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ARTICLE

Limited Efficiency of Monetary Policy on Local Inflation Rates and Output

Eficiencia limitada de la política monetaria sobre las tasas de inflación y el producto local

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ABSTRACT

This is the second article of a series of two that documents the limited efficiency of the Peruvian monetary policy on local inflation rates. With this research I deepen on my preliminary findings on the unobserved effects of Peruvian monetary policy using departmental Phillips curves. On this occasion, the motivation seeks to answer the question: by incorporating the NAIRU-Keynesian and neo-Keynesian structural model criteria for the Peruvian case, what other unobserved effects of monetary policy would be found in Peru's departments?

Two models of structural equations are developed to estimate the impact of monetary policy at sub-national levels, the first considers the unemployment rate (NAIRU-Keynesian) and the second considers the departmental GDP gap, from which there are counterproductive results that start from the misalignment of departmental economic cycles with the national one which generates inefficiency of monetary policy to reduce departmental inflation, the increase in departmental unemployment and the decrease in the departmental GDP gap.

Keywords: Monetary policy, decentralised effects, inflation, GDP gap, unemployment, structural monetary model.
JEL Code: JEL E37, E52, E58, E61.

RESUMEN

Este es el segundo artículo de una serie de dos que documenta limitaciones en la eficiencia de la política monetaria peruana en las tasas de inflación locales. Con la presente investigación profundizo mis hallazgos preliminares sobre los efectos no observados de la política monetaria peruana utilizando curvas departamentales de Phillips. En esta ocasión, la motivación busca responder a la pregunta: al incorporar los criterios del modelo estructural NAIRU-keynesiano y Neokeynesiano para el caso peruano, ¿qué otros efectos no observados de la política monetaria se encontrarían en los departamentos del Perú?

Se desarrollan dos sistemas de ecuaciones estructurales para estimar el impacto de la política monetaria al nivel subnacional, el primero considera la tasa de desempleo (NAIRU-Keynesiana) y el segundo considera la brecha del PIB departamental, de lo cual se obtienen resultados contraproducentes que documentan el desalineamiento de los ciclos económicos departamentales con el nacional lo que genera ineficiencia de la política monetaria para reducir la inflación departamental, el aumento del desempleo departamental y la disminución de la brecha del PIB departamental.

Palabras clave: Economic policy, financial policy, financial resources, microcredit.
Código JEL: JEL E37, E52, E58, E61.

1. Introduction

The document gives continuity to an investigation that identifies unobserved effects of monetary policy in Peru's departments unemployment and output gap (Mendoza Vargas, 2022), inspired by the regional Phillips curve estimation methodologies proposed by Fitzgerald and Nicolini (2014) for the case of 24 USA cities, and Barrera (2019) for the case of Peru's departments. On this occasion, the structural monetary models derived by these authors in their methodological development to the monetary case are adapted by assuming two approaches: The first where the monetary authority administers its policy through a Neo-Keynesian system with an output gap; the second where the monetary authority administers its policy through a Keynesian system of not-accelerated inflation rate with unemployment, NAIRU.

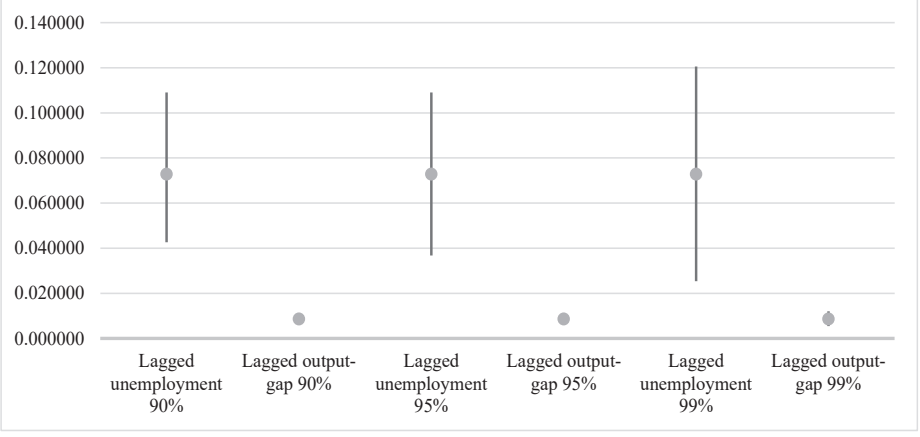
The strategies of Fitzgerald and Nicolini (2014) and Barrera (2019) differ between them. First, Fitzgerald and Nicolini (2014) document the stability of the Phillips curve for the USA case: 1) They emphasize that the endogeneity of monetary policy implies that the aggregated data are largely uninformative about the existence of a stable relationship between unemployment and future inflation at the level of the cities studied; 2) Using a NAIRU-Keynesian model, they identify a structural relationship between unemployment and future inflation. On the other hand, Barrera (2019) starts from the linear model of Fitzgerald and Nicolini (2014) to derive a non-linear model for estimating the departmental Phillips' curves such that: 1) His empirical evidence does not favour the hypothesis that the parameter of the output gap is null concerning the variation of the inflation rate using a non-linear model which considers heteroscedasticity; and 2) In the case of the nonlinear model that assumes homoscedasticity in Peru's departments, the evidence favours the existence of a horizontal section of the Phillips' curve.

As a contrast and assuming the combination of Fitzgerald and Nicolini (2014) and Barrera approaches (2019) for linear models with heteroscedasticity of the neo-Keynesian and NAIRU-Keynesian Phillips' curves I document some unobserved effects of monetary policy (Mendoza Vargas, 2022): 1) Barrera's (2019) findings on the flattening of the departmental Phillips's curve are confirmed when estimated with the output gap; 2) When estimating the Phillips' curves with the

departmental unemployment rates, which are lower than the national employment rates because of the biased generated by Lima department and the constitutional province of Callao, the parameter of the Phillips curve is positive; and 3) As highlighted in Figure 1, the relationship between inflation and departmental unemployment is more elastic than the relationship between inflation and the departmental output gap.

Figure 1

Confidence intervals produced for departmental Phillips curves with unemployment and output gap for Peru's departments.



Notes: Confidence intervals produced for c^1 using the equation (13) of Mendoza Vargas (2022) at 90 %, 95 % and 99 % confidence levels. The departmental Phillips curves estimated with the output gap are more flattened than the corresponding ones produced with departmental unemployment rates.

