Wrocławsko-Lwowskie Zeszyty Prawnicze 14 (2023)
Вроцлавсько-львівський юридичний збірник 14 (2023)
ISSN: 2082-4939

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Relationship between unemployment and inflation in Poland in the context of the Phillips curve — a time of pandemic and war in Ukraine

https://doi.org/10.19195/2082-4939.14.12

Abstract

In this article we undertake a verification of the Phillips curve in Polish conditions during the pandemic and the war in Ukraine. The theoretical part introduces evolution of Phillips's theory and the review of literature and its verification in the conditions of Polish economy. Additionally, theoretical aspects regarding crisis and exogenous shocks are discussed. The aim of the empirical part of the work was to investigate the existence of the Phillips curve in the Polish economy in 2013–2022. The direction and strength of the relationship between inflation and unemployment rates were tested based on monthly data on full period and the pandemic period. In the research econometric methods were used in order to estimate parameters of an autoregressive inflation model, including both the influence of unemployment on the inflation rate and exogenous shock that were caused by periods of economic disruption reflected by binary, sustained and interaction variables. It was concluded that in the pandemic time the effect of the Phillips curve was present and that was accentuated by the war. However, in the longer term, this effect was not perceived as a negative relationship between characteristics under study. Nevertheless, in the full period of the study,

disruptions in inflation patterns which were caused by the pandemic and the period of Russian aggression against Ukraine were evident.

Keywords
Phillips curve, inflation, unemployment, COVID-19 pandemic, war in Ukraine

Introduction

Inflation is one of the key macroeconomic indicators. It is determined by a scope of factors, both domestic and international. Moreover, it is also sensitive to supply and demand shocks and also instability in global markets. One of such shocks, and later an element that caused economic instability of countries, was the successive wave of the COVID pandemic and the outbreak of war in Ukraine. In the economic history of the world, the COVID-19 crisis emerges as an unprecedented event — which represents as a simultaneous shock to aggregate demand and supply and uncertainties of the entire global economy. The outbreak of the COVID-19 pandemic and authorities' decision in response to it have created significant uncertainty for inflation forecasts around the world. Some of the observers warned of higher inflation whereas others were more optimistic when the economies were driven by stimulus and recorded recovery after lockdowns period. After a sudden drop in 2020, over the past few months, inflation has exceeded the forecasts from the beginning of 2021.

The non-linearity of the Phillips curve, combined with global factors, such as global commodity prices, global unused production resources, exchange rates and competition in terms of manufactures' prices played a major role in triggering sharp fluctuations in inflation rates during the COVID-19 crisis. What is more, the outbreak of war in Ukraine contributed to a significant inflation growth in Poland which resulted in many negative consequences for the society. The Phillips curve, however, is a simplified presentation of many deeper relationships, with slight modifications of its standard linear version and it will be useful to better understand some of the recent pandemic and war inflation "puzzles". Understanding how prices react to the abovementioned disruptions is very significant for such small open economies such as Poland, which are particularly vulnerable to such structural changes. The pandemic and accompanying restrictions, and also Russian invasion on Ukraine caused supply and demand shocks that simultaneously affected many economies and led to disruptions of the economic mechanisms.

It was specific for Poland to keep a high level of inflation during the pandemic (including increasing base inflation — in Poland base inflation was the highest in the last 18 years in June 2020). It is explained, among other reasons, by passing the costs of sanitary regime and other costs generated during the pandemic and necessary changes in a way of collecting prices by statistical offices in a face of closing economies. Price increases started to be more visible after the outbreak of war in Ukraine, however, the genesis of overpricing goes back to the beginning of 2020 and coronavirus pandemic. It means that econometric modelling of inflation processes

of the researched period of COVID-19 pandemic and the war in Ukraine should take into consideration exogenous shocks and instability. It also stems from the fact that, together with the growth of global economic integrity, the increase of exposition of Polish economy to global shocks has been noticed.

The main empirical aim of this study is an analysis of inflation processes in Poland in the last decade, specifically focusing on the impact of pandemic and the outbreak of the war on inflation in Poland and mutual relationship between inflation and the unemployment rate. However, proper modelling of economic relationships in different periods of time requires to use methodology that takes into consideration structural changes which is a relatively common problem, in particular in empirical studies on economies under transitions.

1. The outbreak of covid pandemic and war in Ukraine as exogenous shocks

In the subject literature there is not one universal and unanimous solution that allows to define "crisis". When analysing crisis from the point of view of economy it can be defined as cyclical phase of economic process (economic downturn) which is distinguished by decrease in economic climate i.e. revenues and profits of enterprises and society, and also the size of production and investments, which is very often accompanied by decrease of prices and unemployment growth.[1] According to A. Shaikh, crisis should be defined as accumulation of political and economic failures.[2] On the other hand, according to M. Rothbard, crisis is a result of misjudgements, wrong decisions and improper investments. What is more, crisis is not something undesirable. It is a kind of necessary "cleaning up" of the economy that allows to go back on a normal track after a period of flourishing, excess and waste.[3]

Variables that can cause economic crisis were defined by C. Reinhart and K. Rogoff. They named four factors such as:[4]

— currency crises,
— excessive inflation,
— bank crises,
— national mistakes.

According to E. Avgouleas, over 50% of crises are strongly connected with stress psychology and behavioural factors. People can fall into states of anxiety when confronted with information that potentially announces danger, such as the loss of social position, health or property.[5] When investing, the risk of losing savings

[1] K. Czech, *Polska gospodarka w początkowym okresie pandemii COVID-19*, Warszawa 2020, p. 3.
[2] A. Shaikh, *An Introduction to the History of Crisis Theories*, New York 1978, pp. 219–241.
[3] M.N. Rothbard, *Wielki Kryzys w Ameryce*, transl. M. Zieliński, W. Falkowski, Kraków 2010, p. 17.
[4] C.M. Reinhart, K.S. Rogoff, *This Time is Different: A Panoramic View of Eight Centuries of Financial Crises*, New York 2008, p. 44.
[5] E. Avgouleas, "The global financial crisis, behavioural finance and financial regulation: In search of a new orthodoxy", *Journal of Corporate Law Studies* 9, 2009, no. 1, pp. 23–59.

can cause paralysing fear and so-called crowd psychosis or herd effect can occur (irrational collective behaviour, lack of objective situation evaluation, following other players in financial market).[6]

