Deflation, Recession and Slowing Growth: Finding the Empirical Links

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Does price deflation cause recession? Though deflation has become a matter of concern for the Federal Reserve, recent studies suggest that the historical and causal record is mixed. In this article, the authors use historical data for the output and price level of the United States of America, and find that a simple Granger causality approach confirms the doubts about the effect. A closer look, however, shows that while deflation alone may not cause recession, but when combined with recession, it may cause lower subsequent growth. Although interaction can lead to a downward spiral of output and prices, the authors find that they dissipate with time.

Introduction

Does price deflation cause recession? Though Friedman (1969) argued that the optimal rate of inflation should be equal to the negative real interest rate, at least for a stable population, it is widely accepted that price deflation could be bad for real economic activity, provided that certain conditions are met (Fisher's debt deflation problem). The interest in the issue goes beyond its purely theoretical aspects, of course. Deflation is considered by many of those who study Japan's economy as part of the explanation for the continued stagnation since the collapse of its asset price bubble in the early 1990s (Krugman, 2000; Eggertsson and Woodford, 2003). Indeed the potential problems associated with deflation have recently been a matter of concern in policy circles, as shown by the Federal Reserve's Federal Open Market Committee press releases of June 25, 2003, and December 9, 2003, noting that the "probability of an unwelcome substantial fall in inflation, though minor, exceeds that of a pickup in inflation from its already low level" (FRB, 2003). Though the language is muted, Bernanke (2003) argues that this statement explicitly recognized the asymmetry between inflation and deflation, and officially made the avoidance of price deflation a part of the US monetary policy.

Uncovering the links between deflation and real economic activity is far from trivial, though, and Atkeson and Kehoe (2004) argue that the empirical link between deflation and recession is limited to the Great Depression. Using a panel data set containing more

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than a century of annual observations of price inflation and GDP growth for 17 countries, they examine five-year increments and found little correlation between the two, except during the 1929-1933 period. Even then, they found that while all economies in their sample experienced negative growth, only half experienced deflation, and while the slope coefficient in a regression of growth on inflation was 0.4 for that period (i.e., a 1% deflation rate was associated with a 0.4% reduction in the growth rate), the t-statistic was not very high even then.

Yet, an alternative interpretation of Atkeson and Kehoe's results is that deflations may be bad only under certain circumstances, and this is the line of inquiry this paper pursues. We first review why deflation could have asymmetric effects on the economy, i.e., price deflation might cause recession even though price inflation does not cause growth, and low rates of deflation might have substantially different effects than low rates of inflation. We then examine an annual data set of approximately two centuries of output growth and price level changes for the case of the United States. After examining issues of stationarity and Granger Causality, we confirm the overall result of Atkeson and Kehoe (2004) that price deflation does not, in general, cause recession, though not surprisingly, recessions may cause deflation. We then consider the causal effect in more detail, and find evidence that price deflations that occur together with recessions can reduce subsequent growth. This effect eventually disappears, since real output and price level do not share a long run equilibrium relationship. However, this article finds that it takes two or more years for the negative effects of deflation on subsequent real output growth to be eliminated, thus providing a reduced-form justification for policymakers' concerns about the potentially disruptive effects of deflation on real economic activity.

The Economic Effects of Price Deflation

Why would a decrease in the overall price level adversely affect the economy? Most basic macroeconomic models focus on the role of the price level in clearing output markets, so that a decrease in aggregate demand should lead to a fall in the price level, but this deflation in turn should lead to rising output as the real value of money holdings increases. That is, recession may cause deflation (or at least disinflation), but deflation should in turn be expansionary in the presence of the well-known real balances effect.

However, there are several reasons why under certain conditions deflation can reduce economic growth in the short to medium term, as Eggertsson and Woodford (2003) and Cargill and Parker (2003), among others, point out. The effects of inflation and deflation may further be asymmetric: low rates of deflation may have effects similar in magnitude to much higher rates of inflation, as Taylor (2001) finds for Japan, and Engelbrecht and Langley (2001) uncover for a larger sample of countries. The effects of deflation are largely connected to the effect of deflation on real interest rates due to the nominal rate's zero lower bound. As currency yields a nominal rate of zero, it becomes impossible for bonds and loans, which must include a risk premium, to pay a non-positive return without an explicit tax on currency holdings. Deflation leads to a real rate of interest in excess of the nominal rate, and if deflation rates are high enough then the real interest rate rises.

