid. In most of the estimated models and in the selected models, as shown in Tables 6-7 and Tables 33-36 (the latter ones are provided in Appendix 6), the null hypothesis is not rejected, indicating an appropriate use of the instruments.

Models with different instrument sets are compared using two moment selection criteria proposed by Andrews (1999). One of them is Schwarz-based criterion, and the other one is Hannan-Quinn-based criterion. The selected models are presented in Tables 6-7. The instrument sets of these models contain four lags of inflation, four lags of real marginal cost, three lags of unemployment rate and two lags of trading partners' inflation (instead of the last two in an open economy case three lags of trading partners' inflation are used).

To test whether the residuals of the estimated models are serially correlated, the Ljung-Box Q-statistic and the Durbin-Watson (DW) statistic are used. The null hypothesis for the Ljung-Box Q-statistic states that up to specific lag there is no autocorrelation. In most of the estimated models and in the selected models the latter null hypothesis is rejected, indicating the serial correlation in the residuals. The same evidence on the serial correlation in the residuals is suggested by the DW-statistic. Therefore all the estimations are performed using heteroscedasticity and autocorrelation robust standard errors.

Estimates for the baseline NKPC indicate a rather similar role of the real marginal costs and the expected inflation in shaping the inflation in the closed economy case and the open economy case (see Table 6). In both cases the real marginal costs appear to be statistically significant, though the reduced-form parameters, representing the importance of these costs, are quite low. Such kind of finding is common in the New Keynesian literature.

The obtained estimates show a highly important role of the inflation expectations, as reflected by the parameter β. This parameter stands at 0.95 in the closed economy case and 0.96 in the open economy case. The estimations yield statistically significant estimates for the structural parameters representing a fraction of firms that keep prices unchanged. These parameters are 0.78 in the closed

economy case and 0.75 in the open economy case. Such values of θ imply a price duration of around 4.0-4.6 quarters. The implied duration is lower than that found for the euro area and the US as the estimates for the baseline NKPC show in Galí et al. (2001).

Table 6. Estimates for baseline New Keynesian Phillips curve
(estimation period – 1998Q4 through 2010Q4)

	Closed economy				*Open economy*			
	Reduced-form estimates		*Structural estimates*		*Reduced-form estimates*		*Structural estimates*	
	λ	0.072**	θ	0.781***	λ	0.093***	θ	0.750***
	β	0.953***	β	0.953***	β	0.960***	β	0.960***
SE of regression	0.026		0.026		0.026		0.026	
DW-statistic	3.203		3.203		3.156		3.156	
Q-statistic (lag 1)	20.958		20.958		19.671		19.671	
Prob. (Q-statistic (lag 1))	0.000		0.000		0.000		0.000	
Q-statistic (lag 4)	28.238		28.238		26.957		26.957	
Prob. (Q-statistic (lag 4))	0.000		0.000		0.000		0.000	
J-statistic	6.566		6.566		6.727		6.727	
Prob. (J-statistic)	0.885		0.885		0.916		0.916	
Number of observations	49		49		49		49	

*Notes: * indicates statistical significance at the level of 10 percent, ** indicates statistical significance at the level of 5 percent, *** indicates statistical significance at the level of 1 percent; p-values are computed using heteroscedasticity and autocorrelation robust standard errors; instruments include four lags of inflation, four lags of real marginal cost, three lags of unemployment rate and two lags of trading partners' inflation (in an open economy case three lags of trading partners' inflation are used instead); all variables represent deviations from their respective steady state values; in an open economy case price mark-up is set to 1.2, elasticity of substitution between labour and imported goods is set to 0.5.*
Source: author's estimations.

The hybrid NKPC estimates show that in addition to the inflation expectations the inflation is also governed by its inertia (see Table 7). The reduced-form parameters, reflecting the importance of the lagged inflation, are of considerable size and statistically significant in the closed economy case and the open economy case. The magnitude of these parameters, however, is lower than that of the parameters

corresponding to the inflation expectations – one more result typical for the New Keynesian literature. The role of the real marginal costs is found to be important only in the open economy case, though the size of the parameter $\tilde{\lambda}$ appears to be low.

Table 7. Estimates for hybrid New Keynesian Phillips curve
(estimation period – 1998Q4 through 2010Q4)

	Closed economy				Open economy			
	Reduced-form estimates		*Structural estimates*		*Reduced-form estimates*		*Structural estimates*	
	$\tilde{\lambda}$	*0.038*	θ	*0.783****	$\tilde{\lambda}$	*0.054**	θ	*0.734****
	γ_b	*0.238***	ω	*0.181*	γ_b	*0.275****	ω	*0.232***
	γ_f	*0.794****			γ_f	*0.762****		
SE of regression	*0.025*		*0.025*		*0.025*		*0.024*	
DW-statistic	*3.419*		*3.376*		*3.421*		*3.378*	
Q-statistic (lag 1)	*28.086*		*26.532*		*28.162*		*26.657*	
Prob. (Q-statistic (lag 1))	*0.000*		*0.000*		*0.000*		*0.000*	
Q-statistic (lag 4)	*40.194*		*37.578*		*40.979*		*38.728*	
Prob. (Q-statistic (lag 4))	*0.000*		*0.000*		*0.000*		*0.000*	
J-statistic	*6.430*		*6.724*		*6.554*		*6.757*	
Prob. (J-statistic)	*0.843*		*0.875*		*0.886*		*0.914*	
Number of observations	*49*		*49*		*49*		*49*	

Notes: * indicates statistical significance at the level of 10 percent, ** indicates statistical significance at the level of 5 percent, *** indicates statistical significance at the level of 1 percent; p-values are computed using heteroscedasticity and autocorrelation robust standard errors; instruments include four lags of inflation, four lags of real marginal cost, three lags of unemployment rate and two lags of trading partners' inflation (in an open economy case three lags of trading partners' inflation are used instead); all variables represent deviations from their respective steady state values; in an open economy case price mark-up is set to 1.2, elasticity of substitution between labour and imported goods is set to 0.5; discount factor is set to 0.95.
Source: author's estimations.

The hybrid NKPC analysis yields statistically significant estimates for the fraction of firms that keep prices unchanged in the closed economy case and the open economy case. The estimate for this fraction of firms in the closed economy case is 0.78, and the estimate in the open economy case is 0.73. The estimates imply that a price duration under the hybrid NKPC formulation amounts to around 3.8-4.6

quarters. The implied price duration is again lower than that in the euro area and the US as indicated by the hybrid NKPC estimates in Galí et al. (2001)[21].

The evidence on the structural parameter representing a fraction of firms that adjust prices according to the backward looking rule of thumb is less conclusive. The structural parameter ω is found to be statistically significant only in the open economy case where this parameter stands at 0.23.

The estimates for the fraction of firms that keep prices unchanged and the implied price duration stand close to the survey evidence, albeit NKPC estimates yield somewhat lower frequency of price changes. According to the survey, which referred to the period of 2007, most of the firms in Lithuania – around one quarter – change the prices quarterly to half yearly, approximately one fifth of the firms change the prices once a year, and somewhat more than one tenth of the firms change the prices less frequently than once a year (more on this see Section 3.4).

To analyse the robustness of the results, the baseline and the hybrid NKPC in the open economy are estimated with the alternative measures of the real marginal cost. To construct the alternative real marginal cost measures the price mark-up value of 1.2 is replaced by 1.15 and 1.25. The estimation results indicate that the lower (higher) mark-up value yields somewhat lower (higher) estimates for the discount factor β and the reduced-form parameter representing the expected inflation in the hybrid NKPC (see Tables 33-36 in Appendix 6). The reduced-form parameters, showing the importance of the real marginal costs (in both the baseline and the hybrid NKPC), the structural parameters of the fraction of firms that keep prices unchanged (in both the baseline and the hybrid NKPC), and the structural parameters of the fraction of firms that adjust prices according to the backward looking rule of thumb change only marginally once the mark-up value is replaced. This might indicate a robustness of the estimation results to altering the assumed value of the price mark-up.

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[21] The estimates obtained in the dissertation are not directly comparable to the ones reported in Dabušinskas and Kulikov (2007) as in the latter study the real marginal costs are assumed to differ across the firms. The obtained estimates are also not directly comparable to the ones of Mihailov et al. (2010) since the authors of this study use only the real GDP series to construct the measure of the real marginal cost.

2.5. Concluding summary

The NKPC models provide a framework to analyse the inflation in a structural way. The NKPC are the models that relate the inflation to the real economic activity, the inflation expectations and, possibly, the inflation inertia. The considered models are theory-based. They evolve from the optimising behaviour of the monopolistically competitive firms that set the prices in a constrained way. The NKPC models, thus, incorporate the nominal rigidities that can be analysed in more detail.

The dissertation considers the baseline NKPC model, where the real marginal cost and the expected inflation govern the inflation, and the hybrid NKPC model, where the lagged inflation is accounted for, as outlined in Galí and Gertler (1999) and Galí et al. (2001). The dissertation covers the closed economy case and the open economy case. The latter economy extension introduces the open economy effects by allowing for the imported goods to be used in the consumption and in the production as in Leith and Malley (2007). Different economy setups render different real marginal cost measures. In the closed economy case the real marginal cost is proxied by the labour income share or equivalently by the real unit labour cost, while in the open economy case the real marginal cost is a combination of the labour income share, the real GDP and the domestic costs/prices relative to the import prices.

Estimates for the hybrid NKPC in Lithuania are available in Dabušinskas and Kulikov (2007). The authors provide estimates under the real marginal cost proxies derived for the closed economy case (as in Galí and Gertler, 1999, and Galí et al., 2001) and two open economy cases (one of them follows Leith and Malley, 2007, the other one incorporates the energy production factor). The baseline and hybrid NKPC for Lithuania are estimated in Mihailov et al. (2010). The authors consider the closed and the open economy cases, where the latter case accounts for the terms of trade as in Galí and Monacelli (2005). The study of Mihailov et al. (2010) uses the real GDP series to construct a measure of the real marginal cost.

One of the tasks raised in this dissertation is to identify the role of inflation factors in Lithuania as suggested by the NKPC models. The dissertation estimates the baseline and the hybrid NKPC models considering the closed economy case and the open economy case. The undertaken study estimates the reduced-form parameters that represent the role of the real marginal cost, the lagged inflation and the expected

inflation in governing the inflation process. The study also estimates the structural parameters that underlie the price setting. One of the structural parameters is the fraction of firms that keep prices unchanged. This is a parameter used in the Calvo (1983) price setting formulation, which is employed in the considered NKPC models. This parameter allows deducing the estimate of price duration that is often viewed as a measure of price stickiness. The other estimated structural parameter is the fraction of firms that adjust prices following the backward looking rule of thumb. This parameter is used in the hybrid NKPC formulation to account for the inflation inertia.

The dissertation provides a detailed derivation of the baseline and the hybrid NKPC formulations. In the baseline case the current inflation is related to the current real marginal cost and to the inflation, which is expected to prevail in the next period. In the hybrid NKPC the current inflation, in addition to the mentioned determinants, also depends on the lagged inflation. The derivations show that in a limiting case, when all the firms, which reset the prices, are forward looking, i.e. when there are no firms that adjust the prices following the backward looking rule of thumb, the hybrid NKPC falls into the baseline one. Only when there is some fraction of firms, which reset their prices according to the backward looking rule, the lagged inflation obtains the weight in governing the present inflation. The fraction of rule of thumb firms affects the weight of both the lagged and the expected inflation. The higher the fraction of the backward looking firms, the stronger is the role of the lagged inflation and the weaker is role of the expected inflation in determining the current inflation. The impact of the fraction of firms, which are not allowed to reset prices, is the opposite. If the proportion of firms, which keep their prices unchanged, is higher, the role of the lagged inflation is weaker and the role of the expected inflation is stronger.

The estimates, obtained in this dissertation, indicate the statistically significant role of the real marginal costs in inflation formation in Lithuania, though the size of the parameters, representing the importance of these costs, is quite low. This is a common result in the New Keynesian literature. The inflation in Lithuania appears to be primarily driven by the inflation expectations and, in the hybrid NKPC case, the past inflation with the magnitude of parameters, reflecting the importance of the lagged inflation, lower than that of the parameters corresponding to the expected inflation.

The dissertation analysis yields statistically significant estimates for the fraction of firms that keep prices unchanged, the Calvo parameter used in the considered models. These estimates range between 0.73 and 0.78. This implies that the price duration in Lithuania stands at around 3.8-4.6 quarters.

The conducted research provides less conclusive evidence on the fraction of firms that adjust prices according to the backward looking rule of thumb, the parameter used in the hybrid NKPC formulation to account for the inflation inertia. This parameter is found to be statistically significant only in the open economy case where it stands at 0.23.

CHAPTER 3. MICROECONOMIC ANALYSIS OF PRICE SETTING AND PRICE STICKINESS: SURVEY BASED EVIDENCE

3.1. Survey conduct in the price setting research

The ways prices are determined may have an impact on the real economic output. Economic shocks may have effects if prices are adjusted in a less responsive pattern. Stickiness of prices adds to a magnitude and length the shocks affect economy, influencing their transmission and having implications for policy design. Practices of pricing therefore constitute important part of economic setting providing a momentous venue for the research.

This chapter of the dissertation provides survey evidence on pricing patterns in Lithuania. The study draws on the experience of the euro area and non-euro area EU countries that carried out the research within the Inflation Persistence Network (IPN) and the Wage Dynamics Network (WDN) coordinated by the European Central Bank. The networks analysed the price setting (and also the wage setting) using, among other sources, firm-level data obtained from ad hoc surveys conducted in the participating countries. The IPN and WDN surveys delivered a number of stylised facts on the review and the adjustment of prices (and wages) and on determinants of the price (and wage) setting in EU firms shedding the light on their behaviour in qualitative terms.

The survey approach to analyse pricing was introduced by Blinder (1991, 1994) and Blinder et al. (1998). This work investigated the price setting behaviour in the US. A similar approach was also used to analyse pricing in other countries. Hall et al. (2000) conducted a research for the UK, Apel et al. (2005) – for Sweden, Amirault et al. (2006) – for Canada. The participants of IPN carried out the survey-based pricing research in nine euro area countries[22]. Dabušinskas and Randveer

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[22] The survey based pricing research was carried out in Austria (Kwapil et al., 2007), Belgium (Aucremanne and Druant, 2005), France (Loupias and Ricart, 2004), Germany (Stahl, 2005), Italy (Fabiani et al., 2004), Luxembourg (Lünnemann and Mathä, 2006), the Netherlands (Hoeberichts and Stokman, 2010), Portugal (Martins, 2005) and Spain (Álvarez and

(2006) investigated the pricing behaviour in Estonia performing a study similar to the one undertaken under IPN. As a follow-up, survey-based price (and wage) setting research was carried out under WDN in twelve euro area and five non-euro area countries of EU[23].

The survey analysis carries a few advantages compared to the other methods of study in the price setting research. Surveys on prices allow asking respondents to assess the factors underlying the price decisions that are difficult to unveil on the basis of other sources. The pricing questionnaires, for instance, may tackle the reasons for price unresponsiveness or the asymmetric adjustment that are hard to analyse using the data on final prices and price indices. The survey questionnaires may scrutinise patterns of the price adjustment separately from the ones of the price review – something not captured in other datasets. Along the advantages, the method of survey has some disadvantages. Results of the surveys depend critically on the wording of questions. Theoretical concepts may be difficult to explain in a way understandable for the respondents. Because of complexity, the surveys are not always conducted repeatedly limiting possibilities to investigate the issues in a time dimension.

The purpose of the analysis, undertaken in this chapter of the dissertation, is to investigate the price setting practices of Lithuanian firms determining the pricing ways and outcomes as well as identifying, among others, the technological, institutional and market competition factors that lie behind the behaviour of firms. The dissertation uses firm-level data from an ad hoc survey of the Bank of Lithuania

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Hernando, 2005). The survey findings for the euro area countries are summarised in Fabiani et al. (2006).

[23] The WDN survey was carried out in Austria, Belgium, the Czech Republic, Estonia, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Slovenia and Spain. The obtained survey evidence for some of the individual countries is provided in: Druant et al. (2008) – for Belgium, Babecký et al. (2008) – for the Czech Republic, Dabušinskas and Rõõm (2011) – for Estonia, Montornès and Sauner-Leroy (2009) – for France, Kézdi and Kónya (2011) – for Hungary, Keeney Lawless (2010) – for Ireland, Martins (2011) – for Portugal. The results covering most of the countries that carried out the WDN survey are documented in Babecký et al. (2009a), Babecký et al. (2009b), Bertola et al. (2009), Druant et al. (2009), Galuščák et al. (2010).

"On Price and Wage Setting" conducted in 2008[24]. The survey comprises of questions used in the IPN and the WDN research as well as in the study on Estonian pricing conducted by Dabušinskas and Randveer (2006). Therefore the obtained results for Lithuania to some extent compare to the ones available for the euro area and non-euro area EU countries.

The analysis covers a few pricing aspects. It considers the time-dependent and the state-dependent price reviewing practices as these practices have implications for the degree of price responsiveness. The study investigates the frequency of price changes, which is, as mentioned in Chapter 1, often viewed as a measure of price stickiness. The frequency of price changes is compared to the frequency of price review and the pattern of wage adjustment. The study also looks into the reasons for the delayed price adjustment when there are some motives to increase or lower prices. It investigates ten potential explanations for the upward and downward stickiness of prices. The analysis, finally, scrutinises firms' responses to the economic shocks. It compares the adjustment through prices, margins, output and costs following the specific shocks. It also studies differences in the price response to the heightened demand and the dampened demand and in response to the higher costs and the lower costs. Besides reaction to the shocks, the analysis looks into the differences in factors for the upward and downward change in prices.

3.2. Conduct of the survey and some of the results

The survey "On Price and Wage Setting" was conducted in April and May 2008. It was carried out by contacting respondents by mail, telephone and face-to-face. When answering the questions, respondents were asked to refer to their operational activities during the calendar year of 2007. This period was marked by a particularly strong economic expansion, which had been continuing for a number of years. At that time the labour market of Lithuania was undergoing exceptionally severe pressures as the level of unemployment was notably low and the vacancy rate was reaching a peak. This was a period of the elevated growth rates of prices and wages.

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[24] The questions from the survey "On Price and Wage Setting" are provided in Appendix 7.

The firms satisfying certain criteria were stratified according to economic activity (Sections D-K of NACE rev. 1.1)[25] and firm size (as measured by the number of employees, with size brackets of 5-19, 20-49, 50-149, 150-249 and 250 or more employees). Firms operating in agriculture and fishing (Sections A and B of NACE rev. 1.1) were excluded from the analysis since they are to a large extent handled by sole proprietorships with simplified operational activities. Sole proprietorships were not targeted. Mining and quarrying (Section C of NACE rev. 1.1) was excluded due to the relatively small number of firms operating in this activity. Firms operating in public administration, education and health care (Sections L-N of NACE rev. 1.1) were not targeted since price formation in public services often features administrative characteristics. Small firms (with up to 5 employees) were excluded since many of them are sole proprietorships. In total 2,810 firms were contacted. The targeted sample was 500 firms. However, some of them provided incomplete answers, so that the responses of only 343 firms are used in the analysis. In other words the realised sample consists of 343 firms. The composition of the realised sample of firms is provided in Table 8.

Table 8. Realised sample composition of firms by economic activity and firm size (number of firms)

	Firms that employ:			Total
	up to 19 employees	*20 to 49 employees*	*50 and more employees*	
Manufacturing	*51*	*22*	*24*	*97*
Construction	*7*	*12*	*8*	*27*
Trade	*74*	*19*	*11*	*104*
Business services	*74*	*26*	*15*	*115*
Total	*206*	*79*	*58*	*343*

Sources: the survey "On Price and Wage Setting" and author's calculations.

In terms of the number of firms, the realised sample mostly consists of small firms (with up to 19 employees). In this sample there are 97 manufacturing, 27 construction, 104 trade and 115 business services firms. In the realised sample the highest share of employees work in large companies (with 50 or more employees; see

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[25] In this study, unless otherwise stated, "manufacturing" refers to manufacturing and supply of electricity, gas and water (Sections D and E of NACE rev. 1.1); "construction" and "trade" are self-explanatory (Sections F and G of NACE rev. 1.1 respectively); "business services" refer to other market services (Sections H-K of NACE rev. 1.1).

Table 9). In this sample most of the employees work in business services and manufacturing.

Table 9. Realised sample composition of employees by economic activity and firm size (number of employees)

	Firms that employ:			Total
	up to 19 employees	20 to 49 employees	50 and more employees	
Manufacturing	568	705	3 444	4 717
Construction	83	409	951	1 443
Trade	731	570	975	2 276
Business services	686	782	3 379	4 847
Total	2 068	2 466	8 749	13 283

Sources: the survey "On Price and Wage Setting" and author's calculations.

3.2.1. Sampling weights

To ensure that the realised sample reflects as closely as possible the distribution of the total population of firms, in this study descriptive analysis is based on firms' responses that are weighted by the employment-adjusted sampling weights. These weights adjust for the different probability of firms ending up in the realised sample and also adjust the realised sample to make the employees it covers representative of the total population.

For the firm to be included in the realised sample, two conditions should be fulfilled: the firm should be included in the potential sample population, i.e. the firm should be selected to answer the questionnaire, and the firm, which is included in the potential sample population, should fall into the realised sample, i.e. the firm should answer the questionnaire once it receives the questionnaire.

The probability that the firm in the stratum s is selected for the potential sample population, i.e. the probability that the firm in the stratum s receives the questionnaire, can be described as

$$p_s = \frac{j_s^*}{J_s} \tag{3.2.1}$$

where j_s^* denotes a number of firms in the stratum s in the potential sample population, J_s denotes a number of firms in the stratum s in the general population. The factor that adjusts for the unequal probability to be included in the potential sample population equals to the inverse of (3.2.1)

$$w_{1,s} = \frac{J_s}{j_s^*}.$$
(3.2.2)

Analogously, the factor that corrects for the different probability of the firm in the stratum s to be included in the realised sample, if this firm is selected for the potential sample population, equals to

$$w_{2,s} = \frac{j_s^*}{j_s}$$
(3.2.3)

where j_s denotes a number of firms in the stratum s in the realised sample.

