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Mind the Gap: City-Level Inflation Synchronization

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Abstract

The post-pandemic rise in consumer prices across the world has renewed interest in inflation dynamics after decades of global disinflation. This paper provides a spatial investigation of inflation synchronicity at the city level in Lithuania using disaggregated monthly data during the period 2000–2021. The empirical analysis provides strong evidence that (i) the co-movement of city-level inflation rates—estimated using the instantaneous quasi-correlation approach—is significantly weaker than the extent of synchronization suggested by the simple correlation analysis; (ii) there is substantial heterogeneity in the instantaneous quasi-correlation of inflation subcomponents between city pairs; and (iii) there are significant changes in the degree of city-level synchronization over time, reflecting important economic developments in history such as the global financial crisis, the adoption of euro, and the COVID-19 pandemic.

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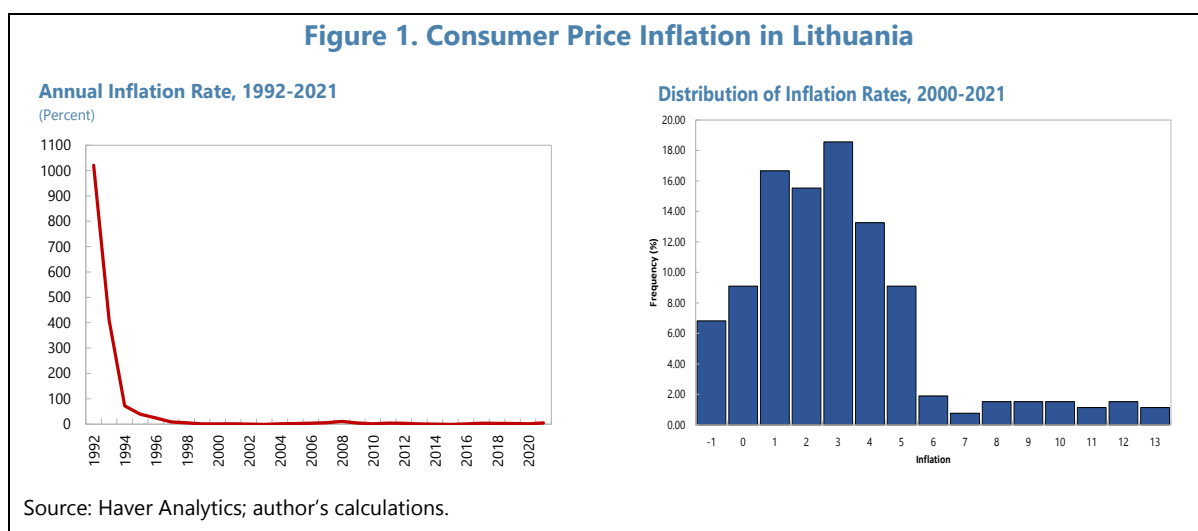
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I. INTRODUCTION

The post-pandemic surge in inflation across the world has renewed interest in underlying price dynamics after decades of global disinflation. Consumer price inflation in the euro area, for example, reached 8.6 percent on an annual basis in June 2022—the highest level since the creation of the euro. After decades of inflation convergence, there is still significant variation among eurozone countries. While it was running at 6.1 percent in Malta, it moved into double-digits in Lithuania with an annualized rate of 20.5 percent. These inflationary pressures have emerged from a plethora of global and domestic developments, the extent and nature of which vary across countries. While the spike in international energy prices or supply-chain disruptions may be transitory phenomena, tight labor market conditions with significant wage increases may reflect structural factors that could have a long-lasting effect on inflation dynamics.

The continuing bout of inflation threatens hard-won macroeconomic stability in transition economies like Lithuania. Inflation declined from the peak of 1,163 percent in 1992 to an average of 1.7 percent after the country joined the euro area in 2015. Achieving disinflation and price stability in the post-Soviet period was an arduous progression with ups and downs along the way (Grennes, 1996; Ghosh, 1997; Christoffersen and Doyle, 1998; Cihak and Holub, 2001; Flanagan and Hammermann, 2007). Cross-country studies are useful in modelling inflation dynamics, but may not be sufficient to capture the spatial convergence of inflation rates within countries. Furthermore, although the law of one price implies that price differences between tradable goods sold in different locations should be small, prices may still vary within a country due to regional wage differentiation, transportation costs, local taxes and differences in regional productivity or consumer preferences (Rogoff, Froot, and Kim, 2001).

There is an extensive body of literature on the convergence of aggregate inflation rates across countries and over time. Examining the nature of the deviations from the law of one price across cities in Canada and the U.S., for example, Engel and Rogers (1996) find that the distance between cities explains a significant amount of the variation in the prices of similar goods in different cities, but the variation of the price is much higher for two cities located in



different countries than for two equidistant cities in the same country. Using a panel of 19 cities in the U.S. during the period 1918–1995, Cecchetti, Mark, and Sonora (2002) conclude that convergence is slow due to transportation costs and differential rates of adjustment to small and large shocks. Similarly, Chen and Devereux (2003) study the dispersion of absolute price levels for U.S. cities since 1918 and find strong evidence that consumer prices converge over time. Comparing the sources of heterogeneity in regional prices in Europe and in the U.S., Beck, Hubrich, and Marcellino (2006) show that factor market distortions and structural characteristics, rather than market-driven forces, are the most important factors. Furthermore, Hegwood and Nath (2013) find that the speed of price convergence in the U.S. is faster with structural break than that reported by previous panel studies with no structural break that use similar long time-series data. On the other hand, focusing on Japan, Nagayasu (2011) show that not only does the average inflation differ significantly across regions, but regional inflation responds differently to common economic and monetary factors, with no evidence of price convergence among regions.

