Determinants of low inflation in an emerging, small open economy.
A comparison of aggregated and disaggregated approaches.

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Abstract

We analyse the determinants of the protracted period of exceptionally low inflation in the emerging, small open economy of Poland. We consider a fairly standard set of macroeconomic variables and establish a structural VAR model estimated using Bayesian methods and disentangle the influence of the global and domestic, supply and demand factors affecting headline and core inflation by means of the mixture of zero and sign restrictions. Next, we extend the analysis on a battery of inflation components and construct inflation indices sensitive to the global and domestic factors. We find that the excessive disinflation has been primarily caused by the deteriorating domestic conditions whilst deflation has resulted from the convolution of waning global demand and plummeting oil prices. Disaggregated analysis corroborates the conclusion of the aggregated approach but reveals considerable heterogeneities in the sensitivity of inflation components to the identified shocks. We conclude that the disaggregated analysis brings important information for the monetary policy conduct.

JEL: C32, E31, E52

Keywords: low inflation, small open economy, Bayesian Vector Autoregression, sign restrictions

Highlights:

1. The importance of the drivers shaping low inflation assessed.
2. Bayesian estimation of a SVAR model relying on the sign restriction identification scheme employed.
3. Deteriorating domestic conditions behind the excessive disinflation.
4. Deflation considered as an entirely imported phenomenon.
5. Significant heterogeneities found in the sensitivity of inflation components to the identified shocks.

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1. Introduction

For several years the development of the headline inflation rates in many countries has continued to surprise macroeconomic analysts, central bankers and the general public. Two exceptional periods are frequently distinguished in the empirical literature. First, following the outburst of the great financial crisis headline inflation in a number of economies has not decreased accordingly to the severity of the recession raising the question of the missing deflation. Second, after 2011 headline inflation has been systematically declining across major advanced and emerging economies, disproportionately to the level of the observed domestic real activity. This phenomenon has sparked an extensive debate on the determinants of the period of systematically falling inflation and an unexpected and protracted period of persistently low inflation. Consequently, it has attracted sizeable attention of both policy makers (e.g Wickman-Parak, 2013; Constâncio, 2016) as well as established a topic for an intense economic research (to mention only few recent works: Coibion and Gorodnichenko, 2015; Christiano et al., 2015; Friedrich, 2016; International Monetary Fund, 2016; Conti et al., 2017; Bobeica and Jarocinski, 2017; European Central Bank, 2017). In the paper we extend this discussion by studying the relative importance of the global and domestic demand and supply factors shaping the recent nominal fluctuations in an emerging, small open economy. For this purpose we examine the Polish case.

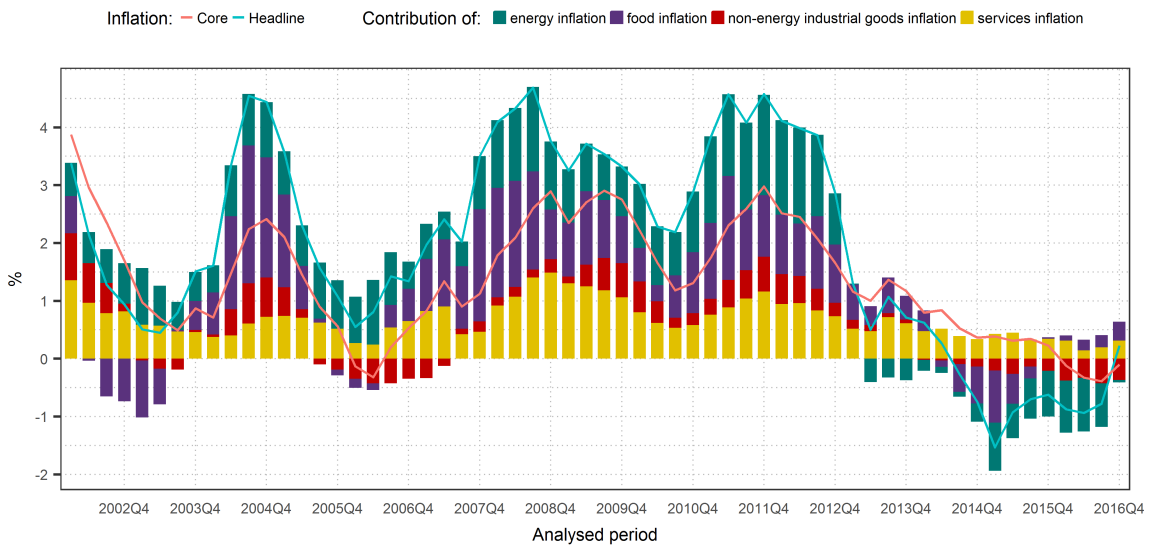
To the best of our knowledge, at the current juncture little empirical evidence has been presented for small, open economies experiencing a period of persistently low inflation. Therefore, the principal aim and the main contribution of this paper is to fill this niche in the literature. We shed light on this under-explored phenomenon by identifying the determinants of the low inflation in Poland.

We follow a recent notion in the empirical literature and disentangle the structural shocks influencing the headline and the core inflation by employing a mixture of zero and sign restrictions in a Bayesian VAR framework. For that purpose we adopt the methodology presented in Bobeica and Jarocinski (2017) as well as Conti et al. (2017). In this approach we grant the identified shocks an economic interpretation and assess the relative importance of the global and domestic, supply and demand factors shaping inflation in Poland. Secondly, we extend this analysis on a large number of inflation components to inspect whether conclusions drawn from the disaggregated approach justify the results of the analysis performed on the aggregated level. We take further advantage of the disaggregated approach by marking inflation components as sensitive or resilient to the developments of the global and domestic factors and construct indices measuring the foreign and domestic nominal fluctuations.

The phenomenon of the excessive disinflation and a subsequent, protracted period of deflation is a subject of the economic discussion also in emerging, small open economies (Szafranek, 2017). As illustrated on figure 1, the peculiar behaviour of inflation after the outburst of the great financial crisis is particularly starkly exemplified in Poland. On the one hand, the headline inflation has remained elevated in the aftermath of the global financial crisis as the firm domestic demand cushioned the Polish economy from the impact of the negative external shocks. On the other hand, after 2011 the the headline inflation has been subordinated to the phenomenon of the excessive disinflation (missing inflation) that manifested predominantly in the European countries. After reaching 4.4% in 2011Q4, the annual headline inflation rate in Poland has experienced an abrupt and unanticipated decrease to -1.5%, a historically low level. Deflation was hardly a short-lived episode as the decline in the consumer prices endured for an unprecedented period of two and a half years. A simple decomposition illustrates that the diminishing price dynamics has resulted predominantly from the falling and negative energy and food inflation which analysts have primarily attributed to the excess supply of the main commodities on the global market. However, since the end of the 2011 core inflation has been systematically declining as well.

This conundrum seems especially baffling when looking through the lenses of the adjustments in the domestic real activity. Experiencing only a short breath at the turn of 2012, the economic growth in Poland has remained robust throughout the global financial crisis and the subsequent European sovereign debt crisis. Simultaneously, the situation on the labour market has continued to systematically improve

Figure 1: The development of the headline and core inflation along with the decomposition of the annual headline inflation rate in Poland



Note: The figure presents the annual headline and core inflation rate as well as the contribution of the changes in the inflation of food, energy, non-energy industrial goods and services to the overall headline inflation developments in Poland. Source: Central Statistical Office in Poland, own calculations.

leading to the historically lowest unemployment and exceptionally high consumer confidence. However, the increase in the wage dynamics has not been profound, partly due to the underutilization of labour (Wyszyński, 2016). The downward pressure on wages could be further exacerbated by recently intensified immigration of the labour force with low bargaining power, similarly to the Spanish case (Bentolila et al., 2008). Currently, while the headline inflation has rebounded vigorously primarily due to the fading statistical effect of low commodity prices, the core inflation remains only marginally positive. Taking these developments into consideration, we focus our attention on the period of low inflation starting in 2012 which urges us to investigate and reassess the relative importance of the global and domestic shocks influencing the consumer prices in Poland. We put forward a hypothesis that the underlying domestic inflation remains low due to inadequate demand while the importance of the global factors has strengthened for both aggregate headline inflation measure as well as across the disaggregated components of the Polish consumer price index.

Understanding the prevailing regime is important for the monetary policy conduct. Identifying the determinants shaping headline inflation is crucial to achieve the central bank's main purpose – maintaining the stability of prices. Moreover, it provides a useful tool for the proper communication process with the general public (Blinder et al., 2008). From the central bank's standpoint our study entails three valuable pieces of information. Firstly, it evaluates the relative importance of the demand and supply shocks affecting inflation. The former resemble the changes in the domestic or the foreign real activity and their effects are likely distributed over a period of time. Moreover, domestic demand shocks often lead to adjusting the monetary policy. On the other hand, supply shocks have mostly exogenous and transitory nature. However, as they often influence the prices of primary consumer goods (e.g. food and energy), some central banks could be more anxious to mitigate the negative effects of imported shocks (Holtemöller and Mallick, 2016) even at the expense of slower economic growth. Secondly, the study discusses the extent of the global nature of inflation in Poland. Rising impact of the foreign factors on the domestic consumer prices decreases the effectiveness of the monetary policy in fighting inflationary or deflationary pressures. Thirdly, the study introduced indices of inflation determined by different economic developments which help track the source of the nominal fluctuations on a regular basis.

Several conclusions are warranted in the paper. Firstly, we show that the domestic demand remains a significant determinant of inflation in the emerging, small open economy of Poland. In particular, the deteriorating domestic conditions have turned out to be the primary source of the excessive disinflation in Poland. Secondly, we identify the rising importance of the global factors during the deflation period. In particular, we conclude that deflation has been an entirely imported phenomenon as the waning global demand and plummeting oil prices have exerted a considerable downward pressure on consumer prices. This is further confirmed by the development of the inflation index of components sensitive to the domestic demand. Thirdly, the presented evidence on the relative importance of the global and domestic shocks corroborates recent findings in the empirical literature. Hence, it indicates that in the period of low inflation a structural break in the mechanism of setting prices has not appeared. Fourthly, the analysis repeated on the number of inflation components generally validates the conclusions of the study performed on the aggregate inflation indices. However, we find substantial heterogeneities in the relative importance of shocks across the distinguished inflation indices during the excessive disinflation and deflation. Whereas some inflation components remain resilient to the developments in the global economy, we argue that during deflation the inflation of services has been increasingly influenced by the foreign factors. Lastly, we conclude that the monetary policy has remained neutral throughout the low inflation period.

The outline of the paper is as follows. In section 2 we review the recent empirical literature on the determinants of low inflation. We present also a broader perspective on the inflation determinants. In section 3 we describe the data as well as the applied methodology. The main results as well as the robustness check along with the discussion of the outcomes are presented in section 4. Section 5 concludes.

2. Literature review

The debate on the relative importance of the global and domestic demand and supply factors shaping inflation developments remains unsettled and concentrates mainly on highly developed economies. In this section we discuss the presented evidence on the determinants of the recent nominal fluctuations. Our empirical study is closely related to four recent articles by: Globan et al. (2016), Jovičić and Kunovac (2017), Conti et al. (2017) as well as Bobeica and Jarocinski (2017) which provide an in-depth analyses of the sources of the inflation behaviour in the U.S., the euro area and the EU new member states. Inspired by these works, we take a broader perspective on the phenomenon of low inflation in Poland by comparing the conclusions from the aggregated and disaggregated approach.

