

DEFLATION AND ECONOMIC GROWTH: THE GREAT DEPRESSION AS THE GREAT OUTLIER

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ABSTRACT: This paper deals with the relationship between deflation and economic growth. Although there are numerous theories on the potential effects of deflation on real output, empirical evidence in this field is still incomplete. In order to explore the relationship between prices and output in a more comprehensive way, I use a large panel data set of 20 countries over roughly 150 years, which contains frequent deflationary episodes. Since mainstream macroeconomists often refer to alleged bad historical experience with deflation, I employ an econometric model to examine both contemporaneous and lagged correlation between prices and output. There are two important results. First, there is no general relationship between price growth and output growth. Coefficient estimates have very small magnitude in both the whole sample and in different monetary regimes. Second, well-known episodes of deflation differ a lot. The Great Depression is the only period where deflation seems to be strongly associated with recession. By contrast, Japan in the 1990s and 2000s bears no resemblance to it. Here, both empirically and theoretically, deflation is highly unlikely to have caused economic stagnation.

KEYWORDS: deflation, price level, economic growth, monetary systems, panel data, economic history

JEL CLASSIFICATION: E31, E42, C33, N10

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1. INTRODUCTION

Between the years 1804 and 1900, the price level in the United States decreased by almost 30 percent, and over the same period, output grew more than 40-fold. Price deflation was an ordinary phenomenon that did not provoke necessarily bad connotations. Nowadays, however, deflation has a bad reputation. Both the current and the former chair of the Federal Reserve have expressed strong commitment to prevent deflation from appearing. As Ben Bernanke noted, “Sustained deflation can be highly destructive to a modern economy and should be strongly resisted.” (Bernanke, 2002, p. 8) What is responsible for this view? The legacy of the Great Depression, which associated economic contraction with falling prices, and the lackluster economic performance of Japan, which has seen occasional deflation in the past 25 years, are the primary reasons. The 2013 announcement of the Bank of Japan to launch an unprecedented expansion of the monetary base to reverse deflationary pressures and attain a 2 percent inflation rate is a symbol of how much deflation is feared. The repeated ‘quantitative easing’ programs in the US in 2009–2014 are another example.

Mainstream macroeconomists often turn to empirical evidence to assert the validity of their theories. However, the situation with deflation is asymmetric: there appear many arguments why deflation should be bad for economic growth, but there is little empirical evidence to support it. Most references are concerned with the Great Depression, but they very rarely mention any other period.

The present work aims to fill this gap and provide a more comprehensive look at what we know about the relationship between deflation and economic growth. To do so, I have assembled a large dataset that contains annual data on output and prices for 20 countries over the past 130–200 years. Thanks to the length of the time series, it is possible to draw valuable information from pre-World War I data which are rich in episodes of deflation. The goal of this paper is to find out whether deflation is associated with recession—as is often suggested—when taking into account long-run empirical evidence.

The text proceeds as follows. In Section 2, I provide a brief survey of the current state of knowledge about deflation, both from a

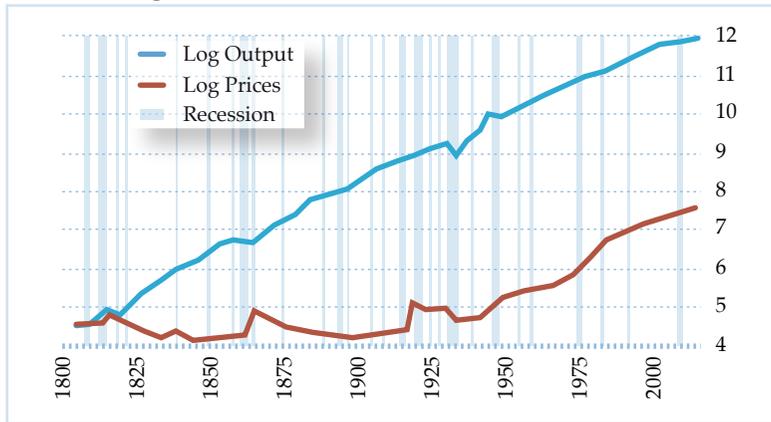
theoretical and empirical point of view. In Section 3, I present the dataset used in this paper and show basic properties of output and inflation data. I then use an econometric model in Section 4 to see whether changes in prices have an effect on changes in output and whether deflation is in general associated with a weaker economic performance. Overall, the results provide very little evidence of an effect of prices on output. Special attention is paid to the Great Depression and Japan's recent economic performance. Section 5 concludes the paper.

2. CURRENT KNOWLEDGE ABOUT DEFLATION

2.1 Two Theoretical Approaches

The theoretical literature on deflation has one strikingly clear division line that splits researchers into two categories. The first group, which is the more numerous and influential one, tends to approach deflation as a *cause*. These authors show how decreasing prices may affect aggregate demand or financial stability through various channels and almost uniformly conclude that deflation should be avoided. They typically point to the Great Depression as a distinct empirical example (see Figure 1 for the concurrent drop in prices and output in the US between 1929 and 1933). By contrast, the second group approaches deflation as a *symptom*. Either deflation can arise as a consequence of economic growth in a regime with constant money supply, which was typically the case of the second half of the 19th century (see Figure 1), or it can just as well occur in periods of distressed selling in recessions. Either way, however, economists of this second group argue that deflation should be let to run its course as it is not a cause, but a symptom of forces working in the background. Each approach is discussed below.

Figure 1: US Real GDP and Consumer Price Index 1804 – 2015
(log of index where 1804 = 100)



Deflation as a Cause

There are four basic lines of reasoning according to which deflation is harmful. First, deflation causes a delay in spending. When consumers see decreasing prices, they expect them to decrease further and want to take advantage of this by buying cheaper in the future. That reduces current consumption and causes a contraction of aggregate demand.

Second, deflation increases the real interest rate. Generally, the Mundell-Tobin effect states that due to people's portfolio decisions, inflation does not influence only the nominal interest rate, but also the real interest rate. When prices start to fall, holding cash earns a return and people shift a part of their wealth from interest-bearing assets to money balances. That causes the real rate of interest to rise, which lowers investment. A special case is the Keynesian liquidity trap. Here, the nominal interest rate is fixed at zero and the deeper is deflation, the higher is the real interest rate by the same magnitude (as seen in the Fisher equation $i = r + \pi$). That depresses investment and aggregate demand. In the case of Japan in the 1990s, Krugman (1998) argues that deflation is responsible for the stagnation of the economy in an environment of a liquidity trap. Christina Romer (1992) argues similarly for the Great Depression period in the US.