The first effect of deflation is Fisher's (1933) debt-deflation connection, as unexpected price deflation raises the cost of debt repayment. When deflation is combined with recession, this can lead to an increased rate of default by firms and other borrowers, with predictable results on the financial system. Second, the expectation of further deflation may increase real money demand because it creates a positive real return on currency and deposits. Indeed, Cargill and Parker (2004a) compare the evidence for the United States during the Great Depression, and both Japan and China during the last decade, and find that in addition to the expected effect of changing nominal interest rates, deflation had an asymmetric effect on money demand in both the United States and Japan, though not for China. Third, expected deflation can decrease current consumption in anticipation, a relationship that is consistent with the hypothesis that deflation increases real money demand,[1] and Cargill and Parker (2004b) find some evidence supporting this hypothesis for Japan.

Finally, price deflation appears to lead to a fall in the deposit expansion multiplier. As the nominal interest rate approaches zero, the risk premium for bank lending over government bonds is compressed. In Japan, banks have moved a significant fraction of their portfolio from loans to government bonds, and the net result has sometimes been interpreted as generating a discontinuity in monetary policy, popularly known as the 'liquidity trap'.[2] Though widely understood as implying that monetary policy would become impotent in a severe recession, this discontinuity may instead be considered a reason to believe that monetary policy becomes less effective unless monetary authorities are able to eliminate medium-term expectations of deflation. As a deflation continues, the amount of expansion in the monetary base needed to generate anticipations of price inflation also increases, and these expectations may display a certain inertia. If correct, this interpretation implies that Japan's monetary policy of zero nominal interest rates was bound to be ineffective (as argued, among others by Eggertsson and Woodford, 2003; and Ito and Mishkin, 2004), because it was an explicitly temporary effort, and could have better been replaced with a policy of price level targeting.

Thus, we can argue that deflation would 'cause' recession only in a specific set of cases, in which particular shocks within a particular environment combine with poor monetary policy to create a tragic result. Only under those circumstances could deflation set off a downward economic spiral.

The historical record on this issue is a complex one. In a broad review of worldwide deflation during the past two centuries, Borio and Filardo (2004:7) argue that deflationary periods may be grouped into three types: "the good, the bad and the ugly." Good deflations could result from productivity improvements, bad deflations could result from nominal price rigidities, and ugly deflations could be those rare cases where self-reinforcing price deflation spirals out of control. Both approaches are conceptually useful, but, as Bordo and

[1] In a standard representative agent framework where both money and consumption are arguments in the utility function, the assumption that the cross partial derivative of the utility function with respect to money and consumption is positive, guarantees this result.

[2] Meltzer (1999) disputes the existence of a liquidity trap in the recent Japanese experience.

Redish (2003) note, from the empirical economist's standpoint deflations are not easily separated into good and bad categories. An effort was made by Bordo, Landon, and Redish (2003), who used a vector autoregression model and found, for instance, that productivity-driven deflation tended to dominate during the period of the Gold Standard in the United States, the United Kingdom, and Germany. Deflations likely result from simultaneous combinations of negative monetary shocks and positive shocks to supply, as Bordo and Redish (2003) document for both the United States and Canada.

Recessions and Deflations in the United States

In this paper, we examine the historical record of recession and deflation in the United States (1789-2003), using annual data for real output and the price level from Johnston and Williamson (2004). While annual data may not help us identify every period of recession and deflation, quarterly data is available only for the post-war period, for which deflation has been largely absent. Of course, economic data from the 19th century is subject to error, and as such, our results should be interpreted with that caveat in mind.

In Table 1, we summarize the annual changes in real aggregate output and the price level by period. We include the average rate of growth and inflation, with the standard deviation, along with the number of years observed with negative growth and deflation. Deflations were a common experience before WWII, and rare afterwards. Recessions became less common, and the standard deviation of both growth and inflation declines.