The prevailing evidence on the determinants of the low inflation episode in the emerging, small open economies is scarce. Globan et al. (2016) focus on the ongoing debate regarding the drivers of inflation in UE new member states. The authors argue that foreign shocks play a dominant role in explaining the dynamics of consumer prices in the medium-term in the majority of the analysed economies while in the short run domestic shocks affect inflation to the major extent. However, from our perspective the study leaves room for further empirical research. Firstly, the presented evidence does not take into account the low inflation episode in the European economies which could introduce a qualitative change. Secondly, the authors identify the structural shocks by employing a mixture of short-run and long-run zero restrictions. Therefore, the results can be sensitive to the specific assumptions regarding the ordering of the variables. A similar structural approach – based on the timing restriction – is employed by Hałka and Kotłowski (2016). Using a two-step procedure and the sample of a battery of inflation components ending before the period of the protracted deflation in Poland, Hałka and Kotłowski (2016) find that the sources of inflation fluctuations are country-specific, but domestic conditions prevail as an important factor behind the developments of consumer prices.

In our approach we alleviate the shortcomings of the Choleski identification scheme by pursuing a sign restriction identification pattern for our VAR model that enables us to precisely identify all structural shocks and grant them an economic interpretation. Moreover, due to data availability we include in our analysis the whole period of low inflation. However, contrary to the analyses by Globan et al. (2016) as well as Hałka and Kotłowski (2016), we zoom in on this phenomenon by studying only the Polish case. In this context, our framework is similar to the approach by Jovičić and Kunovac (2017) who examine in a recent paper the low inflation episode from the Croatian perspective and find that foreign shocks are relevant drivers of the Croatian economy. However, one important difference is the cyclical position of the Croatian economy during the low inflation period – contrary to the Polish case the GDP growth rate has been deeply negative since the global financial crisis for a prolonged period of time.

The phenomenon of low inflation is investigated thoroughly for advanced economies. In particular, Conti et al. (2017) argue that with a varying intensity the collapsing oil prices as well as a significant weakness in the aggregate demand have played a considerable role in shaping headline inflation rates across main countries of the euro area. The popular puzzles of missing deflation and missing inflation in the euro area and the U.S. are also investigated by Bobeica and Jarocinski (2017). The authors employ a conditional forecast exercise based on a medium-scale Bayesian VAR and a complementary, more parsimonious structural VAR model to conclude that the inflation development in the studied economies in the immediate wake of the great financial crisis has been primarily driven by the global determinants, whereas the missing inflation episode has been mainly caused by the deplorable domestic demand. They signal that at the end of their sample waning global demand and the plummeting oil prices began to contribute to the rising importance of the external developments. Our paper is inspired by these analyses and presents complementary evidence, as we examine an emerging, small open European economy tightly connected with the euro area. Moreover, while our preferred identification scheme follows a similar logic, we introduce some additional restrictions given the nature of the examined economy. Furthermore, we extend the analysis on a number of inflation components.

In a broader perspective, we voice our stance on the determinants of inflation in an emerging, small open economy after the great financial crisis. Firstly, a large strand of literature is devoted to the relation between inflation and the domestic real activity. In particular, the flattening of the Phillips curve is exemplified in numerous, prominent studies for advanced economies (e.g. Musso et al., 2009; Matheson and Stavrev, 2013; Blanchard et al., 2015) implying that the domestic real activity gradually ceases to impact inflation at the expense of global developments (e.g. Ciccarelli and Mojon, 2010). Moreover, increasing integration of the European transition economies has systematically decreased the relevance of the domestic economic conditions at the advantage of supply shocks in triggering inflation episodes (Petrović et al., 2011). The analysis of the new Keynesian Phillips curve in an emerging, small open economy of Poland (Szafranek, 2017) delivers similar conclusions. With the structural analysis conducted in this paper we aim to provides further evidence on the relative importance of the global and domestic factors shaping inflation in Poland.

Secondly, the Polish economy becomes increasingly open and vulnerable to the varying global economic conditions or turmoil in commodity prices. From the theoretical standpoint, increasing openness and the tightening of the integration through trade diminished mark-ups and lowers inflation across economies (Melitz and Ottaviano, 2008). A significant body of empirical literature postulates that inflation measured at the national level becomes a globally determined phenomenon which reduces its average level and variability (Mumtaz and Surico, 2012). In an influential analysis, Borio and Filardo (2007) argue that inflation in many countries is heavily impacted by the global demand and supply factors. Moreover they suggest that exchange rate pass through weakens which has been proved for Poland (Kapuściński et al., 2016) as well as the euro area (Comunale and Kunovac, 2017). The prevailing paradigm of the global inflation is postulated also by, *inter alia*, Ciccarelli and Mojon (2010), Aastveit et al. (2016) as well as Ferroni and Mojon (2016) who state that a dominant fraction (around 50-70%) of the variance of national inflation rates remains under a heavy influence of the global component. Recent inflation variability is typically associated with the substantial decline in the commodity prices (e.g. Conti et al., 2017; Bobeica and Jarocinski, 2017) as well as a sluggish international trade growth after the great trade collapse (Lewis and De Schryder, 2015; Constantinescu et al., 2015; International Monetary Fund, 2016) which has affected the prices of the tradable goods. Moreover, increasing importance of the global value chains leading to rising direct and indirect competition puts higher priority on the global economic slack (Auer et al., 2017). Finally, spillovers between large developed economies as well as small, open emerging economies can markedly influence inflation (Hałka and Szafranek, 2016). In the paper we connect with these notions by inspecting the extent of headline inflation as well as its components affected by the external developments.

Finally, an important question arises whether the policy conclusions drawn from the analysis conducted on the aggregated data and disaggregated data are concurrent. Several studies examine the issue of disaggregation in the context of the forecast accuracy of inflation indices (e.g Duarte and Rua, 2007; Bermingham and D'Agostino, 2014). A relatively limited strand of literature dwells on the dependencies between the macroeconomic conditions and the disaggregated price development. However, empirical analyses conducted on the disaggregated data reveal that not all inflation components react in the same manner. Firstly, Bryan and Meyer (2010) point out that the sensitivity of individual prices may differ. Moreover, the prices of certain goods and services react differently to the changes in the domestic real economic activity. Froehling and Lommatzsch (2011) as well as Hałka and Kotłowski (2014) show that a sizeable fraction of inflation components remains resilient to the changes in the domestic economic slack in the euro area countries and in Poland. Finally, Monacelli and Sala (2009) show that a level of aggregation matters for policy conclusions. Their evaluation of a lower bound for the contribution of international factors at 15-30% of the variance of consumer prices at disaggregated level stands in contrast with the evidence put forward by Ciccarelli and Mojon (2010). In our paper we compare if the policy conclusions from disaggregated approach and aggregated approach are consistent.

3. Methodology and data

In this section we introduce the vector autoregression (VAR) model in both the reduced and the structural form. In the second step, we discuss briefly the Bayesian estimation we employ. Next, we present the data used for the estimation in the aggregate as well as the disaggregate approaches. With this respect, we introduce a simple methodology of marking inflation components as sensitive or resilient to the identified shocks and briefly discuss an alternative approach based on the traditional, classic estimation. We end this section by devoting considerable attention to the identification of the economically interpretable structural shocks via the combination of zero and sign restrictions.

3.1. The model and the data

Let $y_t = (y_{t,1}, \ldots, y_{t,n})$ denote a $n \times 1$ vector of macroeconomic variables. Firstly, we start by establishing a reduced-form VAR model describing the joint dynamics of the distinguished variables as given in equation (1):

$$y_t = B_1 y_{t-1} + B_2 y_{t-2} + \cdots + B_p y_{t-p} + C x_t + \epsilon_t \quad e_t \sim N(0, \Sigma_n) \quad t = 1, \ldots, T \tag{1}$$

where: B_j is a $n \times n$ matrix of fixed parameters for $1 \leq j \leq p$, C is a matrix of fixed coefficients of dimension $n \times m$ for the vector of exogenous regressors x_t of size $m \times 1$, $\epsilon_t = (\epsilon_{1,t}, \ldots, \epsilon_{n,t})$ denotes the vector of residuals following the multivariate normal distribution with zero mean and the variance-covariance matrix Σ_n. The sample size is denoted by T.

Secondly, to distinguish the structural shocks we introduce a structural version of the model (1). The joint dynamics of the variables in a structural vector autoregression is described by the following system of linear equations:

$$A_0 y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + D x_t + \nu_t \quad \nu_t \sim N(0, I_n) \quad t = 1, \ldots, T \tag{2}$$

where: A_0 is invertible and ν_t represents the vector of structural innovations with zero mean and the variance-covariance matrix I_n. This implies that the shocks are mutually orthogonal (uncorrelated) and arise independently. The link between the structural model (2) with its reduced-form representation (1) is given by the following set of equations: $B_j = A_0^{-1} A_j$, $C = A_0^{-1} D$ and $\epsilon_t = A_0^{-1} \nu_t$. As a results, $E(\nu_t \nu_t^T) = \Omega = (A_0^T A_0)^{-1}$. Identification of the structural shocks is conducted with means of the combination of zero and sign restrictions imposed upon the contemporaneous matrix A_0. We discuss it in detail in the next section.

Due to the relative scarcity of observations we estimate the model by employing the Bayesian framework. For the estimation we assume the natural-conjugate (i.e the Normal-Wishart) prior in the tradition of Sims and Zha (1998) with most of the hyperparameters in line with Bobeica and Jarocinski (2017). In particular, we fix the value of the own first lag coefficient to $\beta_0 = 0.8$, set the overall tightness $\lambda_1 = 0.05$, the cross-specific weighting $\lambda_2 = 0.5$, the lag decay factor $\lambda_3 = 1$, the exogenous variable tightness $\lambda_4 = 2.5 \times 10^3$. Additionally, we include the weight on the no-cointegration (i.e the sum-of-coefficient) dummy observation prior $\lambda_5 = 2$ and the weight on the one unit root dummy observation prior (i.e. the initial dummy observation) $\lambda_6 = 2$. As a robustness, we experiment with different priors and various set of hyperparameters, but broadly they deliver qualitatively similar results. In all estimations we rely on the routines developed by Dieppe et al. (2016) where further technical aspects regarding the estimation of the VAR models in a Bayesian manner as well as imposing zero and sign restrictions are thoroughly reported. Since computing a considerable number of structural models identified with the means of zero and sign restrictions is a time-consuming process, we set the total number of draws to 2500 with 1500 burn-in iterations.

Our preferred VAR model includes six variables ($n = 6$) and a constant term ($m = 1$). In the model we include the nominal effective exchange rate, the short-term interest rate, the oil prices, the ratio between

the real GDP in Poland and the rest-of-the-world GDP (approximated by the real GDP of the twenty major economies), the domestic output gap and a selected price index. The interest rate, the output gap as well as the share indicating the relative size of the Polish in the global economy enter the model in levels. The remaining three variables are log-transformed first. Additionally, we have seasonally adjusted variables with clear seasonal patters using the Arima-X13-Seats procedure. The data cover the period 2002Q1-2016Q4 ($T = 60$). Although the sample is relatively short, employing the Bayesian framework helps to alleviate the problem of overparametrization of the model, present in the traditional approach. As we utilize quarterly data we set the maximum lag of the reduced-form VAR model to $p = 4$.

