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Deflation and economic growth in long-term perspective

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IES Working Paper: 18/2014



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Deflation and Economic Growth in Long-Term Perspective

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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 scarce and partial. In order to explore the relationship between prices and output in a more comprehensive way, I use a large panel data set of 19 countries over roughly 150 years, which contains frequent deflationary episodes. I employ the fixed effects model to look at both contemporaneous and lagged correlation between prices and output, and I include control variables to remove potential bias.

There are several important results. First, there is no general relationship between prices and output. The lagged negative effect of deflation on output growth, alleged by some authors, disappears after adding a control variable. Second, monetary regimes seem to affect the relationship. Deflation appears to become associated with output slightly negatively with the advent of the fiat money system, while it was benign under the classical gold standard. Third, 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: 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 which did not provoke good or 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) The legacy of the Great Depression, which associated economic contraction with falling prices, and the lackluster economic performance of Japan, which has seen frequent deflation in the past 20 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.

Is this fear warranted? From an academic perspective, little research on the relationship between deflation and economic growth has been done. It was not until the late 1990s that, due to Japan, several pieces of research appeared, but very few looked at empirical data. The reason is evident: the best available post-war datasets offer only scarce deflationary episodes. The research that did look beyond the postwar data is, however, only partial and brief.

The present work aims to provide a more comprehensive look at what we know about the relationship between deflation and economic growth from empirical data. To do so, I have assembled a large dataset that contains annual data on output and prices for 19 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 the fixed effects 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. 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. Each approach is discussed below.

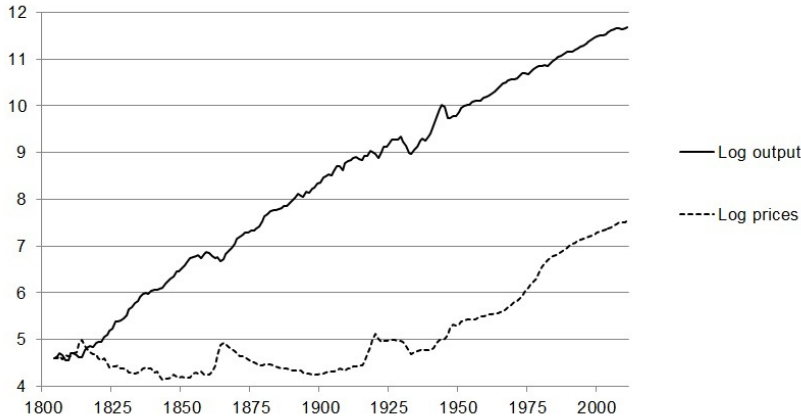


Figure 1: US real GDP and Consumer Price Index 1804 - 2011 (log of index where 1804 = 100)

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 it 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. This is seen easily in the Fisher equation $i = r + \pi$. 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, depressing investment. Aggregate demand contracts again. 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. 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) are highly indebted and 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 of them 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.¹

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 can 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.²

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 from, rather than to deflation per se and its possible secondary effects. 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, and 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 how 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. Microeconomic theory offers a simple reason why economic growth should produce downward pressure on prices. Economic growth (in its intensive rather than extensive form) stems from increasing productivity. Increasing productivity, in turn, is equivalent to lower costs of production per unit of output. Therefore, during the process of economic growth, curves of market supply move to the right, reflecting lower marginal costs, 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 modern macroeconomics, deflation resulting from productivity growth is equivalent to the aggregate supply curve shifting to the right in the AS-AD diagram.³

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

²It 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 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.

³Hayek (1931) is an important early work that argues in detail why deflation is a symptom of healthy economic growth.

2.2 Empirical Literature

Many empirical studies deal with the relationship between output and prices. McCandless and Weber (1995), for example, use data for 110 countries between 1960 and 1990 and find that the correlation between output growth and inflation is not significantly different from zero. However, such studies compare low and high inflation rather than inflation and deflation, since postwar data (and especially the period 1960 - 1990) contain only sporadically years with negative price growth. For the purpose of studying deflation, these studies have little to say.

In contrast, a few papers look exclusively at years that abound with deflation. Bordo and Redish (2003) explore the impact of prices on output in the United States and Canada in 1870 - 1913. They find that prices did not affect output in either direction. In this respect, an especially interesting conclusion they reach is that the inflation that started in the United States towards the end of the 19th century (see Figure 1), was *not* the reason for the higher growth rate of output that the US had in that period. Bordo, Lane and Redish (2004) look at the US, UK and Germany in the period 1880 - 1913. They find that most of the recorded deflation was ‘good’, i.e. associated with growing output. An obvious drawback of these studies is the limited number of countries and years.