Therefore, the question arises, what other unobserved effects of monetary policy would be found in Peru's departments? To respond this inquiry, I follow an structural strategy to identify the parameters that represent the relationship between future inflation rates and economic activity (unemployment whether incorporating the NAIRU-Keynesian approach, or GDP gap whether incorporating the neo-Keynesian approach) After the empirical evaluation of the structural models developed in this research, counterproductive results are found, such as the inefficiency of monetary policy to reduce departmental inflation, the increase in departmental unemployment and the decrease in the departmental GDP gap, which are explained by the misalignments of departmental business cycles with national business cycles.

The document, apart from the introduction, is organized into four sections: In section 2 a summary description of the stylized facts of inflation, unemployment and the output gap for Peru's departments is made, assuming the structural relations documented by Aquino (2019) and Barrera (2019). Section 3 presents the development of the structural models of Mendoza Vargas (2022) with unemployment and output gap. Section 4 describes the origin of the data, and the econometric estimation strategy for the Peruvian case and presents the results of the impulse-response functions for unemployment and the output gap in response to innovations in monetary policy. Finally, section 5 concludes with a discussion of the findings, monetary policy lessons, and further research opportunities.

2. Stylized facts of inflation, the output gap and unemployment in Peru's departments

One of the most discussed aspects in the economic literature is the effects of monetary policy on economic activity, which affects inflation, production and unemployment, which is represented by the Phillips curve and its different specifications over time (Phillips, 1958; Lucas, 1972; Clarida, Galí and Gertler, 1999; Reifschneider, Tetlow and Williams, 1999; Atkeson and Ohanian, 2001; Fitzgerald and Nicolini, 2014; Aquino, 2019; Barrera, 2019; Gao, Kulish and Nicolini, 2021)

In the Peruvian case, the monetary authority has adopted explicit inflation targets schemes, EIT, since January 2002. However, referring to Armas *et al.* (2001), the Central Reserve Bank of Peru, BCRP, before adopting the EIT scheme had an announced quantitative inflation target, AQIT, in 1994 as part of the commitments made with the International Monetary Fund, IMF. Both schemes have contributed to controlling the hyperinflation generated because of the first APRA government in the second half of the 1980 decade (Vega, 2018).

Figure 2 shows the evolution of inflation rates at the departmental level, compared to the reference inflation rate for monetary policy that corresponds to that of Metropolitan Lima, from which the following stands out:

- Departmental inflation rates follow the movements of inflation rates that the policymaker takes as a reference for his policy actions, almost in a synchronized manner.
- The cases of the constitutional province of Callao and the department of Lima stand out, whose alignment is exact to the extent that they are oriented by the same inflation rate.
- The departments of Ayacucho, Cajamarca, Huancavelica, Huánuco, Piura, and Puno have an alignment of their inflation rates quite close to the rates corresponding to Metropolitan Lima.
- The departments of Amazonas, Ancash, Apurímac, Cusco, Ica, Lambayeque, Moquegua, Pasco, and Tacna present misalignment in inflation rates for the period 2001 – 2008, and a more aligned behaviour for the period 2009 – 2020.
- The departments with misaligned behaviours for the entire time series are Arequipa, Ica, Junín, La Libertad, Loreto, Madre de Dios, Puno, San Martín, Tumbes, and Ucayali.

Figure 3 shows the evolution of the output gaps for Peru's departments compared to the national gross domestic product, and GDP, as estimated with the Hodrick and Prescott filter (1997). The following features are highlighted below:

- In general terms, the evolution of departmental GDP gaps replicates the approximate movements of the national GDP gap, some simultaneously, in some cases as advances, in other cases as lags, and exceptional cases in a misaligned manner.
- The departments that replicate the movements of the national GDP gap simultaneously are and with an approximate alignment are Ayacucho, the constitutional province of Callao, Cusco, Ica, La Libertad, Lima, Madre de Dios, Piura, Puno, and San Martín.
- The departments that replicate the movements of the national GDP gap as advances are Áncash, Arequipa, Cajamarca, Huancavelica, Junín, Moquegua, and Tacna, coincidentally the departments that accumulate mainly the production and mining reserves of the country.

- The departments that replicate the movements of the national GDP gap with lag are Amazonas, Apurímac, Loreto, and Tumbes.
- The departments that have behaviours quite misaligned with the behaviour of the national GDP gap are Huánuco, Lambayeque, Pasco, Tacna, and Ucayali.

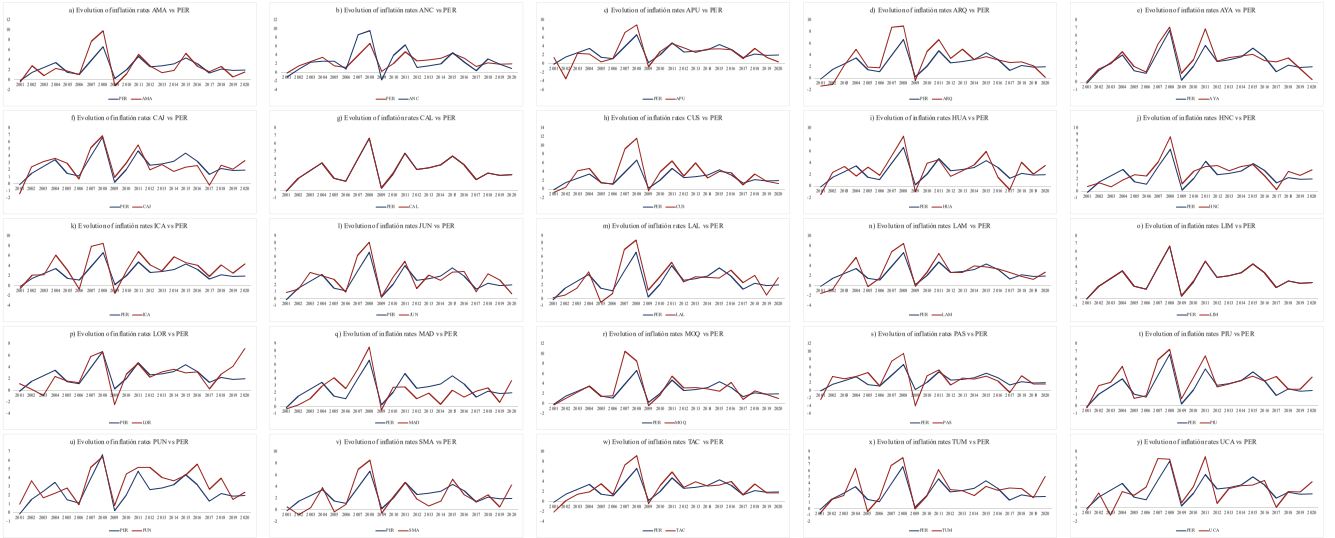
Figure 4 shows the evolution of unemployment rates in Peru's departments compared to the national unemployment rate; from which the following stands out:

