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Has the Phillips Curve Become Steeper?

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Has the Phillips Curve Become Steeper?

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ABSTRACT: This paper analyzes whether structural changes in the aftermath of the pandemic have steepened the Phillips curves in advanced economies, reversing the flattening observed in recent decades and reducing the sacrifice ratio associated with disinflation. Particularly, analysis of granular price quote data from the UK indicates that increased digitalization may have raised price flexibility, while de-globalization may have made inflation more responsive to domestic economic conditions again. Using sectoral data from 24 advanced economies in Europe, higher digitalization and lower trade intensity are shown to be associated with steeper Phillips curves. Post-pandemic Phillips curve estimates indicate some steepening in the UK, Spain, Italy and the euro area as a whole, but at magnitudes that are too small to explain the entire surge in inflation in 2021–22, suggesting an important role for outward shifts in the Phillips curve.

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WORKING PAPERS

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1. Introduction

The Phillips curve, defined as the empirical relationship between unemployment and inflation, illustrates the trade-off between maintaining price stability and achieving full capacity utilization. The recent history of the Phillips curve has been a puzzle. Many studies have concluded that the Phillips curve has flattened in advanced economies in recent decades (see e.g., Blanchard, 2016; Del Negro and others, 2020 among many others), while others have documented the muted reaction of inflation to large changes in unemployment during and after the Great Recession (Coibion and Gorodnichenko, 2015; Heise and others, 2022).

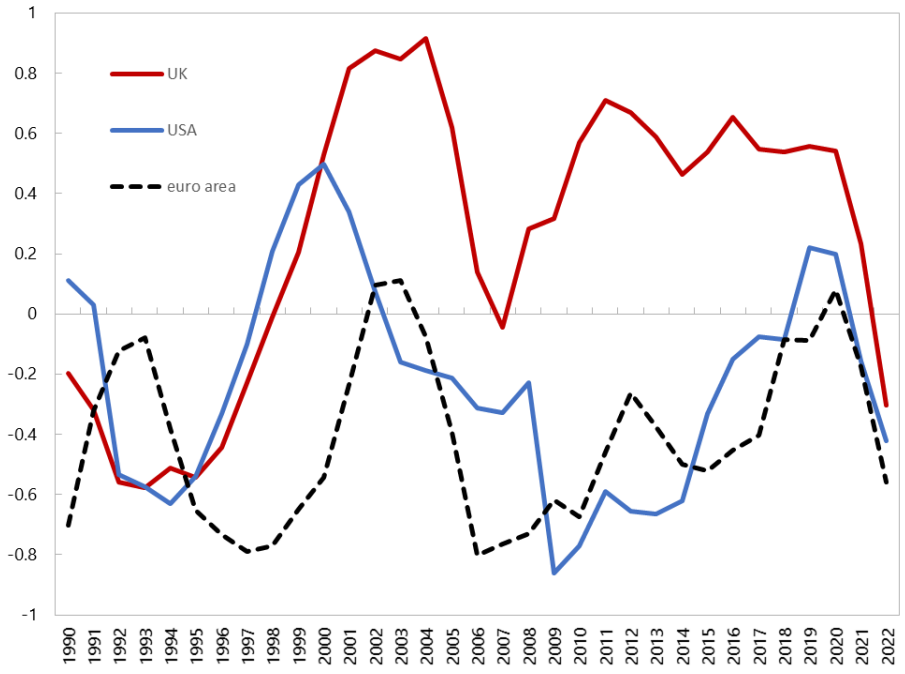
The literature has proposed a number of explanations for this phenomenon. First, the implementation of inflation targeting may have increased the capacity of monetary policy to neutralize demand shocks (which would move inflation and unemployment in opposite directions), leaving supply shocks (which move them in the same direction, shifting the Phillips curve inwards/outwards) as the main source of aggregate volatility (Broadbent, 2020; Bergholt, and others, 2023). Second, firmer anchoring of inflation expectations may have reduced second-round effects of relative price shocks (Borio and others, 2021). Third, globalization may have reduced the responsiveness of inflation to domestic economic slack and unemployment (Heise and others, 2022), including by raising labor market flexibility through a reduction in labor bargaining power (Lombardi and others, 2020). Fourth, increased market power may have augmented firms' capacity to absorb cost-push shocks in their markups (Baqaee, Farhi and Sangani, 2021).

Some of these structural trends may have started to reverse in recent years. The recent rise in inflation to historically high levels in advanced economies risks weakening the anchoring of inflation expectations achieved over the past two decades. A de-globalization scenario may also make the domestic output gap more relevant again, as well as restoring some labor bargaining power (Goodhart and Pradhan, 2020). New structural factors may have also contributed to a steepening of the Phillips curve reducing nominal rigidities. Notably, more widespread digitalization, including in response to the COVID-19 pandemic, has raised the share of online retail, where prices are typically more flexible (Gorodnichenko and Talavera, 2017; Cavallo, 2018).