We start by estimating the model for the headline inflation. As central banks frequently downplay the direct impact of foreign developments on inflation, in the second step we inspect the drivers of the core inflation defined as the headline inflation net of food, non-alcoholic beverages and energy prices which should, at least in principle, better reflect the medium-term inflationary pressure. Thirdly, in the disaggregate analysis we re-estimate the specified model treating each inflation component at the 3-digit COICOP level as the variable of interest. Specific information regarding all variables used in our analysis is listed in the Table 2.

We take an additional advantage of the disaggregated approach by marking each of the forty-four inflation components as sensitive or resilient to the identified shocks. For that purpose we check whether the response of the selected price index following a specific shock has the proper direction and is statistically significant at the confidence level $\alpha = 0.99$ in the period for which the influence has the largest magnitude. If the condition is fulfilled, we state that the particular price index is sensitive to the examined shock. If not, the price index remains resilient to this shock. In this manner, for each inflation component and each shock we create a binary sensitivity indicator. We then use the weights of the inflation components in the CPI, the sensitivity indicators as well as the annual rate of change of the inflation components to calculate theoretical measures of inflation sensitive and resilient to the influence of specific shocks or groups of shocks.

In order to perform a robustness check of the aforementioned classification, for each inflation component we also estimate a traditional structural VAR model as defined by equation (2). The maximum lag length is set to $p = 1$ as indicated by the Bayesian information criterion. In this approach we include block-exogeneity to prevent the domestic variables from exerting impact on foreign variables (i.e. the prices of oil, the foreign output and the nominal effective exchange rate). Moreover, as we rely on the Choleski factorization linking the reduced-form and the structural model, we order the variables so that oil prices, foreign GDP and nominal effective exchange rate deemed as global are first. Next, we include the domestic output gap, a price index and the short-term interest rate. Hence, the domestic variables do not impact the foreign variables contemporaneously. The identification scheme is summarised in the table 2. Within this framework the nominal effective exchange rate, the oil prices, the foreign GDP and the price index enters the model in a log-differenced form, while the domestic output gap and the short-term interest rate remain in levels. We generate the confidence intervals for the impulse responses at the significance level $\alpha = 0.99$ using 5000 bootstrap replications.

3.2. The identification scheme

The identification of the structural shocks based on the Choleski factorisation is characterized by several important caveats. Firstly, as it relies on the timing restriction the identified shocks are not based on clear theoretical foundations and cannot be strictly interpreted. Secondly, the ordering of the variables may impact the estimation outcomes in the Choleski identification scheme. Identification via sign restrictions allow to distinguish a full set of economically interpretable structural shocks and the order of the variables entering the VAR model does not affect the outcomes. In this paper we adopt the identification strategy based on a mixture of zero and sign restrictions recently exploited by Bobeica and Jarocinski (2017). We introduce small refinements due to the nature of the examined economy and identify

Table 1: Abbreviations of variables used alond with their expansions and additional information.

Variable	Explanation	Transformation	Source
NEER	Nominal Effective Exchange Rate	$ln(\cdot)$	BIS
WIBOR	Three-month Warsaw Interbank Offered Rate	in level	Reuters
OIL	Spot oil prices	$ln(\cdot)$	IMF
ROW	Real GDP in the G20 economies	sa, in level	OECD
RGDP	Real GDP in Poland	sa, in level	NBP
PLRT	Ratio of the Polish real GDP to the G20 real GDP	in level	OECD, NBP
OG	Output gap in Poland derived from a production function	in %	NBP
CPI	Headline inflation index	sa, $ln(\cdot)$	CSO
CORE	Core inflation index	sa, $ln(\cdot)$	NBP
C011	Food inflation index	sa, $ln(\cdot)$	CSO
C012	Non-alcoholic beverages inflation index	sa, $ln(\cdot)$	CSO
C021	Alcoholic beverages inflation index	sa, $ln(\cdot)$	CSO
C022	Tobacco inflation index	sa, $ln(\cdot)$	CSO
C031	Clothing inflation index	sa, $ln(\cdot)$	CSO
C032	Footwear inflation index	sa, $ln(\cdot)$	CSO
C041	Actual rentals for housing inflation index	sa, $ln(\cdot)$	CSO
C043	Maintenance and repair of the dwelling inflation index	sa, $ln(\cdot)$	CSO
C044	Water supply and miscellaneous services relating to the dwelling inflation index	sa, $ln(\cdot)$	CSO
C045	Electricity, gas and other fuels inflation index	sa, $ln(\cdot)$	CSO
C051	Furniture and furnishings, carpets and other floor coverings inflation index	sa, $ln(\cdot)$	CSO
C052	Household textiles inflation index	sa, $ln(\cdot)$	CSO
C053	Household appliances inflation index	sa, $ln(\cdot)$	CSO
C054	Glassware, tableware and household utensils inflation index	sa, $ln(\cdot)$	CSO
C055	Tools and equipment for house and garden inflation index	sa, $ln(\cdot)$	CSO
C056	Goods and services for routine household maintenance inflation index	sa, $ln(\cdot)$	CSO
C061	Medical products, appliances and equipment inflation index	sa, $ln(\cdot)$	CSO
C062	Out-patient services inflation index	sa, $ln(\cdot)$	CSO
C063	Hospital services inflation index	sa, $ln(\cdot)$	CSO
C071	Purchase of vehicles inflation index	sa, $ln(\cdot)$	CSO
C072	Operation of personal transport equipment inflation index	sa, $ln(\cdot)$	CSO
C073	Transport services inflation index	sa, $ln(\cdot)$	CSO
C081	Postal services inflation index	sa, $ln(\cdot)$	CSO
C082	Telephone and telefax equipment inflation index	sa, $ln(\cdot)$	CSO
C083	Telephone and telefax services inflation index	sa, $ln(\cdot)$	CSO
C091	Audio-visual, photographic and information processing equipment inflation index	sa, $ln(\cdot)$	CSO
C092	Other major durables for recreation and culture inflation index	sa, $ln(\cdot)$	CSO
C093	Other recreational items and equipment, gardens and pets inflation index	sa, $ln(\cdot)$	CSO
C094	Recreational and cultural services inflation index	sa, $ln(\cdot)$	CSO
C095	Newspapers, books and stationery inflation index	sa, $ln(\cdot)$	CSO
C096	Package holidays inflation index	sa, $ln(\cdot)$	CSO
C101	Pre-primary and primary education inflation index	sa, $ln(\cdot)$	CSO
C102	Secondary education inflation index	sa, $ln(\cdot)$	CSO
C103	Post-secondary non-tertiary education inflation index	sa, $ln(\cdot)$	CSO
C104	Tertiary education inflation index	sa, $ln(\cdot)$	CSO
C105	Education not definable by level inflation index	sa, $ln(\cdot)$	CSO
C111	Catering services inflation index	sa, $ln(\cdot)$	CSO
C112	Accommodation services inflation index	sa, $ln(\cdot)$	CSO
C121	Personal care inflation index	sa, $ln(\cdot)$	CSO
C123	Personal effects n.e.c. inflation index	sa, $ln(\cdot)$	CSO
C124	Social protection inflation index	sa, $ln(\cdot)$	CSO
C125	Insurance inflation index	sa, $ln(\cdot)$	CSO
C126	Financial services n.e.c. inflation index	sa, $ln(\cdot)$	CSO
C127	Other services n.e.c. inflation index	sa, $ln(\cdot)$	CSO

Note: In the table sa denotes a seasonally adjusted variable, whereas $ln(\cdot)$ signals that the variable enters the equation in logarithms. Source: own elaborations.

the exchange rate shock, the monetary policy shock, the global oil supply shock, the foreign demand shock, the domestic demand shock and the domestic supply shock. Our preferred identification scheme I is summarized in the table 2. We apply the restrictions upon the contemporaneous matrix A_0. We do not extend the restrictions on any further periods as Canova and Paustian (2011) show that imposing the restrictions upon the contemporaneous relationships between the variables mitigates several types of model misspecification. During the estimation we use the routines implemented by Dieppe et al. (2016) that follow the proposal by Arias et al. (2014).

The first shock is an exchange rate shock. Following Bobeica and Jarocinski (2017) we identify this shock using the timing restriction – an appreciation of the exchange rate is exogenous and has no contemporaneous impact on any other variable in the system. Moreover, as we report in the results the importance of this shock in explaining inflation is minor. This allows us to downplay the possible

misspecification pointed out by Conti et al. (2017) who argue that identifying the shock in this particular manner may capture several foreign shocks, for instance a monetary policy shock in the U.S. (or in the euro area for that matter).

We define the second shock as a conventional monetary policy shock. Recursively identified, the shock immediately increases the short-term interest rates and adjusts the nominal effective exchange rate. Due to the imposed zero restrictions, other variables in the system can be influenced by this shock with a lag of one period.

The identification of the remaining four shocks relies on the sign restrictions. Firstly, we assume that a contractionary global oil supply shock leads to the increase in the prices of oil. Obviously, direct effects of higher oil prices emerge instantly and feed into the selected inflation measure. Moreover, higher oil prices pick up energy costs which propagate to the production costs of firms, inducing indirect effects and exerting further upward pressure on inflation. Evidence for the euro area suggests that the direct effects have increased at the expense of indirect and second round effects (Álvarez et al., 2011), presumably due to the increased central bank credibility. On the other hand, Szafranek (2017) points out that the importance of the indirect effects in the period of low inflation in Poland has magnified. In any case, the identified oil shock should include both the direct as well as indirect effects of the fluctuation of oil prices. Furthermore, following a negative (positive) oil supply shock the output should decrease (increase) quicker than the potential output resulting in the proper adjustment of the output gap. Moreover, despite the dilemma an oil supply shock poses for the monetary authorities, especially in the emerging, open economies highly dependent on the evolution of commodity prices (Holtemöller and Mallick, 2016), we assume that the central bank in Poland does not react initially to the shock perceived as transitory. This assumption is justified by the minutes published by the Polish central bank in times of swiftly rising commodity prices (Narodowy Bank Polski, 2007, 2008). Hence, opposite to Conti et al. (2017) we restrict the response of the short-term interest rate to zero. Finally, given the correlation between the oil price shock and the nominal exchange rate we force the nominal effective exchange rate to appreciate following a negative oil supply shock. The response of the variable measuring the relative importance of the Polish economy with respect to the global economy is left unconstrained.

Secondly, a crucial assumption is connected with distinguishing the global demand shock from the domestic demand shock. We rely on the identification scheme presented by Corsetti et al. (2014) as well as Bobeica and Jarocinski (2017). In particular, in our model we assume that since a global shock originates abroad it should primarily impact the foreign economy. As a result, we expect the relative size of the domestic economy with respect to the global economy to diminish. Still, due to the openness of the domestic economy, an increase in the foreign demand should lead to a higher domestic output gap exerting an upward pressure on prices. Moreover, a positive global demand shock should lead to the increase in the oil prices since the global demand rises. In this context, Baumeister and Kilian (2016) as well as Caldara et al. (2016) point out that the movements in oil prices do not only suffer from strategic decisions of producers and emerging technology, but are heavily influenced by the adjustments in the demand as well. That said, the recent slowdown in the international trade (Lewis and De Schryder, 2015) and the subdued global activity has not only curbed the oil prices (Baumeister and Kilian, 2016) but may have affected the prices of tradable goods as well, leading to a more severe reaction of the headline inflation. In identifying the global demand shock we acknowledge the caveat aired by Bobeica and Jarocinski (2017) who argue that a shock global in its nature may in fact increase the demand for domestic products by a wider margin than for the foreign products. This would induce a positive co-movement between the domestic output gap and the share of the domestic economy in the world economy and should be labelled as a domestic shock. As a result, the following identification may deem some foreign shocks as domestic.