Most crises have its origin, which in literature is called shock. The concept of shock appears in many disciplines and has many various meanings in everyday life. Nevertheless, the term of exogenous shock is studied in the area of many other scientific disciplines. Most often the context of shock appears in psychology and medicine as an individual phenomenon and in sociology and economics as a social phenomenon.[7] According to N. Taleb, P. Krugman and R. Dornbusch, exogenous shock is understood as unexpected and large changes in external factors that affect and influence internal factors.[8] Some of academic and political environments share the view that at the root of social development there must be shock phenomena that are the source of ground-breaking changes.[9]

COVID-19 pandemic is a phenomenon that is of a global character and has a major impact not only on functioning of global economy but also on social and political processes. Its unpredictability, rapid spreading and reaction of international community certainly have hallmarks of exogenous shock.[10]

The spread of coronavirus at the beginning of 2020 is described by economists as so-called "giant black swan" (an irregular event of a global significance, impossible to predict[11]), so at the same time is one of the most dangerous and important economic events since decades and economic situation that was triggered by COVID-19 pandemic has been compared to that of World War II with the most vital global consequences including[12]:

— increase in share price variability;
— decrease of nominal interest rates;
— decrease in real GDP;
— increase of global poverty;
— depreciation of stock indices;
— significant reduction of population mobility;
— breaking supply chains;

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[6] Ibid.

[7] A. Di Crosta, I. Ceccato, D. Marchetti et al., "Psychological factors and consumer behavior during the COVID-19 pandemic", *PLOS ONE* 16, 2021, no. 8, p. 1–23.

[8] H. Karpavičius, "Classification and interpretation of macroeconomic exogenous shocks — the case of Lithuania", *Socialiniai Tyrimai* 2012, no. 2 (27), pp. 89–97.

[9] D. Rodrik, "Where did all the growth go? External shocks, social conflict, and growth collapses", *Journal of Economic Growth* 4, 1999, no. 4, pp. 385–412; B. Savun, D.C. Tirone, "Exogenous shocks, foreign aid, and civil war", *International Organization* 66, 2012, no. 3, pp. 363–393.

[10] E. Kohlscheen, B. Mojon, D. Rees, "The macroeconomic spillover effects of the pandemic on the global economy", *BIS Bulletin* 2020, no. 4, https://doi.org/10.2139/ssrn.3569554 (accessed: 15.06.2023). W.J. McKibbin, R. Fernando, *The Global Macroeconomic Impacts of COVID-19: Seven Scenarios*, CAMA Working Paper No. 19/2020, Washington, DC 2020, http://dx.doi.org/10.2139/ssrn.3547729 (accessed: 11.10.2022); I. Noy, A. Nualsri, *What do Exogenous Shocks Tell Us about Growth Theories?*, SSCIE Working Paper 07–16, Santa Cruz 2007.

[11] M. Bishop, *Essential Economics: An A–Z Guide*, New York, 2009, p. 40.

[12] S. Gossling, D. Scott, C.M. Hall, "Pandemics, tourism and global change: A rapid assessment of COVID-19", *Journal of Sustainable Tourism* 29, 2021, no. 1, pp. 1–20.

— decrease in economic activity;
— new threats of financial stability.

The abovementioned examples are some of the effects of COVID-19 pandemic. Each of them caused a chain reaction resulting in drastic economic repercussions that many economists believe brought one of the most severe crisis on a global scale.[13] It is worth mentioning that preventive measures and those that slowed down spreading of coronavirus very often contribute to deepening the economic crisis.[14] According to official information from World Health Organisation, there were more than 750 million people that have been affected by COVID-19 worldwide and 6.8 million lost their lives to it. In Poland nearly 6.5 million citizens have contracted the disease and almost 120,000 have died.[15]

The shock that was caused by COVID-19 pandemic is being compared to the shock that was caused by a financial crisis in 2008.[16] The studies that have been conducted for years on the uncertainty and its drivers indicate that impact of the pandemic on uncertainty measured by indices is far less than it was during financial crisis.[17]

On the other hand, Russian invasion of Ukraine was a turning point for global security, international economy and global energy architecture, hence it can also be seen as exogenous shock. In a globalised world it is impossible to confine this war only to one region. It is not possible to think that consequences of Russia's assault on Ukraine will stay in geographical boundaries of one country, nor to eliminate one country from the fragility of supply chain. Before the war, due to educated work force and developed trade infrastructure, Ukraine had been one of the biggest world exporters of wheat and dominated world's sunflower oil market, being the biggest producers of steel.

The most visible and perhaps most noticeable effect of the war in Ukraine is inflation which was not seen for more than a quarter of a century. General level of prices of goods and services in Poland in 2021 have been in constant growth, which in majority was triggered by COVID-19 pandemic. At the beginning of the year the inflation was at 2.6%, which was the central bank's target. As a result of gradual monthly increase in December the value of price level stood at 8.6%. In February 2022 the inflation started to decrease for the first time and reached 8.5%. Nevertheless, this process did not last for long. Due to the outbreak of war in Ukraine, in the next month, the inflation significantly increased up to 11.0%. Since February it has risen every month by 1 percentage point compared to previous period. The situation has become worrying.[18]

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[13] A. Sumner, Ch. Hoy, E. Ortiz-Juarez, *Estimates of the Impact of COVID-19 on Global Poverty*, Wider Working Paper wp-2020-43, Helsinki 2020, p. 202.

[14] K. Czech, *Polska gospodarka w początkowym okresie pandemii…*, p. 16.

[15] "WHO COVID-19 dashboard", World Health Organization, https://covid19.who.int/ (accessed: 12.03.2023).

[16] C. Tang, K. Aruga, "Effects of the 2008 financial crisis and COVID-19 pandemic on the dynamic relationship between the Chinese and international fossil fuel markets", *Journal of Risk and Financial Management* 14, 2021, no. 5, p. 207.

[17] P. Benigno, P. Canofari, G. Di Bartolomeo et al., *Uncertainty and the Pandemic Shocks*, European Parliament Monetary Dialogue Paper PE 658.199, Luxembourg 2020.

[18] A. Kępka, N. Pająk, "Wpływ wojny w Ukrainie na wysokość inflacji w Polsce", *Studia Ekonomiczne, Prawne i Administracyjne* 4, 2022, pp. 59–72.

