

Dorval, Bill; Smith, Gregor W.

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## Interwar Deflation and Depression

Bill Dorval  
Queen

Gregor W. Smith  
Queen

Department of Economics  
Queen's University  
94 University Avenue  
Kingston, Ontario, Canada  
K7L 3N6

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# Interwar Deflation and Depression

Bill Dorval and Gregor W. Smith\*

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## Abstract

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Interwar macroeconomic history is a natural place to look for evidence on the correlations between (a) deflation and depression and (b) unexpected deflation and depression. We apply time-series methods to measure unexpected deflation or inflation for 26 countries from 1922 to 1939. The results suggest much variation across countries in the degree to which the ongoing deflation of the 1930s was unexpected. There is a significant, positive correlation between deflation and depression for the entire period but relatively little evidence of a correlation between unexpected deflation and depression.

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\* Department of Economics, Queen's University, Kingston Ontario Canada K7L 3N6; dorvalb@econ.queensu.ca; smithgw@econ.queensu.ca. We thank conference participants at the Canadian Network for Economic History for comments and the Social Sciences and Humanities Research Council of Canada and the Bank of Canada fellowship programme for support of this research. The views expressed herein are not necessarily those of the Bank of Canada and are the authors' alone.

## 1. Introduction

The interwar period, with its volatility, multiple policy regimes, and international heterogeneity, is a natural place to look for lessons on business cycles and in particular for evidence on the relationship between monetary phenomena and the real economy. For example, numerous countries experienced deflations during the 1920s and 1930s, and so evidence from this period remains widely cited in more recent debates on the causes and effects of deflation. A variety of economic theories distinguish between the effects of the expected and unexpected components of inflation or deflation. Yet there is little research that tries to distinguish these two components (and study their correlations with output growth) for multiple countries during the interwar period.

We use quarterly retail price indexes for 26 countries (and wholesale price indexes for 24 countries) in a time-series model, to try to distinguish between expected and unexpected inflation. We find considerable variation in inflation persistence across countries. Thus the extent to which the deflation of the early 1930s was expected to continue may well have differed significantly across countries too.

We then see whether there is a correlation between inflation/deflation and output growth, first in a cross-section of averages for 1929–1934 and second in the panel of countries year-by-year from 1922–1939. The cross-section provides no evidence of a significant correlation. But the panel data allow us to control for country-specific, average growth rates over the entire interwar period. In that statistical environment, there is a clear, positive correlation between inflation and output growth. Notably, the linear relationship has no detectable kink at a zero inflation rate or at high inflation rates. There also is relatively little statistical evidence of a correlation between unexpected inflation and output growth given actual inflation.

## 2. Research Background

A key component in the research background is the study by Atkeson and Kehoe (2004). They found little historical evidence of a correlation between deflations and depressions. For the Great Depression, they measured average growth rates in real output

over 1929–1934 for 16 countries, and regressed them on a constant and average inflation rates in this cross-section. They found a slope of 0.4 with a standard error of 0.28, thus providing some evidence of a link, albeit with low statistical significance. Notably, they found that the link was even weaker for other time periods. Thus they questioned the popular view that deflations are associated with depressions.

A second key component is the study by Benhabib and Spiegel (2009). They considered the possibility that the relationship might be nonlinear; positive at low or moderate inflation rates (or in deflations) but turning negative at high inflation rates, to form an inverted U-shape. They studied the same set of countries as Atkeson and Kehoe, again with averages within 5-year periods. By estimating in a panel, as opposed to a cross-section, they allowed for country-specific fixed effects in economic growth. Measuring the nonlinearity either with a term in squared inflation or using a threshold model, they found a nonlinear relationship that was positive below a threshold at a moderate level of inflation and negative or insignificant above it.

Our research also is related to studies for the US that try to measure the extent to which the ongoing deflation during the Great Depression was anticipated. Cecchetti (1992) argued that, once deflation began, it was largely anticipated at 3-6 month horizons. He found evidence for anticipated deflation in (a) the US history of deflations prior to 1929, (b) time-series models of the inflation rate, and (c) information in short-term nominal interest rates. His time-series modelling is particularly relevant to our approach below, since we do not have detailed information from fixed-income markets in the international panel. Cecchetti measured inflation quarterly, at annual rates, and for 1919–1940 found an AR(1) model had persistence coefficient of 0.52. Forecasts from this model suggested that up to three-quarters of ongoing deflation was anticipated, so that *ex ante* real interest rates were high, a likely cause of continued depression.

Nelson (1991) studied the contemporary business press and concluded that deflation was expected after the middle of 1930. In a similar vein, Romer and Romer (2013) tracked editorial opinion in *Business Week* and concluded that by the autumn of 1930 deflation was anticipated and, further, that this forecast was attributed to inaction by the Fed.

They too concluded that the low nominal interest rates of the period were consistent with high expected real interest rates.

In contrast, Dominguez, Fair, and Shapiro (1988) summarized evidence both from vector autoregressions and from contemporary sources and concluded that the US deflation was largely unanticipated. Hamilton (1992) noted the variability of forecasts from time-series models that have similar in-sample fit. He thus supplemented these models with information from commodity futures markets, essentially using the historical link between commodity prices and the overall consumer price index as the observation equation in a Kalman filtering exercise. He concluded that expected deflations were only about half as severe as those that occurred in the second and third years of the Great Depression. Evans and Wachtel (1993) described uncertainty about Fed policy as the Depression began, and modelled inflation expectations with a regime-switching model. They estimated investors' views of the probability of a return to stable prices by using information in monthly interest rates. Like Hamilton, they concluded the deflation was largely unanticipated. This finding implies that real interest rates were not so high once the Depression began, so that the propagation mechanism may have been through unexpected deflation causing bankruptcy instead. Overall then, this debate also reminds us that both anticipated and unanticipated deflation may have real effects.

Few studies examine the degree to which interwar deflations were expected for other countries. An exception is the study by Fregert and Jonung (2004), who looked at the reported beliefs of employers, workers, and policymakers in Sweden, and how they differed between the deflations of 1921–1923 and 1931–1933.

