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Modeling economic policy issues

Regional heterogeneity and the provincial Phillips curve in China

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ABSTRACT

This paper explores the presence of regional heterogeneity in the response of inflation to changes in the output gap in China. We estimate the slope of the provincial Phillips curve for four different price indices using quarterly data over the period 2000–2022. The presence of regional heterogeneity is tested by comparing a fixed effects and a mean group estimator. Heterogeneity in the provincial slope is confirmed robustly only in the case of the CPI with around half of provinces exhibiting a positive coefficient. Our findings point to the share of industry and market advancement as significant contributors to the sensitivity of inflation to provincial demand shocks. Moreover, we reveal a relatively low correlation between the national and provincial output gaps as well as inflation rates, which suggests that regional heterogeneity diminishes the effectiveness of unitary monetary policy that targets CPI inflation.

1. Introduction

The Phillips curve, which in its original version refers to the link between wage inflation and unemployment and in its New Keynesian version examines the relationship between price inflation and the output gap, is a key component of the forecasting models used by monetary authorities to guide their policy decisions. Its slope is traditionally estimated at the national level, but over the past two decades a growing number of studies motivated by various reasons have chosen to utilize regional data. Coen et al. (1999) point out that, unlike the rich data at the regional level, national data on inflation and unemployment have a limited range of observations, producing estimates that rely on extrapolations of fitted relationships, while Kapetanios et al. (2021) argue that aggregation in the presence of heterogeneity at the disaggregate level leads to biased estimates.

Furthermore, the regional approach can solve some fundamental issues that plague the identification and estimation of the Phillips curve. For instance, a successful monetary policy aimed at offsetting demand shocks at the national level will eliminate the variation in the output gap, leaving inflation to be determined by supply shocks that are unforecastable by the monetary authorities. Fitzgerald and Nicolini (2014) and McLeay and Tenreyro (2019) show that regional data can help distinguish demand from supply shocks because a unitary monetary policy cannot offset regional demand shocks. Another issue relates to the difficulty of accounting for inflation expectations as estimates are extremely sensitive to specification choices (Mavroeidis et al., 2014). Hazell et al. (2022) demonstrate that time fixed effects in a panel regression with regional data absorb the variation in the long-run inflation expectations as they are determined by beliefs about the monetary regime common to all regions.

The literature on the regional Phillips curve focuses predominantly on US cities and states as well as Euro Area countries (Beraja et al., 2019; Berk and Swank, 2011; Fitzgerald et al., 2020; Hooper et al., 2019; Hazell et al., 2022; Schuffels et al., 2022), while only a few studies have conducted a similar investigation on emerging economies due to the lack of appropriate regional data of sufficient length. Behera et al. (2018) estimate a Phillips curve for India using annual CPI data for 21 Indian states over the period

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2011–2016. Averina et al. (2018) analyze regional heterogeneity in Russia by estimating Phillips curves for four regional clusters over the period 2000–2015, while Orlov and Postnikov (2022) utilize quarterly data to generate separate Phillips curves for 80 Russian regions.

This paper contributes to existing research by exploring the relationship between inflation and the output gap at the regional level in China. In particular, we calculate inflation for four different price indices using quarterly data for 29 Chinese provinces over the period 2000–2022. The price indices contain different combinations of tradables and non-tradables, allowing us to distinguish between prices set at the national and regional levels. For instance, prices of services are much more sensitive to local demand or supply shocks, whereas prices of intermediate goods that are imported or regulated at the national level are less likely to react to province-specific changes in the output gap.

Furthermore, we test for the regional homogeneity of the slope of the provincial Phillips curve in China. For this purpose, we estimate two model specifications. The fixed effects model produces a single estimate of the provincial slope, while the mean group estimator obtains the slopes for each province and reports the average. Using a Hausman test, we determine which model is preferred across the four price indices. In the presence of regional homogeneity, the fixed effects model is consistent and efficient, whereas the mean group model is superior, if the inflationary response varies by province. In those cases where regional heterogeneity is detected, we use the mean group estimator to obtain the individual slopes for each province and employ regression analysis to identify the factors responsible for the cross-regional variation. Lastly, we generate an estimate for the slope of the national Phillips curve and compare it to the regional one from our analysis. The robustness of our results is checked for a reduced sample of provinces (excluding autonomous regions and metropolitan areas) and time (pre-COVID period and the years 2009–2019).

Our paper is unique in applying a panel model with time and province fixed effects that was originally proposed by Hazell et al. (2022) to identify the true slope of the national Phillips curve using regional data. Hazell et al. (2022) focus on goods that even between regions of the same country can be considered non-tradable, so that regional demand differences cause the prices of such goods to deviate from their national mean. If the underlying structural parameters of the Phillips curve for those non-tradables and a broader basket of goods are identical, the slope of the regional Phillips curve reflects the true national Phillips curve that might be obfuscated by monetary policy when using national aggregates.