Russian invasion on Ukraine brings many consequences that are visible in everyday life of many Polish citizens. The war has huge impact on prices of energy resources, in particular oil. Although Poland is not involved in the war, its effects are palpable. The conflict in Ukraine has strong impact on inflation level which translates to people's everyday life. Since Russia is one of the main exporters of oil and gas, the prices of fuels and energy carriers grow in Poland. The society experiences high food prices due to suspension of grain supply from Ukraine. Polish zloty loses its value and Poles have problems to get credit due to rising interest rates. Growing inflation contributes to lower standard of living since fewer goods can be purchased for the same amount of money as few months before.

2. The concept of Phillips curve in theory of economy

The idea of perceiving unemployment and inflation as interacting phenomena is far older than considerations of A.W. Phillips.[19] This subject had been investigated by I. Fischer, who could be considered as a pioneer of the analysis of this problem. He was the first one to observe that these variables are negatively correlated. Fischer's explanations for negative correlations between inflation and unemployment were the following: Entrepreneurs perceive inflation in a positive way because their revenues increase proportionally to increasing prices level, whereas expenses grow slower as they come from more long-term contracts. As a result, entrepreneurs' profits increase during inflation, at the same time stimulating employment and levelling unemployment. It is different in case of deflation, when the revenues decrease faster than expenses and as a result profit levels decrease triggering job losses and unemployment growth.[20]

It was A.W. Phillips, however, who has made the most significant observations in the sphere of interactions of inflation and unemployment by analysing economy of Great Britain.[21] A.W. Phillips did not examine relationship between change of prices and unemployment, instead, he focused on change of nominal salary and unemployment. By analysing changes in the level of inflation rates and unemployment, A.W. Phillips came to three important conclusions. Firstly, he noticed that there is reverse relationship between unemployment rate and a level of nominal salary. Secondly, change of salaries depends not only on current level of unemployment but also the rate of changes. His third observation, however, was an indication of relationship between salary changes and inflation rate. These findings allowed Phillips to introduce a model which is called "Phillips curve" and which was introduced to economics by P. Samuelson and R. Solow.[22]

[19] T.M. Humphrey, "The evolution and policy implications of Phillips curve analysis", *Economic Review* 71, 1985, no. 2, p. 3.
[20] I. Fisher, "A statistical relation between unemployment and price changes", *International Labour Review* 13, 1926, no. 6, pp. 786–788.
[21] A.W. Phillips, "The relation between unemployment and the rate of change of money wage rates in United Kingdom, 1861–1957", *Economica* 25, 1958, no. 100, pp. 283–299.
[22] P. Samuelson, R. Solow, "Analytical aspects of anti-inflation policy", *American Economic Review* 50, 1960, no. 2: *Papers and Proceedings of the Seventy-second Annual Meeting of the American Economic Association (May, 1960)*, pp. 177–194.

The model was criticized by M. Friedman and E. Phelps in their studies. Friedman accepted Fisher's idea about negative correlation between inflation and unemployment, however, in a short period of time when an increase of money supply and income will be reflected in a production growth and employment rate than in price increase.[23] On the other hand, E. Phelps focused on the analysing causes of frictions when setting the prices and salaries.[24] In his opinion both companies and workers observe the increase of prices and salaries in a particular sector and increase in the productivity without noticing that there was increase of prices throughout the economy. Additionally, E. Phelps made an assumption since there was frictional unemployment in the labour market and each company increases the salaries, the workers would not switch to a better paid job. So the employed workers are caught up in a reduction of frictional unemployment and macroeconomic data show a fall in unemployment rate. This phenomenon occurs only for a short period of time.

In the 1970s Friedman-Phelps model came under criticism. The issue of unexpected increase of inflation rate, the amount of which could be dependent on current or future changes in policy, was questioned. That is why neo-Keynesians developed a postulate that government's choice of particular, short-term combination of inflation and unemployment rate has the influence on expectations of economic entities, leading to a change of the balance point (understood here as a relationship between inflation and unemployment) in the economy.

Representatives of a new classical school — Lucas, Sargent and Wallace — had the similar view on the lack of relationship between unemployment and inflation in a long period of time.[25] In their opinion, possibilities of substitution between analysed categories is not possible in a long period and is very doubtful in a short period of time. In order for this to happen, one of the two situations must have come into existence: when decision-makers increase money supply by the higher percentage than the systematic growth component implied by the rule and when in the economy there will be deviations of current, real salary from a "standard" growth rate and deviations of price level from its previous trend.[26] In 1978 R.E. Lucas together with T.J. Sargent referred, in their joint article, to the phenomenon of stagflation in US which was caused by supply shocks connected with oil crisis. These researchers have explicitly pointed out that economic entities formulate their expectations on the basis of the same information that decision makers that are responsible for economic policy of the country and, as a result, act to neutralise political actions that interfere in economic balance.[27] They set the primary objective as of the government to keep the stability of prices and state's influence on the value of supply.

The not so strong relationships between inflation and the state of economy and unemployment are also indicated by models on the neo-Keynesian Phillips curve,

[23] M. Friedman, "The role of monetary policy", *American Economic Review* 58, 1967, pp. 1–17.

[24] E. Phelps, "Phillips curves, expectations of inflation and optimal unemployment over time", Economica (New Series) 34, 1967, no. 135, pp. 254–281.

[25] T.J. Sargent, N. Wallace, "'Rational' expectations, the optimal monetary instrument and the optimal money supply rule", *Journal of Political Economy*' 83, 1975, no. 2, pp. 241–254.

[26] R.E. Jr. Lucas, L.A. Rapping, "Real wages, employment and inflation", *Journal of Political Economy* 77, 1969, no. 5, pp. 721–754.

[27] R.E. Lucas, T.J. Sargent, "After Keynesian macroeconomics", *Federal Bank of Minnesota Quarterly Review* 3, 1979, no. 2, pp. 49–72.

which highlight that prices are not changed so often so their relationships with cycle phase are limited.[28] The neo-Keynesian Phillips curve model indicated that a particular relation of an actual inflation rate to the expected one is the result not only of changes in the expectations of economic entities but also of a process of slow adjustments of salaries and prices.[29]

In the second half of the 1990s, Phillips curve models interested the economists from so-called neoclassical synthesis movement. This trend combined elements of neo-Keyonesism and the theory of real business cycle, indicating the links between inflation and economic activity. In this approach a conception of real expectations and a phenomenon of imperfect competition was accepted.[30] In 1999 a so-called conception of a hybrid Phillips curve model was introduced which is considered a main example of the contribution of neoclassical new synthesis theory to the development of the Phillips curve.[31] In their work J. Gali and M. Gertler showed that in the economy there are entities that base their inflation expectations both on past events as well as on forecasts prepared on the basis of current events.