- In general terms, unemployment rates replicate the trend movements of the national unemployment rate, with the difference that, for most cases, departmental unemployment is much lower than the national unemployment rate, which is biased by the concentration of the labour market in the department of Lima and the constitutional province of Callao.
- The departments that have unemployment rates like the national unemployment rate are Arequipa, the constitutional province of Callao, Lambayeque, Lima, Moquegua, and Pasco.
- The following departments reach unemployment rates like the national unemployment rate for the period 2008 – 2013 are Ica, Tacna, and Tumbes.
- The departments of La Libertad and Piura have unemployment rates like those of the national ones for the period 2013 – 2020.
- The rest of the department: Amazonas, Áncash, Apurímac, Ayacucho, Cajamarca, Cusco, Huancavelica, Huánuco, Junín, Loreto, Madre de Dios, Puno, San Martín, and Ucayali have unemployment rates well below the national unemployment rate.

The above description highlights possible misalignments of economic cycles in the departments of Peru with the national economic cycle, which is not observed by the monetary authority to implement its policy actions; consequently, possible unobserved effects could be inferred from these actions.

Figure 2

Evolution of the inflation rates of Peru's departments regarding the evolution of Metropolitan Lima's inflation rates for the period 2001 – 2020



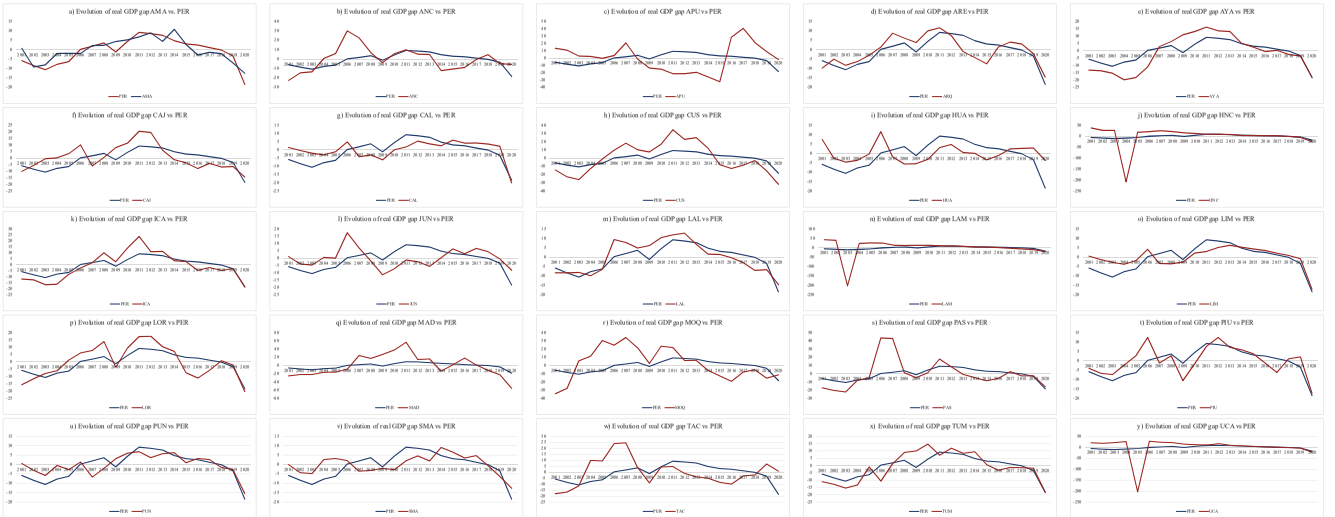
Notes: Although the departmental inflation rates replicate the movements of the Metropolitan Lima's inflation rates, except, in the cases of the constitutional province of Callao and the Lima department, the misalignment of departmental inflation rates is evident.

Source: National Institute of Statistics and Informatics (2021e), Central Reserve Bank of Peru (2021a)

Elaboration: Own.

Figure 3

Evolution of the gross domestic product gaps of Peru's departments regarding the evolution of the national gross domestic product gap for the period 2001 – 2020



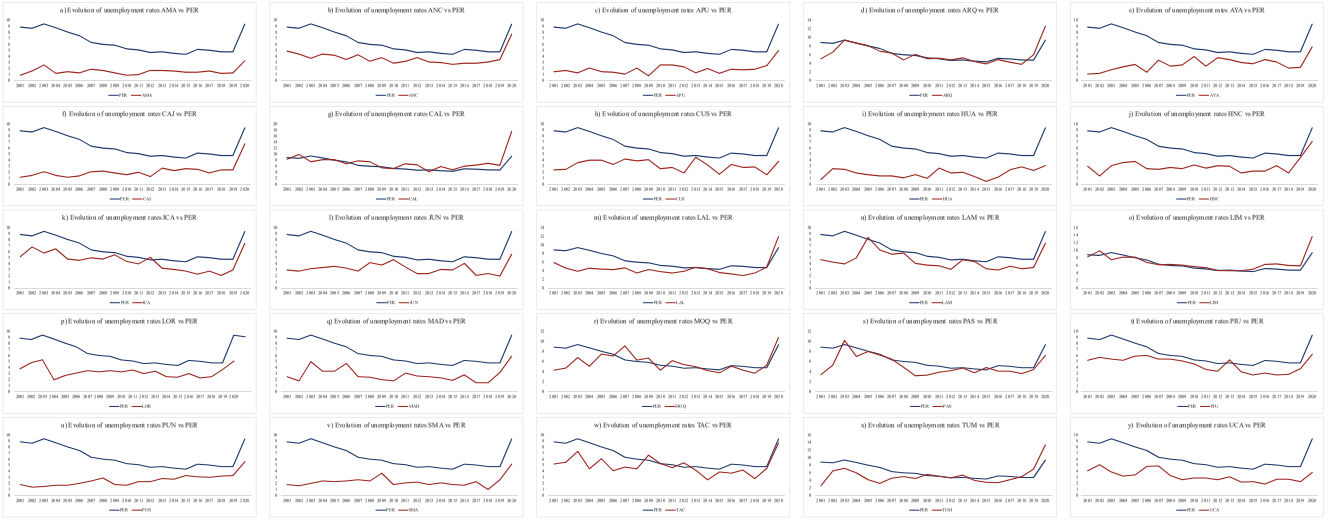
Notes: Gross domestic product gaps have been estimated with the Hodrick and Prescot (1997) filter. An approximate behaviour of the national GDP gap is sketched for Ayacucho, Callao, Cusco, Ica, La Libertad, Lima, Madre de Dios, Piura, Puno, and San Martín. The rest of the departments have misaligned behaviours such as advances, lags, or complete misalignment for the study period.