The factor – the weight – that adjusts for the unequal probability of the firm in the stratum s to be included in the realised sample is then a product of (3.2.2) and (3.2.3)

$$w_s^* = w_{1,s} w_{2,s} = \frac{J_s}{j_s^*} \frac{j_s^*}{j_s} = \frac{J_s}{j_s}.$$
(3.2.4)

It is noticeable that the weights w_s^* within the stratum add up to the number of firms in the stratum in the general population $\sum_{j_s} w_s^* = J_s$ as the weights within the stratum for all the firms are the same.

In addition to the correction of the different probability of the firm to end up in the realised sample, the considered weights take into account the differences of the employment in all the strata in the general population. The factor that adjusts for the significance of the employment in each stratum in the general population is

$$w_{3,s} = \frac{N_s}{J_s}$$
(3.2.5)

where N_s denotes a number of employees in the stratum s in the general population.

All in all, the factor – the weight – that adjusts for the unequal probability of the firm in the stratum s to appear in the realised sample and for the differences of the employment across the strata in the general population is then a combination of (3.2.4) and (3.2.5)

$$w_s^{**} = w_s^* w_{3,s} = \frac{J_s}{j_s} \frac{N_s}{J_s} = \frac{N_s}{j_s}.$$
(3.2.6)

The employment-adjusted sampling weights w_s^{**} within the stratum add up to the number of employees in the stratum in the general population $\sum_{j_s} w_s^{**} = N_s$ as the weights within the stratum for all the firms are the same.

The computation of the employment-adjusted sampling weights w_s^{**} are based on the number of firms in each stratum s in the realised sample, j_s, and the number of employees in each stratum s in the general population, N_s. The information on the number of firms in each stratum in the realised sample is available from the survey, while the data on the number of employees in each stratum in the general population is not directly available. To derive the latter data, the number of employees in each firm (within the stratum) in the realised sample is used – to be more specific, the average number of employees in the firm (within the stratum) in the realised sample is multiplied by the number of firms (within the stratum) in the general population (the latter information is available as it is used to construct the strata of the survey; the number of firms in the different strata in the general population is provided in Appendix 8). So that to match the total number of employees in the general population (the number to be matched is taken from the Statistics Lithuania; it covers the employees in Sections D-K of NACE rev. 1.1; it refers to the number of employees at the end of 2007, which is the period used to report the number of employees by the surveyed firms), the derived number of employees in each stratum in the general population is rescaled. The implied number of employees in the different strata in the general population as well as the normalised employment-adjusted sampling weights of the firms are provided in Appendix 8.

3.2.2. Selected indicators of the surveyed firms

Before turning to a more detailed analysis, this section overviews some of the characteristics of firms related to employee structure, labour compensation, ways and environment of the price setting.

The survey showed that for approximately 13 percent of employees the flexible forms of employment are applied (see Table 10). In the surveyed firms 9.1 percent of the employees are part-time permanent workers and 3.8 percent are temporary workers. The flexible forms of employment are more popular in business services,

where 14 percent of employees are part-time permanent workers and 5 percent are temporary workers. In the other economic activities the use of such forms of employment is less popular.

According to the survey, in terms of occupational groups most of the employees fall into the categories of low-skilled and high-skilled blue-collar employees. Low-skilled blue-collar employees account for more than half of the employees in manufacturing, while high-skilled blue-collar employees constitute more than 40 percent of the employees in construction. Another substantial share of employees is made up of high-skilled white-collar employees, who are more widely employed by business services firms.

The survey showed that quite a sizable share of firms use the flexible forms of remuneration. More than one third of the firms use the piece-rate remuneration and another 16.4 percent of the firms use the hourly remuneration as the main form of employee compensation. Piece-rate remuneration is more popular in construction and manufacturing, while hourly wages are more common in business services. The firms also indicated rather widespread use of the performance-related bonuses. Flexible wage components (performance-related bonuses) are used by 73.5 percent of the firms, and they account for 17.1 percent of the total wage bill. The highest share of wages paid through the performance-related bonuses is observed in construction as well as in trade and business services.

Approximately half of the surveyed firms use a policy that adapts changes in base wages to inflation. Except in business services, wage changes are mostly adapted to past rather than expected inflation. Relatively widespread use of this policy during the reference period of the survey (the year of 2007) may tentatively be explained by the rather high inflation rate at that time. The latter might also explain relatively more popular use of the informal (non-automatic) rules to account for inflation when adjusting wages.

The survey also pointed out rather low presence of the collective pay agreements in the investigated firms. It was found out that approximately one quarter of the firms apply the collective pay agreements signed at the firm level, while the collective pay agreements are very rare at the national level. In the surveyed firms the coverage by these agreements amounts to 15.7 percent of employees. The presence of

the collective pay agreements and the highest coverage are mostly observed in business services.

The survey referred to approaches used to determine the prices. As figured out, the most common practice is to choose the prices according to costs and completely self-determined profit margin. This way of pricing – the mark-up pricing (often used in imperfectly competitive settings) – is reported by approximately half of the investigated firms. Another incidental way to set the prices is to follow the main competitors. This practice is applied by more than a quarter of firms. The mark-up pricing is widely used in all economic activities, while the pricing following the main competitors finds more support in trade.

The study pointed to rather widespread use of price discrimination in the investigated firms. Somewhat less than half of the considered firms set the prices individually for each consumer(s), and in approximately one quarter of the firms prices are dependent on quantity of orders. Price discrimination is, thus, reported by almost three quarters of the firms. Individual price setting for each consumer(s) is more common in construction, and the price setting dependent on quantity of orders is more widely used in trade and manufacturing. No use of price discrimination was admitted by less than a fifth of the examined firms. A practice to set the same prices for all customers is more popular in business services.

Responses to survey questions deliver information on the customer institutional setup. In the surveyed firms more than 40 percent of the total revenue is generated by sales to the final consumers, around one quarter of the total revenue is due to wholesale and retail firms, and somewhat less than a tenth of the total revenue is due to public sector institutions and public sector firms. Sales to the final consumers are the most prevalent in trade, construction and business services, while in manufacturing sales to the wholesale firms generate the most sizeable share of the total revenue. The customers of the surveyed firms include not only the final consumers, implying that the practices, captured by the survey results, reflect the price setting at both the consumer and the producer level.

The study pointed to rather high share of revenue generated by sales to the customers that are described as regular ones. Sales to the customers with lasting business relationship account for around two thirds of the total revenue. Such sales are more widespread in manufacturing and business services.

Table 10. Selected indicators of the surveyed firms
(percent)

	Manu-facturing	Cons-truction	Trade	Business services	Total
Employees by employment status:					
share of full-time permanent employees	90.4	93.5	88.4	81.0	87.1
share of part-time permanent employees	5.4	3.2	9.8	14.0	9.1
share of temporary employees	4.2	3.3	1.7	5.0	3.8
Employees by occupational group:					
share of low-skilled blue-collar employees	51.3	31.8	30.3	32.0	37.2
share of high-skilled blue-collar employees	25.6	40.5	24.9	25.2	27.4
share of low-skilled white-collar employees	6.8	5.9	8.5	6.5	6.9
share of high-skilled white-collar employees	10.8	15.3	20.0	29.8	20.2
Labour compensation principles:					
share of firms paying hourly base wages	16.9	8.6	8.0	24.1	16.4
share of firms paying piece-rate base wages	45.7	68.2	27.8	24.5	37.4
share of firms paying monthly base wages	37.4	23.3	63.7	50.0	45.6
Use of performance-related bonuses:					
share of firms paying bonuses	70.7	92.1	72.7	68.8	73.5
share of bonuses in total wage bill	10.0	27.4	18.5	18.1	17.1
Use of policies to adapt changes in wages to inflation:					
share of firms in which wage changes are automatically linked to					
past inflation	8.4	2.0	3.3	10.5	7.1
expected inflation	1.0	6.3	1.4	6.1	3.6
share of firms in which there is no formal rule however wage changes take into account					
past inflation	30.3	38.9	34.1	9.8	25.0
expected inflation	7.3	9.8	11.4	19.5	12.9
share of firms that do not use such policies	53.0	43.0	49.9	54.5	51.5
Application of collective pay agreements:					
share of firms applying collective pay agreements signed at the national level	0.2	2.0	1.1	0.9	0.9
share of firms applying collective pay agreements signed at the firm level	21.9	8.6	23.1	32.1	24.0
share of employees covered by collective pay agreements	15.4	5.4	16.5	19.6	15.7

Notes and sources are provided beneath the table continuation on the next page.

Table 10 (continued). Selected indicators of the surveyed firms (percent)

	Manu-facturing	Cons-truction	Trade	Business services	Total
Price setting ways:					
share of firms in which the price is regulated or set by the parent company or by main customer	21.0	2.3	3.8	22.6	15.3
share of firms that set the price following main competitors	28.3	19.7	42.9	19.3	27.0
share of firms that set the price according to costs and completely self-determined profit margin	44.4	68.2	44.8	51.5	50.3
share of firms that set the price in other way	6.4	9.8	8.6	6.5	7.4
Use of price discrimination:					
share of firms that set the same price for all customers	10.5	6.3	18.4	28.2	17.9
share of firms in which price depends on quantity of orders	35.0	10.5	40.0	16.9	26.2
share of firms in which price is set for each customer(s) individually	51.0	83.2	34.2	35.1	46.2
share of firms in which price is set in other way	3.6	0.0	7.4	19.8	9.7
Customer institutional setup:					
share of revenue from sales to wholesale firms	28.3	5.4	6.2	6.5	12.7
share of revenue from sales to retail firms	17.1	6.4	17.3	6.1	11.8
share of revenue from sales to public sector institutions and firms	1.5	9.2	4.9	13.6	7.5
share of revenue from sales to final consumers	27.6	44.8	56.5	43.4	41.8
share of revenue from sales to other customers	25.5	34.1	15.1	30.3	26.1
Customer relationship (share of revenue from sales to regular customers)	76.2	46.6	54.3	67.1	64.1
Foreign sales (share of revenue from sales in foreign markets)	38.1	1.6	6.9	14.5	17.9
Implied degree of price competition:					
share of firms that face higher price competition	47.5	60.0	60.5	51.1	53.3
share of firms that face lower price competition	40.0	35.7	30.4	31.9	34.5
share of firms for which the assessment does not apply	12.5	4.3	9.1	17.0	12.2

Notes: responses are employment-weighted and rescaled to exclude non-responses; "higher price competition" refers to the firms that indicate the "likely" or "very likely" price adjustment, while "lower price competition" refers to the firms that report the "not at all" likely or "not likely" change in their prices following the price decrease of the product of the main competitor.
Sources: the survey "On Price and Wage Setting" and author's calculations.

The surveyed firms reported a substantial degree of openness to competition in the foreign markets. Firms indicated generating somewhat less than a fifth of their total revenue via activities in the foreign countries. The highest share of total revenue raised by the sales in foreign markets is found in manufacturing and business services.

To investigate the competition in prices the survey asked whether the firms decrease their prices following the price decrease of the product of the main competitor. Firms were asked to indicate whether their response by decreasing prices would be "very likely", "likely", "not likely", "not at all" likely or "it doesn't apply". Firms indicating the "very likely" or "likely" price adjustment could be assumed to face higher price competition, while the firms reporting the "not likely" or "not at all" likely change in prices could be possibly viewed as those experiencing lower price competition.

Analysis shows a substantial degree of response heterogeneity when reacting to movements in the competitor prices. Somewhat more than half of the firms would find themselves reacting strongly, while around one third of the firms would exhibit a more contained reaction to the price decrease of the product of the main competitor. Higher price competition is more evident in a larger share of trade and construction firms.

3.3. Time-dependent and state-dependent price review

Literature differentiates the time-dependent and the state-dependent pricing rules. If firms are following the time-dependent rules, the time between reset of prices is viewed as independent from the economic shocks.

One of the time-dependent models was used by Taylor (1980), who applied the idea of non-continuous adjustment of labour contracts. In the suggested framework only some share of firms are allowed to change the contracts. The adjusted contracts remain unchanged for a certain period of time, which is assumed to be the same for all the firms. Contracts are adjusted in a non-continuous way, therefore the firms, which review the contracts, take into account all the economic factors that are expected to prevail until the next review of contracts.

The other time-dependent model is due to Calvo (1983) that considers a staggered price setting. The model is similar to the one of Taylor except for the assumption on nominal contract duration. In the Calvo model the price duration is assumed to be random and uncertain when prices are reset.

In the time-dependent models firms may not react immediately to the economic shocks unless the shocks occur at the time when firms review the prices. The possibility of response to economic shocks, contingent on the timing and the intensity of shocks, is considered in the state-dependent models. All else equal, the state-dependent pricing yields a more responsive price adjustment than the time-dependent pricing.

State-dependent models were used by Barro (1972) and developed further by Sheshinski and Weiss (1977). In Sheshinski and Weiss firms are targeting the difference between the optimal and the actual price and are following the pricing rule (s, S). Firms are setting prices so that the difference equals S and do not adjust the prices, owing to adjustment costs, until the difference reaches s. Firms, thus, follow the pricing rule under which reset the prices in the state-dependent way.

To investigate the incidence of the time-dependent and the state-dependent pricing, the conducted survey asked the firms to characterise the way of price review. Survey asked the firms whether (1) they review the prices regularly, (2) they review the prices in certain cases (for instance, when costs or demand change), (3) they review the prices regularly and additionally in certain cases (for instance, when costs or demand change), (4) they review the prices due to other reasons or (5) they never review prices without changing them. In the first case the price review is interpreted as the time-dependent one, in the second case – as the state-dependent one, and in the third case – as the time-dependent one with a switch to the state-dependent price review when it is deemed necessary (thereafter named as the time- and state-dependent price review).

As shown in Table 11, most of the surveyed Lithuanian firms follow the time- and state-dependent practice to review the prices. A practice to review the prices regularly and additionally to review them in certain cases was indicated by 45 percent of the firms. Comparing the incidence of the time-dependent and the state-dependent price reviewing practices, the latter practice appears to be more widely used than the former one. A similar prevalence of the price reviewing practices is found in

manufacturing and trade, while in construction and business services it is somewhat different. In construction, as opposed to practices observed in other economic activities, the state-dependent price review appears to be less widely used than the time-dependent one. In business services the time- and state-dependent price reviewing practice dominates though it finds a considerably lower support than in the other activities.

Table 11. Price reviewing practices
(share of firms; percent)

	Manu-facturing	*Cons-truction*	*Trade*	*Business services*	*Total*
Price is reviewed regularly	*16.5*	*21.0*	*21.2*	*20.4*	*19.5*
Price is reviewed in certain cases (for instance, when costs or demand change)	*30.3*	*18.1*	*26.0*	*34.0*	*29.0*
Price is usually reviewed regularly and additionally in certain cases (for instance, when costs or demand change)	*49.8*	*54.7*	*47.6*	*35.9*	*45.0*
Price is reviewed due to other reasons	*3.2*	*4.0*	*2.1*	*5.1*	*3.7*
Price is never reviewed without changing it	*0.2*	*2.3*	*2.9*	*4.6*	*2.6*

Notes: responses are employment-weighted and rescaled to exclude non-responses.
Sources: the survey "On Price and Wage Setting" and author's calculations.

Compared to the existing evidence for countries of the euro area (Fabiani et al., 2006) and Estonia[26] (Dabušinskas and Randveer, 2006) – the countries where similar surveys were carried out as in Lithuania, the use of price reviewing practices in Lithuania appears to be somewhat tilted to the state-dependent pricing. Although the incidence of the time- and state-dependent price reviewing rule in the euro area, Estonia and Lithuania is quite close, the use of the state-dependent practice is less widely used than the time-dependent one in the euro area and Estonia, while the opposite is found in Lithuania.

Those firms that characterised their price review as a regular one (the cases of the time-dependent as well as the time- and state-dependent price review) were asked to provide the information on how frequently they review the prices. Firms were inquired to indicate whether the price reviews occur (1) daily, (2) weekly, (3)

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[26] The survey in Estonia was conducted before this country joined the euro area.

monthly, (4) quarterly, (5) half yearly, (6) once a year, (7) once every two years or (8) less frequently than once every two years.

The survey results show that in Lithuania approximately one third of all the surveyed firms (including those that do not characterise their price review as a regular one) review the prices daily to monthly. In almost one quarter of the firms the price review takes a place quarterly to half yearly. Prices appear to be reviewed somewhat more frequently in trade and construction and less frequently in business services.

Table 12. Frequency of price review
(share of firms; percent)

	Price review occurs:				
	daily to monthly	*quarterly to half yearly*	*once a year*	*less frequently than once a year*	*no regular pattern, price never reviewed without changing it*
Manufacturing	28.2	33.4	4.7	0.0	33.8
Construction	41.5	31.8	2.3	0.0	24.3
Trade	50.8	16.0	1.1	1.1	31.1
Business services	24.3	17.2	10.3	4.6	43.7
Total	33.5	23.7	5.6	1.9	35.4

Notes: responses are employment-weighted and rescaled to exclude non-responses; frequency of price review under category "no regular pattern, price never reviewed without changing it" reflects the share of firms that do not review prices regularly as indicated in Table 11 under price reviewing categories "price is reviewed in certain cases (for instance, when costs or demand change)", "price is reviewed due to other reasons" and "price is never reviewed without changing it".
Sources: the survey "On Price and Wage Setting" and author's calculations.

In comparison to the existing evidence for the euro area (Fabiani et al., 2006) and Estonia (Dabušinskas and Randveer, 2006), prices in Lithuania seem to be reviewed more frequently. Among those firms that review the prices regularly, in the euro area and Estonia more than half of the firms review the prices up to three times a year, prices are reviewed monthly or more frequently in around one quarter of the firms, while in Lithuania, as it is found out, most of the investigated firms (more than half if to consider only those that review the prices regularly) review the prices daily to monthly.

3.4. Frequency of price change and link to wage change

As described in Chapter 1, frequency of price changes might be viewed as a measure of price stickiness. A shorter period during which the price is not changed, i.e. shorter price duration, might imply that the price is more flexible – the pricing is more sensitive to the economic changes. On the other hand, a longer period during which the price is not changed might imply greater stickiness – weaker price reaction to the economic shocks. As discussed, frequency of price adjustment is not a perfect measure of price stickiness. Prices may remain non-optimal even if they are adjusted frequently, and prices may appear optimal under lower frequency of the adjustment. Nevertheless, the frequency of price adjustment does represent the outcome of the price setting, which heavily depends on the degree of flexibility in taking price decisions.

The conducted survey explicitly asked the firms how frequently the price of the firm's main product is typically changed. Firms were asked to indicate whether the change occurs (1) daily, (2) weekly, (3) monthly, (4) quarterly, (5) half yearly, (6) once a year, (7) once every two years, (8) less frequently than once every two years, (9) never or (10) there is no defined pattern.

The survey results show that in Lithuania in approximately one third of the firms the frequency of price changes does not follow any specific pattern. In approximately one quarter of the firms prices are changed on a quarterly to half yearly basis, and in approximately one fifth of the firms prices are changed once a year. Prices seem to be changed more frequently in manufacturing and less frequently in business services.

Evidence on the frequency of price changes stands in line with the evidence on price duration indicated by the estimates obtained within the NKPC framework, though the NKPC estimates point to somewhat lower frequency of price changes. NKPC analysis shows that the price duration in Lithuania stands at around 3.8-4.6 quarters (see Section 2.4).

Compared to the frequency of price reviews, as reported in Section 3.3, prices in Lithuania are changed less frequently than they are reviewed. Most of the firms in Lithuania review prices daily to half yearly, while most of the firms change the prices

quarterly to once a year. The pricing process, thus, takes a place in two stages – the price reviewing stage and the price adjustment stage. This suggests that some forms of the price stickiness may occur when prices are reviewed and when they are adjusted.

Table 13. Frequency of price changes
(share of firms; percent)

	Price change occurs:				
	daily to monthly	*quarterly to half yearly*	*once a year*	*less frequently than once a year*	*never/no pattern*
Manufacturing	*6.8*	*39.0*	*13.7*	*13.9*	*26.6*
Construction	*2.0*	*37.0*	*28.2*	*0.0*	*32.8*
Trade	*18.9*	*15.5*	*15.0*	*2.1*	*48.5*
Business services	*6.8*	*21.3*	*26.0*	*20.9*	*25.1*
Total	*8.7*	*27.3*	*20.4*	*11.9*	*31.6*

Notes: responses are employment-weighted and rescaled to exclude non-responses.
Sources: the survey "On Price and Wage Setting" and author's calculations.

In comparison to the other countries, prices in Lithuania appear to be changed more frequently (Druant et al., 2009). In both the euro area and non-euro area countries prices are typically changed once a year while, as mentioned above, in Lithuania they are typically changed on a more frequent basis. It should be noted that some studies show that the frequency of price increases is positively associated with the level of inflation (Vermeulen et al., 2007, Dhyne et al., 2006). Elevated inflation during the reference period of the survey could have contributed to the higher frequency of price changes in Lithuania.

To compare the frequency of price changes to the one of wage changes, the conducted survey explicitly asked the firms how frequently the base wage is typically changed. Respondents were asked to indicate whether the change occurs (1) more than once a year, (2) once a year, (3) once every two years, (4) less frequently than once every two years or (5) change never occurs or pattern is not known. The survey asked the respondents to provide the information on the frequency of wage changes due to tenure, due to inflation and due to reasons other than tenure and inflation.

As shown in Table 14, the surveyed Lithuanian firms reported that most of the wage changes occur due to the reasons other than tenure and inflation. This was the answer given by 78.9 percent of the firms. Due to the reasons other than tenure and inflation the wage is typically changed once a year or more frequently than once a

year. This pattern of frequency of wage changes is quite similar across economic activities.