3. Verification of the Phillips curve in Poland in the subject literature

In the subject literature there are numerous empirical studies presented that confirm the existence of correlation between inflation and unemployment. Among these works on Polish economy, it is worth noticing the studies of G. Kuczyński and K. Strzała.[32] In particular, they investigated the validity of the Phillips curve theory in Poland. Their analysis covered the period of 1990s. The researchers found out that in this period of time there was a positive correlation between the level of unemployment and inflation. Researches that are interesting for Poland were conducted by M. Brycz based on data from 1997 to 2006.[33] In the researched period of time, large impact of unit labour cost on inflation was visible and the characteristics of the Phillips curve did not differ from the ones of euro area countries.

There are other conclusions that come from the research conducted by T. Grabia.[34] In the published article he attempts to analyse the impact of inflation rate on unemployment rate in Poland in years 1990–2006. The analysis shows that the Phillips

[28] G.A. Akerlof, W.T. Dickens, G.L. Perry, "Near rational wage and price setting and the optimal rates of inflation and unemployment", *Brooking Papers on Economic Activity* 2000, no. 1, pp. 1–60.

[29] R.J. Gordon, *The History of the Phillips Curve: An American Perspective*, Evanston 2008, pp. 22–28.

[30] M. Brycz, "Pięćdziesiąt lat krzywej Phillipsa", [in:] *Problemy ekonomii i polityki gospodarczej. Materiały konferencyjne Międzynarodowej Konferencji „Ekonomiczne wyzwania XXI wieku. Polska – Unia Europejska – Świat"*, ed. G. Maniak, Szczecin 2008, pp. 81–114.

[31] J. Gali, M. Gertler, "Inflation dynamics: A structural econometric analysis", *Journal of Monetary Economics* 44, 1999, no. 2, pp. 195–222.

[32] G. Kuczyński, K. Strzała, *Phillips Curve in Poland: Myth or Fact?*, Łódź 2002.

[33] M. Brycz, "Dyskusja nad neo-keynesowską krzywą Phillipsa – wnioski dla Polski", [in:] *Zachowania rynkowe w teorii i praktyce*, ed. D. Kopycińska, Szczecin 2007, pp. 120–145.

[34] T. Grabia, "Rynek pracy w Polsce w okresie transformacji w świetle różnych wariantów Krzywej Phillipsa", [in:] *Wykorzystanie zasobów pracy we współczesnej gospodarce*, ed. D. Kopycińska, Szczecin 2007, pp.124–144.

curve was indisputably present in Poland in 1998–2003. The author investigated the Phillips curve for the whole Visegrad group (Poland, the Czech Republic, Hungary and Slovakia) from 1997 to 2016. The research showed that the classical version of a negatively sloped Phillips curve was partially confirmed only in the Czech Republic. In case of Poland and Hungary this kind of relationship was only present in some sub-periods. Against this background, the case of Slovakia stood out clearly, were a direction of inflation and unemployment changes were almost identical. This is totally contradictory to the classic, short-term Phillips curve.[35]

M. Mańkowski, A. Ostrowski and R.W. Włodarczyk work investigated the existence of the Phillips curve in Polish economy in years 1990–2010. The direction and strength of the relationship of inflation and unemployment rate was verified on the basis of monthly, quarterly, semi-annual and annual data. It was also concluded that at the time of world financial crisis there was no effect of the Phillips curve itself (only in some of its sub-periods).[36]

In contrast, in his work J. Wallusch presented evolution of the neo-Keynesian Phillips curve from its original version based on Calvo model that made inflation conditional on anticipatory inflation expectations and demand variable, to a hybrid version, extending basic model with autoregressive element. In this work simulations for Poland were based on both versions of the neo-Keynesian Phillips curve, which suggests cautious treatment of this theory in conditions of imperfect information and disinflation process.[37]

Researches on the Phillips curve in the conditions of Polish economy were also conducted by Z. Mongiało. The usage of the Phillips curve in macroeconomic conditions in Poland in 1998–2011 was analysed. He found out that the classic Phillips curve in researched years did not always define relationship between unemployment and inflation.[38]

4. An analysis of relationship between inflation and unemployment taking into account exogenous shocks and instability

The first step of the research examined the evolution of inflation and unemployment rate in 2013–2022, which can be considered as a long period of time. Data regarding monthly levels of processes under the study were taken from the website of the Central Statistical Office. The evolution of inflation is illustrated in Figure 1. An increasing trend of a process is evident and this trend is not linear, that is why a quadratic trend in the model was proposed. Additionally, a shape of relationships

[35] T. Grabia, "Krzywe Phillipsa w krajach Grupy Wyszehradzkiej", *Studia i Prace WNEIZ US* 41, 2017, no. 2, pp. 171–182.
[36] M. Mańkowski, A. Ostrowski, R.W. Włodarczyk, "Związek między bezrobociem a inflacją w Polsce na tle krzywej Phillipsa", *Ruch Prawniczy, Ekonomiczny i Socjologiczny* 74, 2012, no. 2, pp. 141–159.
[37] J. Wallusch, "Ewolucja nowokeynesowskiej krzywej Phillipsa", *Ekonomista* 2008, no. 5, pp. 577–592.
[38] Z. Mongiało, "Krzywa Phillipsa w aspekcie danych makroekonomicznych dla Polski", *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu. Ekonometria* 34, 2011, no. 200, pp. 339–353.

between unemployment and inflation was analysed (Figure 1). In this case, a non-linear character of relationships between variables is visible. Since the subject literature suggests to consider hyperbolic dependencies, such relationships were taken into account in modelling an inflation process, hence *inverse_unemployment* variable was generated which is the inverse for the *unemployment* variable.