There are also studies focusing on subnational inflation differentials and relative price synchronization in developing countries. Using the Consumer Price Index (CPI) data for 34 cities in Mexico over the period 1982–2000, Sonora (2005) tests the purchasing power parity hypothesis and finds that relative prices are found to be stationary and estimated convergence rates are relatively fast compared to other investigations of intercity price behavior in low inflation countries. On the other hand, investigating the relationship between monetary regimes and price convergence across 13 cities in Turkey, Yazgan and Yilmazkuday (2016) find slower convergence during the period of low inflation under the inflation-targeting regime. Focusing on the cities of Brazil, Arruda *et al.* (2018) reach a similar conclusion that price convergence is slow because of trade and bureaucratic barriers, market failures, and changes in the composition of price indexes. Examining the impact of region-specific and commodity-specific factors in consumer prices in Russia, Deryugina *et al.* (2019) find little evidence of association between subnational factors and inflation developments. Last but not the least, analyzing 82 cities in Indonesia during 2013–2018, Purwono, Yasin, and Mubin (2020) show the speed of inflation convergence varies with transportation linkages and localized initiatives to control inflation.

This paper contributes to the literature with a systematic analysis of co-movement in inflation rates at the city level in Lithuania. Using city-level disaggregate monthly CPI data during the period 2000–2021, the analysis provides granular evidence that (i) the co-movement of city-level inflation rates—estimated using the instantaneous quasi-correlation approach—is significantly weaker than the extent of synchronization suggested by the simple correlation analysis; (ii) there is substantial heterogeneity in the instantaneous quasi-correlation of inflation subcomponents between city pairs; and (iii) there are significant changes in the degree of synchronization across cities over time, reflecting important economic developments in history such as the global financial crisis, the adoption of euro, and the COVID-19 pandemic.

The granular evidence presented in this paper indicates that city-level inflation cycles and pricing behavior in Lithuania still lack full synchronization. This may reflect a range of factors including transportation costs, market concentration, structural and demographic differences, and labor market conditions. The disaggregate analysis at the city level helps better understand

the evolution of aggregate inflation and identify country-level and local sources of heterogeneity in inflation rates. For policymakers, granular information provides valuable insights not only on the factors driving inflation dynamics and relative price convergence within the country, but also on the city-level differences in real wages and real interest rates that influence the directions of labor and capital flows and thus regional growth within the country.

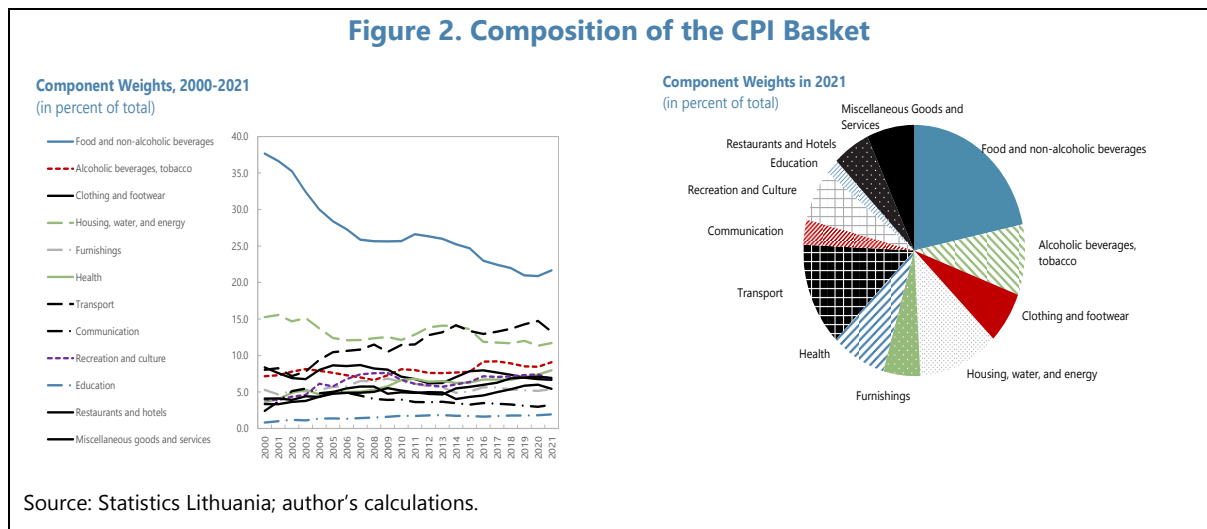
The remainder of this paper is structured as follows. Section II provides an overview of the data used in the empirical analysis. Section III describes the econometric methodology. Section IV discusses the findings. Finally, Section IV summarizes and provides concluding remarks.

II. DATA OVERVIEW

The empirical analysis is based on a balanced panel dataset of monthly observations of the CPI covering 5 major cities in Lithuania during the period 2000–2021.² These city-level CPI series are obtained from Statistics Lithuania and include the overall index and its 12 subcomponents. Inflation rates are computed on a monthly basis as the year-on-year percentage change in the CPI for each city as follows:

$$\pi_{c,t} = \left(\frac{CPI_{c,t}}{CPI_{c,t-12}} \right) * 100$$

where $\pi_{c,t}$ is the year-on-year rate of inflation in city c at month t based on the headline CPI and its subcomponents, including (1) food and non-alcoholic beverages, (2) alcoholic beverages and tobacco, (3) clothing and footwear, (4) housing, water, electricity, gas and other fuels, (5) furnishings, household equipment and routine house maintenance, (6) healthcare, (7) transportation, (8) communication, (9) recreation and culture, (10) education, (11) restaurants and hotels, and (12) miscellaneous goods and services. As presented in Figure 2, the composition of



² The cities in the sample are Kaunas, Klaipeda, Panevezys, Siauliai, and Vilnius.

the CPI basket has changed over time with rising income levels and evolving consumer preferences in Lithuania during the sample period 2000–2021. For example, the share of food and non-alcoholic beverages declined from 37.7 percent of total in 2000 to 21.7 percent by 2021, while the share of healthcare increased from 3.6 percent to 8 percent over the same period.