We too examine the links between inflation (or deflation) and output growth, particularly for the interwar period and for a large set of countries. Our focus is on whether a readily-constructed measure of unanticipated deflation affects conclusions about the correlation between deflation and depression. Our forecasting model uses the time-series properties of inflation (as in Cecchetti, 1992) largely because the additional information sources considered in the research on the US are not available for most other countries. We have not found existing studies that use a panel of countries to assess the correlation be-

tween unexpected deflation and the business cycle in the Great Depression or the interwar period more generally. This paper is an attempt to address this question.

### 3. The Information: Interwar Price and Output Data

We use both retail (or consumer) and wholesale price indexes from the League of Nations *Statistical Yearbook* for 32 countries. The starting dates vary from 1921 to 1928 while the ending dates vary between 1938 and 1944. Monthly data are available for some countries and time periods, but all results are reported for quarterly data for comparability. Table 1 contains the list of countries, the codes used to label them, and the country-specific time span of quarterly, retail price data. (Wholesale price data are unavailable for Greece, Ireland, and Romania but are available for an additional country: Spain.)

The time spans exclude episodes of hyperinflation in the early 1920s in Austria, Germany, Hungary, and Poland. However, there remains a great deal of heterogeneity in the inflation experiences. For example, the panel data include some of the deflations associated with the restoration of the gold standard after the 1914–1918 War and those associated with the Great Depression. However, the League of Nations data begin in 1921, so we do not capture all of the postwar deflations. Price indexes of course exist for some countries earlier but to our knowledge there is no international panel at high frequency before this period.

Real output is measured in millions of 1990 international Geary-Khamis dollars, from Maddison (2003) and <http://www.ggdc.net/maddison/maddison-project/data.htm>. These series are at annual frequency. Asterisks in table 1 indicate countries for which Maddison’s real GDP data are available, overlapping with the League of Nations price data. This intersection includes 26 countries for retail prices and 24 countries for wholesale prices.

Let  $P_{it}$  denote the price index in country  $i$  and quarter  $t$ . The inflation rate is measured as the 4-quarter growth rate of the price index:

$$\pi_{it} = 100 \cdot \left[ \left( \frac{P_{it}}{P_{it-4}} \right) - 1 \right]. \quad (1)$$

This inflation rate (as opposed to the annualized, quarter-to-quarter rate) seems appropriate because we later look at its correlation with the growth rate of real GDP, which is measured at annual frequency.

For retail price inflation, table 2 contains the means, standard deviations, and standard deviations relative to the United States, for the panel of inflation rates. Average inflation rates varied widely across countries, with Belgium, France, Greece, and Romania all having average inflation over 4% at annual rates, while 8 countries — including the US and UK — on average experienced deflation. The US experienced the lowest volatility of inflation (as measured by the standard deviation) other than New Zealand and South Africa. Again there was considerable variation across countries in this statistical moment.

#### 4. Forecasting Model

Several sources of information available to the modern forecaster are not present for the interwar period. National income accounts are available only at annual frequency. We do not have access to surveys of professional forecasts (with one or two infrequent exceptions), to inflation-indexed bond prices, or, indeed to natural covariates such as unemployment rates or output gaps at high frequency. There is ongoing research on the role of these covariates in forecasting inflation in contemporary data, as discussed by Stock and Watson (2007) and Faust and Wright (2012), but we cannot generally check on that possibility for most countries in the interwar period.

Thus we focus on univariate, time-series methods. We estimate:

$$\pi_{it} = \mu_i + \rho_i \pi_{it-4} + \epsilon_{it}, \tag{2}$$

where  $t$  counts quarters and  $\epsilon_{it}$  is an error term assumed to have mean zero and be uncorrelated with lagged inflation. This lag-4 autoregression has the appealing features that (a) it involves only two parameters per country, (b) it tends to remove any potential seasonality in inflation, and (c) its forecasts can be averaged over quarters to produce realistic, annual forecasts, given the 4-quarter lag, yet (d) it still uses the high frequency of the price data to add precision (as opposed to simply estimating a time-series model in



annual averages). The parameter  $\rho_i$  — varying across countries — captures the decay or memory in actual inflation and hence potentially estimates a property of expectations.

We represent inflation forecasts in two ways, first by using recursive estimates of the parameters, then by using estimates based on the full sample. The recursive estimates use only data prior to the date of the forecast, so that forecasted inflation is:

$$E_{t-4}\pi_{it} = \hat{\mu}_{it-4} + \hat{\rho}_{it-4}\pi_{it-4}, \quad (3)$$

where the time subscript on the parameters denotes the last observation used in estimation. We construct the first forecast when there are 8 quarterly observations in the estimation. But if that first forecast is not the first quarter of a calendar year, we continue to add observations and defer forecasts until that condition is satisfied. That way the annual averaging always involves the same number of actual inflation rates and forecasted ones, and the annual averages of expected and unexpected inflation always add up to actual inflation for each year.

A benefit of adopting the recursive approach is that it uses no information from the properties of inflation in the 1930s to estimate the parameters for constructing expected inflation during the 1920s. But a cost is that it uses relatively few observations early in the sample and likewise requires a later starting date. The delayed starting date means that we do not measure unexpected deflations in 1921 or 1922 (though it might be difficult to argue they could be predicted from previous history even were price indexes available for the prior decade and the 1914–1918 War). But we do use the properties of such deflations to parametrize the forecasting models and hence measure inflation expectations in the deflations of the 1930s, which are a key feature of this historical period.

For comparison with the recursive forecasts we also forecast inflation using parameter estimates  $\{\hat{\mu}_i, \hat{\rho}_i\}$  from the full interwar sample, so that forecasted inflation is:

$$E_{t-4}\pi_{it} = \hat{\mu}_i + \hat{\rho}_i\pi_{it-4}. \quad (4)$$

Future work might consider adding to the forecasting information set, with indicators including the unemployment rate (where available), the inflation rates of neighboring countries, the US inflation rate, the exchange-rate change, or gold-standard status.

