Writing Sample

Does Service-Oriented Economy Contribute to Flattening the Phillips Curve?

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Abstract

This study aims to explore the global phenomenon of the Phillips Curve flattening and to investigate whether more service-oriented countries exhibit a flatter or steeper slope of the Phillips Curve. By utilizing quarterly data from 57 countries spanning from Q1 1998 to Q4 2022, this research re-examines the Phillips Curve flattening using the New Keynesian Phillips Curve (NKPC) model. We verify the trend of slope through expanding window regression and by comparing changes in the slope across two distinct periods. Employing the Employment in Services as a variable to represent services, the study utilizes OLS regression methods to assess if the Employment in Services will affect the Phillips Curve slope. We have found that the slope of the Phillips Curve has indeed declined, suggesting a decreased sensitivity of inflation to the output gap compared to the past. However, this study has not conclusively confirmed whether this decline is attributable to the expansion in the Services.

Keywords: *New Keynesian Phillips Curve; Expanding Window Regression;*

1. Introduction

The Phillips Curve, integral to the New Keynesian macroeconomic model, portrays the relationship between unemployment rates and inflation. Initially, Phillips noted a

negative correlation between the unemployment rate and nominal wage growth in the United Kingdom. It's widely recognized that the inflation rate is roughly the sum of nominal wage growth and long-term productivity growth. Therefore, the observed negative correlation between the unemployment rate and nominal wage growth implies a similar relationship with inflation (Gordon [2011]). As the concept of the Phillips Curve evolved, it became commonly viewed as a representation of the relationship between aggregate economic activity and inflation. The discourse has branched into various directions, including exploring statistical relationships between unemployment or output and future inflation (or its changes) and examining economic structural relationships that illustrate the synchronous adjustments between real economic activities and inflation rates (Stock and Watson [1999]). This paper concentrates on the former, scrutinizing the relationship between the output gap and inflation.

During the Great Depression, the United States encountered severe deflation, with annual inflation rates declining by over 10% starting in 1932. Japan, too, faced a prolonged deflationary period from the early 1990s after the collapse of its real estate and stock market bubbles until the mid-2000s. However, following the 2008 financial crisis, many advanced economies experienced "Missing Disinflation", a phenomenon where despite rising unemployment rates, the corresponding decrease in inflation rates was less pronounced than expected. According to the Phillips Curve, the inflation rate during high unemployment periods should be lower, yet the actual inflation rate remained relatively stable, averaging around 1-2%, leading scholars to question the Phillips Curve's reliability (Gordon [2013]). However, regarding the concept of missing disinflation, some papers hold divergent views. Hazell et al. [2022], for instance, argues that the sharp decline in core inflation during the early 1980s was primarily due to changing expectations about long-term monetary policy, rather than being a result of a steep Phillips curve. Additionally, the increased stability of inflation from 1990 to 2020 is attributed chiefly to the more firmly anchored long-term inflation expectations.

Apart from this "Missing Disinflation" during the financial crisis, the Phillips Curve's most notable failure occurred during the 1970s oil crisis, characterized by stagflation – simultaneous high inflation and unemployment rates. The Federal Reserve's response, raising the federal funds rate to control inflation, precipitated the economic recession of 1981. Economist Milton Friedman critiqued the Phillips Curve for neglecting the public's anticipatory psychology and overlooking the long-term labor supply's ability to adjust prices. Friedman advocated for rational expectations, proposing that the Phillips Curve should be vertical over time, indicating a lack of trade-off.

However, Barnes and Olivei observed that by the early 1990s, the consensus was that as long as supply-side shocks were controlled, the Phillips Curve maintained a stable trade-off and continued to be applied in various macroeconomic models for policy analysis (Barnes and Olivei [2003]). The flattening of the Phillips Curve brings both positive and negative implications. If monetary policy is geared towards price stability,

such flattening not only maintains low and stable inflation levels but also helps anchor inflation expectations, thereby mitigating the impact of external shocks on inflation (Mishkin [2007]). Conversely, if the correlation between inflation and the unemployment or output gap weakens, the effectiveness of government and central bank interventions in the economy through monetary and fiscal policies might be reduced.

