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Estimation of historical inflation expectations

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Abstract

Expected inflation is a central variable in economic theory. Economic historians have estimated historical inflation expectations for a variety of purposes, including studies of the Fisher effect, the debt deflation hypothesis, central bank credibility, and expectations formation. I survey the statistical, narrative, and market-based approaches that have been used to estimate inflation expectations in historical eras, including the classical gold standard era, the hyperinflations of the 1920s, and the Great Depression, highlighting key methodological considerations and identifying areas that warrant further research. A meta-analysis of inflation expectations at the onset of the Great Depression reveals that the deflation of the early 1930s was mostly unanticipated, supporting the debt deflation hypothesis, and shows how these results are sensitive to estimation methodology.

JEL classification: N11; N12; N13; N14; E30; E31; D84
Keywords: Inflation expectations; Fisher effect; gold standard; Hyperinflation; Great Depression; Rational expectations; Debt deflation

1. Introduction

Expected inflation is a variable of central importance in economic theory. Inflation expectations appear in two of the most empirically scrutinized macroeconomic relationships, the Fisher effect and the Phillips curve. Today, central banks around the world devote considerable resources to monitoring the inflation expectations of consumers, forecasters, and financial market participants using surveys and financial data. But for much of economic history, such indicators do not exist. In this piece, I survey the approaches used to estimate historical inflation expectations, highlight key methodological considerations, and introduce a new approach using quantitative news analysis.

I group approaches to estimating historical inflation expectations into three main categories: time series, market-based, and narrative. Time series approaches use univariate or multivariate statistical methods to construct inflation forecasts and use these forecasts as proxies for historical agents' expectations. Market-based approaches use asset prices to make inferences about inflation expectations. The narrative approach entails examination of news articles or other records to gather information about what agents believed and expected.

All three approaches have been employed to test for the presence of the Fisher effect during the classical gold standard era (Barsky and DeLong, 1991; Perez and Siegler, 2003; Mitchener and Weidenmier, 2010). Motivated by the work of Cagan (1956), researchers have also estimated inflation expectations in the 1920s hyperinflation economies (Frenkel, 1977; Garber, 1982).

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Explanations of the onset of the Great Depression hinge on whether deflation was anticipated, while explanations of the recovery depend on when positive inflation expectations reappeared, and whether a "regime change" under Roosevelt generated inflationary expectations (Cecchetti, 1992; Temin and Wigmore, 1990; Eggertsson, 2008; Jalil and Rua, 2015).

Table 1 summarizes the papers that estimate inflation expectations in these eras by category of approach. Different approaches to estimating inflation expectations lead to different results, and even papers that use the same category of approach can obtain different results depending on data selection and other choices. For example, Fig. 1 plots three estimates of expected inflation from 1928 to 34. These and other estimates differ in the extent to which deflation was anticipated and in the timing of the return of positive inflation expectations.

The primary challenge of estimating historical inflation expectations is that it requires inferring what agents *would have* expected, given their information sets and models of the economy, not what agents *could have* expected using modern econometric methods and data. *Forecastable* is not equivalent to *expected*, but time series approaches use the former as a proxy for the latter. For example, many early studies of the pre-war classical gold standard era estimate univariate time series models of inflation to measure its persistence. Findings of low persistence are interpreted as evidence that inflation was unforecastable based on its lags, and therefore that expectations were roughly constant.

Investors in the Great Depression era and earlier certainly did not explicitly use time series methods to forecast inflation before these methods were invented or sufficient computing power was available. The question is whether they used rules of thumb that would resemble the results of such methods. This is not implausible; Fisher (1930) notes that "if inflation is going on, [businessmen] will scent rising prices ahead," possibly *as if* they used a simple autoregressive model of inflation dynamics.

Estimation of inflation expectations via the time series approach is very sensitive to the choice of price index used to construct the inflation measure. Wholesale price data displays less persistence than retail price data (Hanes, 1999). Measurement error also leads to underestimation of inflation persistence through attenuation bias. This can lead to a false conclusion that inflation was unforecastable based on its own lags, even if businessmen did form expectations adaptively. Estimation of models of inflation dynamics should ideally use real-time data and construct out-of-sample forecasts that are more likely to resemble forecasts that could have feasibly been made ex ante. Even with real-time data, however, the time series approach will not detect a regime change in inflation expectations, as is hypothesized to have occured in 1933.

Table 1
Approaches to estimating historical inflation expectations in the literature.

	Time Series	Narrative	Market
Classical gold standard	Fisher (1930) Sargent (1973a) Shiller and Siegel (1977) Barsky (1987) Benjamin and Kochin (1984) Barsky and DeLong (1991) Perez and Siegler (2003)	Barsky and DeLong (1991)	Perez and Siegler (2003) Mitchener and Weidenmier (2010)
Hyperinflation	Cagan (1956) Sargent and Wallace (1973) Salemi (1976) Khan (1977)		Frenkel (1977) Garber (1982) Webb (1986)
Great Deflation	Dominguez et al. (1988) Cecchetti (1992) Romer (1992) Evans and Wachtel (1993) Fackler and Parker (2005) Dorval and Smith (2013) Davis (2015)	Dominguez et al. (1988) Nelson (1991) Evans and Wachtel (1993) Klug et al. (2005) Romer and Romer (2013)	Hamilton (1987); Hamilton (1992) Voth (1999) Fackler and Parker (2005)
Recovery from Great Depression	Dominguez et al. (1988) Cecchetti (1992) Romer (1992) Eggertsson (2008) Davis (2015)	Jalil and Rua (2015) Orphanides (2004) Klug et al. (2005)	Temin and Wigmore (1990) Hamilton (1992)

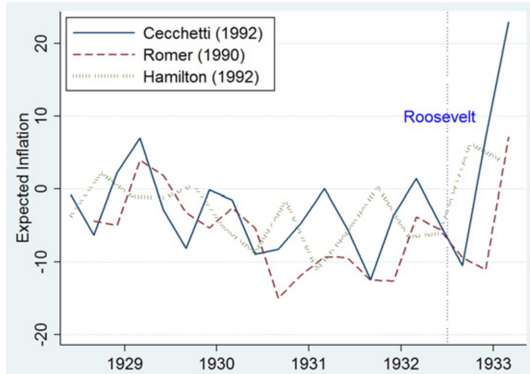

Fig. 1. Three estimates of Great Depression inflation expectations in the literature **Notes:** Estimates of expected inflation in the literature differ in the extent to which deflation was anticipated and how quickly positive inflation expectations returned after Roosevelt took office (vertical line).

Market-based approaches overcome many of the problems of time series approaches by allowing inference of inflation expectations from investors' behavior. For example, the difference between spot and futures prices of commodities reflects expectations about the change in commodity prices. If there is a stable relationship between expectations of commodity price changes and expectations of overall price changes, then we can infer inflation expectations from futures market data. A challenge of the market-based approach is establishing that the interest rate spread under consideration primarily reflects inflation compensation, rather than risk premia, anticipated mean reversion of spot prices, or institutional factors. This challenge, in fact, remains in modern estimates of inflation expectations derived from Treasury Inflation-Protected Securities (TIPS) and inflation derivatives.[1]

Both the time series and market-based approaches should be supplemented with narrative evidence regarding the information and reasoning that was historically used to form expectations. The narrative approach is valuable for understanding what people expected and why, including the information and models they used to forecast inflation. For example, an econometrician with hindsight can see that lagged gold production helps forecast inflation in the classical gold standard era, but Barsky and DeLong (1991) find that writers of the *Economist* did not expect the wave of gold discoveries in the late nineteenth century to significantly raise prices. They also find high uncertainty and disagreement about the correct model of inflation dynamics. Disagreement and uncertainty about inflation, also revealed in Great Depression era narrative evidence, are interesting in their own right,[2] especially when policymakers' beliefs and expectations about inflation dynamics differ from those of the private sector, resulting in unexpected policy decisions (Orphanides, 2004). For the sake of testing the Fisher effect, the most relevant expectations are those of investors. For estimating the Phillips curve, the relevant expectations are those of price and wage setters.

Narrative descriptions of inflation expectations are often qualitative, not quantitative. I introduce a new method of quantitative news analysis based on the frequency of the terms "inflation," "reflation," and "deflation" in the news. I show that estimates of expected inflation obtained with this approach for the Great Depression era are strongly positively correlated with Hamilton's (1992) estimates derived from the commodities futures market. I also check the validity of this approach by using it to estimate inflation expectations in more recent years and comparing my estimates to inflation expectations reported on the Michigan Survey of Consumers. The correlation between the quantitative news estimate and survey expectations is 0.68 and the series have similar means and standard deviations.

[1] A large recent literature, summarized in Gospodinov and Wei (2015), focuses on decomposing market measures of inflation compensation into inflation expectations, the risk premium, and other factors. This has recently drawn considerable attention, as the five-year/five-year forward breakeven inflation rate has declined below the Federal Reserve's inflation target, leading to concerns that long-term inflation expectations are unanchored. Gospodinov and Wei argue, however, that the breakeven inflation rate reflects other factors, including hedging in the TIPS market after oil price declines and volatility in global financial markets, and that adjusting for these factors, long-run inflation expectations remain stable.

[2] Inflation uncertainty may have real economic consequences and also affect the risk premium on nominal assets (Friedman, 1977; Fama and Schwert, 1977).

Finally, I conduct a meta-regression analysis of inflation expectations at the onset of the Great Depression. Romer & Romer, (2013, p. 68) note that a “cottage industry” of research appeared in the early 1990s devoted to the question of whether the deflation of 1930–32 was anticipated, as this differentiates alternative interpretations of the contraction. The meta-regression shows how estimates of the timing of deflation expectations depend on methodological choices. Estimates constructed via the time series approach find the earliest arrival of negative inflation expectations, but only if they use a consumer price index. This is because consumer price indices display greater inflation persistence than wholesale price indices, so as soon as deflation begins, it is incorporated into expectations. The main takeaway of the meta-analysis is that expectations did not turn substantially negative until at least 1931, supporting Fisher’s debt deflation hypothesis.

The paper is organized as follows. Section 2 outlines the role of inflation expectations in the history of economic thought. Sections 3, 4, and 5 discuss time series, narrative, and market-based approaches, respectively. Section 6 presents the meta-analysis of inflation expectations at the onset of the Great Depression, and Section 7 concludes.

2. Inflation expectations in economic thought

Inflation expectations play an important role in macroeconomic and monetary theory and in the history of economic thought. A central figure in this history is Irving Fisher, whose interest in inflation expectations was central to his work on interest rates, debt deflation, price indices,and monetary regimes. In his lifetime, survey data on inflation expectations was not collected. But Fisher (1911) suspected that his contemporaries’ ineptitude at forecasting inflation was harmful, and wrote that “the real evils of changing price levels do not lie in these changes per se, but in the fact that they usually take us unawares.”

At the time, the United States and much of the world was on the gold standard. Gold served as the *nominal anchor*, a constraint on the value of domestic money intended to promote price stability by pinning down inflation expectations (Mishkin, 1998). At least since the eighteenth century, proposals for monetary reform have aimed to mitigate the undesirable consequences of changes – especially unanticipated changes – in the price level.[3] Foreshadowing Fisher, Steuart (1767) proposed a system in which the value of a unit of account would be tied to a bundle of commodities instead of a precious metal. Lowe, (1823, p. 335) refined this idea, arguing for a tabular standard of money in which an index number of consumption would serve as a measure of value to “admit of no doubt or dispute, the power in purchase of any given sum in one year, compared to its power of purchase in another.”

The practicality of Lowe’s proposal was hindered by the lack of a developed theory of index numbers, which would follow over the late nineteenth and early twentieth centuries with the work of Jevons, Edgeworth, and Fisher (Aschheim and Tavlas, 1994). But Lowe’s reasoning, namely that “contracts for a series of years ought to be made with reference to the power of money in purchasing the necessaries and comforts of life” (p. 96), is an intellectual precursor to Fisher’s theories of interest rates and debt deflation.

2.1. The Fisher effect and debt deflation

In *The Theory of Interest*, Fisher (1930) hypothesizes that the nominal interest rate is the sum of the real interest rate and expected inflation. To formalize, let π_t^j denote the inflation rate from period t to $t+j$ and $E[\pi_t^j | \Omega_t]$ denote the expectation of inflation conditional on the information set Ω_t. Let i_t^j and r_t^j be the nominal and real interest rates, respectively, at time t for the period t to $t+j$. Then the *Fisher hypothesis* or *Fisher effect* is:

$$i_t^j = r_t{}^j + E\left[\pi_t{}^j | \Omega_t\right]. \tag{1}$$

As I detail in Section 3.1.1, Fisher modeled inflation expectations as a long-run weighted average of past inflation. Under this assumption, he found a positive correlation between nominal interest rates and expected inflation, as hypothesized. Moreover, if expected inflation is a long-run weighted average of past inflation, then the price *level* and expected inflation are positively correlated, so the Fisher effect can explain the *Gibson paradox*, a much-discussed correlation between the British console yield and the wholesale price level (Keynes, 1930; Summers, 1983; Coulombe, 1998).

