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Abstract

Using inflation forecasts from the OECD *Economic Outlook* as proxy measures of inflation expectations, we examine the impact of inflation expectations on the sacrifice ratio for 20 OECD countries. The regression analysis considers four different empirical models of the determinants of the sacrifice ratio typically found in the existing literature. The impact of the *level* of inflation expectations is negative and significant, implying that a higher level of expected inflation is associated with lower sacrifice ratios. This result is consistent with the theoretical role of nominal wage and price rigidities in that reductions in wage and price stickiness diminish the tradeoffs between disinflations and output losses. Interaction effects indicate that higher levels of expected inflation allow policymakers to pursue 'cold

turkey’ inflation reductions even more aggressively. The effect of the *change* in inflation expectations is negative and significant, implying that faster adjusting inflation expectations are associated with lower sacrifice ratios.

INTRODUCTION

Using inflation forecasts from the OECD Economic Outlook as proxy measures of inflation expectations, we examine the impact of inflation expectations on the sacrifice ratio for 20 OECD countries. The regression analysis considers four different empirical models of the determinants of the sacrifice ratio typically found in the existing literature. The impact of the level of inflation expectations is negative and significant, implying that a higher level of expected inflation is associated with lower sacrifice ratios. This result is consistent with the theoretical role of nominal wage and price rigidities in that reductions in wage and price stickiness diminish the tradeoffs between disinflations and output losses. Interaction effects indicate that higher levels of expected inflation allow policymakers to pursue 'cold turkey' inflation reductions even more aggressively. The effect of the change in inflation expectations is negative and significant, implying that faster adjusting inflation expectations are associated with lower sacrifice ratios.

There have been a number of studies on the determinants of the sacrifice ratio or the tradeoff between output and inflation. The sacrifice ratio was first quantified by Ball ([4]) to examine the output loss associated with a disinflationary episode. Early studies focused on the relationship between the sacrifice ratio and the speed of the disinflation, to determine whether a gradual disinflation or 'cold turkey' disinflation resulted in a lower output loss. Subsequent studies considered economy-wide characteristics such as the degree of trade openness, central bank independence, wage stickiness, the exchange rate regime or inflation targeting, and exchange-rate pass-through, to name a few.

Theoretical models on (1) price/wage stickiness; (2) policymaking credibility/commitment; and (3) macroeconomic variability introduced via policy actions suggest channels that link inflation expectations, as well as the speed of adjustment of inflation expectations, to the inflation-output trade-off. Limiting consideration to price and wage stickiness, we would a priori assume an estimated negative relationship between expected inflation and the sacrifice ratio.

Once policy credibility effects are taken into account, however, the predicted sign of this relationship becomes less obvious, as endogenously determined inflation expectations and the credibility of macroeconomic policies can move together or in opposing directions. Empirical treatment of the influence of policy credibility would, therefore, yield an ambiguous prediction for the relationship between expected inflation and the sacrifice ratio.

In contrast, policy-induced macroeconomic volatility, itself depending on policy credibility, impacts the optimal degree of wage stickiness that leads to output losses from disinflations. Taking this channel, by itself, into consideration suggests a positive relationship between expected inflation and the sacrifice ratio. Overall, these three channels operating together through the macroeconomic policy process suggest a likely positive relationship between expected inflation and the sacrifice ratio. Given some degree of ambiguity, however, the relationship remains an empirical question, which is the motivation for this study.

Using inflation forecasts from the OECD *Economic Outlook* as proxy measures of inflation expectations, we examine the impact of the level of inflation expectations and changes in inflation expectations on the sacrifice ratio for 20 OECD countries. The regression analysis considers four different empirical models of the determinants of the sacrifice ratio typically found in the existing literature. The first sets of regressions compare the impact of the level of inflation expectations prevailing at the beginning of a disinflationary episode to the effect of initial, or peak inflation at the beginning of a disinflationary period. The direct impact of the level of inflation expectations—or the total impact in models with interaction terms—is negative and significant in all models, implying that a higher level of expected inflation is associated with a lower sacrifice ratio. This result is consistent with the theoretical role of nominal price and wage rigidities, in that reductions in wage and price stickiness diminish the tradeoffs between disinflations and output losses. Interaction effects indicate that higher levels of expected inflation, consistent with reduced wage and price stickiness, allow policymakers to pursue 'cold turkey' inflation reductions even more aggressively.