Figure 1. Inflation in the period from January 2013–December 2022 and a graph of correlation between processes

Source: Self-study

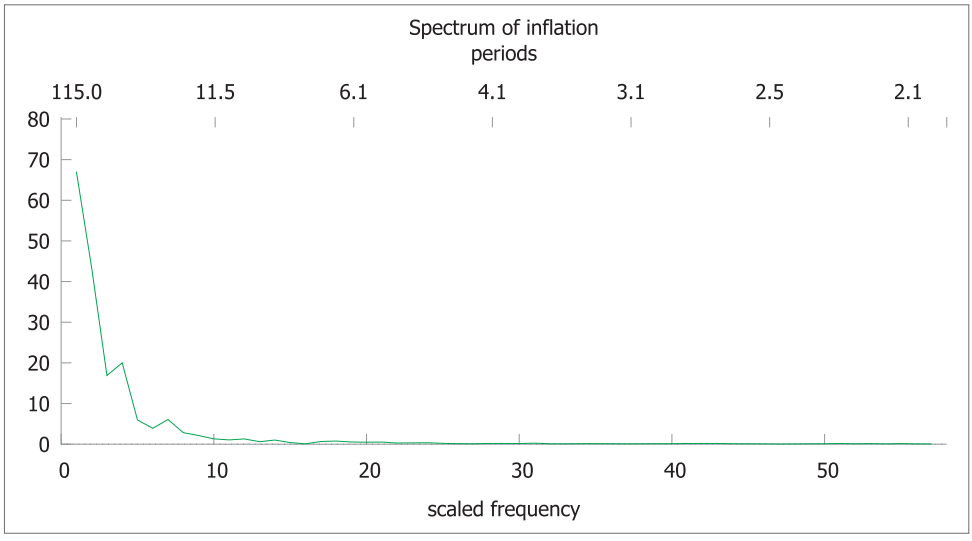

Figure 2. Periodogram for inflation process
Source: Self-study

Additionally, taking into consideration cyclical nature of inflation process (Figure 2), the usage of ADL(1,1) autoregressive model was discussed. The lag orders were determined in a Ljung-Box test and PACF chart for processes: *inflation* and *inverse_unemployment* (Figure 3).

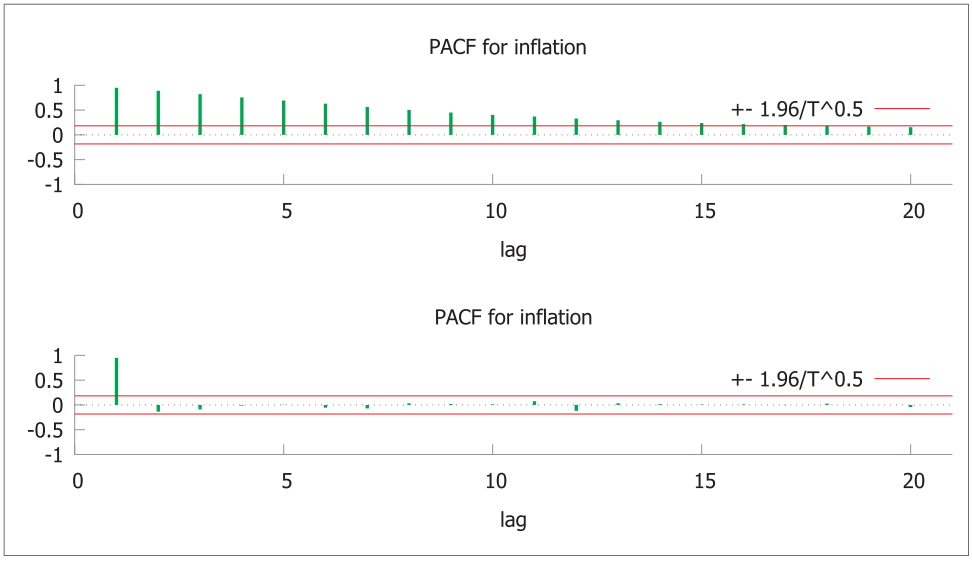

Figure 3. PACF for process: inflation and unemployment
Source: Self-study

Since the aim of this study was to indicate the impact (or the lack of impact) of COVID pandemic in the analysed process, additionally binary variables were also taken into consideration, which are corresponding to qualitative events, concerning the emergence of pandemic and its course:

— *COVID_Poland* — a binary variable, taking the value 1 in March 2020 (the appearance of first cases of the virus in Poland was recorded at the end of March 2020),

— *COVID_world* — a binary variable, taking the value 1 in December 2019 (the appearance of first cases of the virus worldwide was recorded at the end of year 2019),

— *lockdown1* — a binary variable, taking the value 1 in Q2 2020 (in March/April 2020 many restrictions were introduced, among them a ban on movement except for justified situations),

— *lockdown2* — a binary variable, taking value 1 in March and April 2021 (introduced in March 2021 when the number of infections settled around 30,000 daily. From Saturday, 27th March, new safety rules were introduced which were valid till Easter holidays),

— *wave 2* — a binary variable, taking value 1 in Q4 of 2020 (second wave started in Poland from 24th September 2020),

— *wave 3* — a binary variable, taking the value 1 in Q2 2021 (started at the beginning of March 2021),

— *COVID* — a binary variable sustained, taking value 1 in the pandemic (from March 2020 till the end of the researched period),

— *interaction* — an interaction variable between *time* variable and *COVID*, that is supposed to verify process trend changes in the pandemic,

— *interaction2* — an interaction variable between variable *time^2* and *COVID*, which is supposed to verify process trend changes in the pandemic,

— *interaction3* — an interaction variable between *COVID* and *inverse_ unemployment* variable.

Additionally, shock and interaction variables were introduced to the analysis that reflect the qualitative phenomenon that was the outbreak of war in Ukraine:

— *war_outbreak* — a binary variable, taking value 1 in March 2022 (Russia's aggression against Ukraine started on Thursday, 24th February 2022, and since it was the end of the month, it was decided that the "shock" after the outbreak was accentuated in the following month),

— *war* — a variable sustained, taking the value 1 in a period from the outbreak of the war till the end of researched period,

— *interaction4* — an interaction variable between *time* variable and *war* variable, which supposed to verify process trend changes during the war,

— *interaction5* — interaction variable between *time^2* variable and *war* variable which is supposed to verify process trend changes during the pandemic period,

— *interaction6* — an interaction variable between *war* variable and the inverse of the *unemployment* variable.

Taking into consideration all of the variables that should have been used in the analysis, the parameters of the inflation model were estimated (Model 1).