Figure 1 demonstrates both the flattening of the Phillips curve in recent decades and more recent signs of steepening. The empirical correlation between unemployment and inflation which had gone from being negative to broadly zero in the US and the euro area, and positive in the UK, has again turned negative since the pandemic.

Figure 1: Phillips Curve Slope

(10 year rolling correlation of the unemployment rate and CPI inflation)



Source: ONS and IMF staff calculations

In view of these developments, this paper analyzes the impact of recent structural changes in trade intensity and digitalization on the slope of the Phillips curve. To do this, we first estimate a sectoral Phillips curve using quarterly data from 17 sectors in 24 advanced economies in Europe over 2012Q1–2019Q4.1 We find that both structural factors have a statistically significant impact in steepening the Phillips curve. These findings are robust to controlling for various sources of non-linearities and endogenous monetary policy responses to shocks.

To shed further light on the mechanism through which digitalization steepens the Phillips curve, we complement this analysis with price quote data from the UK (i.e., individual prices for goods in specific establishments). Particularly, we use monthly data from January 2008 to June 2021 to show that greater e-commerce intensity at the sectoral level is associated with a significantly higher frequency of individual price changes.[2] This finding is consistent with previous results from Gorodnichenko and Talavera (2017) and Cavallo (2018).

[1] Estimating sectoral Phillips curves allows us to exploit much more variation in the structural variables we consider, increasing the power of our estimations. The implicit assumption that underlies this identification strategy is that production factors are not perfectly mobile across sectors, allowing for output gaps to differ across sectors.

[2] This finding is robust to defining price flexibility with either positive or negative price changes only and including sector and year fixed effects.

Finally, we apply the sectoral Phillips curve results to infer changes in the post-pandemic Phillips curve for five large European economies–France, Germany, Italy, Spain and the UK—as well as a euro area aggregate. While we find that the Phillips curve has indeed steepened in the UK, Spain, Italy, and the euro area, the extent of steepening is limited, and post-pandemic Phillips curves remain largely flat. This conclusion holds even in a hypothetical de-globalization scenario where trade intensity falls substantially. It also suggests an important role for outwards shifts in the Phillips curve (which could be due to higher inflation expectations, supply shocks, or other structural changes) in explaining the surge in inflation in 2021–22.

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the empirical strategy and data. Section 4 provides the results and robustness checks. Section 5 estimates Phillips curve slopes in the aftermath of the pandemic and in a de-globalization scenario. Section 6 concludes.

2. Related Literature

Our paper is closely related to the literature on the slope of the Phillips curve. Blanchard (2016), Mishkin (2007) and Powell (2018) document that the US Phillips curve has flattened in the 1980s, while Haldane and Quah (1999) reach a similar conclusion for the UK. Leduc and Wilson (2017) and Murphy (2018) document that the wage Phillips curve has also become flatter. Del Negro and others (2020) and Coibion and Gorodnichenko (2015) consider the flattening of the Phillips curve as a possible explanation for missing deflation during the Great Recession, and Heise and others (2022) use it to provide an explanation for missing inflation in the 2010s. Abdih and others (2018) argue that high inflation persistence can account for missing inflation puzzles in the euro area.

Fitzgerald and Nicolini (2014), McLeay and Tenreyro (2020), and Hooper, Mishkin and Sufi (2020) argue that endogenous monetary policy responses may result in an underestimation of the slope of the Phillips curve and show that estimates based on US regional data indicate a steeper Phillips curve. In contrast, IMF (2021) shows that instrumenting for changes in unemployment with monetary policy shocks does not lead to a steeper Phillips curve slope estimate for advanced economies. Hazell and others (2022) find evidence of a modest flattening of the US Phillips curve using regional data. Similarly, Tuckett (2018) uses regional data to show that the UK Phillips curve has become flatter. While we rely on economy-wide data in our study, 20 of the 24 economies in our sample are either members of the euro area or have a currency peg with the euro, and thus can be thought of as “regions” within a monetary union. Using the sub-sample of euro (pegged) countries and the same approach as the above studies, we show that our findings are robust to controlling for monetary policy responses.

Other studies argue that the time-variance in the slope of the Phillips curve may be attributed to non-linearities. Barnes and Olivei (2003) propose a piecewise-linear Phillips curve specification where inflation responds more strongly to unemployment when unemployment is below a threshold, and Doser and others (2023) show that such a specification can account for missing disinflation during the Great Recession. Speigner (2014) finds that long-term unemployment has a significant effect on inflation once convexities are allowed for during the

estimation process. We also consider non-linear Phillips curve specifications in our empirical analysis and find that our results also remain robust to accounting for these.