Table 14. Frequency of wage changes
(share of firms; percent)

	Wage change occurs:			
	more frequently than once a year	*once a year*	*less frequently than once a year*	*never/do not know*
Due to tenure:				
manufacturing	7.6	15.7	21.6	55.1
construction	19.7	18.4	9.5	52.4
trade	10.4	25.8	22.0	41.8
business services	3.1	28.4	19.6	49.0
total	8.3	22.8	19.3	49.7
Due to inflation:				
manufacturing	17.5	33.2	11.4	37.9
construction	21.6	51.2	4.0	23.3
trade	16.3	28.9	12.8	42.1
business services	16.2	27.4	11.4	45.0
total	17.3	32.7	10.7	39.3
Due to other reasons:				
manufacturing	29.0	37.0	8.2	25.8
construction	31.5	59.9	0.0	8.6
trade	29.4	29.6	16.0	25.1
business services	30.5	35.1	14.7	19.7
total	30.0	37.9	11.0	21.1
Due to all reasons:				
manufacturing	43.6	45.0	5.8	5.5
construction	54.8	43.2	2.0	0.0
trade	40.6	45.8	8.5	5.1
business services	38.0	41.6	10.2	10.3
total	42.5	43.7	7.4	6.3

Notes: responses are employment-weighted and rescaled to exclude non-responses; frequencies of wage changes "due to all reasons" are calculated by assigning each firm the highest frequency of wage change irrespective the reason behind the change.
Sources: the survey "On Price and Wage Setting" and author's calculations.

Due to inflation the wages are changed in 60.7 percent of the firms. Due to this reason the change in wages mostly occurs once in a year. This is observed in all economic activities. As reported by the firms, the least common are wage changes due to tenure. This is observed in slightly more than half of the surveyed firms. Due to tenure the wage changes typically occur once a year or less frequently than once a year. Thus, due to tenure the wages are changed less frequently than due to inflation and due to the reasons other than tenure and inflation. A somewhat different wage

setting pattern is observed in construction, where due to tenure wages are typically changed more frequently than once a year.

To get a perception on how frequently the wages are changed in general, the wage change frequencies across all investigated reasons were combined into one variable by assigning each firm the highest frequency of wage change irrespective the reason behind the change. It turned out that in Lithuania in slightly more than 40 percent of the surveyed firms wages are changed once a year and in approximately the same share of firms wages are changed more than once a year. A somewhat higher frequency of wage changes is observed in construction and manufacturing, while the frequency is somewhat lower in business services.

Change in wages appears to occur somewhat less frequently than the one of prices. Both wages and prices in many instances are changed more frequently than once a year, however, the annual adjustment of wages stands out as a more common practice than the annual adjustment of prices. This indicates that if prices respond less sensitively, it might be a result of the wage persistence.

Compared to the other countries, wages in Lithuania seem to be changed more frequently (Druant et al., 2009). As in Lithuania, in both the euro area and non-euro area EU countries wages are typically changed once a year. However, in Lithuania a considerably larger part of the firms change wages more frequently than once a year. One should keep in mind that in the case of the Lithuanian survey the respondents were asked to provide the information based on their operational activities in 2007, a period of particularly strong economic growth and elevated inflation. This could have contributed to relatively high frequency of wage changes in Lithuania.

As discussed in Section 3.3, prices (as well as wages) might adjust less sensitively in response to the economic shocks if adjustments occur in a predefined pattern. Prices (and wages) might become less flexible if they are changed in a time-dependent way. Therefore, along with questions about the frequency of price (and wage) changes, the survey also asked the firms whether the price (and wage) changes occur in any particular month(s).

The survey revealed that in Lithuania 14.9 percent of the firms typically change the prices in a particular month, while the wages are changed in a particular month by 16.9 percent of the firms. In almost half of the month-dependent firms prices are typically changed in January, while the first month of the year was indicated as the

month in which wages are typically changed by almost two thirds of the month-dependent firms (see Figure 5 in Appendix 9). Other peaks occur at the beginning of the other quarters of the year, i.e. in April, July, and October. Adjustment of prices and wages appears to be more month-dependent in construction firms.

As documented in Druant et al. (2009), month-dependence of price and wage changes in Lithuania stands at a relatively low level compared to the other countries. It is considerably lower than on average in the euro area countries, where prices and wages are typically changed in a particular month(s) in more than 40 percent and more than 60 percent of the firms respectively. It is also somewhat lower than on average in non-euro area countries.

Table 15. Share of firms reporting that price and wage changes occur in a particular month(s)
(percent)

	Price change	Wage change
Manufacturing	10.7	15.1
Construction	23.6	23.6
Trade	13.9	10.1
Business services	15.6	19.8
Total	14.9	16.9

Notes: responses are employment-weighted and rescaled to exclude non-responses.
Sources: the survey "On Price and Wage Setting" and author's calculations.

To analyse the link between price and wage changes the survey explicitly asked the question how does the timing of price changes relate to that of wage changes. Firms were inquired to indicate if (1) there is no link between the two, (2) there is a link but no particular pattern, (3) decisions are taken simultaneously, (4) price changes tend to follow wage changes, (5) wage changes tend to follow price changes or (6) firms do not know.

As shown in Table 16, approximately three quarters of the firms report that the link between the price changes and the wage changes exists. Firms admit that the link exists however most of them acknowledge that there is no pattern for this relationship. No link between the investigated changes is reported by somewhat more than a fifth of the firms. The link between the price changes and the wage changes is more incidental in construction.

Compared to the evidence of other countries, the relationship between the price changes and the wage changes in Lithuania appears to be stronger. As documented in Druant et al. (2009) roughly 40 percent of EU firms acknowledge that the link

between the price changes and the wage changes exists, more than half of EU firms report that there is no link, while, as mentioned, in Lithuania the link between the investigated changes is more apparent.

Table 16. Link between price and wage changes
(share of firms; percent)

	There is a link with pattern:			There is a link but no pattern	No link	Do not know
	prices follow wages	*wages follow prices*	*simulta-neous changes*			
Manufacturing	10.0	10.1	6.2	48.8	24.7	0.2
Construction	18.1	8.9	13.4	57.6	2.0	0.0
Trade	5.3	1.1	6.7	52.7	33.3	1.1
Business services	2.9	7.3	8.6	54.7	18.0	8.6
Total	7.6	7.0	8.2	53.0	21.0	3.4

Notes: responses are employment-weighted and rescaled to exclude non-responses.
Sources: the survey "On Price and Wage Setting" and author's calculations.

The frequency of price and wage changes might be affected by a number of factors related to the firm's production technology, labour compensation settings, market competition and some other factors. To better understand the frequency of price and wage changes, these frequencies are modelled using ordered probits. Both models (i.e. the model of the frequency of price changes and the model of the frequency of wage changes) include three sets of explanatory variables: the one accounting for differences in production technologies; another one reflecting labour compensation arrangements; and a third one proxying market competition.

The set of explanatory variables that account for the differences in production technologies includes:

- *labour share* – this is the share of the total costs of a firm that are incurred due to the hiring of employees (it includes wages, individual or company performance-related bonuses, social contributions, training expenses, etc.); this variable is expressed as a percentage;

- *trade firms* and *services firms* – these are economic activity dummy variables; the dummy variable *trade firms* takes the value 1 if the firm is a trade firm (Section G of NACE rev. 1.1); the dummy variable *services firms* takes the value 1 if the firm is any other market services firm (Sections H-K of NACE rev. 1.1); otherwise these variables take the value

0; the reference category is manufacturing firms (Sections D-F of NACE rev. 1.1);

- *firms 20-49* and *firms 50 or more* – these are firm size dummy variables; these dummy variables take the value 1 if the number of employees in a firm is between 20 and 49 or 50 or more respectively and takes the value 0 otherwise; the reference category is those firms that employ up to 19 employees.

Labour compensation arrangements are reflected by two variables. One of them accounts for the presence of the wage bargaining institutional setup. This variable – *collective pay agreements* – is constructed as a dummy variable that takes the value 1 if the firm applies a collective pay agreement signed outside the firm or signed at the firm and takes the value 0 if no collective pay agreement is applied. Another variable represents the use of flexible wage components. The variable *flexible wage share* is the share of total wage bill, which is due to individual or company performance-related bonuses. The latter variable is expressed as a percentage.

Market competition is captured by two variables. The variable *competition* is generated using the answers to the question whether the firm decreases its own price following the price decrease of the product of the main competitor. This variable is a dummy variable that takes the value 1 if the firm is "very likely" to decrease its price and takes the value 0 if the firm is "likely" or "not likely" to decrease the price or responds "not at all". One more variable to capture the competition pressures is related to the exposure of the firm to foreign markets. A higher share of revenue arising from sales in foreign markets might imply a more competitive environment. Therefore the *foreign sales share* is another way to proxy the intensity of the competition in the product market. The latter variable is expressed as a percentage.

In addition to the factors described above, the model of the frequency of price changes also includes a variable reflecting the price regulation. The explanatory variable *price regulation* is constructed as a dummy variable that takes the value 1 if a firm does not have an autonomous price setting policy (the price is regulated by the state, set by a parent company or set by a main customer(s)) and takes the value 0 if the price is set following the main competitors or the price is set according to costs and a self-determined profit margin.

Apart from the three sets of explanatory variables outlined above, the model of the frequency of wage changes also accounts for the presence of an institutional setting that adapts changes in base wages to inflation. The explanatory variable *policy to account for inflation* is constructed as a dummy variable that takes the value 1 if such kind of setting is used in a firm (i.e. wage changes are automatically linked to inflation or there is no formal rule however wage changes take into account inflation) and takes the value 0 if there is no such setting.

In both models (i.e. in the model of frequency of price changes and in the model of frequency of wage changes) the dependent variable is the categorical variable that increases with the frequency of price and wage changes: 1 = price or wage is changed less frequently than once a year, 2 = price or wage is changed once a year, 3 = price or wage is changed more frequently than once a year. As in the analysis above, the variable that reflects the frequency of wage changes is constructed by assigning each firm the highest frequency of wage change irrespective the reason behind the change.

Estimation results are provided in Table 17. For simplicity purposes, the analysis is limited to the marginal effects on the highest probability cell. In particular, Table 17 provides only the marginal effects on the probability that price or wage change occurs more frequently than once a year.

The frequency of price changes is found to be positively affected by market competition. It is affected negatively by price regulation. Analysis shows that services firms tend to change prices less frequently than manufacturing firms. Contrary to the findings on the price setting in the euro area (Vermeulen et al., 2007) and the findings based on a broader range of countries (Druant et al., 2009), the labour cost share does not appear to be significant in affecting the frequency of price changes in Lithuanian firms.

Regression analysis shows that the frequency of wage changes is affected by the institutional features of the firms. In particular, the frequency of wage changes is more likely to be higher in firms that apply collective pay agreements and in firms that adapt changes in base wages to inflation. The statistically significant role of the presence of collective pay agreements is in line with the fact that most of these agreements are signed at the firm level (rather than the national level), which enable to bargain for wages on a more frequent basis. As the changes in wages mostly reflect upward revisions, the presence of these agreements, along with the other factors,

mostly contributes to a more frequent increases in wages. Analysis also shows that wages are more likely to be changed more frequently in larger firms compared to smaller ones.

Table 17. Explanations for frequency of wage and price changes
(marginal effects for ordered probit models; the table provides only marginal effects on the probability that price or wage change occurs more frequently than once a year)

	Frequency of price change	*Frequency of wage change*
Labour share	*0.000*	*0.000*
Trade firms	*-0.002*	*-0.043*
Services firms	*-0.179***	*-0.070*
Firms 20-49	*-0.045*	*0.160***
Firms 50 and more	*-0.093*	*0.166***
Collective pay agreements	*-0.037*	*0.153***
Flexible wage share	*0.000*	*0.002*
Competition	*0.207***	*0.067*
Foreign sales share	*0.001*	*-0.001*
Price regulation	*-0.264***	*-*
Policy to account for inflation	*-*	*0.108***
Pseudo R-squared	*0.053*	*0.048*
Wald statistic	*19.750*	*29.370*
Prob. (Wald statistic)	*0.032*	*0.001*
Number of observations	*198*	*292*

*Notes: * coefficient is statistically significant at the level of 10 percent, ** – significant at the level of 5 percent, *** – significant at the level of 1 percent; p-values are computed using Huber-White robust standard errors.*
Sources: the survey "On Price and Wage Setting" and author's estimations.

To check the robustness of the results described above, both regressions were estimated using different definitions of the dependent variables. The dependent variables were constructed as binary variables: 0 = price or wage is changed less frequently than once a year or once a year, 1 = price or wage is changed more frequently than once a year. Robustness analysis revealed that, contrary to the results described above, it cannot be concluded that the presence of price regulation affects the frequency of price changes (see Appendix 10). It also turned out that under different definition of the dependent variable it is not possible to conclude that wages are changed more frequently in firms that adapt changes in base wages to inflation and in larger firms.

3.5. Upward and downward price stickiness

Stickiness of prices may occur due to numerous reasons. Firms may shy away from price decisions because it may be costly to review the prices. Firms may also find it costly to adjust the prices or disadvantageous to change them due to response of customers or reaction of competitors. Stickiness of prices may originate at both the price reviewing stage and the price adjustment stage.

To investigate the reasons that prevent from upward and downward price adjustment occurring at both price setting stages the survey analysed the relevance of ten potential explanations for the price stickiness. The examined explanations are described below[27]:

- at the starting point, stickiness of prices might be a result of no substantial changes in the costs related to the firms' operational activities (extrinsic stickiness). If firms are following the *cost-based pricing*, firms do not alter the prices as long as there are no changes in the costs;

- the prices may remain unchanged due to *explicit contracts* between the firms and their customers. The contracts may foresee the constant prices for the prolonged periods of time contributing to the enduring business relationship between the sellers and the buyers of the products. Explicit contracts allow the firms to plan the sales, while customers benefit from lower information and transaction costs;

- business relationship between the firms and their customers may also be build up without engaging into formal contracts. It is observed, that if prices are increased due to the costs, the customers may judge it as a legitimate way of pricing, while if prices are increased due to heightened demand, the customers may view it as unfair. Firms, therefore, may opt to raise the prices following the cost shocks, and they may decide to keep the prices constant when facing the demand shocks, thus effectively engaging into *implicit contracts*. The specifics of the cost- and demand-induced increases of prices was noted by Okun (1981) and used by Rotemberg (2005);

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[27] A summary of explanations for the upward and downward price stickiness rests on Fabiani et al. (2006) and Dhyne et al. (2009).

- the change in prices might bear costs. It may be costly to print new labels and to attach them, to print new catalogues and to distribute them. The change in prices might also pose some other *menu costs*, like advertising and negotiation costs. As shown by Akerlof and Yellen (1985), Mankiw (1985) and Dixit (1991), even low menu costs might end up in substantial stickiness of prices having sizeable effects on the aggregate variables. As already mentioned, price adjustment costs are used in the state-dependent models of Barro (1972) and Sheshinski and Weiss (1977) where the authors use the price adjustment costs that are not related to the size and the timing of price changes (hence these costs are menu costs).

  The evidence on the size of menu costs is rather scarce, though it shows that menu costs are quite sizeable. Levy et al. (1997) analyse the price adjustment costs at the retailers' level. The authors find that costs of changing price labels amount to around 0.7 percent of total revenue and around 35 percent of profit margins.

  Zbaracki et al. (2004), in addition to physical price adjustment costs, investigate managerial price review costs[28] as well as customer communication and negotiation costs in an industrial firm. According to this study the total price adjustment costs are equal to around 1.23 percent of total revenue and around 20 percent of profit margins;

- apart from physical price adjustment costs, advertising and negotiation costs, change in prices is related to *information costs*. Before deciding upon new prices, firms analyse the markets, the competition pressures and the consumer sentiments, thus incurring costs of information gathering and information processing. Information costs that may prevent from frequent price adjustment are used by Mankiw and Reis (2002, 2006) and Reis (2006);

- product price is an important feature of the product, though it goes along the other features. Every product is accompanied by delivery conditions, repair and replacement schemes, services of update and some other attributes. Firms, therefore, may opt to use the *non-price* elements of

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[28] In Zbaracki et al. (2004), among the other costs, managerial price review costs include information costs that are reviewed further below.

competition when they face the shocks. They can change the time of the delivery, introduce or cut some other services, thus managing the product features and the costs, while keeping prices fixed instead of altering them;

- some features of the product, in particular, the quality, are not observed directly. To identify these features the customers may scrutinise the other (observable) characteristics of the product, for instance, product price. If price goes down, the customers may interpret it as a switch to lower quality. Therefore, similarly as in the case above, firms may decide to keep the prices constant even if they can lower them in order to abstain from possibly misleading *quality signal*;

- pricing pattern can also be affected by firms' interaction in the product market. Firms may opt to keep the prices without increasing them if firms expect that the competitors will not be raising prices in response. On the other hand, firms may also wish to keep the prices instead of lowering them if they anticipate that the other firms will cut the prices afterwards. *Coordination failure*, thus, leads to a kinked demand curve, implying losses for the firms if they increase the prices and only minor gains if they reduce the prices;

- the economic shocks may differ in terms of their nature as well as in their persistence. The shocks may be short lived, the shocks may be long lasting. If firms expect a shock to be a temporary one, they may decide to keep the prices fixed instead of changing them when shock occurs and revising them again when shock reverses back. The *temporary character of shocks*, thus, may imply a sticker price behaviour;

- customers may find some price levels more attractive than the other ones. This is particularly true if customers pay less attention to the last price digit and focus more attention to the other digits. Such kind of *price thresholds* imply a stepwise demand function, which make it optimal for firms to change the prices only if the new prices reach the new thresholds also called the pricing points. Firms, thus, may maintain the prices if economic shocks are not significant enough to move the prices to the new price thresholds.

The survey asked respondents how relevant are the above provided explanations for not immediate price adjustment when there are some factors forcing to increase or lower price. The list of explanations did not include a reference to *quality signal* in the case of price increase and did not refer to *implicit contracts* in the case of price decrease. Firms were asked to indicate whether each of explanations is (1) not relevant, (2) of little relevance, (3) relevant, (4) very relevant or (5) they do not know.

As shown in Table 18, the most important explanation for not adjusting prices, when there are some reasons to increase them, rests on *cost-based pricing*. Firms indicate that they are not willing to engage into upward price adjustment as long as costs do not change. This is consistent with the relatively wide use of mark-up pricing, as it was mentioned in Section 3.2.2. The second and the third most important reasons for maintaining prices constant instead of raising them are *explicit contracts* and *implicit contracts*. This mirrors the significance to treasure the business relationship between the firms and their customers avoiding disappointing moves in prices. The finding stands in line with rather substantial role of regular customers in generating income.

Table 18. Explanations for upward price stickiness
(share of firms for which the explanation is "relevant" or "very relevant"; percent)

	Manu-facturing	*Cons-truction*	*Trade*	*Business services*	*Total*
Cost-based pricing	*74.0*	*88.2*	*65.8*	*74.0*	*74.2*
Explicit contracts	*70.5*	*64.6*	*48.2*	*65.9*	*63.2*
Implicit contracts	*70.4*	*51.2*	*40.2*	*41.5*	*50.9*
Coordination failure	*39.6*	*48.1*	*53.9*	*31.8*	*41.1*
Information costs	*37.0*	*40.3*	*38.6*	*44.7*	*40.5*
Temporary character of shocks	*37.1*	*45.9*	*34.9*	*24.6*	*33.4*
Price thresholds	*26.8*	*4.3*	*32.2*	*17.5*	*21.5*
Non-price competition	*24.9*	*21.3*	*17.6*	*12.3*	*18.3*
Menu costs	*15.8*	*2.0*	*26.0*	*18.2*	*17.0*

Notes: responses are employment-weighted and rescaled to exclude non-responses.
Sources: the survey "On Price and Wage Setting" and author's calculations.

The next important reason not to raise the prices relates to firms' concern that the other firms will not adjust the prices. The *coordination failure*, thus, proves to be important in the price setting resembling the evidence on incidence of firms that set the prices following the main competitors. The other rather decisive explanation for not adjusting prices upwards relates to *information costs*. Quite a substantial share of

firms admits that information costs prevent from price decisions, thus indicating that stickiness of prices also occurs at the price reviewing stage.

The other explanations for stickiness of prices – *temporary character of shocks*, *price thresholds*, *non-price competition* and *menu costs* – appear to be less relevant for firms when they decide if to increase the prices. Interestingly, the physical price adjustment costs – *menu costs* – are reported as the least important reason to abstain from price adjustment, though this explanation for price stickiness is frequently used in the literature.

A ranking of the five most important explanations for upward price stickiness in all economic activities is different from the one found for the entire set of firms. For the firms in manufacturing and construction *temporary character of shocks* appears to have greater significance than *information costs* in preventing price increase. Firms in trade report that *coordination failure* is a more relevant explanation for maintaining prices constant instead of raising them as compared to the relevance of *explicit contracts* and *implicit contracts*. This corresponds to observation that trade firms follow the main competitors more often when setting prices. Business services firms express relatively larger importance of *information costs* in comparison to *implicit contracts* and *coordination failure* in clarifying the significance of reasons for upward price stickiness.

The undertaken study shows that three out of five the most important reasons preventing from increasing prices are also relevant when distinguishing the most momentous factors making to abstain from lowering prices. Firms report that *cost-based pricing*, *explicit contracts* and *coordination failure* are among the most important causes of downward price stickiness (see Table 19). In addition, firms indicate that *temporary character of shocks* is very relevant in determination to maintain the prices constant although there are some reasons to decrease them. Firms also find important to keep the prices constant due to a *quality signal*.

Information costs, *non-price competition*, *price thresholds* and *menu costs* are found as less momentous factors maintaining prices constant when there are some reasons to decrease them. Similarly as in the case of upward stickiness of prices, *menu costs* appear to be the least important factor in preventing downward price adjustment.

Firms in manufacturing, construction and business services indicate the same five most relevant explanations for downward stickiness of prices as they are reported for the whole sample of investigated firms, though in manufacturing the explanations rank in a different way. Firms in manufacturing claim that a wish to prevent a *quality signal* stands above all the other reasons for price stickiness. *Quality signal* also appears to be the most important factor in trade firms in deciding to maintain the prices constant instead of lowering them. In these firms *quality signal* is followed by *cost-based pricing*, *temporary character of shocks*, *non-price competition* and *coordination failure*.