Inflation dynamics have evolved significantly in Lithuania since gaining its independence from the Soviet Union in 1991. The collapse of centralized economy in 1991 led to a historical realignment of prices and consequently an unprecedented surge in inflation across all transition economies. After experiencing an annual inflation rate of over 1,000 percent in 1992, Lithuania managed to lower the pace of inflation to less than 1 percent by 1999. Although inflation accelerated to more than 10 percent before the global financial crisis in 2008, it declined steadily since then to around 2 percent. As displayed in Appendix Figure A1, headline inflation rates moved broadly in synch since 2000, but still with variation across cities and over time.

Variable	Obs	Mean	Std. Dev.	Min	Max
Consumer Price Index					
Headline	1,265	131.2	20.9	98.7	181.4
Food	1,265	142.7	29.7	93.6	204.3
Alcohol & tobacco	1,265	160.7	48.5	95.2	245.6
Clothing & footwear	1,265	62.5	18.6	26.3	98.9
Housing & energy	1,265	185.8	49.3	108.2	296.2
Furnishings	1,265	95.0	6.8	83.0	121.0
Healthcare	1,265	168.1	44.4	93.8	250.7
Transportation	1,265	136.1	22.9	88.0	185.7
Communication	1,265	100.8	19.0	76.0	143.9
Recreation & culture	1,265	96.0	7.0	85.0	120.7
Education	1,265	145.8	33.4	96.6	260.9
Restaurants & hotels	1,265	160.0	46.2	97.9	281.3
Miscellaneous	1,265	133.4	25.1	96.3	193.5
Inflation Rates					
Headline	1,205	2.4	3.0	-4.2	13.5
Food	1,205	3.1	4.9	-8.1	19.6
Alcohol & tobacco	1,205	4.7	5.0	-2.5	22.6
Clothing & footwear	1,205	-3.3	5.1	-25.2	13.2
Housing & energy	1,205	3.9	7.4	-12.3	34.9
Furnishings	1,205	0.4	2.7	-7.6	10.3
Healthcare	1,205	4.8	4.4	-2.4	22.7
Transportation	1,205	-0.4	10.7	-23.8	29.8
Communication	1,205	-1.9	5.0	-15.1	22.5
Recreation & culture	1,205	0.7	2.7	-5.6	10.1
Education	1,205	3.2	5.1	-7.7	26.6
Restaurants & hotels	1,205	4.6	4.1	-3.3	23.0
Miscellaneous	1,205	2.9	3.4	-5.4	14.7

Source: Statistics Lithuania; author's calculations.

A correlation analysis is the simplest approach to summarize the co-movement of inflation rates across cities. Table 1 presents the summary statistics of city-level CPI and inflation rates, showing significant differences over time and in subcomponents across the country. In particular, Klaipeda experienced lower inflation than other cities on average, while Panevezys had the highest rate during the sample period. Table 2 presents simple cross-city correlations between headline inflation and its subcomponents, indicating a high degree of synchronization across five cities over the period 2000–2021. However, the extent of synchronization varies from city to city, and correlation at the headline level could fail to show substantial variation in subcomponents of the CPI at the city level. This is why it is necessary to provide a robust analysis of disaggregate data.

Table 2. Correlation Matrix: Headline Inflation Rates

	Kaunas	Klaipeda	Panevezys	Siauliai	Vilnius
Kaunas	1.00				
Klaipeda	0.96	1.00			
Panevezys	0.97	0.96	1.00		
Siauliai	0.96	0.96	0.96	1.00	
Vilnius	0.94	0.95	0.94	0.95	1.00

Source: Statistics Lithuania; author's calculations.

III. ECONOMETRIC METHODOLOGY

This paper estimates the synchronization of city-level inflation rates between city pairs using the instantaneous quasi-correlation approach. Following Morgan, Rime, and Strahan (2004), Abiad *et al.* (2013), Duval *et al.* (2016), and Blagrove (2020), this measure of inflation synchronization is defined as:

$$QCorrel_{c,j,t} = \frac{(\pi_{c,t} - \pi_{c,t}^*) * (\pi_{j,t} - \pi_{j,t}^*)}{\sigma_c * \sigma_j}$$

where $\pi_{c,t}$ is the annual rate of inflation in city c at month t based on the headline CPI and its subcomponents as described in the previous section; $\pi_{c,t}^*$ and $\pi_{j,t}^*$ denote an equilibrium level of consumer price inflation in city c and j at month t defined as the time-varying trend inflation rates estimated according the Hodrick-Prescott (HP) filter³; σ_c and σ_j are standard deviation of inflation rates in city c and j , respectively, over the sample period. The main advantage of the instantaneous quasi-correlation approach is to provide a dynamic measure of inflation co-movements with high-frequency data at any point in time.

IV. EMPIRICAL RESULTS

Have city-level inflation rates moved in tandem and led to the convergence of consumer prices over the last two decades in Lithuania? To answer these questions, this paper analyzes

³ The estimation results presented in this paper remain broadly unchanged with the use of alternative filters, such as the Baxter and King (1999) filter, to decompose a univariate time series into trend and cyclical components.

the co-movement of inflation rates at the city level over the period from January 2000 to December 2021. Furthermore, the dataset is divided into subsamples to identify different periods marking significant economic developments that may influence the evolution of inflation differentials: (1) period before the global financial crisis (2000–2007); (2) period after the global financial crisis (2008–2021); (3) period before adopting euro (2000–2014); (4) period after joining the euro area (2015–2021); (5) pre-pandemic period (2000–2019); and (6) post-pandemic period (2020–2021).