Contrarily, our paper is interested in the Phillips curve's regional component for its own sake. When regional demand causes regional price deviations, traditional monetary policy faces obstacles in stabilizing prices, especially in large heterogeneous countries like China where economic development varies widely across regions. Unlike Hazell et al. (2022), we, therefore, look at various broader price indices that contain different shares of tradables. The existence of Phillips-curve behavior after controlling for time fixed effects implies frictions to domestic trade of the products in the respective market baskets. Furthermore, regional heterogeneity in the slope of the regional Phillips curve would indicate regional variation in those frictions.

Keeping in mind that our primary motivation is to test for and explore the variation in the sensitivity of price inflation to demand shocks across Chinese provinces, this study makes several important contributions to the existing literature. First, we conduct the estimation using quarterly data over the past two decades. While quarterly data is widely used at the national level, all regional Phillips curves for China so far have been estimated with annual data, resulting in a relatively small number of observations (as only Holz and Mehrotra (2016) take advantage of a panel specification). Second, we obtain estimates for four different price indices that help us identify the province-specific sensitivity of inflation, whereas most previous studies have focused on one or two price measures. Third, we test for regional heterogeneity and report the individual slopes for each province but, unlike the existing literature on China, we use a panel setting which enables us to control for the national effects common to all provinces. Fourth, we investigate the determinants of the variation in the provincial slope, which has not been undertaken before.[1] Last but not least, our study on a major emerging economy expands the scope of the literature on the regional Phillips curve beyond its focus on the US and the Euro Area.

The rest of the paper is structured as follows. The next section offers a brief review of the literature on the Phillips curve in China. Section 3 presents the methodology used to estimate the provincial Phillips curve, while Section 4 describes the data. Section 5 discusses the results and Section 6 provides some conclusions.

2. The Phillips curve in China

A number of studies estimate a Phillips curve for China at the national level (Vines and Scheibe, 2005; Funke, 2006; Zhang and Murasawa, 2011, 2012; Mazumder, 2014). Zhang (2013) shows that a hybrid New Keynesian Phillips curve model with an extended lagged inflation structure provides a good description of China's inflation dynamics over the period 1992–2011, confirming the role of the conventional output gap as a key determinant. Zhang (2017) emphasizes the existence of non-linearities in the relationship between inflation and the output gap in China. Depending on the phase of the business cycle, the Phillips curve can exhibit a positive or negative slope and be even vertical.

To the best of our knowledge, only four papers use regional data in the context of the Phillips curve for China. Ji et al. (2015) explore the relationship between CPI inflation and the vacancy-jobseeker ratio (as a proxy for unemployment) for 26 Chinese cities over the years 2001–2013. They estimate various specifications of the model, including fixed effects, but fail to control for common

[1] Mehrotra et al. (2010) try to address this question by estimating probit regressions with the dependent variable taking the value of one, if the coefficients of the output gap and forward-looking inflation in the provincial Phillips curve models are statistically significant, and zero otherwise. However, this empirical framework does not explain the variation in the slope across provinces.

shocks via time fixed effects. The coefficient for the vacancy-jobseeker ratio is positive and significant for the full sample and for the subsample of coastal cities but turns insignificant for cities in Central and Western China.

Holz and Mehrotra (2016) investigate the impact of unit labor costs on inflation in a Phillips curve framework using panel data of annual frequency for 30 provinces over the period 1998–2010. They use wages and three different price indices (CPI, retail price index, and producer price index) to measure inflation. The results show that the coefficient of the province-level output gap in the long run takes the expected positive sign and is significant across all three price indices but regional heterogeneity is not investigated further.

Mehrotra et al. (2010) use a hybrid New Keynesian Phillips Curve to model provincial inflation over the period 1978–2004. They use annual data for 29 provinces and measure inflation with the help of the retail price index. The individually estimated Phillips curves indicate that the coefficient for the output gap is positive and statistically significant for only nine provinces, while it is negative but insignificant for three provinces. Moreover, the authors test whether the coefficients from the provincial model can be set equal to the pooled national estimate. The test is rejected for only six provinces. Lastly, a probit estimation is conducted for each province individually, revealing that a positive and significant slope of the Phillips curve is correlated with coastal provinces, financial deepening, trade openness, and a larger industry share.

Chen et al. (2017) examine the impact of the national output gap on provincial wage and price inflation, estimating separate Phillips curves for 29 provinces over the years 1978–2014. Their hypothesis is that a deepening regional integration would make inflation more responsive to the national (rather than the local) economic slack. The authors use annual data (n = 37) to estimate two different specifications of provincial Phillips curves that take into account the national and provincial output gap, respectively. For inflation measured using the retail price index, the model with the province-level output gap is rejected in favor of the national output gap for 21 provinces, while the opposite is confirmed for only two provinces. For CPI inflation, 14 provinces are shown to respond significantly to the national output gap, while five were more sensitive to province-specific slack.