Table 3 gives parameter estimates from full-sample estimation, for quarterly inflation rates measured with both retail and wholesale price indexes, for the countries for which Maddison provided output data. Standard errors are robust to residual autocorrelation. Notice that countries with relatively volatile inflation in table 2 — such as Belgium, Bulgaria, Hungary, and Romania — also tend to have relatively low forecastability (measured by  $R^2$ ) in table 3. Also notice the wide variation in inflation persistence across countries. In retail price inflation, for example, Finland, Japan, and the US have much more persistence than France or the Netherlands.

Of course the recursive parameter estimates vary over time as well as across countries. Rather than graphing them we directly illustrate their effects by graphing inflation and its unexpected component. Here, the variation in estimated persistence is transmitted into the properties of unexpected inflation or deflation. First, figure 1 graphs retail price inflation (the solid, black line) and unexpected inflation (the dashed, gray line) for the US, where persistence is both relatively high and precisely estimated, with  $\hat{\rho}_i = 0.498$  in the full sample. The persistence in inflation is inherited by the forecasts, so that forecast errors have less persistence. Notice, then, that during the deflation of the early 1930s the US forecast errors bounce back up, away from the actual deflation rates, so that a significant part of the ongoing deflation is expected. Because the persistence parameters are recursively estimated, they reflect the US-specific inflation history of the 1920s.

Figure 2, in contrast, shows actual inflation and unexpected inflation for France, a country with low persistence, where the full-sample persistence coefficient is  $\hat{\rho}_i = 0.183$  and insignificantly different from zero at conventional levels of significance. Here inflation is viewed by the statistical model as virtually unforecastable, a finding which makes considerable sense given France’s very volatile inflation history during the 1920s. Unexpected inflation thus is relatively persistent during the deflation of the early 1930s, with no tendency to ‘snap back’ as deflation continued. We later test whether such larger inflation ‘shocks’ are associated with larger movements in real output.

## 5. Deflation and Depression on Average: 1930–1934

Atkeson and Kehoe (2004) pointed out that there generally is little evidence of a

correlation between deflation and low growth in historical data. But the one episode for which they *did* find a correlation was the Great Depression, and specifically the period from 1930 to 1934 (which thus involves the levels of output and prices from 1929 to 1934). They studied a group of 16 countries, and illustrated their findings with a scatter plot of real output growth against inflation, with averages for each country over those 5 years.

In this section we first duplicate their method for a larger set of 26 countries. Second, as they noted (p 99) “we have made no attempt to distinguish anticipated from unanticipated deflations, while theory, of course, makes a sharp distinction.” We use the recursive and full-sample forecasting models from section 4 to make this distinction and repeat the scatter plot using the resulting measures of unexpected inflation or deflation. Third, we also apply the method using wholesale as well as retail prices.

To construct annual measures of inflation and unexpected inflation corresponding to annual growth rates in real output, we average the corresponding quarterly measures within calendar years. We include all observations for which there are at least two quarters of observations on inflation and forecasted inflation. We then average a second time, over the years 1930–1934, just as Atkeson and Kehoe did. Our measures of unexpected inflation rely on quarterly price indexes, which are not available for all countries. But we have such measures for 12 of the 16 countries studied by Atkeson and Kehoe: Australia, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Sweden, the UK, and the US. As for the remaining 4 countries in the Atkeson-Kehoe study, we do not have data for Argentina, Brazil, or Portugal and for Spain our only data are for wholesale prices. But we do have data for 14 additional countries, labelled with asterisks in table 1.

Figure 3 shows the scatter plot of average output growth during 1930–1934, on the vertical axis, against average retail price inflation, on the horizontal axis. The upper panel shows the plot for the 12 countries also studied by Atkeson and Kehoe, while the lower panel shows the plot for the additional 14 countries. In each plot the dark circles represent actual inflation rates, while the light circles represent unexpected inflation rates, estimated recursively. Thus the horizontal distance between the two, for a given country, is the expected inflation rate.

The dark circles in the upper panel show a weak, positive relationship between average output growth and average inflation, just as Atkeson and Kehoe found for these countries. When we switch to unexpected inflation, in the light circles, the correlation appears to be lower, though. Moreover, in the lower panel the correlation for the additional 14 countries appears to be roughly zero for actual inflation and negative for unexpected inflation. These results are influenced by countries such as Austria, which experienced prolonged depression with virtually no deflation, and Bulgaria, which experienced modest growth on average with significant deflation.

Table 4 shows the corresponding regression results. Let  $\bar{y}_i$  denote average output growth in country  $i$  from 1930 to 1934, and  $\bar{\pi}_i$  denote average inflation. The regression model is:

$$\bar{y}_i = \alpha + \beta_\pi \bar{\pi}_i + \epsilon_i. \quad (5)$$

We also replace average realized inflation with average unexpected inflation, with parameter  $\beta_u$ . Unexpected inflation is estimated two ways, first recursively and then using the full sample.

The upper panel of table 4 pertains to retail prices and regresses average output growth on a constant and either actual inflation or unexpected inflation in the cross-section of countries. We first study 12 countries studied by Atkeson and Kehoe and then the full set of 26 countries. (Denmark and Japan are absent from the recursive estimates though, because their price indexes begin too late to allow 8 quarters of observations prior to 1930.) This panel shows that there is no statistically significant pattern for either group of countries or for actual or unexpected inflation. It is noteworthy that measuring unexpected inflation or deflation provides no added evidence of a pattern.

The lower panel of table 4 pertains to wholesale prices, where we lack data for Greece, Ireland, and Romania but can add data from Spain for a total of 24 countries. In this case the point estimates are all positive, and there is more explanatory power than in the case of retail price inflation, but still no  $p$ -value is less than 0.10.