Model 1. KMNK estimation, observations used 2013:06-2022:12 (N = 115)
Dependent variable (Y): inflation

	Index	*Standard error*	*t-Student*	*value p*	
const	17,3887	11,8681	1,465	0,1461	
inverse_unemployment	–4,23068	10,8115	–0,3913	0,6964	
inverse_unemployment_1	–5,44347	11,0989	–0,4905	0,6249	
time	–0,0899357	0,0627745	–1,433	0,1552	
sq_time	0,000186807	0,000114038	1,638	0,1047	
COVID_Poland	0,310223	0,618414	0,5016	0,6171	
COVID_world	0,547223	0,380573	1,438	0,1537	
lockdown1	0,196853	0,376093	0,5234	0,6019	
lockdown2	0,730889	0,446374	1,637	0,1048	
wave2	–0,401061	0,251370	–1,596	0,1139	
wave3	–0,0677020	0,386671	–0,1751	0,8614	
COVID	–1079,03	244,677	–4,410	<0,0001	***
interaction1	6,10947	1,38961	4,397	<0,0001	***
interaction2	–0,00871566	0,00197411	–4,415	<0,0001	***
interaction3	47,4116	13,5046	3,511	0,0007	***
war_outbreak	1,15778	0,575142	2,013	0,0469	**
war	0,706160	5,45086	0,1296	0,8972	
interaction6	5,70024	29,8731	0,1908	0,8491	
inflation_1	0,940288	0,0491640	19,13	<0,0001	***

Arithmetic mean of dependent variable	102,8870	Standard deviation of the dependent variable	4,481434
Residual sum of squares	12,37021	Residual standard error	0,358966
Coefficient of determination R -square	0,994597	Adjusted R - square	0,993584
F(18, 96)	981,7649	A value p for a test F	2,0e-100
Logarithm of reliability	–34,97359	Akaike information criterion	107,9472
Bayesian information criterion	160,1009	Hannan-Quinn criterion	129,1161
Autocorrelation of the residuals- rho1	0,166444	Durbin statistics h	2,100576

Since the results showed symptoms of collinearity of the variables visible, in the next step variables responsible for this collinearity were eliminated (evaluation of collinearity was conducted on the basis of variance expansion factor), then father irrelevant variables were removed and Model 2 was obtained.

Model 2. KMNK estimation, observations used 2013:06-2022:12 (N = 115)
Dependent variable (Y): inflation

	index	standard error	t-Student	value p	
const	41,0879	11,8402	3,470	0,0008	***
inverse_unemployment_1	–18,7735	5,48112	–3,425	0,0009	***
time	–0,218477	0,0587412	–3,719	0,0003	***
sq_time	0,000433319	0,000102168	4,241	4,80e-05	***
lockdown2	0,771863	0,314460	2,455	0,0157	**
interaction3	39,8607	11,2319	3,549	0,0006	***
war	14,7858	3,76457	3,928	0,0002	***
interaction6	–74,2864	20,8146	–3,569	0,0005	***
inflation_1	0,877966	0,0438210	20,04	1,16e-037	***

Arithmetic mean of dependent variable	102,8870	Standard deviation of the dependent variable	4,481434
Residual sum of squares	16,21502	Residual standard error	0,392974
Coefficient of determination R -square	0,992918	Adjusted R - square	0,992311
F(9, 105)	1635,616	A value p for a test F	1,4E-108
Logarithm of reliability	–50,53575	Akaike information criterion	121,0715
Bayesian information criterion	148,5208	Hannan-Quinn criterion	132,2130
Autocorrelation of the residuals - rho1	0,209700	Durbin statistics h	1,547602

High value of the coefficient of determination indicates a very good fit of the model and empirical data (model defines changeability of inflation process in 99%). Empirical and equalized data were presented in Figure 5.

Further all KMNK assumptions were verified. All the assumptions were met so it was possible to interpret obtained results.

The results show a positive relationship between unemployment and inflation in the time before pandemic, however, this relationship is shifted in time by one month, i.e. the level of inflation in a given month was influenced in a positive way by an unemployment level in a previous month. It is not surprising, since as it was discussed in Chapter 2, the Phillips curve does not have any justification in the long period. All "shock" variables were removed as they were irrelevant for the model, which means that level of inflation and its relationship with unemployment was not influenced by the appearance of SARS-CoV2 virus in the world and Poland (confirmed by lack of important parameters with *COVID_world* and *COVID_Poland* variables). What is more, no pandemic wave influenced evolution of inflation, however, introduction of restrictions by the Polish Government had the impact on the increase of value

of inflation during second lockdown. The outbreak of war itself did not affect the process of inflation in Poland and its dependence on the size of unemployment, nevertheless, prolonging time of war increased the inflation of 14 p.p. on average, and changed the nature of the relationship between the investigated process.

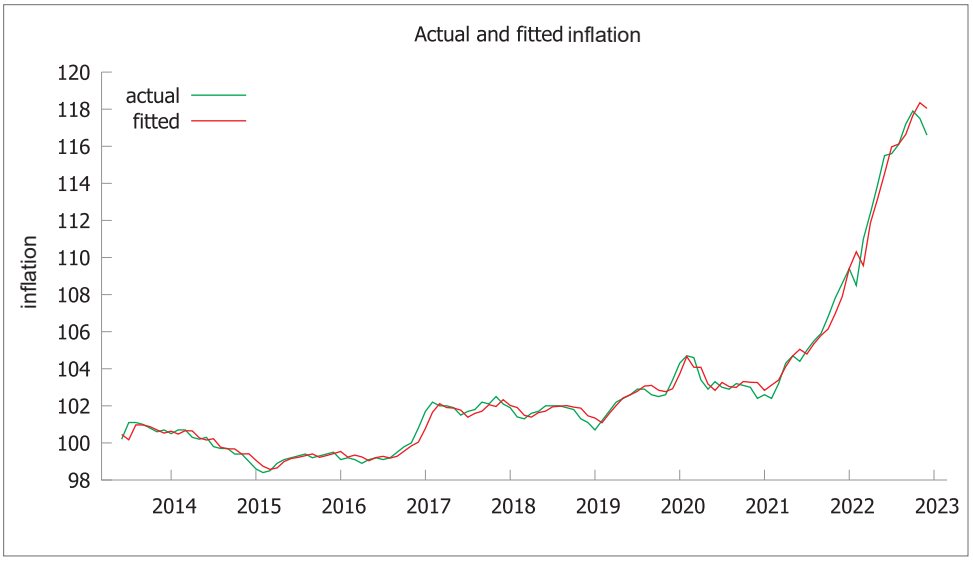

Figure 4. Figure of empirical and equalized data of *inflation* variable
Source: Self-study

However, it is evident that previous relationship between unemployment and inflation during the pandemic (outside the war period) changed its character, which is confirmed by the significant parameters along with sustained and interaction variables associated with this period of time. The positive parameter at the interactive variable indicates that during pandemic the performance of these process in line with the Phillips curve (the influence of unemployment and inflation expressed by long-run multiplier is equal to 21.09, i.e. the relationship is negative). Nonetheless, during the wartime period, this dependency changed its character again (the long-run multiplier took on a negative value).