The literature has also offered various theoretical explanations for the flattening of the Phillips curve. Nalewaik (2016) and Borio and others (2021) attribute it to firmer anchoring of inflation expectations. Ball and Mazumder (2011) argue that a decline in the level and variability of inflation has reduced price flexibility given costly price adjustment. Daly and Hobjin (2014) emphasize similar interactions between low inflation and downward nominal wage rigidities, while Afrouzi and Yang (2020) focus on the role of rational inattention in price setting decisions. Baqaee, Farhi and Sangani (2021) and Rubbo (2022) instead relate the flattening of the Phillips curve to markups and intermediate inputs, both of which dampen the pass through of shocks into prices. Lombardi and others (2020) suggest that the flattening is due to a weakening in labor bargaining power, which may in turn be related to declining unionization and globalization. Auer and others (2017) and Heise and others (2022) also identify globalization as a driving factor but propose different transmission channels that reduce the responsiveness of inflation to the domestic output gap. Auer and others (2017) focus on the role of international input-output linkages, while Heise and others (2022) consider import competition.

To our knowledge, this paper is among the first to study a steepening of the Phillips curve in the post-pandemic era. We consider two structural factors—de-globalization and digitalization—as potential drivers of a steeper Phillips curve. Alfonso and others (2021) document the growth of e-commerce in recent years and its acceleration during the pandemic, and Gorodnichenko and Talavera (2017) and Cavallo (2018) show that prices in online markets are more flexible. Glocker and Piribauer (2021) find that monetary policy shocks have less impact on output when the share of online retail trade is high, in line with our results. Witt (2019) and Razin (2020) argue that trade globalization (as measured by share of trade in world GDP) has reversed course since the global financial crisis. Our use of trade intensity as a proxy for de-globalization is similar to Heise and others (2022), who rely on import penetration as a proxy. While post-pandemic data do not register a decline in trade intensity in large European economies and the euro area, a de-globalization scenario is a relevant risk given tensions between the US and China and Russia's war in Ukraine, which have raised concerns about the reliability of supply chains (Handley, Kamal and Monarch, 2020).

Finally, this paper also relates to recent studies that provide a bottom-up accounting of the recent surge in inflation in Europe, including by estimating Phillips curves (McGregor and Toscani, 2022; IMF, 2022; Baba and others, 2023). These studies find that Phillips curves estimated on historical data and changes in energy and other commodity prices can only explain about half of the increase in inflation in 2022 in advanced and emerging European economies.[3] These findings are consistent with our estimates of flat Phillips curve slopes for large European economies in this paper.

[3] Relatedly, Hodge and others (2022) use a DSGE model to show that, even with a steeper Phillips curve slope, policy actions would not have explained the inflation surge in either the euro area or the US.

3. Empirical Framework and Data

This section first introduces the empirical frameworks for sectoral Phillips curve estimates and the analysis of the impact of digitalization on price flexibility. Then it describes the data sources and data construction.

3.1 Sectoral Phillips Curve Estimation

The analysis is based on a panel of 17 sectors in 24 advanced economies in Europe, at quarterly frequency over 2012Q1–2019Q4.[4] The baseline specification reflects a standard open economy, expectations-augmented Phillips curve relationship (see e.g., Kamber, Mohanty and Morley, 2020) and can be written as follows:

$$\pi_{i,s,t} = \alpha_i + \alpha_s + \alpha_t + \alpha_{i,s} + \beta\hat{y}_{i,s,t} + \gamma E_t\left[\pi_{i,t+4}\right] + \sum_{k=1}^{2}\lambda_k\pi_{i,s,t-k} + \theta\Delta s_{i,t} + \delta X_{i,s,t} + \phi\,\hat{y}_{i,s,t}X_{i,s,t} + \epsilon_{i,s,t}\ . \quad (1)$$

where i, s, t denote country, sector, and time such that $(\alpha_i, \alpha_s, \alpha_t, \alpha_{i,s})$ are respectively country, sector, time, and country-sector fixed effects. $\pi_{i,s,t}$ represents inflation, $\hat{y}_{i,s,t}$ is the output gap and $E_t\left[\pi_{i,t+1}\right]$ captures inflation expectations as is standard in the literature. We also follow Gali and Gertler (1999) in introducing lagged inflation terms to control for adaptive components of inflation expectations as well as lagged changes in other determinants of inflation. Additionally, as is standard for open economies with a large proportion of imported goods and services, we also control for appreciation in the real effective exchange rate $\Delta s_{i,t}$. The vector $X_{i,s,t}$ captures structural changes associated with trade intensity and digitalization, and $\epsilon_{i,s,t}$ is the residual.

The key coefficients that we aim to estimate are denoted by the vector $\hat{\phi}$, which captures the impact of structural factors on the slope of the Phillips curve. Particularly, a negative estimate for the trade intensity coefficient and a positive estimate for the digitalization coefficient in this vector would indicate that de-globalization and digitalization are associated with a steeper Phillips curve.