The co-movement of city-level inflation rates is significantly weaker than the extent of synchronization suggested by the simple correlation analysis. The instantaneous quasi-correlation of inflation between city pairs, presented in Table 3, reveals that the co-movement of city-level inflation rates is not as strong as the extent of synchronization suggested by the simple correlation analysis. For example, the average quasi-correlation of headline inflation rates between Kaunas and Klaipeda is 0.37 over the whole sample period (2000–2021), not 0.96 indicated by the simple correlation matrix presented in Table 2. This is the case for all city pairs, with some registering as low as 0.30 and none more than a quasi-correlation of 0.38 according to headline inflation rates. An interesting observation is that the lowest level of inflation synchronization among all city pairs in the sample appears always to be with respect to Vilnius, which may suggest greater commonality in inflation dynamics in smaller cities. The estimated quasi-correlation of inflation rates for each city pair in the sample is also displayed visually in Figure 3. As shown in these charts, there are periods of significant increase in inflation synchronicity over the period 2000–2021, determined in large part by external shocks such as the global financial crisis and, more recently, the COVID-19 pandemic.

A granular analysis using disaggregate CPI data shows significant heterogeneity in the instantaneous quasi-correlation of inflation subcomponents between city pairs. For example, the average quasi-correlation of inflation in food and transportation between Kaunas and Klaipeda during the period 2000–2021 is 0.45 and 2.25, respectively, which are much higher than the quasi-correlation of headline inflation rates (0.37) between the two cities. This empirical observation too holds true across all city pairs in the sample, but there is also substantial city-level differences in the quasi-correlation of CPI subcomponents. While Kaunas and Klaipeda have the highest level of quasi-correlation in food inflation (0.45) over the entire sample period, it varies considerably across city pairs with the lowest level of 0.37 between Siauliai and Vilnius.

There are substantial changes in the degree of inflation synchronization over time, reflecting important economic developments in history. Estimations show that the quasi-correlation of headline inflation rates between, for example, Kaunas and Klaipeda increased to 0.46 after the global financial crisis (2008–2021) from 0.18 during the pre-crisis period (2000–2007). This is the case for all city pairs in the sample, but the rate of change in inflation co-movements varies from city to city. While city pairs like Siauliai-Vilnius and Klaipeda-Vilnius experienced an increase of 243 and 181 percent, respectively, in the quasi-correlation of inflation rates after the global financial crisis, the extent of change was limited to 80 percent in other city pairs like Panevezys-Siauliai. These variations appears to reflect the different rates of change in the instantaneous quasi-correlation of some CPI subcomponents among city pairs over time.

Table 3. Instantaneous Quasi-Correlation of Inflation Rates

	2000-2021	Pre-GFC	Post-GFC	Pre-Euro	Post-Euro	Pre-Pandemic	Post-Pandemic
Kaunas-Klaipeda							
Headline	0.37	0.18	0.46	0.42	0.29	0.35	0.61
Food	0.45	0.34	0.50	0.61	0.14	0.47	0.22
Alcohol & tobacco	0.39	0.13	0.50	0.38	0.40	0.43	0.04
Clothing & footwear	0.39	0.17	0.48	0.35	0.45	0.34	0.76
Housing & energy	0.37	0.12	0.48	0.33	0.44	0.29	1.09
Furnishings	0.47	0.19	0.59	0.54	0.34	0.48	0.40
Healthcare	0.38	0.24	0.44	0.49	0.18	0.38	0.39
Transportation	2.25	1.17	2.73	0.79	4.99	1.78	6.57
Communication	0.45	1.00	0.21	0.58	0.21	0.50	0.04
Recreation & culture	0.36	0.29	0.40	0.28	0.53	0.37	0.34
Education	0.35	0.12	0.46	0.51	0.06	0.39	0.02
Restaurants & hotels	0.37	0.19	0.45	0.49	0.14	0.39	0.21
Miscellaneous	0.64	0.62	0.65	0.90	0.16	0.70	0.13
Kaunas-Panevezys							
Headline	0.32	0.18	0.38	0.35	0.38	0.37	0.37
Food	0.42	0.32	0.47	0.58	0.46	0.45	0.44
Alcohol & tobacco	0.35	0.13	0.45	0.34	0.45	0.45	0.45
Clothing & footwear	0.54	0.37	0.62	0.50	0.62	0.62	0.62
Housing & energy	0.47	0.14	0.62	0.41	0.62	0.62	0.63
Furnishings	0.61	0.34	0.73	0.70	0.73	0.74	0.74
Healthcare	0.44	0.23	0.52	0.56	0.53	0.53	0.53
Transportation	1.39	1.06	1.53	0.58	1.54	1.55	1.56
Communication	0.45	1.00	0.21	0.59	0.21	0.21	0.21
Recreation & culture	0.31	0.27	0.34	0.26	0.34	0.34	0.34
Education	0.26	0.09	0.33	0.37	0.34	0.34	0.34
Restaurants & hotels	0.30	0.15	0.37	0.40	0.37	0.37	0.37
Miscellaneous	0.57	0.57	0.58	0.81	0.58	0.58	0.58
Kaunas-Siauliai							
Headline	0.31	0.18	0.36	0.34	0.36	0.35	0.35
Food	0.41	0.32	0.45	0.56	0.44	0.44	0.42
Alcohol & tobacco	0.36	0.13	0.46	0.36	0.47	0.47	0.46
Clothing & footwear	0.37	0.22	0.44	0.33	0.44	0.44	0.43
Housing & energy	0.36	0.12	0.46	0.33	0.46	0.46	0.47
Furnishings	0.51	0.24	0.63	0.57	0.63	0.64	0.64
Healthcare	0.31	0.14	0.39	0.41	0.39	0.39	0.39
Transportation	2.48	0.93	3.16	0.71	3.17	3.19	3.20
Communication	0.45	1.00	0.22	0.58	0.21	0.21	0.21
Recreation & culture	0.38	0.31	0.42	0.29	0.42	0.42	0.42
Education	0.19	0.06	0.25	0.27	0.25	0.25	0.25
Restaurants & hotels	0.32	0.21	0.38	0.43	0.37	0.38	0.37
Miscellaneous	0.51	0.51	0.51	0.71	0.51	0.51	0.51
Kaunas-Vilnius							
Headline	0.34	0.17	0.42	0.38	0.42	0.41	0.40
Food	0.41	0.31	0.45	0.55	0.44	0.44	0.42
Alcohol & tobacco	0.38	0.13	0.49	0.38	0.49	0.49	0.49
Clothing & footwear	0.31	0.15	0.38	0.28	0.38	0.37	0.37
Housing & energy	0.40	0.12	0.53	0.37	0.53	0.53	0.53
Furnishings	0.44	0.21	0.55	0.50	0.55	0.55	0.55
Healthcare	0.36	0.20	0.43	0.46	0.44	0.44	0.44
Transportation	2.52	0.93	3.21	0.83	3.22	3.23	3.24
Communication	0.45	1.00	0.21	0.58	0.21	0.21	0.21
Recreation & culture	0.34	0.27	0.37	0.26	0.37	0.38	0.38
Education	0.31	0.11	0.40	0.45	0.41	0.41	0.41
Restaurants & hotels	0.35	0.15	0.44	0.47	0.44	0.44	0.44
Miscellaneous	0.56	0.57	0.56	0.79	0.56	0.56	0.56
Klaipeda-Panevezys							
Headline	0.30	0.14	0.37	0.33	0.37	0.37	0.37
Food	0.38	0.30	0.42	0.52	0.42	0.41	0.40
Alcohol & tobacco	0.27	0.15	0.32	0.28	0.32	0.32	0.32
Clothing & footwear	0.61	0.42	0.70	0.51	0.69	0.69	0.69
Housing & energy	0.54	0.07	0.75	0.60	0.75	0.75	0.75
Furnishings	0.40	0.16	0.50	0.43	0.50	0.51	0.51
Healthcare	0.29	0.16	0.35	0.41	0.35	0.35	0.35
Transportation	1.81	2.19	1.64	1.36	1.65	1.66	1.67
Communication	0.43	0.99	0.19	0.55	0.18	0.18	0.18
Recreation & culture	0.37	0.18	0.46	0.27	0.46	0.46	0.46
Education	0.64	1.03	0.48	0.73	0.48	0.48	0.49
Restaurants & hotels	0.31	0.35	0.29	0.33	0.29	0.29	0.29
Miscellaneous	0.48	0.62	0.42	0.66	0.42	0.42	0.43

