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Inflation dynamics and real marginal costs: New evidence from U.S. manufacturing industries

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ABSTRACT

This paper deals with the analysis of price-setting in U.S. manufacturing industries. Recent studies have heavily criticized the ability of the New Keynesian Phillips curve (NKPC) to fit aggregate inflation (see, e.g., Rudd and Whelan, 2006). We challenge this evidence, showing that forward-looking behavior as implied by the New Keynesian model of price-setting is widely supported at the sectoral level. In fact, current and expected future values of the income share of intermediate goods emerge as an effective driver of inflation dynamics. Unlike alternative proxies for the forcing variable, the cost of intermediate goods presents dynamic properties in line with the predictions of the New Keynesian theory.

1. Introduction

In the last decade the New Keynesian Phillips curve (NKPC hereafter) has become an important workhorse in the study of inflation dynamics. In light of the key role played by this relationship in modern monetary policy analysis, a vast literature has developed with the aim of testing its validity on empirical grounds. To this end, most of the existing contributions have relied on aggregate data. Among others, Galí and Gertler (1999), Woodford (2001) and Sbordone (2002) report evidence in support of the NKPC. More recently, their findings have been extensively criticized in a series of papers by Rudd and Whelan,[1] who show that the type of rational forward-looking behavior embodied in the NKPC finds poor empirical support. The present paper contributes to this debate, showing that aggregation plays a central role in the analysis of Rudd and Whelan.

We explore inflation dynamics in U.S. manufacturing industries defined at the SIC 4-digit level. Looking at sectoral inflation is important in that it allows us to account for the role of heterogeneous price-setting[2] in producing biased estimates of the "aggregate" NKPC. As in Rudd and Whelan (2006), we focus on the testable implications of the closed-form solutions to both purely forward-looking and hybrid versions of the NKPC. Our evidence suggests that imposing sectoral homogeneity may result in overstating the relative importance of lagged inflation, while under-estimating the

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[1] See Rudd and Whelan (2005a,b,2006). Rudd and Whelan (2007) survey the main results in this strand of the literature.

[2] A number of papers exploring sectoral price-setting indicate that the degree of price rigidity can change markedly across sectors (see, e.g., Bils and Klenow, 2004; Dhyne et al., 2005; Nakamura and Steinsson, 2008).

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impact of current and future expected realizations of the driving term. This result bears close resemblance with that of Imbs et al. (2007), who are primarily focused on the direction and magnitude of the bias in aggregate estimates.[3] We complement their study, showing that aggregation plays a central role also in the empirical validation of forward-looking behavior as implied by the NKPC. Employing an appropriate proxy for the driving term of inflation dynamics is paramount to our results, as the selected variable needs to display dynamic properties in line with the predictions of the New Keynesian theory (see Galí and Gertler, 1999). We consider both cost-based measures and detrended output at the sectoral level. Among these variables, only the income share of intermediate goods implies a counter-cyclical mark-up, while co-moving negatively (positively) with past (future) inflation, as postulated by Rotemberg and Woodford (1991).

We document widespread sectoral evidence in support of the price-setting mechanism embodied in the NKPC. Specifically, a hybrid NKPC featuring preponderance of forward-looking price setters can closely predict inflation dynamics in a large number of sectors, although most of inflation variability is accounted for by its lagged term. Most importantly, the slope of the NKPC is on average significant for the manufacturing industry as a whole, with the sectoral estimates indicating that current and expected future values of the income share of input materials exert a statistically significant (and economically meaningful) impact on the rate of inflation in a large number of sectors.[4] We also show that our implied estimates of price rigidity are in substantial agreement with those obtained by Nakamura and Steinsson (2008) from highly disaggregated U.S. data on producer price indices. This evidence reinforces our confidence in the NKPC as a plausible model of price-setting: although the estimated impact of the forcing variable may generally appear rather low, yet it reflects empirically relevant frequencies of price changes.

The remainder of the paper is laid out as follows: Section 2 sketches a simple model for the analysis of sectoral inflation dynamics; Section 3 presents the dataset and some preliminary results on the fit of alternative dynamic specifications of the NKPC; Section 4 presents evidence from the GMM estimation of the NKPC and examines the role of heterogeneity in producing biased estimates at the aggregate level; Section 5 includes additional evidence in support of the results presented in the previous section; Section 6 concludes.

2. Sectoral inflation dynamics

Consider an economy with I sectors of production, each sector being composed of a continuum of firms producing differentiated products. The production of each good is carried out by combining intermediate goods and labor. Specifically, the zth firm in the ith sector employs a Cobb–Douglas production technology with constant returns to scale

$$Y_{it}(z) = M_{it}(z)^{1-\alpha_i} L_{it}(z)^{\alpha_i}, \tag{1}$$

where $Y_{it}(z)$, $L_{it}(z)$ and $M_{it}(z)$ denote the gross product, labor and material inputs employed by firm z in sector i, respectively. At any given period, each firm minimizes its cost of production to meet demand at the equilibrium price. The first order conditions from this problem result into the following relationships:

$$MC_{it}(z)Y_{it}(z) = \frac{W_{it}L_{it}(z)}{\alpha_i} = \frac{P_{it}^M M_{it}(z)}{1-\alpha_i}, \tag{2}$$

where $MC_{it}(z)$ is the nominal marginal cost faced by firm z in sector i, while W_{it} and P_{it}^M denote the nominal wage and the price of the bundle of input materials in the ith sector. Under the assumption of within-sector homogeneity, (2) implies that the sector-specific real marginal cost (RMC_{it}) is proportional to the labor share of income ($S_{it}^L \equiv (W_{it}L_{it})(P_{it}Y_{it})^{-1}$) and the income share of intermediate goods ($S_{it}^M \equiv (P_{it}^M M_{it})(P_{it}Y_{it})^{-1}$).

Assuming that firms are able to reset their prices at random intervals of time (Calvo, 1983) implies that the rate of inflation can be expressed as a function of expected inflation and the real marginal cost. Linearizing and aggregating the pricing decisions of firms in each sector produces the following sector-specific NKPC:

$$\pi_{it} = \beta E_t \pi_{it+1} + \gamma_i(rmc_{it} + \phi_i) + \eta_{it}, \quad \forall i, \tag{3}$$

where π_{it} denotes sector-specific inflation, rmc_{it} is the logarithm of the real marginal cost in the ith sector, η_{it} is an iid exogenous cost-shifter, β denotes the steady-state discount factor, $\phi_i = \log(\epsilon_i/(\epsilon_i - 1))$ is the steady-state sector-specific mark-up (where ϵ_i denotes the elasticity of substitution between goods produced in the ith sector) and $\gamma_i = (1-\beta\theta_i)(1-\theta_i)\theta_i^{-1}$, where $1-\theta_i$ is the probability faced by sector i producers of being able to reset prices in a given period.

A key implication of the NKPC is that inflation depends on current and expected future realizations of the forcing variable

$$\pi_{it} = \gamma_i E_t \sum_{s=0}^{\infty} \beta^s x_{it+s} + \eta_{it}, \tag{4}$$

[3] Imbs et al. (2007) base their study on the initial premise that both the forward and backward looking terms in the NKPC are relevant for inflation dynamics, as earlier established by Galí and Gertler (1999). As such, their analysis may be subject to the criticism expressed by Rudd and Whelan (2005b).

[4] Alternatively, using other proxies, such as detrended output and the labor income share, returns poor evidence.