Atkeson and Kehoe (2004) and Guerrero and Parker (2006) are two notable studies that use both long and broad datasets to look at deflation and growth. Atkeson and Kehoe analyse a sample of 17 countries over a period of more than 100 years, with the longest series starting as early as 1820. Regressing growth of output on growth of prices, they find that the slope coefficient estimate is 0.08. That is, a reduction in the rate of growth of prices has only a negligible (albeit negative) impact on the growth rate of output. They conclude that “Overall, the data show virtually no link between deflation and depression.” (p. 102)

In contrast, Guerrero and Parker (2006) find that deflation is associated with depression. In a Granger causality test, Guerrero and Parker restrict their attention to years with both recession and deflation and find that deflation Granger causes recession. They also estimate a fixed effects model in which they include both deflation and inflation episodes. They conclude that lagged deflation has a negative effect on growth, with this effect being economically small but statistically significant.^{4 5}

Although the two existing empirical pieces on deflation mentioned above provide valuable preliminary results, they have a number of limitations. First, Atkeson and Kehoe (2004) use 5-year averages of output growth and inflation as input in their regression, which may conceal some of the variation in the data. Guerrero and Parker (2006) object to this practice and use

⁴Specifically, the reported slope coefficient is 0.12 for the longer of two datasets that they use. That means that in order to reduce output growth by a sizable magnitude, say 1 percentage point, growth in prices must be roughly 8 percentage points lower once it is *already* in negative territory. (The reported slope coefficient refers only to deflation in the preceding year, not any price change, positive or negative.) Episodes with deflation this deep or deeper have been scarce, so the economic meaning of this finding is limited.

⁵Guerrero and Parker run all regressions for a long, historical dataset, similar to that used in Atkeson and Kehoe (2004), and for a postwar 1960-2001 dataset that is much shorter but has more countries. It is noteworthy that all their results that show a negative effect of deflation on growth are more statistically significant in the postwar dataset than in the long dataset. That might suggest that the nature of observed deflation episodes has changed considerably over the last 200 years, perhaps from a benign, growth deflation before World War I to a recession-linked cash-building inflation after World War II.

annual data, but they rely exclusively on lagged inflation as the regressor. That leaves out potential contemporaneous correlation and makes the study hard to compare with Akteson’s and Kehoe’s results.

Second, Guerrero and Parker find a negative impact of deflation on growth based on Granger causality tests. But in the regression equation they only consider years which had both deflation and recession. Therefore, what they find is that deeper deflation leads to deeper recession *if* deflation is accompanied by recession. Thus, the results do not say anything about episodes where there is deflation with output growth, since these cases are a priori excluded. It also says nothing on whether economies do better under inflation or deflation, although this is one of the key questions.

Third, neither of the works attempts to include control variables to remove a potential bias in the slope coefficient. As such, the effect of price growth on output growth they find may well reflect an effect of another variable which is not included in the regression.

The present paper estimates fixed effects models, considers both contemporaneous and lagged effects and, where possible, includes a control variable to avoid omitted variable bias.

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. The dataset consists of 19 countries and spans from the 19th century to 2011.⁶ 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, with GDP estimates generally starting earlier than prices. Altogether, there are 3031 annual observations that have both a reading for price growth and output growth.

However, 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 not help answer the question whether mild inflation is preferable to mild deflation.⁷ Therefore, I exclude all years with price growth greater than 20% or lower than -20%. The sample that I use below contains 2789 observations.

3.2 Basic Statistics

In the sample, positive price growth prevails, with years that saw positive inflation accounting for 70% of all annual observations. Inflation rates between 2 and 4% 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.

⁶The starting years are different for each country according to data availability. See the Appendix for a list of countries, availability of data and data sources.

⁷There is a wide agreement that very high inflation is adverse for growth. Although very deep deflation, in the magnitude of tens of percent, has not been studied in the literature, it is because these cases are extremely scarce and usually happen only after hyperinflations.

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.