The Fisher effect also implies a relationship between *ex ante* and *ex post* real interest rates. By rearranging (1), ex ante real interest rates are given by $r_t^j = i_t^j - E[\pi_t^j | \Omega_t]$. If realized inflation is lower than expected inflation, then ex post real interest rates ($i_t^j - \pi_t^j$) are higher than ex ante real interest rates. When debt is nominal, therefore, unanticipated deflation transfers wealth from debtors to creditors. If creditors have lower propensities to

[3] See Aschheim and Tavlas (1994) for an overview of the early works in this vein, including Hume (1752) and Mar (1885).

consume out of wealth than debtors, then unanticipated deflation has not only distributional consequences, but also adverse aggregate consequences. The Fisher hypothesis thus underpins Fisher's *debt deflation* theory of the Great Depression (1933), later formalized and extended by Bernanke (1983) and Eggertsson and Krugman (2012). For debt deflation to have operated, the deflation at the onset of the Depression must have been largely unanticipated.

In contrast, Friedman and Schwartz (1963) attribute the onset of the Depression to contractionary monetary shocks. Temin (1976) contends that declining nominal interest rates over this period do not indicate monetary stringency, arguing instead that declines in consumption and exports reduced income and the demand for money. Schwartz (1987) criticizes Temin for neglecting the distinction between real and nominal interest rates. If monetary contraction led to *anticipated* deflation, then monetary forces would be responsible for rising *real* rates, and the monetary hypothesis would be plausible. Thus, determining the extent and timing of deflation expectations is key to understanding the contraction (Schwartz, 1981; Romer and Romer, 2013). This is why, in Table 1, so much of the literature on estimating inflation expectations focuses on the Great Deflation.

Fisher not only believed that the deflation was unanticipated, but also that it was inherently unjust, given its unexpected distributional consequences. He repeatedly advocated inflationary policies in his many letters to Presidents Herbert Hoover and Franklin Delano Roosevelt (Allen, 1977). Friedman and Schwartz attribute the recovery and end of deflation to monetary expansion in the form of gold flows from Europe to the U.S. after the U.S. abandoned the gold standard on April 19, 1933. Indeed, in European and Latin American countries, departure from the gold standard facilitated recovery by permitting monetary expansion (Eichengreen and Sachs, 1985; Campa, 1990). Romer (1992) notes that since nominal interest rates were near the zero lower bound in early 1933, for monetary expansion to have stimulated aggregate demand, money growth must have lowered real interest rates by generating expectations of inflation. Since industrial production increased from the first to the second quarter of 1933, while the money supply was still declining, Temin and Wigmore (1990) and Eggertsson (2008) argue that Roosevelt brought about a *regime change* that shifted inflation expectations upward dramatically, stimulating the economy by lowering real interest rates. Thus, interpreting the recovery requires evidence of not only the timing but also the causes of increased inflation expectations.

2.2. From Bretton Woods to stagflation

After the abandonment of the gold standard, Fisher continued to advocate for a "compensated dollar" scheme in which the dollar would represent not a constant quantity of gold, but rather a constant purchasing power, as he first proposed in *The Purchasing Power of Money* (1911). He admired the Swedish monetary policy regime, a form of price-level targeting, that followed Sweden's abandonment of the gold standard in 1931 (Jonung, 1979; Burdekin et al., 2012). Fisher, (1937, p. 87) argued that "The most ideal standard would seem to be one which should satisfy the reasonable anticipations of the contracting parties to a debt; and, fundamentally, justice is best served in a loan contract if the reasonable anticipations of the parties are met."

Fisher would not see his hopes come to pass. Three years prior to his death, the 1944 Bretton Woods agreement established a nominal anchor based on convertibility of the U.S. dollar to gold and fixed exchange rates against the dollar. This system unraveled in the late 1960s, under the strain of the U.S. balance of payments deficit and domestic inflation, and collapsed in 1971. The increasingly-high inflation and unemployment that followed was an important influence on the development of the theory of the role of inflation expectations in inflation and output dynamics.

Policymakers in the 1960s attempted to exploit a negative statistical relationship between price inflation and unemployment, documented by Fisher (1926); Phillips (1958) and Samuelson and Solow (1960), hoping to achieve permanently lower unemployment at a cost of moderately higher inflation (Hetzel, 2013). But Friedman (1968) and Phelps (1969) warned that the relationships between these variables is not stable, but rather shifts depending on expectations of inflation.[4] In general, the *expectations-augmented Phillips curve* takes the form:

$$\pi_t^j = \gamma E\left[\pi_t^j \middle| \Omega_t\right] + \lambda X_t + \varepsilon_t, \tag{2}$$

where X_t is a measure of real economic slack, such as the deviation of unemployment from the natural rate.[5] In Friedman's early analysis of the expectations-augmented Phillips curve, he, like Fisher, modeled inflation

[4] See Gordon (2011) for a more thorough history of the Phillips curve.

[5] The exact specification of Eq. (2) in a microfounded Phillips curve depends on assumptions about wage and price setting. In New Keynesian models with sticky prices, X_t is marginal cost and γ is the discount factor.

expectations as backward-looking, albeit with shorter lags. This was standard, following Hicks (1939) and others. Wicksell, a central figure in the Stockholm School of Economics, assumed that inflation expectations are formed with “an expectations elasticity of unity” (Blaug, 1962, p. 643), corresponding to a simple form of backward-looking expectations in which $E[\pi_t^1 | \Omega_t] = \pi_{t-1}^1$.

2.3. The rational expectations revolution

John Muth, (1961, p. 315) noted that the Stockholm School “has undoubtedly been a major motivation for studies of business expectations and intentions...[T]he approach is limited, however, because it does not include an explanation of the way expectations are formed.” The *rational expectations* approach that Muth championed assumes that individuals make full use the information embodied in the structure of a macroeconomic model, so expectations are model consistent. In particular, note that realized inflation can always be written as the sum of expected inflation and an error term:

$$\pi_t^j = E\left[\pi_t^j | \Omega_t\right] + \varepsilon_t^j. \tag{3}$$

Under rational expectations, $E[\varepsilon_t^j | \Omega_t] = 0$ and ε_t^j is independent of $E[\pi_t^j | \Omega_t]$. A convenient feature of the rational expectations assumption is that it allows empirical tests of relationships involving inflation expectations even when expectations are unobservable. Mishkin (1992) notes that if an econometrician could observe $E[\pi_t^j | \Omega_t]$, then a basic test of the Fisher effect would entail a test of $\beta_j = 1$ in regression of the form:

$$E\left[\pi_t^j | \Omega_t\right] = \alpha_j + \beta_j i_t^j + u_t^j. \tag{4}$$

If π_t^j is observed and $E[\pi_t^j | \Omega_t]$ is not, the econometrician can substitute Eqs. (3) into (4) to obtain:

$$\pi_t^j = \alpha_j + \beta_j i_t^j + u_t^j + \varepsilon_t^j \tag{5}$$

To estimate Eq. (5) by ordinary least squares (OLS), the error term $u_t^j + \varepsilon_t^j$ must be orthogonal to i_t^j. This is the case under an assumption of rational expectations, since i_t^j is in the information set Ω_t. Then the Fisher effect implies a cointegrating relationship between nominal interest rates and inflation with a unit slope on inflation—an implication not reflected in the data in Fisher’s time. American and British price levels declined from 1870 to 1896. The trend then reversed, with positive inflation until 1914, yet nominal interest rates were no higher (Barsky and DeLong, 1991). Many studies fail to reject the null hypothesis of no cointegration between nominal interest rates and inflation. However, failure to reject this null does not disprove Fisher’s hypothesis if expectations are not rational. For example, if investors have money illusion or do not understand the quantity theory of money, then correlation between ε_t^j and i_t^j results in biased estimates of β_j and the non-adjustment of nominal interest rates to *ex post* inflation can be reconciled with the Fisher hypothesis (Summers, 1983).

(Coibion and Gorodnichenko, 2012), p. 117 describe the replacement of backward-looking with rational expectations as “one of the defining features in the rebuilding of macroeconomics starting in the 1970s.” Rational expectations were incorporated into analysis of the Fisher effect and the Phillips curve and became influential in policy (Lucas, 1972; Sargent, 1973b). (Sargent, 1982) examined hyperinflation episodes in Hungary, Austria, Poland, and Germany after World War I and found that prices stabilize abruptly when the government credibly commits to a policy regime change. He interpreted these experiences as consistent with the rational expectations view.[6] Federal Reserve Chairman Paul Volcker, influenced by the rational expectations approach, recognized the need to manage inflation expectations to escape stagflation (Goodfriend and King, 2005). The Volcker disinflation “reflected an improved understanding of the importance of providing a firm anchor, secured by the credibility of the central bank, for the private sector’s inflation expectations” (Bernanke, 2013).

2.4. Expectations formation and modern monetary policy

The rational expectations assumption was widely but not universally adopted, especially as newly-available survey data began to allow study of reported expectations. Prescott (1977) argued that “Like utility, expectations are not observed, and surveys cannot be used to test the rational expectations hypothesis.” But Lovell (1986) contended that the rational expectations hypothesis implies testable implications that do not always hold up in survey data. Later, sticky information and rational inattention models were developed to reflect the idea that information is costly to attain and process (Mankiw and Reis, 2002; Sims, 2003). Understanding the expectations-formation process and how it may vary over time and across agents remains an active area of research (Coibion and Gorodnichenko, 2012).

[6] Garber (1982) and Wicker (1986) find that stabilization from hyperinflation is, in fact, costly, which could imply that inflation expectations do not change as abruptly as Sargent hypothesizes.

Both the Fisher hypothesis and the expectations-augmented Phillips curve remain influential in monetary theory and policymaking. Today, instead of using gold as a nominal anchor, many central banks adopt explicit numerical inflation targets in an effort to reduce inflation volatility and uncertainty (Bernanke, 2007). Central banks closely monitor inflation expectations from surveys and financial instruments as they attempt to establish credibility and anchor inflation expectations to obtain a more favorable tradeoff between inflation and real activity (Curtin, 2010; Yellen, 2013).

The empirical fit of the Phillips curve appears to vary over time (Ball and Mazumder, 2011; Gordon, 2013). This may stem in part from choices about the measure of inflation expectations to use in estimation. Adam and Padula (2003) find that the slope of a Phillips curve estimated with the assumption of rational expectations has the incorrect sign, but the sign is correct using survey expectations. In the Great Recession, a Phillips curve estimated with the inflation expectations from the Survey of Professional Forecasters predicts that a much larger disinflation should have occured. The use of inflation expectations from the Michigan Survey of Consumers, especially those of high-income, college-educated, male consumers, results in a better fit to inflation dynamics (Coibion and Gorodnichenko, 2015; Binder, 2015b).

As Japan in the 1990s, and other central banks around the world in the Great Repression, encountered the zero lower bound (ZLB), ongoing debates about inflation expectations and the causes and remedies of the Great Depression took on not only historical interest, but also policy relevance (Krugman, 1998; Romer, 2013). The Fisher effect implies that when nominal interest rates are constrained by the ZLB, unconventional monetary policies that raise expectations of inflation can stimulate demand by lowering the real interest rate, though empirical evidence on the link between inflation expectations and consumer spending is mixed (Eggertsson and Krugman, 2012; Bachmann et al., 2013; D'Acunto et al., 2015). Revisiting the role of inflation expectations in economic history should be a high priority for historians and macroeconomists. Accurate measures of historical inflation expectations are important for understanding both real economic activity, inflation dynamics, and policy efficacy. The next sections discuss approaches to estimating inflation expectations in the literature.

3. Time series approaches

The critical role of inflation expectations in economic theory has led to a variety of attempts to consruct empirical estimates of inflation expectations. One category of approaches to estimating inflation expectations, time series approaches, involves modeling the stochastic process governing inflation dynamics and using constructed forecasts as a measure of inflation expectations. As seen in Table 1, the time series approach is the most common and oldest of the three approach categories. In the time series approach, estimates rely on assumptions about the models and information sets agents used to form their expectations. Suppose agents form inflation expectations π_t^e according to:

$$\pi_t^e = f(\Omega_t). \tag{6}$$

The econometrician does not know agents' information set Ω_t or model f of the inflation process, but assumes that the information set is $\tilde{\Omega}_t$ and that agents make forecasts using $\tilde{f}(\tilde{\Omega})$, and estimates:

$$\pi_{t+1} = \tilde{f}\left(\tilde{\Omega}_t\right) + \varepsilon_t. \tag{7}$$

Using the estimate $\widehat{\tilde{f}}$ of $\tilde{f}$, her estimate of agents' inflation expectations is $\hat{\pi}_t^e = \widehat{\tilde{f}}(\tilde{\Omega}_t)$. If the elements of Ω_t do not help to forecast inflation, that is, if the R^2 in estimation of Eq. (7) is low, then the econometrician concludes that the forecastability of inflation was low, and estimates that expected inflation at time t is simply the unconditional mean of inflation. Many tests of the Fisher effect for the gold standard era amount to a test of the forecastability of inflation. If the rise in inflation after 1896 were unforecastable, then the non-adjustment of nominal interest rates to ex post inflation is reconcilable with the Fisher effect (McCallum, 1984; Barsky and DeLong, 1991).