Source: National Institute of Statistics and Informatics (2021a; 2021b; 2021c).

Elaboration: Own.

Figure 4

Evolution of the unemployment rates of Peru's departments regarding the evolution of the national unemployment rate for the period 2001 – 2020



Notes: The departments that have unemployment rates like the national unemployment rate are Arequipa, the constitutional province of Callao, Lambayeque, Lima, Moquegua, and Pasco; the rest of the departments have lower unemployment rates for the entire study period, or for the first half of the time series.

Source: National Institute of Statistics and Informatics (2021d; 2021e).

Elaboration: Own.

3. Structural models to identify the impact of monetary policy in Peru's departments

It is important to consider that Fisher (1973) documented a strong statistical correlation between the change in employment volume and the change in price levels for the USA in 1926. Phillips subsequently (1958) highlighted a negative statistical correlation between unemployment and the exchange rate in nominal wages in the UK. For their part, Samuelson, and Solow (1960) argued that a sloppy monetary policy which allows inflation to rise can reduce unemployment for several quarters. Lucas (1972) critically highlighted the non-structural relationship between unemployment and inflation, which is strengthened or weakened depending on the parameters that govern monetary policy; concluding that there is no compromise between inflation and unemployment. After many years, Atkeson and Ohanian (2001), using a NAIRU model, demonstrate a negative relationship between unemployment and the growth of future inflation, controlling for monetary policy, changes in the Phillips curve parameters and external shocks that affect this curve. From another point of view, Sims (1992), Clarida, Galí, and Gertler (1999); and Reifschneider, Tetlow, and Williams (1999) developed structural models to identify the relationship between monetary variables, including inflation, unemployment and output.

On the other hand, Fitzgerald and Nicolini (2014), Barrera (2019), and Mendoza Vargas (2022) developed models to estimate regional Phillips curves. By contrast, Aquino (2019), Barrera (2019), and Gao, Kulish and Nicolini (2021) developed non-linear models for Phillips curve.

Following the argument proposed by Mendoza Vargas (2022), a model of structural equations for Peruvian monetary policy is developed that starts from the following assumptions:

- An economy with a single good and input (work) is assumed.
- The economy is organized in *N* very similar geographical areas, with common characteristics:
    - Existence of price friction within each area.
    - The same currency.

- The same legal system.
- The same financial system, etc.
- All economies are closed for labour input, that is, there is no migration.

- All geographical areas are subject to the same monetary policy actions of the single monetary authority, reflected in changes in the real interest rate $r_{j,t}$ because of changes in the reference interest rates d_t.
- It follows that all geographical areas share the same parameters in the following structural equations that correspond to the solution of a NAIRU-Keynesian model without micro foundations (Sims, 1980; Clarida, Galí and Gertler, 1999; Atkeson and Ohanian, 2001) for the *j* scope in terms of their inflation $\pi_{j,t}$, the unemployment rate $u_{j,t}$, and the real interest rate $r_{j,t}$:

$$
\begin{aligned}
\pi_{j,t+1} &= a^1 + b^1\pi_{j,t} + c^1 u_{j,t} + d^1 d_t + \epsilon^{\pi}_{j,t+1} + \xi^{\pi}_{t+1} \\
u_{j,t+1} &= a^2 + b^2\pi_{j,t} + c^2 u_{j,t} + d^2 d_t + \epsilon^{u}_{j,t+1} + \xi^{u}_{t+1} \\
r_{j,t+1} &= a^3 + b^3\pi_{j,t} + c^3 u_{j,t} + d^3 d_t + \epsilon^{r}_{j,t+1} + \xi^{r}_{t+1}
\end{aligned} \tag{1}
$$

From equations system (1) the reader should note that $\epsilon^{m}_{j,t+1}, m \in \{\pi, u, r\}$ represent, respectively, idiosyncratic shocks corresponding to each department in the expectations of inflation, unemployment, and real interest rate. In turn $\xi^{m}_{t+1}, m \in \{\pi, u, r\}$ represent, respectively, stochastic shocks that affect departmental inflation, unemployment, and real interest rate expectations. The properties of the shocks to be white noises are the following:

- $\epsilon^{m}_{j,t+1}$ and $\xi^{m}_{j,t+1}$ are independent and identically distributed for $m \in \{\pi, u, r\}, \forall\, t$.
- $E_{t+1}\left[\epsilon^{m}_{j,t+1}\right] = E_{t+1}\left[\xi^{m}_{j,t+1}\right] = 0, m \in \{\pi, u, r\}$, i.e., they have zero conditional means.

Following the argument proposed by Barrera (2019) for the case of the structural model for Peruvian monetary policy considering a neo-

Keynesian approach with an output gap, the system of equations (1) would be expressed, for this case, as:

$$
\begin{aligned}
\pi_{j,t+1} &= a^1 + b^1\pi_{j,t} + c^1 y_{j,t} + d^1 d_t + \epsilon^{\pi}_{j,t+1} + \xi^{\pi}_{t+1} \\
y_{j,t+1} &= a^2 + b^2\pi_{j,t} + c^2 y_{j,t} + d^2 d_t + \epsilon^{u}_{j,t+1} + \xi^{y}_{t+1} \\
r_{j,t+1} &= a^3 + b^3\pi_{j,t} + c^3 y_{j,t} + d^3 d_t + \epsilon^{r}_{j,t+1} + \xi^{r}_{t+1}
\end{aligned} \tag{2}
$$

Similarly, in equations system (2) $\epsilon^{m}_{j,t+1}, m \in \{\pi, y, r\}$ represent, respectively, idiosyncratic shocks corresponding to each department in inflation expectations, the GDP gap, and the real interest rate. In turn $\xi^{m}_{t+1}, m \in \{\pi, y, r\}$ represent, respectively, stochastic shocks that affect inflation expectations, the GDP gap, and the departmental real interest rate. Likewise, the properties of the shocks to be white noises are the following:

- $\epsilon^{m}_{j,t+1}$ and $\xi^{m}_{j,t+1}$ are independent and identically distributed for $m \in \{\pi, y, r\}, \forall\, t$.
- $E_{t+1}\left[\epsilon^{m}_{j,t+1}\right] = E_{t+1}\left[\xi^{m}_{j,t+1}\right] = 0, m \in \{\pi, y, r\}$, i.e., they have zero conditional means.