Given the relevance of the trade-off between inflation and the output gap for monetary policy, it is worth providing a brief review of China's monetary policy framework. The legal foundations regulating the functions of the People's Bank of China (PBOC) as a modern central bank were laid only in the mid-1990s with price stability stipulated as one of several key objectives. CPI inflation targets are set annually by the State Council in consultation with the PBC and have varied between 1% and 4.8% since the early 2000s. At the same time, given the multiple objectives, targets, and instruments used by the PBC, China does not operate under a conventional inflation-targeting regime. In terms of intermediate targets, quantity-based measures (such as the growth of M2) have played a more prominent role over the 2000s, although financial reforms and the liberalization of interest rates over the past decade have initiated a gradual shift towards price-based instruments (such as interest rates) (Girardin et al., 2017; Jones and Bowman, 2019).

3. Methodology

Our empirical model follows the standard specification of the Phillips curve given by:

$$\pi_{it} = \alpha + \beta_1 \pi_{i,t-1} + \beta_2 \tilde{y}_{it} + \eta_t + u_i + \varepsilon_{it} \tag{1}$$

where π_{it} is year-over-year inflation of province i in quarter t. We estimate the model for four different price indices described in the next section. $\tilde{y}$ is the output gap measured as the HP-filtered log GDP of province i in quarter t. The main coefficient of interest is β_2, the slope of the Phillips curve, which represents the sensitivity of inflation to the output gap.

Besides province fixed effects (u_i), the model in Eq. (1) also includes time fixed effects (η_t) which are important in the context of the regional Phillips curve because they control for monetary policy, long-run inflation expectations, and other national measures that vary over time but are constant across regions within a monetary union. In particular, Hazell et al. (2022) show for US states that the slope of the regional Phillips curve is considerably smaller than the national one, arguing that this is the result of time fixed effects absorbing the long-run inflation expectation. We also explore this aspect by comparing the slopes of the provincial and national Phillips curves in China.

We use two different techniques to estimate the Phillips curve in Eq. (1). The first one is a standard fixed effects (FE) model, which allows the intercepts to differ across groups but constrains the other coefficients to be the same. Accordingly, we obtain a single β_2 estimate for the slope of the provincial Phillips curve in China. The second approach adopts a mean group (MG) estimator suggested by Pesaran and Smith (1995), which allows the slope coefficient to differ across groups. The resulting β_2 in Eq. (1) is then the mean of the individually estimated $\beta_{2,i}$ coefficients for each province.

We determine whether the slope of the Phillips curve is homogeneous across Chinese provinces by comparing the two aforementioned estimators via a Hausman test. If the slope is indeed homogeneous, then both estimators are consistent but only the FE is efficient (null hypothesis). If the β_2 coefficient actually varies across provinces, MG is consistent while FE is not (alternative hypothesis). In other words, if the Hausman test fails to reject the null hypothesis, then the FE estimator is preferable to MG. If we reject the null hypothesis, then the MG estimator is superior to FE. In that case, the single slope coefficient representing the provincial average is still meaningful but compels us to explore regional heterogeneity in more detail.

4. Data

We employ quarterly data for 29 (out of a total of 31) Chinese provinces over the period 2000q1–2022q4, excluding Tibet due to the lack of data and Chongqing because data issues cause seasonal adjustment to fail. The year-over-year inflation is calculated for

Table 1
Descriptive statistics of inflation and the output gap by province, 2000–2022.