Third, deflation may prove especially harmful in an environment of high indebtedness. Fisher (1933) asserted that if economic agents (especially firms) have their debt contracts specified in nominal terms, then deflation causes the real value of their debt to rise. Since this real growth in debt is not matched by a similar real growth in their revenues, many firms find themselves unable to pay off debts and declare bankruptcy. In addition, the very effort to sell assets in order to pay debts makes the situation only worse as these efforts further depress prices and reinforce the increase in real debt burden. This gives rise to a debt-deflation spiral, which causes a contraction in both aggregate demand and aggregate supply. The mechanism works mainly when deflation is unanticipated. Otherwise, an anticipated path of prices may already be reflected in the debt contract.^{1,2}

Fourth, prices of certain factors of production may be rigid downwards, which in a deflationary environment causes their real prices to rise and their utilization to fall. This concerns especially wages whose flexibility may be limited, at least in the short run. If wages do not decrease or decrease less than other prices, the labour market does not clear, causing unemployment and reduction in production. Bernanke (1995) asserts that the failure of wages to adjust played a considerable role in the Great Depression.³

Deflation as a Symptom

By contrast, some economists view deflation—and price changes in general—rather as a symptom of other, independent processes. In their view, attention should be paid to where deflation comes

¹ A modern variation on Fisher's debt-deflation is from Bernanke and Gertler (1989), who incorporate the effect of firms' net worth on the ability to borrow in an environment of asymmetric information.

² Hülsmann (2008) criticized the debt-deflation theory on grounds that bankruptcies do not mean disappearance of assets, but rather their transfer to new owners. This transfer of ownership is only a reverse of the previous inflationary redistribution of wealth.

³ It is interesting that Keynesian-oriented economists are not in agreement when drawing conclusions from downward rigidity of wages. Some recognize that if wages were flexible, deflation would not do harm to the economy. Others like DeLong and Summers (1986) or Palley (2008) argue that deflation is also harmful for other reasons (such as those listed above), and thus for deflation not to spread, downward rigidity of prices should be reinforced.

from, rather than to deflation per se and its possible secondary effects. Selgin (1997, 1999), Šíma (2002), Salerno (2003), and Bagus (2015) represent this point of view. Salerno (2003) identifies several general sources of deflation: bank-credit deflation, stemming from deflationary monetary policy or bank runs, cash-building deflation, caused by individuals' change in preferences towards holding more money balances, confiscatory deflation, where the government seizes people's cash balances, and finally growth deflation, arising from increasing output. Interestingly, some types of deflation like bank-credit deflation and cash-building deflation are usually associated with recessions, while growth deflation comes directly from growth in output. This illustrates that when regarded as a symptom, there is no unambiguous way to match deflation with either recessions or booms.

Growth deflation is of special interest since it may explain long periods of deflation with increasing output observed in the gold standard era of the late 19th century. Economic growth can take two forms: extensive, where factors of production increase in numbers or amount, and intensive, where investment increases factors' productivity. Increasing productivity, in turn, is equivalent to lower costs of production per unit of output. Therefore, as firms have lower marginal costs, they can attract more marginal demand. Supply curves move downward and lead to higher equilibrium quantities and lower equilibrium prices. At a macroeconomic level, this is seen from the quantitative equation $M \cdot V = P \cdot Y$. If money velocity is assumed to be constant, then any increase in output greater than increase in money supply must necessarily cause the price level to fall. In terms of mainstream macroeconomics, deflation resulting from economic growth is equivalent to the aggregate supply curve shifting to the right in the AS-AD diagram.⁴ Selgin (1997, 1999) argues in detail why deflation that results from productivity growth does *not* have the harmful effects on output as presented above.

2.2 Empirical Literature

Several studies have explored the relationship between output and prices but only a part of them covers a large enough sample to allow general conclusions. Bordo and Redish (2003) and Bordo,

⁴ Hayek (1931) is an important early work that argues in detail why deflation is a symptom of healthy economic growth.

Lane and Redish (2004) focus on the classical gold standard period in 1870–1913 and 1880–1913, respectively. They find no evidence of prices influencing output in these periods. McCandless and Weber (1995) look at a large number of countries between 1960–1990. Similarly, they find little evidence of a relationship between output and prices, but their sample is limited to a period that had generally few episodes of deflation.

Some studies have covered samples that are longer in time. Atkeson and Kehoe (2004) look at a sample that spans from the 19th century until the modern day. Their general conclusion is that inflation had at best a very small positive impact on economic growth. They highlight that the Great Depression is different from the rest of the sample. Borio and Filardo (2004) report a relationship between inflation and growth only in some subsamples of their dataset but not a general one. Similarly, Borio, Erdem, Filardo and Hofmann (2015) find that there is correlation between economic growth and asset prices rather than broad consumer prices.

By contrast, Guerrero and Parker (2006) side with the opposite view. They find a lagged negative impact of deflation on economic growth, although the economic significance (the magnitude of the coefficient) is rather small. Finally, Benhabib and Spiegel (2009) explore a non-linear relationship—i.e., one that changes with the crossing of a certain threshold in the inflation rate. They conclude that the relationship is an inverted U-shape—that is, inflation positively affects economic growth until a certain threshold from which the effect becomes negative.

Independently of the conclusions reached, the cited studies have certain drawbacks. Atkeson and Kehoe (2004) explore a relatively long dataset but they use 5-year averages for their regressions. That has the disadvantage of missing some of the short-term variation. Guerrero and Parker (2006) use yearly observations but they rely only on the lagged effect of prices on output. However, most importantly, none of the studies attempts to use a control variable which would remove some of the potential omitted-variable bias. In other words, if a certain important determinant of output is missing from the regression, the coefficient for inflation could be biased because it takes on some of the effects from the omitted variables.

In the present paper, I include the investment-output ratio as a control variable and explore both contemporaneous and lagged

effects in order to obtain more robust results compared to the previous studies.

3. DATA

3.1 Data Description

I have compiled a large historical dataset with annual observations on prices and output. Output is measured as real GDP and prices are represented by the Consumer Price Index or the GDP Deflator.⁵ As a control variable, I also use the investment-output ratio in the regressions below. The reason for the use of the investment-output ratio is that it is the most historically available complementary variable that is likely correlated with output and therefore should be included in the regression. The dataset consists of 20 countries and spans from the 19th century to 2015.⁶ To give a glimpse of the length of the time series, the earliest observations on prices start as early as 1804 for Sweden and the US. Most countries, however, have records on prices that begin several decades later. Altogether, there are 3293 annual observations that have both a reading for price growth and output growth.

Below for basic statistics, I present the dataset in two forms. First, I use the complete dataset, and second, a truncated dataset where

⁵ The reason for the use of both indices is availability. I use the Consumer Price Index where possible since it is today the generally preferred measure of inflation by most economists and organizations. I use the GDP deflator where the CPI is unavailable, which is true particularly for the older observations. It is generally possible to retrieve very long times series on prices such as from Reinhart and Rogoff (2011), which span back to the 18th century, but these are based on narrow baskets or individual goods' prices, not on broad indices. Here, I only use CPI or the GDP deflator.