Thirdly, we expect a domestic demand shock to increase the relative share of the Polish output in the foreign output as the shock originates domestically and influences primarily the small, open economy. Due to the rise in the demand, the consumer prices should pick up as well. Moreover, opposite to the identification schemes provided for the euro area (Bobeica and Jarocinski, 2017; Conti et al., 2017) given

the size of the Polish economy we restrict a domestic demand shock not to influence the prices of oil. Finally, we do not impose any restrictions on the responses of the nominal effective exchange rate or the short-term interest rate following the identified demand shocks.

Fourthly, in line with the conventional approach we disentangle the domestic supply shock from the domestic demand shock by restricting the reaction of inflation and the real activity following the appearance of the shocks. Whereas for the demand shock we force the response of the output gap and inflation to be positive, we assume that after a positive domestic supply shock the output gap should increase as it takes time for the potential output to adjust while the prices should decrease due to lower production costs and higher profit margins. Again, we label the shock domestic due to the relative increase in the share of the Polish output in the foreign output. Finally, we assume that the nominal effective exchange rate should appreciate following a domestic supply shock.

Throughout the analysis we focus our attention on the relative importance of each shock in contributing to the overall inflation fluctuations in the period of low inflation (2012Q1-2016Q4). For that purpose we employ the historical decomposition delivering the relative contribution of each structural shock to the observed development of the headline and core inflation measures. However, we inspect also the relative importance of shocks in a broader manner by classifying them into somewhat simpler categories: global, domestic, demand and supply. From the perspective of a small, open economy we assume that an oil supply shock, a foreign demand as well as a nominal effective exchange shocks rate are global in their nature. On the other hand, we perceive a domestic demand, a domestic supply and a monetary policy shocks as domestic. Moreover, we group domestic and foreign demand, exchange rate and monetary policy shocks as demand shocks with the rest being categorized as supply ones.

Table 2: Identification scheme of shocks in the VAR models.

	I. Sign restriction identification scheme					
	Exchange rate shock	Monetary policy shock	Global oil supply shock	Global demand shock	Domestic demand shock	Domestic supply shock
NEER	+	·	+	·	·	+
WIBOR	0	+	0	·	·	·
OIL	0	0	+	+	0	·
PLRT	0	0	·	-	+	+
OG	0	0	-	+	+	+
INF	0	0	+	+	+	-

	II. Choleski identification scheme					
	Global shock	Global shock	Global shock	Domestic shock	Own shock	Domestic shock
OIL	+	0	0	0	0	0
ROW	·	+	0	0	0	0
NEER	·	·	+	0	0	0
OG	·	·	·	+	0	0
INF	·	·	·	·	+	0
WIBOR	·	·	·	·	·	+

Note: The table presents the identification schemes employed to identify the shocks in the VAR model. The baseline model uses the combination of zero and sign restriction identification scheme. Choleski recursive identification pattern is employed for robustness. In the table · denotes unconstrained reaction, + denotes an increase and − denotes a decrease of the response of a given variable following a specific shock. All restrictions are imposed upon the contemporaneous matrix A_0. Source: own elaborations.

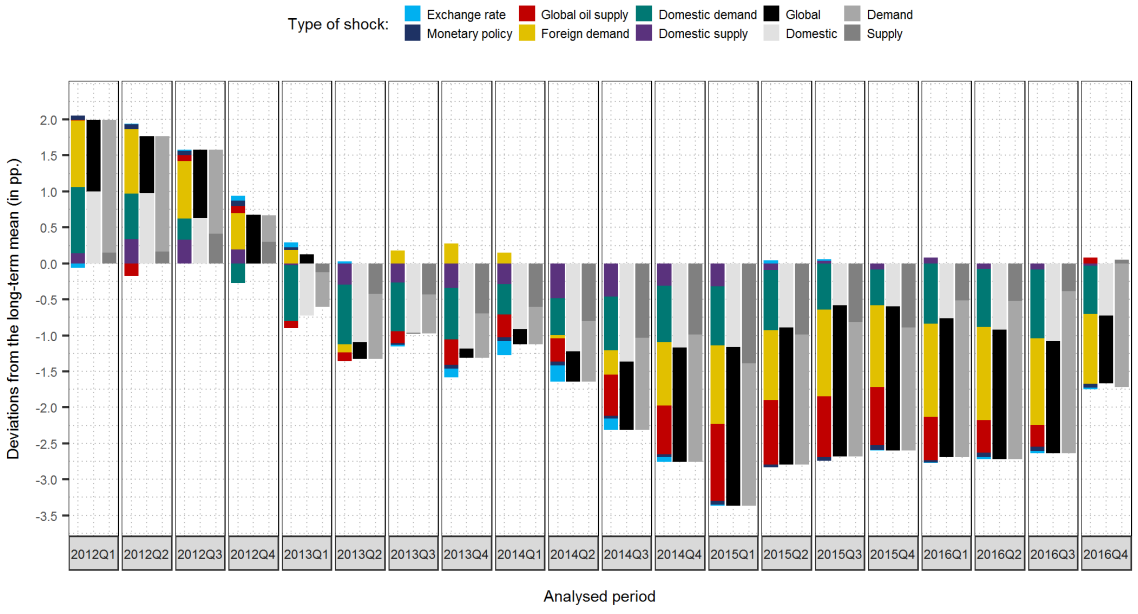
4. Results

In this section we present the results of the conducted analysis. Firstly, we discuss the determinants of the recent headline and core inflation behaviour relying on the historical decomposition – a recently popular method of identifying the sources of low inflation in the U.S. and the euro area countries (e.g. Bobeica and Jarocinski, 2017; Conti et al., 2017). Secondly, taking a cross-section perspective across inflation components we inspect the relative importance of the drivers of the consumer prices in the period of excessive disinflation and deflation. Thirdly, we report the indices of inflation sensitive and resilient to the identified shocks. Finally, we present the robustness check based on the estimation of the SVAR models in a traditional manner.

4.1. Inflation determinants during low inflation

We start the discussion of the results by presenting the historical decomposition of the annual rate of change of the headline and core inflation from the aggregated and disaggregated approaches. Figures 2-3 and 5-6 display the contribution of the identified shocks to the annual rate of the selected price index. During the analysis we zoom in on two particular periods: the excessive disinflation (2012Q1-2014Q2) and the protracted period of deflation (2014Q3-2016Q4). The breakpoint set in 2014Q2 is singled out subjectively as the last quarter of the positive inflation. For clarity purposes, we show the decomposition for each quarter in three equivalent variants. First, colour bars indicate the contribution of each identified shock to the deviation of the inflation measure from its long-term mean. Second, the black and off-white bars show the contribution of the global and domestic shocks. Third, the bars in the grey scale present the relative importance of the demand and supply shocks. All contributions are reported in percentage points (henceforth pp.).

Figure 2: Historical decomposition of the annual headline inflation in Poland during low inflation



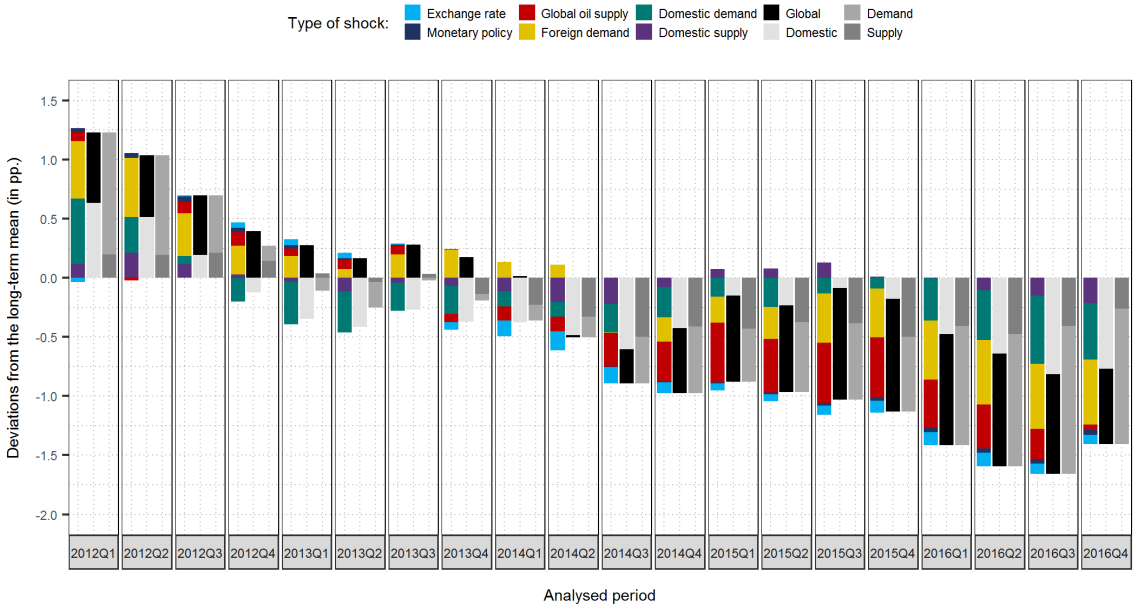
Note: The figure presents the contribution of the structural shocks to the deviation of the annual headline inflation from its long-term mean in percentage points during the low inflation period. Source: own calculations.

Regardless of the type of the analysis as well as the preferred inflation measure, the presented historical decompositions have four common features. Firstly, they reveal that the deteriorating domestic conditions should be held responsible for the substantial decline in inflation since 2012 as the domestic output gap

has considerably widened following a transitory slowdown in the domestic economy. Secondly, during deflation the relative downturn in the global economic conditions as well as plummeting oil prices have played a predominant role in explaining the fall in consumer prices. Moreover, supposing the contribution of the global shock in a counter-factual analysis was null, the deflation in the Polish economy would not appear. Hence, we conclude that deflation has been an entirely imported phenomenon. Thirdly, the monetary policy has remained neutral throughout the whole period of low inflation. Lastly, the exchange rate shock plays a minor role in shaping the nominal fluctuations in Poland supporting the conclusions of the analysis of the exchange rate pass-through conducted by Kapuściński et al. (2016).

Our results for the small open economy are consistent with previous findings in the empirical literature. During the low inflation period the contribution of the global shocks has been marginally larger and explained more than 50% of the total deviation of the headline and core inflation from their long-term means. Although the impact of foreign factors on inflation has increased, domestic conditions have prevailed as a significant determinant of consumer prices. Finally, our estimate for the influence of the global shock resides within the bands provided by recent empirical studies (50-70%) as argued by Aastveit et al. (2016) as well as Ferroni and Mojon (2016). This indicates that during low inflation a structural break in the mechanism of setting prices has not emerged. However, at a disaggregated level we provide evidence similar to Monacelli and Sala (2009) pointing out a considerable heterogeneity in the sensitivity of inflation components to the identified shocks. We now discuss the results in more detail.