The literature identifies two primary factors for the flattening of the Phillips Curve: the anchoring of long-term inflation expectations (Bernanke et al. [2007]) and changes in firms' price-setting behavior (Kuttner and Robinson [2010]). Heightened global competition, coupled with increased international trade and investment activities, as well as rising labor mobility, have constrained firms' ability to raise prices in response to domestic demand growth. This has subsequently diminished the responsiveness of goods and service prices to domestic demand (Iakova [2007]), rendering inflation less reactive.

Peach et al. [2013] highlighted the importance of separately modeling inflation for goods and services. Their research found that the unemployment gap exerts minimal influence on core goods inflation but significantly impacts core services inflation. Del Negro et al. [2020] also reported a heterogeneous decline in the sensitivity of inflation to the business cycle across different goods and services. Thus, this study proposes using Services as a research parameter, in alignment with one of the identified reasons for the Phillips Curve flattening: a shift in price-setting behavior.

This study operates under the assumption that the Keynesian Phillips Curve governs the true data-generating process. This framework will be employed to investigate whether the Phillips Curve in various countries demonstrates a trend toward flattening. Additionally, the study aims to ascertain if the slope of the Phillips Curve in each country correlates with Services.

2. Methodology

2.1. New Keynesian Phillips curve

We calculate the slope through the Reduced form of the New Keynesian Phillips Curve from macroeconomic textbooks, specifically the versions by Woodford and Walsh [2005] and Galí [2015], using the output gap as an estimator to forecast the inflation rate:

$$\pi_t = c + \beta E_t \pi_{t+1} + \kappa x_t + v_t \tag{1}$$

In this framework, inflation, denoted as π_t, is influenced by three primary factors: firstly, expected future inflation, symbolized as $E_t\pi_{t+1}$; secondly, the output gap x_t, which in this context is measured by the deviation of real GDP from its trend component; and thirdly, cost-push shocks, represented by v_t. The parameter κ, which denotes the slope of the Phillips curve, reflects the degree to which inflation is responsive to changes

in the output gap.

2.2. Measurement of Variables

The data collection period for this study spans from 1998 to 2022 for 57 countries, and the data sources for this study are as follows:

Item	Source	Frequency
Real GDP	IMF	Quarterly
CPI	World Bank	Quarterly
Employment in Services (% of total employment)	World Bank	Annually

Table 1. Data Sources

In this paper, the method for calculating the inflation rate π_t is defined as follows:

$$\pi_t = 100 \times \frac{P_t - P_{t-4}}{P_{t-4}} \tag{2}$$

Here, P_t represents the Consumer Price Index (CPI) at time t, and P_{t-4} denotes the CPI from four quarters prior. Therefore, the inflation rate P_t is calculated as the quarter-over-quarter growth rate of the CPI.

$E_t\pi_{t+1}$, is derived by referencing Ball and Mazumder [2011], Coibion and Gorodnichenko [2015], and Höynck [2020], using the backward-looking method, by calculating the arithmetic average of inflation rates over the previous four quarters as the expected inflation rate, expressed as follows:

$$E_t\pi_{t+1} = \frac{1}{4}(\pi_{t-1} + \pi_{t-2} + \pi_{t-3} + \pi_{t-4}). \tag{3}$$

The output gap is estimated by the Hodrick-Prescott (HP) filter Hodrick and Prescott [1997]. HP filter is a trend-cycle decomposition method, and it sets the potential component of output to minimize the loss function, L,

$$L = \sum_{t=1}^{T}(y_t - \tilde{y}_t)^2 + \lambda \sum_{t=2}^{T}(\Delta\tilde{y}_t - \Delta\tilde{y}_{t-1})^2 \tag{4}$$

The trend component $\tilde{y}_t$ is meant to capture the long-run growth of y_t and the residual $y_t - \tilde{y}_t$ is often taken to represent a business cycle component, which is the output gap of real GDP in this case. The parameter λ can be interpreted as the noise-to-signal ratio under specific restrictive conditions. These conditions include the assumption that the cyclical components and the differences of the trend components are identically and

independently distributed. Based on standard practice in the literature, setting λ to 1600 in quarterly data is recommended. Notice that the variables are transformed by logarithm.