⁶ The starting years are different for each country according to data availability. The countries included are Argentina, Australia, Belgium, Brazil, Canada, Chile, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States. Prices before 1980 are from Atkeson and Kehoe (2004) and Jorda et al. (2017), except for Australia, Denmark, Switzerland and Belgium which are taken from Bordo (2010). Prices from 1980 onwards are from IMF (2017) and World Bank (2017) for all countries. Output is defined as GDP or GNP in constant currency. Data on output before 1980 is from Atkeson and Kehoe (2004), Jorda et al. (2017), Mitchell (2003) and Smits et al. (2009), except for Australia, Belgium, Denmark and Switzerland which is taken from Maddison (2010). GDP from 1980 onwards is from Maddison (2010) and World Bank (2017) for all countries. The investment-output ratio is the fraction of gross investment and GDP or GNP, both in current prices. The data is from Jorda et al. (2017) and from the World Bank (2017).

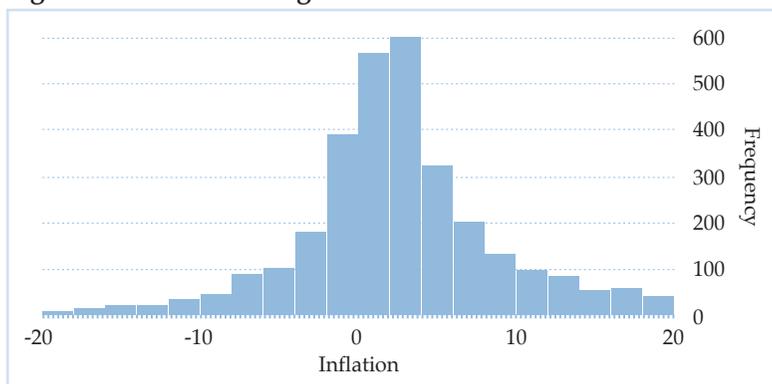
I leave out observations with extreme values of price growth. The reason is that the main question of interest is how economies perform under reasonably ‘normal’ inflation rates compared to ‘normal’ deflation rates. Leaving hyperinflations as well as extremely deep deflations in the sample would severely bias the regression results and would not help answer the question whether mild inflation is preferable to mild deflation. I exclude all years with price growth greater than 20 percent or lower than -20 percent.⁷

3.2 Basic Statistics

In the complete sample, positive price growth prevails, with years that saw positive inflation accounting for 72 percent of all annual observations. Inflation rates between 2 and 4 percent are the most frequent observation (see Figure 2). This prevalence of inflation over deflation in the sample mostly reflects the generally inflationary post-World War II period which saw only sporadic deflation.

However, thanks to the inclusion of the pre-World War I data, deflation is far from infrequent and allows a comparison of economic performance under inflation and deflation.

Figure 2: Inflation: histogram for all data



⁷ The choice of such a boundary is necessarily arbitrary. I follow Atkeson and Kehoe (2004), Ichiue and Nishiguchi (2014) and Bachmann et al. (2015) who all use the 20 percent and -20 percent thresholds. A 20 percent inflation is roughly the one that developed economies reached at the height of inflation in the late 1970s and early 1980s.

Figure 3 illustrates the major difference in the behavior of the price level before and after World War I. Under the classical gold standard, which was in place in most countries until roughly 1914, very mild deflation of 0 to –2 percent was the most common observation. After the abandonment of the classical gold standard, the average inflation rate shot up and positive inflation became the standard.⁸

Table 1 compares economic growth under inflation and deflation.⁹ There are several important observations. First, economic growth was positive in 81.1 percent of years with inflation and in 74.8 percent of years with deflation. While this preliminary observation shows that deflation is far from recessionary, economies still seem to fare a bit better under inflation. A second and more meaningful approach is to compare the average growth rate of output. Under inflation, output grew 2.85 percent per year on average, while under deflation the growth rate was 2.73 percent. Again, this suggests that the output loss of having deflation instead of inflation is very small. Third, output growth appears to be slightly less volatile under inflation than under deflation, as measured by standard deviations.

To test whether the observed differences of output behaviour are statistically significant, in Table 2 I present formal tests of equality of parameters.¹⁰ Interestingly, it is not possible to reject the null hypothesis (at any standard significance level) that the average output growth rates under inflation and deflation are equal. Similarly, the variances are not statistically different either. To sum up, there is no statistically significant difference in the average growth rate of output or in the variance of output growth under inflation versus deflation.

⁸ The term ‘classical gold standard’ denotes what was in most countries the period from approximately the 1870s until the beginning of World War I. The later forms of the gold standard did not guarantee full convertibility of currency into gold.

⁹ ‘Zero price change’ is included in Table 1 as there are observations, though not many, with exactly zero reported inflation. This is due to rounding of the index in the original data source.

¹⁰ The sign * denotes statistical significance at 10%, ** at 5% and *** at 1%. I use the Welch (unequal variances) two-sample t-test for the equality of means and the F-test for equality of variances.

Figure 3: Inflation: comparison of histograms for two monetary regimes

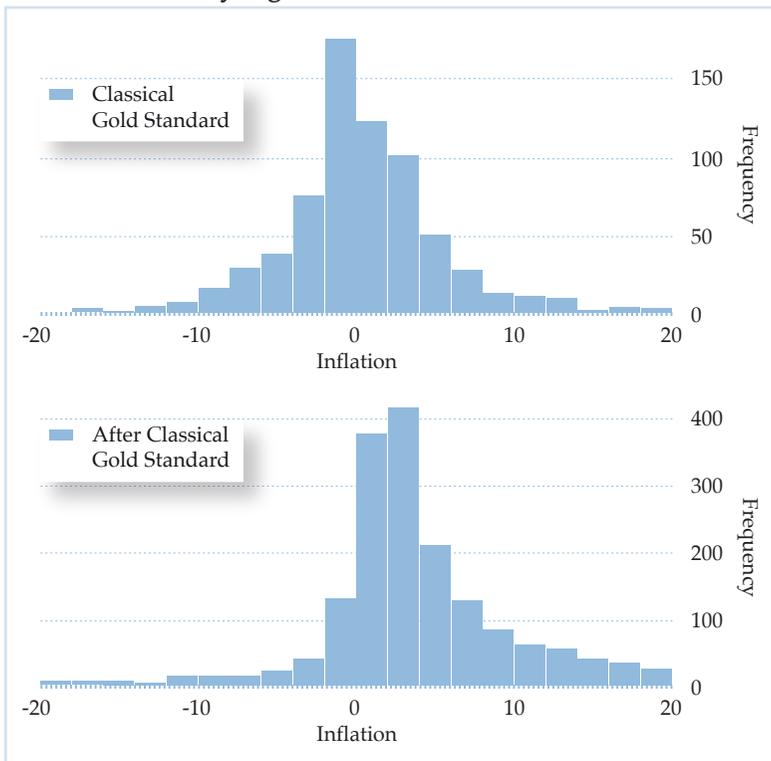


Table 1: Output growth under different price scenarios: all data

	All data	Inflation	Zero price change	Deflation
Total observations	3293	2387	106	800
- obs. with output increase	79.6%	81.1%	84.0%	74.8%
- obs. with output unchanged	0.4%	0.3%	0%	0.6%
- obs. with output decrease	20.0%	18.6%	16.0%	24.6%
Average output growth	2.85	2.85	3.52	2.73
Output growth st. deviation	5.59	5.58	4.69	5.74

Table 2: Tests of equality of parameters: inflation vs. deflation

	Test statistic	P-value
T-test for equality of means	-0.507	0.612
F-test for equality of variances	1.059	0.158

Tables 3 and 4 report the same computations, but now with the sample reduced to contain only inflation rates in the interval $[-20\%, 20\%]$. The results suggest that this limitation works in favor of inflation: a slightly higher percentage of inflationary observations now have output increase and also the average output growth under inflation increases to 2.98 percent. Similarly, the variance of growth under inflation drops significantly.