In this document, I do not present the derivation of the departmental equilibria for each geographical area in response to the monetary authority's actions because they are detailed extensively in Mendoza Vargas (2022) for the case of the NAIRU-Keynesian structural model and in Barrera (2019) for the case of the neo-Keynesian structural model.

The equation systems (1) and (2), as models with expectations, facilitate the identification of the monetary policy parameters, to the extent that the monetary authority will modify its policy instrument d_t after observing the behaviour of inflation with a lag. This implies that the behaviour of past inflation generates the action of the monetary authority, which is endogenous to the model as explained by Fitzgerald and Nicolini (2014). In turn, the monetary authority actions affect real interest rates in a contemporary way and, at the same time, in a contemporary and lagging way the behaviour of agents through the GDP gap and the inflation rate. It is important to understand that the effect of monetary policy on departmental equilibria depends on the existing alignment of business cycles in each geographical area regarding the national business cycle.

Both equation systems are estimated with a *VAR*(5) for the period 2006 to 2020, which includes 375 observations after adjustment.

1. The impact of monetary policy on Peru's departments

4.1. Source and characteristics of structural system data

To explore the implications of the impact of monetary policy on Peru's departmental equilibria, the following data sources have been considered:

- I used data from the Regional Information System for Decision Making of the National Institute of Statistics and Informatics, INEI (2021e) for the departmental unemployment rates for the period 2001 – 2018, the GDP by departments for the period 2007 – 2020 at prices of the year 2007, the consumer price indices with base 2009 for the period 2009 – 2020 and with base 2007 for the period 2001 – 2008, from which the series was standardized with base 2007 taking into account the annual variation of these indices for each department.

- The series of departmental unemployment rates for the period 2019 – 2020 was complemented by the Microdata base (INEI, 2021c). In the case of the GDP, the series was completed for the period 2001 – 2006 using the current values reported in the publication of National Accounts by departments (INEI, 2013) and converting it to current values of 2007 with the respective CPI.

- The nominal interest rate information comes from the Superintendency of Banking, Insurance and Private Pensions Found, SBS (2021) from which the annual averages for the country were estimated and then transformed into real rates for each department discounting them with the corresponding CPI.

- Information on unemployment rates for the country comes from the INEI (2021b) for the period 2007 – 2020 and the BCRP (2021a) for the period 2001 – 2006. For its part, the information on the national GDP for the period 2001 – 2020 comes from the National Accounts (INEI, 2021a)

- It is also important to mention that departmental and national GDP gaps were estimated using the Hodrick and Prescott (1997) filter.

According to Sims' (1980) critique, the structural systems (1) and (2) require a joint solution, for which I applied Granger's joint causality tests for heterogeneous panel data (Dumitrescu & Hurlin, 2012), documenting the joint dependence for both structural systems. I determined the criteria for the extension of lags through Wald tests for the exclusion of lags in the VARs, finding joint significance up to the fifth lag for both systems. I also applied Jarque-Bera tests of normality for VAR residues where heteroscedasticity is highlighted for Peru's departments in both systems. The summary of this test results is presented in Table 1.

4.2. The impulse-response functions of departmental structural systems to innovations in monetary policy

To understand the impulse-response information presented as follows: the monetary interest rate is denoted *D*01, *P* is the inflation rate, *U* is the unemployment rate, *I* is the interest rate of the financial system, and *Y_GAP*is the GDP gap. Figure 5 shows the cumulative impulse-response functions estimated with a *VAR*(5) for the structural system (1) with departmental unemployment rates, from which the increase in inflation generates the lagging response of the monetary authority through the increase in the reference rate of monetary policy, at the same time, the increase in the monetary policy rate generates an immediate increase in the real active interest rate of Peru's departments, which is sustained for approximately three periods, and then descends to zero after 6 periods. The increase in the monetary policy rate has no immediate effect on the departmental inflation rate, which would be explained by the misalignment of departmental rates from Metropolitan Lima rates. Only after three periods, the departmental inflation rate shows a slight decrease, which lasts two periods. At the same time, the increase in the monetary policy rate does not have an immediate effect on the unemployment rates of the departments of Peru, however, in the third period, departmental unemployment increases, and the impact is maintained until the sixth period.

Table 1

Summary of VAR tests analysis

Criteria 1: VAR Granger Causality | Block Exogeneity Wald Test

Equation System (1)					Equation System (2)				
Dependent Variable	Excluded Variable	Chi-sq	df	Prob	Dependent Variable	Excluded Variable	Chi-sq	df	Prob
D01	P	7012.85	5	0.0000	D01	P	17441.04	5	0.0000
D01	U	10.35	5	0.0659	D01	Y_GAP	20.73443	5	0.0009
D01	I	10531.09	5	0.0000	D01	I	34994.93	5	0.0000
D01	All	13245.76	15	0.0000	D01	All	83598.16	15	0.0000

Criteria 2: Lag Exclusion Wald Tests

Equation System (1)

		D01	P	U	I	Joint
Lag 1	Chi-sq	12.9353	3.5201	38.4997	2.4214	138.1562
	Prob.	[0.011596]	[0.474835]	[8.84e-08]	[0.658762]	[0.000000]
Lag 2	Chi-sq	3926.3230	10.8423	4.2434	25.9783	4007.3880
	Prob.	[0.000000]	[0.028394]	[0.374062]	[3.20e-05]	[0.000000]
Lag 3	Chi-sq	2799.7120	7.9777	0.8310	0.4124	3084.1150
	Prob.	[0.000000]	[0.092397]	[0.934248]	[0.981449]	[0.000000]
Lag 4	Chi-sq	4703.9590	4.5708	1.0842	22.8677	5416.9840
	Prob.	[0.000000]	[0.334238]	[0.896768]	[0.000135]	[0.000000]
Lag 5	Chi-sq	393.8979	4.5157	3.8677	5.2258	481.8259
	Prob.	[0.000000]	[0.340691]	[0.424207]	[0.264904]	[0.000000]
df		4	4	4	4	16