2.3. Methods for Investigating the Flattening of the Phillips Curve

Following the completion of data collection and transformation, our objective is to examine the phenomenon of flattening in the Phillips Curve across 57 countries from 1998 to 2022. We employ two distinct methods for this analysis:

2.3.1. Aggregate Data Analysis

The data are divided into two periods: from the first quarter of 1998 to the fourth quarter of 2009, and from the first quarter of 2010 to the fourth quarter of 2022. In each time segment, we conduct OLS linear regression analyses within the framework of the New Keynesian Phillips Curve (NKPC), observing aggregate changes in the κ parameter during these two periods.

In this approach, we merge data from all countries into a single column for an OLS linear regression analysis. We will obtain κ_1 and κ_2, where 1 and 2 denote time periods 1 and 2, respectively. If $\kappa_2 - \kappa_1 < 0$, then we can conclude that the Phillips curve for that country exhibits a downward trend."This approach aims to determine whether there is a global trend of decreasing the slope of the Phillips curve on average.

2.3.2. Expanding Window Regression

Initially, a regression analysis is conducted on data up to the first quarter of 2011. Then, we sequentially add data for each quarter to the regression analysis. This expanding window regression approach aids in understanding how the relationship between the output gap (x_t) and inflation rate (π_t) evolves over time.

These methodologies collectively provide a comprehensive assessment of the trend in the flattening of the Phillips Curve across various countries and time periods.

2.4. Relationship Between the Phillips Curve Slope and Services

We proceed to explore the association between the slope of the Phillips Curve, denoted as κ, and the Services from 1998 to 2022, Services refer to a broad category of economic activities that do not result in the production of physical goods. This investigation employs the variable: 'Employment in Services', to assess the correlation with κ. The hypothesized relationship is expressed as:

$$\kappa_k = \alpha + \gamma \times X_k^{Serv} + \epsilon \tag{5}$$

Here, κ signifies the slope of the Phillips curve for k countries, reflecting the degree to which inflation responds to changes in the output gap. In this context, Kappa is a k by 1 matrix. γ illustrates the impact of Services on κ, while X_k^{Serv}, representing Employment in Services, is also a k by 1 matrix. It is noteworthy that due to data availability constraints, our analysis is confined to annually collected X_k^{Serv} data. Consequently, in aligning with the k by 1 dimension of κ, we utilize the averages of Employment in Services from 1998 to 2022. The term *epsilon* denotes the residual, capturing the unexplained or unobservable factor by the model.

Therefore, this model fundamentally seeks to elucidate how indicators of Services in k countries influence the slope of the Phillips Curve. Specifically, it investigates whether nations with higher averages in Employment in Services tend to exhibit a flatter Phillips Curve, indicative of a smaller κ.

3. Results

In this section, we divide our analysis into two distinct parts. The first part discusses the flattening of the Phillips Curve across various countries. The second part examines the relationship between the slope of the Phillips Curve and the Services sector.

3.1. Is Phillips Curve Flattening?

3.1.1. Average Decline in the Slope of the Phillips Curve

Table 2 and Table 3 display the regression results of global aggregate panel data spanning from 1998 to 2009 and from 2010 to 2022. A comparison of the κ across these two time periods reveals that the global slope of the Phillips Curve has, on average, indeed decreased from 0.199 to 0.180.

Variable	**1998-2009 Estimate**	**2010-2022 Estimate**
Constant	0.693	0.405
	(0.114)	(0.090)
κ	0.199	0.180
	(0.045)	(0.031)
β	0.814	1.009
	(0.001)	(0.015)

Table 2. Estimated Coefficients for the Periods 1998-2009 and 2010-2022

Statistic	1998-2009	2010-2022
Number of Observations	2736	2736
Error Degrees of Freedom	2733	2733
Root Mean Squared Error	5.23	4.12
R-squared	0.709	0.637
Adjusted R-squared	0.709	0.636

Table 3. Additional Statistical Details for the Periods 1998-2009 and 2010-2022

3.1.2. Expanding window regression on NKPC

Figure 1 shows the results of an Expanding Window Regression, where data was added on a quarterly basis beginning from 2011Q1, followed by regression analysis. Notably, this graph only includes countries with statistically significant κ. From an initial group of 57 countries, countries with insignificant statistics were excluded, resulting in 39 lines in the chart, each representing one of the 39 countries included in the analysis.