This shift is easy to explain. Hyperinflations and very fast inflations are harmful to economic growth and also cause its higher volatility. As a result, leaving these extreme values out of the sample helps the statistical properties of growth under inflation. By contrast, growth under deflation does not profit from the truncation. The reason is also apparent: very deep deflations below -20 percent rarely occur under 'normal' conditions; instead, they appear often as a reversal of wartime inflations. Therefore, growth under these extreme deflations is often solid since it reflects post-war recoveries. This is the reason why leaving out extreme deflations leads to a slightly lower average output growth under deflation. However, the statistical tests again fail to reject the hypothesis that the two output growth rates are equal (Table 4). In other words, given the size of the samples and the variation in observations, the two rates of output growth are very similar. Only the variances are confirmed to be different.

Overall, when using all available observations, there is little doubt that economic performance is very similar under inflation and deflation. Even when extreme observations are omitted from the sample, which 'helps' growth under inflation, the economic performances are still very comparable. This runs against the deflation-recession theories.

Table 3: Output growth under different price scenarios: inflation narrowed to [-20%, 20%]

	All data	Inflation	Zero price change	Deflation
Total observations	3029	2141	106	782
- obs. with output increase	80.9%	83.0%	84.0%	74.7%
- obs. with output unchanged	0.4%	0.3%	0%	0.6%
- obs. with output decrease	18.7%	16.7%	16%	24.7%
Average output growth	2.91	2.98	3.52	2.63
Output growth st. deviation	4.97	4.74	4.69	5.58

Table 4: Tests of equality of parameters: inflation vs. deflation

	Test statistic	P-value
T-test for equality of means	-1.561	0.119
F-test for equality of variances	1.387***	< 0.001

A cautionary note is due, however. The statistical relationships say nothing about causation. Theory is key in interpreting the data. A mainstream interpretation would be that the perhaps slightly higher growth rate under inflation proves that inflation is conducive to growth. In contrast, it could well be that this observation is due to the composition of data. While deflation was a normal growth symptom before World War I, the postwar years with much more inflation only saw deflation during distressed selling and recessions. The 'ordinary' growth deflation that had been allowed before World War I could not be observed after it due to permanent increases in money supply after currencies had been separated from gold. Therefore, the observation of 'bad' deflations after World War I could prevail, but this does not imply anything about deflation in general or the direction of causation. To be able to answer more, I look at the data in more detail in the next section.¹¹

¹¹ A remark is due concerning the higher standard deviation of output growth under deflation than under inflation in Table 1. As much more deflation was recorded

4. REGRESSION ANALYSIS

4.1 Method

I use a regression model in which inflation (or deflation) is the explanatory variable, while current output growth is the explained variable. The model reflects the common notion in mainstream macroeconomics that causation runs from prices to output—that is, that inflation or deflation affect the growth of output (see Section 2.1). The regression also contains lagged prices and lagged output to account for a potential delayed response of output to prices. As such, it constitutes the often-used autoregressive model. Although the model uses panel data with a long time dimension, it is designed to capture a relatively short-run (contemporaneous or one-year lagged) effect of prices on output. This is line with the current focus of theory and monetary policy on short-run effects of deflation—for example, the postponement of current spending in favor of the future. Finally, the model contains the so-called unobserved effects—i.e., any other factors specific for a country that may affect output but cannot be included among the regressors since the data is not available.

As a result, the model is of the form

$$y_{it} = \beta_0 + \beta_1 y_{it-1} + \beta_2 p_{it} + \beta_3 p_{it-1} + a_i + u_{it}$$

where y is real output growth, p growth in the price level (both in percent terms), a_i the country-specific unobserved effect and u_{it} the error term. Below I call this model ‘unconditional’ since the only additional regressor besides p is the own past value of y .

I estimate the model using the so-called fixed-effects method. This method allows arbitrary correlation between the unobserved cross-sectional effects a_i and regressors y_{it-1} , p_{it} , p_{it-1} . For example, institutional arrangement in country i (included in a_i) may affect

in the 19th century than in recent times, there is the possibility that the higher standard deviation of growth during deflation is caused by the imprecision of measurement for the older observations. There was no systematic measurement of GDP, GDP deflator or broad consumer price indices in the 19th century. The series have not been measured, but rather estimated from other series such as industrial production, agricultural production and wholesale price indices, which are themselves typically more volatile. This could add to the volatility of the derived series. I thank an anonymous referee for pointing this out.

both the explained variable (output growth), but also some of the explanatory variables (price growth).

As noted above, a major shortcoming of the existing research is the absence of control variables. Out of candidate control variables, the investment-output ratio stands out as being both important for output and relatively available as historical data. The second, enlarged model which includes investment is

$$y_{it} = \beta_0 + \beta_1 y_{it-1} + \beta_2 p_{it} + \beta_3 p_{it-1} + \beta_4 invr_{it} + \beta_5 invr_{it-1} + a_i + u_{it}$$

where *invr* is growth in the investment-output ratio (again in percent terms). I call this model 'conditional' below. The inclusion of *invr* comes at a cost: since this variable is not available as far back as output and prices, roughly a 1/3 of observations is lost after its inclusion. Still, the sample has more than 2000 observations.¹²

As the model contains the lagged dependent variable y_{it-1} among regressors, the fixed-effects estimator is generally not consistent. That is, the estimated coefficients do not converge to the 'true' value as the number of observations grows. However, the bias falls at a rate $1/T$ as T (the time dimension of the sample) grows. For a time dimension high enough, the bias is negligible.¹³ This is the case here, where in the full sample, T is between 130 and 200 years, so inconsistency is not of concern.¹⁴ A robust variance matrix estimator was used when heteroskedasticity or serial correlation were detected.

4.2 Full Sample

Table 5 presents the results for the whole sample. The unconditional and conditional regressions show very similar results: the

¹² The investment-output ratio is available as a fraction of investment and output, both in *current* prices. Its growth rate $invr_{it}$ is therefore not in constant prices, so it does not correspond perfectly to the growth in *real* output y_{it} . However, it is still the best control variable available.

¹³ See Nickell (1981) for the original reasoning and Wooldridge (2002, p. 302) for a shorter review.