What agents *would have* expected had they used Eq. (7) is not the same as what they *did* expect using Eq. (6). The difference between estimated and true inflation expectations is:

$$\begin{aligned}\hat{\pi}_t^e - \pi_t^e &= \widehat{\tilde{f}}\left(\tilde{\Omega}_t\right) - f(\Omega_t) \\ &= \left(\tilde{f}\left(\tilde{\Omega}_t\right) - f(\Omega_t)\right) \\ &\quad + \left(\widehat{\tilde{f}}\left(\tilde{\Omega}_t\right) - \tilde{f}\left(\tilde{\Omega}_t\right)\right).\end{aligned} \tag{8}$$

The first term arises because the econometrician does not know what information set agents used or how agents used their information to form expectations. The second term is estimation error from Eq. (7), including measurement error. The magnitudes of these errors depend on the econometrician's choice of $\tilde{\Omega}$, $\tilde{f}(\tilde{\Omega})$, the price index used to compute π_t, and other data and computational choices which I will discuss in turn.

3.1. Choice of information set and model

An econometrician using the time series approach to estimate historical inflation expectations must make assumptions about the information agents used to form their inflation expectations and how they used it. Univariate models include only lags of inflation in the information set $\tilde{\Omega}$, while multivariate models include additional variables, reformulating the Mishkin (1981) approach, which uses a projection of the ex post real rate on current and lagged information as an estimate of the ex ante real rate. The function $\tilde{f}$ is nearly always assumed to be linear. For example, if $\tilde{\Omega} = \{\pi_{t-1}\}$ and $\tilde{f}$ is a linear function, then the econometrician estimates a first-order autoregressive (AR(1)) model:

$$\pi_t = c + \rho\pi_{t-1} + \varepsilon_t, \tag{9}$$

where c is a constant and ε_t is white noise.

Most authors who use the time series approach would not argue that agents *explicitly* estimated regression models before such models were developed and widely known. Galton (1888) and Pearson (1896) were among the earliest developers of correlation analysis and linear regression for work on heredity (Stanton, 2001), but by the 1920s, the use of time series statistical methods were still not universally accepted for economic forecasting. In his 1923 presidential address at the 85th annual meeting of the American Statistical Association, Warren Persons remarked that "Given as he [the statistician] must, that the consecutive items of a statistical series are, in fact, related, he admits that the mathematical theory of probability is inapplicable," and therefore one must rather forecast "by the application of the usual methods of inductive argument." In 1930, Fisher, a talented statistician, did compute correlation coefficients, but merchants in his day likely did not. Many of the time series techniques used to estimate Eq. (7) in the papers I will discuss were developed in the 1960s or later, e.g. in Granger and Hatanak (1964) and Jenkins and Watts (1969). Even if agents in the gold standard or Great Depression eras had known about regression analysis, a lack of computing power would have made it unfeasible for them to use regressions to forecast inflation.

While the assumption that these agents used regression analysis to form inflation expectations can be rejected at face value, the question is whether the assumption remains a reasonable approximation of how expectations were formed. People may be aware of correlations between economic variables, or have an informal model of inflation dynamics in mind, that provides qualitatively similar forecasts to an econometrician's model. For example, if inflation was quite persistent and agents did believe that current inflation was a good predictor of future inflation, then the first component of the error in Eq. (8), $(\tilde{f}(\tilde{\Omega}_t) - f(\Omega_t))$, would be small when using the AR(1) model in Eq. (9). Fisher's own discussion and model of his contemporaries' inflation expectations provides some insights into the information that agents in his era may have used to forecast inflation.

3.1.1. Fisher and Cagan's analysis

Fisher (1930) uses a univariate model of his contemporaries' inflation expectations, noting that "the business man makes a definite effort to look ahead...[to] the trend of prices." He models inflation expectations as a weighted average of past inflation, based on his earlier work (Fisher, 1925). Instead of using a regression to estimate the weights, he assumes that the weights decrease arithmetically over time, so that "price changes do not exhaust their effects in a single year but manifest their influence with diminishing intensity." He uses wholesale commodity price index inflation.

Fisher's estimates of inflation expectations are explicitly constructed to maximize the correlation between expected inflation and nominal interest rates subject to the assumption of arithmetically declining weights. He experiments with the number of lags of inflation included, and finds that for Great Britain, the correlation between expected inflation and nominal interest rates is highest (0.98) when expected inflation is a weighted average of 28 years of past inflation. For the U.S., the correlation is highest (0.86) when expected inflation is a weighted average of 20 years of past inflation.

Fisher is not confident in his model of his contemporaries' expectation formation. He writes, "A change in the value of money is hard to determine. Few business men have any clear ideas about it...Most people are subject to what may be called 'the money illusion,' and think instinctively of money as constant and incapable of appreciation or depreciation." Fisher (1906) also recognizes that variables other than past inflation are inputs to the expectations formation process. For example, "during 1898–1905 the increase of prices in the United States is known to have been due largely to the increase in gold production."

Cagan (1956) takes a similar approach to Fisher in his seminal study of hyperinflations in Austria, Germany, Greece, Hungary, Poland, and Russia. He assumes that expected inflation is a distributed lag of current and past inflation with geometrically (as opposed to arithmetically) declining lag weights: $\pi_t^e = (1-\lambda)\sum_{i=0}^{\infty}\lambda^i\pi_t$. This is equivalent to assuming that revisions to expectations are proportional to the difference between realized inflation and the rate that was expected. Sargent and Wallace (1973) point out that such an assumption is ad hoc, but is compatible with rational expectations under certain conditions, namely, the presence of feedback from inflation to subsequent rates of money creation. With this functional form, infinitely many lags of inflation influence current inflation expectations, but more recent lags have much more weight. Sargent (1973a) shows that Fisher would have found similar results with geometrically declining weights.

Like Fisher, Cagan explicitly chooses the weights to best fit his hypothesis by substituting his parametric expression for expected inflation into his equation for money demand:

$$\log(M_t/P_t)^d = \gamma - \alpha\pi_t^e + u_t \tag{10}$$

where M is the nominal money stock, P is the price level, $(M/P)^d$ is the demand for real cash balances, α and γ are parameters, and u is a mean-zero stochastic term. He estimates Eq. (10) by OLS and backs out an estimate of λ. The estimate of λ, and therefore the estimates of expected inflation, maximize the goodness of fit of his money demand model, subject to the constraint of geometrically declining weights, by construction.

Later studies that estimate inflation expectations maximize the goodness of fit of Eq. (7), rather than maximizing the strength of the Fisher effect or another economic model by construction. These estimates of expecations can then be used to test Fisher's hypothesis. Many authors, like Fisher and Cagan, use univariate models in which inflation expectations depend on lagged inflation.

3.1.2. Univariate models

Sargent (1973a) notes that much of the early criticism of Fisher's work (e.g. in Macaulay (1938)) concerns the plausibility of such long lags of inflation. Referencing Muth's, 1961 "suggestion that the expectations of the market can fruitfully be hypothesized to be the same as the optimal forecasts of economic and statistical theory" [p. 387–388], Sargent estimates the weights on lagged inflation from univariate models of the inflation process, and finds that these "optimal weights," though quite noisy, do imply shorter lag lengths than found by Fisher.

The class of models that Sargent considers are mixed autoregressive moving average (ARMA) models. This class of models is quite useful because, due to Wold's theorem, any covariance stationary process can be approximated by an ARMA(p,q) model with a finite number of parameters to estimate. Box and Jenkins (1976) present criteria for selection of p and q, though many authors simply select a parsimonious representation with low p and q. Sargent, for example, studies ARMA(1,1) and ARMA(2,2) models, but cannot reject the hypothesis that inflation is a white noise process, i.e. mean zero with no serial correlation.

Other early studies of the univariate time series properties of inflation in the pre-war classical gold standard also find no serial correlation, implying a constant inflation forecast (Shiller and Siegel, 1977; Benjamin and Kochin, 1984; Barsky, 1987; Bordo and Kydland, 1995a). Across core and peripheral countries, estimated inflation persistence increases from the gold standard period to the interwar period (Alogoskoufis and Smith, 1991; Bordo and Kydland, 1995b). Inflation during the German hyperinflation exhibits stronger serial correlation (Sargent and Wallace, 1973; Salemi, 1976). See Williams (2006) for a discussion of how inflation persistence depends on the monetary regime.

For the Great Depression era, Cecchetti (1992) uses the Box-Jenkins methodology to select p and q in ARMA(p,q) estimates of the inflation process. With quarterly data from 1919 to 1928, the MA(2) model is selected, but with data from 1919 to 1940, the AR(1) model is selected, so he constructs both MA(2) and AR(1) forecasts. The AR(1) estimates are smoother than the MA(2) estimates, but the estimated coefficients for both of these processes imply significant inflation persistence, so Cecchetti concludes that once deflation began in 1929, agents would have expected it to continue. Dorval and Smith (2013) estimate AR(1) models of inflation for 26 countries and find considerable cross-country variation across countries in the degree to which the deflation was anticipated. In the U.S., where inflation persistence was relatively high, they conclude that deflation was quickly incorporated into expectations after it began.

Generally, when using a univariate model to estimate inflation expectations, the specific choice of ARMA(p,q) representation is not particularly important. This is because the ARMA representation a given time series is not unique; an AR(1) model is the same as a particular MA(∞) model, for example (Hamilton, 1994). Estimates of persistence should be similar regardless of choice of p and q. Therefore, if one is going to use a univariate model as a baseline approach to estimating inflation expectations, I recommend using an AR(1) model, which is easiest to estimate and to use to construct forecasts at varying horizons. Because of this relative computational ease, it is also most likely to resemble "rule-of-thumb" forecasts by backward-looking agents. The more important decisions are whether to include other variables in Ω_t and the choice of price index to compute the inflation rate.

3.1.3. Multivariate models

Historical agents may have used information other than past inflation to form expectations. The R^2 in estimates of Eq. (7) weakly increases with the inclusion of more variables in Ω_t. Thus, the more variables and lags that are included, the more closely estimates of expected inflation will track realized inflation. However, that a variable can help forecast inflation does not mean that agents knew to use it in their inflation forecasts. If the econometrician includes information in $\tilde{\Omega}_t$ that is correlated with π_{t+1} but uncorrelated with information in Ω_t, then estimates of inflation expectations deteriorate.

Barsky and DeLong (1991) find that U.S. inflation was not serially correlated in the classical gold standard period, but was forecastable using lagged gold production. If investors used gold production optimally to forecast inflation, expectations should have risen by three percentage points from 1890 to 1910. This is why Barsky and DeLong combine the time series approach with the narrative approach (see Section 5) to look for evidence as to whether the statistical relationship between gold production and inflation was used to formulate inflation expectations and to "infer both what investors should have thought and what investors did think about inflation" (p. 820). They find that although commentators claimed to believe the quantity theory, they were uncertain about the model and parameters to use, and thus were reluctant to forecast higher inflation even when gold mining increased.

The multivariate approaches of Cecchetti (1992)and Romer (1992) for the Great Depression also conform to quantity theory in finding that monetary growth measures help forecast inflation. Cecchetti considers nominal interest rates, growth rates of the monetary base, the M1 and M2 money stocks, and industrial production as candidates for inclusion in $\tilde{\Omega}_t$. Wald tests of the explanatory power of each variable find that only the coefficients on M2 and the monetary base are significant. Romer includes nominal interest rates, industrial production, and the M1 growth rate, and finds the most statistical significance on lagged M1 growth. Multivariate estimates for the onset of the Depression are similar to univariate estimates, as I show in the meta-analysis in Section 6.

3.1.4. Multi-equation structural models

In the studies described above, Eq. (7) is reduced form. Another approach is to build a *structural* model of the economy in which inflation is determined in general equilibrium. Bordo et al. (2000) build a standard neoclassical model in which a representative agent with rational expectations makes consumption and investment decisions to maximize utility subject to a budget constraint. The model allows for monetary nonneutrality by introducing wage rigidity in the form of nominal wage contracts. They calibrate the model to best match selected moments of the data in the Great Depression.

The calibrated parameters imply that prices respond quickly to monetary shocks, so the deflation of the Great Depression was largely unanticipated. A combination of unanticipated deflation and sluggish nominal wage adjustment account for the severity of the Great Depression compared to the depression of 1920–21, for which the deflation was mostly anticipated. These estimates of expected inflation should be interpreted cautiously since the model underpredicts the contraction in hours worked beginning in 1932 and greatly overestimates the strength of the recovery beginning in 1933. The estimates are sensitive to how nominal wage rigidity is modeled.

Eggertsson (2008) also builds a dynamic general equilibrium model of the U.S. economy in the Great Depression, but with price rigitidy instead of wage rigidity. He explicitly models the "policy dogmas" that constrained Hoover but not Roosevelt. His calibration implies that inflation expectations rose sharply when Roosevelt took office and the Hoover's "balanced budget dogma" was relaxed, allowing deficit spending. Eggertsson notes that his work is a formalization of Temin and Wigmore (1990), with the major difference being the importance of the zero lower bound in Eggertsson's model but not in Temin and Wigmore's analysis. Eggertsson's findings are also sensitive to his modeling assumptions; the channel by which deficit spending leads to higher inflation expectations relies on the fact that his model includes sticky prices.