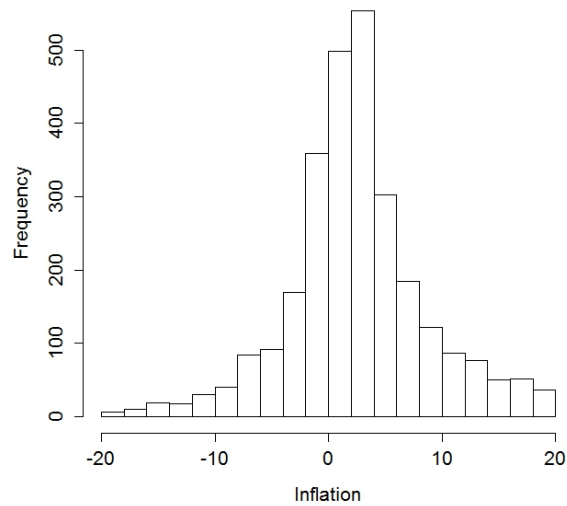


Figure 2: Inflation: histogram for all data

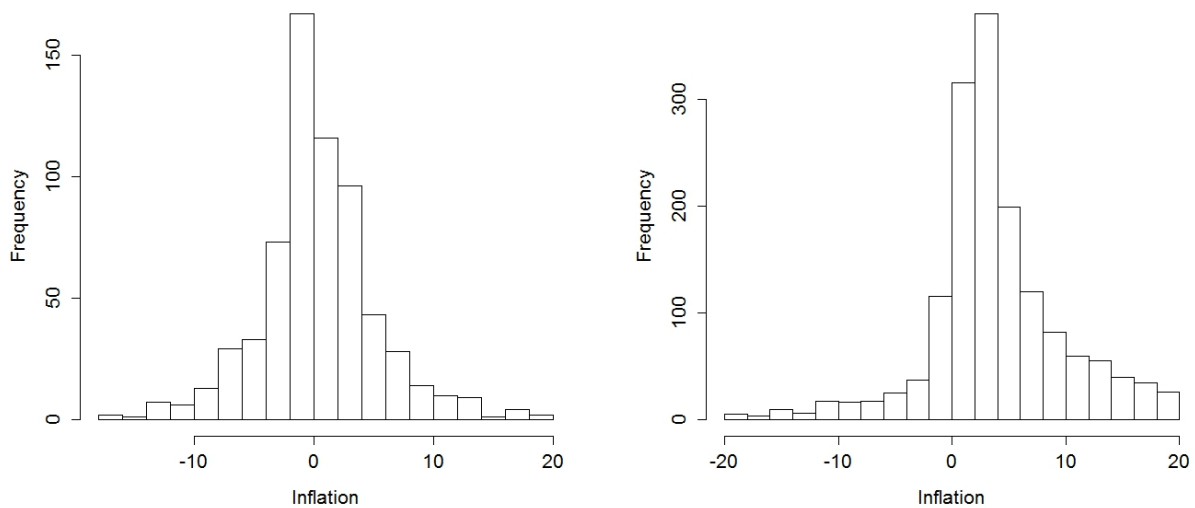


Figure 3: Inflation: histogram for (a) classical gold standard and (b) after classical gold standard

Figure 3 illustrates the major difference in the behaviour 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% 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

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

Table 1 compares economic growth under inflation and deflation.⁹ There are several important observations. First, economic growth was positive in 82.6% of years with inflation and in 73.9% 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 3.04% per year on average, while under deflation the growth rate was 2.72%. Again, this suggests that inflationary environment is a little more conducive to growth, although the output loss of having deflation instead of inflation is not great. Third, output growth appears to be less volatile under inflation than under deflation, as measured by standard deviations.

	All data	Inflation	Zero price change	Deflation
Observations	2789	1963	93	733
- obs. with output increase	80.2%	82.6%	79.6%	73.9%
- obs. with output unchanged	0.8%	0.7%	0%	1.2%
- obs. with output decrease	19.0%	16.7%	20.4%	24.8%
Average output growth	2.96	3.04	3.27	2.72
Output growth st. deviation	5.12	4.90	4.24	5.74

Table 1: Output growth under inflation and deflation

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 refuse the null hypothesis (at any standard significance level) that the average output growth rates under inflation and deflation are equal. On the contrary, the variances are confirmed to be significantly different. To sum up, although the sample shows that there is more volatility in output growth under deflation as opposed to inflation, there is no statistically significant difference in the average growth rate of output.

	Test statistic	P-value
T-test for equality of means	-1.32	0.19
F-test for equality of variances	1.37***	< 0.001

Table 2: Formal tests of equality of parameters

4 Regression Analysis

4.1 Method

As the series for each country starts in a different year, the sample at hand is an unbalanced panel dataset. To account for potential unobserved country-specific effects, I use the fixed effects model.

⁹'Zero price change' is included in Table 1 as there are observations, though not many, with exactly zero reported inflation.

¹⁰The sign * denotes statistical significance at 10%, ** at 5% and *** at 1%.

fects model to estimate the effect of price growth on output growth. The preference of fixed effects over random effects results from the consideration that the countries are not chosen randomly from a large enough population. Moreover, the random effects model assumes that the unobserved country-specific effects are uncorrelated with the regressors. Although this could be a reasonable assumption for some countries in the sample, for others, such as Argentina or Brazil, it is rather probable that unobserved institutional arrangements have caused their inflation rate to be permanently higher than that of other countries. Here fixed effects, which allow for correlation between unobserved cross-sectional effects and regressors, are more suitable.¹¹

The basic model for output growth that I use is an autoregressive process which has as explanatory variables the lagged value of output growth and both the contemporaneous and lagged change in prices. That is,

$$\Delta Y_{it} = \beta_0 + \beta_1 \Delta Y_{it-1} + \beta_2 \Delta P_{it} + \beta_3 \Delta P_{it-1} + a_i + u_{it}$$

where ΔY is real output growth, ΔP 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 ΔP is the own past value of ΔY .