Table 19. Explanations for downward price stickiness
(share of firms for which the explanation is "relevant" or "very relevant"; percent)

	Manu-facturing	Cons-truction	Trade	Business services	Total
Cost-based pricing	56.3	75.3	51.5	66.8	61.7
Explicit contracts	56.3	62.6	26.8	57.1	51.1
Temporary character of shocks	53.8	57.6	47.8	47.7	50.9
Quality signal	59.2	46.5	51.7	37.5	48.1
Coordination failure	43.8	44.2	33.0	33.2	37.8
Information costs	37.4	28.5	32.8	23.5	30.2
Non-price competition	24.4	33.4	36.5	22.0	27.4
Price thresholds	24.5	4.0	20.2	21.3	19.6
Menu costs	24.1	0.0	21.6	13.5	16.4

Notes: responses are employment-weighted and rescaled to exclude non-responses.
Sources: the survey "On Price and Wage Setting" and author's calculations.

The relative importance of factors for sticky price behaviour in Lithuania stands close to the existing evidence obtained for the euro area (Fabiani et al., 2006) and Estonia (Dabušinskas and Randveer, 2006). The undertaken study in the euro area investigated reasons of price stickiness without distinguishing the factors preventing from upward and downward price adjustment, therefore results for the euro area are comparable to the ones for Lithuania only to a limited extent. Nevertheless, a few the most important explanations for sticky price behaviour in the euro area appear to be relevant in Lithuania. In particular, *cost-based pricing*, *explicit contracts* and *coordination failure* turn out to be among the most momentous factors explaining stickiness of prices in the euro area and sluggishness of upward and downward price adjustment in Lithuania. In addition, *implicit contracts* are also reported as an important explanation for maintaining prices constant in the euro area and Lithuania (this applies for Lithuania when firms consider if to increase the prices). In contrast to

results obtained for Lithuania, *information costs* do not appear among the most explanatory factors of price stickiness in the euro area.

The survey in Estonia, similarly as in Lithuania, inquired the firms to evaluate separately the factors preventing from upward and downward price adjustment. This survey, however, did not include *temporary character of shocks* as a potential explanation for sticky price behaviour, while it included *implicit contracts* as an explanatory factor for sticky downward price adjustment. The results indicate that Estonia and Lithuania share a few the most important explanations for upward and downward stickiness of prices, namely, *cost-based pricing*, *explicit contracts*, *implicit contracts*, *coordination failure* and *quality signal*. As opposed to the case of Lithuania, *information costs* do not rank among the most momentous factors preventing from the price adjustment in Estonia.

3.6. Adjustment following the economic shocks

3.6.1. Adjustment through prices, margins, output and costs

For a better understanding of price and wage setting and the overall behaviour of firms, the conducted survey included several questions on the possible adjustment channels that may be used when responding to the economic shocks. The responses to these questions, combined with the available covariates, might reveal the role of certain facilitators as well as impediments stemming from characteristics of firms when reacting to changes in the economic environment.

The survey asked respondents how relevant certain strategies are when the firm faces three types of shocks: (1) an unanticipated slowdown in demand; (2) an unanticipated increase in the cost of an intermediate input, which affects all the firms in the market; and (3) an unanticipated permanent increase in wages (e.g. due to the renewal of the collective pay agreement or due to an increase in the minimum monthly wage) affecting all the firms in the market. Firms were asked to indicate whether a reduction or increase in prices, a reduction in margins, a reduction in output and a reduction in costs is (1) not relevant, (2) of little relevance, (3) relevant, (4) very relevant in response to the shocks or (5) they do not know.

As shown in Table 20 the most popular response to the shock is to use a combination of strategies. In response to the slowdown in demand firms tend to choose the cost reduction together with other strategies. Firms report that in face of this shock they would be least willing to lower the prices thus indicating some degree of downward price stickiness. Following both of the cost shocks change in prices is more common reaction among the firms. Nevertheless, combinations of increases in prices with other types of strategies are more widely used implying that higher intermediate input costs and higher wages are only partially passed on to the prices. In the case of both kinds of the cost shocks firms clearly avoid reducing output. This points to an active search for efficiency gains.

Table 20. Distribution of the responses of firms to different types of shocks (share of firms for which the use of certain combinations of responses is "relevant" or "very relevant"; percent)

Combination of responses to a shock	Type of shock:		
	slowdown in demand	*increase in the cost of an intermediate input*	*increase in wages (e.g. due to increase in the minimum monthly wage)*
Price	0.2	5.6	6.2
Margin	1.3	2.0	3.7
Output	1.8	0.0	0.0
Costs	2.1	5.7	6.6
Price / margin	3.7	8.0	12.9
Price / output	0.3	1.1	0.1
Price / costs	3.9	11.2	9.5
Margin / output	5.0	0.0	0.3
Margin / costs	7.0	1.8	9.4
Costs / output	12.9	1.5	0.9
Price / margin / output	4.0	1.4	0.3
Price / margin / costs	9.5	21.6	21.6
Price / output / costs	1.6	4.6	2.2
Margin / output / costs	11.5	3.8	3.4
Price / margin / output / costs	29.1	20.4	15.7
None	6.1	11.2	7.2
Price / any combination	52.3	73.8	68.5
Margin / any combination	71.1	59.1	67.4
Output / any combination	66.2	32.9	22.9
Costs / any combination	77.6	70.8	69.3

Notes: responses are employment-weighted and rescaled to exclude non-responses; "price" indicates price decrease or price increase, "margin" indicates margin decrease, "output" indicates output decrease and "costs" indicates a reduction in costs.
Sources: the survey "On Price and Wage Setting" and author's calculations.

Those respondents, who indicated that the reduction in costs was of any relevance following the shocks, were asked to identify particular ways of cost cutting. Possible answers included (1) a reduction in base wages, (2) a reduction in the flexible wage components, (3) a reduction in the number of permanent employees, (4) a reduction in the number of temporary employees, (5) a reduction in the number of hours worked per employee and (6) a reduction in non-labour costs.

As shown in Table 21, the cost cutting ways are quite similar in response of each of the shocks. As expected, the firms very rarely cut costs by reducing the base wages. This confirms a widespread perception that nominal cuts in base wages are very seldom. Although (as already mentioned) performance-related bonuses account for a quite significant share of the total wage bill, the adjustment through flexible wage components is reported as being less important than the adjustment through employment. In response to each of the shocks the adjustment through the reduction in non-labour costs is considered as the most important.

Table 21. Use of cost cutting strategies in response to different types of shocks
(share of firms for which cost-cutting is "of little relevance", "relevant" or "very relevant"; percent)

	Type of shock:		
	slowdown in demand	*increase in the cost of an intermediate input*	*increase in wages (e.g. due to increase in the minimum monthly wage)*
Reduction in base wages	3.0	1.3	-
Reduction in flexible wage components	11.3	12.6	8.5
Reduction in the number of permanent employees	10.9	7.9	13.5
Reduction in the number of temporary employees	12.8	11.3	14.6
Reduction in the number of hours worked per employee	6.1	2.7	3.2
Reduction in non-labour costs	55.8	64.2	60.2

Notes: responses are employment-weighted and rescaled to exclude non-responses.
Sources: the survey "On Price and Wage Setting" and author's calculations.

The channels of adjustment used to respond to the economic shocks may be determined by a number of characteristics of firms including the ones investigated in the analysis of the frequency of price and wage changes. To keep the analysis focused, the responses to each of the shocks are modelled using ordered probits that

include only three sets of explanatory variables, related to production technologies, labour compensation arrangements and market competition, as described in Section 3.4. The dependent variable in all the models is the categorical variable that increases with the intensity of strategy use: 1 = use of the strategy (i.e. the price change, the margin decrease, the output decrease or the reduction in costs) is not relevant, 2 = use of the strategy is of little relevance, 3 = use of the strategy is relevant, 4 = use of the strategy is very relevant.

Estimation results are provided in Tables 22-24. These tables provide only the marginal effects on the probability that the firm's response to the particular shock is "very relevant". Thus, as in Section 3.4, the analysis is limited to the marginal effects on the highest probability cell.

As shown in Tables 22-24, the investigated set of explanatory variables does not describe satisfactorily the features of firms that respond to the shocks by lowering costs and the characteristics of firms that reduce the output following the wage shock. Therefore no inferences are based on the latter probits.

Table 22. Explanations for responses to a slowdown in demand
(marginal effects for ordered probit models; the table provides only marginal effects on the probability that response is "very relevant")

	Type of response to a shock:			
	price decrease	*margin decrease*	*output decrease*	*cost reduction*
Labour share	*0.001*	*0.002***	*0.000*	*0.001*
Trade firms	*-0.011*	*-0.100****	*-0.088****	*-0.002*
Services firms	*-0.058****	*-0.115****	*-0.082****	*0.006*
Firms 20-49	*-0.014*	*0.039*	*0.119****	*0.067*
Firms 50 and more	*0.014*	*0.008*	*0.110***	*0.068*
Collective pay agreements	*0.028*	*0.035*	*0.016*	*-0.056*
Flexible wage share	*0.000*	*-0.002***	*-0.002****	*0.000*
Competition	*0.137****	*0.111***	*0.051*	*0.049*
Foreign sales share	*0.000*	*0.000*	*0.000*	*-0.001*
Pseudo R-squared	*0.039*	*0.041*	*0.050*	*0.010*
Wald statistic	*25.970*	*33.580*	*33.750*	*6.400*
Prob. (Wald statistic)	*0.002*	*0.000*	*0.000*	*0.699*
Number of observations	*295*	*298*	*294*	*298*

*Notes: * coefficient is statistically significant at the level of 10 percent, ** – significant at the level of 5 percent, *** – significant at the level of 1 percent; p-values are computed using Huber-White robust standard errors.*
Sources: the survey "On Price and Wage Setting" and author's estimations.

Regression analysis reveals that pricing decisions are significantly affected by the level of competition. In the case of the negative demand shock the competition increases the likelihood of the price decrease. In the case of both of the cost shocks the likelihood of the price increase is lowered if the firm's exposure to the foreign markets is higher. It should be noted that, following the permanent increase in wages, a higher labour cost share increases the probability of the price increase. This is an important finding of the survey identifying the link between labour costs and prices. The latter result is also obtained in the available cross-country analysis (Bertola et al., 2009).

Another set of findings relates to the use of flexible wage components. As mentioned above, performance-related bonuses account for quite a significant part of labour costs, although the adjustment through bonuses is reported as being less important than the adjustment through some other channels. Nevertheless, regression analysis reveals that a higher flexible wage share mitigates the responses to the slowdown in demand (it lowers the likelihood of the margin and output decreases) and to the intermediate input cost increase (it makes the likelihood of the price increase and the margin decrease lower).

Table 23. Explanations for responses to an increase in cost of an intermediate input (marginal effects for ordered probit models; the table provides only marginal effects on the probability that response is "very relevant")

	Type of response to a shock:			
	price increase	*margin decrease*	*output decrease*	*cost reduction*
Labour share	0.000	0.000	0.000	0.000
Trade firms	-0.137***	-0.079***	-0.028**	0.015
Services firms	-0.177***	-0.108***	-0.019	-0.054
Firms 20-49	0.015	-0.022	0.014	0.075
Firms 50 and more	-0.037	0.023	0.048**	0.059
Collective pay agreements	0.073	0.040	0.014	0.018
Flexible wage share	-0.002**	-0.002**	0.000	0.000
Competition	0.076	0.064	0.016	-0.025
Foreign sales share	-0.002***	0.001**	0.000	0.000
Pseudo R-squared	0.045	0.046	0.023	0.011
Wald statistic	32.520	32.230	17.500	7.690
Prob. (Wald statistic)	0.000	0.000	0.041	0.566
Number of observations	295	293	283	294

*Notes: * coefficient is statistically significant at the level of 10 percent, ** – significant at the level of 5 percent, *** – significant at the level of 1 percent; p-values are computed using Huber-White robust standard errors.*
Sources: the survey "On Price and Wage Setting" and author's estimations.

As could be expected, the role of collective pay agreements appears to be mostly insignificant in response to the investigated shocks. This is consistent with the relatively rare use of these agreements in Lithuanian firms. Nevertheless, the presence of collective pay agreements is found to be important in the case of wage shock. Collective pay agreements increase the likelihood of margin decrease following this shock.

Ordered probit estimates highlight the importance of competition in the behaviour of Lithuanian firms. In several regressions higher levels of competition and a greater exposure to foreign markets are associated with more sensitive reaction to the shocks. In addition to the above-mentioned role of competition and the foreign sales share in pricing decisions, these covariates point to a greater likelihood of margin decrease.

Table 24. Explanations for responses to a permanent increase in wages
(marginal effects for ordered probit models; the table provides only marginal effects on the probability that response is "very relevant")

| | Type of response to a shock: | | | |
	price increase	margin decrease	output decrease	cost reduction
Labour share	0.002**	0.000	0.000	0.001
Trade firms	-0.121***	-0.077**	-0.012	-0.024
Services firms	-0.043	-0.069**	0.004	-0.064*
Firms 20-49	0.04	0.033	-0.007	0.030
Firms 50 and more	0.027	0.010	0.015	0.059
Collective pay agreements	0.001	0.070*	0.029	-0.013
Flexible wage share	-0.001	0.000	0.000	0.000
Competition	-0.021	0.075*	0.014	0.033
Foreign sales share	-0.002***	0.001	0.000	0.001
Pseudo R-squared	0.036	0.027	0.016	0.012
Wald statistic	23.750	21.910	10.520	7.020
Prob. (Wald statistic)	0.005	0.009	0.310	0.635
Number of observations	300	295	283	296

*Notes: * coefficient is statistically significant at the level of 10 percent, ** – significant at the level of 5 percent, *** – significant at the level of 1 percent; p-values are computed using Huber-White robust standard errors.*
Sources: the survey "On Price and Wage Setting" and author's estimations.

Regression analysis shows that trade and services firms are less likely to lower the margin in response to all the investigated shocks compared to the manufacturing firms. Trade and/or services firms also tend to respond less sensitively by changing

prices and output following the certain shocks. Larger firms appear to be more likely than smaller ones to lower the output when they face the slowdown in demand or the increase in the intermediate input cost.

To check the robustness of the estimation results all the regressions were also estimated using different definitions of the dependent variables. In particular, the dependent variables were constructed as binary variables: 0 = use of the strategy (i.e. the price change, the margin decrease, the output decrease, the reduction in costs) is not relevant or of little relevance, 1 = use of the strategy is relevant or very relevant. It was found out that under the different definition of the dependent variable it is not possible to conclude (in contrary to the above-described results) that a higher flexible wage share is statistically significant in lowering the likelihood of the price increase following the intermediate input cost shock (see Appendix 11). Robustness analysis revealed that it cannot be concluded that trade firms are less likely to lower the output compared to manufacturing firms in response to the increase in the intermediate input cost. Additionally, this analysis showed that the investigated set of variables is not statistically significant in explaining firms' adjustment of margins following the permanent increase in wages.

3.6.2. Asymmetries in price adjustment

Pricing behaviour may feature different characteristics in the face of distinct economic shocks. Firms may find it optimal, for instance, because of customer specifics, to handle prices differently when demand increases and demand decreases. Firms may also deal with prices dissimilarly, say, due to employed technologies, when costs go up and costs go down.

To analyse the asymmetries of price response to economic shocks, the survey asked the firms if they adjust the prices when the demand changes or the costs change enough to review the prices. Firms were inquired whether (1) they would change the prices, (2) they would not change the prices or (3) they do not know what their reaction would be in response to four types of shocks: a demand increase shock, a demand decrease shock, a cost increase shock and a cost decrease shock.

The answers make it difficult to infer whether firms react differently in the case of the heightened demand and the dampened demand, while firms' reaction to the

higher costs and the lower costs appears to embed some asymmetry. As shown in Table 25, the share of firms that adjust the prices following the demand increase is somewhat higher than the share of firms changing the prices in the case of demand decrease. Along with this, the survey shows that the fraction of firms maintaining the prices in the face of heightened demand is also higher than the fraction of firms not changing the prices in the case of dampened demand. This pattern of responses is observed in manufacturing, while in other economic activities it differs somewhat. In construction and business services larger share of firms adjust the prices and smaller share of firms maintain the prices in the case of higher demand than in the case of lower demand, while in trade the opposite pattern of reaction to the demand shocks is observed.

Table 25. Incidence of price change in response to demand and cost shocks (share of firms; percent)

	Manu-facturing	Cons-truction	Trade	Business services	Total
Demand increase shock:					
firms that change the price	49.2	72.1	44.7	50.2	51.7
firms that do not change the price	47.6	27.9	50.0	42.7	43.6
firms that do not know	3.3	0.0	5.3	7.1	4.6
Demand decrease shock:					
firms that change the price	48.4	46.2	52.0	30.4	42.4
firms that do not change the price	42.4	34.5	36.1	49.6	42.5
firms that do not know	9.2	19.3	11.9	20.1	15.1
Cost increase shock:					
firms that change the price	92.2	95.7	76.6	80.9	85.3
firms that do not change the price	7.4	2.3	11.7	4.6	6.6
firms that do not know	0.5	2.0	11.6	14.6	8.1
Cost decrease shock:					
firms that change the price	37.4	42.3	27.8	23.0	30.9
firms that do not change the price	52.2	43.6	63.8	59.2	56.0
firms that do not know	10.4	14.1	8.4	17.7	13.1

Notes: responses are employment-weighted and rescaled to exclude non-responses.
Sources: the survey "On Price and Wage Setting" and author's calculations.

Response of firms to the cost increase and cost decrease shocks turns to possess asymmetric reaction. Considerably larger share of firms adjust the prices in the face of cost increase than in the case of cost decrease, while the fraction of firms maintaining the prices is smaller following the higher cost shock than in the case of the lower cost shock. This response pattern is evident in all the investigated economic activities.

It is noticeable that the firms' response to the demand increase and decrease shocks differs markedly from the response to the respective cost shocks. Smaller share of firms change the prices and larger share of firms maintain the prices when the demand increases compared to the case when the costs increase. Entirely the opposite reaction of firms is observed in the cases of the demand decrease and the costs decrease. Such response pattern is found in all the considered economic activities.

Firms, that indicated a change in prices following the analysed shocks, were asked to provide the information on the length of lag of the price adjustment. As shown in Table 26, the average length of lag of the change in prices ranges from 2.2 to 2.7 months depending on the shock. The length of lag is quite similar in the case of increased demand shock and decreased demand shock, and the length of lag is also quite alike in the case of higher cost shock and lower cost shock. The lag of price adjustment appears to be marginally longer following the cost shocks than in the face of demand shocks. The time elapsed until the prices are changed is somewhat longer in business services.

Table 26. Lag of price change in response to demand and cost shocks (months)

	Manu-facturing	Cons-truction	Trade	Business services	Total
Demand increase shock	2.3	1.6	1.9	2.9	2.3
Demand decrease shock	1.8	2.2	1.8	3.1	2.2
Cost increase shock	2.5	1.9	1.7	3.4	2.5
Cost decrease shock	2.5	2.4	1.8	3.7	2.7

Notes: responses are employment-weighted and rescaled to exclude non-responses.
Sources: the survey "On Price and Wage Setting" and author's calculations.

As discussed in Section 3.6.1, a number of characteristics of firms might affect firms' decisions on prices in response to the shocks. To get a perception of the determinants of pricing decisions in the face of shocks and possible asymmetric influence of some of the factors, firms' reaction to the shocks is modelled using binary probits. All the models (the models of response to the heightened demand, the dampened demand, the higher costs and the lower costs) include four sets of explanatory variables, namely, the one gauging the production technologies, the one accounting for labour compensation settings, the one capturing market competition, and the one reflecting the interaction of firms with their customers. The first three sets

of variables consist of variables that are used in regression analysis in Section 3.4 and Section 3.6.1. Regression analysis includes a set of three explanatory variables that reflect the ways and the outcomes of interaction of firms with their customers:

- *regular customers share* – a variable that is constructed to account for the influence of non-formal business relationship of firms with their customers. The incidence of regular customers could possibly grasp the importance of, as titled above, implicit contracts. *Regular customers share* is the share of revenue generated by sales to such customers. The latter variable is expressed as a percentage;

- *wholesale and retail firms share* – a variable to capture the effects of the type of customer in shaping the behaviour of firms. Different types of customers might incur different costs when searching for an optimal price. The costs might be lower for the firms – wholesale and retail firms, and the costs might be higher for the final consumers. Firms therefore may have different pricing behaviour depending on the customers to whom they sell. *Wholesale and retail firms share* is the share of revenue generated by sales to wholesale and retail firms. The variable is expressed as a percentage;

- *price discrimination* stands to grasp whether firms set the prices differently for different customers. Price discrimination represents the pricing outcome when prices are accommodated to customer ability or willingness to pay. Price discrimination therefore renders a different pricing pattern as compared to the one under non-discriminatory setting. *Price discrimination* – a dummy variable that takes the value 1 if the firm sets the price individually for customer(s) or depending on the quantity of orders or on some other factors and takes the value 0 if the firm sets the price the same for all customers.

The dependent variable in all the models is the binary variable that takes the value 1 if the firm changes the price in response to the shock (i.e. in response to the demand increase, the demand decrease, the cost increase and the cost decrease) and takes the value 0 if it does not change the price.

Estimation results from binary probit models are provided in Table 27. To make it conscious, the analysis considers only the marginal effects on the higher probability

cell. The analysis is, thus, limited to the marginal effects on the probability that the firm changes the price following the shock.

Regression analysis shows that pricing decisions are influenced by the degree of competition when facing the demand shocks. Firms encountering stronger competition are more likely to change the prices not only when the demand decreases but also when the demand increases. The finding on the role of competition in influencing the price response to the dampened demand is in line with the one reported in Section 3.6.1.