The average growth rate slowed slightly in the postwar period (though in per-capita terms, the growth rate actually increased, from an average of 1.7% through 1945 to 1.8% afterwards). The average inflation rate was significantly higher in the postwar era, particularly in the decade between the collapse of Bretton Woods and the end of the Volcker disinflation in 1982. As expected, in the prewar period recessions were most common in the period bookended by the two world wars, while in the postwar period the decade after 1971 was the exception to a record of improving stability.

Table 1: Recessions and Deflation in Annual US Data (values in percentage)

Period	Average Growth	Std. Dev.	Years in Recession	Percentage	Average Inflation	Std. Dev.	Years in Deflation	Percentage
1780-1830	4.2%	(5.3%)	8	20%	0.2%	(5.0%)	20	49%
1831-1873	4.2%	(5.1%)	7	16%	1.3%	(8.5%)	20	47%
1874-1913	3.9%	(4.4%)	7	18%	-0.3%	(2.6%)	17	43%
1914-1945	4.1%	(8.0%)	11	34%	2.2%	(7.6%)	10	31%
1780-1945	4.1%	(5.6%)	33	21%	0.8%	(6.3%)	67	43%
1946-1971	3.1%	(4.0%)	5	19%	3.3%	(3.0%)	1	4%
1972-1982	2.7%	(2.9%)	4	36%	7.3%	(1.8%)	0	0%
1983-2003	3.4%	(1.5%)	1	5%	2.5%	(0.9%)	0	0%
1946-2003	3.1%	(3.1%)	10	17%	3.8%	(2.8%)	1	2%
1780-2003	3.8%	(5.1%)	43	20%	1.6%	(5.8%)	68	32%

If recessions and deflations were uncorrelated, then they would occur together only by coincidence, and the joint probability of such a coincidence would be equal to the product of the individual probabilities. In Table 2, we show the number of annual recessions and deflations over the entire sample, and calculate the expected number of times the two would coincide; if uncorrelated. In the United States, recessions occurred in 20% of the sample and deflation in 32%, so the expected coincidence is 6.5% of the observations, or in 14 observations. We then show the number of times recession and deflation occurred together, recession preceded deflation, and deflation preceded recession.

Table 2: The Coincidence of Recession and Deflation

Observed Recessions	43	
Observed Deflations	68	
Expected Coincidence	14	
Observed:		χ^2 stat
Recession and Deflation	15	0.24
Recession before Deflation	20	5.39*
Deflation before Recession	16	0.73
Total Observations	214	

Note: *Statistically significant at the 5% level.

If deflations were generally 'good', as Bordo, Landon, and Redish (2003) conclude for the period of the Gold Standard, then we would expect to find that the observed coincidence was lower than the expected coincidence. What we actually observe is that the two occur together more than coincidence would predict in all cases, but we calculate the χ^2 test of independence, and find that the difference is not always statistically significant. The null hypothesis that recession does not precede deflation, except by coincidence, is rejected at the 5% level. However, the null hypothesis that deflation does not precede recession cannot be rejected, at least not with this initial examination. The simple evidence is that recessions cause deflation rather than the reverse.

Recession and Deflation: A First Look

In this section, we examine the statistical relationship in our data for the United States between recession and deflation, in an effort to uncover the causal relationship. Following Atkeson and Kehoe (2004), and given constraints imposed by data availability, we study the bivariate relationship between real output growth and price inflation, rather that using a multivariate approach. We first consider some technical issues concerning the stationarity of both the Real GNP and the GNP Deflator data. Second, we study the relationship between the inflation rate and output growth by means of standard Granger causation tests. Our results are in line with the findings reported in the inflation and growth literature (see Guerrero, 2004, for a recent discussion of the cross-country evidence). Finally, the causal links between recessions and deflations are studied by performing similar bilateral Granger causation tests to the data. Results of this first look are in line with those reported in Atkeson and Kehoe (2004), in that deflations alone do not Granger-cause recessions, but recessions do Granger-cause deflations. The relationship, infact is much more complex than this; which will be discussed in the next section.