We also consider a number of robustness tests. First, we repeat the baseline estimates in (1) but cluster the standard errors at the level of sector-country combinations. Second, our estimates may be biased by endogenous monetary policy responses to inflation and the output gap. To address this concern, we also estimate specification (1) using data only from countries that are in the euro area or that have an exchange rate peg with the euro. Since these countries have a common monetary policy, endogenous monetary policy responses would be captured by time fixed effects. A third concern with our identification is that the Phillips curve may be non-linear. To check whether our analysis is robust to non-linearities, we also consider a specification with quadratic terms for the output gap and inflation expectations, such that

$$\pi_{i,s,t} = \alpha_i + \alpha_s + \alpha_t + \alpha_{i,s} + \beta\hat{y}_{i,s,t} + \beta_2\hat{y}_{i,s,t}^2 + \gamma E_t\left[\pi_{i,t+4}\right] + \gamma_2 E_t\left[\pi_{i,t+4}\right]^2\theta\Delta s_{i,t} + \delta X_{i,s,t} + \\ + \sum_{k=1}^{2}\lambda_k\pi_{i,s,t-k} + \phi\,\hat{y}_{i,s,t}X_{i,s,t} + \epsilon_{i,s,t} \quad (2)$$

[4] See section 3.3 for a list of the countries and sectors included. Adding a sectoral dimension to the panel strengthens the identification by allowing to control for sector and country-sector fixed effects.

3.2 Digitalization and Price Flexibility

We further investigate the mechanism through which digitalization affects the slope of the Phillips curve by using monthly data from the UK between January 2008 and June 2021 to analyze whether (off-line) prices are revised more frequently in sectors with higher e-commerce intensity. Our specification is as follows:

$$\mathrm{F}_{s,t} = \alpha_s + \alpha_t + \beta E_{s,t} + \epsilon_{s,t} \quad (3)$$

where s, t denote sector and year and α_s and α_t are respectively sector and year fixed effects as before. $\mathrm{F}_{s,t}$ denotes price flexibility, defined as the monthly rate at which price quotes p for individual items in a given shop are changed within sector s in year t:

$$F_{s,t} \equiv \frac{1}{12N_{s,t}} \sum_{j \in S} \sum_{m \in T} I\left(p_{j,m} - p_{j,m-1} \neq 0\right) \quad (4)$$

where m indicates the month and j the price quote, and $N_{s,t}$ is the number of price quotes in the sample for a given sector-year. For example, a price flexibility of ½ means that the price of an item changes every two months on average. $E_{s,t}$ represents e-commerce intensity, defined as the share of enterprises receiving e-commerce orders within a sector, and $\epsilon_{s,t}$ is the residual.

An estimate of $\hat{\beta} > 0$ would then suggest that greater e-commerce intensity is associated with higher price flexibility. While this could be interpreted as a direct effect of digitalization as in Gorodnichenko and Talavera (2017) and Cavallo (2018), an alternative interpretation would be that e-commerce penetration acts as a deflationary force, triggering price reductions that then create a false impression of increased price flexibility. As a robustness check for such a "deflationary bias," we also repeat our analysis by re-defining $\mathrm{F}_{s,t}$ to alternately exclude all positive and negative price changes, as the frequency of the former would not increase from deflationary pressure.

3.3 Data Sources and Construction

Table 1 reports the countries and sectors included in the panel dataset for the Phillips curve estimates, which covers the period 2014Q4–2019Q4 at quarterly frequency.[5,6] We restrict our analysis to pre-pandemic data as we consider our estimates of interest (captured in $\hat{\phi}$) to be deep parameters that are stable over time but that may have been temporarily "dislodged" by pandemic-related disruptions. The initial time point and sectoral breakdown in our dataset are given by data availability.

We proxy for digitalization with the share of enterprises with e-commerce sales amounting to at least 1 percent of total turnover, which is available from Eurostat at the sectoral breakdown shown in Table 1. We aggregate other sectoral variables with more granular sectoral data up to this level. These include sectoral inflation, measured using implied GDP deflators; the sectoral output gap, constructed by applying a Hodrick-Prescott

[5] Among the countries, Czechia, Norway, Sweden and the UK have independent monetary policies, leading to their exclusion from robustness checks for endogenous monetary policy reactions. The remaining countries are euro area members, except for Denmark which has an exchange rate peg with the euro.

[6] In 2019, the included sectors accounted on average for 42 percent of total gross value added for the countries in the dataset.

filter to real gross value added (GVA) and taking the residual in percentage terms; and sectoral trade intensity (a proxy for (de-)globalization), which is the ratio of sectoral imports and exports to sectoral GVA. These variables are all obtained from Eurostat, with sectoral imports and exports only available from 2012Q1 onwards. Inflation expectations and real effective exchange rates are only available at the country level. We proxy for inflation expectations with one-year-ahead CPI inflation forecasts from Consensus Economics and obtain (CPI-based) real effective exchange rate (REER) data from the IMF's World Economic Outlook database.