As noted above, a major shortcoming of the existing research is the absence of control variables. Out of candidate control variables, investment stands out as being both important for output and relatively available as historical data. Although investment data are generally available for the pre-1914 period which contains most deflation years, they are not available for the approximate period 1914 - 1970, which includes the Great Depression.¹² There is therefore a tradeoff: either the regression is performed without a proper control variable, and then it has all the available data but may suffer from omitted-variable bias, or it is performed with investment growth as control variable, but then it loses roughly 50% of observations due to unavailability of investment data. The second, enlarged model which includes investment is

$$\Delta Y_{it} = \beta_0 + \beta_1 \Delta Y_{it-1} + \beta_2 \Delta P_{it} + \beta_3 \Delta P_{it-1} + \beta_4 \Delta I_{it} + \beta_5 \Delta I_{it-1} + a_i + u_{it}$$

where ΔI is real investment growth (again in percent terms). I call this model ‘conditional’ in what follows.

As the model contains the lagged dependent variable ΔY among regressors, the fixed-effects estimator is generally not consistent. However, as for example Wooldridge (2002) shows, the inconsistency falls at a rate $1/T$ as T grows, and for a time dimension high enough, the inconsistency is negligible.¹³ This is the case here, where in the full sample, T is around 150 years on average, so inconsistency is not of concern.¹⁴

¹¹Overall, however, the choice of the panel data method is not crucial for the results in this paper since the dataset has generally a large time dimension. That causes the results of fixed-effects and random-effects estimation to converge.

¹²See Table 9 in the Appendix for data availability.

¹³See Wooldridge (2002, p. 302).

¹⁴The 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 estimated the regression equation also using the general method of moments as a check, and it did not show substantially different results from those reported here using fixed effects estimation.

Each regression was tested for heteroskedasticity and serial correlation (see Table 10 in the Appendix). When any of them was detected, a robust variance matrix estimator was used to correct the variances and test statistics.

4.2 Full Sample

Table 3 presents the results for the whole sample. In the unconditional regression, there is no evidence of a contemporaneous effect of prices on output. The coefficient for ΔP_t is very small in magnitude and statistically insignificant. By contrast, the lagged inflation coefficient is statistically significant at the 5% level and the sign is positive. This is in line with the finding of Guerrero and Parker (2006) who focused only on lagged inflation. Still, practical implications of this finding should not be overestimated: if this result was taken as evidence that deflation does have negative impact on growth, the economic significance is small. A percentage point increase in inflation increases output growth only by 0.064 percentage points.

	Unconditional		Conditional on I	
	Coefficient	p-value	Coefficient	p-value
ΔY_{t-1}	0.116**	0.020	-0.158***	<0.001
ΔP_t	-0.043	0.212	0.011	0.706
ΔP_{t-1}	0.064**	0.046	0.010	0.650
ΔI_t	-	-	0.156***	<0.001
ΔI_{t-1}	-	-	0.051***	<0.001
Observations	2769		1346	
<i>Adj.R</i> ²	0.022		0.322	

Table 3: Regression of output growth on inflation: All data

Interestingly, the same regression, but this time with investment growth added as a control variable, yields different results. When the control variable is added, the coefficients of both contemporaneous and lagged inflation diminish in absolute value and lose statistical significance, which most likely reflects the omitted-variable bias that was present in the unconditional regression. As expected, investment growth is highly statistically significant and affects output positively. In other words, when we hold prices fixed, changes in investment affect output significantly (i.e. investment affects output independently of prices), but when we hold investment fixed, prices have practically no effect on output. This casts doubt especially on theories that assert adverse effect of deflation on output due to postponed consumption. Finally, a surprising result (though not the focus of this text) may be the negative and statistically significant coefficient of ΔY_{t-1} . That may suggest that output positively affects its future values mainly through investment, so when investment is held fixed, other output components are shown not to be positively correlated in time.

As mentioned above, the inclusion of investment causes a loss of approx. 50% of observations, including the Great Depression. Still, most deflation episodes are kept in the sample, so the results are meaningful despite the smaller dataset.

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. It is therefore of interest whether the change in monetary regime itself had an impact on the relationship between prices and output. Tables 4 and 5 present regression results for the classical gold standard era and for the period since its abandonment until the present time, respectively.