¹⁴ The only instance in this study where T is small is the regression for the Great Depression period in Section 4.4, which is 6 years long. For that case, I also estimate the regression equation using the general method of moments, which confirms the results.

coefficients on p_t and p_{t-1} have opposite signs and are statistically significant. Although this may seem peculiar, the bottom line is that both coefficients are very close to zero. If the positive coefficient of p_t was taken as evidence that contemporaneous inflation affects output positively, the economic magnitude is so small that it offers little practical effect: with a coefficient estimate between 0.058 and 0.066, inflation would have to increase by roughly 17 percentage points to bring about a 1 percentage point increase in real output. The estimate around 0.06 is also very close to Atkeson's and Kehoe's (2004) estimate of 0.08 for their entire sample.

Table 5: Regression of output growth on inflation: All data

	Unconditional		Conditional on Invr	
	Coefficient	p-value	Coefficient	p-value
y_{t-1}	0.213***	<0.001	0.197***	<0.001
p_t	0.066**	0.020	0.058**	0.027
p_{t-1}	-0.042*	0.063	-0.036*	0.093
$invr_t$	-	-	0.048***	<0.001
$invr_{t-1}$	-	-	0.008	0.299
Observations	2158		2158	
Adj. R ²	0.020		0.081	

4.3 Comparison in Time: Monetary Regimes

In Section 3.2, it was shown that deflation was much more common under the classical gold standard before 1914 than in the period after World War I, when the gold standard was gradually loosened or abandoned and inflation became on average positive. This raises the question whether the change in monetary regime itself had an impact on the relationship between prices and output. Table 6 presents regression results for the classical gold standard era and for the period since its abandonment until the present time.

There are two results worth noting. First, the overall small economic magnitude of the coefficient estimates for inflation holds under both monetary regimes and the two regimes do not display big differences. The coefficients on p_t and p_{t-1} are never outside the

interval $(-0.1, 0.1)$ in either case. The stability of results also has an econometric meaning: estimating two parts of the sample separately does not bring a considerable change in the magnitude of coefficient estimates. Second, however, there is a change in statistical significance. After controlling for the investment-output ratio, the effect of inflation becomes statistically insignificant especially in the classical gold standard period. This underlines an expected feature of the classical gold standard: correlation between output and prices was none or negligible since in the long run, output grew while prices were constant thanks to an inelastic money supply.

As an interesting difference, the coefficient estimate on y_{t-1} is negative under the classical gold standard, while it is positive after it. The reason could be that periods of growth and recession alternated more frequently during the gold standard, which renders the coefficient negative. In contrast, the later part of the 20th century became typical for longer periods of positive economic growth (albeit sometimes at a slower annual pace), and this renders the correlation positive.

4.4 Selected Episodes of Deflation

The Great Depression

Many theories on the consequences of deflation resulted from the experience of the Great Depression. Is this episode special? Table 7 shows regression results for the Great Depression period (1929–1934) and for all data in the sample outside the Great Depression.

The results show a clear difference. The Great Depression period yields a positive and statistically significant slope coefficient for contemporaneous inflation. Although it drops after controlling for the investment-output ratio, it still stays important at 0.358. The drop in the coefficient estimate after the inclusion of $invr_t$ suggests that there is some effect of investment on output which is not linked to prices. Importantly, unlike all previous results, the coefficients on p_t at 0.690 and 0.358 for the two models are not only economically substantial, but also highly statistically significant. In contrast, the sample of all data except the Great Depression yields statistically and economically insignificant results. The big difference in slope

coefficient on p_t is seen in Figure 4.^{15,16} Due to the much lower time dimension (6 years in 1929–1934), the fixed-effects approach is at risk of reporting biased coefficient estimates when including the lagged value of output y_{t-1} . As a check, I re-ran the regressions using general method of moments (GMM) estimation, which is more appropriate in such cases. GMM confirms the significant and relatively large coefficient on p_t (0.499 for the unconditional and 0.544 for the conditional model, respectively, and both significant at 1 percent.).

Table 6: Regression of output growth on inflation: Classical gold standard period and after

Classical gold standard	Unconditional		Conditional on Invr	
	Coefficient	p-value	Coefficient	p-value
y_{t-1}	-0.172***	<0.001	-0.201***	<0.001
p_t	0.082*	0.054	0.043	0.376
p_{t-1}	0.069	0.115	0.037	0.452
$invr_t$	-	-	0.080***	<0.001
$invr_{t-1}$	-	-	0.037***	0.002
Observations	543		543	
Adj. R ²	0.036		0.090	

After classical gold standard	Unconditional		Conditional on Invr	
	Coefficient	p-value	Coefficient	p-value
y_{t-1}	0.341***	<0.001	0.333***	0.096
p_t	0.064*	0.094	0.051	0.178
p_{t-1}	-0.080**	0.040	-0.065	0.111
$invr_t$	-	-	0.045**	0.018
$invr_{t-1}$	-	-	-0.002	0.617
Observations	1428		1428	
Adj. R ²	0.132		0.156	

¹⁵ The economically and statistically significant slope coefficient for p_t in the Great Depression does not change considerably after the exclusion of the most apparent outliers.

¹⁶ Since the regression line in Figure 4 was estimated by fixed effects (or ‘within transformation’) and this model subtracts all time-constant elements, the intercept β_0 cannot be estimated. Therefore, the regression line has by default an intercept of zero and visually may not go through the main cluster of the data. Nevertheless, the point is to show the slope.

Overall, the results show that apart from the Great Depression, the sample does not reveal a link between inflation and economic growth. From the perspective of correlations, the Great Depression is an exception rather than a rule.

It is highly likely that rather than a single factor, a number of forces caused the strong positive relationship between prices and output during the Great Depression. Many authors reason that it was the collapse in money supply and prices that led to the depression: Friedman and Schwartz (1963) blamed the Fed for allowing money supply to fall, while Christina Romer (1992) stressed liquidity-trap theories and depressed investment, implying reflation as the answer. In stark contrast, Rothbard (2000) saw the previous money supply expansion in the 1920s as the root cause of the depression and the depression itself as liquidation of malinvestment. In his opinion, the depression in the United States was further exacerbated by the government's intrusion in the setting of prices and especially wages.

Table 7: Regression of output growth on inflation: Great Depression and outside of it

Great Depression	Unconditional		Conditional on Invr	
	Coefficient	p-value	Coefficient	p-value
y_{t-1}	0.018	0.897	-0.074	0.467
p_t	0.690***	<0.001	0.358***	<0.001
p_{t-1}	-0.074	0.721	-0.126	0.325
$invr_t$	-	-	0.124***	<0.001
$invr_{t-1}$	-	-	0.039**	0.022
Observations	90		90	
Adj. R ²	0.253		0.453	
All data except Great Depression	Unconditional		Conditional on Invr	
	Coefficient	p-value	Coefficient	p-value
y_{t-1}	0.189***	<0.001	0.182***	<0.001
p_t	0.028	0.298	0.025*	0.320
p_{t-1}	-0.043*	0.095	-0.040	0.129
$invr_t$	-	-	0.030*	0.079
$invr_{t-1}$	-	-	0.005	0.528
Observations	2068		2068	
Adj. R ²	0.039		0.049	