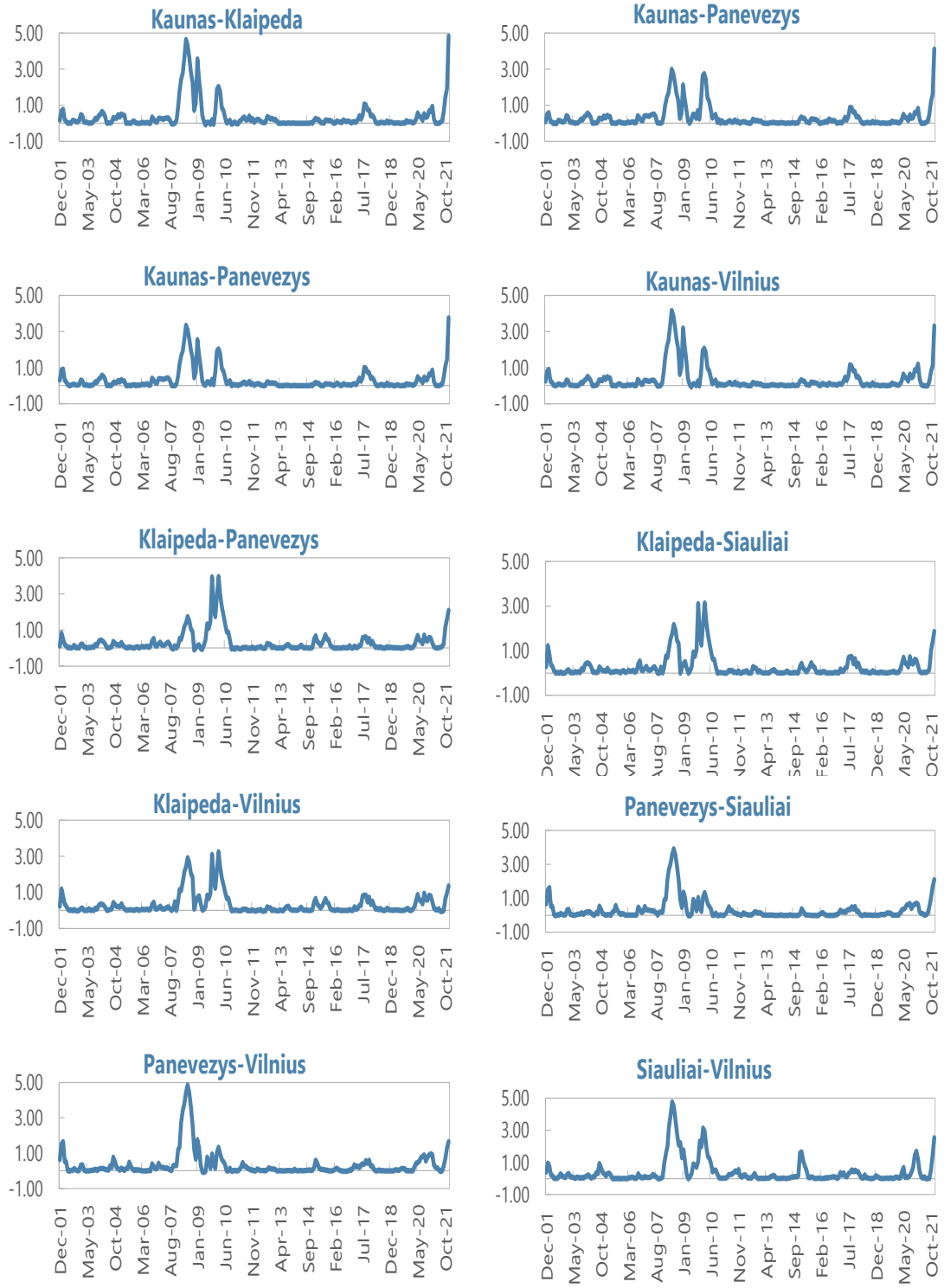
Source: Author's estimations.