	Unconditional		Conditional on I	
	Coefficient	p-value	Coefficient	p-value
ΔY_{t-1}	-0.130***	0.002	-0.247***	<0.001
ΔP_t	-0.060	0.103	-0.029	0.505
ΔP_{t-1}	0.060*	0.079	0.046	0.408
ΔI_t	-	-	0.152***	<0.001
ΔI_{t-1}	-	-	0.052***	<0.001
Observations	639		517	
<i>Adj.R</i> ²	0.028		0.383	

Table 4: Regression of output growth on inflation: Classical gold standard period

	Unconditional		Conditional on I	
	Coefficient	p-value	Coefficient	p-value
ΔY_{t-1}	0.249***	<0.001	0.110*	0.096
ΔP_t	-0.012	0.693	0.053*	0.073
ΔP_{t-1}	0.064	0.201	0.003	0.79
ΔI_t	-	-	0.183***	<0.001
ΔI_{t-1}	-	-	0.014	0.509
Observations	1557		666	
<i>Adj.R</i> ²	0.078		0.540	

Table 5: Regression of output growth on inflation: After classical gold standard

As for the classical gold standard era in Table 4, the results are not much different from the overall results for all data in the previous section. The coefficients for both contemporaneous and lagged inflation are largely statistically insignificant. However, the results for the post-gold standard period in Table 5 show a positive and statistically significant relationship between output and prices, even after controlling for investment. Although the economic magnitude is small (coefficient 0.053), it does seem that economies started behaving differently after the change in monetary regime.

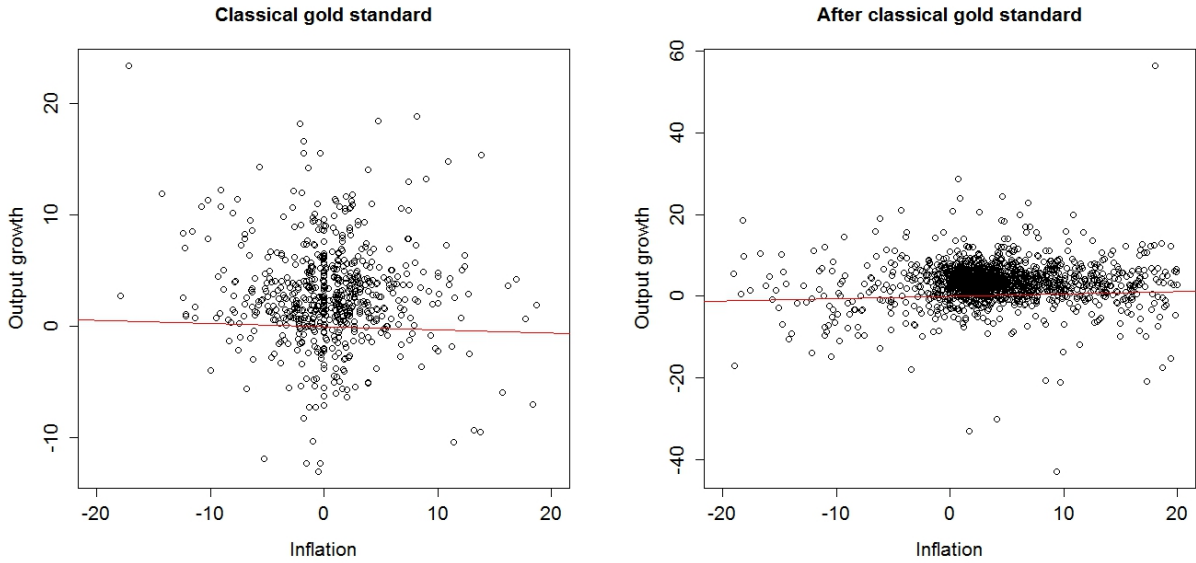


Figure 4: Regression for (a) classical gold standard period and (b) period after classical gold standard

This could be explained by the theory laid out above. In the arrangement of the gold standard, which kept the money stock more or less constant, deflation appeared as a consequence of either output growth or occasional cash-building and distressed selling during recessions. Therefore, the overall relationship with output growth was neutral. By contrast, under a regime with permanently expanding money supply and hence permanent inflation, deflation could not appear as a consequence of growth and only appeared during severe economic and financial crises when households and firms hoarded cash or sold under distress. The crisis of 2009 with deflation in some countries is a recent example. Therefore, deflation turned out to be negatively related to output growth. The comparison of coefficients for ΔP_t under the two monetary regimes (for the conditional regression) is in Figure 4.¹⁵

4.4 Selected Episodes of Deflation

Great Depression

Many theories on the consequences of deflation resulted from the experience of the Great Depression. Is this episode special? Table 6 shows regression results for the Great Depression period (1929 - 1934) and Table 7 for all data in the sample except Great Depression. As noted above, a limitation here is the unavailability of investment data for the Great Depression period, so I present only unconditional regressions in both tables.

