

Dynamics of the U.S. price distribution<sup>☆</sup>David Berger<sup>a,b</sup>, Joseph Vavra<sup>c,\*</sup><sup>a</sup> Northwestern, United States<sup>b</sup> NBER, United States<sup>c</sup> Chicago Booth, United States

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## ABSTRACT

We use microdata underlying U.S. consumer, producer and import price indices to document how the distribution of price changes evolves over time. Two striking features characterize pricing across all three datasets: (1) Frequency of price adjustments is countercyclical. (2) Frequency of price adjustments is correlated with variance. Conversely, other statistics that have received recent attention, like kurtosis, do not exhibit uniform patterns across our data sets. What implications do our empirical results have for monetary policy? Using a flexible accounting framework that collapses the high-dimensional distribution of price changes into a single measure of aggregate price flexibility, we show that flexibility is highly variable and countercyclical.

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## 1. Introduction

A growing literature argues that the *microeconomic* distribution of price changes matters for *macroeconomic* price flexibility and thus monetary policy. In this paper, we extend the existing empirical literature by systematically documenting the time-series evolution of the entire distribution of U.S. price changes at different stages of the distribution chain. Using the Bureau of Labor Statistics (BLS) microdata that underlies the Consumer, Producer and Import Price Indices we show that there are important common patterns in the distribution of price changes over time. We then explore the implications of this variation for aggregate price flexibility. Using a simple, flexible accounting framework we argue that price flexibility rises in recessions.

While there has been widespread attention to first moments<sup>1</sup> of the price change distribution, there has been much less empirical study of higher moments of the distribution and their relationship to the broader business cycle.<sup>2</sup> Furthermore, existing studies have focused on particular moments and data sets in isolation, which makes it more challenging to identify

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<sup>1</sup> Studies typically focus on e.g. the frequency and size of price changes and their relationship to inflation.

<sup>2</sup> Klenow and Malin (2010) and Vavra (2014) are exceptions

robust features of pricing behavior.<sup>3</sup> In this paper, we show that there are striking common patterns in the distribution of price changes across retail, producer and import prices, but there are also certain features that are unique to particular data sets.

We systematically report time-series statistics for numerous moments and percentiles that go well beyond the existing literature, and several empirical regularities emerge from this analysis: (1) There are large movements across time in all percentiles of the distribution of price changes. (2) The frequency of adjustment is positively correlated with the variance of price changes. (3) The frequency of adjustment and variance of price changes are strongly countercyclical. We show that these basic facts hold across each of our data sets and regardless of how price series are filtered.<sup>4</sup> Conversely, some patterns related to higher moments of the distribution of price changes differ across CPI, PPI and IPP data, or are sensitive to measurement issues. In particular: (4) Various measures of price change kurtosis are strongly procyclical and are negatively correlated with frequency in the CPI, but not in PPI or IPP data. (5) Statistics related to skewness are highly sensitive to the particular measure used and also vary substantially across data sets.

Why is it important to study the distribution of price changes and what should we take from the array of statistics computed in the first half of the paper? Microeconomic price-setting behavior influences the degree of aggregate price flexibility, which will in turn have strong implications for the real response of the economy to nominal shocks. While existing studies have focused on particular data sets in isolation, studying price flexibility comprehensively combining data at the dock for import prices, at the producer-wholesale level and at the consumer-retail level is important for assessing the overall degree of price flexibility in the economy. In the second half of the paper, we introduce an accounting framework that allows us to collapse the complicated high dimensional distribution of price changes at each point in time into a single, easily interpretable measure of price flexibility. We then show that price flexibility in each data set representing different distribution stages is countercyclical, which amplifies the conclusions reached from studying any one data set in isolation.

Constructing measures of price flexibility necessarily requires introducing additional structure, but we try to do so in a highly flexible way. For example, in a Calvo model, firms are selected to adjust prices at random so aggregate price flexibility is completely determined by the average frequency of adjustment. At the opposite extreme, in the [Caplin and Spulber \(1987\)](#) model, adjusting firms change prices by such large amounts that the aggregate price level is fully flexible regardless of the underlying frequency of adjustment. Rather than taking a strong stand on a particular price-setting environment, we use a version of the generalized Ss model of [Caballero and Engel \(2007\)](#), which nests many of these extremes. Furthermore, we estimate this model using a highly flexible functional form which imposes minimal restrictions on the distribution of desired price changes at a point in time and no restrictions on the evolution across time.

The flexible modeling framework of [Caballero and Engel \(2007\)](#) is useful for summarizing our somewhat complicated pricing facts and their implications for how price flexibility varies over time. We show that greater frequency, greater variance and smaller kurtosis are all associated with greater price flexibility in this model. In contrast, the skewness of firms' desired price changes has little relationship with aggregate price flexibility. Thus, movements across time in the frequency of adjustment, variance or kurtosis of price changes should be associated with movements in aggregate price flexibility. When viewed through the lens of our model, we find that most of the time-series patterns we document in the BLS data imply time-varying flexibility that rises during recessions. That is, aggregate price flexibility is both highly variable and strongly countercyclical.

What drives time-series variation in price flexibility in general and countercyclicity of price flexibility in particular? We find that for understanding overall fluctuations in price flexibility within a given data set, time-series changes in frequency plus many higher moments of the distribution are important. This implies that a Calvo model that exogenously matched the frequency of adjustment across time would substantially understate the time-variation in price flexibility in the data. While overall fluctuations in price flexibility are driven by the whole distribution of price changes, we find that *countercyclicity* of price flexibility is largely driven by countercyclical frequency and variance. Interestingly, these are also the statistics that exhibit stable patterns across data sets. Other moments such as skewness and kurtosis can drive movements in idiosyncratic price flexibility with a data set, but they do not exhibit robust cyclical patterns or commonality across data sets.

Many recent papers have used fully specified structural models to argue that the distribution of price changes has important implications for aggregate price flexibility. For example, [Midrigan \(2011\)](#) and [Alvarez et al. \(2014\)](#) show that theory assigns a large role to the price change distribution in shaping the average response of inaction to nominal shocks. [Vavra \(2014\)](#) argues that similar mechanisms lead to increases in price flexibility during recessions, and [Luo and Villar \(2017\)](#) argue that looking at the skewness of price changes is important for differentiating pricing models during the Great Inflation. While they concentrate on various different statistics such as kurtosis, variance, and skewness, the common theme to these structural models is that higher moments matter.

<sup>3</sup> For example, using CPI data, [Vavra \(2014\)](#) and [Alvarez and Lippi \(2014\)](#) explore the implications of the variance of price changes for monetary policy while [Midrigan \(2011\)](#), [Alvarez et al. \(2014, 2016\)](#) focus on the implications of kurtosis. [Berger and Vavra \(2017\)](#) focus on the implications of variance in IPP import price data.

<sup>4</sup> It is important to note that many, but not all of these empirical facts are new. In particular, all of the empirical facts relating to “centered moments” of the CPI from an earlier draft of this paper were subsumed in [Vavra \(2014\)](#). In particular, Table 1 in [Vavra \(2014\)](#) documents that the frequency is countercyclical as well as the business cycle co-movement of the variance, skewness and kurtosis of the distribution of price changes. [Berger and Vavra \(2017\)](#) document the countercyclical standard deviation of price changes in IPP data. All remaining statistics are to the best of our knowledge new to this paper.

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