Table 27. Explanations for price change in response to demand and cost shocks
(marginal effects for binary probit models; the table provides only marginal effects on the
probability that the price is changed in response to the shock)

	Type of shock:			
	demand increase	*demand decrease*	*cost increase*	*cost decrease*
Labour share	*0.001*	*-0.001*	*0.000*	*-0.003***
Trade firms	*-0.028*	*0.036*	*-0.067**	*-0.035*
Services firms	*0.057*	*-0.031*	*0.038*	*-0.035*
Firms 20-49	*-0.151**	*-0.023*	*0.040****	*-0.102*
Firms 50 and more	*0.079*	*0.084*	*0.012*	*0.007*
Collective pay agreements	*-0.085*	*-0.034*	*0.006*	*-0.090*
Flexible wage share	*0.002*	*-0.002*	*-0.001*	*-0.001*
Competition	*0.205******	*0.201******	*-0.023*	*0.086*
Foreign sales share	*0.002*	*-0.001*	*-0.001****	*0.001*
Regular customers share	*-0.003******	*-0.002*	*0.001****	*0.001*
Wholesale and retail firms share	*-0.001*	*0.000*	*0.000*	*-0.001*
Price discrimination	*0.147**	*0.244******	*-0.021*	*-0.080*
Pseudo R-squared	*0.077*	*0.056*	*0.143*	*0.037*
Wald statistic	*27.690*	*19.110*	*21.600*	*13.340*
Prob. (Wald statistic)	*0.006*	*0.086*	*0.042*	*0.345*
Number of observations	*287*	*264*	*291*	*267*

*Notes: * coefficient is statistically significant at the level of 10 percent, ** – significant at the level of 5 percent, *** – significant at the level of 1 percent; p-values are computed using Huber-White robust standard errors.*
Sources: the survey "On Price and Wage Setting" and author's estimations.

The results indicate that the price adjustment is less likely in the face of demand increase when firm's revenue generated by sales to the regular customers is higher. This shows the importance of non-formal – implicit – contracts in taking decisions on prices and corroborates with the conclusions drawn on the upward stickiness of

prices. Higher share of sales to the regular customers does not appear to be statistically significant in shaping the reaction of firms to the demand decrease.

Analysis shows that the firms accommodating prices to different customers are more likely to adjust the prices when facing the demand shocks. Firms that adhere to price discrimination are more likely to change the prices responding to both the demand increase and the demand decrease shocks. One more factor having an impact on price decisions when the demand varies is the size of the firm. Firms with 20 to 49 employees are less likely to adjust the prices following the demand increase as compared to the smaller firms. Firm size does not show up as a factor for price decisions in the case of demand decrease.

The study identifies a few forces influencing the pricing pattern following the higher costs shock, while the above described explanatory variables do not explain satisfactorily the pricing behaviour in the face of the lower costs shock, therefore no inferences are drawn from the latter regression. Estimates show that higher share of revenue generated by foreign sales reduces the likelihood of price adjustment when costs increase. Presumably this relates to stronger competition effects. The higher share of revenue generated by sales to the regular customers has an opposite impact. In the face of cost increase shock, in contrast to the case of demand increase shock, price adjustment appears to be more likely when the firms have stronger business relationship with their customers. This corresponds to propositions laid down in the implicit contracts theory.

Regression estimates point to another two factors associated with price decisions when costs increase. Firms in trade turn out to be less likely to adjust the prices in response to the higher costs as compared to the manufacturing firms, and the firms that employ 20 to 49 employees seem to be more likely to alter the prices following this shock than the smaller firms.

To check the robustness of estimation results, all the models are estimated using alternative definitions of the dependent variables. These variables are constructed as binary variables that take the value 1 if the price is adjusted in three or less months following the shock (i.e. following the demand increase, the demand decrease, the cost increase and the cost decrease) and take the value 0 if the price is changed after three months or it is not changed. Robustness analysis shows that under the different definition of the dependent variable it cannot be concluded that in the face of demand

increase the price adjustment is more likely in firms that use price discrimination (see Appendix 12). Firms that employ 20 to 49 employees, contrary to the findings mentioned above, do not turn out to be less likely to respond to the higher demand by changing prices as compared to the smaller firms. Additionally, the examination shows that the investigated set of variables is not statistically significant in describing the firms' response to cost increase using an alternative definition of the dependent variable.

Further regression analysis is conducted to test whether the firms are more or less likely to react to the demand increase and the cost increase as opposed to the demand decrease and the cost decrease. Data on both demand shocks and both cost shocks is pooled together. The model of responses to changes in demand and the model of responses to movements in costs include all explanatory variables outlined above. Apart from these variables, the models include a dummy variable indicating whether responses concern the upward change in demand and the upward change in costs respectively. *Demand increase* and *cost increase* take the value 1 if responses indicate reaction of firms to the increase in demand and the increase in costs respectively and take the value 0 otherwise. The dependent variables are defined as binary variables taking the value 1 if the firm changes the price following the investigated shocks and take the value 0 if it does not. Regression results conform to the ones presented earlier in this section. They point to a more likely response of firms by adjusting prices following the cost increase rather than the cost decrease, while the difference in the reaction to opposite changes in the demand is not found to be statistically significant (see Table 28).

The inferences concerning reaction to upward as opposed to downward change in demand and costs appear to be robust when the dependent variables in the models of pooled demand and pooled cost shocks are redefined as in the robustness analysis above (see Appendix 13).

To investigate the asymmetries in price adjustment the survey also inquired the firms to provide the information on the reasons that caused the upward change in prices and the reasons that were behind the downward change in prices in recent years. Firms were asked to render an assessment of the following potential explanations for the change in prices: a change in labour costs, a change in capital costs, a change in prices of raw materials or services that the firms buy, a change in

taxes, a change in prices of the competitors, a regularity of the price change, a change in the demand, the administrative measures of public authorities, a general price level (price change) in the country, and a change in the prospects of the inflation and/or other macroeconomic variables. The list of potential explanations for price increase also included a change in quality of the main product, while the series of potential explanations for price decrease also covered a change in the technology that lowered the costs and competitors' introduction of new and better products. Firms were requested to indicate whether the provided explanations were (1) not relevant, (2) of little relevance, (3) relevant, (4) very relevant for the price increase and for the price decrease or (5) they do not know.

Table 28. Explanations for price change in response to pooled demand and cost shocks (marginal effects for binary probit models; the table provides only marginal effects on the probability that the price is changed in response to the shock)

	Type of shock:	
	demand change	*cost change*
Labour share	*0.000*	*-0.002*
Trade firms	*0.005*	*-0.104**
Services firms	*0.017*	*0.001*
Firms 20-49	*-0.087*	*-0.014*
Firms 50 and more	*0.084*	*0.016*
Collective pay agreements	*-0.059*	*-0.056*
Flexible wage share	*0.000*	*-0.002*
Competition	*0.202****	*0.028*
Foreign sales share	*0.000*	*0.000*
Regular customers share	*-0.002****	*0.001*
Wholesale and retail firms share	*0.000*	*-0.001*
Price discrimination	*0.192****	*-0.069*
Demand increase	*-0.025*	*-*
Cost increase	*-*	*0.608****
Pseudo R-squared	*0.051*	*0.351*
Wald statistic	*36.430*	*216.630*
Prob. (Wald statistic)	*0.001*	*0.000*
Number of observations	*551*	*558*

Notes: * coefficient is statistically significant at the level of 10 percent, ** – significant at the level of 5 percent, *** – significant at the level of 1 percent; p-values are computed using Huber-White robust standard errors.
Sources: the survey "On Price and Wage Setting" and author's estimations.

The firms responded that the most momentous reasons for the upward price adjustment are related to the costs. In particular, higher prices of raw materials or

services that the firms buy and higher labour costs top the list of reasons for the price increase (see Table 29). Among the other five most decisive factors of the upward change in prices are a consideration of the general price level (price increase) in the country, higher quality of the main product and higher taxes. The analysed factors related to market conditions, like, an increase in prices of the competitors and an increase in the demand, stand out as somewhat less explanatory reasons for the price increase. A change in the prospects of the inflation and/or other macroeconomic variables and an increase in costs of capital are also viewed as somewhat less momentous explanations for the upward change in prices, while a regular increase in prices and a consideration of the administrative measures of public authorities rank as the factors of the lowest importance.

Table 29. Reasons for price increase during recent years
(share of firms for which the reason is "relevant" or "very relevant"; percent)

	Manu-facturing	Cons-truction	Trade	Business services	Total
Prices of raw materials or services (that the firm buys) increased	98.6	100.0	95.3	92.4	96.1
Labour costs increased	92.4	90.5	79.3	95.8	90.4
General price level (price increase) in the country was taken into account	57.0	89.5	64.4	59.1	64.5
Quality of the main product increased	67.8	44.9	53.2	70.5	61.9
Taxes increased	53.9	71.2	48.2	62.8	58.4
Prospects of the inflation and/or other macroeconomic variables changed	44.5	62.2	42.0	55.0	50.3
Competitors increased the price	49.7	48.8	49.3	36.1	45.0
Demand increased	31.0	60.3	40.2	49.6	43.8
Capital costs increased	34.2	48.8	50.3	38.2	41.3
Price is increased regularly	23.9	35.7	19.6	29.4	26.7
Administrative measures of public authorities were taken into account	8.5	4.6	7.2	10.9	8.4

Notes: responses are employment-weighted and rescaled to exclude non-responses.
Sources: the survey "On Price and Wage Setting" and author's calculations.

Firms in manufacturing and business services point out the same five factors that are viewed as the most momentous ones for the upward price adjustment as they are found for the whole sample of the surveyed firms. Construction and trade firms, however, attach relatively more importance to some other factors. In particular, for the firms in construction higher quality of the main product ranks somewhat below and a change in the prospects of the inflation and/or other macroeconomic variables

ranks somewhat higher in the list of explanations for the price increase. Trade firms attach relatively lower importance to higher taxes and greater importance to higher costs of capital when assessing the reasons for upward price adjustment.

Survey rendered rather different ranking of the explanations for price decrease as compared to the ranking of the factors for price increase. Firms indicated that the most decisive explanations for the downward price adjustment are related to market conditions. A decrease in prices of the competitors, a decrease in the demand and competitors' introduction of new and better products stand out among the five most momentous factors for the price decrease (see Table 30). The other most decisive factors are a consideration of the general price level (price decrease) in the country and a decrease in prices of raw materials or services that the firms buy. A change in the technology that lowered the costs and a change in the prospects of the inflation and/or other macroeconomic variables are regarded as less important explanations for the downward price adjustment. All the other investigated explanations, including those related to the costs – a decrease in costs of capital and a decrease in labour costs – are viewed as least relevant ones.

Table 30. Reasons for price decrease during recent years
(share of firms for which the reason is "relevant" or "very relevant"; percent)

	Manu-facturing	Cons-truction	Trade	Business services	Total
Competitors lowered the price	96.2	92.5	89.7	42.8	82.3
Demand decreased	85.0	64.2	75.4	12.2	63.6
General price level (price decrease) in the country was taken into account	50.9	100.0	58.5	41.1	57.7
Competitors introduced new and better products	71.5	64.2	62.6	6.9	53.9
Prices of raw materials or services (that the firm buys) decreased	46.8	71.6	58.6	34.2	51.1
Technologies improved what in turn lowered the costs	64.5	43.3	29.3	53.9	48.7
Prospects of the inflation and/or other macroeconomic variables changed	24.3	92.5	28.5	30.9	36.1
Capital costs decreased	12.6	35.8	23.0	29.3	22.5
Labour costs decreased	22.2	7.5	15.2	25.7	18.8
Taxes decreased	11.0	14.9	23.1	25.7	18.3
Price is lowered regularly	19.9	0.0	13.6	27.3	16.9
Administrative measures of public authorities were taken into account	10.3	0.0	8.1	0.0	6.1

Notes: responses are employment-weighted and rescaled to exclude non-responses.
Sources: the survey "On Price and Wage Setting" and author's calculations.

Firms in trade report a similar set of the five most explanatory factors of the downward price adjustment, while firms in other economic activities assign somewhat larger importance to some other factors. Firms in manufacturing rate a decrease in prices of raw materials or services that the firms buy somewhat lower, and they rate a change in the technology that lowered the costs somewhat higher. Construction firms express greater significance of a change in the prospects of the inflation and/or other macroeconomic variables and lower significance of a decrease in the demand and competitors' introduction of new and better products in explaining the downward price adjustment. Firms in business services render a particularly different ranking of the most decisive reasons for price decrease. These firms lend a significantly lower importance to a decrease in the demand and competitors' introduction of new and better products, and they assign higher importance to a change in the technology that lowered the costs and a change in the prospects of the inflation and/or other macroeconomic variables.

The evidence on reasons for the price increase and the price decrease in Lithuania compares to the one obtained for the euro area and Estonia. The studies on both the euro area (Fabiani et al., 2006) and Estonia (Dabušinskas and Randveer, 2006) assess five potential explanations for the upward and downward change in prices, in particular, a change in labour costs, a change in costs of raw materials, a change in financial costs, a change in the demand, and a change in prices of the competitors. These studies point to an increase in costs of raw materials and an increase in labour costs as the most momentous explanations for the upward price adjustment in the euro area and Estonia exactly matching the reported findings for Lithuania. The studies on the euro area and on Estonia show that the most decisive reasons for the downward price adjustment in these countries are a decrease in prices of the competitors, a decrease in costs of raw materials and a decrease in the demand. It conforms to the evidence elicited in the case of Lithuania where all these three explanations for the price decrease rank among the top ones.

Assessment of the investigated explanations for the movements in prices reveals asymmetric influence of some of the factors on the upward and downward change in prices. The cost factors, specifically, a change in labour costs and a change in prices of raw materials or services that the firms buy, turn out to be more decisive in invoking the price increase rather than the price decrease (see Table 31). This

corroborates with the above unfolded evidence on rather more likely price adjustment following the cost increase than in response to the cost decrease. The factors related to market conditions, in particular, a change in prices of the competitors and a change in the demand, appear to be more momentous in inducing the price decrease rather than the price increase – the observation that did not come out in the preceding shock analysis.

Table 31. Asymmetry of price change reasons
(difference between the shares of firms for which the reason for price increase and price decrease is "relevant" or "very relevant"; percentage points)

	Manu-facturing	Cons-truction	Trade	Business services	Total
Labour costs changed	*70.2*	*83.0*	*64.1*	*70.1*	*71.6*
Prices of raw materials or services (that the firm buys) changed	*51.9*	*28.4*	*36.6*	*58.2*	*45.0*
Taxes changed	*42.9*	*56.3*	*25.1*	*37.1*	*40.1*
Capital costs changed	*21.6*	*13.0*	*27.3*	*9.0*	*18.8*
Prospects of the inflation and/or other macroeconomic variables changed	*20.2*	*-30.3*	*13.5*	*24.1*	*14.2*
Price is changed regularly	*4.0*	*35.7*	*6.0*	*2.1*	*9.8*
General price level (price change) in the country was taken into account	*6.1*	*-10.5*	*5.9*	*18.0*	*6.9*
Administrative measures of public authorities were taken into account	*-1.8*	*4.6*	*-0.9*	*10.9*	*2.3*
Demand changed	*-54.1*	*-3.9*	*-35.2*	*37.4*	*-19.9*
Competitors changed the price	*-46.5*	*-43.7*	*-40.4*	*-6.7*	*-37.2*

Notes: responses are employment-weighted and rescaled to exclude non-responses.
Sources: the survey "On Price and Wage Setting" and author's calculations.

Manufacturing, trade and business services firms report the same most important factors leading to more likely price increase and more likely price decrease as they are found out for the whole set of the analysed firms with one exception in business services. In the latter economic activity only a change in prices of the competitors is viewed as the explanation for more likely downward change in prices. In construction somewhat different list of concerning factors is uncovered. Here, among the factors invoking more likely price increase, a change in taxes ranks somewhat higher than a change in prices of raw materials or services that the firms buy, and, among the factors causing more likely price decrease, a change in the prospects of the inflation and/or other macroeconomic variables is regarded as more important than a change in the demand.

The reported most decisive factors causing the price increase rather than the price decrease and vice versa stand out in line with the ones reported for the euro area (Fabiani et al., 2006) and Estonia (Dabušinskas and Randveer, 2006).

3.7. Concluding summary

The dissertation investigates features of the price setting in Lithuania using a unique dataset obtained in ad hoc survey "On Price and Wage Setting". The study aims to analyse the pricing ways and the outcomes at the micro level identifying, among others, the technological, institutional and market competition factors behind the behaviour of firms.

Analysis draws on the experience of the euro area and non-euro area EU countries that conducted the price (and wage) setting research based on firm-level data obtained from ad hoc surveys. The study uses the survey approach to analyse pricing introduced by Blinder (1991, 1994) and Blinder et al. (1998) who investigated the price setting patterns in the US. The method of survey proves to be useful to scrutinise factors of price decisions that are hard to uncover using other approaches of study and other sources of data. The surveys, for instance, allow investigating the explanations for sticky or asymmetric changes in prices that are difficult to address exploring the data on final prices and price indices. The surveys provide possibilities to study the adjustment of prices separately from the price review – something not scrutinised by other approaches in the price setting research.

The study of the firm-level data from an ad hoc survey disclosed a series of features of the price setting practices in Lithuanian firms. The survey pointed to the incidence of both the time-dependent and the state-dependent price reviewing policies used by the investigated firms. Most of them review the prices depending on the time and in certain – state-dependent – cases. Nevertheless, the price reviewing practices are somewhat tilted to the state-dependent pricing as the occurrence of the firms, reviewing prices only in certain cases, is more widespread than the prevalence of the firms that review the prices only regularly. All else equal, the state-dependent pricing implies a more responsive way of price setting.

According to the survey, somewhat more than one third of all the analysed firms review the prices in a non-regular pattern. Approximately one third of the

investigated firms review the prices daily to monthly, and almost one quarter of the firms review them quarterly to half yearly. Prices turn out to be reviewed more frequently than they are changed. As shown by the survey, in approximately one third of the firms the frequency of price changes does not follow any specific pattern, in approximately one quarter of the firms prices are changed on a quarterly to half yearly basis, and in approximately one fifth of the firms prices are changed once a year. This implies that stickiness of prices might occur at both the price reviewing stage and the price adjustment stage.

The survey showed that the change in prices is somewhat more frequent than the change in wages. In slightly more than 40 percent of the firms wages are changed once a year, and in approximately the same share of firms wages are changed more than once a year. This indicates that if prices respond less sensitively, it might be a result of the wage persistence.

The study revealed that the most common way to set prices is to choose them according to costs and completely self-determined profit margin. Notwithstanding the incidence of the pricing following the main competitors, this points to imperfectly competitive market in Lithuania. Other than perfectly competitive market is also suggested by rather widespread use of price discrimination.

In examining the delay in price adjustment when there are reasons to increase or lower prices, firms mostly refer to explanations related to the price adjustment stage. Firms indicate that the most momentous explanations for not adjusting prices either upwards or downwards are related to the costs that they encounter in operational activities – cost-based pricing – and the formal contracts (or, alternatively, explicit contracts) with their customers. The list of reasons for the upward stickiness of prices is followed by the non-formal contracts (or, alternatively, implicit contracts), the lack of coordinated actions with other firms – coordination failure – and the information costs. Among the most important factors for the sticky downward price adjustment firms also mention the temporary character of shocks, the possibly misleading signal on the quality and aforementioned failure of coordination between the firms. The physical price adjustment costs – menu costs – are viewed as least significant in causing the upward and downward stickiness of prices.

The analysis finds an asymmetric influence of some of the price factors. The cost factors, namely, movements in labour costs and movements in prices of raw

materials or services that the firms buy, appear to be more decisive in invoking the price increase rather than the price decrease. In corroboration, survey results indicate that prices are more likely to respond to the higher cost shocks rather than to the lower cost shocks. At the same time, evidence on the influence of factors related to market conditions is less clear-cut.

Regression analysis pointed to the asymmetry in the effects stemming from operational characteristics of firms when they decide on prices. The non-formal contracts, proxied by the revenue from sales to regular customers, are found to limit price adjustment when demand goes up, but not when demand goes down. Price accommodation to different customers turns out to contribute to the response of prices to the demand decrease, but not to the demand increase.

The survey yielded somewhat mixed evidence on the relationship between labour costs and prices. Analysis showed that a considerable share of the surveyed firms would increase prices in response to the wage shock. The labour cost share appeared to be an important determinant of price increase in response to this shock. Quite many firms also admitted that there is a link between the timing of price changes and wage changes. However, the labour cost share was not found to be significant in affecting the frequency of price changes.

Apart from characteristics of the pricing patterns, the survey yielded some features and indications on the role of labour compensation settings and market competition. It was found out that Lithuanian firms tend to use performance-related bonuses as a form of labour compensation. 73.5 percent of the firms use flexible wage components that account for 17.1 percent of the total wage bill. Regression analysis revealed that a higher flexible wage share mitigates firms' responses to the slowdown in demand by lowering the likelihood of the margin decrease and the output decrease. It also mitigates responses to the intermediate input cost rise by making the likelihood of margin adjustment lower.

The survey showed relatively low presence of collective pay agreements. Approximately one quarter of the firms apply collective pay agreements signed at the firm level, while collective pay agreements are very rare at the national level. In the surveyed firms 15.7 percent of employees are covered by these agreements. The role of collective pay agreements is found to be rather limited in shaping the responses of

firms to economic shocks. These agreements, however, appear to be associated with more frequent wage adjustment.

Regression analysis pointed to the importance of competition behind the behaviour of Lithuanian firms. It was found out that a higher level of competition increases the likelihood of the price change following both the positive and the negative demand shocks. Greater exposure to foreign markets, which is associated with higher competition pressures, appears to be significant in lowering the likelihood of the price increase in response to the intermediate input cost and wage shocks. Competition and exposure to foreign markets were found to be important in fostering adjustment through margins. Higher competition also turned to be significant in contributing to more frequent change in prices.

CHAPTER 4.   GENERAL CONCLUSIONS OF THE DISSERTATION

The dissertation investigates the price setting and the price stickiness in Lithuania. The study explores aggregate and firm-level data to analyse the ways and the outcomes of pricing identifying, among others, the technological, institutional and market competition factors that lie behind the behaviour of firms.

To analyse the pricing behaviour from a macroeconomic perspective, the dissertation uses a NKPC framework following Galí and Gertler (1999) and Galí et al. (2001) for the closed economy case and Leith and Malley (2007) for the open economy case. The framework allows examining the role of the real marginal cost, the expected inflation and the lagged inflation in governing the present inflation. It also enables investigating the structural parameters that underlie the inflation process, namely, the fraction of firms that keep prices unchanged – a parameter used in Calvo price setting applied in the deduction of the estimate of the price duration, and the fraction of firms that adjust the prices following the backward looking rule of thumb – parameter used in the hybrid NKPC formulation to account for inflation inertia.