Table 1: Countries and Sectors Included in the Panel Dataset

Countries:	Austria, Belgium, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.
Sectors:	
NACE Rev. 2 sector code	**Sector name**
C10-C12	Manufacture of food products; beverages and tobacco products
C13-C15	Manufacture of textiles, wearing apparel, leather and related products
C16-C18	Manufacture of wood, paper, printing and reproduction
C19	Manufacture of coke and refined petroleum products
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22-C23	Manufacture of rubber and plastic products and other non-metallic mineral products
C24-C25	Manufacture of basic metals and fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products
C27-C28	Manufacture of electrical equipment and machinery and equipment n.e.c.
C29-C30	Manufacture of motor vehicles, trailers, semi-trailers and of other transport equipment
C31-C33	Manufacture of furniture; jewelry, musical instruments, toys; repair and installation of machinery and equipment
H49-H53	Land transport and transport via pipelines, water and air transport, warehousing and support activities for transportation, postal and courier activities
I	Accommodation and food service activities
J58-J60	Publishing activities, motion picture, video and television programme production, sound recording and music publishing activities, programming and broadcasting activities
J61	Telecommunications
J62-J63	Computer programming, consultancy, and information service activities

Our analysis on the impact of digitalization on price flexibility relies on the same proxy for digitalization as used in the Phillips curve analysis, along with price-quote data from the UK's Office of National Statistics (ONS). The ONS tracks the consumer prices of individual items at individual shops at a monthly frequency for the purpose of constructing the CPI measure of inflation. After excluding price quotes not validated by the ONS and those where a different comparable product was used (but retaining price changes due to sales), we use these data to calculate the rate of price changes for each item-shop pairing. For duplicate item-shop-region-month observations, we select the observation with the lowest price, which tends to diminish the rate of price changes. We then aggregate price flexibility by COICOP sectors and manually match these to NACE 2-digit sectoral categories for which the digitalization proxy is available.[7]

It is worth noting that the ONS data only cover physical shops, which would likely lead us to under-estimate price flexibility in sectors with a higher share of online retail, in light of Gorodnichenko and Talavera (2017)'s finding of higher price flexibility in online markets. That is, our estimates of specification (3) speak to whether physical shops in sectors with a higher penetration of e-commerce responded to competition from e-commerce with more frequent price adjustments, rather than capturing price flexibility for the sector inclusive of e-commerce.

4. Empirical Results and Robustness

4.1 Sectoral Phillips Curve Regressions

Table 2 reports the baseline Phillips curve regression results, with columns (i)–(vi) showing variants of specification (1) including different sets of fixed effects and lagged inflation terms. Among these, column (vi) is the preferred specification for the purpose of identification, as it controls for country-sector and time fixed effects.

The bold lines contain the key coefficients of interest, which capture the impact of digitalization and trade intensity on the slope of the Phillips curve. The estimation results confirm the hypotheses that greater digitalization and lower trade-intensity are associated with a steeper Phillips curve. In all columns, the interactions of digitalization and trade intensity with the output gap are statistically significant with positive and negative coefficients, respectively. In columns (i)–(iv), which do not control for country-sector fixed effects, the standalone digitalization term and inflation expectations have statistically significant coefficients with positive signs, indicating that a rise in either would shift the Phillips curve outward. While an outward shift due to higher inflation expectations is consistent with a canonical expectations-augmented Phillips curve, the positive sign on the digitalization coefficient contrasts with theories that higher digitalization restrains inflation through increased competition.[8] However, these relationships are not robust to controlling for country-sector fixed effects, so they could be driven by omitted variable bias.

[7] The manual matching is available upon request.

[8] The interaction term between digitalization and the output gap does not matter for the overall effect of digitalization since the average output gap by country is zero by construction.

Table 3 reports the results of various robustness tests on the validity of the baseline results from column (vi) of Table 2. Column (i) of Table 3 indicates that the results are robust to including quadratic terms of the output gap and inflation expectations. Notably, the quadratic output gap term is positive and significant, indicating that the Phillips curve is convex. Column (ii) shows that the results are also robust to restricting the sample to euro area members and countries with an exchange rate peg, where endogenous monetary policy responses are fully absorbed by time fixed effects. Although the coefficients of interest are slightly attenuated, they remain statistically significant. Column (iii) shows that the results are robust to clustering standard errors at the sector-country combination level. Finally, Column (iv) uses the Arellano-Bond estimator show that the results are not driven by Nickell bias.

