Lodz Economics Working Papers

Patterns of regional inflation persistence in a CEE country. The case of Poland

Paweł Gajewski

5/2017

FACULTY OF ECONOMICS AND SOCIOLOGY

University of LODZ

Patterns of regional inflation persistence in a CEE country. The case of Poland[1][2]

Paweł Gajewski

Faculty of Economics and Sociology, University of Lodz,

POW 3/5, 90-214 Lodz, Poland

E-mail: pawelg@uni.lodz.pl

January, 2017

Abstract

This paper investigates patterns of regional inflation persistence in Poland, a representative CEE country. We first argue that the CEE perspective is relevant in the context of this study due to the recent transitions, incomplete processes of forming forward-looking inflation expectations and pronounced spatial inequalities. Using individual and panel regressions on disaggregate data we provide evidence of the aggregation bias and marked differences in inflation persistence across product categories. Furthermore, we show that cross-regional differences in inflation persistence remain, even after controlling for the product category. While we generally confirm the earlier finding of Vaona and Ascari (2012) that more backward regions exhibit higher CPI inflation persistence, we also show that the picture is more nuanced at the product category level.

JEL Classification:

Key Words: Regional economic dynamics, CEE, inflation persistence

[1] Research financed by National Science Centre, Poland (within research project DEC-2014/15/B/HS4/01996).

[2] The help of Szymon Wójcik with preparing and processing statistical data as well as graphics is gratefully acknowledged.

1. Introduction

Inflation persistence is often defined as the extent to which shocks in the past have an effect on current inflation (Fuhrer & Moore, 1995). Understanding how shocks that have affected inflation in the distant past are reflected in current inflation as well as how long it takes for inflation to approach a new equilibrium after a shock is crucial for a central bank in determining its response in order to reach the desired objectives (Ascari & Sbordone, 2014). It thus comes as no surprise that inflation persistence has attracted considerable research interest around the world, manifested in the works of Steinsson (2003), Benigno and Lopez-Salido (2006) or Stock and Watson (2007), to name just a few of many.

Theoretical underpinnings, which can serve to improve understanding the nature of inflation persistence are very rich. In an excellent survey, Cecchetti and Debelle (2006) show that canonical versions of time-dependent and state-dependent price-setting models predict no inflation persistence, while the limited information models typically introduce only small amount of it. They make an obvious, yet important distinction between price level persistence and inflation persistence. In time-dependent models, such as those proposed by Taylor (1980) or Calvo (1983), prices are determined in a sequence of overlapping contracts, which are set based on contemporary available information and last for a fixed *n* number of periods. This implies that all shocks to price levels will have an impact on these prices for the subsequent *n*-1 periods. However, this price-setting mechanisms do not generate any persistence in the rate of inflation, especially that the price-setters are forward-looking. On contrary, inflation immediately moves to the new level, following the shock. Also state-dependent models, such as the menu-cost based price-setting mechanism do not provide any direct and universal link between individual price changes and inflation persistence. What is more, even the impact on aggregate price level persistence is not unambiguously determined as it can differently respond to individual price changes, depending on the length of contracts, price elasticities of

demand and also the properties of shocks themselves. Only in the limited information models price adjustments are slowed down by the time of solving the information problem of price-setters, which leaves some room for gradual changes of inflation after the shock, i.e. the persistence.

Cecchetti and Debelle (2006) argue that the most important source of inflation persistence lies in inflation expectations. The more they are backward-looking, the more persistent inflation is in the economy. Should agents be purely forward-looking, inflation persistence would be zero. As inflation expectations can be influenced by the monetary policy, some studies investigate (and find positive) the role of following the inflation targeting strategy and of overall monetary policy credibility for bringing inflation persistence down (Sargent, 1999) (Erceg & Levin, 2006); (Orphanides & Williams, 2005).

The rising interest in inflation persistence has been accompanied by growing interest in the behavior of prices and inflation rates at disaggregate levels (Clark, 2006). Both Erceg and Levin (2006) and Barsky, House, and Kimball (2003) are mostly interested in durable and nondurable goods and both find that prices of the former are more sensitive to monetary policy shocks. Babecky, Coricelli, and Horvath (2009) investigate detailed product-level consumer price indices in the Czech Republic and find that raw goods and non-durables, followed by services, display smaller inflation persistence than durables and processed goods. They also explicitly provide evidence for the aggregation bias in the form of high aggregate inflation persistence, relative to persistence in the underlying disaggregated series. Also, Clark (2006) finds that average persistence of disaggregate inflation is consistently below aggregate persistence and thus adds support to the problem of aggregation bias. Contrary to the results of Erceg and Levin (2006), Barsky et al. (2003) and Babecky et al. (2009), Clark (2006) finds no difference in inflation persistence between these product categories (and also services), even though considerable difference are found at a higher level of disaggregation.

Interestingly, the results of Altissimo, Mojon, and Zafaroni (2007) are exactly the opposite: they find inflation being most persistent in the case of food, housing and transportation. The second group (with some signs of positive persistence) encompasses alcohol and tobacco as well as furniture and health, with positive but very low persistence. Finally, communication, miscellaneous, recreation, clothing, restaurants and education all fall into the third group, with small and negative inflation persistence. Altissimo et al. (2007) arrive at some other interesting results. Most importantly, they show how high volatility and low persistence, observed on average at the level of sectoral inflation, are consistent with the aggregate smoothness and high persistence. Additionally, they document the strong cross-sectoral heterogeneity of the propagation mechanism of shocks.