3.2. Choice of price index

In addition to selecting a model of inflation dynamics, an econometrician implementing the time series approach must select a price index to calculate inflation. This choice can drastically alter estimates of expected inflation if alternative choices of price indices differ in the degree of inflation *persistence*. Note that in Eq. (9), if the econometrician estimates that ρ, the persistence or autocorrelation of the inflation process, is near zero, then estimates of expected inflation will always be near the constant c, regardless of realized inflation. If ρ is near one, then estimates of expected inflation closely track realized inflation. Biased estimates of ρ lead to errors in inference about the Fisher effect.

Alternative price indices lead to different estimates of inflation persistence for two primary reasons: differences in measurement error and differences in the components included in the index. When one or more lags of inflation are included as independent variables in the estimation of Eq. (7), measurement error for inflation leads to *attenuation bias*, biasing the estimated coefficients on lags of inflation toward zero. This in turn biases estimates of expected inflation toward the unconditional mean of the inflation process and away from realized inflation.

Fisher himself is responsible for much of the development of the theory of index numbers and construction of price indices (Fisher, 1922, 1923, 1930). Fisher began publishing a commodity price index in his weekly newspaper column in 1923, a Laspeyre's index with price data on 200 comodities from *Dun's Weekly Review* with weights given by the War Industries Board. Concurrently, the Harvard Economic Service included ten commodities in its "Curve B″ which were selected based on their predictive power in previous years (Dominguez et al., 1988).

Many studies of the Fisher effect use wholesale commodity price indices. Sargent (1973a) also uses wholesale commodity price inflation because of data availability, but notes that he would prefer to use retail price inflation. Barsky (1987) uses the wholesale price index (WPI) calculated by Warren and Pearson (1932). Barsky and DeLong (1991) use a gross national product (GNP) deflator constructed by Kuznets (1961); Kendrick (1961), and Gallman (1966). These indices suffer similar problems. Warren and Pearson (1932) omit services and more highly processed goods from their price index, leading to systematic understatement of the degree of persistence in prices. The Kuznets-Kendrick-Gallman GNP deflator proxies for the prices of finished goods using prices of raw materials and intermediate products, which also leads to an understatement of persistence (Hanes, 1999).

Because of concerns that previous work falsely characterizes inflation as white noise, Perez and Siegler (2003) use two alternative price indices to study the forecastability of inflation in the gold standard era. One is the GNP deflator constructed by Balke and Gordon (1989) with consumer price data from Hoover (1960) and Rees (1961) and the construction price index from Gottlieb (1965). Perez and Siegler note that the Balke and Gordon GNP deflator shares some of the problems of the Kuznets-Kendrick-Gallman and Warren and Pearson measures; namely, Hoover's index for the 1880s comes exclusively from wholesale prices, and Gottlieb's is essentially the components index for building materials from the Warren and Pearson WPI. Perez and Siegler construct a consumer price index that is very similar to the Balke and Gordon GNP deflator, but replaces Hoover's data for the 1880s with data from Long (1960). A problem with these indices is that the expenditure weights were selected to represent the cost of living for low-wage workers in a fixed year.[7] Perez and Siegler find that using these series, a substantial portion of the inflationary and deflationary episodes before World War I could have been anticipated using lagged inflation or lagged inflation and money growth, and estimates of expected inflation are correlated with nominal interest rates.

Dorval and Smith (2013) estimate the persistence of both retail and wholesale price inflation using data from the Great Depression era for 26 countries. Similarly, they find that retail price inflation is more persistent than wholesale price inflation in the majority of countries. The autoregressive coefficient on retail inflation for the U.S. is 0.50, compared to 0.14 for wholesale inflation. Other Great Depression studies use both producer and consumer prices. Romer (1992) uses the producer price index from the Bureau of Labor Statistics (BLS). Cecchetti (1992) uses cost-of-living indexes constructed from monthly surveys by the National Industrial Conference Board. For dates prior to 1919, he uses consumer price data from the BLS, but notes that these appear to be constructed by interpolating data at a frequency of approximately six months. The meta-analysis in Section 6 shows that time series studies using wholesale price inflation estimate that inflation expectations turned negative ten months later than time series studies using consumer price inflation.

More recent literature examines differences in persistence across categories of disaggregated price data. See Fuhrer (2009) for an overview. The persistence of disaggregate inflation rates is below aggregate inflation persistence for nearly all consumer prices (Clark, 2006). The idiosyncratic low-persistence components of disaggregate inflation series "wash out" when many series are aggregated (Boivin et al., 2009). This suggests that series that use fewer price categories to construct aggregate price indices will underrepresent aggregate inflation persistence.

[7] Hoover (1960) weights prices according to the average expenditures of 397 working families in Massachusetts in 1875; Long (1960) and Rees (1961) based weights on the expenditures of 2567 working families in 1901.

3.3. Real-time data, sample, and horizon

Many price indices and other data series used in the time series approach were not constructed until decades later. *Real-time data*, which would have been available when agents formed their expectations, is more likely to resemble the elements of Ω_t (Orphanides, 2003). *Out-of-sample* forecasts, estimated with an expanding or rolling sample, are also more likely than in-sample forecasts to resemble true expectations because data from after time t is not used to estimate the model of inflation dynamics used at time t. In theory, the start date for the expanding sample or the window length for the rolling sample should depend on how far back in history people looked to draw inferences about economic correlations. In practice, this decision often depends on data availability.

Presenting results from different combinations of forecast windows and data series helps determine whether results are sensitive to these choices. Dominguez et al. (1988) construct multivariate estimates of inflation expectations in the early 1930s that differ in the forecast window and data series used. Some use data that would have been available to agents in real time, while others use data that was not available until more recently. In a few specifications using longer samples (with data beginning in 1891 or 1906 instead of 1920 or 1926), the early stages of the deflation seem more predictable. However, given the highly sensitive nature of these estimates, they conclude that “These forecasting successes should not be overemphasized, however, because the forecasts are very unstable as the initial conditions and coefficient estimates change. Hence, aside from a hint of forecastability of the deflation, the Depression was unforecastable using our time-series methods” (p. 605).

Cecchetti (1992) does not find much difference between his in-sample estimates, which use data from 1919 to 1940 to estimate parameters of the inflation process, and his out-of-sample estimates, which use data from 1919 to 1928. Both use consumer price inflation, which was persistent over the shorter and longer samples, resulting in his finding that moderate deflation was anticipated by the end of 1929 and that positive inflation expectations resumed following positive inflation in mid-1933. In contrast, Dorval and Smith (2013), using wholesale price inflation in multiple countries in the interwar period, do find notable differences between in-sample and out-of-sample forecasts. The response of output growth to unexpected wholesale inflation is statistically significant only when using estimates from out-of-sample forecasts, which are more likely to be accurate.

It is possible to use the time series approach to estimate inflation expectations over any time horizon. Sargent, (1973a, p. 390) notes that if expectations are formed adaptively, “speeds of adjustment of expectations of inflation are likely to vary with respect to horizon and hence across bond maturities.” If the estimated statistical process for inflation is mean-reverting, then estimates of expected inflation will be closer to the unconditional mean of the inflation process at longer horizons. For example, the AR(1) process in Eq. (9) has unconditional mean $c/(1-\rho)$. If $\rho<1$, so the process is stable, then estimates of expected inflation approach $c/(1-\rho)$ as the horizon approaches infinity.

The choice of horizon should depend on the intended use of the inflation expectations series. Recall from Eq. (1) that the Fisher effect implies that the nominal interest rate at time t for a bond maturing at time $t+j$ is the real interest rate plus expected inflation from time t to $t+j$. Thus, tests of the Fisher effect should use estimates of expected inflation over the same horizon as the nominal interest rates under consideration. As Fackler and Parker (2005) note, expectations over longer horizons are more relevant to the debt deflation hypothesis, which depends on deflation being unanticipated when the debt was being issued. Long-run expectations are also more relevant for Phillips curve estimation and for evaluation of monetary policy credibility (Preston, 2005).

3.4. Regime change

By construction, the time series approach is ill-suited for detecting a regime change of the sort hypothesized by Temin and Wigmore (1990). Suppose that agents initially believe that inflation follows a particular process, but beliefs suddenly change and they expect inflation to follow a different process. The econometrician will obtain biased estimates by using a single process to model inflation before and after the regime change. The January 1933 *Review of Economic Statistics* (*RES*) refers to “the recrudescence of inflationary proposals” as “political factors about which scientific forecast is impossible.” Any perceived relationship between current and future inflation prior to 1933 might have been abandoned in light of these political factors.

Statistical methods can detect a regime change in the inflation process itself (Levin and Piger, 2003). Fackler and Parker (2005) estimate a Markov switching model with two states— a deflationary state and a stable prices state—and estimate the probability that the economy is in the deflationary state in each period. Only after mid-1930 did the probability rise from near zero to near one. They conclude that agents would not have anticipated deflation in the 1920s when nominal debt was issued in great volume. But even a Markov switching model like that of Evans & Wachtel, (1993) or Fackler and Parker (2005) can only detect a change in the statistical inflation process, rather than a change in agents' *perception* of the inflation process, a critical distinction.

3.5. Interpretation of confidence bands

A final note on the use of the time series approach is that standard errors or confidence bands, as presented on Cecchetti and others' graphs of estimated inflation expectations, must be interpreted with care. These confidence intervals are computed from the standard errors of the estimates from Eq. (7). They tell us the precision of an econometrician's forecasts of inflation, given that she uses the model $\pi_{t+1} = \tilde{f}(\tilde{\Omega})$ of theinflation process. They should *not* be interpreted as a 95% confidence interval for the true value of historical agents' expectations, because they are uninformative about the potential difference between $\tilde{f}(\tilde{\Omega})$ and $f(\Omega)$.

4. Market-based approaches

Market-based approaches posit a dependence of some market price or quantity on inflation expectations and use the relationship to make inferences about inflation expectations. These approaches are based on the *expectations hypothesis*, which states that agents are indifferent between prospects if and only if the expected returns are equal (Salemi, 1980). The *breakeven* inflation rate, the rate at which the returns of two assets (for example, a real bond and a nominal bond) are equal, provides a measure of market participants' inflation expectations.

Fisher (1930) provides an early example of the reasoning behind this approach when he describes how the difference in returns on two types of U.S. bonds from 1870 to 1896, one paid in coin and the other in currency, reflected inflation expectations:

In 1870 the investor realized 6.4% in terms of gold but was willing to accept a return of only 5.4% currency. Why should a gold bond be thus inferior to a paper bond? This has become intelligible in the light of the theory which was explained in Chapter II. It meant the hope of resumption. Just because paper was depreciated below gold and there was a chance of bringing it up to par, there was in prospect a great rise in its value, as compared with gold. It was not until 1878, just before resumption, when the prospect of any further rise disappeared, that the relative position of the two rates of interest was reversed. After resumption in 1879, when paper money did reach par with gold, the two bond rates remained very nearly equal for several years, until fears of inflation from Greenbackism and Free-Silverism again produced a divergence.

Newer markets for inflation-linked assets such as Treasury Inflation-Protected Securities (TIPS) enable fairly straightforward calculation of market participants' inflation expectations (Haubrich et al., 2011). However, even in modern markets for inflation-linked assets, establishing that the expectations hypothesis holds can be challenging. If a market is segmented or underdeveloped, the expectations theory may not hold (Salemi, 1980; Frenkel, 1980). For example, in Japan, markets for inflation-protected government bonds and inflation swaps are too thin to convey reliable information about inflation expectations in recent years (Mandel and Barnes, 2013). Institutional influences on yields also add noise to market estimates of expected inflation; for example, the volatility of TIPS yields in late 2008 resulted from the unwinding of institutional positions after the failure of Lehman Brothers (Campbell et al., 2009). Asset prices also contain risk premia which may vary over time (Lucca and Schaumburg, 2011). Even in the very large and liquid market for U.K. inflation-linked bonds, Evans (1988) strongly rejects the null hypothesis of constant inflation risk premia, and explains how using information from the entire term structure of inflation-linked bonds can help correct for this.

The use of older markets for stocks and bonds, commodities futures, and foreign exchange to draw inference about historical inflation expectations poses similar challenges. Nonetheless, market-based estimates of inflation expectations have several important benefits. They represent a bet on future inflation by market participants willing to "put their money where their mouth is" (Kwan, 2005). Since they proxy for the expectations of market participants, as opposed to other agents, they are suitable for tests of the Fisher hypothesis. They are often available at high frequency, and the maturity horizon of the asset specifies the horizon over which inflation is expected. Very importantly, unlike time series approaches, they do not require assumptions about how agents form expectations.

4.1. Stock And Bond Markets

The asset most similar to TIPS in the classical gold standard era was gold bonds. Mitchener and Weidenmier (2010) use the interest-rate differential between gold bonds and paper bonds, which required an inflation premium, to derive a measure of inflation expectations from 1880 to 1911 in Austria, the only European country to issue paper, silver, and gold bonds on the major exchanges for the majority of the era. This measure of inflation expectations is persistent and highly correlated with nominal interest rates. Similar methodology is used by Garber (1982), who compares interest rates on nominal bonds and gold bonds to gauge expectations of inflation in Germany, where, at the height of hyperinflation in 1923, prices rose 500% per week. Interest rates in 1924 indicate that market participants learned rapidly about the central bank's new stable price policy; expected annual inflation was about 20–30% in the spring of 1924, and negligible within eight months of the central bank's imposition of credit restrictions, supporting Sargent's (1982) regime change hypothesis.