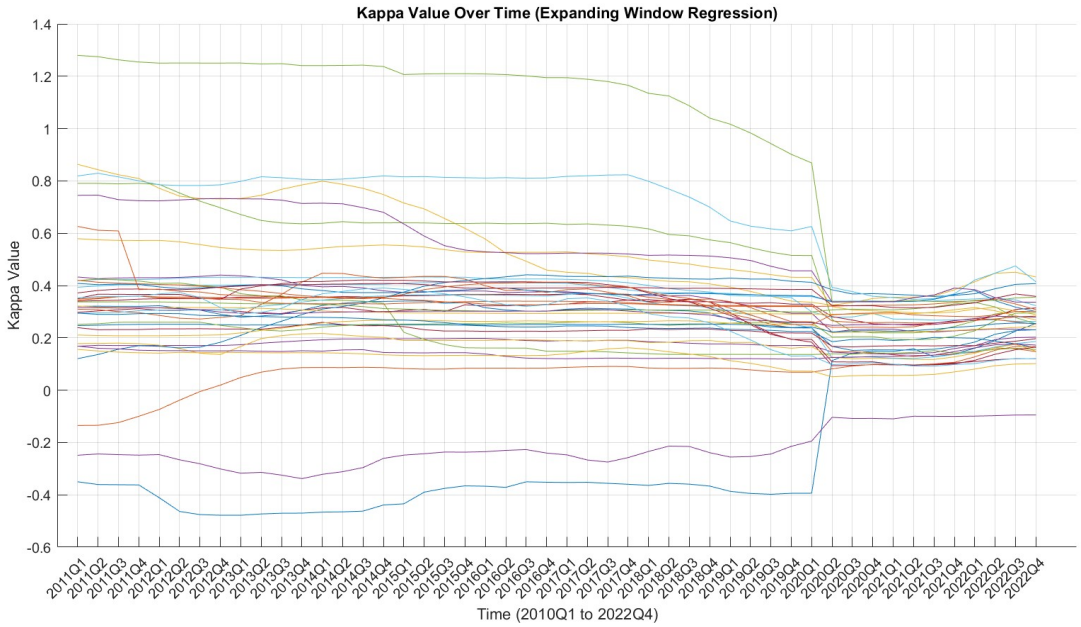

Figure 1. Kappa Value Over Time

In Figure 2, we observe that most of the 39 countries exhibit a positive κ, aligning with theoretical expectations. Furthermore, a gradual decline in κ values is noticeable quarter by quarter. For the three countries exhibiting negative κ, their slopes' absolute values converge toward zero, indicating a weakening relationship between the output gap and inflation.

Notably, between 2020Q1 and 2020Q2, there was a significant convergence in κ.

Upon reviewing the data, it was found that during this period, real GDP significantly declined. Consequently, after applying the HP filter, the cycle component, i.e., the output gap, displayed more pronounced negative values than in previous periods, while the inflation rate and expected inflation rate remained relatively steady. The following figure presents a simultaneous display of the output gap and inflation rate, corroborating these observations. This suggests that the output gap slump in 2021Q1 was not reflected in the inflation rate.