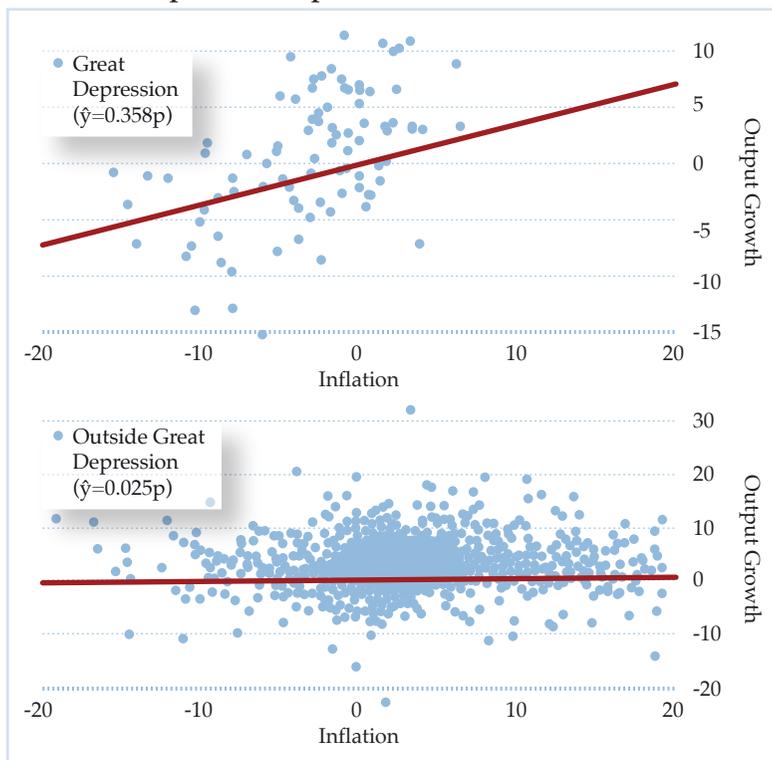
More recently, this view was supported by Ohanian (2009) who emphasized the role of labor unions and government in preventing nominal wages from adjusting downward, creating mass unemployment.

Although the Great Depression overall shows a link between deflation and recession, the picture is not as unambiguous as is commonly believed. There are two interesting aspects of the data at hand: one regards what preceded the Great Depression and the other regards cross-country differences.

First, deflation in most countries did *not* appear simultaneously with the Great Depression. Figures 5 to 8 show that in many countries, prices started falling already in the 1920s when most economies grew solidly. This illustrates the pitfall of analyzing only the most debated period 1929–1934. Deflation in the 1920s could well be of the ‘good’ sort, reflecting growth in output. But if inflation and deflation are defined in terms of prices and not money, then the malign price deflation of the 1930s should be fairly weighed against the benign price deflation of the 1920s.

Second, countries differed sharply in terms of decreases in prices and output. Figure 5 shows the United States and Germany, which are the textbook cases of ‘malign’ deflation. Both countries went through a deep and long slump in output accompanied by a deep drop in prices. A similar situation was experienced by Canada, Argentina, Brazil, Chile, Australia and to a certain extent also France.

Figure 4: Regression for (a) Great Depression and (b) all data except Great Depression



However, other countries had very different experiences. I show three different pairs of countries in Figures 6 to 8. Japan and Norway (Figure 6) did have sharp recessions, but these lasted only one year and their economies quickly recovered while prices kept falling. Norway is a striking case as it had been experiencing deflation many years before any recession came and also long after the recession ended. Italy and Denmark (Figure 7) had only moderate recessions that one would probably hesitate to call the 'Great Depression'. In Italy, real GDP was higher in 1934 compared to 1929 while prices continued to drop every year.

Finally, Figure 8 shows atypical evolutions of output and prices in the Netherlands and in Portugal. The Netherlands had an

extreme drop in prices, unseen even in the United States. Its price level dropped 47 percent between 1924 and 1934. If we narrow our attention to the period 1929–1933, prices in the Netherlands dropped by 28 percent, a quicker pace than in the US (24 percent). However, output decreased only by 6 percent, while in the US output decreased by 27 percent over the same period. This starkly different situation with a similar drop in prices suggests that the rate of deflation alone cannot account for the depth of the depression. The second atypical case is Portugal, which defies the pattern seen in other countries. Portugal had repeated sharp recessions in the 1920s, but its economy started a rapid growth phase in 1931 while prices continued to fall.

It is outside the scope of this text to analyze the situation in each country and find out why the evolution of output differed so much across countries. The point here is only to highlight the empirical differences—i.e., that the Great Depression was not a homogeneous event from the perspective of prices and output. One thing can be said for sure: although the early 1930s' recession appeared in almost all countries, deflationary years on the whole were not at all a synonym for recession. Nevertheless, it seems that the sharp concurrent drop in output and prices in the US lead to a certain bias in American academic research which started to take the deflation-depression logic as given.

Figure 5: Great Depression and before (1924 = 100): Deep and long contractions

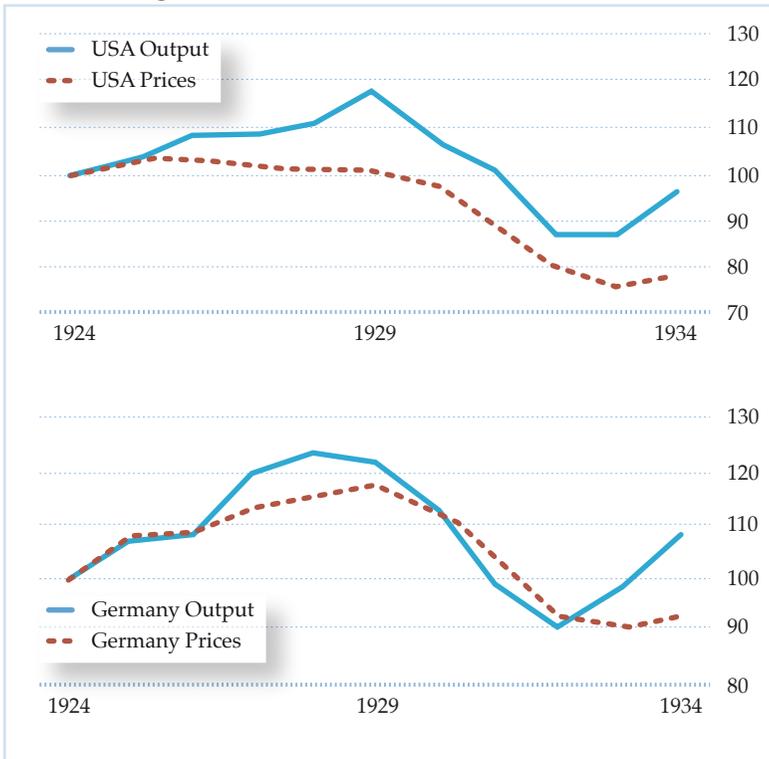
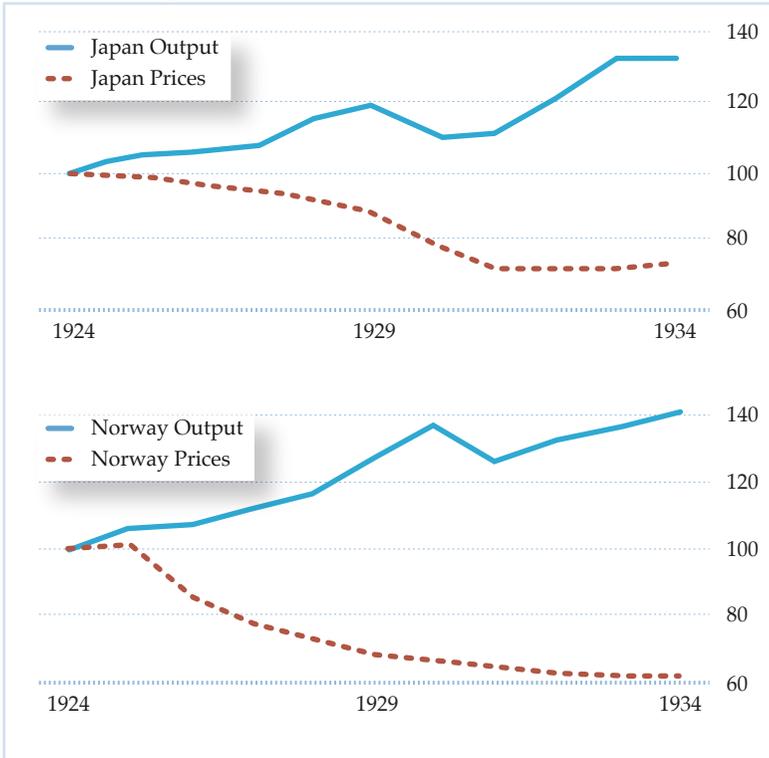