4.1.1. Qualitative estimates

Other studies draw qualitative inferences about inflation expectations based on people's choice of assets to hold. Temin and Wigmore (1990) note that when people expect deflation, they hold cash for the real return it provides, but when they expect positive inflation, they shift into assets whose value rises with inflation, such as stocks. Stocks were at a trough in March 1933, and rose sharply until July. The doubling of industrial stock prices from March to July, Temin and Wigmore argue, indicates a regime change in inflation expectations. Similarly, Fackler and Parker (2005) note that anticipated deflation should cause some borrowers to defer borrowing or choose longer-term debt to minimize repayment in deflated dollars. The private debt to income ratio grew rapidly prior to the Depression, the volume of corporate debt offerings did not fall substantially until 1932, and the relative shares of long-term and short-term debt did not change until after the deflation began. These all provide signs that deflation was unanticipated, but do not quantify the unanticipated deflation.

4.1.2. The Fisherian Golden Rule

The "Golden Rule" hypothesis of Phelps (1961) equates the real interest rate and the output growth rate in long-run equilibrium. If both the Golden Rule and the Fisher hypothesis hold, then the difference between nominal bond rates and real growth trends provides a measure of trends in expected inflation. Dewald (1998, 2003) and Bordo and Dewald (2001) calculate this "Fisherian Golden Rule" measure of inflation expectations. U.S. inflation expectations were near zero in the 1950s and early 60s, and underestimated inflation from the late 1960s through the early 1980s (Dewald, 1998). Across 13 industrial countries, expectated inflation was much lower for the 1881–1913 gold standard era compared to 1962–1995 period (Bordo and Dewald, 2001). Dewald (2003) calculates Fisherian Golden Rule inflation expectations for thirteen major industrial countries from 1880 to 2001 using alternative assumptions about real growth trends and finds that the surges in inflation that occurred during and after World Wars I and II were not anticipated. Since the measure is constructed by *assuming* the Fisher hypothesis is true, it cannot be used to *test* the Fisher hypothesis.

The Fisherian Golden Rule measure is not suited for studying short-run movements in expected inflation since the real rate of interest and output growth need not be equal in the short run. New multi-country evidence from Hamilton et al. (2015) shows that Phelps' Golden Rule lacks empirical support even as a longer-run relationship. Thus, the Fisherian Golden Rule may not even be useful for capturing longer-term trends in expected inflation. This method should be avoided, at least until more evidence regarding the relationship between real interest rates and output growth rates is available.

4.2. Commodities futures markets

Hamilton (1986) and Cornell and French (1986) introduce the use of futures markets to uncover expectations of inflation. For risk-neutral investors, the difference between the futures price and spot price of a commodity is the expected price change of the commodity. If investors are risk-averse, the difference will also incorporate a risk premium. If there is a stable correlation between expected commodity price changes and expected changes in the general price level, then futures market data can be used to infer expectations of inflation. Mishkin (1990) expresses pessimism about this approach, arguing that the relationship between commodity and aggregate price level changes is very noisy.

Hamilton (1992) counters that Mishkin simplistically models expected commodity price inflation as a direct proxy for the expected change in the aggregate price level. Hamilton instead derives the statistically optimal weights to be placed on expected price changes of a number of different commodities, and shows that this provides a more informative indicator of the expected change in the aggregate price level. Hamilton (1987, 1992) finds that for most of the Great Depression, futures prices were above spot prices, indicating that declines in agricultural prices caught people by surprise. He infers that the deflation of the early 1930s was largely unanticipated and that positive inflation expectations resumed in the second trimester of 1933.

Cecchetti (1992) argues that physical stocks of commodities were high during the Great Depression, and the price of stored commodities cannot be expected to fall. However, Hamilton counters that inventories are held to facilitate milling, processing, and distribution, not just for the capital-gains motive. The difference between spot and futures prices ranges from very positive to very negative values in the data. It is thus both theoretically and empirically possible for the price of stored commodities to be expected to fall. Cecchetti also points out that the U.S. government intervened in commodities futures markets as part of a policy goal of preventing agricultural commodities from falling. Hamilton responds that commodities were so openly traded on world markets that the U.S. government's ability to control their price is questionable.

Voth (1999) uses futures prices to estimate inflation expectations in Germany during the Depression, and finds that fear of inflation was prominent in 1931–32. Perez and Siegler (2003) uses Hamilton's method with agricultural commodity futures markets data from the Chicago Board of Trade to estimate expected price changes for corn, wheat, and oats from 1886 to 1914. Commodity price changes were partially anticipated, with correlation coefficients of around 0.5 between expected and actual inflation for these commodities. These expectations are positively correlated with nominal interest rates, evidence of a short-run Fisher effect.

A benefit of the futures market approach is that futures markets have existed at the Chicago Board of Trade since the mid-1800s, and earlier in other countries (West, 2000). It should also be noted that the difference between futures and spot prices has a straightforward interpretation as the market expectation of commodity price change only for non-storable commodities; for storable commodities with large inventory overhangs, futures prices reflect the current spot price plus carrying costs (Emmons and Yeager, 2002). Thus, a recommendation with the futures market approach is to compare futures prices with different settlement dates instead of comparing futures prices with spot prices, which may diverge due to storage costs or other reasons (Voth, 1999).

4.3. Foreign exchange markets

Foreign exchange markets also have a long history and can be used to draw inference about investors' expectations. Frenkel (1977) notes that in a high-inflation economy with flexible exchange rates, foreign exchange is an important substitute for domestic currency holdings. Let S_t be the spot exchange rate in deutsche mark per pound sterling, and let F_t be the price at t of exchange to be delivered at $t+1$. Applying covered interest parity, the forward premium $(F_t - S_t)/S_t$ is approximately equal to the difference between the expected German inflation rate and the expected British inflation rate from t to $t+1$. Frenkel assumes that during the German hyperinflation after World War I, expected inflation in Britain is approximately constant relative to expected inflation in Germany, so the forward premium provides a measure of German inflation expectations.

To examine the efficiency of the foreign exchange market, Frenkel regresses $\log(S_t)$ on $\log(F_{t-1})$ and a constant. Since the constant term does not differ significantly from zero, the slope coefficient does not differ significantly from one, and the error term is serially uncorrelated, he concludes that the market is efficient, supporting its use as the basis for inference on expectations. Frenkel uses his measure of inflation expectations to estimate Cagan's (1956) money demand model, and finds "support for the notion that during the hyperinflation expectations may have behaved rationally in the sense of Muth...It stands to reason that the larger variability of the exchange rate increases the rate of return from and the amount of resources invested in accurate forecasting" (p. 655–56).

Webb (1986) use the same methodology as Frenkel to calculate inflation expectations in Germany from 1919 to 1923. He combines these estimates with a narrative account of fiscal policy news about the government's ability to run surpluses resulting from allied demands for reparations, occupation of the Ruhr, domestic revolts, and tax reforms. He finds that "Inflationary expectations were rational at least in that the major turning points corresponded in the predicted direction and with roughly the right timing to the major news about Germany's fiscal future" (p. 794). Webb notes one downside of the foreign exchange market approach: since the main forward market was in London, and exchange controls restricted the access of Germans, these estimates reflect the expectations of Londoners about German inflation, rather than reflecting Germans' expectations.

The foreign exchange market also provides information on inflation expectations under alternative exchange rate regimes, including target zones and metallic standards. Here, the difference between spot and future exchange rates reflects investors' perception of the credibility of the target (Svensson, 1991). While inflation and devaluation are not identical, they were perceived as synonymous during the gold standard era, so expectations of devaluation are indicative of inflation expectations (Eichengreen, 1992). Hsieh and Romer (2006) use data from the foreign exchange market to estimate expectations of devaluation in the U.S. around the time of the Federal Reserve's open market operations of 1932. Their intent is to examine whether this expansionary monetary policy led investors to believe that the U.S., then on the gold standard, would devalue. They show that the forward exchange premium of the dollar relative to the currencies of several countries considered firmly wedded to the gold standard did not move in response to news about the Fed's open market operations.

Hsieh and Romer's study demonstrates several good practices for researchers. First, they obtain exchange rate data from multiple sources: Einzig (1937), the *Economist*, and the *Financial Times*, and show that all three are generally very similar. Since the *Economist* and *Financial Times*series each exhibit a few idiosyncratic movements not reflected in the other series, Hsieh and Romer use the Einzig series. This reduces the risk that estimates are contaminated by measurement error from one historical data series. Averaging the three series, instead of choosing the least idiosyncratic series, would have achieved a similar result. They also account for the possibility that the spot rate may exhibit mean reversion. Svensson (1993) notes that if people are aware of this mean reversion, then differences between the spot rate and the futures rate may simply reflect expectations that the spot rate will revert to its mean, i.e. that it will rise if it is temporarily low for some reason. Hsieh and Romer estimate the mean reversion of the spot rate over 1928 to 1931 (i.e. prior to their estimates of interest for 1932), then subtract the predicted change in the spot rate due to mean reversion from the uncorrected measure of expected devaluation. It turns out that in this sample, movements of the spot rate are so small relative to the spot-forward differential that correcting for mean reversion in the spot rate does not notably alter estimates of expected devaluation. However, in settings where movements in the spot rate are larger, this correction can be more important.

5. Narrative approaches

News articles, surveys, and other documents provide contextual and explanatory evidence of what people understood and expected about the circumstances of their time. The statistical approaches to estimating expectations discussed in Section 3 rely on assumptions about the information sets and models that agents used to form expectations. The narrative record can reveal the information and reasoning used by forecasters and the public to form expectations, supplementing time series and market-based approaches. Sources of narrative evidence include magazines and newspapers, surveys, reports of professional forecasting services, and the policy record. Most of the literature using the narrative approach has focused on the Great Deflation and Great Depression (see Table 1).

5.1. Expectations formation, uncertainty, and disagreement

Time series estimates of inflation expectations suppose that agents optimally used the statistical relationship between inflation, its past values, and possibly other variables to form their expectations. In reality, agents may not have known that certain variables could help forecast inflation or may have disagreed about or been uncertain about the determinants of inflation dynamics. Barsky and DeLong read the London *Economist* for narrative evidence of a perceived link between gold quantities and the price level during the classical gold standard. Even though gold production could statistically forecast inflation, writers for the *Economist* appear not to have exploited this relationship in their expectations formation and did not forecast that the wave of gold discoveries at the end of the nineteenth century would substantially raise prices.

The narrative record often presents evidence of disparate opinions about inflationary conditions and dynamics. Expectations may differ from one businessman to another, or between businessmen, academics, and policymakers. Barsky and DeLong also read the *American Economic Review* and find controversy among academics regarding the relationship between gold production and inflation. Monetarists like Fisher believed that the increase in the secular rate of inflation from 1898 to 1905 was a direct result of the increased output of the world's gold mines, but academic opinion was split. The presence of differing expectations is both a challenge and a benefit of the narrative approach. The challenge is selecting the appropriate expectations to use for tests of the Fisher effect or other hypotheses. In Fisher's, 1930 discussion of his hypothesis, he refers to the inflation expectations of "the business man;" views presented in the financial press may be more relevant for this purpose than the views of academics. But as Mankiw et al., (2004, p. 210) discuss, "disagreement about expectations is itself an interesting variable for students of monetary policy and the business cycle."

Likewise, uncertainty about inflation is interesting in and of itself, as a real cost of inflation and an indicator of monetary policy credibility (Friedman, 1977). The effects of inflation uncertainty on interest rates are theoretically ambiguous. Inflation uncertainty may raise interest rates by increasing the inflation risk premium, or lower rates by prompting an increase in precautionary saving (Berument et al., 2005; Wright, 2011). The narrative record can be useful in indicating how uncertain agents were about their inflation expectations. Barsky and DeLong (1991) note that the failure of the *Economist's* editors to forecast high future inflation stems from model and parameter uncertainty; reluctance to forecast high inflation, despite acceptance of quantity theory, stemmed from reasonable "fear that the underlying structure might be changing over time, so that correlations characterizing the past might not characterize the future" (p. 835).

Uncertainty and disagreement also characterize expectations at the onset of the Great Depression. Though several commentators anticipated deflation, this view was not widespread. After World War I, economists Ralph Hawtrey and Gustav Cassel worried that restoring the international gold standard without restricting international demand for gold could result in major deflation, but their warnings leading up to the Depression went largely unheeded (Batchelder and Glasner, 2013). The well-known forecaster Roger Babson predicted the stock market crash and was pessimistic about business conditions and prices.[8] But other well-known forecasters remained optimistic even after the Depression began. Dominguez et al. (1988) analyze the pronouncements by the Harvard Economic Service (HES) and by Fisher in 1929-30.[9] Neither predicted such a severe recession. Through the summer of 1929, HES noted signs of recession, while Fisher was bullish about the economy. In late 1929 and 1930, HES also grew optimistic, expressing confidence in the ability of the reserve system to ease the money market and prevent depression.