Within-country regional inflation processes have so far received less attention, with some notable exceptions. For example, Cecchetti, Mark, and Sonora (2002) find a very slow rate of convergence between price levels across U.S. cities, which they attribute to transportation costs, differential speeds of adjustment to small and large shocks and the role of non-tradable goods.

The closest to our study (and its inspiration) is the paper by Vaona and Ascari (2012), who investigate provincial, disaggregated inflation series in Italy. They show that economically inflation persistence is indeed statistically different across Italian provinces and that backward regions display greater inflation persistence. This paper might be considered a convenient benchmark for our study, also because of some similarities between Italy and Poland. They are two similar-sized European countries with strong cross-regional divide. The North-South divide in Italy broadly corresponds to the West-East divide in Poland.

To summarize, the aim of this paper is to shed some light on disaggregate inflation persistence in Poland. More specifically, it identifies product groups and regions that exhibit

highest and lowest inflation persistence, and tests whether cross-regional differences remain after sectoral differences are accounted for. Finally, some inference is drawn to address the hypothesis of Vaona and Ascari (2012) that inflation persistence is related to economic backwardness of a region.

2. The CEE perspective

As noted in the previous section, the primary source of inflation persistence are considered to be inflation expectations. The CEE experience with centrally-planned economies, usually rapid transitions and subsequent rapid economic integration with the EU, must have affected the process of forming inflation expectations in these countries. This is where the first CEE-specific element kicks in. The process of forming forward-looking inflation expectations takes time and is largely dependent upon monetary policy credibility. To build the latter, it also takes time.

The environment for conducting monetary policy in CEE (and building its credibility) has been very challenging due to the multitude of constraints and forces shaping national inflation developments. Indeed, countries there are typically relatively vulnerable to international capital flows and monetary policy actions taken in the Eurozone, while also coping with internal shocks related to their more dynamic economic structures, progressing privatization, etc. Additionally, the monetary policy environment has been constantly changing in the past three decades, which forced frequent adjustments in monetary and exchange rate policy regimes. Poland again serves as a good example of a CEE country, which in the past decades had no choice but adapt to the rapidly changing conditions. Starting from 1990, monetary policy target there evolved from combating post-transition shock hyperinflation with the help of money supply control, while also preserving the exchange rate fixed (with a changing currency basket), through following a crawling peg and enforcing disinflation, all the way

towards introducing inflation targeting (from 1998 on) and a flexible exchange rate (from 2000 on) in the dynamic environment of progressing integration with the EU, that was gradually limiting the scope of independent monetary policy vis-à-vis the Eurozone. It should be acknowledged, that despite this turbulent conditions, most CEE monetary policies have been fairly successful in stabilizing their economies, achieving price stability and building its credibility. Admittedly, the progress in the latter element has not been equal and largely depends on initial conditions and starting dates of the economic transitions. Most studies would find Czech monetary policy as the most successful in establishing it credibility as well as raising forward-lookingness of inflation expectations, followed by Slovakia (now a Eurozone member), followed by Poland and Hungary (Arestis & Mouratidis, 2005) (Baxa, Plasil, & Vasicek, 2015). However, a recent study of Sousa and Yetman (2016) provides evidence that in four CEE countries (Czech Republic, Hungary, Poland and Romania) inflation expectations have already been fairly firmly anchored, which speaks in favour of monetary policy credibility. Also Baranowski and Gajewski (2016) show that the National Bank of Poland put its monetary policy to a credibility test in 2013 and 2014 by launching forward guidance and this test can be considered as passed. All this most recent evidence would suggest that CEE monetary policies are advanced in the process of credibility-building, although the finding of (Franta, Saxa, & Smidkova, 2010) who show that backward-looking behaviour may be a more important in explaining inflation dynamics in CEE countries than in "old" EU member states, will probably remain valid for some time.

As underlined in the previous section, existing empirical evidence also points to substantial differences in inflation persistence across product categories and regions. The extent to which this aspect is valid in CEE countries thus depends on intra-national disparities. Monastiriotis (2011) examines the growth process in CEE countries since the start of their transition to market economies, through the prism of spatial patterns. He shows that the catching-up

processes vis-à-vis Western Europe observed at the national level were accompanied by a "*complex pattern of non-linear regional growth dynamics with convergence tendencies largely swaddled by processes of cumulative causation"*(Monastiriotis, 2011). Consequently, regional evolutions were generally found divergent, hereby deepening existing disparities and polarisation. Similar conclusions, of relatively large and growing regional disparities in CEE countries, compared to the rest of EU, are reached by Smetkowski (2013). It should be acknowledged, that this aspect is also relevant in relatively small countries of the region. Banerjee and Jesenko (2015) and Dokic, Frohlich, and Bakaric (2016) demonstrate substantial regional development disparities in Slovenia and Croatia, respectively.