Table 3. Instantaneous Quasi-Correlation of Inflation Rates (cont.)

	2000-2021	Pre-GFC	Post-GFC	Pre-Euro	Post-Euro	Pre-Pandemic	Post-Pandemic
Klaipeda-Siauliai							
Headline	0.28	0.15	0.34	0.32	0.22	0.28	0.42
Food	0.37	0.30	0.40	0.50	0.12	0.37	0.19
Alcohol & tobacco	0.28	0.15	0.33	0.29	0.26	0.28	0.03
Clothing & footwear	0.41	0.23	0.49	0.34	0.56	0.41	0.50
Housing & energy	0.41	0.08	0.56	0.47	0.30	0.41	0.63
Furnishings	0.32	0.12	0.41	0.34	0.29	0.32	0.50
Healthcare	0.21	0.10	0.26	0.30	0.05	0.21	0.08
Transportation	2.46	1.39	2.92	0.87	5.42	2.46	8.14
Communication	0.43	1.00	0.19	0.55	0.22	0.43	0.04
Recreation & culture	0.45	0.20	0.56	0.33	0.68	0.45	0.91
Education	0.47	0.77	0.34	0.54	0.35	0.47	0.41
Restaurants & hotels	0.32	0.37	0.29	0.35	0.26	0.32	0.08
Miscellaneous	0.43	0.55	0.37	0.58	0.14	0.43	0.13
Klaipeda-Vilnius							
Headline	0.32	0.14	0.40	0.35	0.26	0.32	0.44
Food	0.37	0.30	0.40	0.50	0.12	0.37	0.19
Alcohol & tobacco	0.29	0.16	0.35	0.31	0.26	0.29	0.03
Clothing & footwear	0.33	0.18	0.39	0.24	0.49	0.33	0.36
Housing & energy	0.46	0.07	0.63	0.52	0.35	0.46	0.65
Furnishings	0.28	0.12	0.34	0.28	0.26	0.28	0.49
Healthcare	0.24	0.13	0.29	0.34	0.06	0.24	0.10
Transportation	2.41	1.53	2.79	0.90	5.23	2.41	7.39
Communication	0.43	0.99	0.19	0.55	0.21	0.43	0.04
Recreation & culture	0.40	0.17	0.50	0.29	0.61	0.40	0.79
Education	0.73	1.19	0.52	0.82	0.54	0.73	0.54
Restaurants & hotels	0.35	0.38	0.34	0.38	0.29	0.35	0.10
Miscellaneous	0.46	0.61	0.40	0.63	0.14	0.46	0.12
Panevezys-Siauliai							
Headline	0.30	0.19	0.35	0.35	0.21	0.30	0.50
Food	0.42	0.33	0.46	0.56	0.15	0.42	0.20
Alcohol & tobacco	0.33	0.17	0.40	0.35	0.29	0.33	0.03
Clothing & footwear	0.41	0.46	0.39	0.44	0.36	0.41	0.61
Housing & energy	0.28	0.10	0.36	0.26	0.31	0.28	0.67
Furnishings	0.26	0.11	0.33	0.22	0.35	0.26	0.30
Healthcare	0.26	0.13	0.32	0.38	0.05	0.26	0.01
Transportation	1.59	1.39	1.68	0.78	3.11	1.59	5.42
Communication	0.43	0.98	0.19	0.55	0.21	0.43	0.05
Recreation & culture	0.52	0.24	0.64	0.32	0.89	0.52	0.74
Education	0.35	0.26	0.39	0.43	0.21	0.35	0.02
Restaurants & hotels	0.47	0.26	0.56	0.69	0.06	0.47	0.02
Miscellaneous	0.41	0.80	0.24	0.58	0.09	0.41	0.09
Panevezys-Vilnius							
Headline	0.34	0.19	0.41	0.39	0.24	0.34	0.53
Food	0.42	0.33	0.46	0.56	0.15	0.42	0.20
Alcohol & tobacco	0.35	0.18	0.42	0.38	0.29	0.35	0.04
Clothing & footwear	0.35	0.38	0.33	0.38	0.28	0.35	0.39
Housing & energy	0.31	0.09	0.40	0.28	0.35	0.31	0.70
Furnishings	0.22	0.11	0.27	0.18	0.30	0.22	0.38
Healthcare	0.30	0.18	0.35	0.43	0.06	0.30	0.02
Transportation	1.39	1.53	1.33	0.55	2.96	1.39	5.02
Communication	0.43	0.98	0.19	0.55	0.20	0.43	0.04
Recreation & culture	0.46	0.20	0.58	0.29	0.79	0.46	0.65
Education	0.56	0.41	0.62	0.68	0.33	0.56	-0.01
Restaurants & hotels	0.53	0.22	0.66	0.77	0.07	0.53	0.02
Miscellaneous	0.45	0.89	0.27	0.64	0.10	0.45	0.08
Siauliai-Vilnius							
Headline	0.41	0.15	0.52	0.47	0.29	0.41	0.51
Food	0.42	0.34	0.45	0.58	0.13	0.42	0.27
Alcohol & tobacco	0.35	0.17	0.42	0.37	0.30	0.35	0.03
Clothing & footwear	0.38	0.10	0.50	0.23	0.65	0.38	0.91
Housing & energy	0.47	0.06	0.64	0.47	0.46	0.47	0.83
Furnishings	0.36	0.06	0.49	0.41	0.27	0.36	0.01
Healthcare	0.48	0.35	0.53	0.62	0.21	0.48	0.09
Transportation	2.70	0.98	3.45	0.98	5.92	2.70	8.26
Communication	0.44	1.03	0.18	0.57	0.20	0.44	0.06
Recreation & culture	0.38	0.21	0.45	0.23	0.65	0.38	0.43
Education	1.02	0.61	1.19	1.48	0.16	1.02	0.16
Restaurants & hotels	0.46	0.25	0.55	0.60	0.20	0.46	0.21
Miscellaneous	0.60	0.83	0.50	0.78	0.26	0.60	0.27

Source: Author's estimations.