We have added additional countries, wholesale prices, and time-series-based measures of unexpected inflation or deflation to Atkeson and Kehoe's study. But, if anything, these

steps weaken the evidence for a positive correlation between inflation or deflation and growth from 1930 to 1934. Before concluding there is no correlation though, we next consider two related, statistical possibilities. First, there may be information in the year-by-year observations for each country that is obscured by the 1930–1934 averages. Second, there may be a difference in average output growth rates across countries, unrelated to rates of inflation or deflation, that one needs to control for in measuring the impact of inflation surprises. Atkeson and Kehoe (2004, p 102) argued that “standard theories, either neoclassical or new Keynesian, would have a hard time blaming Japan’s secular growth slowdown [from the 1960s to the 1990s] on its secular decline in inflation.” We concur and similarly would like to allow for differences in average growth rates over the entire interwar period that may be due to growth convergence or other features unrelated to inflation or deflation. The next section studies these issues.

## 6. Deflation and Depression Year-by-Year 1922–1939

To further study the correlation between inflation and growth (or deflation and depression) we next study the interwar history year-by-year from 1922 to 1939, indexed by the subscript  $\tau$ . We relate output growth in country  $i$  and year  $\tau$ ,  $\dot{y}_{i\tau}$ , to combinations of realized inflation, unexpected inflation, and expected inflation. To illustrate the notation we collect the regressors this way:

$$\dot{y}_{i\tau} = \alpha_i + \beta_\pi \pi_{i\tau} + \beta_u (\pi_{i\tau} - E_{\tau-1} \pi_{i\tau}) + \beta_e (E_{\tau-1} \pi_{i\tau}) + \epsilon_{i\tau}, \quad (6)$$

even though actual inflation, unexpected inflation, and expected inflation of course cannot all be included at once. With a relatively short panel, working with growth rates and country-specific intercepts (fixed effects) seems a reasonable specification. With the added time-series dimension, we now can identify a value  $\alpha_i$  specific to each country. The underlying economic assumption is that a component of the long-term, average growth rate over this period was not related to the inflation rate. Benhabib and Spiegel (2009) also controlled for country fixed effects, in averages over successive 5-year periods.

Table 5 presents results from several special cases for retail price inflation. The data include 18 years and 26 countries. The recursive forecasts involve a start-up period and,

as table 1 showed, not all price indexes began in 1922, so the number of observations is 336. The first row contains the actual inflation rate only and finds it to have a coefficient of 0.33 with  $t$ -statistic of 6.1. A deflation of 1% per year thus is associated with output falling by 0.33% per year. Some of the variation in predicted output growth rates is due to the fixed effects though; the centered  $R^2$  is 0.17 while the uncentered value is 0.30. These significant differences in  $\hat{\alpha}_i$  across countries may explain the lack of correlation in table 4 and figure 3, for they were not controlled for there.

The second and third rows include only expected inflation and unexpected inflation respectively and find that they too are significant at conventional levels of significance. However, the fourth through sixth rows contain the possible combinations of the three terms. They show that expected and unexpected inflation enter with virtually the same coefficients (thus adding up to actual inflation) and that these two terms are each insignificant when actual inflation is included. Actual inflation or deflation thus is the clear winner in this contest to statistically explain the time-series variation in output growth rates.

We also studied the regressions in table 5 with forecasts constructed from the full-sample estimates of  $\{\hat{\mu}_i, \hat{\rho}_i\}$ , rather than the recursive or real-time ones. This modification did not affect the findings. And we examined the specification in the first row, with only actual inflation, including all observations on actual inflation (rather than restricting ourselves to the observations for which we also can measure expected inflation), which increased the sample size to 411. In this case the coefficient  $\hat{\beta}_\pi$  was 0.24 with a standard error of 0.05. The overall message from table 5 thus is simple: there is a strong correlation between actual inflation in retail prices and growth in real output (or between deflation and depression) once we control for country-specific trends.

For wholesale price inflation the results (not shown in table 5) are more nuanced. When we use the full-sample forecasts the results are very similar to those for retail price inflation: actual inflation or deflation matters but its components do not. But when we study the recursive forecasts both actual inflation and unexpected inflation are statistically significant.

Notice that the expected and unexpected inflation rates are generated regressors in

that constructing them involves sampling variability in the forecasting coefficients,  $\{\hat{\mu}_i, \hat{\rho}_i\}$ . Pagan (1984) showed that the standard error for the coefficient on *expected* inflation,  $\hat{\beta}_e$ , will underestimate the correct one. Valid inference requires either instrumental-variables estimation (challenging here because of the difficulty in finding instruments that forecast annual growth rates) or system estimation (challenging here because of the different frequencies of the quarterly forecasting equation and annual regressions). However we find that expected inflation is statistically insignificant with actual inflation included in the regressions, so further reducing its significance by correcting its standard error would not change our conclusion. Pagan also showed that the OLS standard error for *unexpected* inflation is valid.

Several statistical extensions to these regressions come to mind, but are not practical for the interwar period. First, one might explore the correlation country-by-country, using a time-series model with some dynamics in the form of single lags in output growth and inflation:

$$\dot{y}_{i\tau} = \alpha_i + \lambda_i \dot{y}_{i\tau-1} + \beta_{1i\pi} \pi_{i\tau} + \beta_{2i\pi} \pi_{i\tau-1} + \epsilon_{i\tau}, \quad (7)$$

and country-specific coefficients. But in this case there are only 18 annual observations per country; too few for reliable inference. With high-frequency data one could estimate a vector autoregression and use it to measure surprises in inflation or deflation and their impacts. Smith (2006) summarizes some existing work in this vein for the interwar period, but it is infeasible for most countries because even quarterly data on output growth are absent.

Second, one might allow for some dynamics in the panel. As is well-known, though, OLS estimation of a panel with a lagged dependent variable and fixed effects (country-specific intercepts) leads to bias that dissipates only as the time dimension becomes large. Estimators that correct for this bias involve instrumental variables. But instrumenting requires forecasting growth rates, again with relatively few time-series observations. In this context the first-stage regression generally fits poorly, leading to challenging inference because of weak instruments.