Figure 3: Historical decomposition of the annual core inflation in Poland during low inflation

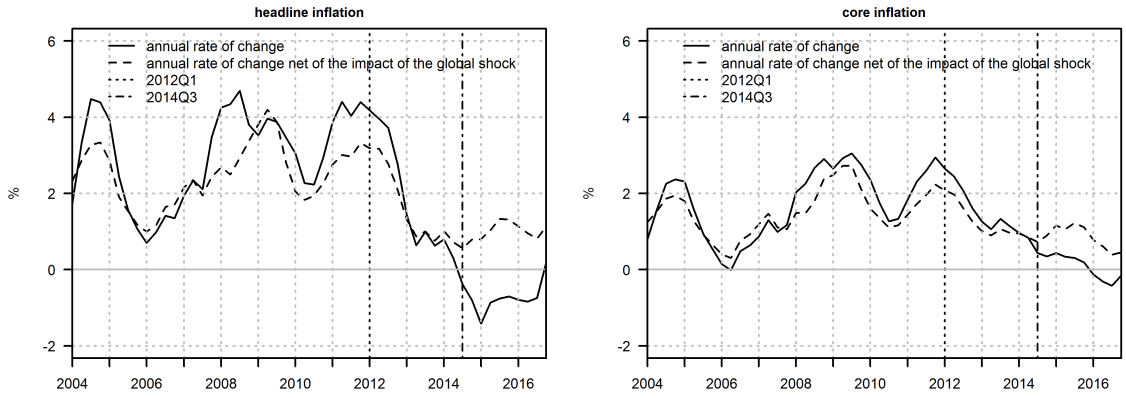


Note: The figure presents the contribution of the structural shocks to the deviation of the annual core inflation from its long-term mean in percentage points during the low inflation period. Source: own calculations.

The analysis conducted for the headline and core inflation in the aggregated approach indicates that the excessive disinflation has been primarily caused by the abating demand shocks as illustrated on figures 2-3. However, although their relative strength has systematically decreased over time, they have prevailed a significant drivers of consumer prices. Breaking down the aggregated shocks into the originally identified ones, we conclude that the main factor behind the diminishing headline inflation rate has been the systematically fading domestic demand. Furthermore, since the fourth quarter of 2012 its contribution has turned and remained negative reflecting the persistently inadequate real activity in Poland, despite the observed stable economic growth. In particular, the impact of the domestic demand shock has been largest in 2013 accounting for around 54% of the deviation from the long-term mean and lowering headline

inflation by approximately 0.8 pp. This has coincided with the decrease in the domestic output gap to around -3%. Further fall in the inflation rate has been exacerbated by the waning global demand that only occasionally has turned positive as well as slightly decreasing oil prices.

Figure 4: Annual rate of change of headline and core inflation net of the impact of the global shock



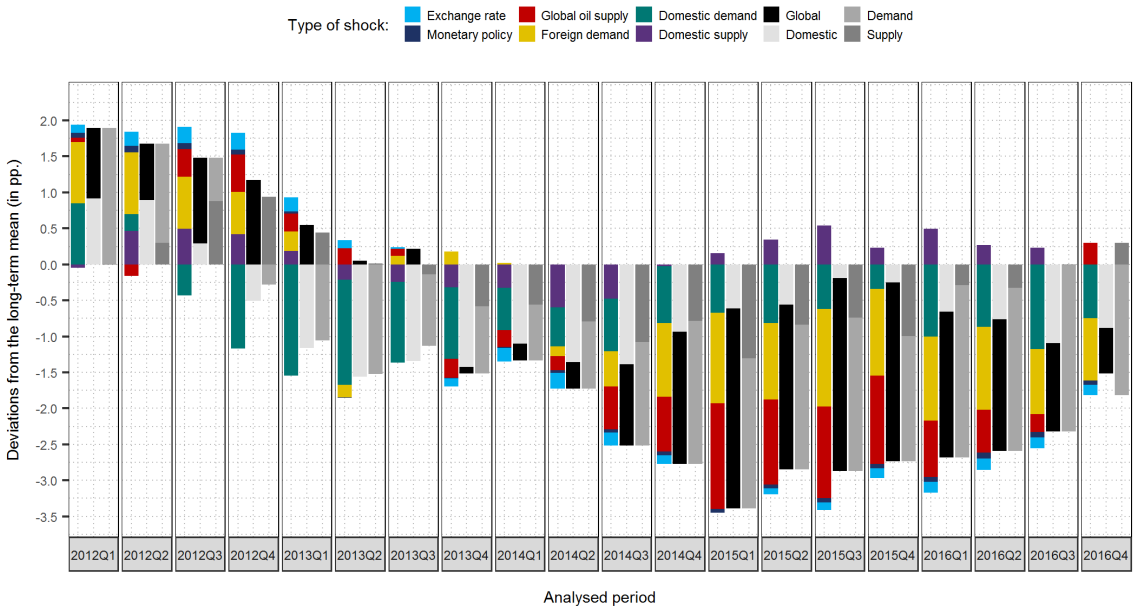
Note: The figure presents the annual rate of change of the headline and core inflation in Poland together with the annual rate of change of these measures supposing the impact of the global shock has been null throughout the whole period of analysis. Source: own calculations.

The period of the protracted deflation has brought a considerable change. Throughout this episode the relative importance of the supply shock has significantly risen as has the impact of the globally determined factors, contributing a total of 64% of the observed deviation of the headline inflation from its long-term mean. There are two main sources of this variation. Firstly, the bulk of this change can be attributed to the international trade and economic slowdown lowering the headline inflation rate in Poland by as much as 1.3 pp. via weaker foreign demand. Secondly, the collapse in the oil prices has contributed as much as an additional 1.1 pp. drop in the first quarter of 2015. Furthermore, a simple counterfactual analysis illustrates that deflation has been an entirely imported phenomenon. Supposing the contribution of the global shock was null during the analysed period, the deflation would not be present in the Polish economy as depicted on figure 4. That said, throughout 2016 some symptoms of the stronger economic growth have appeared again while the prices of oil have stabilized. In the fourth quarter of 2016 we observe a sizeable decrease in the negative contribution of the global demand shock while the oil supply shock turns positive. Throughout the low inflation period the impact of the exchange rate shock has been negligible while the monetary policy has remained neutral to the development in consumer prices.

The conclusions for the core inflation measure are qualitatively similar. During the excessive disinflation the demand shocks have played a major role in decreasing the core inflation with the exception of slightly positive impact of foreign demand. As the core inflation measure neglects the direct effects of volatile commodity prices and focuses more on the domestic developments, the relative importance of the global shock is somewhat smaller, but not by a large margin. During the deflation period the average contribution of the global shock to the deviation of core inflation from its long-term mean rises to around 62% signalling that considerable indirect effects are present. For instance, as the oil prices have plummeted the core inflation has decreased by as much as 0.5 pp. We interpret this as a positive shock to mark-ups of the firms which has allowed them to cut prices of non-energy industrial goods and services without the need to sacrifice profits. Moreover, the importance of the foreign demand shock is less pronounced but with time its contribution stabilizes at around 0.5 pp. suggesting that some part of the low inflation has been imported via the channel of tradable goods.

We now turn to the results obtained in the disaggregated approach. In short, the methodology we employ is the following. Firstly we estimate the preferred model for each inflation component and perform a historical decomposition. Secondly, we aggregate all historical decompositions using the specific weights each inflation component has in the inflation basket. Thirdly, we inspect if the aggregated and disaggregated

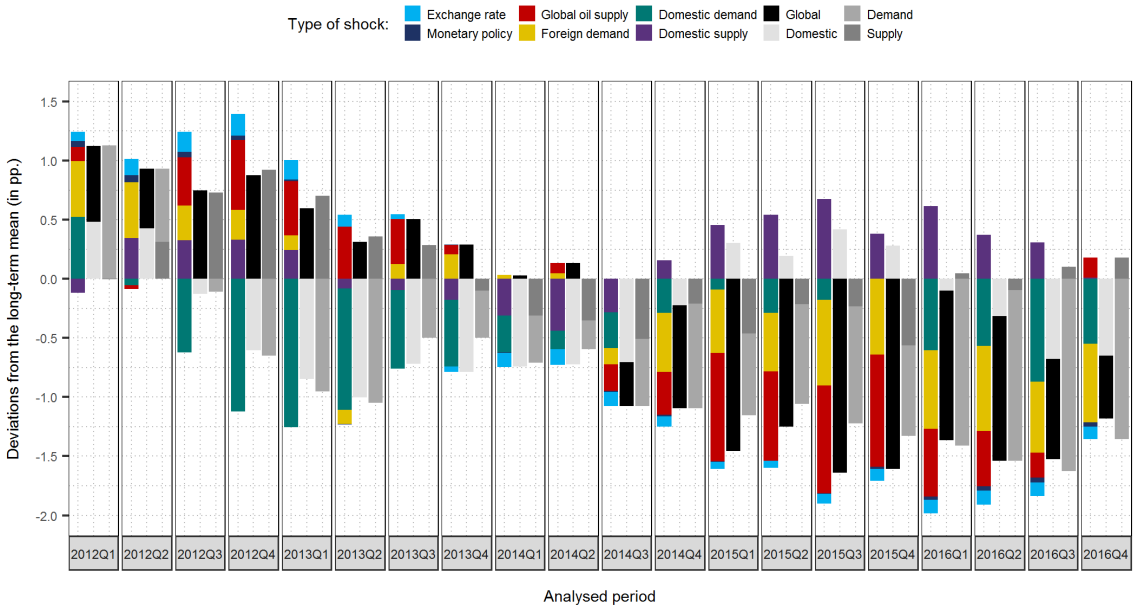
Figure 5: Historical decomposition of the annual headline inflation in Poland after 2011 as a aggregation of the shocks from the disaggregated models



Note: The figure presents the contribution of the structural shocks in percentage points to the the deviation of the headline inflation from its long-term mean in percentage points after 2011. The shocks are aggregated from all disaggregated models. The long-term mean is calculated as a weighted average of the long-term means from models on disaggregated data. Source: own calculations.

approaches yield similar conclusions. We believe that the analysis based on the disaggregated level may add some additional information about the nature of the price-setting process and the identification of factors affecting inflation in Poland.

Figure 6: Historical decomposition of the annual core inflation in Poland during low inflation as a aggregation of the shocks from the disaggregated models



Note: The figure presents the contribution of the structural shocks in percentage points to the the deviation of the core inflation from its long-term mean in percentage points during low inflation period. The shocks are aggregated from all disaggregated models. The long-term mean is calculated as a weighted average of the long-term means from models on disaggregated data. Source: own calculations.