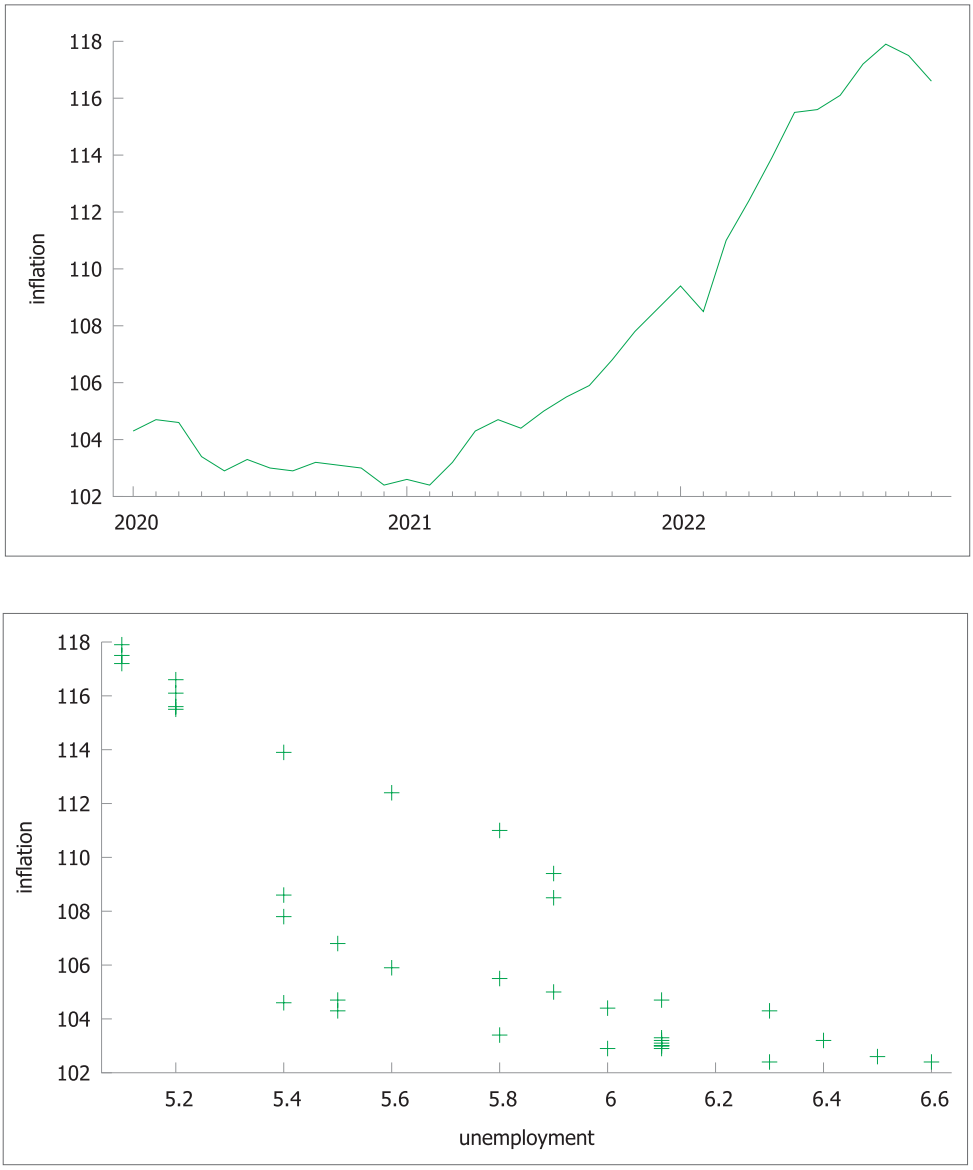

Figure 5. Inflation and spreadsheet between inflation and unemployment in the pandemic period
Source: Self-study

That is why in the next step pandemic period and the wartime in Ukraine was taken under analysis, the period from January 2020 till December 2022. The development and dependency of inflation and unemployment was illustrated in Figure 5.

Noticeable are: non-linear tendency of inflation in time and non-linear character of the correlation between analysed process and unemployment. Additionally, an analysis of correlograms and periodogram for the process[39] implied again the usage of autoregressive ADL(1,1) model to model the relationship under the study. The model structure did not include binary variable sustained COVID nor any other from interaction variables (we are already analysing pandemic period of time).

Model 3. KMNK estimation, observations used 2020:01-2022:12 (N = 36)
Dependent variable (Y): inflation

	Index	*Standard error*	*t-Student*	*value p*	
inverse_unemployment	61,4655	13,5789	4,527	<0,0001	***
time	0,105880	0,0164911	6,420	<0,0001	***
war	2,04140	0,304148	6,712	<0,0001	***
inflation_1	0,547995	0,0697789	7,853	<0,0001	***

Arithmetic mean of average variable	107,6000	Standard deviation of the dependent variable	5,314455
Residual sum of squares	8,028692	Residual standard error	0,500896
Uncentered R-square	0,999981	Centred R — square	0,991878
F(4, 32)	416286,9	A value p for a test F	5,88e-75
Logarithm of reliability	–24,07283	Akaike information criterion	56,14567
Bayesian information criterion	62,47975	Hannan-Quinn criterion	58,35643
Autocorrelation of the residuals - rho1	0,223032	Durbin statistics h	1,473556

After estimating model parameters and irrelevant variables reduction, finally Model 3 was created for which KMNK assumptions were verified. The model passed the verification which means that it can be used for further studies. So all "shock" variables were removed due to their insignificance for the model, indicating that the inflation size and its relationship with unemployment was not influenced by the occurrence of SARS-CoV2 virus both in the world and in Poland (which is demonstrated by lack of relevant parameters with *COVID_world* and *COVID_Poland* variables) and the outbreak of war in Ukraine (which is demonstrated by lack of relevant parameters with *war_outbreak* variable).