Equation System (2)

		D01	P	Y_GAP	I	Joint
Lag 1	Chi-sq	539.8281	1.5819	52.5756	1.8498	748.5979
	Prob.	[0.000000]	[0.812046]	[1.05e-10]	[0.763354]	[0.000000]
Lag 2	Chi-sq	183172.7000	8.8813	3.3359	20.3031	241498.6000
	Prob.	[0.000000]	[0.064135]	[0.503260]	[0.000435]	[0.000000]
Lag 3	Chi-sq	114.7971	2.1518	5.3500	3.3622	178.9983
	Prob.	[0.000000]	[0.707864]	[0.253236]	[0.499133]	[0.000000]
Lag 4	Chi-sq	91224.0400	7.1907	6.6328	15.0493	127979.0000
	Prob.	[0.000000]	[0.126148]	[0.156613]	[0.004600]	[0.000000]
Lag 5	Chi-sq	967.7876	3.9986	7.1571	6.2834	1086.5740
	Prob.	[0.000000]	[0.406189]	[0.127814]	[0.178960]	[0.000000]
df		4	4	4	4	16

Criteria 3: VAR Residual Normality Test | Orthogonalization Cholesky (Lutkepohl)

Equation System (1)

Component	Jarque-Bera	df	Prob.
1	81.3994	2	0.0000
2	33.8089	2	0.0000
3	1421.8860	2	0.0000
4	2588.7540	2	0.0000
Joint	4125.8480	8	0.0000

Equation System (2)

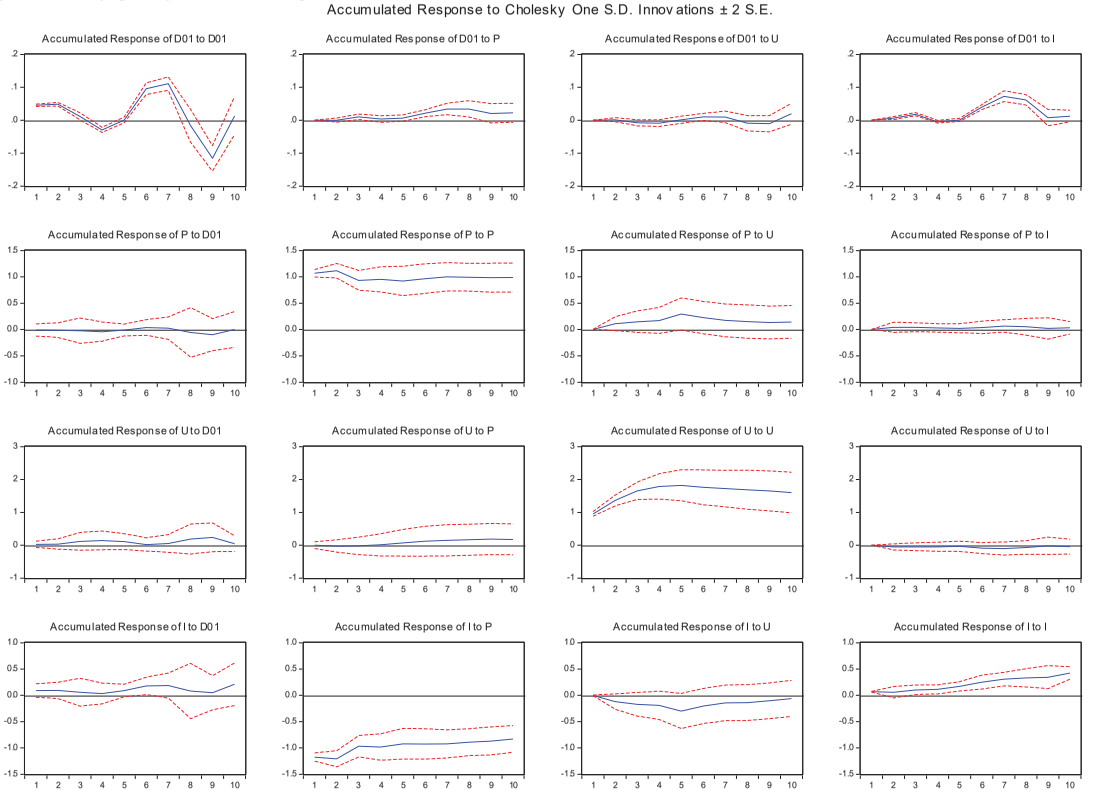
Component	Jarque-Bera	df	Prob.
1	183.9785	2	0.0000
2	39.3777	2	0.0000
3	735.8265	2	0.0000
4	1628.6650	2	0.0000
Joint	2587.8480	8	0.0000

Notes: The table below is organised in three sections. Section 1 shows Granger's joint causality tests results for heterogeneous panel data (Dumitrescu & Hurlin, 2012). Section 2 shows Wald tests results for the exclusion of lags in the VARs. Section 3 shows Jarque-Bera tests of normality for VAR residues. In each section the test results are divided into two equation systems.

Figure 6 highlights the cumulative impulse-response functions estimated with a *VARS*(5) for the structural system (2) with departmental GDP gaps, from which it is confirmed, again, that the increase in inflation generates the lagging response of the monetary authority through the increase in the reference rate of monetary policy. Like the previous case, the increase in the monetary policy rate generates a slight immediate increase in the real active interest rate of the departments of Peru, which is sustained over time. Unlike the previous model, the increase in the monetary policy rate does not affect the departmental inflation rate, exposing the inefficiency of monetary policy. Counterproductively, the increase in the monetary policy rate harms the departmental GDP gap that is sustained over time.