Table 2: Baseline Empirical Results

Dependent variable:	Sectoral inflation (implicit deflator)					
Independent variables:	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Output gap	-0.0263	-0.0217	-0.0195	0.00287	0.0192	0.0141
	(0.0547)	(0.0519)	(0.0503)	(0.0555)	(0.0461)	(0.0560)
Inflation expectations	0.442**	0.433**	0.408**	0.0596	0.199	-0.217
	(0.193)	(0.191)	(0.192)	(0.362)	(0.309)	(0.343)
Real effective exchange rate appreciation	-9.917	-10.06	-11.17	-11.54	-4.151	4.458
	(7.422)	(7.316)	(7.303)	(7.328)	(5.943)	(7.874)
Sectoral inflation (lagged one quarter)		0.111***	0.106***	0.0733**	-0.223***	-0.188***
		(0.0343)	(0.0318)	(0.0306)	(0.0332)	(0.0412)
Sectoral inflation (lagged two quarters)			0.0749***	0.0362	-0.239***	-0.201***
			(0.0286)	(0.0276)	(0.0333)	(0.0404)
Digitalization	2.574***	2.215***	2.025***	2.653**	1.305	-0.0640
	(0.729)	(0.743)	(0.759)	(1.323)	(1.733)	(1.583)
Trade intensity	-0.0923	-0.0720	-0.0549	-0.0322	0.428	0.295
	(0.139)	(0.142)	(0.145)	(0.165)	(0.301)	(0.355)
Output gap * Digitalization	**0.209***	**0.202***	**0.194***	**0.180***	**0.271*****	**0.266*****
	(0.115)	**(0.110)**	**(0.107)**	**(0.108)**	**(0.0996)**	**(0.0977)**
Output gap * Trade intensity	**-0.0377***	**-0.0361***	**-0.0340**	**-0.0380***	**-0.0515*****	**-0.0509****
	(0.0220)	**(0.0212)**	**(0.0207)**	**(0.0208)**	**(0.0185)**	**(0.0210)**
Constant	-0.230	-0.288	-0.310	0.217	0.0668	1.245
	(0.388)	(0.387)	(0.387)	(0.720)	(0.810)	(0.916)
Observations	3,102	3,102	3,102	3,102	3,101	3,101
R-squared	0.032	0.043	0.048	0.089	0.337	0.425
Country FE	NO	NO	NO	YES	NO	NO
Sector FE	NO	NO	NO	YES	NO	NO
Country-Sector FE	NO	NO	NO	NO	YES	YES
Time FE	NO	NO	NO	NO	NO	YES

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The results pertain to sectoral Phillips curve regressions covering 17 sectors at NACE Rev. 2 two-digit classifications in 24 advanced economies in Europe between 2012Q1-2019Q4 at quarterly frequency. Output gap is the residual of a HP-filter of sectoral GVA and is in terms of percent of potential sectoral GVA, with positive values indicating output above potential. Inflation expectations are proxied by 1-year ahead average inflation expectations. Digitalization denotes percentage of enterprises with e-commerce sales of at least 1% of turnover and trade intensity refers to share of trade (i.e., imports and exports) in sectoral GVA. All variables are in annualized terms.
Sources: Consensus Economics, Eurostat, IMF World Economic Outlook, IMF staff calculations

Table 3: Robustness Check

Dependent variable:	Sectoral inflation (implicit deflator)			
Independent variables:	(i)	(ii)	(iii)	(iv)
Output gap	-0.0198	-0.0207	0.0141	0.0424
	(0.0280)	(0.0306)	(0.0360)	(0.0532)
Output gap (squared)	-0.00338***			
	(0.000510)			
Inflation expectations	1.743	-0.414	-0.217	-1.053
	(1.098)	(0.424)	(0.291)	(0.699)
Inflation expectations (squared)	-0.533			
	(0.329)			
d_REER	5.206	-11.50	4.458	3.856
	(7.887)	(21.59)	(5.138)	(7.366)
Sectoral inflation (lagged one quarter)	-0.201***	-0.240***	-0.188***	-0.369***
	(0.0398)	(0.0472)	(0.0463)	(0.0210)
Sectoral inflation (lagged two quarters)	-0.217***	-0.268***	-0.201***	-0.375***
	(0.0392)	(0.0456)	(0.0597)	(0.0204)
Digitalization	0.0455	-0.735	-0.0640	6.497*
	(1.592)	(1.944)	(2.198)	(3.444)
Trade intensity	0.164	0.158	0.295	0.00805
	(0.356)	(0.408)	(0.405)	(0.458)
Output gap * Digitalization	**0.203****	**0.231****	**0.266***	**0.493****
	(0.0961)	**(0.111)**	**(0.136)**	**(0.247)**
Output gap * Trade intensity	**-0.0399****	**-0.0403****	**-0.0509*****	**-0.0846*****
	(0.0176)	**(0.0196)**	**(0.0146)**	**(0.0109)**
Constant	0.00778	1.979*	1.245	2.251
	(1.078)	(1.094)	(0.765)	(1.692)
Observations	3,101	2,331	3,101	2,341
R-squared	0.445	0.378	0.425	n.a.
Lagged inflation	YES	YES	YES	YES
Country-Sector FE	YES	YES	YES	n.a.
Time FE	YES	YES	YES	n.a.
Terms capturing non-linearities	YES	NO	NO	NO
Excl. countries with independent monetary policy	NO	YES	NO	NO
SE clustered around sector-country combinations	NO	NO	YES	NO
Arellano-Bond estimator	NO	NO	NO	YES