Nelson (1991) reads the business and financial press from June 1929 to December 1930, finding that most analysts underestimated future deflation. Only by mid-1930 was the severity of the crisis recognized. Even in late 1930, some analysts expected prices to return to pre-World War I levels. Romer and Romer (2013) examine *Business Week*, which changed its expectations of price movements frequently based on anticipated changes in money and credit conditions. In the first half of 1930, *Business Week* did not consistently expect much deflation. A sentiment that prices could not fall below prewar levels prevailed as late as September 1930. Examining major newspapers in 1929–30, I find that considerable uncertainty surrounded expectations of price changes in particular industries.[10]

The narrative record can illuminate how agents' interpretation of past trends and events influences their expectations. For example, in 1929, analysts at the *Chicago Daily Tribune* found "no appreciable effect" of stock prices on commodity prices from 1925 to 1929,[11] so they believed the stock market crash was unlikely to provoke a fall in commodity prices. Analysts in the Great Depression also looked back to the deflation of 1920–22 as an indicator of how long the deflation would persist. By the start of 1931, deflation had continued for approximately the duration of the previous deflation, leading to a mistaken impression that the end of deflation was "due."[12] This impression would not be captured by time series estimates.

5.2. Policy and expectations

Recall from Section 3.4 that a regime change in inflation expectations, as may be prompted by a major policy change, is undetected by the time series approach. The market-based approach can detect a sudden jump in expectations, but may not reveal which of multiple

[8] See "Babson Officer Lays Crash to Business Ebb; Also Blames Disregard of Mathematics," New York Times, 17 Nov. 1929, p. 2.

[9] The HES, led by Warren Persons, was a subscription service offered to businesses. The HES constructed an Index of General Business Conditions based on a theorized relationship between three "curves" representing speculation (New York bank clearings and industrial stock prices), business (outside bank debits and commodity prices), and money (commercial paper rates). Fisher published a weekly, nationwide syndicated newspaper column on economic affairs, which included a Commodity Price Index beginning in January 1923.

[10] The Wall Street Journal (WSJ) wrote that "What the price of wheat will be for the remainder of this crop season The Wall Street Journal will not attempt to say." ("Upturn in Grain Prices," 11 Nov. 1929: 1.) In November and December of 1929, the WSJ also reported on uncertainty about price trends in the rubber industry ("Rubber Schemes Held Uncertain" 25 Nov. 1929: 17. "Trend in Rubber Still Uncertain" WSJ, 31 Dec. 1929: 6."). The New York Times (NYT) reported in April that the copper market was "so uncertain that even the keenest followers of the market refuse to hazard an opinion as to the course of prices." ("Future Unsettled for Copper Prices," NYT, 20 Apr. 1930: 35.) A WSJ headline proclaimed "Price of Steel More Uncertain."(WSJ, 1 May 1930: 3.)

[11] Chicago Daily Tribute, 14 November 1929, "Good Business is Seen Due to Orderly Marketing," p. 23.

[12] "After the Other 'Deflation,' NYT, January 1, 1931, p. 48.

possible policy announcements were noticed by the public and most strongly shaped expectations. Time series and market approaches also do not reveal differences between the beliefs of policymakers and the public. The narrative record is useful for revealing the effects of policy on inflation expectations as well as the effects of policymakers' beliefs about inflation dynamics on their decisionmaking.

For example, Evans and Wachtel (1993) argue that it would have been reasonable for the public to have expected a quick end to deflation at the start of the Depression, since if monetary policy had continued its earlier course, deflation may have been halted. However, there were two important changes to monetary policymaking. First, in the mid-1920s, the Fed used open market operations to actively offset changes in the supply of reserves. But at the start of 1930, the new Open-market Policy Committee viewed the active use of open market purchases as inappropriate, worrying it would fuel speculative activity. Second, throughout the 1920s, the Fed managed monetary policy to avoid bank panics, but when bank panics and failures reappeared in 1928, the Fed viewed these as a result of local mismanagement and no cause for change in monetary policy. Evans and Wachtel also note that other countries that abandoned the gold standard in the early 1930s were able to stem deflationary pressures. Once the U.K. suspended the gold standard in 1931, Evans and Wachtel claim, observers could have reasonably expected the U.S. to quickly do the same, ending deflation.

Other authors also explore the link between expectations of inflation and devaluation. Eichengreen (1992) notes that in the Great Depression, policymakers and the public viewed inflation and devaluation as synonymous, because they equated the gold standard with price stability. In Germany, fear of inflation, reflected in policy reports and the popular press, precluded departure from gold, even as prices were falling rapidly in 1931 (Voth, 1999).[13] In the U.S., conventional wisdom holds that the Fed could not have conducted monetary expansion to counteract deflation in the early stages of the Great Depression without leading to expectations of devaluation and a speculative attack on the dollar. To test this widsom, Hsieh and Romer (2006) analyze the minutes of the Open Market Policy Conference, the *Economist*, and the *Commercial and Financial Chronicle* and find no evidence that Fed officials or the media worried that the Fed's $1 billion expansionary open market operation would damage the credibility of commitment to the gold standard.

Jalil and Rua (2015) read *Business Week* and the *Economist* and examine business forecasts from the *Magazine of Wall Street*, *Moodyâ€™s Investment Survey*, the *RES*, and *Standard Statistics Company's Standard Trade and Securities* to study inflation expectations from October 1932 to July 1933. Prior to Roosevelt's inauguration, little was known about his economic policies or whether he was committed to a new inflationary movement gaining public attention. Expectations shifted dramatically in the second quarter of 1933. The abandonment of the gold standard, Roosevelt's communication strategy and fireside chats, the Thomas Inflation Amendment of the Farm Relief Bill, parts of the National Industrial Recovery Act, and the World Economic Conference were powerful and credible signals of a new inflationary regime.

Orphanides (2004), citing Keynes (1930), notes that the "mentality and ideas" of policymakers may be a greater limit to policy effectiveness than any real constraints on policy. Orphanides examines the minutes of the Fed and finds that in 1935 and 1936, policymakers were concerned about the potentially inflationary effects of increased gold flows, limiting policy efficacy.[14] The narrative record is the only source of evidence on policymakers' expectations and their effects of policy decisions.

5.3. Narrative evidence from surveys

A benefit of survey measures of expectations is that we often know details about the survey respondents and questions. This makes it easier to interpret whose expectations about what variables are represented. Lovell (1986) discusses surveys of expectations that are available for the 1970s and earlier. Only one of these, the year-end survey of Business Expenditures on Plant and Equipment conducted by the Bureau of Economic Analysis since 1970, asks directly about expectations of price changes. According to this survey, the OPEC price hikes of 1974 and 1981 caught firms by surprise. Forecasters in firms also did not make optimal use of public information, such as capacity utilization and the lagged growth of the money supply, in their inflation forecasts. Thus, even in the 1970s, multivariate

[13] Additional narrative evidence gathered by historians on inflation expectations in Germany is cited in Voth (1999).

[14] He notes that a Fed Staff Memorandum in December 1935 states,"There is the general fear which many people entertain that excess reserves of the present magnitude must sooner or later set in motion inflationary forces which, if not dealt with before they get strongly under way, may prove impossible to control."

time series estimates of inflation expectations (see Section 3.1.3) would result in inaccurately small estimates of actual forecast errors. Biases from the time series approach are not limited to very early eras, but remain a concern even in after the development of more modern statistical methods.

Other surveys of economic expectations documented by Lovell do not ask about price changes directly, but have still been used to make indirect inference about inflation expectations. Klug et al. (2005) analyze a survey of railroad shippers' forecasts of carloadings in the Great Depression and find that managers persistently failed to anticipate the collapse in demand. Klug et al. then estimate the quantitative relationship between inflation and output growth, as proxied by carloadings, to conclude that there was considerable unanticipated deflation. Had the shippers used a modern ARIMA model or a simple backward-looking forecasting rule, forecast errors would have been smaller. Forecast errors in 1933 were much less persistent, meaning that expectations adjusted more rapidly to Roosevelt's regime change. The sharp downturn of 1937–38 took railroad shippers by surprise.

Several surveys of inflation expectations that are not discussed by Lovell begin in the 1960s or later. The Survey of Professional Forecasters begins collecting forecasts for the consumer price index in 1981, but forecasts for real and nominal GDP or GNP begin in 1968, and can together be used to derive forecasts of GDP deflator inflation (Orphanides and Williams, 2012). Many of the early surveys are qualitative. Knoebl (1974) uses qualitative survey data on inflation expectations in Germany from the European Community's Harmonized Business Surveys to construct quantitative estimates of inflation expectations from 1965 to 1974. Batchelor (1986); Nardo (2003) and Terai (2009) provide reviews of methodologies for imputing quantitative expectations from qualitative survey responses. The Carlson and Parkin (1975) (CP) method is most popular. This method assumes that quantitative expectations are unbiased and normally distributed across individuals and that qualitative responses depend on latent thresholds that are homogenous across individuals and constant over time. Lahiri and Zhao (2013) find that the thresholds vary across individuals and over time, depending positively on the current inflation rate, and present a generalization of the CP method that relaxes these assumptions.

The Michigan Survey of Consumers introduced quantitative questions about expectations of price changes in 1978. Most of the research that utilizes this data uses the median expectation as an indicator of consumers' inflation expectations, obscuring substantial cross-sectional heterogeneity. Many consumers, especially those with low income or education, report inflation forecasts that are a multiple of five percentage points. This rounding behavior, which becomes more prevalent in episodes of high uncertainty, biases the median upward in recent years (Binder, 2015a). Analysis of rounding and heterogeneity in the railroad shippers' forecasts would be interesting.

5.4. Quantitative news estimates

Media coverage reflects and shapes the macroeconomic expectations of the public (Doms and Morin, 2004; Lamla and Maag, 2012). Systematic creation of quantitative data from the narrative record has the benefits of objectivity and replicability (Krippendorf, 1989). Digital archives facilitate keyword searches of newspapers, from which indices of news coverage of selected topics can be constructed. The recent work of Baker et al. (2013) and Alexopoulos and Cohen (2015) on economic policy uncertainty demonstrates the usefulness of quantitative news analysis for the study of beliefs and expectations. The frequency of newspaper mentions of uncertainty in the Great Depression is correlated with other uncertainty proxies like credit spreads and predicts declines in output (Mathy, 2014).

Jalil and Rua (2015) plot newspaper mentions of inflation and deflation during the Depression but do not attempt to scale these counts into estimates of inflation expectations. Building on this approach, I use the ProQuest database to search the New York Times (NYT) archives for keywords related to inflation and deflation. Mathy (2014) notes that news coverage in the NYT is strongly correlated to coverage in other papers, and focuses on the NYT as the "paper of record." Let $News_t^+$ be the number of articles containing "(inflation OR reflation) AND (price OR prices)" in year t, and $News_t^-$ be the number of articles containing "deflation AND (price OR prices)" in year t. Fig. 2 plots $News_t^+$ and $News_t^-$ as a percent of total articles each year from 1919 to 1939. Let $News_t = \ln(News_t^+/News_t^-)$ be a measure of relative coverage of inflation versus deflation.[15]

To scale $News_t$ into estimates of expected inflation, suppose that news coverage is related to expected inflation: $News_t = \beta_1 \pi_t^e + \beta_0 + e_t$, where $\pi_t^e = E[\pi_t^1 | \Omega_t]$ is the expectation at time t of inflation from period t to $t+1$ and e_t has

[15] I use the natural logarithm of the ratio of $News_t^+$ to $News_t^-$ instead of the simple ratio because it is symmetric in the sense that $\ln(News_t^+/News_t^-) = -\ln(News_t^-/News_t^+)$, so it does not matter whether I choose to use $News_t^+$ or $News_t^-$ in the numerator.

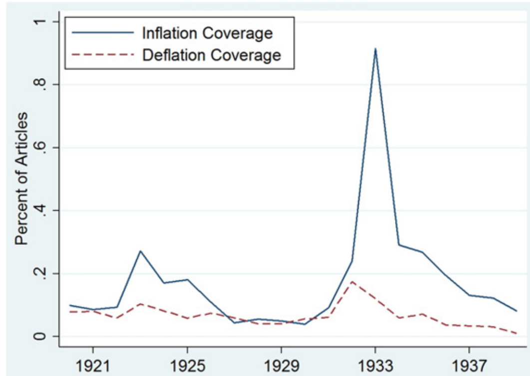

Fig. 2. New York Times coverage of inflation and deflation **Notes:** Figure shows the percent of New York Times articles each year that include the terms "(inflation OR reflation) AND (price OR prices)" and "deflation AND (price OR prices)."

mean zero. Recall from Eq. (3) that realized inflation can be written as the sum of expecteded inflation and an error term: $\pi_t^j = E[\pi_t^j | \Omega_t] + \varepsilon_t^j$. Replacing π_t^e with $\pi_t^1 - \varepsilon_t^1$, we have:

$$News_t = \beta_1\pi_t^e + \beta_0 + e_t = \beta_1\pi_t^1 + \beta_0 + e_t - \beta_1\varepsilon_t^1. \quad (11)$$

Rearranging,

$$\begin{aligned}\pi_t^1 &= (1/\beta_1)News_t - \beta_0/\beta_1 + \left(\beta_1\varepsilon_t^1 - e_t\right)/\beta_1 \\ &= \alpha_0 + \alpha_1 News_t + u_t,\end{aligned} \quad (12)$$

where $u_t \equiv (\beta_1\varepsilon_t^1 - e_t)/\beta_1$ has mean zero if $E_t[\varepsilon_t^1]=0$, which is the case under rational expectations.[16] My estimates of expected inflation are the fitted values from a regression of one-year-ahead inflation on $News_t$ and a constant (Eq. (12)). Table 2 displays the results of regression (12) using both CPI and PPI inflation. The first two columns use a shorter time sample, 1922–34, while the last two use a longer time sample, 1920–39. The estimated coefficients α_1 on $News_t$ are positive, as expected, and statistically significant. Estimated coefficients are not very sensitive to the choice of sample period. Fig. 3 plots the estimates of expected CPI inflation for the shorter and longer samples.