Additionally, none of the pandemic waves impacted the development of transport figures, similarly to the introduction of restrictions by the Polish Government, resulting in the appearance of so-called lockdowns. Nevertheless, there is opposite dependency visible between inflation and unemployment, which is consistent with the Phillips curve. On the other hand, the time of Russian aggression against Ukraine

[39] Due to limitations of the article the charts were not attached.

had a positive influence on inflation rate in Poland (by increasing it by 2 p.p.), without affecting its relationship with unemployment process (demonstrated by irrelevant parameter with interaction variable).

This model, as could be seen, is completed with autoregressive factor which positively influenced its adjustment to empirical data (99.99%) and specification correctness. The empirical and equalized data were presented in Figure 6.

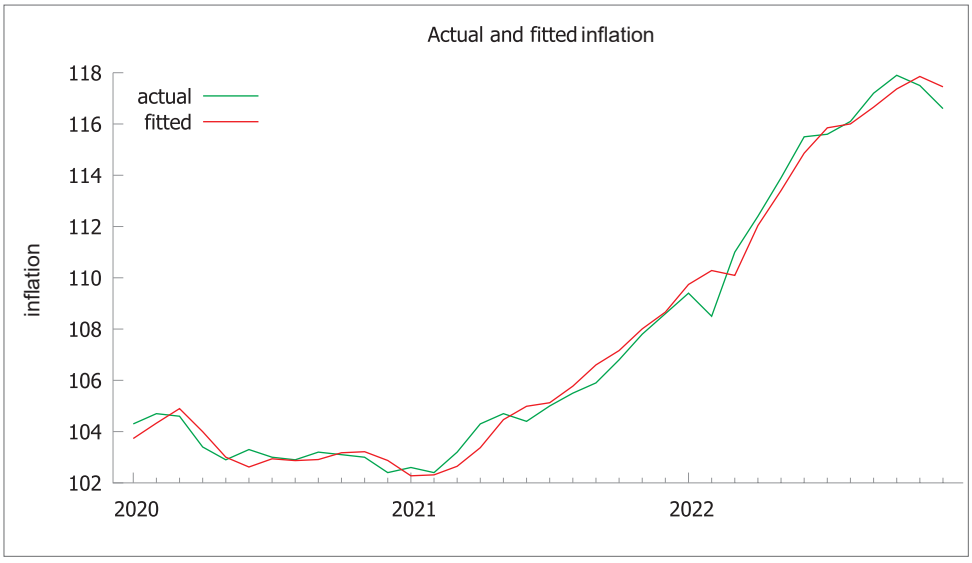

Figure 6. Chart of empirical and equalized values of *inflation* variable for Model 3
Source: Self-study

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Взаємозв'язок між рівнем безробіттям та рівнем інфляції в Польщі в контексті кривої Філліпса в умовах пандемії та війни в Україні

Анотація

У статті апробовано концепцію кривої Філліпса в період пандемії та війни в Україні в умовах функціонуваннях польської економіки. У теоретичній частині представлено еволюцію теорії Філліпса та огляд літератури щодо її верифікації у польському економічному середовищі. Також досліджено теоретичні аспекти кризи та екзогенних шоків. Метою емпіричної частини цієї роботи було дослідити існування кривої Філліпса в економіці Польщі у 2013–2022 роках. Спрямованість та рівень взаємозв'язку між інфляцією та рівнем безробіття перевірено на основі щомісячних даних за досліджуваний період загалом та період пандемії зокрема. У дослідженні використано економетричні методи для оцінки параметрів авторегресійної моделі інфляції, що враховує як вплив безробіття на інфляцію, так і екзогенні шоки, зумовлені періодами економічних потрясінь, представлені бінарними, постійними та інтерактивними змінними. Виявлено, що лише в період пандемії спостерігався ефект кривої Філліпса, який нівелювався періодом війни в Україні. Однак протягом тривалого періоду часу цей ефект не був помітний як негативний зв'язок між досліджуваними характеристиками. Проте за весь період досліджуваного періоду часу були помітні зміни у динаміці інфляції, спричинені як пандемією, так і періодом російської агресії проти України.

Ключові слова
крива Філліпса, інфляція, безробіття, пандемія COVID-19, війна в Україні

Związek między bezrobociem a inflacją w Polsce w kontekście krzywej Phillipsa — czas pandemii i wojna na Ukrainie

Streszczenie

W artykule podjęto się analizy krzywej Phillipsa w warunkach polskich w trakcie pandemii i wojny na Ukrainie. W części teoretycznej przybliżono ewolucję teorii Phillipsa i dokonano przeglądu literatury dotyczącej jej weryfikacji odnośnie do polskiej gospodarki. Opisano też teoretyczne aspekty kryzysu i szoków egzogenicznych. W części empirycznej niniejszej pracy zbadano krzywą Phillipsa w odniesieniu do gospodarki polskiej w latach 2013–2022. Sprawdzono kierunek i siłę związku stóp inflacji i bezrobocia na podstawie danych miesięcznych dla pełnego okresu oraz okresu pandemii. W badaniach wykorzystano metody ekonometryczne do oszacowania parametrów modelu autoregresyjnego inflacji, uwzględniającego zarówno wpływ bezrobocia na wielkość inflacji, jak i szoki egzogeniczne spowodowane zaburzeniami w gospodarce, reprezentowane przez zmienne binarne, podtrzymane i interakcyjne. Stwierdzono, że w pandemii wystąpił efekt samej krzywej Phillipsa, który został wzmocniony w fazie wojny. Natomiast w dłuższym czasie nie zarejestrowano ujemnego związku między badanymi cechami. W pełnym okresie badania widoczne jednak były zaburzenia w kształtowaniu się inflacji wywołane zarówno pandemią, jak i agresją rosyjską na Ukrainę.

Słowa kluczowe
krzywa Phillipsa, inflacja, bezrobocie, pandemia COVID-19, wojna na Ukrainie