## 7. Kinks and Curves

It is possible that the correlation between inflation and growth was different from the one between deflation and depression. We next use a dummy variable  $d_{i\tau}$  to denote observations with deflation, and by interacting this with actual inflation allow for the correlation between inflation and output growth to differ between inflation and deflations. The regression model then becomes:

$$\dot{y}_{i\tau} = \alpha_i + (\beta_\pi + \delta d_{i\tau})\pi_{i\tau} + \epsilon_{i\tau}. \quad (8)$$

Thus the estimated slope is  $\hat{\beta}_\pi$  for inflation and  $\hat{\beta}_\pi + \hat{\delta}$  for deflations. For retail price inflation  $\hat{\delta} = 0.20$  so that the estimated effect of deflation on depression is greater than the effect of inflation on positive growth. However the standard error is 0.16, so this kink in the regression line has a  $t$ -statistic of only 1.33. For wholesale price inflation  $\hat{\delta} = -0.11$  with a standard error of 0.08. In neither case, then, is there a kink in the relationship, at conventional levels of statistical significance, at an inflation rate of zero.

It also is possible that the relationship is monotonic but involves other kinks or curves. To check on that possibility, we use linear regression in ranks, which thus has a valid functional form for any monotone relationship between inflation and output growth. Rank regression also may avoid some measurement errors if they are small enough not to affect ranks. Define  $R[x]$  as the rank statistic for a variable  $x$ . Then the regression is:

$$R[\dot{y}_{i\tau}] = \alpha_i + \lambda_\pi R[\pi_{i\tau}] + \epsilon_{i\tau}. \quad (9)$$

The fixed effects,  $\alpha_i$ , control for country-specific average ranks of output growth rates over the interwar period. The coefficients  $\hat{\lambda}_\pi$ , with standard errors in brackets, are 0.32 (0.05) for retail price inflation and 0.21 (0.05) for wholesale price inflation. With just a constant term  $\alpha$  included the coefficients become Spearman's rank correlation coefficients. These are 0.27 (0.05) for retail prices and 0.20 (0.05) for wholesale prices. These positive, rank correlations are not strong but they are statistically significant at conventional levels of significance.

Benhabib and Spiegel found that the correlation becomes negative at high inflation rates, so the relationship is not monotone, using 5-year averages for 17 countries from



1859–2009. We follow two of their methods. First, we include a term in squared inflation, specifically to see if its coefficient is negative, capturing an inverted U-shape. We find that squared inflation enters with a negative coefficient with a  $p$ -value of 0.07 for retail price inflation — suggesting a non-monotone curve — but a much higher  $p$ -value for wholesale price inflation. Second, we also split the inflation/deflation rates at their medians and fit linear functions for each segment. Again the  $p$ -values for the differences between the two slopes are relatively large, though.

By comparison with Benhabib and Spiegel we study more countries but over a shorter time span for the interwar period only, and with year-by-year data rather than 5-year averages. One might suspect the annual data are simply noisier, but the goodness of fit in our panel estimation is similar to theirs. Like these authors, we are studying correlations rather than a causal model of output growth. But possibly even high inflation rates (other than the central European hyperinflations of the early 1920s) were associated with growth during the interwar period because they followed after deflations and so represented returns to more normal price levels. Figure 1 shows this pattern for inflation in the US during 1934, while figure 2 shows it for inflation in France during 1937. Their inflations were temporary (rather than accelerating) and offset previous deflations.

## 8. Conclusion

This study has re-examined the relationship between deflation and depression (or inflation and growth) for a set of 26 countries during the interwar period, a time of volatility in both real and nominal macroeconomic variables. Nested within the question of whether deflation was correlated with depression is the further question of whether the correlation was due to anticipated deflation (operating through high *ex ante* real interest rates) or unanticipated deflation (operating through bankruptcy perhaps).

To model expectations we take advantage of higher-frequency price data to study a forecasting model with a one-year horizon but estimated at quarterly frequency. We find considerable variation across countries in the persistence of inflation and so possible variation across countries in inflation expectations at the onset of the Great Depression.

We then complement the studies of Atkeson and Kehoe (2004) and Benhabib and Spiegel (2009) by examining data from a larger set of countries and including these measurements of unexpected deflation. From the cross-section of countries during 1930–1934 there is little evidence of a correlation between output growth and either inflation or unexpected inflation. But when we use time-series variation to identify the effect (and allow for country-specific, average, output growth rates over the entire interwar period) there is a clear correlation between output growth and actual inflation or deflation. For the full interwar period a 1% inflation rate is associated with a real growth rate of 0.14–0.34% with 95% confidence.

There are two other noteworthy findings. First, and strikingly, unexpected retail inflation has no statistically significant correlation with output growth once we control for actual inflation. But we do find a role for unexpected wholesale inflation, when forecasts are estimated recursively. Second, the relation between output growth and inflation or deflation seems to be linear, with relatively little evidence of a kink at zero or at higher inflation rates. Bursts of inflation in the interwar period (with the notable exception of the hyperinflations of the 1920s) often were reflations, temporary sequels to deflations, a feature which may explain this finding.

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**Table 1: Countries and Time Spans for Retail Price Data**

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Country	Code	Time Span	Country	Code	Time Span
Australia*	aus	1921q1–1944q4	Italy*	ita	1921q1–1939q2
Austria*	aut	1923q1–1938q1	Japan*	jpn	1928q1–1944q3
Belgium*	bel	1922q1–1940q1	Latvia	lva	1921q1–1940q2
Bulgaria*	bgr	1922q1–1943q2	Lithuania	ltu	1924q1–1940q2
Canada*	can	1921q1–1944q4	Luxembourg	lux	1921q2–1940q1
Czechoslovakia*	cze	1923q3–1939q2	Netherlands*	nld	1921q1–1940q1
Denmark*	dnk	1926q3–1944q4	New Zealand*	nzl	1925q3–1944q4
Egypt	egy	1921q1–1944q4	Norway*	nor	1921q1–1944q4
Estonia	est	1924q3–1940q1	Peru*	per	1924q1–1944q4
Finland*	fin	1921q1–1944q4	Poland*	pol	1924q1–1939q2
France*	fra	1921q1–1938q4	Romania*	rom	1922q1–1941q2
Germany*	deu	1924q1–1944q4	South Africa	zaf	1922q1–1944q4
Greece*	grc	1923q2–1940q4	Sweden*	swe	1921q1–1944q4
Hungary*	hun	1925q1–1943q4	Switzerland*	che	1921q1–1944q4
India*	ind	1921q1–1944q4	United Kingdom*	gbr	1921q1–1944q4
Ireland*	irl	1922q2–1944q4	United States*	usa	1921q1–1944q4

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Sources: League of Nations *Statistical Yearbooks* and Bureau of Labor Statistics.