	CPI	PPI	RPI	PuPI	Output gap
Anhui	2.10 (2.11)	1.96 (5.12)	1.56 (2.22)	3.33 (6.45)	0.103
Beijing	1.93 (1.99)	−0.22 (2.62)	0.04 (1.79)	2.61 (6.92)	0.058
Fujian	1.91 (1.99)	0.40 (2.88)	1.18 (2.27)	2.44 (5.91)	0.031
Gansu	2.39 (2.13)	3.34 (9.39)	1.89 (2.22)	3.86 (9.37)	0.036
Guangdong	1.98 (2.07)	0.42 (2.66)	1.39 (2.24)	1.89 (4.93)	0.026
Guangxi	2.26 (2.51)	2.89 (5.88)	1.50 (2.64)	3.61 (6.44)	0.063
Guizhou	2.09 (2.39)	2.46 (4.83)	1.41 (2.48)	4.10 (6.60)	0.033
Hainan	2.29 (2.42)	1.42 (7.20)	1.68 (2.37)	3.21 (10.2)	0.090
Hebei	2.12 (2.03)	2.60 (8.41)	1.71 (2.10)	4.10 (8.63)	0.131
Heilongjiang	2.03 (2.18)	3.46 (10.9)	1.41 (2.36)	3.77 (8.13)	0.096
Henan	2.29 (2.23)	2.81 (5.05)	1.91 (2.44)	3.89 (5.68)	0.159
Hubei	2.25 (2.11)	1.79 (3.50)	1.59 (2.45)	3.16 (6.33)	0.066
Hunan	2.20 (2.01)	2.24 (4.47)	1.69 (2.10)	3.41 (6.01)	0.024
Inner Mongolia	2.16 (1.78)	3.60 (7.82)	1.63 (2.01)	4.13 (7.32)	0.095
Jiangsu	2.20 (1.80)	1.11 (4.06)	1.45 (1.97)	3.13 (7.67)	0.025
Jiangxi	2.10 (1.92)	2.89 (6.85)	1.46 (2.03)	3.68 (7.34)	0.048
Jilin	2.08 (1.94)	1.21 (3.39)	1.69 (2.16)	2.58 (4.60)	0.104
Liaoning	1.96 (1.92)	2.66 (5.68)	1.32 (2.23)	3.30 (6.28)	0.155
Ningxia	2.37 (2.25)	3.61 (7.57)	1.57 (2.45)	5.17 (9.37)	0.078
Qinghai	2.97 (2.39)	2.97 (8.27)	2.21 (2.60)	3.08 (5.77)	0.027
Shaanxi	2.17 (2.04)	3.26 (7.02)	1.62 (2.28)	3.58 (6.04)	0.143
Shandong	2.09 (1.75)	1.90 (4.69)	1.44 (1.88)	3.03 (5.72)	0.070
Shanghai	2.11 (1.76)	−0.03 (2.98)	0.72 (1.99)	2.04 (7.31)	0.040
Shanxi	2.24 (2.25)	4.15 (11.8)	1.41 (2.45)	4.15 (7.77)	0.063
Sichuan	2.34 (1.97)	1.74 (3.91)	1.66 (2.17)	3.29 (5.27)	0.059
Tianjin	2.02 (1.84)	0.36 (5.74)	0.99 (2.26)	3.00 (7.84)	0.205
Xinjiang	2.34 (2.33)	4.37 (13.9)	1.71 (2.70)	4.73 (11.6)	0.147
Yunnan	2.12 (2.31)	1.72 (5.43)	1.63 (2.41)	2.94 (5.53)	0.034
Zhejiang	2.05 (1.95)	0.97 (3.89)	1.50 (2.29)	2.88 (6.90)	0.034

Note: Average annual inflation with standard deviation in parenthesis using raw data. Last column reports the standard deviation of the output gap. CPI = Consumer Price Index. PPI = Producer Price Index. RPI = Retail Price Index. PuPI = Purchasing Price Index.

four price indices, reflecting different sets of tradables and non-tradables. The Consumer Price Index (CPI) measures the price of a representative basket of goods and services consumed by urban and rural households. The Producer Price Index (PPI) focuses on ex-factory prices for manufactured products from the first commercial transaction, excluding agriculture and services. The Purchasing Price Index (PuPI) reflects the prices of products purchased by industrial enterprises as intermediate inputs, such as raw materials, fuel, and energy.[2] The Retail Price Index (RPI) measures retail prices of goods but excludes services.

The price series are reported on a monthly basis by China's National Bureau of Statistics (NBS), while nominal GDP is available quarterly. We transform the monthly price data into quarterly by taking the corresponding three-month average. All variables are seasonally adjusted using the X-13 ARIMA-SEATS procedure.[3] Nominal GDP is converted to real by deflating it with the CPI. The output gap is estimated with the help of the Hodrick–Prescott (HP) filter.

The descriptive statistics of the two main variables (inflation and output gap) are reported in Table 1, revealing heterogeneity across Chinese provinces.

5. Results

5.1. Slope estimates

We estimate the provincial Phillips curve in Eq. (1) for four price indices and present the results for the full sample in the left panel of Table 2. One of the main objectives of our study is to test for regional heterogeneity of the slope of the Phillips curve. For this purpose, we estimate a FE model that generates a single slope estimate for all provinces and a MG model that averages the individually estimated provincial slopes. We determine which of the two models is the preferred option via a Hausman test.

To test the robustness of our results, we run the regressions for three reduced samples. The first one excludes the four autonomous regions (Guangxi, Inner Mongolia, Ningxia, and Xinjiang) and three metropolitan areas (Beijing, Shanghai, and Tianjin), and the corresponding estimates are presented in the right panel of Table 2. The second and third subsamples involve all 29 provinces but

[2] Two missing observations for PuPI (Inner Mongolia in June 2002 and Zhejiang in October 2002) are interpolated.
[3] Quarterly data has the added advantage of avoiding specific problems with the seasonal adjustment of monthly series due to moving holidays, such as the Chinese New Year.

Table 2
Phillips curve elasticity estimates for Chinese provinces, 2000q1–2022q4.

