The Disappeared Chinese Regional Phillips Curve

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Abstract

We use night light data as an proxy for output and wage data from micro sruvey to estimate a Phillips curve on a regional basis.

1 Introduction

2 Literature Review

An immense volume of literatures has analyzed Phillips curve in different versions. As reviewed by Schorfheide, most of them adopt DSGE or structure model like VAR to avoid the endogeneity problems of the expectation term as well as other model-specific endogenous variables. The results given by those empirical work, however, range from 0.001 to more than 4, almost filling the range one would preconceive as plausible. That indicates the dynamic property of Phillips curve.

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3 Data Description

We derive the real output per capita y and GDP deflator π based on national nominal and real GDP and population derived from CEIC China Database. GDP per capita is more in line with the none population growth setting of the model than its gross counterpart. That's nevertheless slightly problematic in that a baby boom doesn't increase labor supply and won't affect natural output, but will lower the nature output per capita. Thus we will observe an output gap even though all economic conditions are identical with that in line with the nature output. However, we assume it as a reasonable proxy since the population growth is much more stable than the output level.

4 Curve Estimates

In this sector, we first explain our theoretical model and its implications. Then we discuss the empirical results and compare it with the model's prediction.

We omit the deduction of the baseline Phillips curve1 that can be found in many textbooks (like Galí [2015]). Our focus is the slope of Phillips curve: $\kappa = (\sigma + \frac{\phi+\alpha}{1-\alpha})\lambda$, where $\lambda = \frac{(1-\beta\theta)(1-\theta)}{\theta} \frac{1-\alpha}{1-\alpha+\alpha\epsilon}$. Here $\hat{\mu}_t$ is the firms' extra price markup. $\frac{1}{\phi}$ is Frisch elasticity of labor supply. α is the capital share. σ is the parameter of CRRA utility. θ is the fraction of firms that can't reset their prices within a quater. ϵ is the goods' demand elsticity. β is the subjective discount rate. As in Galí's book,Under the baseline calibration of American economy that $\phi = 5, \beta = 0.99, \sigma = 1, \epsilon = 9, \alpha = 0.25, \theta = 3/4$, the slope terms are $\kappa = 0.17, \lambda = 0.02$, which are 0.68 and 0.08 annually.[1] However, the Phillips curves are steeper in those countries with a

[1] Annual inflation is 4 times of quarter inflation but log output gaps are the same whether it's

greater capital share. For example, assuming Chinese labor share is 0.7, the slope will increase to 1.32[2]. That indicates that the change in labor share is not neglectable for those countries away from the balanced path, facing structual changes like China. In that case, using $y_\alpha = \frac{1-\alpha}{2+16\alpha}\tilde{y}$ as the independent variable[3] would make more sense.

$$\pi_t = \beta E_t \pi_{t+1} + \lambda \hat{\mu}_t = \beta E_t \pi_{t+1} + \kappa \tilde{y}_t \tag{1}$$

This simplified model will also suffer from the unobservability of technology shocks which have impact on the natural level of output. The identification problem will be exacerbated in that the HP filter simply derive the cyclical part of output but can't tell whether it's caused by technological shocks or others like monetary or demand shocks, which doesn't impact the nature output. In order to address the issue, we provide additional support to our panel regression by adopting a DSGE model and try to identify the technology shocks.

4.1 National Level NKPC

We first use HP filter 2 to compute the output gap from real GDP time series. As suggested by Ravn and Uhlig, we take $\lambda = 6.5$ for annual data. We follow the method in most literature using GDP deflator as the index of inflation but also adopt CPI as an auxilliary price index.

$$\min_{\tau_t} \left[\sum_{t=1}^{T} (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} \{(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})\}^2 \right] \tag{2}$$

The Baseline OLS estimate, as shown in column (1), is higher than most empirical

computed annually or quarterly.

[2]Under the baseline calibration, $\kappa = \frac{1-\alpha}{2+16\alpha}$.

[3]Though using the term "independent variable", we're not attempting to pin down the causality.

results (but lies in the range [0,4]). Under the assumption that inflation is relatively persistent, the slope could be biased up by the expectation term. If we assume people somewhat have backward formed expectation, we can partly address this problem by adding lagged term of inflation as shown in column (2) and (4). We also try to strictly align our estimate with the structure model and choose $\pi_t - \beta E_t \pi_{t+1}$ as the dependent variable. We proxy the expectation term using the lagged terms in column (3) and the surveyed inflation expectation in column (4). Nevertheless, these estimates either want statistical support or still lies above what implied by theory or reported in literatures.