The analysis in a microeconomic perspective is conducted using a unique dataset obtained in ad hoc survey "On Price and Wage Setting" that was carried out in Lithuania in 2008. The study draws on the experience of the euro area and non-euro area EU countries that conducted the price (and wage) setting research based on firm-level data obtained from ad hoc surveys undertaken in coordinated efforts. The conducted research uses the survey approach to analyse pricing introduced by Blinder (1991, 1994) and Blinder et al. (1998) who investigated the price setting patterns in the US. The method of survey proves to be useful in a number of ways to scrutinise factors of the firms' decisions that are hard to uncover using other datasets.

The conducted research yielded a series of results on the features of price setting in Lithuanian firms. A few results are related to the ways and practices of the price review and the price adjustment as well as to the frequency of this adjustment. Frequency of price changes is often viewed as a measure of prices stickiness, therefore it is of particular interest for the performed research:

- the conducted survey pointed to the incidence of both the time-dependent and the state-dependent price reviewing policies used by the investigated

Lithuanian firms. Most of them review the prices depending on the time and in certain – state-dependent – cases. Price reviewing practices, nevertheless, are somewhat tilted to the state-dependent pricing as the occurrence of the firms, reviewing prices only in certain cases, is more widespread than the prevalence of the firms that review the prices only regularly. All else equal, the state-dependent pricing implies a more responsive way of price setting;

- according to the survey, somewhat more than one third of all the analysed firms review the prices in a non-regular pattern. Approximately one third of the investigated firms review the prices daily to monthly, and almost one quarter of the firms review them quarterly to half yearly. Prices turn out to be reviewed more frequently than they are changed. The survey shows in approximately one third of the firms the frequency of price changes does not follow any specific pattern, while in approximately one quarter of the firms prices are changed on a quarterly to half yearly basis and in approximately one fifth of the firms prices are changed once a year. This implies that stickiness of prices might occur at both the price reviewing stage and the price adjustment stage;

- the survey evidence on the frequency of price changes stands in line with the evidence on price duration implied by the estimates of the fraction of firms that keep prices unchanged – a Calvo parameter used in the considered NKPC models – though NKPC estimates yield somewhat lower frequency of price changes. The estimates of the mentioned fraction of firms range between 0.73 and 0.78. The estimates imply that the price duration in Lithuania stands at around 3.8-4.6 quarters;

in the considered NKPC models the fraction of firms, which are not allowed to change the prices, has the impact on the role of the expected inflation and (in hybrid NKPC case) the lagged inflation in shaping the present inflation. If proportion of firms, which keep their prices unchanged, is higher, the role of the expected inflation is stronger and the role of the lagged inflation (in hybrid NKPC case) is weaker. The obtained estimates indicate that the present inflation in Lithuania is primarily driven by the inflation expectations. In hybrid NKPC case the role of the lagged inflation

is also found to be statistically significant though the magnitude of parameters, reflecting the importance of the lagged inflation, is found to be lower than that of parameters corresponding to the expected inflation. In addition, the estimates point to the presence of real marginal costs in the inflation formation in Lithuania. The size of the parameters, representing the importance of the real marginal costs, however, is quite low. This is a common result in the New Keynesian literature;

the conducted research provides less conclusive evidence on the fraction of firms that adjust the prices according to the backward looking rule of thumb, a parameter used in the hybrid NKPC formulation to account for inflation inertia. The higher the fraction of the backward looking firms, the stronger is the role of the lagged inflation and the weaker is the role of the expected inflation in determining the current inflation. The aforementioned parameter is found to be statistically significant only in the open economy case where it stands at 0.23;

- the survey showed that the change in prices is somewhat more frequent than the change in wages. In slightly more than 40 percent of the firms wages are changed once a year and in approximately the same share of firms wages are changed more than once a year. This indicates that the lower responsiveness of prices might be a result of wage persistence;

- the study revealed that the most common way to set prices is to choose them according to costs and completely self-determined profit margin. The pricing following the main competitors is also incidental though it is less widespread. This points to imperfectly competitive market in Lithuania justifying the assumption of monopolistic competition used in the NKPC research. Other than perfectly competitive market is also suggested by rather widespread use of price discrimination;

- in examining the delay in price adjustment when there are reasons to increase or lower prices, the surveyed firms mostly referred to explanations related to the price adjustment stage. Firms indicated that the most momentous explanations for not adjusting prices either upwards or downwards are related to the costs that they encounter in operational activities – cost-based pricing – and the formal contracts (or, alternatively,

explicit contracts) with their customers. The list of reasons for the upward stickiness of prices is followed by the non-formal contracts (or, alternatively, implicit contracts), the lack of coordinated actions with other firms – coordination failure – and the information costs. Among the most important factors for the sticky downward price adjustment firms also mentioned the temporary character of shocks, the possibly misleading signal on the quality and aforementioned failure of coordination between the firms. The physical price adjustment costs – menu costs – are viewed as least significant in causing the upward and downward stickiness of prices.

The performed analysis found an asymmetric influence of some of the price factors:

- the cost factors, namely, movements in labour costs and movements in prices of raw materials or services that the firms buy, appeared to be more decisive in invoking the price increase rather than the price decrease. In corroboration, survey results indicated that the prices are more likely to respond to the higher cost shocks rather than to the lower cost shocks. At the same time, evidence on the influence of factors related to the market conditions is less clear-cut;

- regression analysis pointed to the asymmetry in the effects stemming from operational characteristics of firms when they decide on prices. The non-formal contracts, proxied by the revenue from sales to regular customers, are found to limit price adjustment when the demand goes up, but not when the demand goes down. Price accommodation to different customers turns out to contribute to the response of prices to the demand decrease, but not to the demand increase.

The conducted research yielded somewhat mixed evidence on the relationship between labour costs and prices. The survey analysis showed that a considerable share of firms would increase prices in response to the wage shock. The labour cost share appeared to be an important determinant of the price increase in response to this shock. Quite many firms admitted that there is a link between the timing of price changes and wage changes. However, the labour cost share was not found to be significant in affecting the frequency of price changes.

Apart from characteristics on the price setting, the analysis yielded a number of features and indications on the role of labour compensation settings and market competition:

- using the survey data it was found out that Lithuanian firms tend to use performance-related bonuses as a form of labour compensation. 73.5 percent of the firms use flexible wage components that account for 17.1 percent of the total wage bill. Regression analysis revealed that a higher flexible wage share mitigates firms' responses to the slowdown in demand by lowering the likelihood of the margin decrease and the output decrease. It also mitigates responses to the intermediate input cost rise by making the likelihood of margin adjustment lower;

- the survey showed relatively low presence of collective pay agreements. Approximately one quarter of the firms apply collective pay agreements signed at the firm level, while collective pay agreements are very rare at the national level. In the surveyed firms 15.7 percent of employees are covered by these agreements. The role of collective pay agreements is found to be rather limited in shaping the responses of firms to the economic shocks. These agreements, however, appeared to be associated with more frequent wage adjustment;

- regression analysis pointed to the importance of competition behind the behaviour of Lithuanian firms. It was found that a higher level of competition increases the likelihood of the price change following both the positive and the negative demand shocks. Greater exposure to foreign markets, which is associated with higher competition pressures, appeared to be significant in lowering the likelihood of price increase in response to the intermediate input cost and wage shocks. Competition and exposure to foreign markets were found to be important in fostering the adjustment through margins. Higher competition also turned to be significant in contributing to a more frequent change in prices.

APPENDICES

Appendix 1. Standard log-linearization

This appendix introduces a standard log-linearization method used to transform the nonlinear functions into their counterparts expressed in terms of log-deviations of the variables from their steady state values.

Log-linearization is performed by applying the first-order Taylor series expansion around the steady state.

In its general form, a Taylor series expansion of a continuously differentiable function $f(x)$ in a neighbourhood of $x = x_0$ is expressed as

$$f(x) \approx f(x_0) + \frac{\partial f(x_0)}{\partial x}(x - x_0) + \frac{1}{2}\frac{\partial f^2(x_0)}{\partial x^2}(x - x_0)^2 + \dots$$

Assume X denotes a steady state value of variable X_t. Define the log-deviation of variable X_t from its steady state as $\hat{x}_t = \ln X_t - \ln X = \ln\left(\frac{X_t}{X}\right) = \ln\left(1 + \frac{X_t - X}{X}\right)$. The first-order Taylor series expansion of the latter expression around the steady state $X_t = X$ is given by $\ln\left(1 + \frac{X_t - X}{X}\right) \approx \ln(1) + \frac{1}{X}(X_t - X) = \frac{X_t - X}{X}$. To put it differently, variable's log-deviation from its steady state approximately equals to its percentage difference from the steady state, i.e.

$$\hat{x}_t = \ln\left(\frac{X_t}{X}\right) \approx \frac{X_t - X}{X}. \tag{A1.1}$$

Depending on the equation needs, (A1.1) could be rearranged as

$$X_t \approx X(1 + \hat{x}_t). \tag{A1.2}$$

A variable X_t can also be expressed as $X_t = Xe^{\ln\left(\frac{X_t}{X}\right)} = Xe^{\hat{x}_t}$. The first-order Taylor series expansion of the latter statement around the steady state $\hat{x}_t = \hat{x}$ is given by $Xe^{\hat{x}_t} \approx Xe^{\hat{x}} + Xe^{\hat{x}}(\hat{x}_t - \hat{x})$. Since $\hat{x} = \ln\hat{x} - \ln\hat{x} = 0$, the derived approximation falls to $X + X\hat{x}_t$ implying $X_t = Xe^{\hat{x}_t} \approx X(1 + \hat{x}_t)$, which compares to (A1.2).

Specific nonlinear functions may require additional approximations so that to transform them into their counterparts expressed in terms of log-deviations of the

variables from their steady state values. Consider the case when variable X_t is raised to the power $1-\varepsilon$. $X_t^{1-\varepsilon} = \left(Xe^{\hat{x}_t}\right)^{1-\varepsilon} = X^{1-\varepsilon}e^{(1-\varepsilon)\hat{x}_t}$ can then be proximated by the first-order Taylor series expansion around the steady state $\hat{x}_t = \hat{x}$ as

$X_t^{1-\varepsilon} \approx X^{1-\varepsilon}e^{(1-\varepsilon)\hat{x}} + X^{1-\varepsilon}e^{(1-\varepsilon)\hat{x}}(1-\varepsilon)(\hat{x}_t - \hat{x})$. Since $\hat{x} = 0$, this approximation results in

$$X_t^{1-\varepsilon} \approx X^{1-\varepsilon} + X^{1-\varepsilon}(1-\varepsilon)\hat{x}_t = X^{1-\varepsilon}\left(1 + (1-\varepsilon)\hat{x}_t\right). \tag{A1.3}$$

The result (A1.3) could be used to log-linearize the price level equation (2.3), which is reproduced below

$$P_t = \left((1-\theta)\left(P_t^*\right)^{1-\varepsilon} + \theta P_{t-1}^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}. \tag{A1.4}$$

Raising both sides of the equation (A1.4) to the power $1-\varepsilon$, applying (A1.3) and assuming that in a steady state $P^* = P$ allows to obtain

$$P_t^{1-\varepsilon} = (1-\theta)\left(P_t^*\right)^{1-\varepsilon} + \theta P_{t-1}^{1-\varepsilon}$$

$$P^{1-\varepsilon}\left(1 + (1-\varepsilon)\hat{p}_t\right) = (1-\theta)\left(P^*\right)^{1-\varepsilon}\left(1 + (1-\varepsilon)\hat{p}_t^*\right) + \theta P^{1-\varepsilon}\left(1 + (1-\varepsilon)\hat{p}_{t-1}\right)$$

$$1 + (1-\varepsilon)\hat{p}_t = (1-\theta)\left(1 + (1-\varepsilon)\hat{p}_t^*\right) + \theta\left(1 + (1-\varepsilon)\hat{p}_{t-1}\right)$$

$$1 + (1-\varepsilon)\hat{p}_t = (1-\theta) + (1-\theta)(1-\varepsilon)\hat{p}_t^* + \theta + \theta(1-\varepsilon)\hat{p}_{t-1}$$

$$(1-\varepsilon)\hat{p}_t = (1-\theta)(1-\varepsilon)\hat{p}_t^* + \theta(1-\varepsilon)\hat{p}_{t-1}$$

$$\hat{p}_t = (1-\theta)\hat{p}_t^* + \theta\hat{p}_{t-1}. \tag{A1.5}$$

To consider a more general case, assume the following equation $f(Y_t) = g(X_t, Z_t)$, which can be expressed as

$$\ln\left(f\left(e^{\ln(Y_t)}\right)\right) = \ln\left(g\left(e^{\ln(X_t)}, e^{\ln(Z_t)}\right)\right). \tag{A1.6}$$

The first-order Taylor series expansion of the left-hand side of equation (A1.6) around the steady state $\ln(Y_t) = \ln(Y)$ is given by

$$\ln(f(Y)) + \frac{1}{f(Y)}f'(Y)Y\hat{y}_t. \tag{A1.7}$$

Analogously, the first-order Taylor series expansion of the right-hand side of equation (A1.6) around the steady state $\ln(X_t) = \ln(X)$ and $\ln(Z_t) = \ln(Z)$ is expressed as

$$\ln(g(X,Z)) + \frac{1}{g(X,Z)}\left(g_1(X,Z)X\hat{x}_t + g_2(X,Z)Z\hat{z}_t\right). \tag{A1.8}$$

Combining (A1.7), (A1.8) and (A1.6) yields a log-linearization rule

$$f'(Y)Y\hat{y}_t \approx g_1(X,Z)X\hat{x}_t + g_2(X,Z)Z\hat{z}_t. \tag{A1.9}$$

For illustrative purposes, the result (A1.9) could be applied to log-linearize once again the price level equation (A1.4). Applying generic log-linearization rule and assuming that in a steady state $P^* = P$ yields

$$P\hat{p} = \frac{1}{1-\varepsilon}\left((1-\theta)(P^*)^{1-\varepsilon} + \theta P^{1-\varepsilon}\right)^{\frac{\varepsilon}{1-\varepsilon}}\left((1-\theta)(1-\varepsilon)(P^*)^{-\varepsilon}P^*\hat{p}_t^* + \theta(1-\varepsilon)P^{-\varepsilon}P\hat{p}_{t-1}\right)$$

$$P\hat{p} = \left((1-\theta)(P^*)^{1-\varepsilon} + \theta P^{1-\varepsilon}\right)^{\frac{\varepsilon}{1-\varepsilon}}\left((1-\theta)(P^*)^{1-\varepsilon}\hat{p}_t^* + \theta P^{1-\varepsilon}\hat{p}_{t-1}\right)$$

$$P\hat{p} = P^{\varepsilon}\left((1-\theta)P^{1-\varepsilon}\hat{p}_t^* + \theta P^{1-\varepsilon}\hat{p}_{t-1}\right)$$

$$P^{1-\varepsilon}\hat{p} = (1-\theta)P^{1-\varepsilon}\hat{p}_t^* + \theta P^{1-\varepsilon}\hat{p}_{t-1}$$

$$\hat{p} = (1-\theta)\hat{p}_t^* + \theta\hat{p}_{t-1}. \qquad (A1.10)$$

Appendix 2. Derivation of optimal price when prices are flexible: closed economy case

In a closed economy, when prices are set in a perfectly flexible way, i.e. firms are not subject to any restrictions to adjust the prices, each of the firms chooses a price P_{jt} so that to maximize its profit in a time t. Firm is solving the profit maximization problem

$$\max_{P_{jt}} \left(P_{jt} Y_{jt} - MC_{jt} Y_{jt} \right) \tag{A2.1}$$

subject to the demand condition $Y_{jt} = \left(\dfrac{P_{jt}}{P_t} \right)^{-\varepsilon} Y_t$.

Substituting the demand function into the firm's maximization problem (A2.1) and taking the first order condition with respect to P_{jt} yields

$$\max_{P_{jt}} \left(P_{jt} \left(\frac{P_{jt}}{P_t} \right)^{-\varepsilon} Y_t - MC_{jt} \left(\frac{P_{jt}}{P_t} \right)^{-\varepsilon} Y_t \right)$$

$$(1-\varepsilon) \left(\frac{P_{jt}}{P_t} \right)^{-\varepsilon} Y + \varepsilon MC_{jt} \left(\frac{P_{jt}}{P_t} \right)^{-\varepsilon} P_{jt}^{-1} Y = 0$$

$$(1-\varepsilon) + \varepsilon MC_{jt} P_{jt}^{-1} = 0$$

$$P_{jt} = \frac{\varepsilon}{\varepsilon - 1} MC_{jt}. \tag{A2.2}$$

The result (A2.2) implies that in a steady state

$$P_j = \frac{\varepsilon}{\varepsilon - 1} MC_j. \tag{A2.3}$$

The outcome (A2.3) postulates that in a steady state in the absence of nominal price setting rigidities and under the assumption of constant-price-elasticity demand each of the firms sets a price P_j as a constant mark-up $\dfrac{\varepsilon}{\varepsilon - 1} = \mu$ over its nominal marginal cost.

Log-linearizing (A2.2) as described in Appendix 1 gives

$$\hat{p}_{jt} = \hat{mc}_{jt} \tag{A2.4}$$

implying that in the current setup in the absence of nominal rigidities for the price setting the prices move in line with the current nominal marginal cost.

Appendix 3. Derivation of optimal price when prices are flexible: open economy case

In an open economy, when prices are set in a perfectly flexible way, each of the firms chooses a price P_{jt}^d in a time t and solves a profit maximization problem analogous to the one in a closed economy

$$\max_{P_{jt}^d} \left(P_{jt}^d Y_{jt} - MC_{jt} Y_{jt} \right) \tag{A3.1}$$

subject to the demand condition $Y_{jt} = \left(\dfrac{P_{jt}^d}{P_t^d} \right)^{-\varepsilon} Y_t$.

A solution to the firm's maximization problem (A3.1) yields a result that compares to the one obtained in the closed economy case

$$P_{jt}^d = \frac{\varepsilon}{\varepsilon - 1} MC_{jt}. \tag{A3.2}$$

In a steady state, the outcome (A3.2) implies

$$P_j^d = \frac{\varepsilon}{\varepsilon - 1} MC_j. \tag{A3.3}$$

To put it differently, the relation (A3.3) says that in a steady state in the absence of nominal price setting rigidities and under the assumption of constant-price-elasticity demand each of the firms sets a price P_j^d as a constant mark-up $\dfrac{\varepsilon}{\varepsilon - 1} = \mu$ over its nominal marginal cost.

The log-linearized version of (A3.2) is

$$\hat{p}_{jt}^d = m\hat{c}_{jt} \tag{A3.4}$$

implying that in the described setup in the absence of nominal rigidities for the price setting the prices move in line with the current nominal marginal cost.

Appendix 4. Variables used as instruments in New Keynesian Phillips curve estimations

Figure 4. Variables used as instruments in New Keynesian Phillips curve estimations
(a) real GDP   *(b) unemployment rate*

(c) wage inflation   *(d) trading partners' real GDP*

(e) trading partners' inflation   *(f) import price inflation*
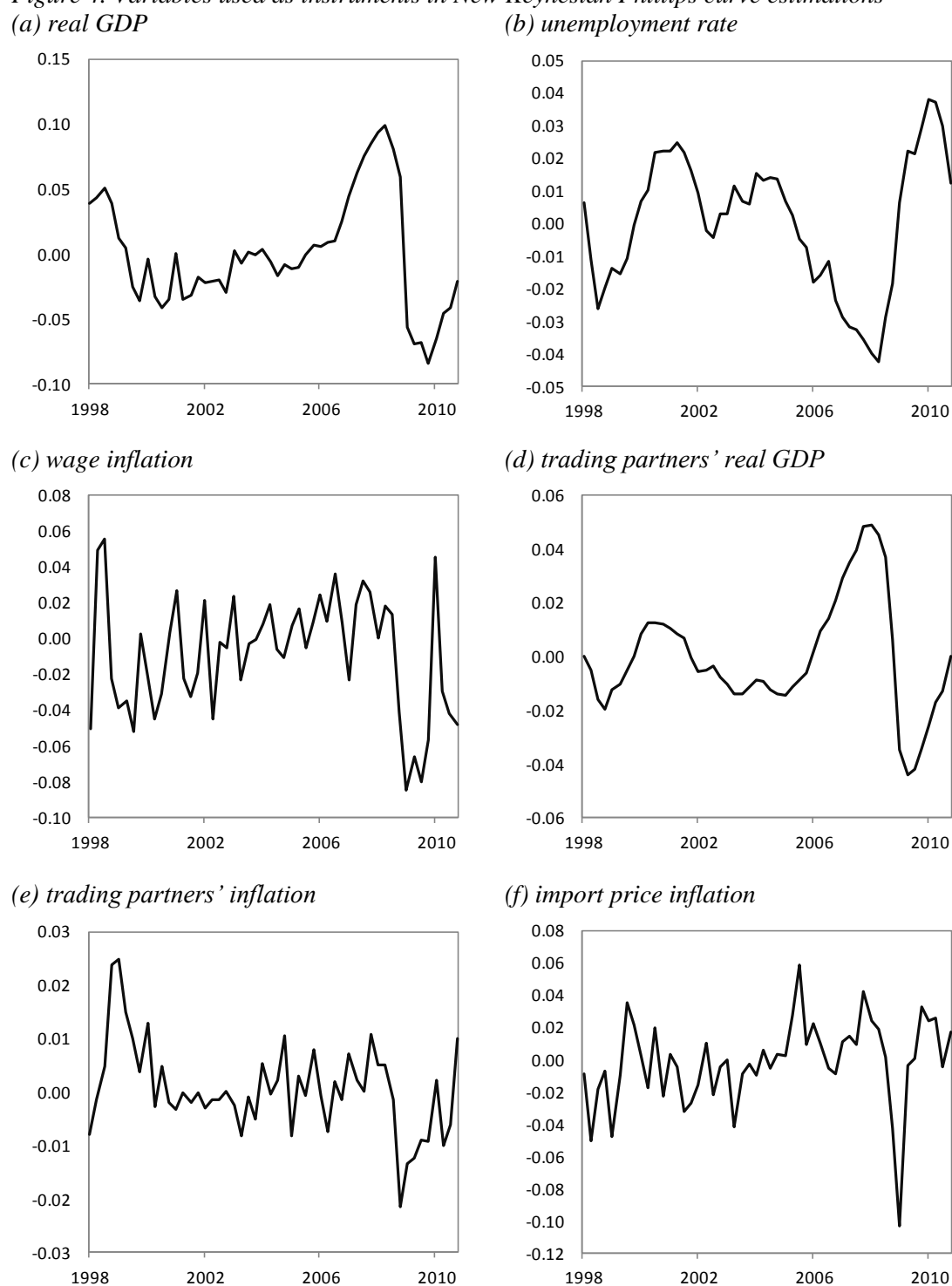
Notes and sources are provided beneath the figure continuation on the next page.