To summarize this section, there is a strong rationale behind investigating inflation persistence with a special focus on disaggregate approaches, in CEE countries. Both the incomplete process of forming forward-looking inflation expectations and sizeable (and growing) regional disparities make inflation persistence an even more important problem there, than in many developed countries with long-track of credible inflation-targeting and more balanced regional distribution of growth and development.

3. Data and empirical model

To the best of our knowledge, Polish Central Statistical Office (Główny Urząd Statystyczny, GUS) is the only one in CEE, which provides NUTS-2 level consumer inflation series, also disaggregated to main product categories, at both annual and quarterly frequency. It is obvious that quarterly data is more appropriate for investigating regional inflation persistence. In CEE there are at least two reasons for that. First, annual frequency is generally too low to capture persistence. For example, Vaona and Ascari (2012) impose one year (four quarters) as a maximum length of persistence and find that in most regions coefficients are statistically significant only up to one or two quarters. Second, annual frequency would require collecting

data from at least 30-40 years in order to make individual estimations feasible. But CEE countries have undergone transitions in the last 30 years (in some cases they are still being completed). Prior to these transitions consumer prices heavily relied on administrative decisions. This makes prices in pre-transition periods not comparable with post-transition prices and incorporating them would introduce severe bias to our results.

We use a dataset containing quarter on quarter CPI index changes, spanning from 1st quarter 2005 to 3rd quarter 2016 for 16 Polish voivodships (NUTS-2 regions), also disaggregated into eight product categories (education, food & non-alcoholic beverages, alcohol & tobacco products, clothing & footwear, housing, health, transport, recreation & culture). The source of data is GUS, and we seasonally adjust all series using the X-13-ARIMA-SEATS method. Descriptive statistics of all our 144 series are presented graphically as boxplots in figure 1. There we can observe that the disinflation process in Poland, which started in early 1990s from the hyperinflation accompanying rapid transition, has been firmly completed before the starting point of our sample. Not only the aggregate CPI inflation, but also price indices in all other product categories do not reveal any track of unusually high values and deviations from the mean are broadly symmetric.

Altogether, during the sample period the country enjoyed a stable economic environment without strong trends and major shocks. The post-EU entry shock faded before the starting point and the 2008 global crisis had only muted impact on the Polish economy. This is why the conventional ADF unit root test, which we execute prior to our empirical exercise, does not raise any major concerns (table 1). It rejects the null of nonstationarity at the 1% or 5% significance levels in all series.

There are several approaches to investigating inflation persistence. Most studies follow a statistical approach and assume univariate representation of the inflation process, which

allows calculating the sum of autoregressive coefficients, the largest autoregressive root or half-life as a measure of persistence (Carlos, 2004). Structural approach on the other hand relies on the Phillips curve with nominal rigidities modeled with a price adjustment mechanism. In the standard Calvo mechanism for example, a fraction of firms is allowed to adjust prices in every period (Calvo, 1983). Even on the aggregate level, the statistical approach outperforms the structural one in terms of data fit (Franta et al., 2010). Earlier, Bils and Klenow (2004)showed that the Calvo model dramatically fails to fit the disaggregate data.

Our empirical exercise is thus performed in two steps. The first step relies on estimating a set of autoregressive models, as in Vaona and Ascari (2012):

$$\pi_{ijt} = \alpha_{ij} + \sum_{k_{ij}=1}^{K_{ij}} \rho_{ijk_{ij}} \pi_{ijt-k_{ij}} + u_{ijt} \qquad (1)$$

where π_{ijt} is quarter on quarter CPI inflation rate in voivodship i, product group j, time t; α_{ij} is the region- and product group-specific intercept. K_{ij} is the lag length, determined individually in each of the 144 estimated equations with the help of the BIC information criterion and u_{ijt} is the error term. As we favour parsimony, each of the model is first estimated as AR(1) and AR(2) processes and the selection between them is based on the BIC criterion. If AR(2) is preferred over AR(1), then we extend the number of lags and repeat the model selection procedure based on BIC. We also follow Vaona and Ascari (2012) in setting an upper limit of four lags to preserve degrees of freedom in individual estimations.

A natural consecutive step to investigate determinants of inflation persistence would be to estimate cross-sectional models with autoregressive terms as a left-hand variable and a set of explanatory variables related to the economic structure, business sector demography or geographic location to track some region-specific sources of inflation persistence. While this

approach is used by Vaona and Ascari (2012), it is inaccessible in our case due to insufficient number of cross-sections. However, we utilize some well-established facts on regional development patterns in Poland to track the role of backwardness for inflation persistence. As is well known, that in terms of the level of development and some deep characteristics, related among others to economic structures and business sector structure, the country can be broadly divided into two parts: the more developed West (commonly referred to as Poland "A") and a backward East (Poland "B", see: (Gajewski & Tchorek, 2017)). Admittedly, some voivodships, mostly those geographically located in the central part of the country, escape this division and do not unambiguously belong to either East or West. For the purpose of this study, we employ the East-West division, which emerges from the formal extraction procedure performed by Gajewski and Tchorek (2017), who arrive at the following composition of the two groups of voivodships:

- East: Lubelskie, Podkarpackie, Podlaskie, Warmińsko-Mazurskie and Świętokrzyskie
- West: Dolnośląskie, Lubuskie, Opolskie, Pomorskie, Wielkopolskie, Zachodniopomorskie and Śląskie.