The role of the level of inflation expectations, however, differ from initial inflation when considering a model that includes a variable for central bank independence. We explore this difference by considering mediation effects via the Sobel-Goodman mediation test (Sobel, [25]). We find that initial inflation is a mediator—that is, it carries some of the influence of central bank independence to the sacrifice ratio. This suggests that a more independent central bank has the power to exploit the inflation-output tradeoff more when the level of inflation at the outset of a disinflation episode starts from a high level. Results for the level of inflation expectations imply that inflation expectations are not a mediator.

A second set of regression models examines the role of changes in inflation expectations that occur over a disinflationary episode rather than the level of inflation expectations. Consistent with the results for the level of expectations, the effect of the change in inflation expectations is negative and significant in all four regression models, implying that faster-adjusting inflation expectations are associated with lower sacrifice ratios. Likewise, the interaction between changes in inflation expectations and the length of the disinflation is negative and significant, indicating that faster-adjusting expectations allow policymakers to pursue disinflations even more quickly. In addition, changes in inflation expectations also have a mediation effect in models that include a measure of central-bank independence. Since the level of expected inflation does not have a mediation effect, whereas the change in expected inflation does, this implies that it is via a change in expectations that central banks can alter output while disinflating. Put in a different way, part of the impact of lowering inflation comes about through inducing a change in inflation expectations.

A final set of regressions combines (1) initial inflation and changes in inflation expectations and (2) the level of inflation expectations and changes in inflation expectations. These results show that (1) initial inflation and changes in inflation expectations have unique and statistically significant effects and that (2) the level of inflation expectations and the change in inflation expectations have unique and statistically significant effects.

The following section examines alternative theoretical perspectives regarding the relationship between expected inflation and the sacrifice ratio. Section 3 discusses the variables and data utilized to evaluate this relationship. Section 4 describes the empirical models and results. Section 5 discusses key implications and concludes by contemplating possible directions for future research.

THEORETICAL ASSESSMENT

Several theoretical rationales for how inflation expectations might be related to the sacrifice ratio are summarized in Table 1. A direct channel involves nominal wage and price rigidities often suggested as necessary for output losses to be associated with disinflations. Conceivable indirect channels operate through the credibility of authorities' policies, arise from underlying reputations of those policymaking authorities, or exist because of contributions of the authorities' policies to macroeconomic volatility.

Table 1. Proposed channels relating expected inflation to the sacrifice ratio

Channel	**Analytical framework**	**Predicted relationship and basic mechanism**
Direct:		
Nominal Wage and Price Rigidities	Fischer (16); Gray (20); Taylor (26)	Negative association between expected inflation and the sacrifice ratio: Lower nominal stickiness reduces the tradeoff between disinflations and output, so higher expected inflation that lessens nominal stickiness decreases the sacrifice ratio.
Indirect:		
Macroeconomic Policymaking	Cukierman (11); Drazen (14)	Ambiguous association between expected inflation and the sacrifice ratio: Increased variance of monetary control error boosts expected inflation while increasing the output loss from disinflations. Higher variance of the central bank's preference weight on its employment objective reduces its credibility, which raises expected inflation while increasing the output loss from disinflations
Reputation of Macroeconomic Policymakers	Backus and Driffill (2,3)	Positive association between expected inflation and the sacrifice ratio: If the central bank is tough and the private sector is weak, expected inflation and the output loss from disinflation fall to zero. If the central bank is weak and the private sector is tough, expected inflation and the output loss from disinflation both increase.
Policy Shocks, Policy Credibility, and Rigidities	Gray (21); Gray and Kandil (22)	Positive association between expected inflation and the sacrifice ratio: Fewer policy shocks and resulting higher macroeconomic policy credibility lower expected inflation and simultaneously reduce output losses from disinflations