Figure 4 (continued). Variables used as instruments in New Keynesian Phillips curve estimations

(g) oil price inflation in the US dollars

(h) oil price inflation in Lithuanian litas
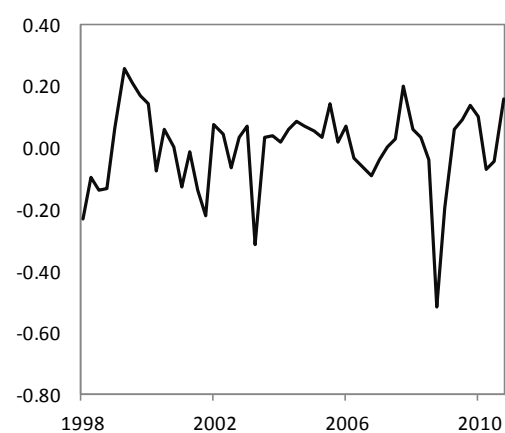
(i) nominal effective exchange rate inflation
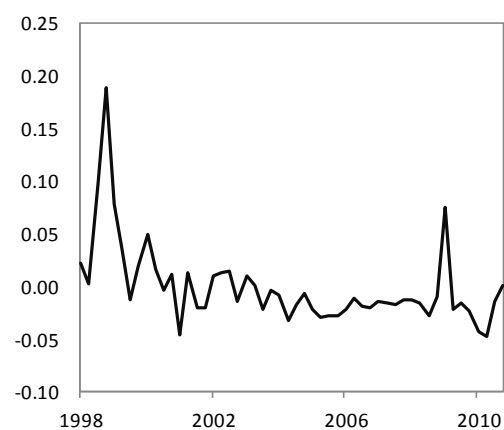
Notes: all variables represent deviations from their respective steady state values.
Sources: Bank of Lithuania, Bloomberg Professional, Eurostat, OECD, RFS and author's calculations.

Appendix 5. Stationarity testing of the variables used in New Keynesian Phillips curve estimations

Table 32. Unit root tests of the variables used in the estimations
(estimation period – 1998Q4 through 2010Q4)

	Inflation	*Closed economy real marginal cost*	*Open economy real marginal cost (1)*	*Open economy real marginal cost (2)*	*Open economy real marginal cost (3)*
t-statistic of augmented Dickey-Fuller test					
Case A	*-3.447**	*-1.483*	*-2.002*	*-1.951*	*-1.906*
Case B	*-3.237***	*-1.469*	*-1.833*	*-1.792*	*-1.756*
Case C	*-3.022****	*-1.623**	*-1.788**	*-1.754**	*-1.724**
t-statistic of Dickey-Fuller GLS test					
Case A	*-3.294***	*-1.498*	*-2.043*	*-1.992*	*-1.946*
Case B	*-2.970****	*-1.401*	*-1.851**	*-1.812**	*-1.778**
t-statistic of Phillips-Perron test					
Case A	*-7.004****	*-1.452*	*-2.107*	*-2.050*	*-1.999*
Case B	*-6.830****	*-1.502*	*-1.908*	*-1.861*	*-1.821*
Case C	*-6.479****	*-1.653**	*-1.849**	*-1.810**	*-1.776**

Notes and the source are provided beneath the table continuation.

Table 32 (continued). Unit root tests of the variables used in the estimations
(estimation period – 1998Q4 through 2010Q4)

	Real GDP	*Unemployment rate*	*Wage inflation*	*Trading partners' real GDP*	*Trading partners' inflation*
t-statistic of augmented Dickey-Fuller test					
Case A	*-2.080*	*-2.677*	*-4.624****	*-4.030***	*-4.210****
Case B	*-2.067*	*-2.640**	*-4.680****	*-4.077****	*-3.763****
Case C	*-2.063***	*-2.676****	*-4.281****	*-4.122****	*-3.785****
t-statistic of Dickey-Fuller GLS test					
Case A	*-1.870*	*-2.471*	*-3.916****	*-4.082****	*-4.241****
Case B	*-1.634*	*-2.522**	*-3.028****	*-4.010****	*-3.641****
t-statistic of Phillips-Perron test					
Case A	*-2.490*	*-2.103*	*-4.684****	*-2.269*	*-4.368****
Case B	*-2.479*	*-2.100*	*-4.737****	*-2.299*	*-3.685****
Case C	*-2.488***	*-2.129***	*-4.359****	*-2.313***	*-3.696****

Notes and the source are provided beneath the table continuation.

Table 32 (continued). Unit root tests of the variables used in the estimations (estimation period – 1998Q4 through 2010Q4)

	Import price inflation	*Oil price inflation in the US dollars*	*Oil price inflation in Lithuanian litas*	*Nominal effective exchange rate inflation*
t-statistic of augmented Dickey-Fuller test				
Case A	*-4.653****	*-4.778****	*-4.804****	*-4.270****
Case B	*-4.586****	*-4.796****	*-4.831****	*-4.023****
Case C	*-4.638****	*-4.823****	*-4.860****	*-4.037****
t-statistic of Dickey-Fuller GLS test				
Case A	*-4.718****	*-4.511****	*-4.533****	*-3.692***
Case B	*-4.374****	*-4.280****	*-4.272****	*-2.180***
t-statistic of Phillips-Perron test				
Case A	*-4.675****	*-4.543****	*-4.834****	*-3.963***
Case B	*-4.600****	*-4.584****	*-4.863****	*-3.839****
Case C	*-4.652****	*-4.621****	*-4.894****	*-3.856****

Notes: * indicates statistical significance at the level of 10 percent, ** indicates statistical significance at the level of 5 percent, *** indicates statistical significance at the level of 1 percent; in case A test equation includes intercept and trend, in case B test equation includes intercept, in case C test equation does not include neither intercept, nor trend; all variables represent deviations from their respective steady state values; open economy real marginal cost is computed by setting price mark-up to 1.15, 1.2 and 1.25 (cases (1), (2) and (3) respectively) and elasticity of substitution between labour and imported goods to 0.5.
Source: author's estimations.

Appendix 6. Estimates for New Keynesian Phillips curve in an open economy: models with alternative assumptions of price mark-up

Table 33. Reduced-form estimates for baseline New Keynesian Phillips curve in an open economy: models with alternative assumptions of price mark-up (estimation period – 1998Q4 through 2010Q4)

	$\mu = 1.15$	$\mu = 1.2$	$\mu = 1.25$
λ	0.095***	0.093***	0.091***
β	0.951***	0.960***	0.968***
SE of regression	0.026	0.026	0.026
DW-statistic	3.146	3.156	3.163
Q-statistic (lag 1)	19.396	19.671	19.889
Prob.(Q-statistic (lag 1))	0.000	0.000	0.000
Q-statistic (lag 4)	26.677	26.957	27.180
Prob.(Q-statistic (lag 4))	0.000	0.000	0.000
J-statistic	6.709	6.727	6.743
Prob.(J-statistic)	0.917	0.916	0.915
Number of observations	49	49	49

*Notes: * indicates statistical significance at the level of 10 percent, ** indicates statistical significance at the level of 5 percent, *** indicates statistical significance at the level of 1 percent; p-values are computed using heteroscedasticity and autocorrelation robust standard errors; instruments include four lags of inflation, four lags of real marginal cost, three lags of unemployment rate and three lags of trading partners' inflation; all variables represent deviations from their respective steady state values; elasticity of substitution between labour and imported goods is set to 0.5.*
Source: author's estimations.

Table 34. Structural estimates for baseline New Keynesian Phillips curve in an open economy: models with alternative assumptions of price mark-up (estimation period – 1998Q4 through 2010Q4)

	$\mu = 1.15$	$\mu = 1.2$	$\mu = 1.25$
θ	0.751***	0.750***	0.750***
β	0.951***	0.960***	0.968***
SE of regression	0.026	0.026	0.026
DW-statistic	3.146	3.156	3.163
Q-statistic (lag 1)	19.396	19.671	19.889
Prob.(Q-statistic (lag 1))	0.000	0.000	0.000
Q-statistic (lag 4)	26.677	26.957	27.180
Prob.(Q-statistic (lag 4))	0.000	0.000	0.000
J-statistic	6.709	6.727	6.743
Prob.(J-statistic)	0.917	0.916	0.915
Number of observations	49	49	49

Notes: * indicates statistical significance at the level of 10 percent, ** indicates statistical significance at the level of 5 percent, *** indicates statistical significance at the level of 1 percent; p-values are computed using heteroscedasticity and autocorrelation robust standard errors; instruments include four lags of inflation, four lags of real marginal cost, three lags of unemployment rate and three lags of trading partners' inflation; all variables represent deviations from their respective steady state values; elasticity of substitution between labour and imported goods is set to 0.5.
Source: author's estimations.

Table 35. Reduced-form estimates for hybrid New Keynesian Phillips curve in an open economy: models with alternative assumptions of price mark-up (estimation period – 1998Q4 through 2010Q4)

	$\mu = 1.15$	$\mu = 1.2$	$\mu = 1.25$
$\tilde{\lambda}$	0.056**	0.054*	0.052*
γ_b	0.276***	0.275***	0.274***
γ_f	0.751***	0.762***	0.770***
SE of regression	0.025	0.025	0.025
DW-statistic	3.416	3.421	3.424
Q-statistic (lag 1)	28.004	28.162	28.289
Prob.(Q-statistic (lag 1))	0.000	0.000	0.000
Q-statistic (lag 4)	40.818	40.979	41.115
Prob.(Q-statistic (lag 4))	0.000	0.000	0.000
J-statistic	6.553	6.554	6.558
Prob.(J-statistic)	0.886	0.886	0.885
Number of observations	49	49	49

*Notes: * indicates statistical significance at the level of 10 percent, ** indicates statistical significance at the level of 5 percent, *** indicates statistical significance at the level of 1 percent; p-values are computed using heteroscedasticity and autocorrelation robust standard errors; instruments include four lags of inflation, four lags of real marginal cost, three lags of unemployment rate and three lags of trading partners' inflation; all variables represent deviations from their respective steady state values; elasticity of substitution between labour and imported goods is set to 0.5.*
Source: author's estimations.

Table 36. Structural estimates for hybrid New Keynesian Phillips curve in an open economy:
models with alternative assumptions of price mark-up
(estimation period – 1998Q4 through 2010Q4)

	$\mu = 1.15$	$\mu = 1.2$	$\mu = 1.25$
θ	0.730***	0.734***	0.737***
ω	0.239**	0.232**	0.225**
SE of regression	0.024	0.024	0.024
DW-statistic	3.379	3.378	3.377
Q-statistic (lag 1)	26.685	26.657	26.628
Prob.(Q-statistic (lag 1))	0.000	0.000	0.000
Q-statistic (lag 4)	38.879	38.728	38.592
Prob.(Q-statistic (lag 4))	0.000	0.000	0.000
J-statistic	6.721	6.757	6.792
Prob.(J-statistic)	0.916	0.914	0.913
Number of observations	49	49	49

*Notes: * indicates statistical significance at the level of 10 percent, ** indicates statistical significance at the level of 5 percent, *** indicates statistical significance at the level of 1 percent; p-values are computed using heteroscedasticity and autocorrelation robust standard errors; instruments include four lags of inflation, four lags of real marginal cost, three lags of unemployment rate and three lags of trading partners' inflation; all variables represent deviations from their respective steady state values; elasticity of substitution between labour and imported goods is set to 0.5; discount factor is set to 0.95.*
Source: author's estimations.

Appendix 7. Questions of the survey "On Price and Wage Setting"

Price setting

1 – What is the main product of your firm? _____ 0101

The main product is defined as a good or group of goods you sell or service you provide that generates the biggest part of your firms' revenue. If your firm produces (or sells) several goods (for instance, produces not only bread and cereal products, but also produces sweets and other products) or provides several services (for instance, not only apparel tailoring, but also apparel cleaning and other services), please provide information about "the main good or service" in 2007 (for instance, information only about bread and cereal products, or only about sweets, or only about apparel tailoring, or only about apparel cleaning).

2 – What share of your total revenues was generated by your main product? _____% 0201

3 – What share of the revenue generated by your firm's main product in the reference period was due to sales in:

Lithuania	____%	0301
EU countries	____%	0302
CIS countries	____%	0303
Other countries	____%	0304
In total	100%	

When providing answers to the rest of the questions of this part, please provide information about **the main product** and **the main market** as in questions **1** and **3**. The main market is the one where the largest revenue is generated.

4 – What was the market share of your main product (revenue generated by your main product compared to the revenue generated in the whole market)? 0401

Less than 1%	□	1
1% – 5%	□	2
6% – 10%	□	3
11% – 20%	□	4
21% – 30%	□	5
31% – 50%	□	6
More than 50%	□	7
Don't know	□	8

5 – What share of revenue was generated by sales of the main product to these customer groups:

Wholesale firms	____%	0501
Retail firms	____%	0502
Other firms	____%	0503
Public sector institutions and firms	____%	0504
Final consumers	____%	0505
Other customers (please identify) _____	____%	0506
In total	100%	

6 – What was the share of revenue generated by sales of the main product to regular clients? ____% 0601

7 – To what extent does your firm experience price competition for its main product?
<u>Please choose a single one option</u> 0701

Severe competition	□	1
Strong competition	□	2
Weak competition	□	3
No competition	□	4
Don't know	□	5

8 – Please asses the importance of these competitiveness factors:
<u>Please asses every factor</u>

	Not relevant	Of little relevance	Relevant	Very relevant	Don't know	
Product price	□ 1	□ 2	□ 3	□ 4	□ 5	0801
Product quality	□ 1	□ 2	□ 3	□ 4	□ 5	0802
Product oneness	□ 1	□ 2	□ 3	□ 4	□ 5	0803
Fast delivery of a product	□ 1	□ 2	□ 3	□ 4	□ 5	0804
Long lasting relationships with clients	□ 1	□ 2	□ 3	□ 4	□ 5	0805
Quality of service/handling	□ 1	□ 2	□ 3	□ 4	□ 5	0806
Other. Please specify _____	□ 1	□ 2	□ 3	□ 4	□ 5	0807

9 – Suppose that the main competitor for your firm's main product decreases its price; how likely is your firm to react by decreasing your own price? Please choose a single one option			0901
Very likely	□	1	
Likely	□	2	
Not likely	□	3	
Not at all	□	4	
It doesn't apply	□	5	

10 – How is the price of your firm's main product set in its main market? Please choose a single one option			1001
There is no autonomous price setting policy because:			
- the price is regulated	□	1	
- the price is set by a parent company	□	2	
- the price is set by the main customer(s)	□	3	
The price is set following the main competitors	□	4	
The price is set fully according to costs and a completely self-determined profit margin	□	5	
Other. Please specify _____	□	6	

11 – Do you set the same price of a main product for all customers?			1101
Yes	□	1	
No. The price depends on quantity of orders	□	2	
No. In each case we set the price individually	□	3	
No. Please specify other reasons _____	□	4	

12 – What percentage of your firm's total costs were due to:			1201
Fixed costs (rent, equipment purchase and the like)	_____ %	1	
Variable costs:			
Labour costs (including bonuses, income taxes, social security contributions and the like)	_____ %	2	
Energy costs (electricity, heat energy, gas)	_____ %	3	
Expenditure on fuels (petrol, diesel, oil)	_____ %	4	
Expenditure on other goods and services	_____ %	5	
In total	100%		

13 – What information do you take into account when you set prices?			1301
We take into account past development of various economic factors (demand, competitors prices, etc.)	□	1	
We take into account the likely future development of various economic factors (demand, competitors prices, etc.)	□	2	
We take into account both sources of information mentioned above	□	3	

14 – In what cases do you consider a possibility to review prices (not necessarily changing them)?			1401
We review regularly	□		1
We review in certain cases (for instance, when costs or demand change)	□ → GO TO QUESTION 16		2
Usually we review regularly and additionally in certain cases (for instance, when costs or demand change)	□		3
We review due to other reasons, for instance due to _____	□ → GO TO QUESTION 16		4
We never review prices without changing them	□ → GO TO QUESTION 16		5

15 – If you review prices regularly, how often do you review them?			1501
More than once in a year:			
- daily	□	1	
- weekly	□	2	
- monthly	□	3	
- quarterly	□	4	
- semi annually	□	5	
Annually	□	6	
Once in two years	□	7	
Less than once in two years	□	8	

16 – Under normal circumstances, how often is the price of the firm's main product typically <u>changed</u>?		
<u>Please choose a single one option</u>		1601

More than once a year:		
- daily	□	1
- weekly	□	2
- monthly	□	3
- quarterly	□	4
- half yearly	□	5
Once a year	□	6
Once every two years	□	7
Less frequently than once every two years	□	8
Never	□	9
There is not a defined pattern	□	10

17 – Under normal circumstances, are these price changes concentrated in any particular month / months?

Yes: Jan. □ Feb. □ March □ April □ May □ June □ July □ August □ Sept. □ Oct. □ Nov. □ Dec. □
1701 1702 1703 1704 1705 1706 1707 1708 1709 1710 1711 1712

No □
1713

18 – If there are factors forcing to increase the price, due to what reasons would you increase the price not immediately?
<u>Please asses every statement</u>

	Not relevant	Of little relevance	Rele-vant	Very relevant	Don't know	
1. If competitors did not increase the price, we would be the first to increase it. We would prefer to wait until competitors increase the price.	□ 1	□ 2	□ 3	□ 4	□ 5	1801
2. We have agreements with clients that limit increase in prices during period of agreement.	□ 1	□ 2	□ 3	□ 4	□ 5	1802
3. The price that we use is psychologically acceptable (for instance, 9.99Lt or 150Lt). We would change the price if new price were psychologically acceptable as well.	□ 1	□ 2	□ 3	□ 4	□ 5	1803
4. Once we increase the price, perhaps we would have to lower it after some time again.	□ 1	□ 2	□ 3	□ 4	□ 5	1804
5. Change of a price costs (for instance, we would have to print new price lists, to change information in internet, etc.).	□ 1	□ 2	□ 3	□ 4	□ 5	1805
6. We would increase the price only due to higher costs. However we would wait a bit before increasing the price.	□ 1	□ 2	□ 3	□ 4	□ 5	1806
7. We would not increase the price. However we would use other measures, for instance, we would lengthen delivery time.	□ 1	□ 2	□ 3	□ 4	□ 5	1807
8. It costs to collect information relevant to price change.	□ 1	□ 2	□ 3	□ 4	□ 5	1808
9. Clients usually are dissatisfied with price increase. We do not change price so that to keep good relationships with clients.	□ 1	□ 2	□ 3	□ 4	□ 5	1809
10. Other. Please specify _____						1810

19 – If there are factors allowing to lower the price, due to what reasons would you lower the price not immediately?
Please asses every statement

	Not relevant	Of little relevance	Rele-vant	Very relevant	Don't know	
1. If competitors did not lower the price, we would be the first to lower it. This might cause "price war".	□ 1	□ 2	□ 3	□ 4	□ 5	1901
2. We have agreements with clients that limit change in prices during period of agreement.	□ 1	□ 2	□ 3	□ 4	□ 5	1902
3. The price that we use is psychologically acceptable (for instance, 9.99Lt or 150Lt). We would change the price if new price were psychologically acceptable as well.	□ 1	□ 2	□ 3	□ 4	□ 5	1903
4. Once we lower the price, perhaps we would have to increase it after some time again.	□ 1	□ 2	□ 3	□ 4	□ 5	1904
5. Change of a price costs (for instance, we would have to print new price lists, to change information in internet, etc.).	□ 1	□ 2	□ 3	□ 4	□ 5	1905
6. We would lower the price only due to lower costs. However we would wait a bit before lowering the price.	□ 1	□ 2	□ 3	□ 4	□ 5	1906
7. We would not lower the price. However we would use other measures, for instance, we would shorten delivery time.	□ 1	□ 2	□ 3	□ 4	□ 5	1907
8. It costs to collect information relevant to price change.	□ 1	□ 2	□ 3	□ 4	□ 5	1908
9. Downward change in price might be perceived as a loss in quality.	□ 1	□ 2	□ 3	□ 4	□ 5	1909
10. Other. Please specify _____						1910

20 – Does the timing of price changes relate to that of wage changes?
Please choose a single one option — 2001

There is no link between the two	□	1
There is a link but no particular pattern	□	2
Decisions are taken simultaneously	□	3
Price changes tend to follow wage changes	□	4
Wage changes tend to follow price changes	□	5
Don't know	□	6

21 – If demand for your main product or costs changed enough to review the price, in what time would you change the price?