The four voivodships which could not be unambiguously qualified to East or West are: Mazowieckie, Łódzkie, Kujawsko-Pomorskie and Małopolskie. The latter three voivodships form a central belt separating the West from the East. Mazowieckie in turn is structurally distinct because of comprising both large, underdeveloped agricultural lands on the one hand and the administrative and financial capital city of Warsaw – on the other.

In the second step of our empirical analysis we pool all regional data and estimate panel-data models, in which we control for differences between the East and West macroregions with the help of interactive terms. Our models have the following form:

$$\pi_{ijt} = \beta_{ij} + \sum_{k=1}^{4} \rho_{ijk} \pi_{ijt-k} + M_n \sum_{k=1}^{4} \rho_{ijk} + \upsilon_{ijt} \qquad (2)$$

where M_n is one of the two (n=2) dummy variables that captures East and West macroregions. Interactive terms $M_n \sum_{k=1}^{4} \rho_{ijk}$ capture deviations in the autoregressive coefficients between East and West from the reference group of regions. More precisely, a model is first estimated with interactive terms containing East and then the reference group is composed of all voivodships excluding those belonging to East. Then the same model is estimated with interactive terms containing West and the reference group becomes all regions excluding West.

4. Results

The first part of our empirical exercise leaves us with estimated 144 individual autoregressive models. It should be acknowledged that the decision to constrain the number of lags to four was sensible as in only five models four lags were selected. In fact, in most cases (68 models) one lag was as optimal choice. Two lags were chosen in 13 models and three lags in 6 models. In 52 models the first autoregressive coefficient was not significant which was interpreted as evidence of no persistence in inflation. Presenting detailed results for all 144 models is not feasible, given the space limitations, but Figure 2 illustrates most important findings from these estimations. It presents autoregressive terms $\sum_{k=1}^{4} \rho_{t-k}$ for all statistically significant coefficients ρ_{t-k}, up to the selected tag length.

Overall CPI quarterly inflation persistence across Polish voivodships ranges from .52 to .73. In order to get a first glance at the relationship between persistence and backwardness, we take two series, for which we have no insignificant autoregressive terms and compute

correlation coefficients between inflation persistence on the one hand and per capita GDP as well as share of employment in agricultural sector on the other. The latter variable serves as a good CEE-specific proxy of development lag. Indeed, this part of Europe still undergoes structural changes which are uneven in space. Regions which are still dominated by agriculture tend to lag behind in many other respects as well.

As we see in Figure 3, there is a moderately strong and positive correlation between inflation persistence and importance of agriculture. An even stronger correlation is observed when aggregate CPI inflation is replaced by housing price inflation. But figure 3 also suggests that the correlation between inflation persistence and per capita GDP is negligible. We believe that this result is due to another CEE-specific feature, namely the concentration of development processes in capital cities (or a low number of largest metropolitan areas). At least during first decades after the transition, growth tended to be concentrated in Warsaw, Prague, Budapest, Bucarest and other capital areas. In Poland, the otherwise agricultural Mazowieckie voievodship is home to the capital city of Warsaw, with its dynamic financial industry and headquarters of many international companies operating in Poland. When this outlier region is excluded, we arrive at a significantly negative, moderately strong correlation. In other words, taking into account the specific CEE-related features, we are able to confirm the hypothesis of Vaona and Ascari (2012) that backward regions exhibit higher degree of persistence, at least with regard to the aggregate and housing inflation rates in Poland.

As expected, and earlier documented e.g. by Altissimo et al. (2007), we also find strong cross-product heterogeneity in inflation persistence. Except of housing, also alcohol & tobacco products are marked by persistent inflation, while in the cases of food & non-alcoholic beverages and also transportation it turns out to be moderately persistent. On the other hand, we find no significant regional autoregressive components in the case of recreation & culture category and only one significant autoregressive term in education, in the western

Dolnośląskie voivodship. The remaining two product groups, clothing & footwear and health, reveal a dual nature: in some regions autoregressive terms are significant (and sometimes high, especially in clothing and footwear), while they appear insignificant in other.

Our results also support the aggregation bias hypothesis. The aggregate CPI index seems to inherit persistence from its most persistent components, such as housing and alcohol & tobacco, and is well above the persistence in the remaining series.

In the second stage, we want to shed some light on the role of backwardness for inflation persistence by examining its patterns in the two distinct macroregions introduced in the previous section. The data is now pooled and panel models are estimated with interactive terms to capture differences in the slope (autoregressive) coefficients between both macroregions and the rest of Poland. Here, no restrictions are imposed on the lag structure, as we are mostly interested in significance of deviations rather than significance of coefficients on autoregressive terms in the reference groups of regions. Table 2 presents the results.

First of all, we observe that our panel regressions confirm earlier findings that aggregate CPI index, housing and alcohol & tobacco inflation all display highest persistence. Similarly, we find support to the result of no inflation persistence in the recreation & culture category, which is reflected in insignificance of the first two autoregressive coefficients. Unlike in individual regressions however, the persistence in education category appears positive, although partly neutralized by negative second-lag autoregressive coefficients. Such pattern can be responsible for insignificant autoregressive terms, found in most our individual regressions.