Asterisks denote countries with annual real GDP data from Maddison (2003).

**Table 2: Summary Statistics for Retail Price Inflation**

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Country	Mean	SD	Relative SD	Country	Mean	SD	Relative SD
aus	0.08	0.77	1.18	ita	0	1.56	2.4
aut	2.23	1.31	2	jpn	3.42	1.33	2.04
bel	4.98	2	3.07	lva	1.6	3.09	4.74
bgr	2.86	1.79	2.74	ltu	-1.73	2.06	3.15
can	-0.37	0.69	1.06	lux	3.35	1.83	2.81
cze	0.92	0.86	1.33	nld	-1.61	0.87	1.33
dnk	2.48	0.95	1.45	nzl	0.54	0.58	0.9
egy	2.73	1.28	1.96	nor	-0.6	1.05	1.62
est	1.79	1.67	2.56	per	2.35	0.95	1.46
fin	2.93	1.28	1.97	pol	0.7	1.81	2.78
fra	4.28	1.65	2.53	rom	8.94	2.21	3.39
deu	0.7	0.76	1.16	zaf	0.72	0.47	0.72
grc	4.22	1.62	2.49	swe	-0.1	0.87	1.33
hun	2.99	1.72	2.64	che	-0.3	0.92	1.42
ind	1.75	1.65	2.53	gbr	-0.6	1.02	1.57
irl	1.94	1.28	1.96	usa	-0.19	0.65	1

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Sources: League of Nations *Statistical Yearbooks* and Bureau of Labor Statistics. Entries are means and standard deviations of annualized, quarterly inflation rates. The relative SD is the ratio of the standard deviation to that in the US.

**Table 3: Full-Sample Inflation Forecast Regressions**

$$\pi_{it} = \mu_i + \rho_i \pi_{it-4} + \epsilon_{it}$$

Country	Retail Prices			Wholesale Prices		
	$\hat{\rho}_i$ (se)	Obs.	$\overline{R}_i^2$	$\hat{\rho}_i$ (se)	Obs.	$\overline{R}_i^2$
aus	0.363* (0.196)	88	0.144	0.0570 (0.100)	92	-0.006
aut	0.228 (0.170)	53	0.119	-0.0283 (0.115)	57	-0.016
bel	0.277* (0.140)	65	0.073	0.150 (0.149)	67	0.008
bgr	0.596** (0.234)	78	0.286	0.558*** (0.144)	70	0.280
can	0.428** (0.166)	88	0.199	0.244** (0.108)	92	0.079
cze	-0.0685 (0.243)	56	-0.015	0.269 (0.171)	78	0.065
dnk	0.446*** (0.131)	66	0.193	0.237** (0.0931)	90	0.068
fin	0.689*** (0.0938)	88	0.481	0.448*** (0.139)	87	0.198
fra	0.183 (0.186)	64	0.019	0.291** (0.120)	70	0.092
deu	0.486** (0.216)	76	0.302	0.551** (0.223)	75	0.305
grc	0.297* (0.166)	63	0.073	—	—	—
hun	0.549*** (0.153)	68	0.236	0.327** (0.163)	71	0.089
ind	0.434* (0.230)	88	0.182	0.314 (0.248)	92	0.090
irl	0.523*** (0.0945)	83	0.268	—	—	—

[continued on the next page]

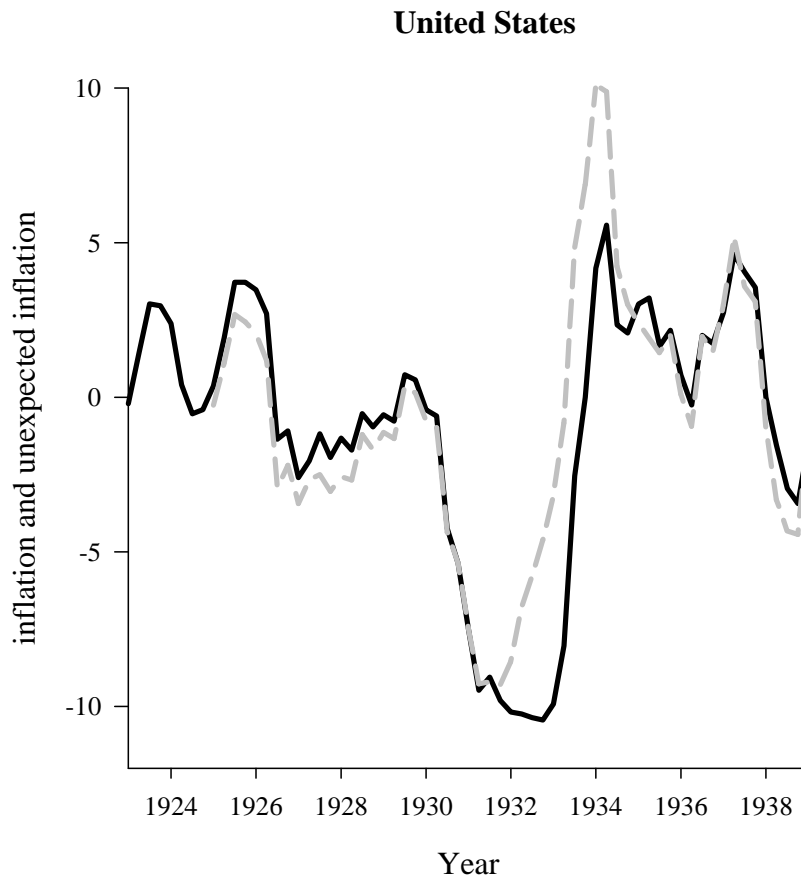
**Table 3: Full-Sample Inflation Forecast Regressions**  
[continued]