	We would change in	We would not change the price	Don't know	
In case of demand increase	_____ months 1	□ 2	□ 3	2101
In case of demand decrease	_____ months 1	□ 2	□ 3	2102
In case of cost increase	_____ months 1	□ 2	□ 3	2103
In case of cost decrease	_____ months 1	□ 2	□ 3	2104

22 – If you increased the price of your main product during last 5 years, due to what reasons did you increase the price?
Please asses every statement

	Not relevant	Of little relevance	Rele-vant	Very relevant	Don't know	
1. Labour costs increased	□ 1	□ 2	□ 3	□ 4	□ 5	2201
2. Capital costs increased (for instance, interest rates increased)	□ 1	□ 2	□ 3	□ 4	□ 5	2202
3. Prices of raw materials or services (that we buy) increased	□ 1	□ 2	□ 3	□ 4	□ 5	2203
4. Taxes increased	□ 1	□ 2	□ 3	□ 4	□ 5	2204
5. We increased the quality of our main product	□ 1	□ 2	□ 3	□ 4	□ 5	2205
6. Competitors increased the price	□ 1	□ 2	□ 3	□ 4	□ 5	2206
7. We increase the price regularly	□ 1	□ 2	□ 3	□ 4	□ 5	2207
8. The demand increased	□ 1	□ 2	□ 3	□ 4	□ 5	2208
9. The price was increased because of administrative measures of public authorities	□ 1	□ 2	□ 3	□ 4	□ 5	2209
10. We increased the price after taking into account general price level (price increase) in the country	□ 1	□ 2	□ 3	□ 4	□ 5	2210
11. We increased the price since prospects of inflation and/or other macroeconomic perspectives have changed	□ 1	□ 2	□ 3	□ 4	□ 5	2211
12. Other. Please specify _____						2212

23 – If you lowered the price of your main product during last 5 years, due to what reasons did you lower the price? Please asses every statement	Not relevant	Of little relevance	Rele-vant	Very relevant	Don't know	
1. Labour costs decreased	□ 1	□ 2	□ 3	□ 4	□ 5	2301
2. Capital costs decreased (for instance, interest rates decreased)	□ 1	□ 2	□ 3	□ 4	□ 5	2302
3. Prices of raw materials or services (that we buy) decreased	□ 1	□ 2	□ 3	□ 4	□ 5	2303
4. Taxes decreased	□ 1	□ 2	□ 3	□ 4	□ 5	2304
5. We improved the technologies what in turn lowered costs	□ 1	□ 2	□ 3	□ 4	□ 5	2305
6. Competitors lowered the price	□ 1	□ 2	□ 3	□ 4	□ 5	2306
7. Competitors introduced new and better products	□ 1	□ 2	□ 3	□ 4	□ 5	2307
8. We lower the price regularly	□ 1	□ 2	□ 3	□ 4	□ 5	2308
9. The demand decreased	□ 1	□ 2	□ 3	□ 4	□ 5	2309
10. The price was decreased because of administrative measures of public authorities	□ 1	□ 2	□ 3	□ 4	□ 5	2310
11. We lowered the price after taking into account general price level (price decrease) in the country	□ 1	□ 2	□ 3	□ 4	□ 5	2311
12. We lowered the price since prospects of inflation and/or other macroeconomic perspectives have changed	□ 1	□ 2	□ 3	□ 4	□ 5	2312
13. Other. Please specify _____						2313

24 – If you increased volume of production or services a bit, what would be the change in variable costs per unit? Please asses every statement		2401
Would increase a lot	□	1
Would increase a bit	□	2
Would not change	□	3
Would decrease a bit	□	4
Would decrease a lot	□	5
Don't know	□	6

Wage setting

25 – How were your firm's employees distributed across the following occupational groups at the end of 2007?		
Low skilled blue collar/Production non-supervisory staff in production or maintenance positions that require no professional training (sorters, assemblers, packers, warehousemen, cleaning staff, transportation equipment operators (drivers), etc.)	____%	2501
High skilled blue collar/Technical employees whose duties would normally require university diploma and who are not primarily involved in the marketing/sales of a product or service (technologists, lab technicians, technology trainers; audio-visual technicians; computer programmers, nursing assistants, etc.)	____%	2502
Low skilled white collar/Clerical non-supervisory staff providing administrative services (secretaries, filing clerks, desk clerks, mail and distribution clerks, etc.)	____%	2503
High skilled white collar/Professional employees whose duties would normally require at least an undergraduate university degree (medical doctors, lawyers, accountants, architects, engineers, economists, psychologists, sociologists, marketing and market research professionals, etc.)	____%	2504
Other employees that are not asigned to the above mentioned employee groups (managers, etc.)	____%	2505
TOTAL (= 100%)	100%	

26 – Does your firm apply a collective pay agreement bargained and signed outside the firm (at the national, regional, sectoral or occupational level)?		2601
Yes	□	1
No	□	2
Such an agreement exist, but we opt out	□	3

27 – Does your firm apply a collective pay agreement signed at the firm level?		2701
Yes	□	1
No	□	2

28 – If "yes" in questions 26 or 27, what percentage of your firm's employees are covered by a collective pay agreement (at any level) _____%		2801

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When answering the following questions, please refer to these definitions:

Base wage – direct remuneration excluding bonuses (for instance, fixed monthly/hourly wage, commissions, piecework payments, etc.).

Bonuses/benefits – part of compensation different from the base wage and usually linked to individual's or firm's performance.

Please provide information about **the main employee group**. Please refer to the answers of the question 25. The main employee group is the largest one.

29 – What is the main principle of remuneration in your firm?
Please choose a single one option   2901

Fixed hourly base wage	□	1
Fixed monthly base wage	□	2
Piecework payments	□	3
Other. Please specify _____	□	4

30 – What percentage of your total wage bill in 2007 was related to individual or firm performance related bonuses or benefits?
_____%   3001

31 – Does your firm have a policy that adapts changes in base wages to inflation?   3101

Yes	□	1
No	□ → GO TO QUESTION 33	2

32 – If "yes" in question 31, please select the options that best reflects the policy followed:

Wage changes are <u>automatically linked</u> to:			
- past inflation	□	1	3201
- expected inflation	□	1	3202
Although there is no formal rule, wage changes <u>take into account</u>:			
- past inflation	□	1	3203
- expected inflation	□	1	3204

33 – How frequently is the base wage of an employee belonging to the main occupational group in your firm typically changed?
Please tick an option for each of the three types of wage changes listed below

	More than once a year	Once a year	Once every two years	Less frequently than once every two years	Never/ don't know	
1. Wage changes due to tenure	□ 1	□ 2	□ 3	□ 4	□ 5	3301
2. Wage changes due to inflation	□ 1	□ 2	□ 3	□ 4	□ 5	3302
3. Wage changes apart from tenure and/or inflation	□ 1	□ 2	□ 3	□ 4	□ 5	3303

34 – Under normal circumstances, are base wage changes concentrated in any particular month/months?

Yes: Jan. □ Feb. □ March □ April □ May □ June □ July □ Aug. □ Sept. □ Oct. □ Nov. □ Dec.□
     3401 3402 3403 3404 3405 3406 3407 3408 3409 3410 3411 3412

No   □
     3413

35 – What strategies have you ever used to reduce labour costs?
Please choose all relevant options

1. Reduction or elimination of bonus payments	□	3501
2. Reduction or elimination of non-pay benefits	□	3502
3. Change in shift assignments	□	3503
4. Reduction of promotions	□	3504
5. Recruitment of new employees (with similar skills and experience) at lower wage than those who left (e.g due to voluntary quits and retirement)	□	3505
6. Use of early retirement to replace high wage employees by entrants with lower wages	□	3506
7. Other strategies. Please specify _____	□	3507

Response to economic shocks

36 – How relevant are each one of the following strategies when your firm faces an unanticipated slowdown in demand?
Please tick an option for each line

	Not relevant	Of little relevance	Rele-vant	Very relevant	Don't know	
1. Reduce prices	□ 1	□ 2	□ 3	□ 4	□ 5	3601
2. Reduce margins	□ 1	□ 2	□ 3	□ 4	□ 5	3602
3. Reduce output	□ 1	□ 2	□ 3	□ 4	□ 5	3603
4. Reduce costs	□ 1	□ 2	□ 3	□ 4	□ 5	3604

37 – If the reduction of costs is of any relevance in your answer to question 36.4, please indicate the main channel through which this goal is achieved:

Please choose a single one option   3701

1. Reduce base wages	□	1
2. Reduce flexible wage components (for example bonuses, benefits, etc.)	□	2
3. Reduce the number of permanent employees	□	3
4. Reduce the number of temporary employees	□	4
5. Adjust the number of hours worked per employee	□	5
6. Reduce non-labour costs	□	6

38 – How relevant are each one of the following strategies when your firm faces an unanticipated increase in the cost of an intermediate input (e.g. increase in prices of gas, wood, agricultural products) affecting all firms in the market?

Please tick an option for each line

	Not relevant	Of little relevance	Rele-vant	Very relevant	Don't know	
1. Increase prices	□ 1	□ 2	□ 3	□ 4	□ 5	3801
2. Reduce margins	□ 1	□ 2	□ 3	□ 4	□ 5	3802
3. Reduce output	□ 1	□ 2	□ 3	□ 4	□ 5	3803
4. Reduce costs	□ 1	□ 2	□ 3	□ 4	□ 5	3804

39 – If the reduction of costs is of any relevance in your answer to question 38.4, please indicate the main channel through which this goal is achieved:

Please choose a single one option   3901

1. Reduce base wages	□	1
2. Reduce flexible wage components (for example bonuses, benefits, etc.)	□	2
3. Reduce the number of permanent employees	□	3
4. Reduce the number of temporary employees	□	4
5. Adjust the number of hours worked per employee	□	5
6. Reduce non-labour costs	□	6

40 – How relevant are each one of the following strategies when your firm faces an unanticipated permanent increase in wages (e.g. due to the renewal of collective agreement or due to increase in minimum monthly wage) affecting all firms in the market?

Please tick an option for each line

	Not relevant	Of little relevance	Rele-vant	Very relevant	Don't know	
1. Increase prices	□ 1	□ 2	□ 3	□ 4	□ 5	4001
2. Reduce margins	□ 1	□ 2	□ 3	□ 4	□ 5	4002
3. Reduce output	□ 1	□ 2	□ 3	□ 4	□ 5	4003
4. Reduce costs	□ 1	□ 2	□ 3	□ 4	□ 5	4004

41 – If the reduction of costs is of any relevance in your answer to question 40.4, please indicate the main channel through which this goal is achieved:

Please choose a single one option   4101

1. Reduce flexible wage components (for example bonuses, benefits, etc.)	□	1
2. Reduce the number of permanent employees	□	2
3. Reduce the number of temporary employees	□	3
4. Adjust the number of hours worked per employee	□	4
5. Reduce non-labour costs	□	5

Information about the firm

42 – How many workers did your firm have at the end of 2007?

	percent		number of employees	
Permanent full time employees (those who have no set termination date and whose regular working hours are the same as collectively agreed or customarily worked)	_____ %	4201	_____	4204
Permanent part time employees (those who have no set termination date and whose working hours are less than those specified for permanent full-time employees)	_____ %	4202	_____	4205
Temporary employees (those who have a set termination date or a specific period of employment)	_____ %	4203	_____	4206
Total (total number of employees that work under employment contract)	100%		_____	4207
Other workers (e.g., consultants from other firms, students, etc.)			_____	4208

43 – How many (permanent and temporary) employees left the firm in 2007? _____   4301

44 – How many (permanent and temporary) employees joined the firm in 2007? _____   4401

45 – How were your firm's permanent employees distributed according to tenure in your firm at the end of 2007?		
Less than 1 year	_____ %	4501
Between 1 and 5 years	_____ %	4502
More than 5 years	_____ %	4503
TOTAL (= 100%)	100%	

Appendix 8. Composition of general population of firms and employees. Employment-adjusted sampling weights

Table 37. Composition of the general population of firms by economic activity and firm size (number of firms)

	Firms that employ:			Total
	up to 19 employees	20 to 49 employees	50 and more employees	
Manufacturing	2 581	1 305	1 226	5 112
Construction	1 599	818	594	3 011
Trade	7 205	1 575	719	9 499
Business services	6 500	1 628	920	9 048
Total	17 885	5 326	3 459	26 670

Sources: Statistics Lithuania and author's calculations.

Table 38. Implied composition of the general population of employees by economic activity and firm size (number of employees)

	Firms that employ:			Total
	up to 19 employees	20 to 49 employees	50 and more employees	
Manufacturing	29 444	42 637	177 748	249 829
Construction	19 402	28 520	72 261	120 183
Trade	72 830	48 365	65 234	186 429
Business services	62 732	48 383	198 138	309 253
Total	184 408	167 905	513 381	865 694

Sources: Statistics Lithuania and author's calculations.

Table 39. Normalised employment-adjusted sampling weights of firms by economic activity and firm size

	Firms that employ:			Total
	up to 19 employees	20 to 49 employees	50 and more employees	
Manufacturing	0.000668	0.002241	0.008565	0.002979
Construction	0.003206	0.002749	0.010446	0.005148
Trade	0.001138	0.002944	0.006859	0.002073
Business services	0.000980	0.002152	0.015276	0.003100
Total	0.001030	0.002458	0.010237	0.002915

Notes: the weights provided in the strata refer to the weight of one firm within the stratum.
Sources: author's calculations.

Appendix 9. Share of firms reporting that price and wage changes occur in a particular month(s)

Figure 5. Share of firms reporting that price and wage changes occur in a particular month(s)
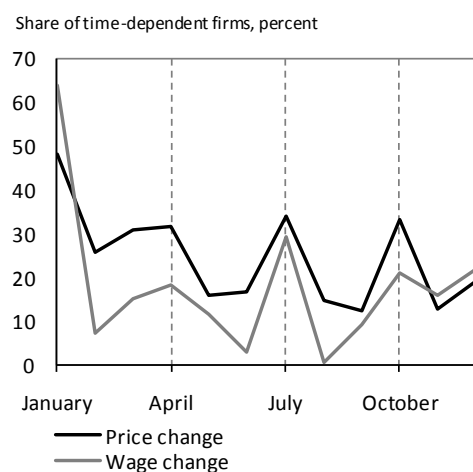
Share of time-dependent firms, percent

Notes: responses are employment-weighted and rescaled to exclude non-responses.
Sources: the survey "On Price and Wage Setting" and author's calculations.

Appendix 10. Explanations for frequency of price and wage changes: models with alternative definitions of dependent variables

Table 40. Explanations for frequency of price and wage changes: models with alternative definitions of dependent variables
(marginal effects for binary probit models; the table provides only marginal effects on the probability that price or wage change occurs more frequently than once a year)

	Frequency of price change	Frequency of wage change
Labour share	-0.002	0.000
Trade firms	0.023	-0.037
Services firms	-0.164*	-0.056
Firms 20-49	-0.021	0.115
Firms 50 and more	-0.011	0.125
Collective pay agreements	0.030	0.162**
Flexible wage share	-0.002	0.001
Competition	0.202**	0.096
Foreign sales share	0.000	-0.002**
Price regulation	-0.214	-
Policy to account for inflation	-	0.092
Pseudo R-squared	0.060	0.050
Wald statistic	16.050	18.470
Prob. (Wald statistic)	0.098	0.048
Number of observations	198	292

*Notes: * coefficient is statistically significant at the level of 10 percent, ** – significant at the level of 5 percent, *** – significant at the level of 1 percent; p-values are computed using Huber-White robust standard errors.*
Sources: the survey "On Price and Wage Setting" and author's estimations.

Appendix 11. Explanations for responses to a slowdown in demand, to an increase in cost of an intermediate input and to a permanent increase in wages: models with alternative definitions of dependent variables

Table 41. Explanations for responses to a slowdown in demand: models with alternative definitions of dependent variables
(marginal effects for binary probit models; the table provides only marginal effects on the probability that response is "relevant" or "very relevant")

	Type of response to a shock:			
	price decrease	*margin decrease*	*output decrease*	*cost reduction*
Labour share	*0.003***	*0.003****	*-0.001*	*0.000*
Trade firms	*0.015*	*-0.139***	*-0.191***	*0.009*
Services firms	*-0.203****	*-0.185****	*-0.163***	*0.021*
Firms 20-49	*-0.050*	*0.011*	*0.117**	*0.088**
Firms 50 and more	*0.035*	*-0.042*	*0.145***	*0.064*
Collective pay agreements	*0.037*	*0.071*	*-0.105*	*-0.013*
Flexible wage share	*-0.001*	*-0.003***	*-0.004***	*0.001*
Competition	*0.227****	*0.117***	*0.023*	*0.101**
Foreign sales share	*0.001*	*0.000*	*0.000*	*-0.001*
Pseudo R-squared	*0.064*	*0.075*	*0.066*	*0.028*
Wald statistic	*23.780*	*26.510*	*23.120*	*8.050*
Prob. (Wald statistic)	*0.005*	*0.002*	*0.006*	*0.529*
Number of observations	*295*	*298*	*294*	*298*

Notes: * coefficient is statistically significant at the level of 10 percent, ** – significant at the level of 5 percent, *** – significant at the level of 1 percent; p-values are computed using Huber-White robust standard errors.
Sources: the survey "On Price and Wage Setting" and author's estimations.

Table 42. Explanations for responses to an increase in cost of an intermediate input: models with alternative definitions of dependent variables
(marginal effects for binary probit models; the table provides only marginal effects on the probability that response is "relevant" or "very relevant")

	Type of response to a shock:			
	price increase	*margin decrease*	*output decrease*	*cost reduction*
Labour share	*0.000*	*0.001*	*-0.002*	*0.001*
Trade firms	*-0.230****	*-0.216****	*-0.101*	*0.032*
Services firms	*-0.265****	*-0.271****	*-0.020*	*-0.065*
Firms 20-49	*0.011*	*-0.070*	*0.069*	*0.150****
Firms 50 and more	*-0.013*	*0.019*	*0.154**	*0.104*
Collective pay agreements	*0.061*	*0.090*	*0.112*	*0.051*
Flexible wage share	*-0.002*	*-0.003***	*-0.003**	*-0.001*
Competition	*-0.002*	*0.072*	*0.078*	*-0.090*
Foreign sales share	*-0.002****	*0.002***	*0.002**	*0.001*
Pseudo R-squared	*0.099*	*0.076*	*0.049*	*0.034*
Wald statistic	*22.340*	*25.760*	*17.610*	*11.640*
Prob. (Wald statistic)	*0.008*	*0.002*	*0.040*	*0.235*
Number of observations	*295*	*293*	*283*	*294*

Notes: * coefficient is statistically significant at the level of 10 percent, ** – significant at the level of 5 percent, *** – significant at the level of 1 percent; p-values are computed using Huber-White robust standard errors.
Sources: the survey "On Price and Wage Setting" and author's estimations.

Table 43. Explanations for responses to a permanent increase in wages: models with alternative definitions of dependent variables
(marginal effects for binary probit models; the table provides only marginal effects on the probability that response is "relevant" or "very relevant")

	Type of response to a shock:			
	price increase	*margin decrease*	*output decrease*	*cost reduction*
Labour share	*0.003***	*0.000*	*-0.001*	*0.001*
Trade firms	*-0.277****	*-0.131**	*-0.070*	*0.002*
Services firms	*-0.051*	*-0.076*	*0.073*	*-0.040*
Firms 20-49	*0.047*	*0.034*	*-0.048*	*0.062*
Firms 50 and more	*0.035*	*0.045*	*-0.022*	*0.071*
Collective pay agreements	*-0.012*	*0.071*	*0.157***	*0.010*
Flexible wage share	*-0.002*	*0.000*	*-0.003*	*0.000*
Competition	*-0.039*	*0.126***	*0.059*	*0.029*
Foreign sales share	*-0.003****	*0.002*	*0.002***	*0.000*
Pseudo R-squared	*0.078*	*0.034*	*0.058*	*0.009*
Wald statistic	*27.090*	*14.200*	*20.730*	*3.020*
Prob. (Wald statistic)	*0.001*	*0.116*	*0.014*	*0.964*
Number of observations	*300*	*295*	*283*	*296*

Notes: * coefficient is statistically significant at the level of 10 percent, ** – significant at the level of 5 percent, *** – significant at the level of 1 percent; p-values are computed using Huber-White robust standard errors.
Sources: the survey "On Price and Wage Setting" and author's estimations.

Appendix 12. Explanations for price change in response to demand and cost shocks: models with alternative definitions of dependent variables

Table 44. Explanations for price change in response to demand and cost shocks: models with alternative definitions of dependent variables
(marginal effects for binary probit models; the table provides only marginal effects on the probability that the price is changed in response to the shock in three or less months)

	Type of shock:			
	demand increase	demand decrease	cost increase	cost decrease
Labour share	0.001	-0.001	0.000	-0.003*
Trade firms	-0.034	0.053	-0.078	-0.033
Services firms	-0.011	-0.036	-0.055	-0.038
Firms 20-49	-0.081	0.022	0.050	-0.096
Firms 50 and more	0.097	0.093	-0.085	-0.002
Collective pay agreements	-0.037	0.063	0.004	-0.069
Flexible wage share	0.001	-0.002	0.000	-0.001
Competition	0.221***	0.282***	-0.022	0.105
Foreign sales share	0.001	-0.001	-0.001	0.001
Regular customers share	-0.003**	-0.001	-0.001	0.000
Wholesale and retail firms share	-0.001	0.000	0.000	-0.001
Price discrimination	0.125	0.233***	-0.011	-0.038
Pseudo R-squared	0.060	0.066	0.028	0.034
Wald statistic	22.760	22.490	9.270	12.090
Prob. (Wald statistic)	0.030	0.032	0.679	0.438
Number of observations	287	264	291	267

Notes: * coefficient is statistically significant at the level of 10 percent, ** – significant at the level of 5 percent, *** – significant at the level of 1 percent; p-values are computed using Huber-White robust standard errors.
Sources: the survey "On Price and Wage Setting" and author's estimations.

Appendix 13. Explanations for price change in response to pooled demand and cost shocks: models with alternative definitions of dependent variables

Table 45. Explanations for price change in response to pooled demand and cost shocks: models with alternative definitions of dependent variables
(marginal effects for binary probit models; the table provides only marginal effects on the probability that the price is changed in response to the shock in three or less months)

	Type of shock:	
	demand change	*cost change*
Labour share	*0.000*	*-0.002*
Trade firms	*0.010*	*-0.070*
Services firms	*-0.020*	*-0.061*
Firms 20-49	*-0.030*	*-0.024*
Firms 50 and more	*0.098*	*-0.057*
Collective pay agreements	*0.011*	*-0.039*
Flexible wage share	*0.000*	*0.000*
Competition	*0.251****	*0.050*
Foreign sales share	*0.000*	*0.000*
Regular customers share	*-0.002***	*0.000*
Wholesale and retail firms share	*0.000*	*-0.001*
Price discrimination	*0.173****	*-0.031*
Demand increase	*-0.038*	*-*
Cost increase	*-*	*0.554****
Pseudo R-squared	*0.053*	*0.250*
Wald statistic	*39.640*	*168.340*
Prob. (Wald statistic)	*0.000*	*0.000*
Number of observations	*551*	*558*

Notes: * coefficient is statistically significant at the level of 10 percent, ** – significant at the level of 5 percent, *** – significant at the level of 1 percent; p-values are computed using Huber-White robust standard errors.
Sources: the survey "On Price and Wage Setting" and author's estimations.

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