



A tale of two correlations: Evidence and theory regarding the phase shift between the price level and output



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ABSTRACT

We examine the relationship between the price level and output at business-cycle frequencies. In the postwar period, there is evidence of a phase shift between the price level and output. Such a phase shift is manifested in the price level being countercyclical and the inflation rate being procyclical or acyclical, depending on the detrending method used. Our examination takes three approaches. First, we apply bootstrapping methods to characterize the two correlations, though the methodology could easily be extended to any set of facts. Second, we specify a model economy with forecast heterogeneity, showing numerically that this model economy can match the observed pair of correlations. Third, we apply robust control theory, deriving conditions in which the price level is countercyclical and the inflation rate is procyclical.

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1. Introduction

In the post-World War II period, there is evidence of phase shift between the price level and output at business cycle frequencies. We see evidence of the phase shift in the unconditional contemporaneous correlation between the price level and output and the inflation rate and output: the price level is procyclical and the inflation rate is either procyclical or acyclical, depending on the detrending method used.

In this paper, we offer two main findings. First, we develop a data-disciplined methodology that answers questions aimed at characterizing the likelihood of joint facts. Second, we introduce a costly forecasting technology into a model economy and use numerical methods to demonstrate that such a model can account for the countercyclical prices and acyclical inflation. This is a tale of two correlations and the phase shift that unifies them. This paper offers a first step toward treating the two correlations jointly.²

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² See Brock and Hommes (1997) for an example of multiple forecasting technologies.

1.1. Some background

Kydland and Prescott (1990) initiated this research line when they reported that after filtering for the business-cycle component, the price level is negatively correlated with output.³ Other researchers began testing the robustness of this finding. Cooley and Ohanian (1991) and Smith (1992) extend the sample. The two papers broadly agree that before World War II, the evidence suggests the price level was procyclical.⁴ After World War II, however, the evidence is consistent with Kydland and Prescott's finding that the price level has been countercyclical.

Cooley and Ohanian also consider the set of business cycle facts to examine the relationship between the cyclical component of the inflation rate and output. They report that inflation rate is procyclical during the post-war sample. Webb (2003) and Kanstantakoulou et al. (2009) are more recent contributions. Webb is especially clear on the stakes involved in the issue of procyclicality of the price level. He states, "The issue is of particular importance to macroeconomists who must choose which model to work with."⁵ Kanstantakoulou et al. investigate the robustness of countercyclicality of the price level and procyclicality of the inflation rate for 9 OECD countries using quarterly data, 1960–2004. For example, they state, "We examine the stylized facts ...prices are countercyclical; inflation is procyclical."⁶ Given the deterministic relationship between the price level and the inflation rate, the qualitative difference deserves attention.

Researchers have debated the implications associated with a countercyclical price level. One debate has centered on the competing role of demand shocks and supply shocks as a source or business cycle fluctuations. Kydland and Prescott asserted the following: "We caution that any theory in which procyclical prices figure crucially in accounting for postwar business cycle fluctuations is doomed to failure." (p. 17, 1990).

Researchers responded along two fronts. One approach focused on the relationship between prices and output at business cycle frequencies. In particular, den Haan (2000) asked why the unconditional correlation coefficient the appropriate measure of comovement between the price level and output? In doing so, den Haan proposes using correlations of k -step-ahead forecast errors from VARs which allows the researcher a richer dynamic set of correlations. Based on this evidence, den Haan counters with the argument that "a theory in which prices do not have some procyclical feature is, at best, missing a part of the explanation of U.S. business cycle fluctuations." (p. 5, 2000).

The other approach focused on showing that sticky-price models can account for relationship between the price level and output. Chadha and Prasad (1994), Ball and Mankiw (1995) and Judd and Trehan (1995) specify versions of sticky price models in which only demand shocks are considered. Each shows that model economies are capable of accounting for the negative unconditional correlation coefficient observed between some detrended versions of output and the price level.⁷ Rotemberg (1996) examines forecastable movements in output and the price level, showing that they are negatively correlated. In a sticky-price model with only demand shocks, Rotemberg can account for the relationship between the forecastable parts of output and the price level.

In a series of recent papers, researchers have examined the role of heterogeneous expectations on business cycle facts. More specifically, building on Brock and Hommes, these researchers are building model economies with cognitive limitations that are manifested in expectations formations. De Grauwe (2011) builds a model populated with optimists and pessimists. In his model economy, the correlation of beliefs produces waves of optimism and pessimism. Indeed, these waves cause business cycle fluctuations akin to Keynes' animal spirits. Branch and Evans (2011) study economies in which agents select best-performing statistical models to compute expected values. Armed with the perceived laws of motion, Branch and Evans use the model to study volatility in inflation and output growth. Massaro (2013) studies a model economy in which there is a combination of agents with cognitive limitations and others with rational expectations.

It is crucial to make that we differentiate our paper from Rotemberg and den Haan. In those two papers, the authors were interested in studying the relationship between output and the price level at business cycle frequencies. Den Haan focused on deriving what the facts were. Rotemberg was interested in developing a Calvo-style sticky price model in which monetary policy shocks alone could match the facts. Rotemberg can account for the negative correlation between predictable output and predictable price movements over long horizons. Throughout his analysis, Rotemberg focuses exclusively on the correlation of expected and unexpected movements in prices, output, and hours. Our contribution is clear in that our aim is to account for the (unconditional) correlation between prices and output and between inflation and output.

Webb (2003) stresses the difference in behavior between commodity prices, final goods prices, and wages over the business cycle. Webb argues that there are key differences in the price-setting institutions: commodity prices are set in spot

³ Kydland and Prescott reported this result because it contradicted the maintained hypothesis that the price level was procyclical. In their view, theory was needed to account for the negative relationship.

⁴ In Cooley and Ohanian, the evidence is ambiguous before World War I. During the interwar period, they report that the price level is procyclical. In Smith, the evidence is that the price level is procyclical before the Great Depression.

One possibility is that there is more than one data-generating process relevant so that as one the researcher looks across the set of business cycles, the correlations change. Wolf (1991) if one looked at the categories of consumer goods, he found that the price indexes and output were positive prior to 1973. Haslag and Hsu (2012) present evidence that there is no structural break in the relationship between the price level and output.

⁵ See Webb (2003, p. 69).

⁶ See Kanstantakoulou et al. (2009, p. 1).

⁷ The intuition rests on output being mean reverting. Given a positive aggregate demand shock, output increases. Because prices were sticky, output would begin falling (mean reverting) and prices would increase eventually, causing real balances to decline and output to decline further. Of course, introduction of sticky prices into the model economy raises another question; specifically, why are prices sticky?

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