Moving on to the east-west divide, we obtain some further noteworthy results. Most of all, we get additional support to the hypothesis that eastern voivodships (East) display stronger overall CPI inflation persistence than non-eastern ones. On contrary, persistence in western

voivodships (West) seems to be lower than elsewhere, although we acknowledge that the difference is only significant on the first autoregressive term. Beyond it, we find no strong evidence that more remote CPI inflation rates influence today's inflation in a different way across both macroregions.

Even stronger deviations in persistence are found in the food products category, but again – only when first lags are compared. The second lag in the West turns out higher than in other regions, while East does not differ from the rest of the country in this respect. But we should acknowledge that the pattern discovered in both the aggregate CPI index and food price index, does not unambiguously hold in other categories. Most notably, there does not seem to be any deviations in persistence neither between East, nor West from the reference groups in two categories: alcohol & tobacco and recreation & culture. In the first group, it is a natural consequence of heavy regulation of spirits and tobacco markets with country-wide impact of administrative decisions on prices. Within recreation & culture category on the other hand, we have both items, which are sold at identical prices across the country (e.g. newspapers, books) and some tradable items (e.g. audio-visual equipment), which can be easily purchased from distant locations, via internet for example. Therefore, the room for regional price discrimination is only limited.

Inflation of clothing & footwear is in turn more persistent in West compared to East and the difference is only visible in the first lag. Differences of inflation persistence in the remaining three product categories (housing, transportation, health) are more subtle and embedded in the distribution of autoregressive terms more than in their sum. Inflation persistence of health-related products and services for example does not deviate in neither of the macroregions initially, but the second inflation lag adds to the overall persistence in West, while the fourth lag removes a part of it. On contrary, East is in this respect virtually undistinguishable from its reference group.

5. Conclusions

The aim of the paper was to shed some light on regional inflation persistence in a CEE country, with all its specific features. Poland was chosen due to data availability and because it shares many peculiarities with other CEE countries. Overall, our results are broadly in line with findings presented in some earlier studies. First, they add support to the existence of the aggregation bias, as documented by Clark (2006) or Babecky et al. (2009), but contrary to Vaona and Ascari (2012). Indeed, the aggregate CPI index in our dataset displays similar persistence to its most persistent components (housing, alcohol & tobacco), being substantially higher than in the remaining series. Second, on the aggregate level we confirm the hypothesis that backward regions exhibit higher degree of inflation persistence. However, when the CPI index is disaggregated into more detailed product categories and if additionally individual lags are accounted for, the picture becomes more complex.

Food & non-alcoholic beverages – the single most important for the CPI product category – exhibits a very similar pattern to the aggregate CPI index in terms of persistence differentials between East and West, while being even stronger. Since the share of food in household expenses diminishes with rising incomes, we may put forward a hypothesis that cross-regional inflation persistence disparities might be relatively high in lower-income countries, at earlier stages of development, when growth is concentrated in strongest urban centres and regional divergence is a common phenomenon. Over time however, when growth spills over to other regions, incomes grow and this growth gains broader geographical base, cross regional differences in inflation persistence should also diminish.

Our panel regression results reinforce the conclusion that inflation is more persistent in the backward regions in Eastern Poland and less persistent in the West. In some product categories, the pattern seems to be more nuanced, however. More specifically, we find that

rather than in the strength of the persistence, the difference between East and West lies in the shape of the impulse response of current inflation to past shocks. Such situation is found in housing, transportation and health product categories.

Literature

Altissimo, F., Mojon, B., & Zafaroni, P. (2007). *Fast Micro and Slow Macro: Can Aggregation Explain the Persistence of Inflation?* ECB Working Papers no. 729. European Central Bank. Frankfurt.

Arestis, P., & Mouratidis, K. (2005). Credibility of monetary policy in four accession countries: A Markov regime-switching approach. *International Journal of Finance & Economics, 10*(1), 81-89. doi:10.1002/ijfe.260

Ascari, G., & Sbordone, A. M. (2014). The Macroeconomics of Trend Inflation. *Journal of Economic Literature, 52*(3), 679-739. doi:10.1257/jel.52.3.679

Babecky, J., Coricelli, F., & Horvath, R. (2009). Assessing Inflation Persistence: Micro Evidence on an Inflation Targeting Economy. *Finance a Uver-Czech Journal of Economics and Finance, 59*(2), 102-127.

Banerjee, B., & Jesenko, M. (2015). Economic Growth and Regional Disparities in Slovenia. *Regional Studies, 49*(10), 1722-1745. doi:10.1080/00343404.2013.879981

Baranowski, P., & Gajewski, P. (2016). Credible enough? Forward guidance and perceived National Bank of Poland's policy rule. *Applied Economics Letters, 23*(2), 89-92. doi:10.1080/13504851.2015.1051651

Barsky, R., House, C. L., & Kimball, M. (2003). *Do Flexible Durable Goods Prices Undermine Sticky Price Models?* Retrieved from

Baxa, J., Plasil, M., & Vasicek, B. (2015). Changes in inflation dynamics under inflation targeting? Evidence from Central European countries. *Economic Modelling, 44*, 116-130. doi:10.1016/j.econmod.2014.10.028

Benigno, P., & Lopez-Salido, J. D. (2006). Inflation persistence and optimal monetary policy in the Euro area. *Journal of Money Credit and Banking, 38*(3), 587-614. doi:10.1353/mcb.2006.0038

Bils, M., & Klenow, P. J. (2004). Some evidence on the importance of sticky prices. *Journal of political economy, 112*(5), 947-985.