	Full sample			Reduced provincial sample		
	FE	MG	Hausman	FE	MG	Hausman
CPI	−0.005	−0.015	54.706	−0.005	−0.018	92.127
	(0.045)	(0.022)	(0.000)	(0.080)	(0.048)	(0.000)
PPI	−0.002	0.015	16.705	0.008	0.026	0.723
	(0.812)	(0.242)	(0.000)	(0.411)	(0.087)	(0.697)
PuPI	0.004	−0.003	0.398	0.010	0.001	0.244
	(0.521)	(0.829)	(0.820)	(0.186)	(0.970)	(0.885)
RPI	−0.002	−0.011	13.373	−0.008	−0.017	435.592
	(0.358)	(0.061)	(0.001)	(0.003)	(0.034)	(0.000)

Note: Reported coefficients represent estimates of β_2 from Eq. (1). p-values in parentheses. CPI = Consumer Price Index. PPI = Producer Price Index. PuPI = Purchasing Price Index. RPI = Retail Price Index. FE = fixed effects model. MG = mean group estimation. Reduced provincial sample excludes 4 autonomous regions and 3 metropolitan areas.

limit the time dimension to the pre-COVID period (2000q1–2019q4) and the years between the aftermath of the global financial crisis (the ''New Normal'') and the start of the pandemic (2009q1–2019q4), respectively. These results are shown in Table 3.

The slope coefficient is expected to carry a positive sign because an increase in the output gap produces inflationary pressures. Our findings for the full sample in the left panel of Table 2 reveal that we obtain negative signs when we measure inflation using CPI and RPI, while for the remaining two price indices (PPI and PuPI), coefficients are positive in some specifications but not statistically significant. To make sense of the results, we need to explore the likely role of tradables and non-tradables across the various price indices. We further need to determine the preferred specification based on the Hausman test.

Tradable goods are shared across Chinese provinces and their prices are likely to be determined at the national level. Consequently, the larger the share of tradables in a provincial price index, the weaker the inflation response to changes in the provincial output gap. By contrast, prices of non-tradables are much more sensitive to regional demand or supply shocks, making them more appropriate for investigating cross-regional variation in inflation. The CPI basket contains both tradables and non-tradables, although their composition changes every five years and their respective weights are not revealed by the NBS. Estimates indicate that between 2016–2019 goods made up 63% of the market basket, while services accounted for the rest (Qu, 2019).

The Hausman test for CPI clearly rejects the notion of regional homogeneity, pointing to MG as the preferred model and suggesting that the slope of the Phillips curve varies across Chinese provinces. This can be explained by the substantial share of services in CPI that are, for the most part, non-tradables. The negative and significant coefficients for CPI in Table 2 could be a reflection of the fact that provincial governments are keen on keeping the prices of basic goods and services in check through administrative measures during expansionary periods. In addition, the negative coefficient represents the average slope across provinces, meaning that some provinces might have the expected positive sign, while others exhibit a negative sign. We explore this aspect in more detail in the next section. The results for CPI are robust across all subsamples and subperiods in Tables 2 and 3.

With regards to the PPI, the Hausman test for the full sample rejects the null hypothesis and the preferred MG estimate has the expected positive sign but lacks statistical significance. Although the manufactured goods included in the PPI are generally tradables, the presence of regional heterogeneity might be explained by the specifics of PPI's measurement in China. One of the 5 key criteria for including a specific good in the index is that the good is representative of or typical for the locality where it is produced (*juyou difang tese de chanpin*). The emphasis on such goods is likely to make PPI more sensitive to changes in the local output gap. However, this result is not robust and seems to be driven by the pandemic and by a small number of provinces. Once we exclude metropolitan areas and autonomous regions (right panel of Table 2) or focus on the subperiods before 2019 (Table 3), regional homogeneity in the slope cannot be rejected. We speculate that the regional lockdowns and the limitations to interprovincial transportation during the pandemic might have boosted the importance of the local component of PPI.

The slope estimates for PuPI are positive but insignificant across all specifications in Tables 2 and 3. Raw materials, fuels, and energy that are included in PuPI are mostly priced at the national level, as they are often imported, produced, or delivered by large national state-owned conglomerates (e.g., Sinopec, CNPC). Accordingly, our estimation shows that PuPI inflation is not significantly linked to changes in the provincial output gap and the slope of the corresponding Phillips curve does not exhibit variation across provinces.

The results for RPI are very similar to those for CPI with negative coefficients, MG estimator as the preferred specification, and robustness across all subsamples and subperiods. One the one hand, this is expected given that RPI includes retail prices for consumer goods that are part of the CPI. The negative sign can also be explained by the administrative measures at the provincial level aimed at preventing inflation and by the fact that the MG estimate is an average of positive and negative slopes across provinces. On the other hand, the crucial difference between the CPI and RPI is that the latter excludes the prices for services and utilities. In other words, the RPI focuses on tradables goods and is, therefore, expected to be less responsive to changes in the provincial output gap. The fact that the coefficient is either not significant or only marginally significant at the 10% level for the pre-pandemic subperiods in Table 3 lets us speculate that the pandemic might be driving some of the results for the RPI, similar to the situation with the PPI.