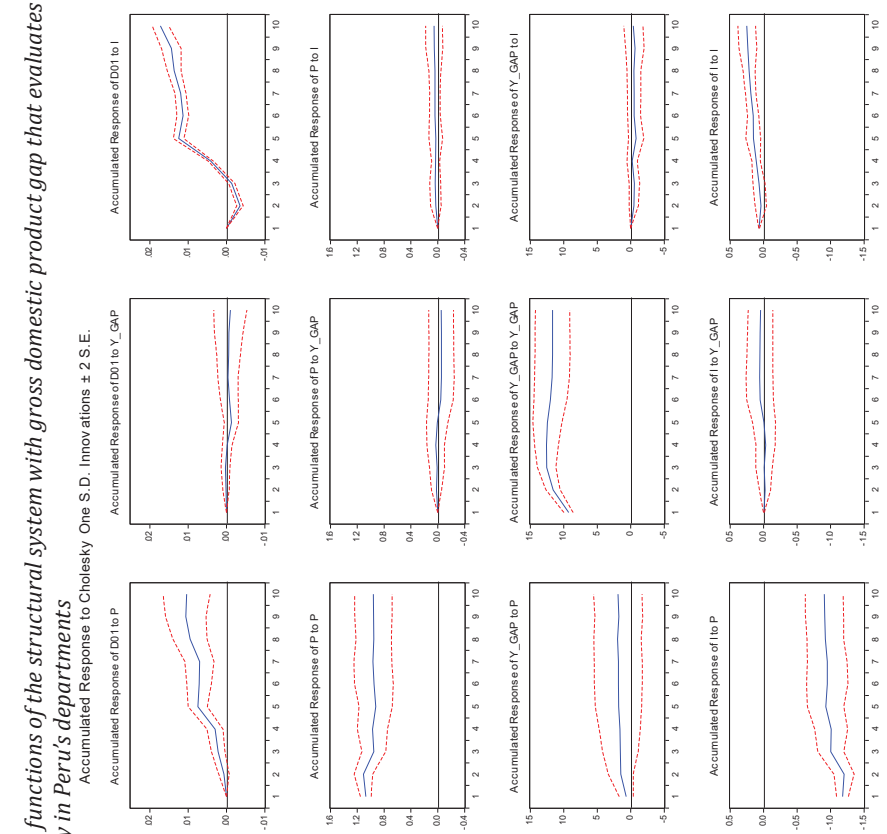
Figure 5

Cumulative impulse-response functions of the structural system with unemployment that evaluates the impact of monetary policy in Peru's department



Elaboration: Own.

Figure 6
Cumulative impulse-response functions of the structural system with gross domestic product gap that evaluates the impact of monetary policy in Peru's departments



Elaboration: Own.

2. Discussion

By way of conclusion, the stylized facts about inflation, unemployment and the GDP gap of Peru's departments exposed in this document reveal, at the descriptive level, the conjecture of Mendoza Vargas (2022) related to the misalignment of departmental economic cycles with the national economic cycle, a condition that would represent limitations for efficiency of monetary policy.

To evaluate the impact of monetary policy in the Peru's departments I developed two structural models: The first with a NAIRU-Keynesian approach that follows Fitzgerald and Nicolini's (2014) line of thought for the case of the USA and Mendoza Vargas' (2022) for the case of Peru's departments, which takes into account the impact of monetary policy considering departmental unemployment. The second model follows Barrera's Neo-Keynesian approach (2019) to the Peruvian case, which measures the impact of monetary policy by considering the departmental GDP gaps.

The research finds counterproductive results on the impact of monetary policy in Peru's departments: The ineffectiveness of monetary policy in reducing departmental inflation. This could be explained by the low response of the real active interest rate in the departments, which is determined by additional criteria of the banking itself, such as the incremental risk of the Peru's departments to Metropolitan Lima, which is not reflected in the SBS's statistics, which publishes national averages, but not departmental averages and which the exercise of finding real rates shows in a certain way. The increase in the monetary policy rate generates an increase in departmental unemployment rates, confirming the hypothesis of Fitzgerald and Nicolini (2014) of the existence of a stable relationship between inflation and unemployment in the departments, explored at the level of partial equilibrium with the departmental Phillips curves by Mendoza Vargas (2022). Likewise, the increase in the monetary policy rate generates a decrease in the departmental GDP gap, which is counterproductive regarding the theoretical framework of the Peruvian economy (Winkelried, 2013; Gutiérrez and Pérez, 2018; Aquino, 2019; Barrera, 2019) and rejecting Lucas' (1972) hypothesis for the case of Peru's departments.

As lines of future research, the following aspects stand out: Improving information regarding real interest rates in the Peru's departments is a commendable task for the SBS to collect information from banks and report it at departmental level. The publication of departmental series on inflation expectations through BCRP (2021) Data, with the purpose of including this variable in the modelling of the monetary policy system, is crucial to improve the impact assessment models of monetary policy at the departmental level. The need to study departmental economic cycles using more frequent data (quarterly or monthly) represents an important line of research, but that has its challenges, such as the most expeditious publication of this information by the National Institute of Statistics and Informatics. The misalignment of departmental economic cycles represents a challenge for the Central Reserve Bank of Peru in terms of evaluating the efficiency of monetary policy and considering more decentralized interventions.

One specific line for further research is related to the idiosyncrasy of the Peruvian case. Despite what the theory says, the Peruvian unemployment rate is one of the lowest in the Latin American region and that is because there is a high percentage of workers who are in vulnerable jobs or are self-employed. The Philips curve usually is true when inflation (or growth) creates new jobs that the unemployed can take and thus unemployment falls. What happens in the context that people are already in jobs (self-employment) when a growth shock comes? The change will not be seen in the unemployment rate, but in the underemployment rate. Nevertheless, underemployment has relation with informal productive activities, which are not considered in official output statistics. About this point, the National Institute of Statistics and Informatics (2022) is publishing informal production stats using national home surveys as a methodology of approximation. Consequently, the development of monetary models incorporating the informal sector is a necessary evolution step to make.