Calvo, G. A. (1983). Staggered Prices in a Utility-Maximizing Framework. *Journal of Monetary Economics, 12*(3), 383-398. doi:Doi 10.1016/0304-3932(83)90060-0

Carlos, M. (2004). Inflation persistence: facts or artefacts? *Working Paper Series*.

Cecchetti, S. G., & Debelle, G. (2006). Has the inflation process changed? *Economic Policy*(46), 311-352.

Cecchetti, S. G., Mark, N. C., & Sonora, R. J. (2002). Price index convergence among United States cities. *International Economic Review, 43*(4), 1081-1099.

Clark, T. E. (2006). Disaggregate evidence on the persistence of consumer price inflation. *Journal of Applied Econometrics, 21*(5), 563-587. doi:10.1002/jae.859

Dokic, I., Frohlich, Z., & Bakaric, I. R. (2016). The impact of the economic crisis on regional disparities in Croatia. *Cambridge Journal of Regions Economy and Society, 9*(1), 179-195. doi:10.1093/cjres/rsv030

Erceg, C., & Levin, A. (2006). Optimal monetary policy with durable consumption goods. *Journal of Monetary Economics, 53*(7), 1341-1359. doi:10.1016/j.jmoneco.2005.05.005

Franta, M., Saxa, B., & Smidkova, K. (2010). The Role of Inflation Persistence in the Inflation Process in the New EU Member States. *Finance a Uver-Czech Journal of Economics and Finance, 60*(6), 480-500.

Fuhrer, L. J., & Moore, G. (1995). Inflation Persistence. *Quarterly Journal of Economics, 110*(1), 127-159.

Gajewski, P., & Tchorek, G. (2017). What drives export performance of firms in Eastern and Western Poland? *Lodz Economics Working Papers, 1/2017*.

Sargent, T. J. (1999). *The conquest of American inflation*: Princeton University Press.

Smetkowski, M. (2013). Regional Disparities in Central and Eastern European Countries: Trends, Drivers and Prospects. *Europe-Asia Studies, 65*(8), 1529-1554. doi:10.1080/09668136.2013.833038

Sousa, R., & Yetman, J. (2016). Inflation expectations and monetary policy.

Steinsson, J. (2003). Optimal monetary policy in an economy with inflation persistence. *Journal of Monetary Economics, 50*(7), 1425-1456. doi:10.1016/j.jmoneco.2003.08.008

Stock, J. H., & Watson, M. W. (2007). Why has US inflation become harder to forecast? *Journal of Money Credit and Banking, 39*(1), 3-33. doi:10.1111/j.1538-4616.2007.00014.x

Taylor, J. B. (1980). Aggregate dynamics and staggered contracts. *Journal of political economy, 88*(1), 1-23.

Vaona, A., & Ascari, G. (2012). Regional Inflation Persistence: Evidence from Italy. *Regional Studies, 46*(4), 509-523. doi:10.1080/00343404.2010.505913

ANNEX

Figure 1. Descriptive statistics of series used in empirical analyses

Notes: Source of data: Polish Central Statistical Office (Główny Urząd Statystyczny, GUS).