Table 3
Robustness tests for two subperiods.

	pre-COVID			2009–2019		
	FE	MG	Hausman	FE	MG	Hausman
CPI	−0.004	−0.013	91.104	0.002	−0.008	93.763
	(0.111)	(0.049)	(0.000)	(0.641)	(0.422)	(0.000)
PPI	0.002	0.029	1.364	0.016	0.022	0.356
	(0.803)	(0.028)	(0.506)	(0.207)	(0.433)	(0.837)
PuPI	0.006	0.001	0.109	0.010	0.035	7.613
	(0.321)	(0.957)	(0.947)	(0.340)	(0.319)	(0.022)
RPI	−0.002	−0.011	19.508	0.000	−0.015	289.309
	(0.485)	(0.103)	(0.000)	(0.988)	(0.088)	(0.000)

Note: Reported coefficients represent estimates of β_2 from Eq. (1). p-values in parentheses. CPI = Consumer Price Index. PPI = Producer Price Index. PuPI = Purchasing Price Index. RPI = Retail Price Index. FE = fixed effects model. MG = mean group estimation. Pre-COVID sample covers the period 2000q1–2019q4.

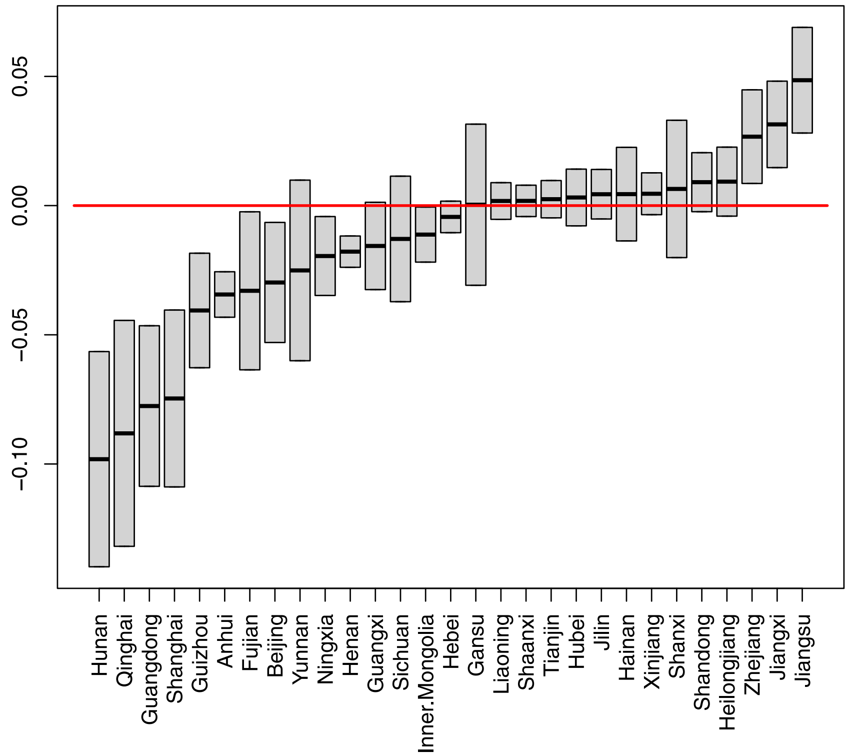

Fig. 1. Slope estimates of the regional Phillips curve with one standard error confidence bounds.
Note: Reported coefficients are estimates of β from Eq. (1) with one standard error confidence bounds obtained from the mean group (MG) estimator.

5.2. Regional heterogeneity

The results in Tables 2 and 3 reveal that the Hausman test fails to reject the null hypothesis of regional homogeneity for PPI, PuPI, and RPI at the 5% level, compelling us to conclude that the FE model is superior to MG for those three price indices, which, as explained in the previous section, is expected given the prominent share of tradables. Only in the case of CPI we identify MG as the preferred estimator across all specifications, producing a negative and statistically significant coefficient. Accordingly, we explore the regional heterogeneity of the CPI further by plotting in Fig. 1 the slopes of the Phillips curve for each province, estimated from the MG application to Eq. (1).

We observe that 15 out of 29 provinces (52%) exhibit a negative slope and the corresponding magnitudes are larger in absolute terms than for the positive slopes. This explains the unexpected negative sign of the CPI coefficient in Tables 2 and 3, which represents the average of the slopes in Fig. 1. Moreover, the composition of the provinces with positive and negative slopes offers some interesting insights. The ones with a positive slope include more coastal provinces and fewer western provinces. The confidence intervals indicate that only Zhejiang, Jiangsu, and Jiangxi have significantly positive slopes. The first two are among the wealthiest and most economically advanced coastal regions of China. The group of provinces with a negative slope includes not only more

Table 4
Phillips curve elasticity estimates for China, 2000q1–2022q4.