Stationarity

We define output (Y) as annual real GNP, the price level (P) as the GNP Deflator, the growth rate (g) as the log difference of real output, and the inflation rate (tt) as the log difference of the price level. We then perform an Augmented Dickey-Fuller (ADF) test on both the levels and the log differences to determine whether these series have unit roots. As Table 3 shows, we cannot reject unit roots for the levels of either output or the price level, but we can reject unit roots for both growth and inflation rates.

Table 3: The Stationarity of Real GNP and the GNP Deflator

Augmented Dickey-Fuller (ADF) tests
H0: There is a unit autoregressive root.

	t-stat	critical *t* (1%)
a) Level, Real GNP	8.33	-3.46
b) Level, GNP deflator	8.33	-3.46
c) Rate of change, Real GNP	-14.4	-3.46
d) Rate of change, GNP Deflator	-9.64	-3.46

Replication of the Baseline Atkeson-Kehoe Cross-country Result

In order to test if the basic Atkeson-Kehoe (2004) cross-country result that deflation does not correlate with recession, except during the period of the Great Depression, we created eight dummy variables for the years of different monetary regimes characterizing the US economy during the sample period: Pre-1880 (i.e., the period of Bimetallism), 1880-1913 (the period corresponding to the Gold Standard), 1914-1918 (the period associated with the brief inconvertibility implied by WWI), 1919-1928 (the return to gold convertibility before the crash of 1929), 1929-1938 (the period of the Great Depression), 1939-1945 (a period when the international payment system was disrupted by WWII), 1946-1971 (the period of the Gold Exchange Standard, under the Bretton Woods institutions), and finally, the period of floating exchange rates, 1971-2002. We define deflation (*d*) as follows:

Table 4: Basic Atkeson-Kehoe Results on the Effects of Deflations on Recessions

Regressing Growth Rate, g, on:

	Coefficient	t-statistic
Constant	0.041	11.41**
d * Time Dummy Pre 1880	-0.048	-0.44
d * Time Dummy 1880-1913	-0.744	-1.44
d * Time Dummy 1914-1918	-	-
d * Time Dummy 1919-1928	-0.383	-1.29
d * Time Dummy 1929-1938	-1.402	-5.22**
d * Time Dummy 1939-1945	-	-
d * Time Dummy 1946-1971	-81.525	-1.01
Number of Observations	213	
R-Squared	0.13	
F-Statistic	6.22	

Note: * Statistically significant at 5% level.
** Statistically significant at 1% level.

Notice: If the deflation rate(d) is also included in the regression, then all the right hand side regressors become statistically insignificant at conventional levels.

$$d = \begin{cases} -\pi, if\ \pi < 0, \\ 0, if\ \pi \geq 0. \end{cases}$$

In defining deflation as the rate of inflation, when negative, rather than with a dummy variable, we follow Cargill and Parker (2004a, 2004b). We then interacted the eight dummy variables with deflation (*d*). If Atkeson and Kehoe's results are valid for the US, then the only deflation-time dummy to be associated with a fall in growth should be the one for the Great Depression period. Table 4 shows that this is indeed the case.

Causality between Growth and Inflation

We next test whether growth (g) and inflation (π) exhibit any temporal ordering by means of conventional bivariate Granger tests. The multivariate causal relation between growth and inflation has been extensively studied and our present bidirectional Granger-causation analysis is in line with previous findings (Gylfason and Herbertsson, 2001; Guerrero, 2004). We test the null hypothesis that there is no Granger-causality for two, three, and four lags. The results are shown in Table 5. We find that changes in the price level Granger-cause (lower) growth: Granger causality is statistically significant for both two and four lags, but not for three. We don't find evidence that growth Granger-causes changes in the price level in any case.

Table 5: Bivariate Causality Tests for Growth and Price Level Changes

	F-statistics
ΔP Granger-causes Growth:	
Four Lags	2.47*
Three Lags	1.98
Two Lags	3.48*
Growth Granger-causes ΔP:	
Four Lags	0.91
Three Lags	1.14
Two Lags	1.55

Note: *Statistically significant at 5% level.