$$\pi_{it} = \mu_i + \rho_i \pi_{it-4} + \epsilon_{it}$$

Country	Retail Prices			Wholesale Prices		
	$\hat{\rho}_i$ (se)	Obs.	$\bar{R}_i^2$	$\hat{\rho}_i$ (se)	Obs.	$\bar{R}_i^2$
ita	0.340** (0.140)	66	0.107	0.418*** (0.116)	80	0.172
jpn	0.616*** (0.200)	59	0.376	0.267** (0.126)	91	0.081
nld	0.240* (0.136)	69	0.055	0.267** (0.125)	73	0.081
nzl	0.669*** (0.181)	70	0.439	0.615*** (0.116)	72	0.396
nor	0.472*** (0.134)	88	0.248	0.433*** (0.115)	92	0.205
per	0.654*** (0.162)	76	0.340	0.554*** (0.127)	89	0.324
pol	0.666*** (0.157)	54	0.582	0.594*** (0.172)	54	0.372
rom	0.607*** (0.201)	70	0.287	—	—	—
esp	—	—	—	0.608*** (0.118)	91	0.447
swe	0.545*** (0.0979)	88	0.495	0.458*** (0.0808)	92	0.327
che	0.405** (0.189)	88	0.281	0.536*** (0.153)	87	0.297
gbr	0.357*** (0.0792)	88	0.181	0.226** (0.0873)	92	0.059
usa	0.498*** (0.173)	88	0.260	0.141 (0.134)	92	0.024

Notes: Newey-West (with 4 lags) standard errors in parentheses.  $p$ -values less than 0.01 denoted \*\*\*, less than 0.05 denoted \*\*, and less than 0.10 denoted \*.

**Figure 1: Quarterly Inflation and Unexpected Inflation**

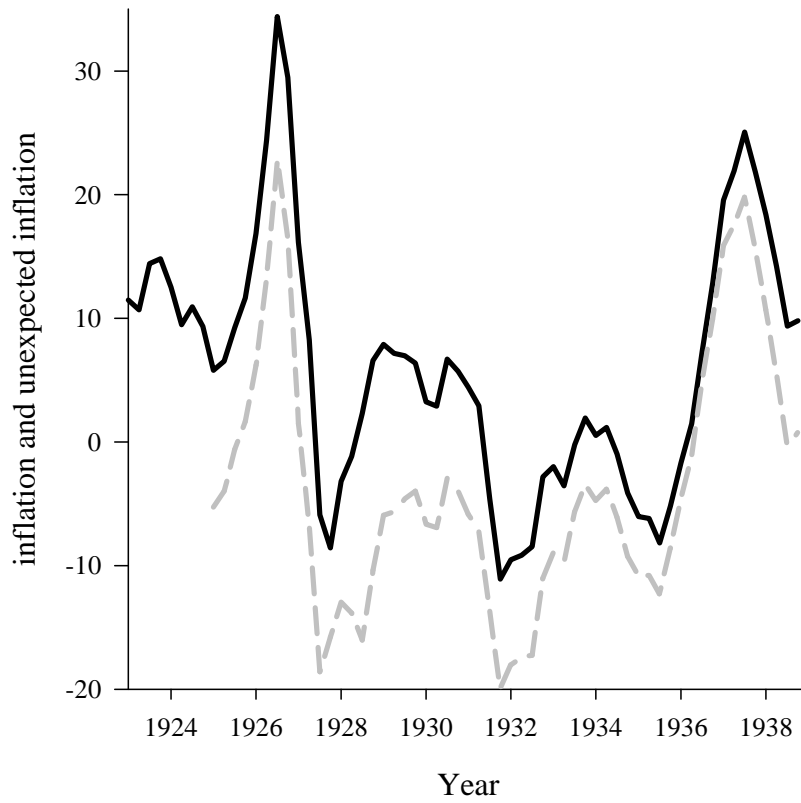


Note: The solid line shows quarterly observations on 4-quarter inflation rates in the retail price index from the League of Nations *Statistical Yearbook*. The dashed line shows the unexpected components; residuals from the recursive forecasting model in section 4.



**Figure 2: Quarterly Inflation and Unexpected Inflation**

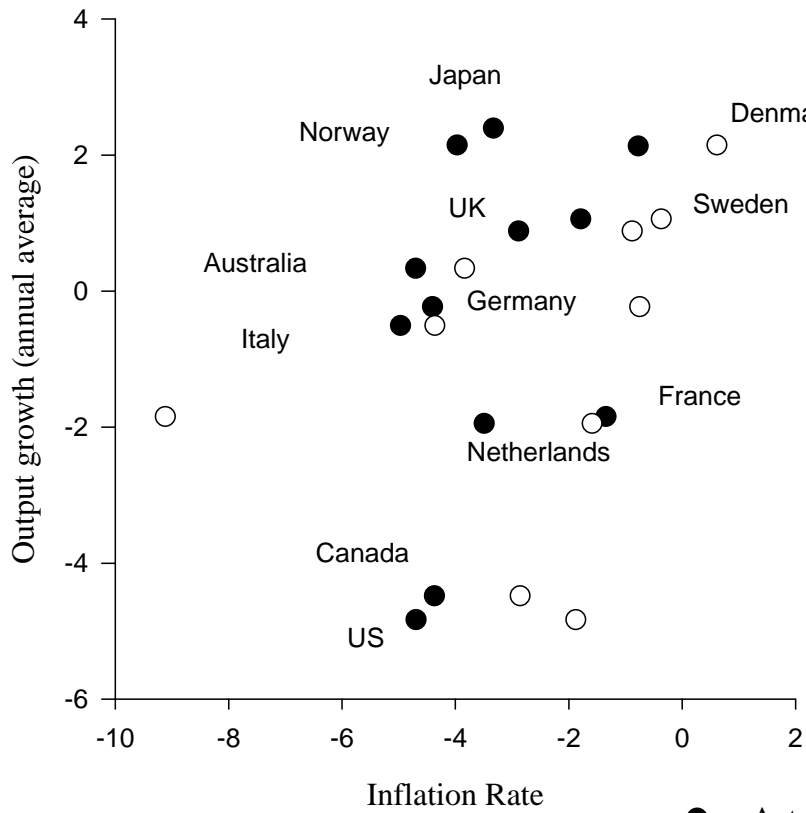
**France**



Note: The solid line shows quarterly observations on 4-quarter inflation rates in the retail price index from the League of Nations *Statistical Yearbook*. The dashed line shows unexpected components; residuals from the recursive forecasting model in section 4.