The outlook presented in the disaggregated analysis provides overall a similar qualitative but somewhat different quantitative conclusions as depicted on figures 5-6. Firstly, during the excessive disinflation the domestic conditions are responsible to a greater extent for the fluctuations of both headline and core inflation. The magnitude of the domestic demand shock shock is much more pronounced as it lowers the headline and core inflation by -1.5 pp. and -1.3 pp., respectively. Moreover, its negative contribution rises again in 2016 along with the widening of the output gap as a result of a considerable fall in investments. Secondly, the impact of the global oil shock is more considerable throughout excessive disinflation as well and remains positive, especially for core inflation which could signal second-round effects of high oil prices feeding into the underlying price pressure. Thirdly, throughout the deflation episode the global factors predominantly contribute to the observed deviation of both headline and core inflation explaining around 61% and 56% of the total deviation from their long-term means, respectively. Again the magnitude of the shocks is larger. In particular, the slowdown in the global economy has lowered the headline and core inflation rate by as much as -1.3 pp. and -0.7 pp., respectively. Moreover, the plummeting oil prices have added an additional -1.4 pp. and -0.9 pp., respectively. Fourthly, the contribution of the domestic supply shock to the headline and core inflation is positive during the deflation period. This shock has the largest impact on prices of some services which intuitively are driven mostly by the domestic conditions (e.g. social protection, education, communication services, services related to the dwelling).

4.2. Comparison between the period of excessive disinflation and deflation

To further assess the relative importance of the global and domestic, demand and supply shocks during low inflation we take a cross-section perspective across all inflation components. Firstly, we report the relative contribution of the global, domestic, supply and demand shocks to the deviation of the selected inflation measure from its long-term mean in the period of the excessive disinflation and the protracted period of deflation in table 3. In the second step, to evaluate the statistical significance of the change in the importance of the global shock ρ, the domestic shock β, the demand shock λ and the supply shock γ we regress their contribution observed in the excessive disinflation period (denoted by *1*) on those reported for the deflation period (denoted by *2*) using a simple OLS estimator. Equation (3) summarizes this step where y represents the contribution of interest:

$$y^{(2)} = \kappa_y y^{(1)} + \epsilon_y, \qquad y = \{\rho, \beta, \lambda, \gamma, \theta\} \tag{3}$$

In the course of the analysis we restrict the intercept of these regressions to zero – that way the estimated parameter κ_y informs us about the average change of the importance between these factors in the two distinguished time periods. We subject the parameter κ_y to a one-sided t-test[1].

Table 3-4 and the figure 7 present the results of the analysis. Each plot illustrates the changes in the contribution of the global, domestic, demand and supply shock to the total deviation from the long-term mean of a selected inflation component. Each point on the graph represents a pair of coefficients. The first coordinate resembles the relative contribution in the excessive disinflation (2012Q1-2014Q2) and the second coordinate reflects the relative contribution during the deflation period (2014Q3-2016Q4). The 45-degree line illustrates the no-change border. Additionally, the results of the fitting procedure through the cloud of points are printed in the top-left corner of the plots.

In general, the comparison between the period of excessive disinflation and the protracted deflation corroborates previous findings. During the period of falling consumer prices the role of global factors has increased considerably at the expense of the domestic determinants. Across all inflation components, the impact of the global shock is on average around 27% stronger and statistically significant. Moreover, we

[1] Under the null hypothesis $H_0 : \kappa_y = 1$ which reflects that the relative importance of the shocks has not changed between samples. The alternative hypothesis is one-sided depending on whether $\kappa_y < 1$ or $\kappa_y > 1$ holds for the parameter κ_y. To account for the probable problem of influential observations we impose a specific HAC correction on the variance-covariance matrix (Cribari-Neto, 2004) which improves the small sample performance of HC estimators.

Table 3: Contribution of the identified shocks to the inflation dynamics.

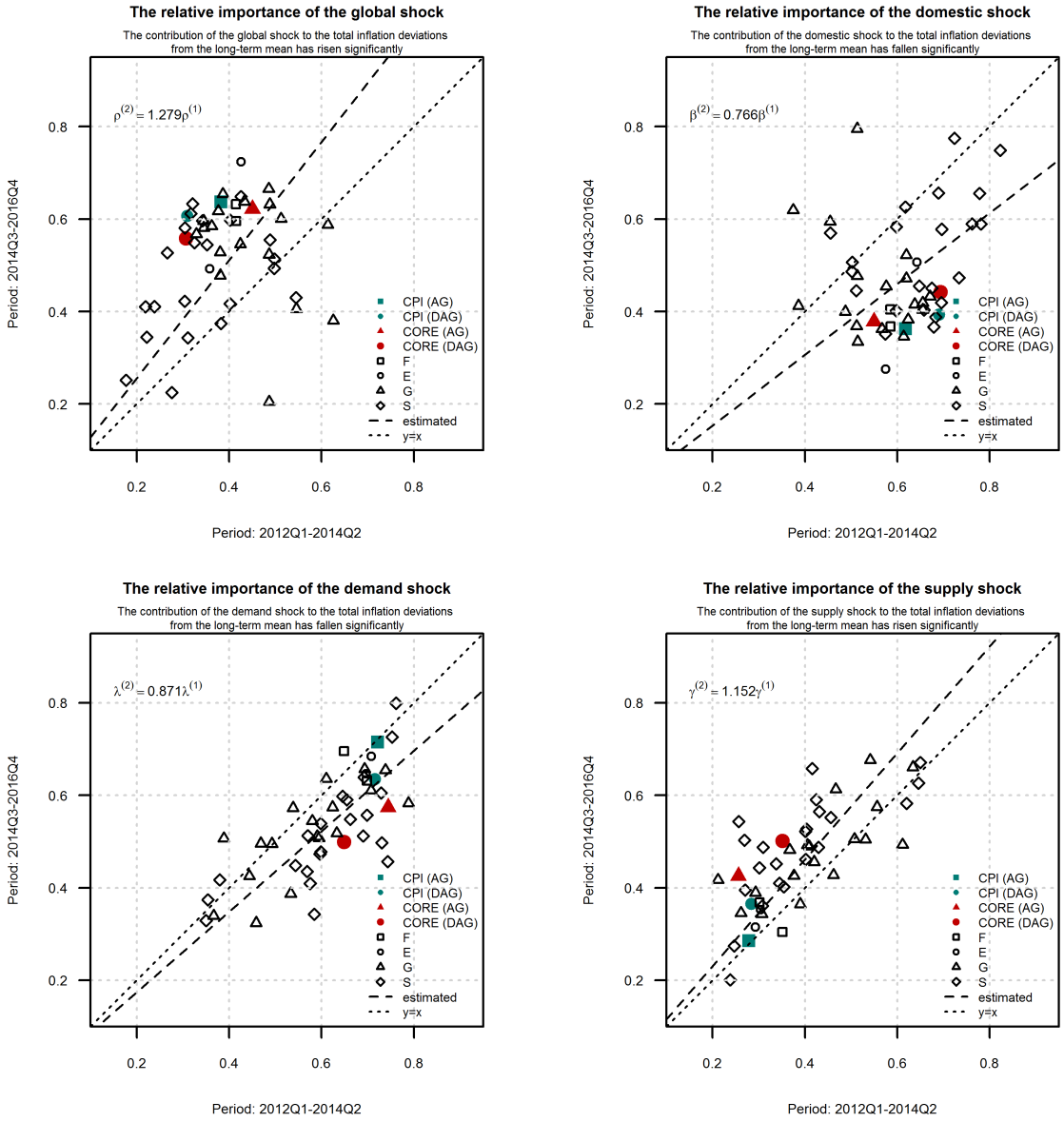
	2012Q1-2014Q2				2014Q3-2016Q4				2012Q1-2016Q4			
	Global	Domestic	Demand	Supply	Global	Domestic	Demand	Supply	Global	Domestic	Demand	Supply
CPI (AG)	38,71%	61,29%	71,74%	28,26%	63,60%	36,40%	71,39%	28,61%	51,15%	48,85%	71,56%	28,44%
CPI (DAG)	31,38%	68,62%	71,78%	28,22%	61,19%	38,81%	65,67%	34,33%	46,29%	53,71%	68,73%	31,27%
CORE (AG)	45,93%	54,07%	74,62%	25,38%	62,07%	37,93%	57,76%	42,24%	53,15%	46,85%	67,37%	32,63%
CORE (DAG)	31,73%	68,27%	65,10%	34,90%	56,47%	43,53%	50,79%	49,21%	44,11%	55,89%	59,83%	40,17%
C011	43,27%	56,73%	69,99%	30,01%	59,36%	40,64%	65,29%	34,71%	51,47%	48,53%	68,17%	31,83%
C012	41,90%	58,10%	65,39%	34,61%	63,99%	36,01%	70,63%	29,37%	52,35%	47,65%	68,81%	31,19%
C021	33,72%	66,28%	59,72%	40,28%	56,68%	43,32%	51,16%	48,84%	44,13%	55,87%	56,80%	43,20%
C022	36,12%	63,88%	79,36%	20,64%	58,77%	41,23%	59,35%	40,65%	46,96%	53,04%	70,25%	29,75%
C031	48,78%	51,22%	47,39%	52,61%	51,54%	48,46%	49,68%	50,32%	49,44%	50,56%	49,18%	50,82%
C032	63,95%	36,05%	35,80%	64,20%	37,20%	62,80%	35,85%	64,15%	49,79%	50,21%	35,34%	64,66%
C041	24,70%	75,30%	73,89%	26,11%	42,69%	57,31%	73,55%	26,45%	33,70%	66,30%	74,14%	25,86%
C043	31,98%	68,02%	66,83%	33,17%	61,15%	38,85%	54,91%	45,09%	46,56%	53,44%	61,95%	38,05%
C044	41,58%	58,42%	61,28%	38,72%	60,59%	39,41%	49,71%	50,29%	50,22%	49,78%	57,12%	42,88%
C045	36,31%	63,69%	69,65%	30,35%	49,88%	50,12%	65,23%	34,77%	42,66%	57,34%	68,57%	31,43%
C051	38,24%	61,76%	73,65%	26,35%	62,70%	37,30%	66,56%	33,44%	49,60%	50,40%	71,04%	28,96%
C052	61,36%	38,64%	40,94%	59,06%	59,10%	40,90%	52,84%	47,16%	60,44%	39,56%	47,51%	52,49%
C053	36,87%	63,13%	53,41%	46,59%	48,73%	51,27%	39,90%	60,10%	42,37%	57,63%	45,79%	54,21%
C054	47,75%	52,25%	70,81%	29,19%	63,22%	36,78%	61,47%	38,53%	54,76%	45,24%	67,39%	32,61%
C055	38,20%	61,80%	63,91%	36,09%	65,51%	34,49%	51,48%	48,52%	51,15%	48,85%	59,20%	40,80%
C056	43,68%	56,32%	61,08%	38,92%	63,82%	36,18%	64,44%	35,56%	53,70%	46,30%	64,22%	35,78%
C061	38,52%	61,48%	69,60%	30,40%	53,00%	47,00%	65,33%	34,67%	45,44%	54,56%	68,43%	31,57%
C062	35,31%	64,69%	67,90%	32,10%	59,76%	40,24%	59,23%	40,77%	47,31%	52,69%	64,80%	35,20%
C063	25,84%	74,16%	74,14%	25,86%	28,66%	71,34%	78,78%	21,22%	26,85%	73,15%	76,61%	23,39%
C071	49,73%	50,27%	45,00%	55,00%	61,12%	38,88%	44,48%	55,52%	54,76%	45,24%	45,11%	54,89%
C072	42,76%	57,24%	70,32%	29,68%	70,99%	29,01%	69,54%	30,46%	56,52%	43,48%	68,43%	31,57%
C073	44,32%	55,68%	64,33%	35,67%	64,27%	35,73%	60,21%	39,79%	53,73%	46,27%	63,19%	36,81%
C081	48,94%	51,06%	41,13%	58,87%	51,48%	48,52%	35,17%	64,83%	50,87%	49,13%	38,17%	61,83%
C082	54,89%	45,11%	40,23%	59,77%	43,16%	56,84%	39,40%	60,60%	48,00%	52,00%	38,77%	61,23%
C083	30,57%	69,43%	59,65%	40,35%	23,54%	76,46%	37,77%	62,23%	28,11%	71,89%	49,34%	50,66%
C091	48,58%	51,42%	45,59%	54,41%	19,78%	80,22%	32,58%	67,42%	33,99%	66,01%	38,31%	61,69%
C092	45,08%	54,92%	54,61%	45,39%	55,11%	44,89%	59,28%	40,72%	49,27%	50,73%	57,86%	42,14%
C093	34,85%	65,15%	59,11%	40,89%	58,26%	41,74%	52,92%	47,08%	46,58%	53,42%	55,22%	44,78%
C094	38,70%	61,30%	58,09%	41,91%	37,15%	62,85%	51,10%	48,90%	38,34%	61,66%	55,30%	44,70%
C095	55,19%	44,81%	50,97%	49,03%	41,62%	58,38%	50,96%	49,04%	48,70%	51,30%	51,80%	48,20%
C096	49,19%	50,81%	38,80%	61,20%	55,82%	44,18%	43,43%	56,57%	52,60%	47,40%	40,34%	59,66%
C101	41,20%	58,80%	58,01%	41,99%	42,36%	57,64%	42,06%	57,94%	42,67%	57,33%	51,00%	49,00%
C102	27,88%	72,12%	73,83%	26,17%	53,08%	46,92%	50,07%	49,93%	39,76%	60,24%	63,14%	36,86%
C103	32,26%	67,74%	72,54%	27,46%	54,69%	45,31%	59,69%	40,31%	43,26%	56,74%	67,43%	32,57%
C104	30,72%	69,28%	59,75%	40,25%	35,07%	64,93%	48,03%	51,97%	33,33%	66,67%	55,82%	44,18%
C105	50,32%	49,68%	56,98%	43,02%	49,68%	50,32%	45,07%	54,93%	49,63%	50,37%	52,54%	47,46%
C111	33,30%	66,70%	70,95%	29,05%	63,89%	36,11%	65,91%	34,09%	48,11%	51,89%	69,31%	30,69%
C112	23,83%	76,17%	75,02%	24,98%	40,61%	59,39%	46,71%	53,29%	33,63%	66,37%	60,61%	39,39%
C121	49,18%	50,82%	58,17%	41,83%	66,22%	33,78%	54,47%	45,53%	56,99%	43,01%	58,21%	41,79%
C123	35,58%	64,42%	62,66%	37,34%	59,84%	40,16%	58,48%	41,52%	47,24%	52,76%	61,91%	38,09%
C124	30,60%	69,40%	59,95%	40,05%	58,83%	41,17%	55,39%	44,61%	44,14%	55,86%	59,02%	40,98%
C125	30,44%	69,56%	68,81%	31,19%	41,97%	58,03%	51,34%	48,66%	36,24%	63,76%	59,67%	40,33%
C126	36,21%	63,79%	70,41%	29,59%	54,26%	45,74%	57,93%	42,07%	45,66%	54,34%	63,87%	36,13%
C127	22,22%	77,78%	55,91%	44,09%	38,38%	61,62%	46,70%	53,30%	29,98%	70,02%	50,89%	49,11%