Note: *** p<0.01, ** p<0.05, * p<0.1. The results pertain to sectoral Phillips curve regressions covering 17 sectors at NACE Rev. 2 two-digit classifications in 24 advanced economies in Europe between 2012Q1-2019Q4 at quarterly frequency. Output gap is the residual of a HP-filter of sectoral GVA and is in terms of percent of potential sectoral GVA, with positive values indicating output above potential. Inflation expectations are proxied by 1-year ahead average inflation expectations. Digitalization denotes percentage of enterprises with e-commerce sales of at least 1% of turnover and trade intensity refers to share of trade (i.e., imports and exports) in sectoral GVA. All variables are in annualized terms.

Sources: Consensus Economics, Eurostat, IMF World Economic Outlook, IMF staff calculations

4.2 Digitalization and Price Flexibility

Table 4 reports the results on the impact of digitalization on price flexibility, which are based on specification (3). Column (i) shows that the coefficient for digitalization is positive and statistically significant, indicating that higher digitalization is associated with a higher frequency of price changes in the UK. Quantitatively, a move from the 25th to the 75th percentile in the sectoral digitalization distribution is associated with an almost doubling of the rate of price changes (from 8.2 to 4.5 months on average).

While we interpret this result as evidence that increased digitalization diminishes price rigidity, an alternative interpretation would be that e-commerce penetration acts as a deflationary force, triggering price reductions that would show as an increased rate of price changes. However, column (ii) and (iii) indicate that defining price flexibility with either positive or negative price changes, respectively, leads to almost identical coefficient estimates (which remain statistically significant), suggesting that deflationary bias is not a significant driver of the findings in column (i).

Table 4: Digitalization and Price Flexibility Results

Dependent variable:	Price flexibility		
Independent variables:	(i)	(ii)	(iii)
Digitalization	0.0045***	0.0022***	0.0022***
	(0.0008)	(0.0007)	(0.0007)
Constant	0.1113***	0.0643***	0.0470***
	(0.0135)	(0.1194)	(0.0116)
Observations	204	204	204
R-squared	0.0208	0.0282	0.0179
Sector FE	YES	YES	YES
Time FE	YES	YES	YES
Price quote changes reflected in price flexibility metric	Positive & negative	Positive only	Negative only

Note: *** p<0.01, ** p<0.05, * p<0.1. The results pertain to specification (3) where price flexibility is defined as the average rate at which price quotes are changed in a sector.
Sources: Eurostat, ONS, IMF staff calculations

5. Post-Pandemic Phillips Curve Estimation

In this section, we apply the results from the sectoral Phillips curve regressions to estimate the slope of the Phillips curve before and after the pandemic, and in an alternative scenario where de-globalization drastically reduces trade intensity. We do this for the UK, the four largest economies in the euro area—France, Germany, Italy, and Spain—and a euro area aggregate.

Using specification (1), the average Phillips curve slope for a country i over a time period $t \in [\underline{t}, \overline{t}]$ is given by the following expression

$$\sum_{t\in[\underline{t},\overline{t}],s\in S} \frac{\partial \pi_{i,s,t}}{\partial \hat{y}_{i,s,t}} = \hat{\beta} + \hat{\phi} \sum_{t\in[\underline{t},\overline{t}],s\in S} X_{i,s,t} \quad (5)$$

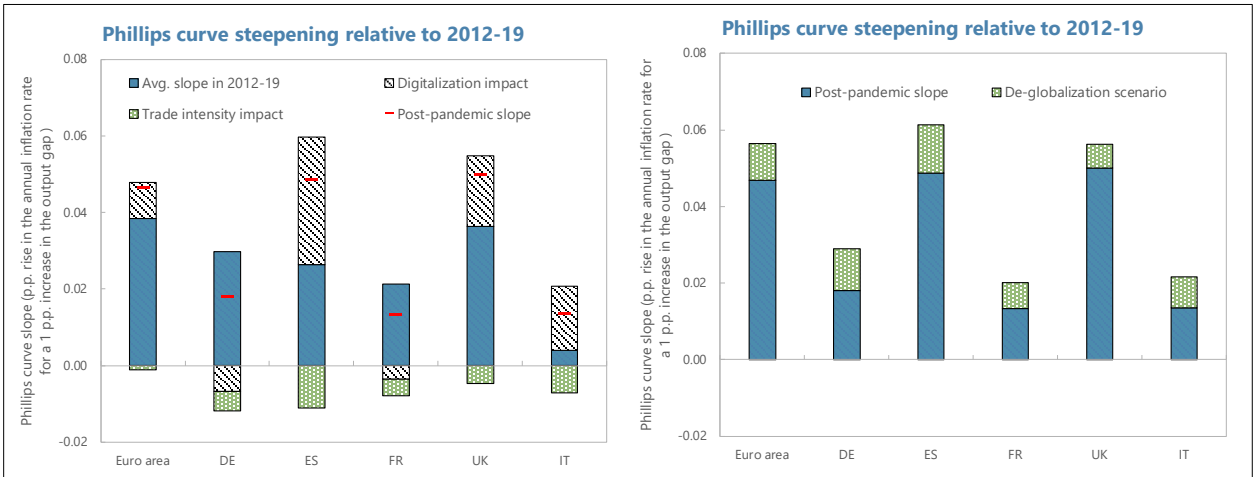
where S is the set of all sectors in the economy, $\hat{\beta}$ and $\hat{\phi}$ are estimated coefficients reported in column (vi) of Table 2 and $X_{i,s,t}$ are regressors in each country-sector-period.