¹⁵Since the regression lines in Figure 4 were 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 lines have 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 slopes.

	Coefficient	p-value
ΔY_{t-1}	-0.006	0.968
ΔP_t	0.571***	<0.001
ΔP_{t-1}	0.240	0.105
Observations	111	
$Adj.R^2$	0.237	

Table 6: Regression of output growth on inflation: Great Depression

	Coefficient	p-value
ΔY_{t-1}	0.087*	0.061
ΔP_t	-0.075**	0.032
ΔP_{t-1}	0.054	0.108
Observations	2658	
$Adj.R^2$	0.017	

Table 7: Regression of output growth on inflation: All data except Great Depression

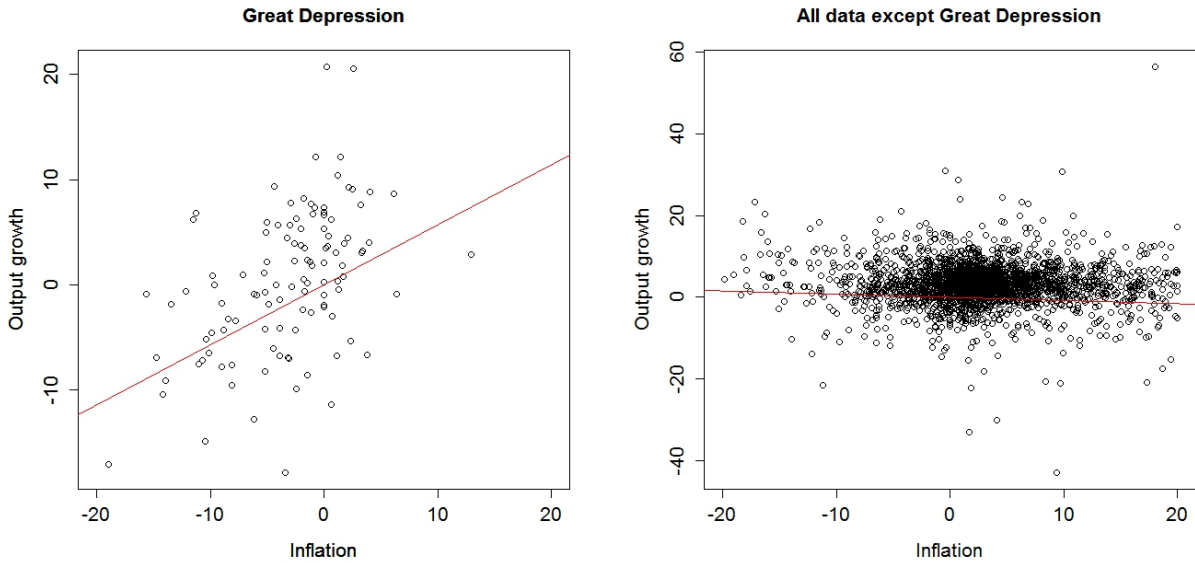


Figure 5: Regression for (a) Great Depression and (b) all data except Great Depression

The results show a clear difference: the Great Depression period yields a positive and statistically significant slope coefficient for contemporaneous inflation (and a narrowly insignificant positive coefficient on lagged inflation), while the ‘all except Great Depression’ regression shows rather mixed results, with the more statistically significant coefficient being negative by contrast. Importantly, unlike all previous results, the coefficient of ΔP_t at 0.571 in the Great Depression period is not only highly statistically significant, but also economically substantial.

The big difference in slope is seen in Figure 5.¹⁶

No other historical episode in the sample shows such a distinct result. 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, like Romer (1992), stress liquidity-trap theories and depressed investment, while others like Ohanian (2009) emphasize the role of labour unions and government in preventing nominal wages from adjusting downward, creating mass unemployment.

Contemporary Japan

The poor growth performance of Japan that started in 1992 and still continues has made it an alleged symbol of the harmfulness of deflation. Since the focus is now only on one country, the data at hand are no longer a panel-data model. Thus, Table 8 presents the results of an ordinary least squares estimation performed on Japanese data in 1992 - 2011. The results illustrate yet again a sharp difference between the conditional and unconditional approaches. The unconditional regression shows large and almost opposite coefficients for contemporaneous and lagged inflation, both being statistically significant. In contrast, coefficients of inflation lose statistical significance, and also much of their economic significance, when conditioned on investment growth. That suggests that there has been virtually no relationship between prices and output in Japan in the past two decades.