References

Aquino, J. C. (2019, diciembre). La curva de Phillips Neokeynesiana de una economía pequeña y abierta: Especificaciones, quiebres estructurales y robustez. *Revista de Estudios Económicos*(38), 43-59. Retrieved from www.bcrp.gob.pe/publicaciones/revista-estudios-economicos.html

Armas, A., Grippa, F., Quispe Misaico, Z., & Valdivia, L. (2001). De metas monetarias a metas de inflación en una economía con dolarización: el caso peruano. *Estudios Económicos*(2), 1-50. Retrieved from https://www.bcrp.gob.pe/docs/Publicaciones/Revista-Estudios-Economicos/07/Estudios-Economicos-7-2.pdf

Atkeson, A., & Ohanian, L. E. (2001). Are Phillips Curves Useful for Forecasting Inflation? *Quartery Review, 25*(1), 2-11. Retrieved from https://www.minneapolisfed.org/research/quarterly-review/are-phillips-curves-useful-for-forecasting-inflation

Banco Central de Reserva del Perú. (2021, diciembre 16). *BCRP Data*. Retrieved from Banco Central de Reserva del Perú: https://estadisticas.bcrp.gob.pe/estadisticas/series/

Barrera, C. (2019, Diciembre). ¿Existe un tramo horizontal en la curva de Phillips? Perú 2005-2017. *Estudios Económicos*(38), 61-80. Retrieved from www.bcrp.gob.pe/publicaciones/revista-estudios-economicos.html

Clarida, R., Galí, J., & Gertler, M. (1999, December). The Science of Monetary Policy: A Ney Keynesian Perspective. *Journal of Economic Literature, XXXVII*, 1661-1707. Retrieved from https://www.crei.cat/wp-content/uploads/users/pages/cggsci~1.pdf

Dumitrescu, E.-I., & Hurlin, C. (2012, July). Testing for Granger non-causality in heterogeneous panels. *Economic Modelling, 29*(4), 1450-1460. doi:https://doi.org/10.1016/j.econmod.2012.02.014

Fisher, I. (1973, March-April). I Discover the Phillips Curve: A Statistical Relation between Unemployment and Price Changes. *Journal of Political Economy, 81*(2), 496-502. doi: https://www.jstor.org/stable/1830534

Fitzgerald, T. J., & Nicolini, J. P. (2014). *Is There a Stable Relationship between Unemployment and Future Inflation? Evidence from U.S. Cities.* Minneapolis: Federal Reserve Bank of Minneapolis.

Gao, H., Kulish, M., & Nicolini, J. P. (2021). Two Illustrations of the Quantity Theory of Money Reloaded. *Staff Report*(633), 1-49. Retrieved from https://www.minneapolisfed.org/research/sr/sr633.pdf

Gutiérrez, A. P., & Pérez, F. (2018). Choque agregados y sectoriales en la economía peruana. *Revista Estudios Económicos*(35), 29-45. Retrieved from https://www.bcrp.gob.pe/docs/Publicaciones/Revista-Estudios-Economicos/35/ree-35-perez-gutierrez.pdf

Hodrick, R. J., & Prescott, E. C. (1997, February). Postwar U.S. Business Cycles: An Empirical Investigation. *Journal of Money, Credit and Banking, 29*(1), 1-16. Retrieved from http://www.jstor.org/stable/2953682

Instituto Nacional de Estadística e Informática. (2013). *Producto Bruto Interno por Departamentos 2001 - 2012.* Jesús María: Instituto Nacional de Estadística e Informática.

Instituto Nacional de Estadística e Informática. (2021, octubre 15). *Cuentas Nacionales*. Retrieved from Instituto Nacional de Estadística e Informática: https://www.inei.gob.pe/estadisticas/indice-tematico/national-accounts/

Instituto Nacional de Estadística e Informática. (2021, diciembre 15). *Empleo*. Retrieved from Instituto Nacional de Estadística e Informática: https://www.inei.gob.pe/estadisticas/indice-tematico/ocupacion-y-vivienda/

Instituto Nacional de Estadística e Informática. (2021, Abril 19). *Microdatos: Base de datos*. Retrieved Abril 5, 2020, from Encuesta Nacional de Hogares y Condiciones de Vida: http://iinei.inei.gob.pe/microdatos/

Instituto Nacional de Estadística e Informática. (2021, octubre 15). *Sistema de Información Regional para la Toma de Decisiones*. Retrieved from Instituto Nacional de Estadística e Informática: https://systems.inei.gob.pe/SIRTOD/

Instituto Nacional de Estadística e Informática. (2022). *Producción y empleo informal en el Perú: Cuenta Satelite de la Economía Informal 2007 - 2021.* Jesús María: Instituto Nacional de Estadística e Informática. Retrieved from https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1878/libro.pdf

Lucas, R. E. (1972, April). Expectations and the neutrality of money. *Journal of Economic Theory, 4*(2), 103-124. doi: https://doi.org/10.1016/0022-0531(72)90142-1

Mendoza Vargas, O. M. (2022). *Unobserved Effects of Monetary Policy in Peru's Departments.* Cercado de Lima: Universidad Nacional Mayor de San Marcos.

Phillips, A. W. (1958, Novembere). The relation between unemployment and the rate of change of money wage rates in the United Kingdom, 1961 - 1957. *Economica*, 283-299. doi: https://doi.org/10.1111/j.1468-0335.1958.tb00003.x

Reifschneider, D., Tetlow, R., & Williams, J. (1999, January). Aggregative Disturbances, Monetary Policy and the Macroeconomy. *Federal Reserve Bulletin*, 1-19. Retrieved from https://www.federalreserve.gov/pubs/bulletin/1999/0199lead.pdf

Samuelson, P. A., & Solow, R. M. (1960, May). Analytical Aspects of Anti-Inflation Policy. *American Economic Review, 50*(2), 177-194. Retrieved from https://www.jstor.org/stable/1815021

Sims, C. A. (1980, January). Macroeconomics and Reality. *Econometrica, 48*(1), 1-48. Retrieved from http://links.jstor.org/sici?sici=0012-9682%28198001%2948%3A1%3C1%3AMAR%3E2.0.CO%3B2-A

Sims, C. A. (1992). Interpreting the macroeconomic time series facts: The effects of monetary policy. *European Economic Review* (36), 975-1011.

Superintendencia de Banca, Seguros y AFP. (2021, setiembre 15). *Estadísticas del Sistema Financiero*. Retrieved from Superintendencia de Banca, Seguros y AFP: https://www.sbs.gob.pe/estadisticas-y-publicaciones/estadisticas-/sistema-financiero_

Vega, M. (2018, marzo). El esquema de metas de inflación y la inflación peruana. *Moneda*(173), 4-8. Retrieved from https://www.bcrp.gob.pe/docs/Publicaciones/Revista-Moneda/moneda-173/moneda-173-01.pdf

Winkelried, D. (2013, Diciembre). Modeo de Proyección Trimestral del BCRP: Actualización y novedades. *Revista Estudios Económicos*(26), 9-60. Retrieved from https://www.bcrp.gob.pe/docs/Publicaciones/Revista-Estudios-Economicos/26/ree-26-winkelried.pdf

Notas al final

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