Figure 6: Great Depression and before (1924 = 100): One-year sharp contractions



**Figure 7: Great Depression and before (1924 = 100):
Moderate contractions**

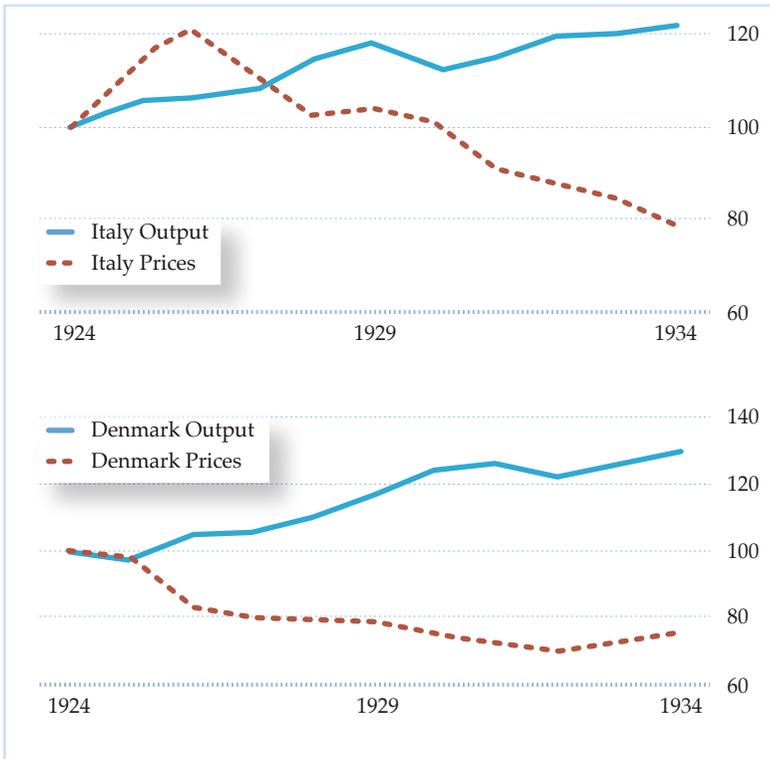
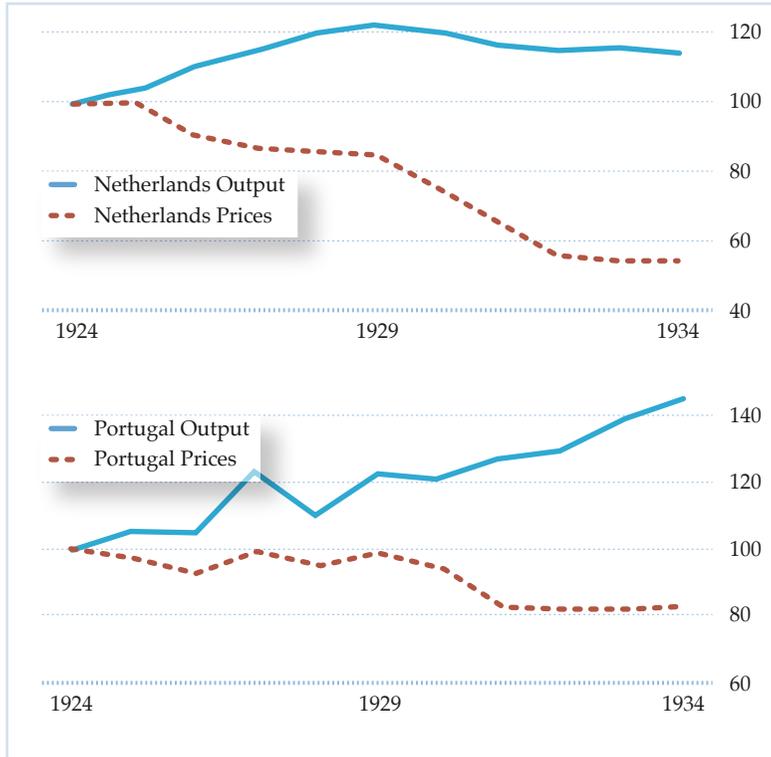


Figure 8: Great Depression and before (1924 = 100): Atypical cases

Contemporary Japan

The relatively poor growth performance of Japan that started roughly in 1992 and still continues has made it an alleged symbol of the harmfulness of deflation. Haruhiko Kuroda, the governor of the Bank of Japan, recently also blamed almost all of Japan's difficulties on price deflation (Kuroda, 2016).

The fact that we are now dealing with only one country over roughly 2 decades leads to a low number of data points and unfortunately limits the possibilities of the above econometric analysis. However, we can make several interesting observations just by going through the data at hand.