Simple Causality between Recession and Deflation

To test whether there is a certain temporal order between recession and deflation, we constrain the rates of change of both variables to take only negative values. To simplify the interpretations of results later on, both series are multiplied by -1 (i.e., Granger regressions are run using the absolute value of the rates of recession and deflation, respectively). We define recession (*r*) as follows:

$$r = \begin{cases} -g, if\ g < 0, \\ 0, if\ g \geq 0. \end{cases}$$

We then perform bidirectional Granger causality tests on *r* and *d*, and we find that recession Granger-causes deflation, for two, three, and four lag cases. Does deflation Granger-cause recession? From our data, as shown in Table 6, it is clear that the answer is negative, for we cannot reject the null hypothesis of no Granger causality with any set of lags. This finding is again in line with that of Atkeson and Kehoe (2004), and suggests

that our data set produces a similar result as theirs. It is interesting that our evidence supports the conclusion that recessions seem to Granger-cause deflations, since recessions may result from shocks in either aggregate supply (leading to contemporaneously higher prices) or aggregate demand (leading to contemporaneously lower prices), but perhaps the time structure of these tests implies that the recovery from a recession results in downward pressure on prices. It is less surprising, however, that deflations do not Granger-cause recessions, since only with demand-side shocks should we expect to find firms struggling to repay their loans and nominal interest rates approaching zero.

Table 6: Bivariate Causality Tests for Recession and Deflation

	F-statistics
Deflation Granger-causes Recession:	
Four Lags	0.71
Three Lags	0.28
Two Lags	0.64
Recession Granger-causes Deflation:	
Four Lags	3.95**
Three Lags	5.13**
Two Lags	4.75**

Note: **Statistically significant at 1% level.

Limitations of Granger Causality Tests

Unfortunately, the fact that deflation does not Granger-cause recession does not permit us to draw the unambiguous conclusion that deflations are irrelevant determinants of recessions. If deflations can be anticipated, then recessions may tend to happen before the fall in the price levels actually occurs (for instance, because consumers postpone consumption if they anticipate lower future prices). In that case, the economically-meaningful causation would indeed run from deflation to recession along a perfect foresight equilibrium path where people don't make mistakes when expecting deflation, but the test would reject the true hypothesis that deflation leads to recession simply because the test is based on the temporal ordering of observed variables. Therefore, the results of the previous tests are suggestive but not definitive, and more analysis is required.

A Long Run relationship between Real GNP and the GNP Deflator?

Before we proceed to investigate the short run co-movements between deflation and growth in detail, it is worth pausing to consider whether there is a long-term relationship between real output and the price level. After all, the Quantity Theory of Money (QTM), a well-established framework for long run inflation analysis, predicts that there should be none. Given the (non)-stationarity results presented in Table 3, a natural way to address the issue is by means of a cointegration test. Table 7 presents Johansen's trace and maximum

Table 7: Cointegration Tests for the Log Levels of Real GNP and GDP Deflator

Johansen's Cointegration Tests		
	t-stat	critical t (1%)
a) Trace Test		
H0: No CEs	6.27	19.94
At most 1 CEs	0.13	6.63
b) Maximum Eigenvalue Test		
H0: No CEs	6.14	18.52
At most 1 CEs	0.13	6.63

eigenvalue cointegration tests on the relationship between the log levels of Y and P. Results are in line with the QTM's prediction: There is no cointegration between the (log of the) price level and the (log of) real output.[3]

Recession and Deflation: A Closer Look

Having established that there is no long run relationship between real output and the price level (i.e., all results obtained for the relationship between deflation and real output pertain exclusively to the short run dynamics of their relationship), we move on to dig further into the short run relationship between deflation and real output. Perhaps the case for a (short run) relationship between recession and deflation is more subtle than we have been able to uncover so far.