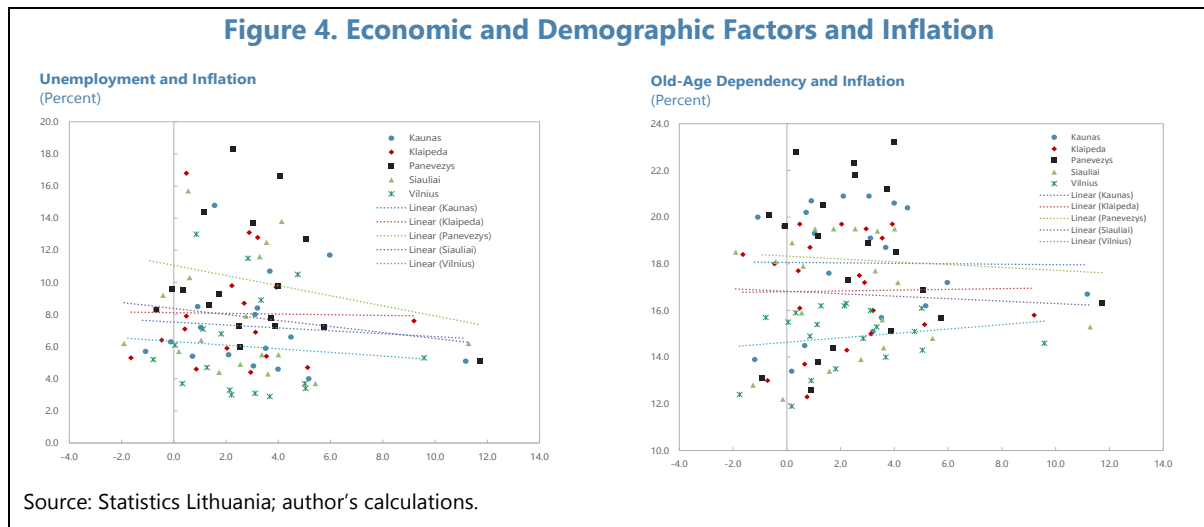
Figure 3. Instantaneous Quasi-Correlation of Inflation Rates



Source: Author's estimations

The quasi-correlation of inflation rates after the adoption of euro in 2015 increased in some city pairs but declined in others. For example, while inflation co-movement between Klaipeda and Panevezys increased by 11 percent after 2015 compared to the period 2000–2014, it declined by as much as 40 percent between Panevezys and Siauliai over the same periods. There is also preliminary evidence that the extent of inflation synchronicity across cities in Lithuania strengthened after the pandemic. In the case of Kaunas and Klaipeda, the quasi-correlation of headline inflation rates increased by 75 percent in 2020–2021, compared to the period 2000–2019. The rate of change is not homogenous across all city-pairs, however, with some like Kaunas-Siauliai and Klaipeda-Panevezys showing almost no change at all after the COVID-19 pandemic.⁴

What do all these estimations of inflation co-movement and convergence over time signify? Diverging trends in inflation synchronicity across cities in Lithuania are driven partly by significant heterogeneity in the co-movement of inflation subcomponents, which in turn may reflect a plethora of factors such as transportation costs, structural differences, and labor market conditions. For example, Lithuania has one of the highest—and increasing—level of regional differences in per capita income, employment, productivity and poverty among OECD countries (Figure 4). This is in part due to an economic infrastructure built under central planning during the Soviet era, which left broad geographical disparities in physical and human capital. As a result, while Vilnius has household income and labor productivity comparable to the OECD average, peripheral cities lag behind with aging population, high unemployment and stalled income growth (Pociute-Sereikiene, 2019; Blochliger and Tusz, 2020). Another potentially important determinant of inflation differentials is the intensity of market concentration at the city level, with lower market competition leading to higher inflation on average.



⁴ There is a similar pattern after joining the EU on May 1, 2004, which led to higher synchronization in some components of the CPI across cities but lower in others. These calculations are available up on request from the author.

Panel data regressions help explore economic and demographic factors contributing to city-level inflation synchronization. The impact of unemployment and demographic aging on city-level consumer price inflation in Lithuania over the period 2000–2021 is estimated with the standard fixed effects model according to the following panel data specification:

$$\pi_{c,t} = \beta_1 + \beta_2 ur_{c,t} + \beta_3 old_{c,t} + \eta_c + \mu_t + \varepsilon_{c,t}$$

where $\pi_{c,t}$ is inflation in city c and time t , and $ur_{c,t}$ and $old_{c,t}$ denote the unemployment rate and the ratio of population aged 65 and over to the working-age population, respectively. The η_c and μ_t coefficients denote the time-invariant city-specific effects and the time effects controlling for common shocks that may affect inflation across all cities in a given year, respectively. $\varepsilon_{c,t}$ is an idiosyncratic error term. To account for possible heteroskedasticity, robust standard errors are clustered at the city level.

These results, presented in Table 4, show that both unemployment and old-age dependency have deflationary effects across cities in Lithuania. The coefficients on the unemployment rate and the old-age dependency ratio are negative and statistically significant at the 1 percent level. These city-level results are consistent with the Phillips curve, which is an inverse relationship between unemployment and inflation, and the deflationary impact of demographic aging, which is observed in a growing number of higher-income countries. In column [2], the logarithm of population is included as an additional variable. While it does not appear to be a significant factor at conventional levels, the negative sign of the estimated coefficient suggest that population—a proxy for market size—may put a downward pressure on consumer price inflation as expected.