First, it is remarkable that most of Japan's deflation occurred not during recessions, but during the longest of modern Japan's growth periods in 2000–2007 (see Figure 9, part (a)). At this point, we can well describe the crux of the disagreement over Japan among economists. On the one hand, it is argued that lower inflation rates in the 1990s were associated with lower output growth as compared to previous decades. While this observation is correct, it is also true that since the 1990s, deflationary years have been accompanied almost exclusively by growth, not recession (see again Figure 9). As a result, it was rather the years with inflation that contributed more to the environment of notoriously slow growth and recession than the years with deflation. Furthermore, Atkeson and Kehoe (2004) point out that the growth rate of GDP in Japan had already been decelerating decade after decade, long before deflation first appeared. Therefore, regardless of which theory of growth or business cycle one sides with, the slowing growth after 1992 was a continuation of a trend that had already been present. It did not come with deflation. The comparison of the price level and the unemployment rate in part (b) of Figure 9 is even more striking. In 1990–2015, the unemployment rate dropped more often after a decrease in prices rather than after an increase in prices.¹⁷

Second, since 1992 (when growth decelerated sharply) prices in Japan have shown either very mild inflation or very mild deflation, with the inflation rate always in the (–2%, 2%) interval except for one year. Overall, the price level grew a cumulative 9.6 percent between 1990 and 2015 (see Figure 9). As such, Japan's mild deflation episodes are incomparable with the deep deflation during the Great Depression or with the frequent and sizeable deflation during the classical gold standard. Therefore, from a theoretical point of view, to automatically apply the experience of the Great Depression to modern Japan, which is for example the approach of Krugman (1998), is a stretch. As shown in the previous section, the Great Depression indeed saw a statistical link between deflation and recession, but the pace of price decreases was much quicker.

Third, the mild deflation that has repeatedly occurred in Japan is asking for particular theoretical questions. Given that the Japanese encountered deflation mostly between –1% and 0% (only

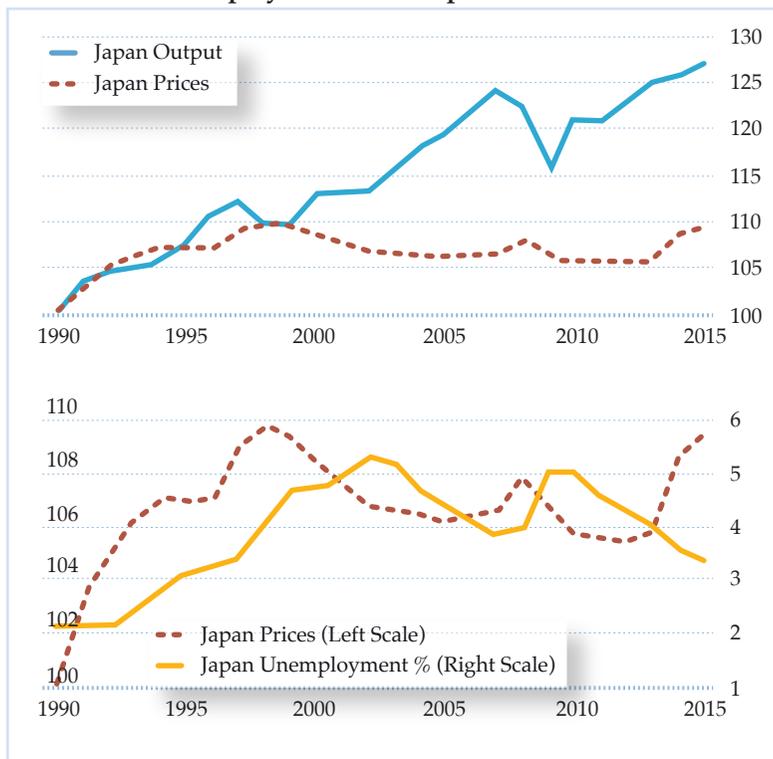
¹⁷ Data on unemployment are from the OECD (2016).

the crisis year 2009 had deflation deeper than -1 percent), could this have tangible economic consequences? For example, if one theory presented in Section 2.1 states that deflation induces people to postpone consumption, it is hardly plausible that consumers would wait one year with their purchase in order to save, say, 0.5 percent of the price. In other words, personal discount rates would have to be virtually zero in order to make this mechanism work. By the same token, if the Japanese economy was in a liquidity trap, deflation would only cause a 0.5 percentage point difference between nominal and real interest rates. With nominal rates permanently low in Japan, deflation would therefore hardly contribute to a level of real interest rates that discourages investment. Finally, the debt-deflation theory rests on the assumption that debtors are caught by surprise by a sudden appearance of deflation when they cannot change their nominally specified contracts. But it seems unlikely that contracts in Japan would not be adjusted to this possibility after, say, 10 years of recurring deflation. While this mechanism could have theoretically played a role in the mid-1990s when deflation was a novelty, it is improbable that it has had an effect in the past decade.

All in all, while the theories which assert that deflation is harmful could perhaps be applicable to the depth of deflation seen in the Great Depression period, they seem very hard to apply to the modern Japanese experience. This is also confirmed by the full sample for all countries and all years: observations with inflation rate in the interval $(-2\%, 2\%)$ —which Japan had all the time between 1992 and 2015 except for one year—have an average output growth of 2.8 percent per year in the entire dataset. This suggests that the rate of inflation common in Japan is in no way generally associated with subpar growth. The reasons for slow growth must lie elsewhere.¹⁸

¹⁸ See Hayashi and Prescott (2002) and Johnson (2005) for non-mainstream views on Japan.

Figure 9: Contemporary Japan (1990 = 100): (a) Output and prices, (b) Unemployment rate and prices



5. CONCLUSION

The empirical approach employed in this paper leads, in my view, to three major results. First, there is no general relationship between output and prices. The coefficient estimates are generally very small, be it in the whole sample or in the subsamples for the classical gold standard and after it. Second, the Great Depression stands out as the only episode in the sample with both a statistically significant and economically important (positive) relationship between output and prices. When one leaves out the Great Depression, which represents only 90 out of 2158 observations used in the regressions, correlations between inflation and output

growth in the rest of the sample lose their significance entirely. Third, Japan's economy in the 1990s and 2000s shows no evidence that poor economic growth was associated with deflation. The very moderate pace of price decreases also looks difficult to reconcile theoretically with the popular notion that deflation has had a profound effect on Japan's economic growth.

Overall, there is very little empirical evidence in favor of theories that assert that deflation is decidedly harmful. Rather it seems that such theories rest on very strict assumptions, which have been satisfied only rarely. The Great Depression, in which some of these theories might have worked, does not generalize to other episodes, including today's Japan.

Nonetheless, empirical research on deflation remains in a preliminary stage and much scope is available for advancement. On the data-related side, finding more control variables which would have enough historical readings remains one of the goals. Inspection of the modern Japanese experience with more frequent data, perhaps quarterly, is another. But completely different ways of assessing the effect of deflation on growth are also possible. Besides simply looking at the relationship between prices and output, one could analyze the particular theories (or transmission channels) of how deflation may affect growth. Those theories presented in Section 2.1, like the Mundell-Tobin effect or the debt-deflation theory, can be used to construct testable hypotheses on investment, indebtedness, and other variables. In the field of consumption and inflation expectations, some work has already been done. Another way forward would be to inspect the behavior of sectors of the economy that today exhibit deflation. That would provide modern-day data on deflation that are otherwise difficult to find in macroeconomic aggregates. These could be promising ways how to learn more about the empirics of deflation and output. So far, however, empirical research has not found much support for the popular notion that deflation is harmful for economic growth.

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