We begin by considering the possibility that deflation reduces the growth rate, even if it does not necessarily cause a full-blown recession. After all, both the results in Table 5 (on the unidirectional effects of changes in the price level on the changes in real GNP) and the previously discussed role of expectations about price level changes could perfectly lead to a situation where deflations lead to growth slowdowns. Next, we consider the possibility that what matters to determine growth slowdowns is the interaction of recession and deflation, rather than just deflation alone. In particular, two natural questions come to mind: (1) Is it possible that deflations that interact with long-enough recessions lead to lower subsequent growth? (2) Is it possible that deflations that interact with deep enough recessions lead to lower subsequent growth? We thus estimate a regression of the form:

$$g = \beta_0 + (\beta_d + \beta_{dR} R_i)d + \beta_g \, lag(g) + e$$

That is, we regress the growth rate, whether negative or positive, on the deflation rate and on the interaction between deflation and a proxy (*R*) for recession, as well as on the lagged dependent variable. We consider three different proxies for recession:

$$R_1 = \begin{cases} 1, if \;\; g < 0 \; and \; lag\,(g) < 0, \\ 0, otherwise; \end{cases}$$

$$R_2 = \begin{cases} 1 + lag(R_2), if \;\; g < 0, \\ 0, otherwise; \end{cases}$$

$$R_3 = lag(r).$$

The first proxy is a dummy variable for a long recession, i.e., a recession lasting two or more years. The second proxy is a count of the number of years a particular recession has lasted. The third proxy is the recession rate from the prior year. In essence, we are

[3] Recall that the rates of growth are the log differences of the variables.

testing the hypothesis that deflations are likely to reduce the growth rate, leading to either a deeper recession or a slower recovery, only if a recession has already occurred.

The regression results for all three cases are shown in Table 8. The coefficient on the lagged dependent variable was statistically insignificant, and the Durbin-Watson statistic was close to two when it was dropped from the regressions, so we do not include this variable. This did not significantly affect the results.

Table 8: Interaction Effects for Growth, Deflation and Recession

Regressing *g* on:		
	Coefficient	**t-statistic**
Proxy R_1 (2+ Year Recession)		
Constant	0.04	9.32**
Deflation rate (*d*)	-0.06	-0.53
Interaction ($d \times R1$)	-0.96	-4.14**
R^2	0.10	
Durbin-Watson Statistic	2.12	
F-Statistic	11.59	
Mean elasticity ($\Delta \ln Y / \Delta \ln P$)	-0.12	
Proxy R_2 (Length of Recession)		
Constant	0.04	11.21**
Deflation rate (*d*)	0.05	0.77
Interaction ($d \times R_2$)	-0.42	-5.06**
R^2	0.13	
Durbin-Watson Statistic	2.08	
F-Statistic	15.96	
Mean elasticity ($\Delta \ln Y / \Delta \ln P$)	0.02	
Proxy R_3 (Depth of Recession)		
Constant	0.04	10.82**
Deflation rate (*d*)	-0.12	-1.03
Interaction ($d \times R_3$)	-6.09	-1.97*
R^2	0.12	
Durbin-Watson Statistic	2.13	
F-Statistic	15.03	
Mean elasticity ($\Delta \ln Y / \Delta \ln P$)	-0.49	

Note: * Statistically significant at 5% level.
**Statistically significant at 1% level.

In all the estimations, the coefficient for deflation alone is statistically insignificant, which is essentially consistent with the cross-country finding of Atkeson and Kehoe (2004). The coefficients for the interaction terms, however, are all significant at least at 5% level. With the first proxy for length, R_1, for recessions of two or more years, the coefficient on the interaction is negative, which implies that deflation leads to lower subsequent growth when the recession is long. A qualitatively similar, but quantitatively smaller result is obtained with the second proxy for length. The coefficient on the interaction with R_2, for the number of years a recession has lasted, also has a negative sign, so deflation leads to lower growth as long as a recession continues. Finally, the coefficient on the interaction with R_3, for the depth of the prior year's recession, has a negative sign, and it is still significant at 5% level.

How robust are these results? Many proxies for recessions were tried, including dummy variables for past recessions and different cut-off values for the fall of real GNP lagged one period (e.g., -1%, -2%, -3%, etc). Results were very similar in all cases. Results for the interaction terms were also very similar when the insignificant deflation variable was dropped. In short, deflation alone may not lead to lower growth, but deflations combined with recessions may.