Note: The table presents the contribution of the demand, supply, domestic and global shocks in the period of excessive disinflation (2012Q1-2014Q2), deflation (2014Q3-2016Q4) and the whole period of low inflation (2012Q1-2016Q4) to the deviation from the long-term mean of the given inflation measure. AG denotes that the results are reported for the aggregate measure of inflation whereas DAG denotes that the results are reported for the aggregation of outcomes of the models for inflation components. Source: own calculations.

have observed an increasing role of the supply factors (by roughly 15%) during deflation due to the severe plunge of the global oil prices.

Still, when inspecting the relative importance of shocks across inflation components we spot a substantial heterogeneity. Firstly, we show that fuel prices are driven mainly by the demand factors which is consistent with the finding for the oil prices in general (Baumeister and Kilian, 2016). Secondly, during the excessive disinflation the majority of services inflation components remains less sensitive to the global conditions and react more to the domestic factors. However, during deflation this situation changes as a

Figure 7: Change of the relative importance of the global, domestic, demand and supply shocks in shaping inflation developments during excessive disinflation and deflation



Note: The figure presents the changes of the relative importance of the global, domestic, demand and supply shocks in two periods: excessive disinflation (2012Q1-2014Q2) and deflation (2014Q3-2016Q4). F, E, G and S denote the food, energy, non-energy industrial goods and services inflation component, respectively. Source: own calculations.

Table 4: Changes in the relative importance of the shocks

Change in the importance of the:	coefficient	standard deviation	p-value
global (ρ)	1,268	0,064	0,000
domestic (β)	0,768	0,027	0,000
demand (λ)	0,879	0,018	0,000
supply (γ)	1,147	0,033	0,000

Note: The table presents the estimates of the parameter κ_y along with their standard deviations calculated using the specific HAC estimator and their p-values. Source: own calculations.

considerable number of services inflation components becomes more sensitive to global shocks. To give an example, the contribution of the global shocks to the transport services inflation or the catering services

inflation rises significantly to around 64% of the total deviation from the long-term mean during deflation. Therefore, we believe that the global shocks influenced the development of the services inflation via the cost channel. Thirdly, during excessive disinflation the contribution of the global shock has been largest mainly for the tradable, heavily imported goods, i.e. footwear, vehicles or clothing. Interestingly, for a limited number of inflation components of the non-energy industrial goods category the relative contribution of the global shock has actually fallen during deflation in comparison to the excessive disinflation period. This is especially visible for goods influenced by the globalization process: audio visual, photographic, telephone equipment or footwear. Fourthly, for a small number of inflation components the demand shock has in fact gained importance during deflation. This is exemplified by the rising contribution of the demand shock to the development of the package holidays inflation, hospital services inflation or other major durables for recreation and culture inflation. Nevertheless, overall in the deflation period the magnitude of the global factors increased and some services become more strongly influenced by the global determinants. This result confirm the hypothesis of rising globalization of services signalled by Hałka and Szafranek (2016).

4.3. Sensitivity indices and robustness check

In this section we deliver two main blocks of results based on the disaggregated analysis. Firstly, we report and discuss the developments of the inflation indices sensitive and resilient to the specific shocks. In the second step we inspect the difference between the indices of inflation sensitive to global and domestic adjustments based on the sensitivity indicators calculated from preferred identification scheme relying on a mixture of zero and sign restrictions as well as for the Choleski factorisation scheme which we implement as a robustness check.

During the disaggregated analysis we mark each inflation component as sensitive or resilient to the identified shocks. Next, we combine the sensitivity indicators, the annual rate of change of all inflation components as well as their weights to obtain inflation indices of goods sensitive or resilient to the specified shocks. These measures are presented on figure 8.

In general, the calculated indices indicate that during financial crisis domestic conditions have heightened inflation whereas foreign demand has put a downward pressure on consumer prices in Poland with the inflation of goods sensitive to foreign demand falling below -3% y-o-y. The weak external conditions after the outbreak of the great financial crisis has lead mainly to the strong decline of prices of vehicles, fuels, footwear, audio-visual and photographic equipment prices – goods strongly affected by the deteriorating demand in the developed as well as emerging economies. At the same time the domestic conditions have been pushing inflation upwards, in some months even above 6% y-o-y. The main factor behind this development was the positive output gap, which influenced the prices of components perceived to be strongly influenced by the domestic conditions, especially services.

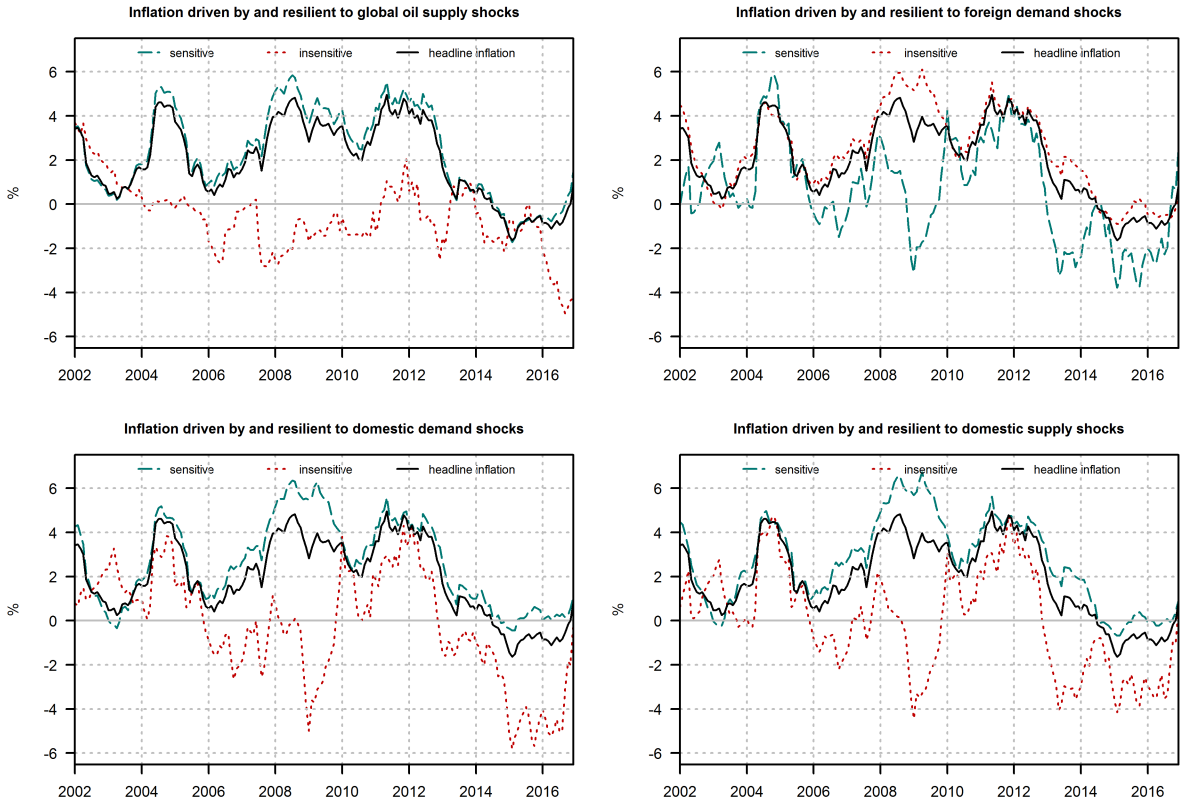
The second episode of deflationary pressure exerted by foreign factors has been the protracted period of deflation in Polish economy. Again, fading external economic conditions has put a downward pressure on consumer prices which have been falling for a prolonged period of two and the half year. However, this time domestic conditions were not favourable either since from the beginning of 2012 the output gap in Poland has remained negative. Yet, the inflation of goods sensitive to the domestic demand during deflation has been low evolving around zero which indicates that the demand pressure in the Polish economy has been narrow but not deflationary. Improving domestic conditions in the second half of 2016 reflected in the acceleration of the economic growth in Poland has lead to the increase of the inflation of goods sensitive to the domestic demand and supply. Additionally, in the last quarter of 2016 the global economic has improved which brought surge of the inflation of goods sensitive to the foreign demand, generating the increase of the Polish inflation.