Table 4. Panel Data Analysis of City-Level Inflation

	[1]	[2]
Unemployment rate	-0.171*** [0.020]	-0.171*** [0.018]
Old-age ratio	-0.595*** [0.082]	-0.644** [0.251]
Population		-1.441 [7.036]
Number of observations	85	85
Fixed effects	Yes	Yes
Adjusted R ²	0.28	0.52

Note: Robust standard errors are reported in brackets. A constant is included in each regression, but not shown in the table. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Author's estimations.

V. CONCLUSION

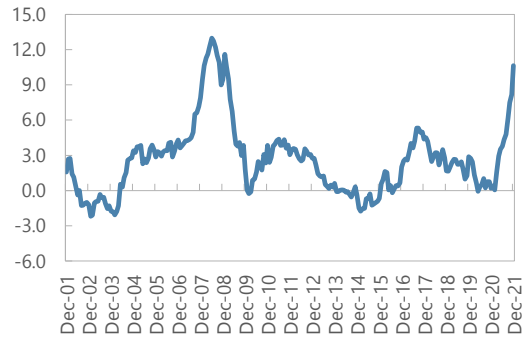
Post-pandemic developments have made inflation a central variable of interest once again for policymakers and market participants. Although most analysts focus on temporal changes in inflation, the analysis of spatial variation in consumer prices and inflation rates within a country is also important to better understand inflation dynamics and the process of price convergence across cities.

This paper contributes to the literature with a systematic analysis of co-movement in inflation rates at the city level in Lithuania. Using disaggregate monthly data on the CPI collected in five major cities during the period 2000–2021, the empirical analysis provides robust evidence that (i) the co-movement of city-level inflation rates—estimated using the instantaneous quasi-correlation approach—is significantly weaker than the extent of synchronization suggested by the simple correlation analysis; (ii) there is substantial heterogeneity in the instantaneous quasi-correlation of inflation subcomponents between city pairs; and (iii) there are significant changes in the degree of synchronization across cities over time, reflecting important economic developments in history such as the global financial crisis, the adoption of euro, and the COVID-19 pandemic.

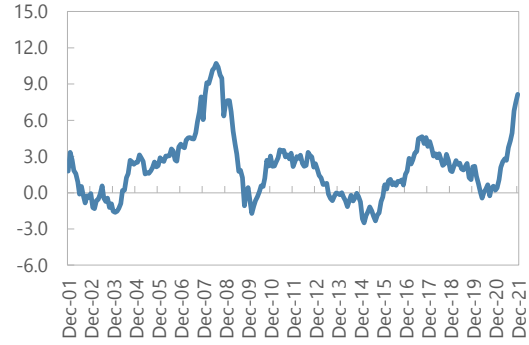
The granular empirical analysis presented in this paper shows that inflation cycles and pricing behavior in Lithuania still lack full synchronization across cities. This may be manifesting a range of factors from the intensity of market concentration and transportation costs to demographic variations, labor market conditions and different standards of living. For policymakers, disaggregate information provides helpful guidance not only on inflation dynamics and relative price convergence within the country, but also on the city-level differences in real wages and real interest rates that could influence the directions of labor and capital flows and thus regional growth within the country.

Appendix Figure A1. City-Level and Aggregate Inflation Rates in Lithuania

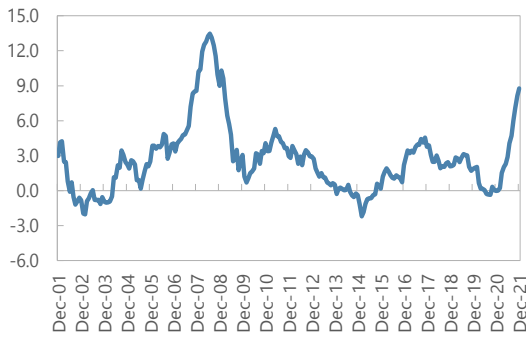
Kaunas



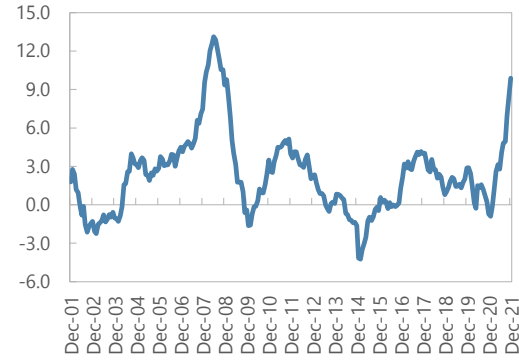
Klaipeda



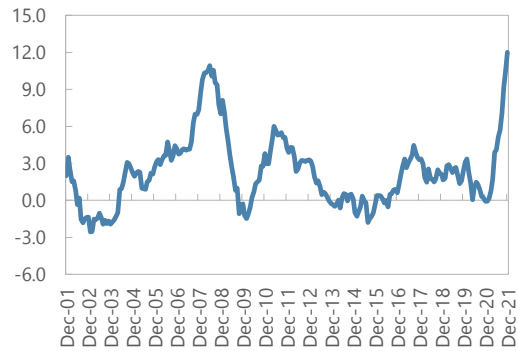
Panevezys



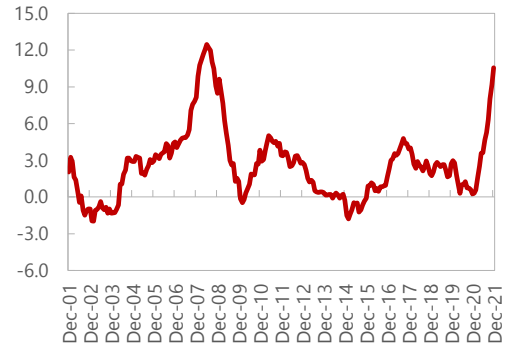
Siauliai



Vilnius



National



Source: Statistics Lithuania; author's calculations.

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