Table 1: National Level Baseline Regression

	(1)	(2)	(3)	(4)	(5)	(6)
y_hp	1.362^{*}	0.795^{+}	0.566	3.996	3.273^{**}	1.516
	(2.46)	(1.73)	(1.42)	(0.22)	(3.09)	(1.74)
_cons	0.0552^{***}	0.0331^{***}	0.00285	2.682^{***}	0.105^{**}	0.960^{***}
	(7.23)	(3.99)	(0.41)	(9.13)	(3.08)	(132.61)
Inflation	Deflator	Deflator	Deflator	CPI	CPI	CPI
Subtract_Epi	No	No	Lag	No	No	Forward
Lags	No	L1 2 4	No	No	L1 2 4	No
N	40	36	39	41	37	15
r2_a	0.158	0.461	0.021	-0.024	0.996	0.086

t statistics in parentheses

$^{+}$ $p < .1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Though the baseline regression (1) has a relatively convincing statistical result, it's prone to criticism for not including the inflation expectation of any form. However, the column (2) (4) shows that neither the lagged term of inflation nor the surveyed expectation can catch enough variation in inflation expectation. Therefore, the Phillips curve doesn't seems to stand on a solid base at the national level unless we identify the expectation term or reestimate with a more complicated model.

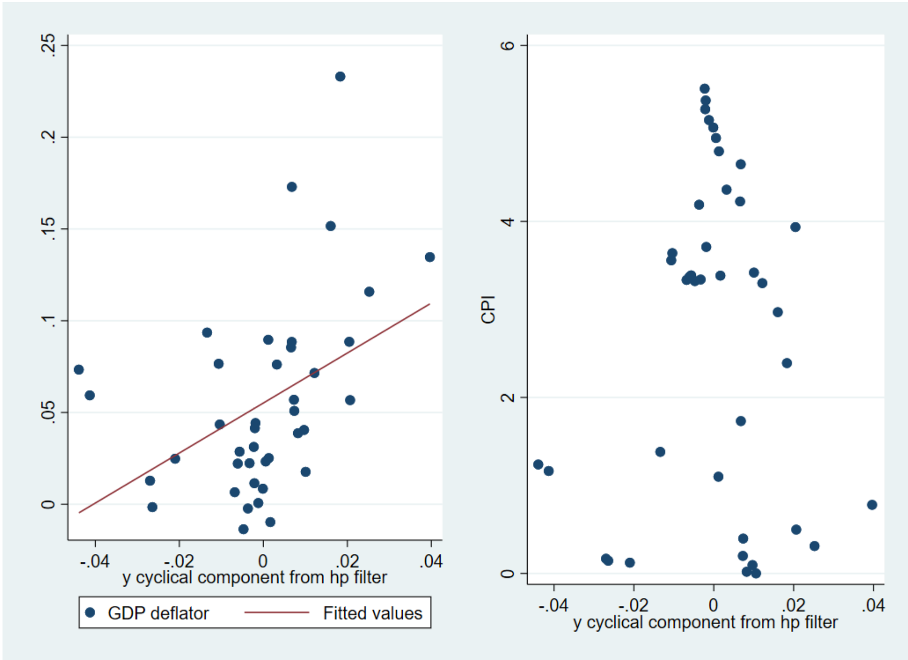

Figure 1: All observations: seemingly ramdom

4.2 Provincial Level NKPC

Unfortunately, the provincial level GDP deflator is not available. We instead deflate local GDP by national level GDP deflator, which can be verified more if the provinces have similar composition of their production. We will also use cpi to deflate nominal GDP and show that the result remains robust.

It's notoriously difficult to address the expectation term in Phillips curve whether by finding a proxy or use structured model. In this paper, one goal is to solve the dilemma using regional level data. There are two reasons for taking this approach. First, China didn't adopt its present economic institution until 1980s, which caused the scarcity of relevant national-level data compared to America. By using the province level data, we can greatly amplify our data and make the regression more robust. Second, the manipulation of interest rate and the vagueness of monetary policy rule make it hard to base the estimate on a structured model. Thus it's more convenient to contrive a method to identify the expectation term in the regression model. Now that all Chinese provinces are under a unified monetary and financial system while receiving shared information concerning macro policy or the fundamentals of economy that reasonably have impact on local economy, they will to some extent form their expectation about the local inflation based on the shared infomation . We assume that people's expectation is a combination of the past experience and the belief about the future. Then we can solve the expectation issue by using the lagged terms to proxy the backward looking part of the expectation and simply dispense with the effort on the forward looking part by letting the year fixed effect absorb it. Therefore, our baseline model3 is a regression equation containing both individual and year fixed effect.

$$\pi_{i,t} = \sum \alpha_i x_i + \sum \beta_t year_t + \kappa \tilde{y}_{i,t} + \epsilon_{i,t} \tag{3}$$

The graph below presents all the observations from 1980-2018. Each point represent a province in a year wich coordinate $(\tilde{y}_{i,t}, \pi_{i,t})$. Those observations as a whole seems totally random and we cann't see a positive relationship between inflation and output gap. Moreover, in 1990s there seems to be a significant negative relationship between the two variables. However, the graph is muted about the year and individual's fixed effect. Chances are that the seemigly random pattern is the result of a positive-slope Phillips curve moving from bottem-right to upper-left cross years.