One particular fact needs to be highlighted. The inflation of goods sensitive to the global oil supply shock closely resembles the headline inflation. This results from the composition this measure as nearly all inflation components are sensitive to the oil supply shock. In fact, the prices of only three important

components are resilient to this shock – clothing (which prices are rather influenced by the globalisation process), medical products (where nearly half of the prices are administered, not depending on the economic conditions, but rather on the negotiation process between the Ministry of Health and the pharmaceutical companies) and recreational and cultural services (like television and radio licence fees which prices are administered[2]. The statistically significant reaction of nearly all CPI subcomponents to the changes in the oil prices is not surprising as the energy prices are an important cost factor in the production of goods and services. The insensitive to the oil supply shock part of the CPI basket is mostly deflationary mainly due to the falling prices of clothing throughout the analysed period.

When inflation of goods sensitive to the domestic conditions is considered, our approach delivers a similar picture to the previous study in the empirical literature employing a Phillips curve framework for disaggregated inflation indices. The correlation between our inflation of goods sensitive to the domestic conditions with the measure put forward by Hałka and Kotłowski (2014) amounts to 0.96.

Figure 8: Indices of inflation sensitive and resilient to the global oil supply, foreign demand, domestic demand and domestic supply shocks



Note: The figure presents inflation indices sensitive and resilient to the global oil supply, foreign demand, domestic demand and domestic supply shocks. The measures are calculated using the sensitivity matrix of the headline inflation components and the system of weights used for calculating the headline inflation in Poland. Source: own calculations.

In second step we provide a robustness check in which we compare calculated indices of goods sensitive to the global and to the domestic shock using two alternative identification scheme – zero and sigh restrictions and Choleski.

Table 5 presents the information on the components which prices are sensitive or resilient to the particular shock depending on the adopted identification scheme. As in the Choleski identification scheme we are not able to distinguish between domestic and supply shocks, due to the specific ordering of the

[2]In case of other administered prices, like electricity, heating energy, gas, transport services changes in the commodity prices on the international markets are also taken into account whilst setting the prices).

Table 5: The sensitivity of the inflation and its components to specific shocks.

	Sign restriction identification scheme		Choleski identification scheme	
	Global	Domestic	Global	Domestic
CPI (AG)	1	1	1	1
CORE (AG)	1	1	1	1
C011	1	1	1	1
C012	1	1	1	1
C021	1	1	1	1
C022	1	1	1	1
C031	**0**	0	1	0
C032	**1**	0	0	0
C041	1	1	1	1
C043	1	**1**	1	0
C044	1	1	1	1
C045	1	**1**	1	0
C051	1	**1**	1	0
C052	0	**1**	0	0
C053	1	0	1	0
C054	1	1	1	1
C055	1	1	1	1
C056	1	1	1	1
C061	**0**	**1**	1	0
C062	1	1	1	1
C063	**0**	**1**	1	0
C071	1	0	1	0
C072	1	0	1	0
C073	1	**1**	1	0
C081	**0**	**1**	1	0
C082	1	**1**	1	0
C083	**1**	**1**	0	0
C091	1	**1**	1	0
C092	1	0	1	0
C093	1	1	1	1
C094	0	1	0	1
C095	0	**1**	0	0
C096	**1**	1	0	1
C101	1	1	1	1
C102	1	1	1	1
C103	1	**1**	1	0
C104	1	0	1	0
C105	1	1	1	1
C111	1	1	1	1
C112	1	1	1	1
C121	1	1	1	1
C123	1	1	1	1
C124	1	1	1	1
C125	**1**	**1**	0	0
C126	1	**1**	1	0
C127	**1**	**1**	0	0

Note: The table presents the sensitivity of the inflation and its components to the specific shocks. In the table '1' indicates that the direction of response of the variable is correct and statistically significant following a specific shock, whereas '0' denotes that the given shock is statistically insignificant. Divergences between the outcomes from the sign restriction identification scheme and the Choleski recursive identification scheme are reported in bold. Source: own calculations.

variables we can only categorize the structural innovations either as global or domestic. To make the results comparable with the outcomes from the sign restriction scheme we proceed as follows. For the outcomes based on sign restriction scheme we assume that if a component is sensitive to at least one of the global shocks (i.e. foreign demand, oil supply and exchange rate) then it is sensitive to the global shock. On the other hand, if the component is affected by at least one of the domestic shock (i.e the domestic demand, the domestic supply or the monetary policy shock) then we mark it as sensitive to the domestic shock. The calculated indices for each scheme are presented on figure 9.

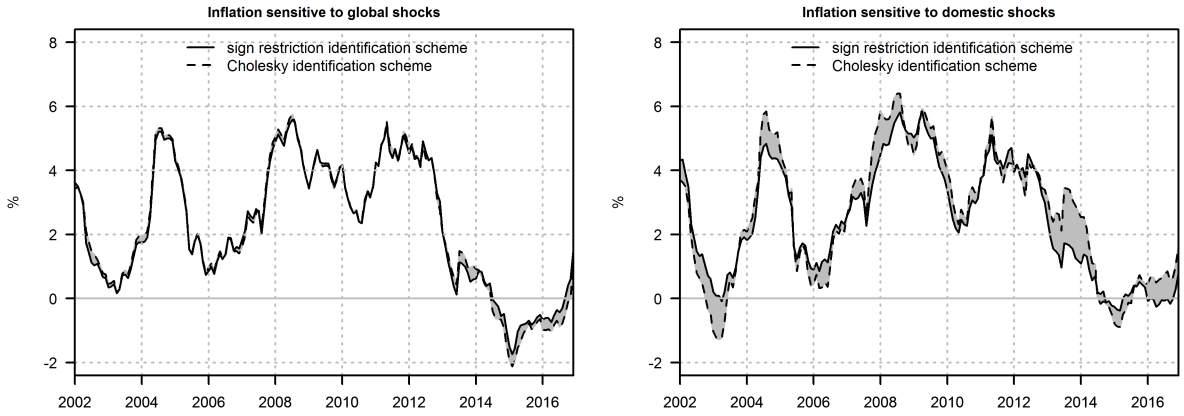
The comparison indicates that regardless of the identification scheme we choose, both calculated indices of goods sensitive to the global shock are similar. However, at the end of the sample inflation of goods sensitive to the global shock is lower when the Choleski method is considered. This stems form the fact that contrary to the Choleski factorisation, the sign restriction scheme categorizes the prices of insurances facing a high inflation in 2016 as sensitive to the global shock. Additionally, the prices of package holidays with the annual rate of change above 3% in 2016 are considered insensitive to the global

shock when the Choleski identification scheme is employed.

The comparison between the indices of goods sensitive to the domestic shocks shows that the difference between the identification schemes in some periods is quite substantial. The largest divergence is visible during the period of disinflation and amounts to almost 2 pp. During deflation the discrepancy is considerably smaller and evolves around 0.8 pp. at the end of 2016. This stems from the fact that the Choleski identification scheme is more restrictive when indicating inflation components sensitive to the domestic shock – approximately 36% less inflation components is found to react to the domestic shock which constitutes a rather substantial part of the CPI basket, namely around 28%. In the case of goods sensitive to the global shock the number of components not marked as sensitive in the Choleski scheme is lower – only approximately 10% with the weight in the CPI below 10%, with the most important and with relatively high inflation components being package holidays and insurance services.

Taking into account the outcomes of the above comparison we conclude that our results are robust in respect to the identification scheme adopted.

Figure 9: Inflation of the components sensitive to the global and domestic shocks



Note: The figure compares the inflation indices sensitive to global and domestic shocks identified using the sign restriction and the Choleski identification scheme. The grey area on the plots represents the overall divergence between the indices. The measures are calculated using the sensitivity matrix of the headline inflation components and the system of weights used for calculating headline inflation. Source: own calculations.

5. Conclusion

In the recent years the development of the headline inflation rates across countries has continued to surprise. This peculiar behaviour of inflation is particularly starkly exemplified in the small open economy of Poland. The main aim of this paper was to identify the determinants of the nominal fluctuations in the period of low inflation in an emerging, small open economy. For this purpose we have considered a fairly standard set of macroeconomic variables and estimated a structural VAR model in a Bayesian framework. We have alleviated the shortcomings of the Choleski factorisation and identified economically interpretable structural shocks affecting consumer prices by following a recent notion in the empirical literature and employing the mixture of zero and sign restrictions. This approach has enabled us to assess the relative importance of the global and domestic, supply and demand factors in shaping inflation developments in Poland. Moreover, we have extend this analysis on a large number of inflation components to inspect whether conclusions drawn from the aggregated approach are in line with the results of the analysis performed on the disaggregated data. We have taken further advantage of the disaggregated approach by marking inflation components as sensitive or resilient to the changes in the developments of the global and domestic factors. Based on the calculated sensitivity indicators we have constructed indices of inflation sensitive and resilient to the distinguished determinants.

Our paper grants several important conclusions. Firstly, in line with the previous studies for the small open economy of Poland we have shown that the domestic demand remains a significant determinant of the nominal fluctuations. In particular, we conclude that the deteriorating domestic conditions have turned out to be a primary source of the excessive disinflation in Poland. Secondly, we confirm the rising importance of the global factors during the deflation period. We provide evidence that deflation has been an entirely imported phenomenon that resulted from the downward pressure exerted by the waning global demand and plummeting oil prices on consumer prices. Further analysis of the development of the inflation indices sensitive to the domestic demand as well as the global shock corroborate this outcome. Thirdly, our presented evidence on the relative importance of the global and domestic shocks is consistent with the findings in the previous empirical studies not necessarily accounting for the low inflation period. We interpret this as a lack of a structural break in the mechanism of setting prices during the episode of falling prices. Fourthly, the analysis repeated on the number of inflation components generally has confirmed the conclusions of the study performed on the aggregate inflation indices. However, we present and discuss substantial heterogeneities in the relative importance of the identified shocks across the distinguished inflation indices during the excessive disinflation and deflation. In particular, whereas some inflation components remain resilient to the developments in the global economy, we argue that during deflation the inflation of services has been increasingly influenced by the foreign factors. Lastly, we present evidence that the monetary policy has remained neutral throughout the low inflation period.

We provide a number of guidelines for the monetary policy. Firstly, despite the increasing role of the global developments the domestic slack remains a significant factor influencing the development of consumer prices in the small, open economy of Poland. Therefore, is should remain as an object of all possible scrutiny. However, as the small open economy becomes increasingly integrated with the global economy the monetary authorities should take into account as wide range of factors as possible when reaching policy decisions. Secondly, we acknowledge the additional information the disaggregated analysis introduces whilst studying the development of the consumer prices. In particular, it should be highlighted that some of the distinguished inflation components react quite differently in the period of disinflation and deflation which should be taken into consideration whilst adjusting the monetary policy. Finally, inflation indices sensitive to the domestic and global conditions may quite precisely reflect foreign and domestic inflationary or deflationary pressures. In fact, we perceive them as a convenient tool to monitor the nominal developments in the domestic economy. Evaluating their forecasting capabilities would be an interesting topic for future research.

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