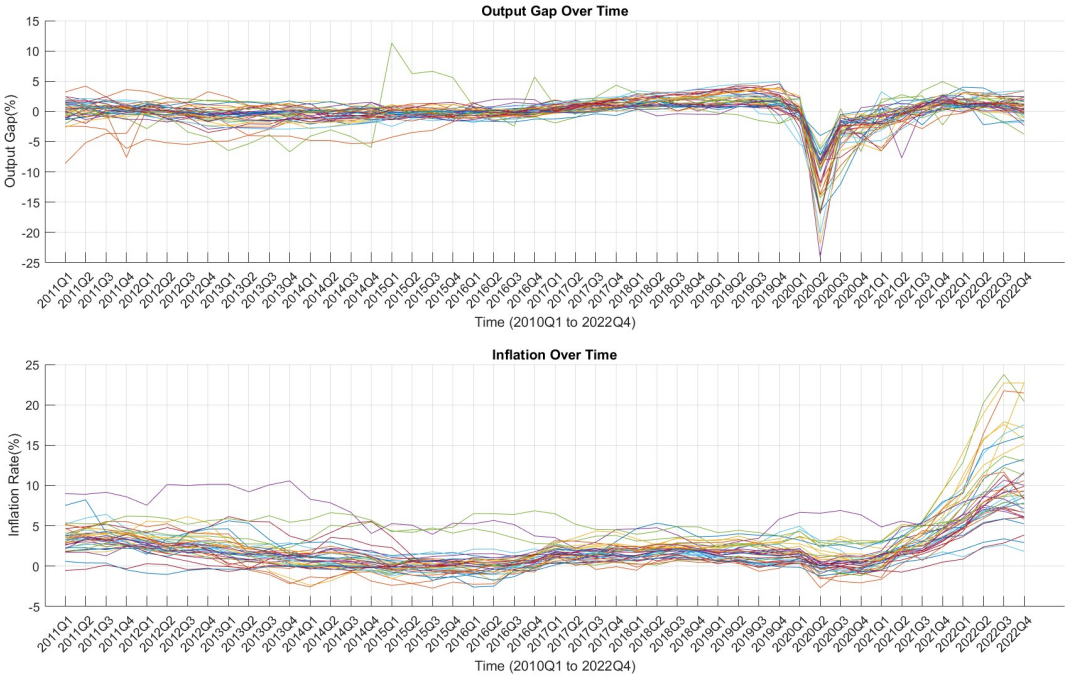

Figure 2. We can notice that there was a negative oscillation in the output gap during 2020, while the inflation remained stable

In the appendix section of the document, a comprehensive table is presented, showcasing the regression results of 57 countries under the New Keynesian Phillips Curve (NKPC) framework. The standard errors have been adjusted using the Newey-West method. Additionally, we highlight the five countries with the highest κ, the κ of the top 5 largest economies, and those countries that exhibited negative κ to inspect if there is some unique pattern of the slope of the Phillips curve.

Country	κ
United States	0.336 ***
China	0.263 ***
Germany	0.163 ***
Japan	0.197 ***
India	-0.095 **

Table 4. Slope of Phillips Curve of G5

Country	κ
Romania	0.830 *
Indonesia	0.727 **
Bulgaria	0.433 **
Poland	0.414 ***
Korea	0.407 ***

Table 5. The Highest Value of Slope in the 57 Countries

Country	κ
India	-0.095 **
Mexico	-0.014
New Zealand	-0.019
Serbia	-0.429
Turkey	-0.037

Table 6. Negative Value of Slope in the 57 Countries

In Table 5 we can notice that the countries that possess steeper slopes are mostly developing countries and we note that the majority of countries with negative values have slopes that are not statistically significant in Table 6. The standard errors are calculated by the Newy-West Method. ***, **, and * respectively indicate significance at the 1%, 5%, and 10% levels.

3.2. Is the Flattening Slope Related to Services?

In this section, we illustrate through a scatter plot the relationship between the average Employment in Services across countries and their respective Phillips curve slopes, κ. Upon observing Figure 3, we find no discernible trends, suggesting an absence of a significant correlation between Employment in Services and the slope of the Phillips Curve.