In order to look deeper into this question, we first estimate the model without year or both individual and year fixed effects in column(1) and (2). Surprisingly, the estimated coefficient is significantly negative, probably due to the shift of Phillips

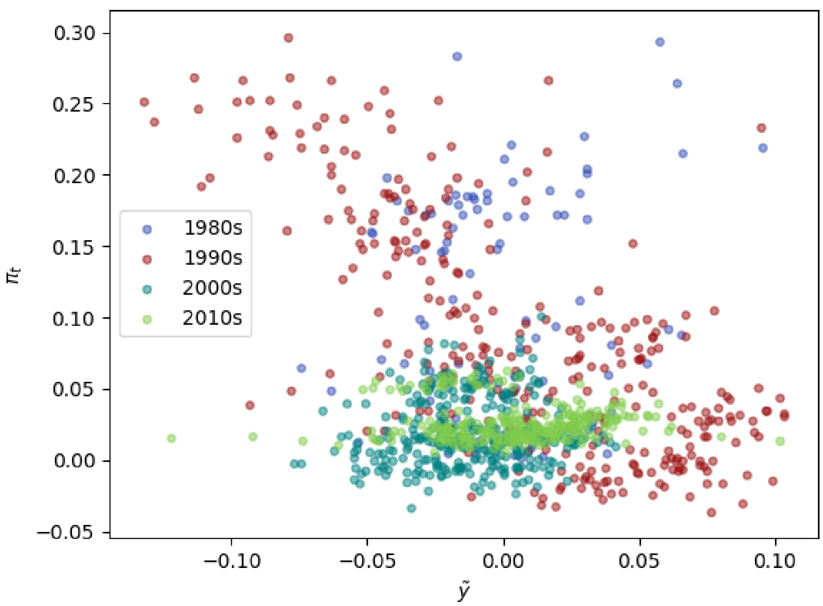

Figure 2: All observations: seemingly ramdom

curve cross time. In fact, that is the case of nearly all the provinces themselves alone. As shown in fig. 4, the negative relationship between local inflation and output gap is extremely prevailing. It's important to note that this result doesn't contradict the positive relationship between inflation and output gap observed at a national level. For example, one can conceive a country consist of two identical provinces in two years. The national observations in the output-gap-inflation system are the mid-points of the two provincial observations in the corresponding year, whose connection can be in any direction.

By similar reason, we can still expect a positive $\hat{\kappa}$ in out baseline model estimate in column(3) which would be in line with our model. The estimated slope 0.0952, which is close to the case where 60% of the firm can't ajust their price in one quarter and the labor income share is 50%. We also use y_α as our independent variable in column(4). Out estimate is higher than the coefficient implied by the theoretical model and baseline calibration, i.e. 1, but lies in a reasonable range. Finally, we try to pin down the backward expectation component by adding lagged 1,2 and 4 period terms of inflation into the regression. The results are shown in column (5) and (6), which is generally similar to baseline model.

We further investigate whether their is a "regional" version of Phillips curve for every single year. As shown in fig. 3, all the observations within one year lie close to a upward line. We tint each province with different color in order to justify that this result is not a simple fact of local variation. As we can see, and as guaranteed by HP filter, each province appear at different places of the line in different year. It's still ture if we subtract the backward expectation component from the inflation rate π_t.

Table 2: Provincial-level Baseline Regression

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	FE	FE	FE	FE	FE
ln_y_real_hp	-0.549***	-0.550***	0.0952*			0.0895*
	(-7.74)	(-9.24)	(2.16)			(2.15)
lny_alpha				1.928*	1.404+	
				(2.13)	(1.82)	
L.p					0.234**	0.235**
					(2.84)	(2.91)
L2.p					-0.112	-0.105
					(-1.37)	(-1.36)
L4.p					-0.0211	-0.0159
					(-0.39)	(-0.31)
_cons	0.0494***	0.0494***	0.0587***	0.0557***	0.0212***	0.0233***
	(25.81)	(1697.82)	(14.96)	(34.78)	(6.02)	(5.48)
Year FE	No	No	Yes	Yes	Yes	Yes
ID_FE	No	Yes	Yes	Yes	Yes	Yes
Cluster	No	Yes	Yes	Yes	Yes	Yes
Lags	No	No	No	No	L1 2 4	L1 2 4
N	980	980	980	845	810	855
r2_a	0.101	0.102	0.952	0.954	0.958	0.959