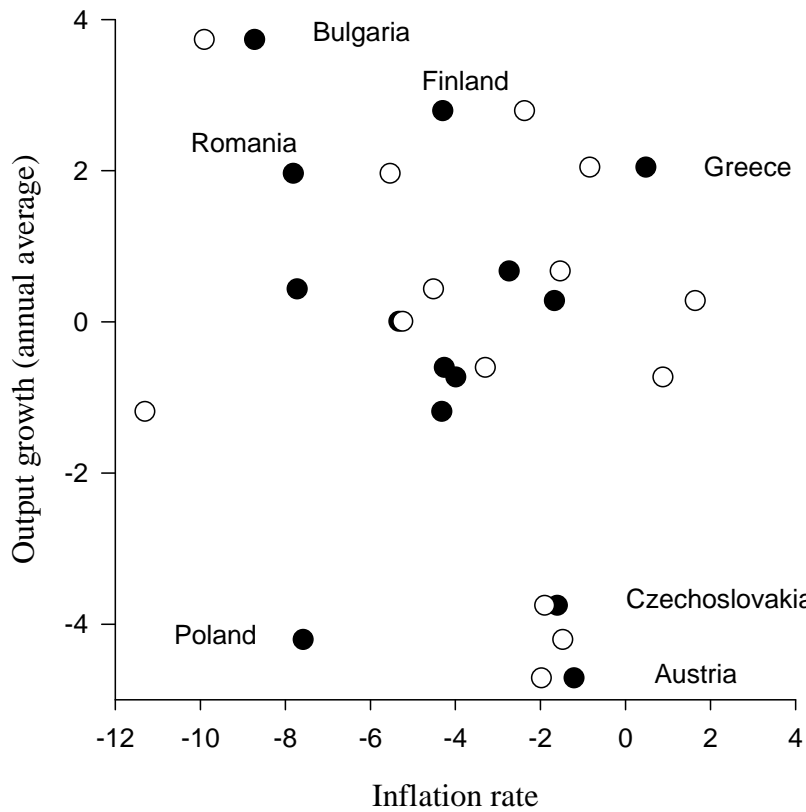
**Figure 3: Average Annual Inflation and Real Output Growth 1929-1934**

**Original 12 Countries**



- Actual inflation rate
- Recursive unexpected inflation rate

**Additional 14 Countries**



**Table 4: Average Output Growth and Inflation Regressions 1930–1934**

	Actual Inflation		Unexpected Recursive		Unexpected Full-Sample	
	$\hat{\beta}_\pi$ (se)	$R^2$	$\hat{\beta}_u$ (se)	$R^2$	$\hat{\beta}_u$ (se)	$R^2$
<b>Retail Prices</b>						
Atkeson-Kehoe 12 countries	0.65 (0.51)	0.14	0.28 (0.28)	0.11	0.34 (0.54)	0.04
26 countries	-0.09 (0.22)	0.01	-0.07 (0.15)	0.01	-0.27 (0.25)	0.05
<b>Wholesale Prices</b>						
Atkeson-Kehoe 13 countries	0.33 (0.21)	0.18	0.29 (0.16)	0.22	0.48 (0.28)	0.21
24 countries	0.22 (0.15)	0.09	0.16 (0.12)	0.08	0.10 (0.18)	0.01

Notes: Output growth is regressed on actual inflation, with coefficient  $\hat{\beta}_\pi$ , or recursive unexpected inflation, or full-sample unexpected inflation, with coefficient  $\hat{\beta}_u$ .  $R^2$  is the centered value. Levels span from 1929–1934 and growth rates from 1930–1934. Denmark and Japan are absent from the recursive forecast averages because their data do not allow 2 years of prior observations. No  $p$ -value is less than 0.10.

**Table 5: Output Growth and Inflation Regressions 1922–1939  
Retail Prices**

$$\dot{y}_{i\tau} = \alpha_i + \beta_\pi \pi_{i\tau} + \beta_u (\pi_{i\tau} - E_{\tau-1} \pi_{i\tau}) + \beta_e (E_{\tau-1} \pi_{i\tau}) + \epsilon_{i\tau}$$

$\hat{\beta}_\pi$ (se)	$\hat{\beta}_u$ (se)	$\hat{\beta}_e$ (se)	$R^2$
0.33*** (0.05)			0.17
	0.26*** (0.06)		0.08
		0.17** (0.08)	0.08
0.33*** (0.06)	0.01 (0.09)		0.17
0.33*** (0.08)		-0.01 (0.08)	0.17
	0.33*** (0.06)	0.33*** (0.08)	0.17

Notes: Brackets contains HAC standard errors.  $R^2$  is the centered value.  $\hat{\beta}_\pi$  is the coefficient on inflation;  $\hat{\beta}_u$  is the coefficient on unexpected inflation;  $\hat{\beta}_e$  is the coefficient on expected inflation. Each system contains country-specific intercepts  $\alpha_i$ . There are 18 annual observations and 26 countries for retail prices. There are 336 total observations, given the start-up period for recursive forecasts. On coefficients,  $p$ -values less than 0.01 are denoted \*\*\*, those less than 0.05 are denoted \*\*, and those less than 0.10 are denoted \*.