The estimates of expectations from this approach (the fitted values from columns 1 and 2 of Table 2) imply that the deflation of the Great Depression was partially anticipated. In 1930, expected CPI and PPI inflation were −5.6% and −9.2%, respectively, while realized CPI and PPI inflation over the next year were −9.4% and −16.8%, respectively. Fig. 4, which plots the quantitative news estimates of expected inflation using CPI inflation and the shorter time sample along with Hamilton's (1992) estimates from the commodities futures market, demonstrates the similarity of the estimates. Hamilton's estimates have mean − 2.3% and standard deviation 2.4%, while the quantitative news estimates have mean − 1.5% and standard deviation 2.8%. The correlation between Hamilton's estimates and the quantitative news estimates is between 0.60 and 0.68 for each of the specifications in Table 2.

As a validation test, I replicate the estimation procedure using more recent news data so that I can compare the estimates to survey measures of inflation expectations. Fig. 5 plots quantitative news estimates for 1978–97[17] with Michigan Survey of Consumers expectations over the same period. The series are similar, with a correlation of 0.68. The survey estimates have mean 4.3% and standard deviation 2.1%, while the news estimates have mean 4.6% and standard deviation 2.3%.

Higher frequency data can also be used with this approach. Fig. 6 plots estimates from monthly, quarterly, and annual data. At higher frequencies, the smaller sample of articles can make estimates noisier. At the monthly frequency, for example, there are often fewer than ten articles containing the key phrases. Still, the higher frequency data is useful for observing larger movements that are unlikely to be attributable to noise. We can observe, for instance, that expectations rose sharply in early 1933, consistent with the timing of the

[16] If expecations are not rational, but have a systematic bias, i.e. $E[\in_t^1] = \mu \neq 0$, then the estimate of α_0 will have a bias of μ, as will the fitted values. Estimates of expected inflation will be shifted by μ, but will still be informative of the size and timing of changes in expectations.

[17] The Michigan Survey begins in 1978. I chose the ending year 1997 so that the sample period would be the same length (20 years) as the estimates beginning in 1920.

Table 2
Quantitative news regressions.

	(1)	(2)	(3)	(4)
	π_t^1 CPI	π_t^1 PPI	π_t^1 CPI	π_t^1 PPI
News	4.16**	7.94**	4.03***	7.58**
	(1.54)	(2.65)	(1.14)	(3.51)
Constant	−4.05**	−6.26**	−5.00***	−9.42**
	(1.38)	(2.37)	(1.22)	(3.75)
N	13	13	20	20
Sample	1922–34	1922–34	1920–39	1920–39
R^2	0.40	0.45	0.41	0.21

Notes: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Standard errors in parentheses. Table shows the results of regression Eq. (12).

regime shift in inflationary expectations found by Jalil and Rua (2015).

6. Meta-analysis of inflation expectations at the onset of the U.S. Great Depression

The onset of the Great Depression in the U.S. is the subject of the widest variety of studies of historical inflation expectations. I conduct a meta-analysis of expectations in this era. Meta-analysis is a technique for combining the findings from multiple studies that independently estimate the same statistical measure. Meta-analysis is widely used in economics and other fields to "identify the extent to which the particular choice of methods, design and data affect reported results" and "help to explain the wide study-to-study variation found among research findings and offer specific reasons, based on the studies themselves, why the evidence on a certain question may appear contradictory or overly varied" (Stanley, 2001, p. 132).

The first step in meta-analysis is to select the sample of studies using search of a standard database. Following Stanley's suggestion, I use the database *EconLit*. I search for scholarly journal articles that contain the words (Great Depression AND deflation AND (expected OR unexpected OR anticipated OR unanticipated)). There are 17 results. I check each result to see if the paper estimates inflation expectations in the U.S. at the onset of the Great Depression. If so, I include that article in the analysis and also check the articles that cite that article according to *EconLit* to see if they construct estimates of inflation expectations. If so, I include them as well. In total, I find 14 papers with estimates of inflation expectations for the time period of interest.

The second step is to select moderator variables, coded characteristics of the study that serve as independent variables in the meta-regression. Some articles include multiple estimates of inflation expectations. For each estimate in each article, I record the author, year, approach category (time series, narrative, or market-based), type of price index, and number of citations in *EconLit* and *Google Scholar*.[18] For time series estimates, I record whether the specification uses multiple variables.

The third step is to choose a summary statistic that reduces the findings of each study to a common metric that will serve as the dependent variable in the meta-regression. Not all of the studies report quantitative estimates of inflation expectations in a way that can easily be compared across studies. To code the findings in a comparable way, I define a variable $DeflationYear_i$ as the year that severe, prolonged deflation began to be expected according to the authors' discussion. This may be recorded as a fraction of a year, for example 1930.5 denotes mid-1930. For robustness, I define an alternative variable, *Expected*1930, that categorizes expectations of deflation as of early 1930. I choose this date because the literature seems to show the least consensus about expectations in the early stages of the Depression after deflation has begun, but before it has reached its most severe levels. The variable takes value 1 if the study concludes that the deflation to come was fully or mostly anticipated, 2 if the deflation was partially anticipated, and 3 if deflation was fully or mostly unanticipated.

Appendix Table 4 summarizes the coded variables, while Appendix Table 5 lists each observation and how it is coded. I treat different estimates in the same paper as unique observations if they differ in approach category, use of wholesale or commodity price index, or use of multiple variables. If a paper includes multiple specifications that are the same in these respects, I treat these estimates as a single observation. In this case the results *DeflationYear* and *Expected*1930 correspond to the author's preferred results, if possible, or the modal results. For example, Dominguez et al. (1988) estimate a large number of VARs with different time samples and variables included, but I treat these are a single observation because they are all multivariate time series approaches with wholesale price indices. Since the majority find that deflation was unanticipated as of early 1930 and the authors draw that conclusion in their discussion, I code *Expected*1930 as category 3. I treat

[18] Google Scholar includes a wider variety and more up-to-date content, so the citation count is higher than in *EconLit*.

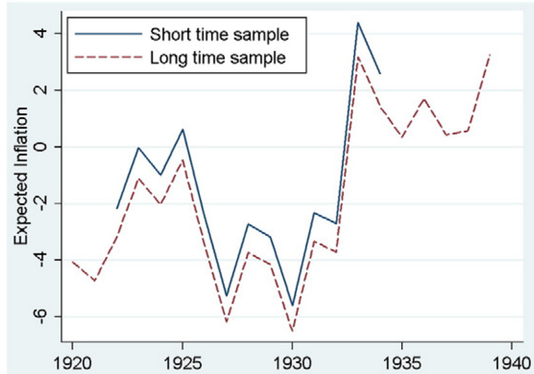

Fig. 3. Quantitative news estimates with short and long time sample **Notes:** Quantitative news estimates are based on New York Times mentions of terms related to inflation and deflation, computed as the fitted values from column 1 and 3 of Table 2.

Hamilton (1987, 1992) as a single observation since the latter builds upon the former and reaches the same conclusion. This leaves me with 19 observations: ten using the time series approach, two using the market approach, and seven using the narrative approach. In Appendix Table 4, since the mean of *DeflationYear* is 1931.2, the studies on average find that deflation was anticipated beginning in February 1931. This table also shows that *Expected*1930 = 3 for 53% of the studies, so most studies find that the deflation to come was mostly or entirely unanticipated as of early 1930.

Table 3 summarizes *DeflationYear* and *Expected*1930 for each approach category. Estimates using the time series approach appear more likely to conclude that the deflation was fully or partly anticipated. The table also summarizes the outcome variables by type of price index. The seven papers that use a wholesale price index find approximately the same arrival date of deflationary expectations as the twelve papers that do not use a wholesale price index. To formally test for differences between approaches, I conduct a meta-regression of the form:

$$\begin{aligned} DeflationYear_i = \beta_0 + \beta_1 Market_i = \beta_2 TimeSeries_i \\ + \beta_3 WPI_i \quad + \beta_4 TimeSeries \quad * WPI \\ + \beta_5 TimeSeries \quad * Multivar + error_i. \end{aligned} \tag{13}$$

The interaction term *TimeSeries* WPI* allows for the possibility that the choice of price index has a different effect on *DeflationYear* for papers using the time series approach. Recall from Section 3.2 that the use of a

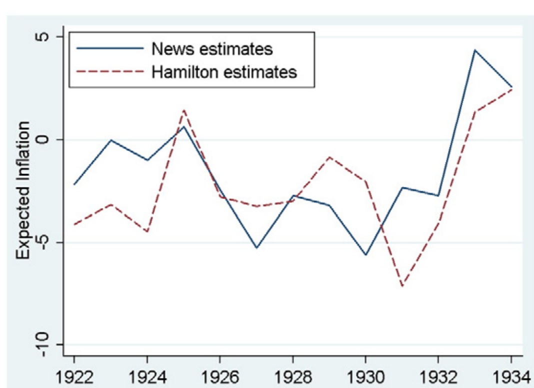

Fig. 4. Quantitative news estimates of expected inflation and Hamilton's (1992) estimates **Notes:** Quantitative news estimates are based on New York Times mentions of terms related to inflation and deflation, computed as the fitted values from column 1 of Table 2. Correlation from 1921 to 1938 is.

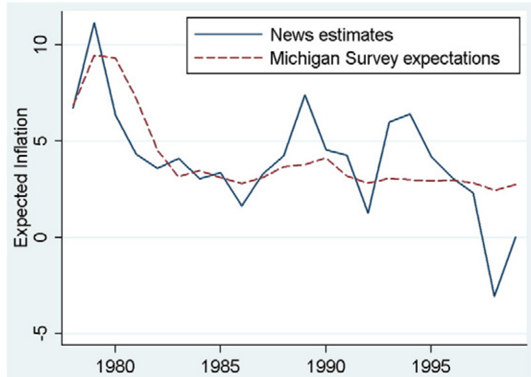

Fig. 5. News and Michigan Survey expectations **Notes:** Quantitative news estimates are based on New York Times mentions of terms related to inflation and deflation. Correlation from 1978 to 2011 is 0.72.

wholesale price index in the time series approach can bias estimates of inflation persistence toward zero, which would lead to a later estimate of the onset of deflationary expectations.

Table 6 displays the regression results. The first four columns include a subset of the moderator variables, while the fifth includes the full set of moderator variables. In column 1, when only dummy variables for market and time series approach are included, both have negative coefficient, but neither is statistically significant. However, if the time series and wholesale price index interaction term is included, as in columns 3 and 5, the coefficients on approach category, WPI, and the interaction term are all statistically significant. This is because results from the time series approach are so sensitive to choice of price index. Time series approaches using a WPI find a later onset of negative inflation expectations because wholesale price inflation is less persistent than consumer price inflation (see Section 3.2), so after deflation begins, it takes longer to be incorporated into expectations. The time series approach with consumer price inflation finds negative inflation expectations in late 1930. The use of multiple variables in the time series approach does not significantly affect results.

The constant term in the final column, 1932.2, indicates the year that inflation expectations turn substantially negative for estimates from the narrative approach using consumer price inflation. Estimates from the market-based approach find slightly earlier expectations of deflation than the narrative approach, possibly because market participants have better information than the press, or because commodity prices were expected to fall earlier than the general price level. Overall, the results point to the plausibility of the debt deflation hypothesis. In the Appendix, I also weight observations according to number of citations and find similar results.

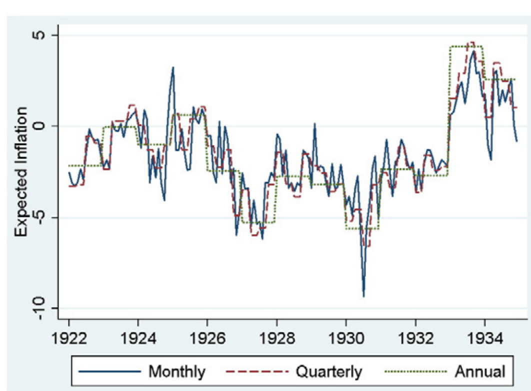

Fig. 6. News estimates at monthly, quarterly, and annual frequency **Notes:** Figure shows estimates of expected year-over-year CPI inflation computed via the quantitative news approach with monthly, quarterly, and annual data from 1922 to 1934.

Table 3
Summary of outcomes by approach category.