t statistics in parentheses

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

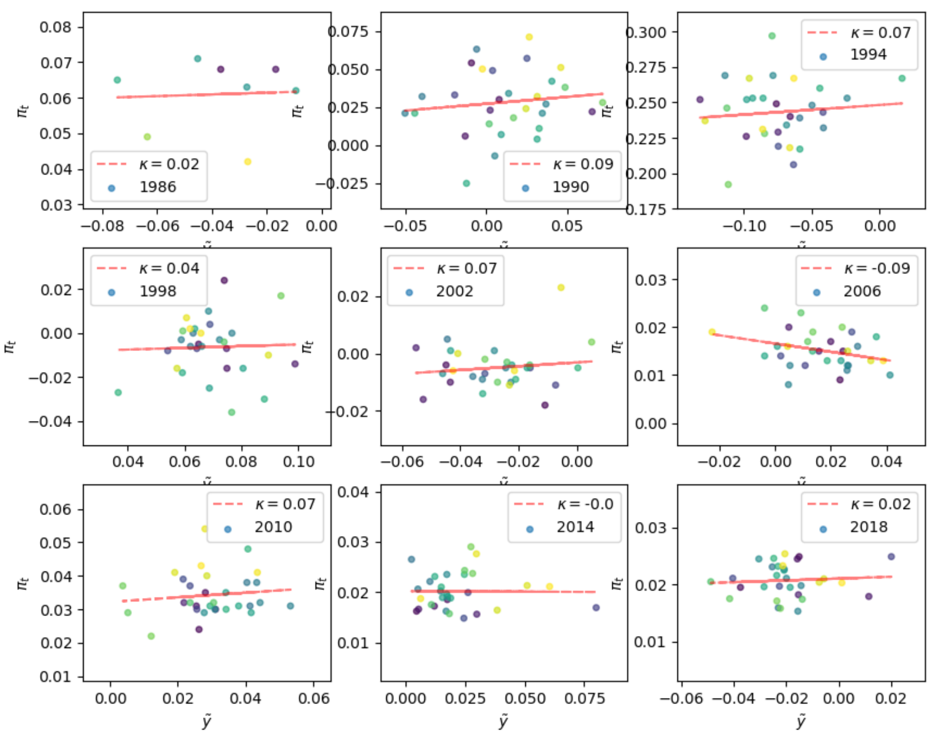

Figure 3: Observations in each year: Phillips Curves appear

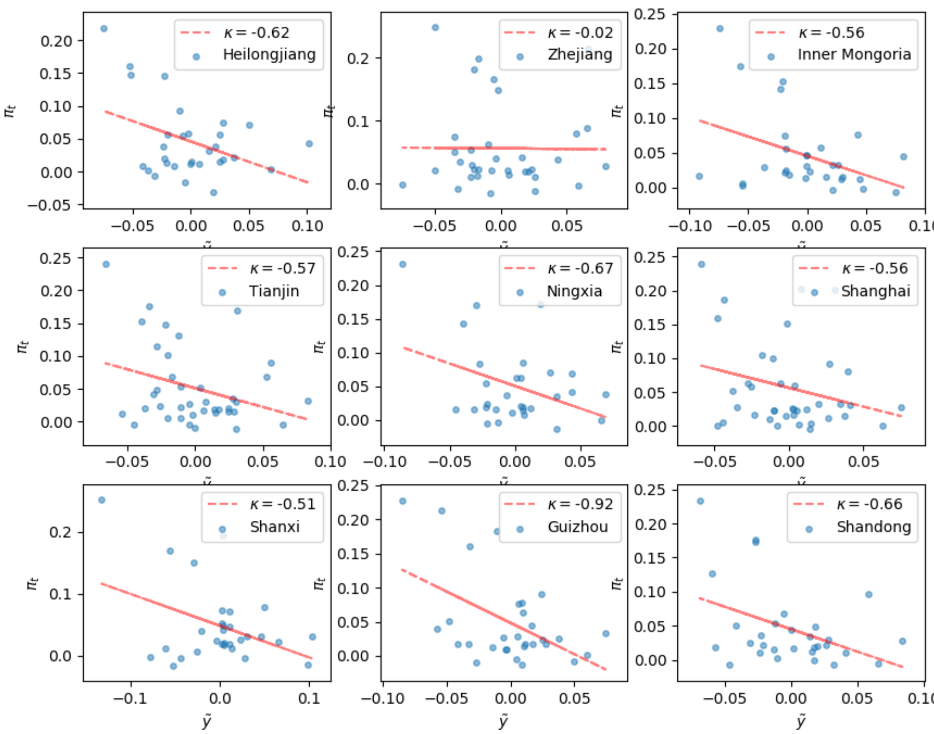

Figure 4: Observations in each province: ”negative slope puzzle”

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A Summary Statistics

Table 3: Summary Statistics

	(1) Provincial	
	mean	sd
ln real GDP per capita	8.61	1.64
GDP deflator (last year=1)	1.06	0.05
CPI	0.05	0.06
Observations	1209	