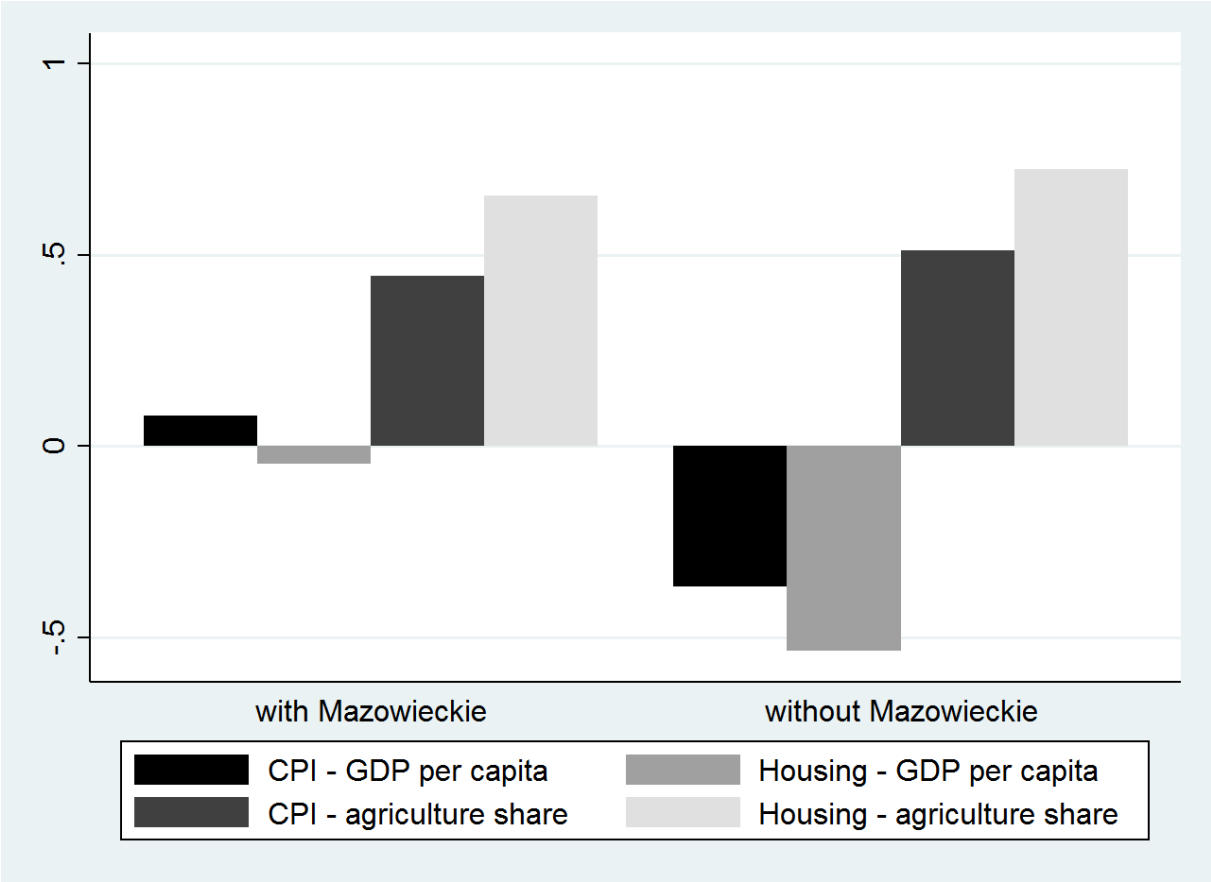
Table 1. ADF unit root test results

	alct	*educ*	*hous*	*clot*	*recr*	*totl*	*tran*	*heal*	*food*
					Dolnośląskie (dol)				
Z(t)	-3.85	-4.18	-3.23	-4.28	-6.18	-2.93	-4.43	-5.23	-4.28
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Kujawsko-Pomorskie (kpm)				
Z(t)	-3.60	-5.02	-3.27	-5.25	-6.25	-3.06	-4.67	-4.43	-3.81
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Lubelskie (lbl)				
Z(t)	-3.28	-5.66	-2.28	-6.54	-4.65	-2.58	-4.56	-5.41	-3.51
p-val	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00
					Łódzkie (ldz)				
Z(t)	-3.89	-4.83	-2.27	-4.05	-6.94	-2.82	-4.47	-5.27	-4.23
p-val	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
					Lubuskie (lub)				
Z(t)	-3.32	-4.06	-3.00	-4.33	-6.97	-3.71	-4.63	-5.17	-5.22
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Mazowieckie (maz)				
Z(t)	-3.01	-4.69	-2.22	-5.01	-6.20	-2.57	-4.40	-4.71	-4.01
p-val	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00
					Małopolskie (mlp)				
Z(t)	-3.75	-4.61	-3.14	-3.22	-6.93	-3.16	-4.91	-7.19	-4.48
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Opolskie (opo)				
Z(t)	-4.03	-4.11	-2.96	-3.79	-6.40	-2.94	-4.48	-4.86	-4.76
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Podkarpackie (pdk)				
Z(t)	-3.19	-4.56	-2.76	-4.07	-5.15	-2.86	-4.39	-5.55	-4.35
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Podlaskie (pdl)				
Z(t)	-3.60	-5.02	-3.27	-5.25	-6.25	-3.06	-4.67	-4.43	-3.81
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Pomorskie (pom)				
Z(t)	-4.46	-4.48	-3.35	-3.73	-5.75	-3.03	-4.63	-6.52	-3.81
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Śląskie (sla)				
Z(t)	-2.56	-4.74	-3.08	-4.88	-6.35	-3.36	-4.91	-4.79	-4.91
p-val	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Świętokrzyskie (swk)				
Z(t)	-3.80	-4.46	-2.48	-5.03	-6.01	-2.69	-4.81	-4.55	-4.32
p-val	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
					Wielkopolskie (wlk)				
Z(t)	-5.00	-6.21	-2.53	-3.23	-5.32	-3.05	-4.65	-5.74	-3.85
p-val	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
					Warmińsko-mazurskie (wmz)				
Z(t)	-3.13	-4.70	-2.72	-4.19	-7.11	-2.89	-4.58	-4.73	-4.00
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Zachodniopomorskie (zpm)				
Z(t)	-3.11	-4.87	-2.65	-4.50	-6.52	-2.71	-4.32	-5.89	-4.82
p-val	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00

Figure 2. Estimated individual regional inflation persistence terms across product categories

Notes: No bar means no statistically significant autoregressive term.

Figure 3. Correlation coefficients between inflation persistence and average per capita GDP and share of employment in agriculture*



*Average GDP per capita (Poland=100) in the period 2005-2014, average share of employment in agriculture in the period 2005-2015.