	N	Deflation year (Std. Dev.)	Share mostly anticipated	Share partly anticipated	Share mostly unanticipated
Approach					
Time Series	10	1931.1 (0.65)	0.2	0.4	0.4
Market	2	1931 (0.35)	0	0	1
Narrative	7	1931.4 (0.98)	0	0.43	0.57
Price Index					
WPI=0	12	1931.1 (0.83)	0.17	0.25	0.58
WPI=1	7	1931.3 (0.63)	0	0.57	0.43

Notes: *N* denotes number of observations. DeflationYear is the unweighted mean across studies of the start of deflationary expectations, with standard deviation across studies in parentheses. The last three columns show the share of observations for which *Expected*1930 was coded as 1, 2, or 3, respectively, indicating that as of early 1930, deflation was mostly anticipated, partly anticipated, or mostly unanticipated.

7. Conclusions

Irving Fisher lacked a direct measure of his contemporaries' inflation expectations, so to study their role in the macroeconomy, he assumed they were backward-looking. Since his time, many scholars have attempted to estimate more accurate proxies for historical inflation expectations, not only to test the Fisher effect, but also to study the role of expectations and policy at the onset and recovery from the Great Depression, in periods of hyperinflation, and under various monetary regimes. The role of expected inflation in theories of inflation dynamics and real activity means that continuing to refine estimates of historical inflation expectations, and constructing estimates for other countries and eras, remains important.

The three main approaches for estimating historical inflation expectations— time series, narrative, and market-based— each present challenges for an economist or historian. The time series approach, in which an estimated model of inflation dynamics is used to construct inflation forecasts that proxy for historical expectations, requires particular caution because estimates are sensitive to the choice of price index. The forecastability of inflation depends on its estimated persistence, which is biased toward zero if measurement error is large, if the price index contains a small number of price series, or if the index omits more persistent prices such as those of more highly-processed goods. More fundamentally, the model and information set used by an econometrician ex post may not resemble the expectations formation process used historically. Barsky & DeLong, (1991, p. 821, 835) explain:

> Econometricians choose models with hindsight, while agents must act in the midst of the structure in which they are embedded... [D]isparity between the econometric rule and the market expectation can be sustained even in the presence of market participants with considerable experience and theoretical knowledge, and in the presence of thick markets in information and analysis.

Market-based estimates are generally more reliable than time series estimates, relying on the expectations hypothesis rather than on assumptions about agents' information sets and models. The difference between future and spot prices for commodities, for example, reveals investors' expectations of future commodity price changes, which in turn reveal information about inflation expectations if there is a stable relationship between expected commodity prices and expected overall prices. Estimates derived from the interest rate differential on nominal and real (inflation-indexed) bonds, such as modern-day TIPS or gold bonds in the gold standard era, provide the most direct estimates of market participants' inflation expectations. Thus, evidence that market-based estimates of inflation expectations were very strongly correlated with nominal interest rates during the classical gold standard is convincing evidence in support of the Fisher effect despite the lack of correlation between time series estimates of inflation expectations and nominal interest rates. Market-based estimates can still be biased if risk or liquidity premia are large and vary with the state of the economy.

Market-based and time series estimates should be supplemented by examining the narrative record. I have shown that newspaper coverage of inflation and deflation can be used to construct a proxy for inflation expectations that is closely correlated to other measures of inflation expectations. Refining this quantitative news methodology is an area for future research. Quantitative news analysis may supplement, but should not replace, qualitative news analysis of agents' beliefs about inflation dynamics. Narrative sources are particularly useful for revealing expectations of policy and its consequences.

Many studies estimate inflation expectations at the onset of the Great Depression since alternative explanations of the Depression are distinguished by when and whether deflation was anticipated. A meta-analysis shows that in the U.S., deflation was mostly unanticipated before and shortly after it began. This suggests that tight monetary conditions alone are unlikely to explain the downturn, and debt deflation could have been operative. This meta-analysis also shows how estimates depend on methodological choices. Most notably, the time series approach finds earlier expectations of deflation if consumer price inflation is used, because consumer price inflation is more persistent than wholesale price inflation, so as soon as deflation begins, it is incorporated into estimates of expectations.

The evidence on inflation expectations in 1933 supports the regime change hypothesis of Temin and Wigmore (1990) and Eggertsson (2008). Market-based and narrative approaches detect an earlier return of positive inflation expectations in the U.S. in 1933 than time series approaches, which by construction cannot detect a regime change. This demonstrates that inflation expectations are not strictly backward-looking, but do respond to credible policy announcements and other salient news. Neither do expectations correspond perfectly to the full-information rational expectations model, as information that can help to forecast inflation is not always incorporated optimally into expectations.

With some expections, most studies of inflation expectations focus on the U.S., the U.K., or Germany. Recently, researchers have had success using estimates of U.S. inflation expectations and purchasing power parity conditions to estimate inflation expectations in other countries (Mandel and Barnes, 2013). This approach could be used with historical data to estimate inflation expectations in other countries. There is also a need for research on inflation expectations in other eras, especially under alternative monetary regimes and nominal anchors. Recently, economists are reassessing the merits of price-level targeting. In theoretical models with rational expectations, price-level targeting can reduce the frequency and severity of zero lower bound episodes compared to inflation targeting because of its effects on expectations (Hatcher and Minford, 2014). Since we lack empirical evidence of inflation expectations under price-level targeting, a detailed study of inflation expectations in Sweden in the 1930s, before, during, and after its unique experience with price-level targeting would be useful. Carlson, (2011, p. 58, 60) reviews the writing of Swedish economists in Swedish newspapers in late 1931 and 1932, and finds that economists and politicians "immediately understood the difference between a fixed exchange rate and domestic price stability. However, opinions naturally differed on the issue of whether it would be *possible* to uphold price stability...Unfortunately, it is not possible to say anything substantial about how well the general public could understand monetary arguments."

Even for recent history, high-quality inflation expectations data is not always available. For many developing countries, surveys of inflation expectations are not available or only recently available, and markets for inflation linked assets are absent or too thin or illiquid to be informative. Hopefully, the methodological discussions in this paper can guide researchers in constructing estimates of inflation expectations in these countries.

Regardless of methodology, obtaining a precise estimate of "true" expected inflation is difficult— in part because there is no single true value. Disagreement among consumers, and between consumers and professional forecasters, is substantial, and many individuals are quite uncertain about future inflation (Mankiw et al., 2004; Carroll, 2003; Binder, 2015a). Studying the heterogeneity and uncertainty of historical inflation expectations is a promising avenue for future research.

Appendix A. Meta-analysis

The following tables correspond to the meta-anlalysis of inflation expectations at the onset of the U.S. Great Depression, discussed in Section 6. Table 7 displays regression results with alternative weightings of observations. It is common in meta-analysis to weight observations by some proxy for the quality of the study, such as the number of times the study was cited. In the first column, all observations receive equal weight. Columns (2) through (4) use weights based on number of citations in *EconLit* or *GoogleScholar*. Since some papers, especially newer papers, have zero citations, in column (2) I add one to the number of *EconLit* citations so that each observation has non-zero weight. In columns (3) and (4), I adjust citation count in *EconLit* and *Google Scholar*, respectively, by year of publication. I regress the number of citations on a constant and the year of publication. Then I subtract the coefficient on year times the number of years since 1988 from the citation count (so for a paper published in 1988, the weight is the unadjusted citation count, and for papers published later than 1988, the weight is the citation count adjusted upward to account for the recency.) These alternative weighting schemes do not notably alter the results.

Table 4
Variables used in meta-analysis.

Variable	Description	Mean
Author	Author last name(s)	
Year	Year of publication	2001
Citations_EconLit	Number of citations of this paper in EconLit	5.9
Citations_Google	Number of citations of this paper in Google Scholar	70.3
TimeSeries	Dummy: time series approach	0.53
MultivarTimeSeries	Dummy: multivariate time series approach	0.26
Market	Dummy: market-based approach	0.11
Narrative	Dummy: narrative approach	0.37
WPI	Dummy: wholesale or commodity price index	0.37
DeflationYear	Year severe and prolonged deflation is first expected	1931.2
Expected1930	1: Deflation mostly or entirely anticipated as of early 1930	10.5%
	2: Deflation partially anticipated as of early 1930	36.8%
	3: Deflation mostly or entirely unanticipated as of early 1930	52.6%

Notes: The mean is calculated across 19 equally-weighted observations.

Table 5
Meta-analysis of inflation expectations at the onset of the U.S. Great Depression.

Paper	Category	Approach Notes	Multi-variate	WPI	Expected 1930	Deflation Year	EconLit Citations	Google Citations
Dominguez et al. (1988)	T	VAR	1	1	3	1932	7	109
Dominguez et al. (1988)	N	Harvard and Yale forecasters	.	1	3	1932	7	109
Nelson (1991)	N	Business press	.	1	3	1930.5	3	44
Cecchetti (1992)	T	AR(1) and MA(2)	0	0	2	1930.75	9	125
Cecchetti (1992)	T	Multivariate	1	0	2	1931.5	9	125
Hamilton (1987, 1992)	M	Commodities futures	.	0	3	1931.25	21	129
Romer (1992)	T	Multivariate	1	1	2	1931.25	35	338
Evans and Wachtel (1993)	T	Regime-switching Markov model	0	0	3	1931	4	45
Evans and Wachtel (1993)	N	Policy record	.	0	3	1932	4	45
Bordo et al. (2000)	T	Calibrated neoclassical model	1	0	3	1931	12	208
Fackler and Parker (2005)	T	Regime-switching Markov model	0	0	3	1931	0	16
Fackler and Parker (2005)	M	Short-term nominal debt	.	0	3	1930.75	0	16
Klug et al. (2005)	N	Railroad survey	.	0	3	1933	2	15
Dorval and Smith (2013)	T	AR(1)	0	0	1	1931	0	0
Dorval and Smith (2013)	T	AR(1)	0	1	2	1931.5	0	0
Romer and Romer (2013)	N	Business Week	.	1	2	1930.5	0	11
Binder (2015a, 2015b)	N	Quantitative NYT	.	1	2	1930.5	0	0
Binder (2015a, 2015b)	N	Quantitative NYT	.	0	2	1931.5	0	0
Davis (2015)	T	Multivariate	1	0	1	1929.5	0	0

Notes: This table summarizes the coding of the papers used in the meta-analysis of inflation expectations at the onset of the U.S. Great Depression. Categories T, N, and M denote time series, narrative, and market, respectively. Only time series approaches were categorized as multivariate or not. WPI denotes the paper used a wholesale or commodity price index (or primarily referred to such prices in the narrative record, if using a narrative approach). See Table 3 for variable descriptions.

Table 6
Meta-regression analysis of timing of deflation expectations in U.S. Great Depression.

	(1)	(2)	(3)	(4)	(5)
Market	−0.43	−0.52	−1.17**	−0.43	−1.17**
	(0.42)	(0.49)	(0.47)	(0.43)	(0.49)
TimeSeries	−0.38	−0.42	−1.35**	−0.38	−1.28**
	(0.40)	(0.43)	(0.50)	(0.40)	(0.45)
WPI		−0.16	−1.29**		−1.29**
		(0.49)	(0.52)		(0.54)
TimeSeries*WPI			2.05***		2.09***
			(0.52)		(0.59)
TimeSeries*Multivar				−0.00	−0.16
				(0.46)	(0.46)
Constant	1931.43***	1931.52***	1932.17***	1931.43***	1932.17***
	(0.37)	(0.45)	(0.42)	(0.38)	(0.44)
N	19	19	19	19	19
R^2	0.06	0.07	0.46	0.06	0.46

Notes: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Standard errors clustered by author in parentheses. Dependent variable is *DeflationYear*, the year that inflation expectations turned substantially negative.

Table 7
Meta-regression analysis of timing of deflation expectations in U.S. Great Depression with alternative weightings.

	(1)	(2)	(3)	(4)
Market	−1.17**	−1.05**	−1.02*	−1.07*
	(0.49)	(0.37)	(0.54)	(0.54)
TimeSeries	−1.28**	−1.40***	−1.22**	−1.20**
	(0.45)	(0.40)	(0.52)	(0.50)
WPI	−1.29**	−0.92	−1.37**	−1.27**
	(0.54)	(0.65)	(0.52)	(0.54)
TimeSeries*WPI	2.09***	1.18*	2.06***	1.93***
	(0.59)	(0.62)	(0.62)	(0.60)
TimeSeries*Multivar	−0.16	0.26	−0.26	−0.17
	(0.46)	(0.28)	(0.40)	(0.38)
Constant	1932.17***	1932.28***	1932.12***	1932.10***
	(0.44)	(0.37)	(0.51)	(0.50)
N	19	19	19	19
R^2	0.46	0.41	0.47	0.42

Notes: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Standard errors clustered by author in parentheses. Dependent variable is *DeflationYear*, the year that inflation expectations turned substantially negative. In column 1, all observations are equally weighted. In column 2, weights are proportional to number of *EconLit* citations plus one. In column 3, weights are proportional to number of *EconLit* citations adjusted for publication year. In column 4, weights are proportional to number of *Google Scholar* citations adjusted for publication year.

Appendix B. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.eeh.2016.01.002.

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