Figure 2 reports the average Phillips curve slopes over 2012–19 and in the aftermath of the pandemic, where the latter captures the latest outturns for digitalization and IMF WEO projections for trade intensity in 2023–24. Similar to the extant literature, our estimates suggest that the Phillips curve was very flat in 2012–19, with an increase in the output gap of 1 percent of potential GDP corresponding to less than a 0.04 percentage point increase in the annualized inflation rate in each country economy and the euro area aggregate. Notably, the estimated Phillips curve is steepest for the UK and the euro area, and nearly horizontal for Italy.

Since the onset of the pandemic, increased digitalization steepens the Phillips curve in the UK, Spain, Italy and the euro area, while the opposite is true for Germany and France, where the extent of digitalization (as measured by e-commerce penetration) has decreased in recent years.[1] Concerns about de-globalization notwithstanding, trade intensity is projected to increase in each economy and the euro area, and therefore weighs against a steeper Phillips curve relative to the pre-pandemic period. Overall, we estimate that the Phillips curve has become steeper in the aftermath of the pandemic in the UK, Spain, Italy and the euro area, but has further flattened in France and Germany. Importantly, however, the estimated changes lack economic significance, amounting to only 0.01–0.02 percentage points in terms of the inflation response to a percentage point increase in the output gap.

We also consider a scenario with more substantial fragmentation of the global economy, and de-globalization leading to a shortening of supply chains and reduced trade between Europe and other regions (but not necessarily within Europe). Specifically, we assume that, in each country, trade intensity declines to the midpoint between its projected levels for 2023–24 and the 1980s averages. Figure 3 reports the Phillips curve slope estimates for this scenario, showing that it would see further steepening, but again with limited economic significance.

[1] The Phillips curve flattening estimated for Germany and France should be interpreted with caution, as the decrease in digitalization observed in these countries is sensitive to the specific proxy used.



Note: Phillips curve slopes are estimated using the coefficients from Table 2, Colum (vi). Post-pandemic slopes are based on the latest available digitalization data from 2022 (with the exception of the UK, the latest available data for which are from 2020) and IMF WEO estimates for trade shares in 2023-24, except for the Euro area composite where Eurostat data on extra-Euro area trade is extended using IMF WEO projections. In the de-globalization scenario, trade intensity is assumed to decline to the midpoint of 2023-24 projections and the 1980-90 average. For the Euro area, trade intensity is assumed to decline by the same amount as the average decline in DE, ES, FR and IT.

6. Conclusion

Motivated by increases in digitalization and concerns about de-globalization in the aftermath of the pandemic, we have analyzed the impact of these changes on the slope of the Phillips curve. Using sectoral data in 24 advanced economies in Europe over 2012–19, we have shown that higher digitalization and lower trade intensity are associated with a steeper Phillips curve, and that this finding is robust to controlling for non-linearities and monetary policy responses to shocks. We have also shed further light on the mechanism through which digitalization steepens the Phillips curve with the use of price quote data from the UK. Particularly, the analysis of monthly price data over 2008–21 shows that greater e-commerce intensity at the sectoral level is associated with a significantly higher frequency of price changes.

Our sectoral curve estimates suggest that the Phillips curve has indeed become steeper in the UK, Spain, Italy, and the euro area following the pandemic, while it has flattened in France and Germany. However, our findings also indicate that the extent of steepening is limited, and post-pandemic Phillips curves remain largely flat, even in a de-globalization scenario with trade intensity falling substantially. Taking our Phillips curve slope estimates at face value, plausible levels of excess demand would be unable to entirely explain the recent surge in inflation, suggesting that the latter was mostly driven by outward shifts in the Phillips curve (e.g., from higher inflation expectations, supply shocks, or other structural changes). That said, our estimates are based on data from 2012–2019, which lack the inflation volatility observed in 2021–22, and may therefore not extend to periods when inflation is substantially above the target. Phillips curve parameter estimates based on data from past episodes of inflation surges, and from the post-pandemic period as more data become available, could thus prove fruitful as an avenue for future research.

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