Table 2. Estimation results of panel models.

	CPI		*Food*		*Education*		*Housing*		*Alcohol&tobacco*		*Clothing*		*Recreaction*		*Transportation*		*Health*	
Y_{t-1}	0.50***	0.56***	0.33***	0.42***	0.38***	0.34***	0.57***	0.56***	0.42***	0.47***	0.30***	0.19***	0.02	0.05	0.37***	0.35***	0.16***	0.19***
	(0.02)	(0.02)	(0.03)	(0.03)	(0.04)	(0.02)	(0.03)	(0.04)	(0.06)	(0.03)	(0.04)	(0.05)	(0.03)	(0.05)	(0.02)	(0.02)	(0.03)	(0.04)
Y_{t-2}	0.03	-0.01	0.11***	0.04	-0.13***	-0.10***	0.12***	0.21***	0.03	0.09***	0.26***	0.30***	0.02	0.04	-0.09***	-0.07**	0.10**	0.21***
	(0.01)	(0.03)	(0.01)	(0.03)	(0.02)	(0.01)	(0.03)	(0.05)	(0.03)	(0.02)	(0.04)	(0.02)	(0.03)	(0.04)	(0.02)	(0.02)	(0.04)	(0.06)
Y_{t-3}	0.25***	0.21***	0.03	0.02	0.04	0.01	0.09***	0.06	0.31***	0.34***	0.10**	0.10*	-0.08***	-0.13***	0.33***	0.26***	0.18***	0.16***
	(0.03)	(0.04)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.04)	(0.03)	(0.03)	(0.05)	(0.05)	(0.02)	(0.04)	(0.02)	(0.03)	(0.04)	(0.03)
Y_{t-4}	0.04**	0.05*	0.01	0.02	0	0.07	-0.04	-0.07	-0.07	-0.21***	0	0.05	-0.23***	-0.19***	-0.12***	-0.09***	-0.05	-0.18***
	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.05)	(0.03)	(0.04)	(0.09)	(0.02)	(0.04)	(0.04)	(0.03)	(0.03)	(0.01)	(0.03)	(0.03)	(0.05)
East* Y_{t-1}	0.09**		0.11*		-0.04		-0.02		0.06		-0.15*		0.08		-0.01		0.06	
	(0.04)		(0.05)		(0.05)		(0.05)		(0.07)		(0.08)		(0.08)		(0.03)		(0.05)	
East* Y_{t-2}	-0.06		-0.09		0.03		0.15**		0.06		0.04		0.07		0.02		0.13	
	(0.05)		(0.05)		(0.03)		(0.06)		(0.04)		(0.04)		(0.04)		(0.04)		(0.09)	
East* Y_{t-3}	-0.04		0		-0.08*		-0.03		0.06		-0.05		-0.07		-0.08*		-0.07	
	(0.05)		(0.04)		(0.04)		(0.05)		(0.05)		(0.08)		(0.06)		(0.04)		(0.05)	
East* Y_{t-4}	0.02		0.02		0.09		-0.09**		-0.16*		0.11*		0.06		0.02		-0.14*	
	(0.04)		(0.03)		(0.08)		(0.04)		(0.09)		(0.06)		(0.06)		(0.04)		(0.07)	
West* Y_{t-1}		-0.08**		-0.14***		0.05		0.01		-0.07		0.13*		0		0.04		-0.02
		(0.03)		(0.04)		(0.06)		(0.05)		(0.09)		(0.07)		(0.06)		(0.03)		(0.05)
West* Y_{t-2}		0.04		0.09***		-0.04		-0.1		-0.08		-0.04		0		-0.05		-0.15**
		(0.03)		(0.03)		(0.04)		(0.06)		(0.04)		(0.05)		(0.06)		(0.03)		(0.07)
West* Y_{t-3}		0.04		0.03		0.04		0.05		-0.04		-0.03		0.06		0.10***		0.01
		(0.05)		(0.04)		(0.04)		(0.04)		(0.05)		(0.08)		(0.04)		(0.03)		(0.06)
West* Y_{t-4}		0		-0.01		-0.09		0.02		0.18		-0.03		-0.06		-0.05		0.18***
		(0.03)		(0.03)		(0.06)		(0.05)		(0.12)		(0.07)		(0.05)		(0.03)		(0.05)
Intercept	0.08***	0.08***	0.35***	0.35***	0.26***	0.26***	0.19***	0.19***	0.29***	0.29***	-0.41***	-0.41***	0.22***	0.22***	0.01*	0.01*	0.32***	0.32***
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)
N	688	688	688	688	688	688	688	688	688	688	688	688	688	688	688	688	688	688
R^2 (within)	0.47	0.47	0.18	0.18	0.12	0.12	0.5	0.49	0.37	0.38	0.27	0.27	0.06	0.05	0.19	0.19	0.10	0.10
Log-likelihood	-404.38	-404.54	-921.9	-921.08	-1098.56	-1098.31	-582.88	-583.51	-683.49	-682.17	-741.51	-742.87	-923.73	-924.53	-1403.9	-1403.5	-679.72	-678.43

Notes: Clustered, robust to heteroscedasticity standard errors in parentheses. Regional fixed effects controlled.