	Unconditional		Conditional on I	
	Coefficient	p-value	Coefficient	p-value
ΔY_{t-1}	-0.250	0.273	-0.387	0.243
ΔP_t	1.420*	0.047	0.348	0.237
ΔP_{t-1}	-1.363*	0.010	-0.085	0.710
ΔI_t	-	-	0.394***	<0.001
ΔI_{t-1}	-	-	0.081	0.511
Observations	20		19	
<i>Adj.R</i> ²	0.255		0.902	

Table 8: Regression of output growth on inflation: Japan in 1992 - 2011

This result might be surprising given the amount of publicity that Japan's deflation has received. But at a closer inspection of the data, it turns out that deflation has indeed had hardly anything to do with economic performance. First, it is remarkable that most of Japan's deflation occurred not during its recessions, but during the longest modern Japan's growth period in 2000 - 2007 (see Figure 6). Although it could be argued that lower inflation rates in the 1990s were associated with lower output growth as compared to previous decades, deflation as such accompanied almost exclusively growth, not recession. The comparison of the price level and the unemployment rate in part (b) of Figure 6 is even more striking. Unemployment rose with inflation and dropped with deflation very closely.

¹⁶The economically and statistically significant slope coefficient for ΔP_t in the Great Depression does not change considerably after the exclusion of the most apparent outliers.

Second, prices in Japan over the past 20 years have shown either very mild inflation or very mild deflation, with the inflation rate never dropping out of the $[-2\%, 2\%]$ interval. Overall, the price level grew a cumulative 2% between 1992 and 2011 (see Figure 6). 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 negative relationship between deflation and growth, but the pace of price decreases was much quicker.

Third, the mild deflation that has repeatedly occurred in Japan is asking for concrete theoretical questions. Given that the Japanese encountered deflation mostly between -1% and 0% (there was only one year with deflation deeper than -1%), 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% 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% 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 played a role in the mid-1990s, it is improbable that it had an effect in the past decade.

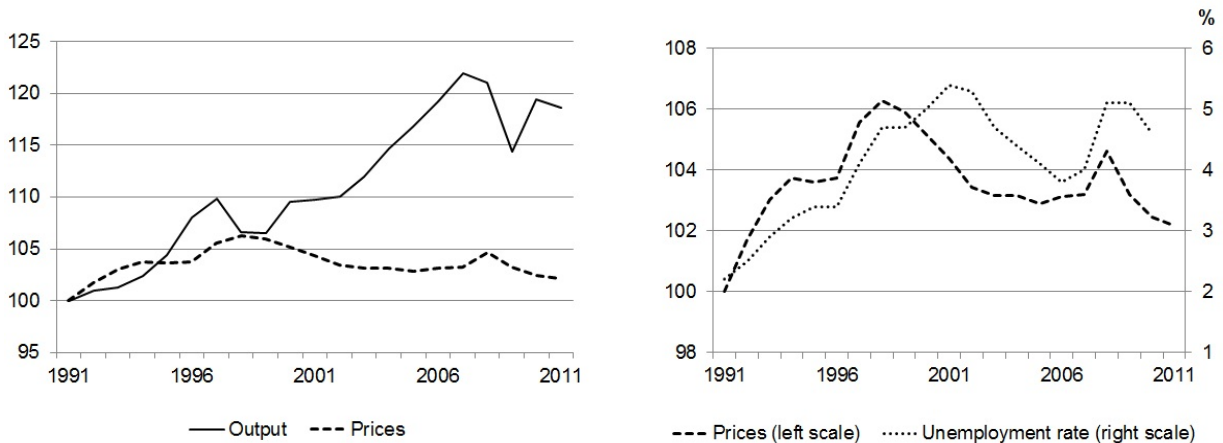


Figure 6: Contemporary Japan (1991 = 100): (a) Output and prices, (b) Unemployment and prices

All in all, while the theories which conclude that deflation is harmful could be applicable to 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 between 1992 and 2011 - have an average output growth of 3.0% in the entire dataset. This suggests that the rate of inflation common in Japan is in no way generally associated with subpar growth.

5 Conclusion

The empirical approach employed in this paper leads, in my view, to four major results. First, there is no general relationship between output and prices that would hold across periods and monetary regimes. While some authors report a positive lagged effect of inflation on growth, the inclusion of a control variable suggests this reported relationship is rather due to omitted-variable bias. Second, the relationship between output and prices appears to be affected by monetary regimes. The classical gold standard period shows no correlation between the two variables, while the more inflationary era that followed it suggests a positive correlation. Third, 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. Fourth, 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 profound effect on Japan's economic growth.