Is the impact of deflation on growth significant in value, as well as significant in statistical terms? We can exploit the fact that the rates of real GNP growth and deflation were both calculated as log differences to obtain the elasticity of changes in real growth to changes in the price level (when negative):[4]

$$\frac{\partial(\Delta \ln Y)}{\partial(\Delta \ln P)}\Big|_{\Delta \ln P<0} = \hat{\beta}_d + \hat{\beta}_{dR} R_i$$

The corresponding elasticities are reported at their mean values in Table 8. For the first recession proxy, the average elasticity equals about -0.1, so that a 1% drop in prices leads to a drop in real output of 0.1. The elasticity for the second proxy is harder to interpret, but on average, it is close to zero. Again, we interpret this value as reflecting that the longer the recession has lasted, the greater the probability of recovery given extra time available for the operation of the automatic stabilizers. Finally, the larger quantitative effect is given by the third calculated elasticity at -0.5. It appears that deflations that combine with deep enough recessions have the strongest detrimental effects on short run real GDP growth. It should be emphasized again that all these elasticity values pertain to the short run dynamics between real output and deflation.

Table 9: Spiral Reversion for Growth, Deflation and Recession

Regressing *g* on:		
	Coefficient	**t-statistic**
Proxy R_1 (2+ Year Recession)		
Constant	0.04	10.15**
$d * R_1$, first lag	-0.39	-1.69*
$d * R_1$, second lag	0.34	1.37
$d * R_1$, third lag	0.18	0.73
$d * R_1$, fourth lag	0.21	0.89
R^2	0.10	
Durbin-Watson Statistic	2.12	
F-Statistic	2.05	
Proxy R_2 (Length of Recession)		
Constant	0.03	11.21***
$d * R_2$, first lag	-0.12	-1.59
$d * R_2$, second lag	0.14	1.80*
$d * R_2$, third lag	0.04	0.55
$d * R_2$, fourth lag	0.10	1.26
R^2	0.04	
Durbin-Watson Statistic	2.06	
F-Statistic	2.06	
Proxy R_3 (Depth of Recession)		
Constant	0.03	10.01***
$d * R_3$, first lag	-6.31	-2.25**
$d * R_3$, second lag	6.18	2.10**
$d * R_3$, third lag	-1.13	-0.39
$d * R_3$, fourth lag	4.65	1.66*
R^2	0.05	
Durbin-Watson Statistic	1.98	
F-Statistic	2.71	

Note: * Statistically significant at 10% level.
** Statistically significant at 5% level.
*** Statistically significant at 1% level.

How long does it take for the downward spirals of deflation and recession to revert themselves? We regress growth on four lags of the interaction term, and in Table 9, we provide a tentative answer of two years for the sign of the interaction effect to reverse

[4] Given the lack of statistical significance of the estimates for the coefficient β_d (the direct effects of deflation on real growth), the discussion about the overall *quantitative* effects is provided only to give an approximation of the potential economic impact of the effects involved.

itself. The regression for the first proxy gave results that were statistically insignificant, but in line with the ones for the other two proxies, both qualitatively (right sign) and quantitatively. These results are essentially unchanged if the deflation rate, *d,* is also added to the regressions.

Summary

In this article, the relationship between deflation, recessions and growth slowdowns was studied. Since deflation and growth interact with each other in many ways, it is not surprising that there is not much literature available evincing that deflations cause recessions. Most economists would expect recessions to lead to subsequent falls in the inflation rate as markets tried to clear, and when the inflation rate is low, we would see deflation. But the effects of deflation on growth are not very distinctive, for only when the economy is in recession and nominal interest rates are low, should we expect deflation to really matter. Indeed, we began by testing for Granger causality, and found that in general, recessions cause deflations more than the reverse.

When recessions and deflations occur together, however, we find evidence that the interaction between the two leads to lower subsequent growth, and this result seems to be statistically significant, and robust to changes in specification. Deflation, when combined with recession, appears to cause more recession. The effect appears to reverse itself for longer recessions, which is consistent with the expectation that there should be no long run relationship between real output and the price level. In other words, deflation and recession do not appear to cause an unending downward spiral. However, our evidence suggests that the downward spiral effects could be present for a long period of time to believe that the monetary authorities are correct in worrying about deflation. Further study with a higher frequency of data will be able to shed more light on the short run dynamics of deflation and real output.

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