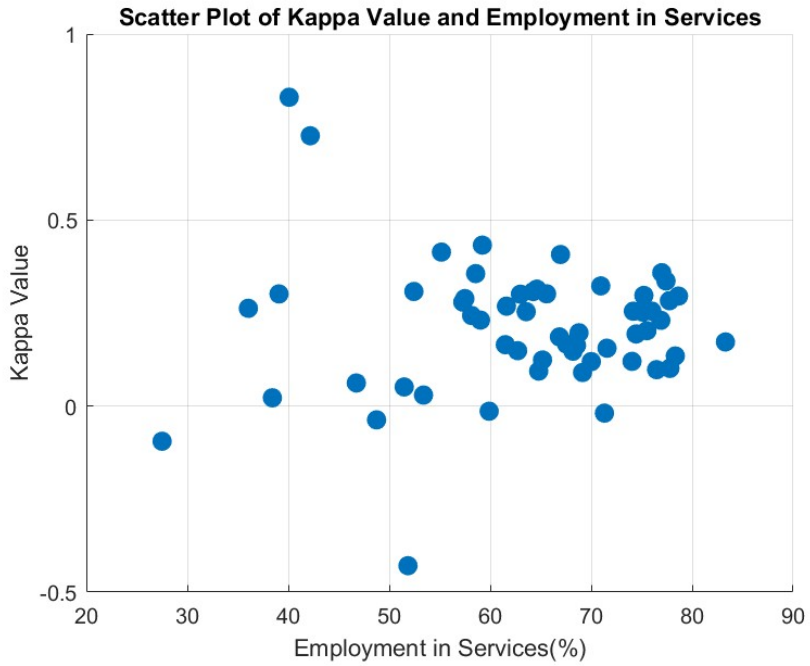

Figure 3. This figure displays the distribution of 57 countries' Employment in Services with respect to κ

In the NKPC equation of 57 countries, we find that the κ for 39 countries is statistically significant at the 0.05 significance level (shown in the appendix). Given that κ is an estimated value, we aim to minimize estimation errors. Consequently, we have excluded countries with non-significant κ and removed one outlier. Utilizing Equation (5), we then proceed to conduct an Ordinary Least Squares regression. The results, including graphical representations and statistical charts, are presented as follows.

Variable	**Estimate**	**Standard Error**	**tStat**	**pValue**
$\alpha(constant)$	0.40534	0.090652	4.4714	7.4592e-05
γ	-0.0022945	0.0013466	-1.7039	0.097022

Table 7. This table presents the estimated coefficients of the slope of Employments in Services and κ

Number of observations: 38, Error degrees of freedom: 36
Root Mean Squared Error: 0.0826
R-squared: 0.0746, Adjusted R-Squared: 0.0489

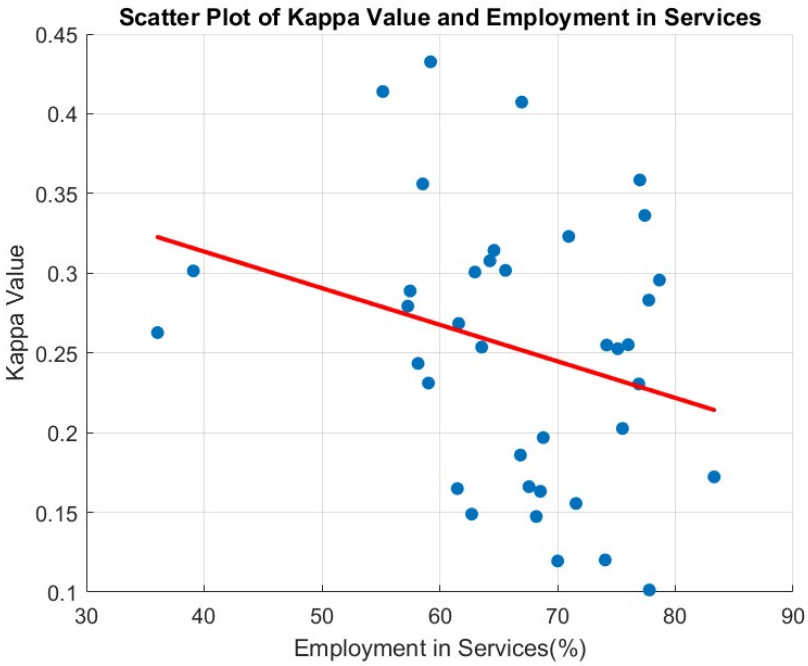

Figure 4. This figure shows the scatter plot of filtered values and the regression line

From Table 7, we observed that the p-values fall between the significance levels of 0.05 and 0.1. This suggests that the coefficient indicating the relationship between Employment in Services and Kappa lacks strong significance. Additionally, the small magnitude of this coefficient further implies that a direct and robust correlation between Employment in Services and Kappa cannot be conclusively drawn.