	CPI	PPI	PuPI	RPI
Constant	0.004**	−0.001	−0.002	0.001
	(0.002)	(0.004)	(0.006)	(0.002)
Inflation lag	0.834***	0.788***	0.782***	0.723***
	(0.054)	(0.069)	(0.069)	(0.072)
Output gap	0.060	0.026	0.015	0.118
	(0.050)	(0.198)	(0.279)	(0.090)
N	91	91	91	91
R^2	0.736	0.610	0.607	0.558
$adj R^2$	0.730	0.601	0.598	0.548
AIC	−577.59	−330.12	−267.43	−473.27

Note: Reported coefficients represent estimates of β_2 from Eq. (1) using quarterly data for China. Standard errors in parentheses. CPI = Consumer Price Index. PPI = Producer Price Index. PuPI = Purchasing Price Index. RPI = Retail Price Index. *** $p < .01$; ** $p < .05$.

Table 5
Correlations between the national and provincial output gap and CPI inflation.

	Output gap	Inflation		Output gap	Inflation
Anhui	0.170	0.560	Jiangxi	0.323	0.597
Beijing	0.215	0.558	Jilin	0.043	0.551
Fujian	0.662	0.457	Liaoning	0.041	0.553
Gansu	0.370	0.547	Ningxia	0.139	0.603
Guangdong	0.770	0.536	Qinghai	0.238	0.527
Guangxi	0.185	0.606	Shaanxi	0.139	0.563
Guizhou	0.167	0.633	Shandong	0.225	0.630
Hainan	0.154	0.516	Shanghai	0.443	0.540
Hebei	0.149	0.586	Shanxi	0.415	0.494
Heilongjiang	0.107	0.512	Sichuan	0.281	0.501
Henan	0.146	0.579	Tianjin	−0.022	0.475
Hubei	0.740	0.618	Xinjiang	0.126	0.575
Hunan	0.489	0.524	Yunnan	0.463	0.549
Inner Mongolia	0.031	0.519	Zhejiang	0.540	0.542
Jiangsu	0.704	0.603	**Average**	**0.291**	**0.554**

Note: Correlation coefficients between the output gap/inflation of China and each province over the entire sample period. The average is the mean across all correlation coefficients.

southwestern, western, and northwestern provinces, which are poorer and less developed, but also the two richest metropolitan areas (Shanghai and Beijing) and two of the most developed coastal regions (Guangdong and Fujian). The slopes for 11 of these provinces attain statistical significance, representing a mixed group of coastal (e.g., Shanghai and Guangdong), central (e.g., Anhui and Hunan), and western (e.g., Qinghai and Ningxia) regions. The composition of the positive/negative groups remains very robust across subsamples and subperiods.[4]

Next, we compare the slope of the regional Phillips curve with the national one for China, which is presented in Table 4. The slope of the national Phillips curve is positive across price indices as expected but does not attain statistical significance.[5] Moreover, the magnitude of the slopes is considerably larger than is the case for the regional Phillips curve in Tables 2 and 3. This matches the findings of Hazell et al. (2022) who construct and use regional price indices for non-tradables, arguing that national data are uninformative regarding the true relationship between inflation and the output gap due to endogeneity issues. Since we, by contrast, explore broad price indices that include tradables, the revelation of a flatter regional Phillips curve for China is not necessarily exclusively driven by an upward bias in the slope of the national Phillips curve, as speculated by Hazell et al. (2022). Given that China is a common market (even if accounting for a certain degree of fragmentation), prices are expected to respond less to local demand shocks due to interprovincial competition.

The differences between the slopes of the national and provincial Phillips curves raise the question of the effectiveness of a unitary monetary policy in the presence of regional heterogeneity. In Table 5, we report the correlation coefficients between the national and provincial levels of CPI inflation and the output gap. The relatively low correlation (0.29) for the output gap supports the view in the literature that business cycles are not well synchronized at the national and regional levels. Only three provinces record correlations of 0.7 and above, while almost half of the sample have correlations of less than 0.2. In the case of inflation, the

[4] The full sample and the pre-Covid sample are identical in both composition and ranking. The reduced sample exhibits the same provinces in the top and bottom quartiles as the full sample. These results are available from the authors upon request.

[5] It is difficult to compare our estimates in Table 4 to the exisiting literature due to different sample periods, data frequency, model specifications, and estimation techniques. Our results are largely in line with previous findings in the sense that we obtain positive slope coefficients for CPI and RPI, which are typically used to measure inflation. Moreover, a number of studies also report insignificant slope coefficients, like Zhang (2013) in his stylized specification over the period 1992–2011 or Vines and Scheibe (2005) in their backward-looking model for the 1990s.