Overall, there is very little empirical evidence in favour 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 very preliminary stage and much scope is available for advancement. On the data-related side, finding a suitable control variable which would have more available historical readings than investment growth that I used 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, postponement of consumption or the debt-deflation theory, can all be used to construct testable hypotheses on investment, consumption, indebtedness, and other variables. After the prices-output relationship is sufficiently studied, this could be a promising way how to learn more about the role of decreasing price level in the economy.

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Appendix

A. Data Definitions and Sources

The following are the definitions and sources of variables used in this work. Some variables are defined as levels and some as rates of change, depending on the form in which they were retrieved from the respective data source.

Prices

Prices refer to the Consumer Price Index. Data before 1980 are taken from Atkeson and Kehoe (2004), except for Australia, Denmark, Switzerland and Belgium which are taken from Bordo (2010). Data from 1980 onwards are from the IMF and World Bank for all countries.

Output

Output is defined as Gross Domestic Product in constant currency, except for the period 1803 - 1870 in the United States, where it is defined as the Gross National Product. Data before 1980 are taken from Atkeson and Kehoe (2004), Mitchell (2003) and Smits et al. (2009), except for Australia, Belgium, Denmark and Switzerland which are taken from Maddison (2010). Data from 1980 onwards are from Maddison (2010) and World Bank for all countries.

Investment growth

Investment growth is the annual percent change in Gross Capital Formation in constant currency. Pre-World War I data are derived from the investment-output ratio data from Schularick, Solomou (2009). Post-World War II data are from the World Bank.

Unemployment

Data on the unemployment rate in Japan in Figure 6 are from the OECD.

B. Data Availability

Table 9 lists the span of data series for each country. (The starting dates of the series are as they were retrieved from their source, but where first differencing was needed, the series used in the regression starts a year later.) There are minor interruptions in the data series, usually a sporadic year of missing data for the pre-World War II era. The biggest interruption is missing data on prices in Belgium in 1915 - 1920 and 1941 - 1946.

Country	Prices	Output	Investment growth
Argentina	1884 - 2011	1884 - 2011	1886 - 1914, 1961 - 2011
Australia	1861 - 2011	1820 - 2011	1866 - 1913, 1966 - 2011
Belgium	1835 - 2011	1846 - 2011	1901 - 1913, 1971 - 2010
Brazil	1880 - 2011	1861 - 2011	1901 - 1914, 1961 - 2011
Canada	1870 - 2011	1870 - 2011	1871 - 1914, 1971 - 2010
Chile	1860 - 2011	1820 - 2011	1901 - 1914, 1961 - 2011
Denmark	1815 - 2011	1820 - 2011	1866 - 1914, 1971 - 2011
France	1820 - 2011	1815 - 2011	1866 - 1913, 1971 - 2011
Germany	1820 - 2011	1850 - 2011	1866 - 1913, 1971 - 2011
Italy	1861 - 2011	1862 - 2011	1866 - 1914, 1971 - 2011
Japan	1880 - 2011	1870 - 2011	1886 - 1914, 1971 - 2010
Netherlands	1880 - 2011	1820 - 2011	1871 - 1913, 1971 - 2011
Norway	1850 - 2011	1830 - 2011	1871 - 1913, 1971 - 2011
Portugal	1833 - 2011	1833 - 2011	1971 - 2011
Spain	1812 - 2011	1849 - 2011	1866 - 1914, 1971 - 2010
Sweden	1804 - 2011	1803 - 2011	1871 - 1913, 1971 - 2011
Switzerland	1882 - 2011	1850 - 2011	1866 - 1913, 1971 - 2010
United Kingdom	1804 - 2011	1830 - 2011	1866 - 1914, 1971 - 2011
United States	1804 - 2011	1803 - 2011	1870 - 1913, 1971 - 2011

Table 9: Data availability

C. Heteroskedasticity and Serial Correlation Tests

Table 10 gives the p-values of the Breusch-Pagan test for heteroskedasticity and for the Breusch-Godfrey test for serial correlation for the respective regressions. The lag order used in the Breusch-Godfrey test for panel data is given by the minimum group numerosity; the lag order used in the Breusch-Godfrey test for the time series for Japan is one. The null hypothesis of the tests is that there is no heteroskedasticity and no serial correlation, respectively.

Dataset	Breusch-Pagan test for heteroskedasticity	Breusch-Godfrey test for serial correlation
All data		
unconditional	<0.001	0.037
conditional on I	<0.001	<0.001
Classical gold standard		
unconditional	0.408	0.085
conditional on I	0.003	0.002
After classical gold standard		
unconditional	<0.001	0.317
conditional on I	<0.001	<0.001
Great Depression		
unconditional	0.354	<0.001
Outside Great Depression		
unconditional	<0.001	<0.001
Japan		
unconditional	0.330	0.206
conditional on I	0.586	0.927

Table 10: Tests for heteroskedasticity and serial correlation: p-values

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