4. Conclusion

In this study, we re-examined the Phillips Curve across 57 countries. In our analysis, we compared the slopes of the Phillips Curve from two distinct periods, 1998 to 2009 and 2010 to 2022. We discovered that, on average, the slope of the Phillips Curve, indicative of the relationship between the output gap and inflation, has indeed experienced a decline. Specifically, in 39 countries where this slope is statistically significant, our expanding window regression over the last 12 years reveals a trend: inflation is now relatively less sensitive to changes in the output gap than before.

It is noteworthy that these findings are linked to the method used for estimating expected inflation. In our study, the estimation of expected inflation was based on a backward-looking method. According to this approach, if past inflation data were stable, this would lead to stable expectations for future inflation. Identifying more comprehensive methods for estimating expected inflation is a promising direction for future research.

In examining whether Services impact the slope of the Phillips Curve, we used Employment in Services as a variable to represent Services and analyzed its effect on the curve's slope. Our findings indicate that it is not reliable to directly conclude that Services influence the slope of the Phillips Curve. Only at a 0.1 significance level do we observe a slight negative impact of Services on the slope. The limited methods available for verification, due to data frequency constraints, suggest that more rigorous structural modeling is required to understand how Services affect the slope of the Phillips Curve, presenting a potential area for future research expansion.

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5. Appendix

Country Name	Kappa	Standard Error	Signifcance
Argentina	0.090	0.2865	
Australia	0.255	0.0951	***
Austria	0.147	0.0560	**
Belgium	0.297	0.1513	
Bolivia	0.062	0.0417	
Brazil	0.094	0.0891	
Bulgaria	0.433	0.2109	**
Canada	0.231	0.0487	***
Chile	0.302	0.1285	**
China	0.263	0.0888	***
Costa Rica	0.314	0.0854	***
Croatia	0.231	0.0714	***
Cyprus	0.253	0.0576	***
Czechia	0.289	0.0858	***
Denmark	0.203	0.0618	***
Ecuador	0.308	0.2221	
Estonia	0.254	0.0904	***
Finland	0.323	0.0571	***
France	0.120	0.0512	**
Germany	0.163	0.0427	***
Greece	0.166	0.0477	***
Hungary	0.149	0.0649	**
India	-0.095	0.0363	**
Indonesia	0.727	0.4359	**
Ireland	0.156	0.0508	***
Israel	0.135	0.0852	
Italy	0.186	0.0813	**
Jamaica	0.124	0.1078	
Japan	0.197	0.0600	***
Jordan	0.194	0.2718	
Korea	0.407	0.1123	***
Latvia	0.308	0.0895	***
Lithuania	0.268	0.0846	***
Luxembourg	0.172	0.0529	***
Mexico	-0.014	0.0439	
Morocco	0.022	0.0486	
Netherlands	0.296	0.0622	***
New Zealand	-0.019	0.0664	

Country Name	Kappa	Standard Error	Signifcance
Norway	0.098	0.0782	
Peru	0.030	0.0352	
Philippines	0.051	0.0363	
Poland	0.414	0.1531	***
Portugal	0.165	0.0696	**
Romania	0.830	0.4846	*
Russian Federation	0.301	0.1176	**
Serbia	-0.429	0.8857	
Singapore	0.283	0.0630	***
Slovak Republic	0.243	0.0674	***
Slovenia	0.279	0.0451	***
South Africa	0.356	0.1578	**
Spain	0.119	0.0393	***
Sweden	0.358	0.0709	***
Switzerland	0.255	0.0514	***
Thailand	0.301	0.1064	***
Turkiye	-0.037	0.2589	
United Kingdom	0.101	0.0405	**
United States	0.336	0.1110	***

Table 8: This table displays the results of OLS across 57 counties, and the standard errors are calculated by the Newy-West Method. ***, **, and * respectively indicate significance at the 1%, 5%, and 10% levels. From the table above, it can be seen that out of the data composed of 57 countries, 52 have a positive Kappa, and 39 of these are statistically significant under the significance level 0.05.