Table 6
Determinants of the slope of the regional Phillips curve.

	(1)	(2)
Industry share	0.266**	0.239**
	(0.111)	(0.108)
SOE	0.345*	0.269*
	(0.179)	(0.154)
Trade	−0.001**	−0.001*
	(0.000)	(0.000)
Marketization	0.027**	
	(0.013)	
Market expansion		0.021*
		(0.011)
N	29	29
R^2	0.26	0.25

Note: Standard errors in parentheses. *** $p < .01$; ** $p < .05$; * $p < .10$.

correlation is higher but still moderate (0.55) and the dispersion is much smaller, ranging between 0.46 and 0.63. These findings suggest that regional heterogeneity in the slope of the Phillips curve presents a challenge for the PBOC to keep regional inflation in check through unitary policy measures.

5.3. Determinants of regional heterogeneity

The regional heterogeneity detected in the previous section calls for a further investigation of the factors that potentially influence the slope of the Phillips curve. Given the relatively small sample size, we select a few relevant variables and employ a simple cross-sectional regression to estimate their effect on the slope. The share of industry in provincial GDP stands for the level of economic development, while the share of state-owned enterprises (SOE) in the industrial sector is a proxy for the role of the government in the provincial economy. Trade is defined as the share of exports and imports in provincial GDP and measures the impact of tradables. The relevant statistics for each province were collected from the CEIC database and the annual values were averaged over the period 2000–2020.

Additional variables explore the broader institutional aspects of provincial economies in China. In particular, we employ the NERI (National Economic Research Institute) Marketization Index, which measures the advancement of the market economy in each province on an annual basis. The data were obtained from the annual NERI reports over the period 2000–2020 Fan and Wang, 2001; Wang et al., 2021. We include the overall marketization index which is averaged across four sub-indices, each ranging from 0 to 10. The four sub-indices measure, respectively, (1) the extent of market expansion relative to state intervention, and the development of the (2) private sector, (3) factor markets, and (4) product markets. In an alternative specification, we replace the overall marketization index with the sub-index for market expansion, which covers aspects related to lowering the tax burden on enterprises, reducing bureaucratic procedures and red tape, and scaling down the government apparatus.

The results of the estimation in Table 6 indicate that all coefficients are statistically significant and carry a positive sign, with the exception of trade. A larger share of industry increases the sensitivity of inflation to changes in the output gap, suggesting that more developed provincial economies will exhibit, on average, a steeper Phillips curve. SOEs are less likely to react to demand shocks by raising prices, be it because they are less exposed to market forces or because of political concerns about inflationary pressures. Trade focuses on tradables goods, whose price is much less responsive to province-specific shocks. It is, therefore, not surprising that the trade coefficient is negative and significant. The overall index of marketization is positively and significantly correlated with the slope of the Phillips curve, suggesting that the more advanced the market economy of a given province, the greater the responsiveness to market signals and the smoother the transmission mechanisms. In the same vein, the positive sign of the sub-index for market expansion signals that less red tape and a smaller government apparatus also contribute to a steeper Phillips curve.

6. Conclusion

This paper explores the response of price inflation to the output gap at the regional level in China over the past two decades. In particular, we provide estimates of the slope of the regional Phillips curve across four different price indices and test for regional heterogeneity by comparing a model with fixed effects and a mean group estimator. In contrast to previous studies on China, we employ quarterly data in a panel setting and include time fixed effects in the model, which absorb national effects common to all provinces. Furthermore, we investigate the potential determinants of the variation in the slope of the Phillips curve across provinces.

Our results indicate that regional heterogeneity in the slope of the provincial Phillips curve is confirmed only for the CPI across all subsamples and subperiods. The coefficients for the other three price indices are either not significant in the preferred specification or are not robust, which can be explained by the predominant share of tradables that weaken the response to province-specific output shocks. The mean group estimator for CPI produces estimates for the 29 provinces in our sample, half of which have the expected positive slope. Our findings point to the share of industry and a stronger market orientation as significant contributors to the sensitivity of inflation to provincial demand shocks, while trade openness is shown to have a negative impact on the slope of the Phillips curve.

From a policy perspective, our analysis suggests that the choice of CPI for inflation-targeting purposes has an adverse impact on the effectiveness of monetary policy in a monetary union with heterogeneous regions like China. The higher sensitivity of regional CPI inflation to changes in the local output gap is likely to make it more difficult for monetary authorities to achieve macroeconomic stability across provinces in the country. This is amplified by our finding of a relatively low correlation between the national and provincial output gaps as well as between the national and provincial inflation rates. Accordingly, the regional heterogeneity in the inflationary response, driven by differences in industrial structure, trade openness, and market advancement, will continue to present a challenge to policymakers at the national level.

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