The direct channel via nominal wage and price rigidities

A direct influence of nominal wage and price rigidities on the output losses associated with disinflations is the most straightforward rationale for a relationship between expected inflation and the sacrifice ratio. In traditional sticky-wage/price models that followed on the heels of those proposed by Fischer ([16]), Gray ([20]), and Taylor ([26]) and summarized within the Blinder and Mankiw ([9]) amalgamated 'archipelago-economy' model, nominal rigidities naturally create conditions that yield a short-term Phillips-curve tradeoff between the inflation rate and real GDP growth.

Although many economists abandoned these traditional models of wage and price rigidity because of mismatches with predicted real wage dynamics, Ball ([5], [6]), Fuhrer and Moore ([18]), and Mankiw ([23]) have shown that basic forward-looking New Keynesian models can adequately explain neither inflation persistence nor output losses from disinflations. Ascari and Ropele ([1]) show within a New Keynesian framework that a 'cold-turkey' disinflation can generate disinflation losses consistent with estimated sacrifice ratios when exogenously specified degrees of wage- and price-inflation indexation happen to lie within appropriate ranges. Nevertheless, consistent with Ball's original arguments, enabling such models to generate disinflationary output losses usually requires the introduction of separate policy-credibility considerations; see, for instance, Erceg and Levin ([15]) and Goodfriend and King ([19]). We shall return to this issue of traditional versus forward-looking New Keynesian perspectives on the sacrifice ratio in Section 5.

Within the traditional nominal-stickiness models, reductions in wage and price stickiness yielded by higher actual and expected rates of product and input price inflation generate a diminished tradeoff between disinflations and aggregate output. Thus, in the presence of nominal wage and price rigidities, *higher* expected inflation is associated with a *lower* sacrifice ratio.

The indirect macroeconomic policymaking channel

Barro and Gordon ([7]) explained how positive mean inflation rates tend to arise in settings in which central banks lack credibility to commitments to restrain inflation. The substantial political economy literature that followed suggests channels through which the policy process could simultaneously influence expected inflation and output losses generated by disinflations. In his review of this substantial literature, Drazen ([14], Chapter 6) notes the importance of differentiating between the credibility of macroeconomic policies versus the credibility of policymakers themselves. We here focus on how the credibility of macroeconomic policymaking can impinge upon the relationship between expected inflation and the sacrifice ratio. We shall contemplate the reputational effects in the following subsection.

In Cukierman's ([11], Chapter 9) classic study of key determinants of central bank credibility, low central credibility is measured by a summary statistic based on negative absolute deviations of planned money growth from the public's expectation of planned money growth. The value of this credibility measure depends negatively on the variance of the central bank's monetary control error; the variance of innovations to its employment objective; and the slope of a Phillips curve relationship relating the deviation of employment from its natural level to the deviation of inflation from its expected level. In Cukierman's model, the endogenously-determined expected inflation of private agents is higher when the variance of the monetary control error is greater. A rise in the variance of the monetary control error, however, pushes down the value of Cukierman's credibility measure and hence raises the cost of a disinflation. Hence, when the central bank experiences a larger variance of the monetary control error, the result in Cukierman's model is *higher* mean inflation at the same time that lower credibility, and hence a *higher* output loss, results from a disinflation.

Nevertheless, Cukierman's credibility measure also depends on the variance of innovations to the central bank's employment objective, which could rise or fall over time with appointments of new leaders, alterations in the legal structure of the central bank, or successful applications of political pressures on those leaders. A higher value of the variance of this objective effectively pushes up the overall net relative weight on inflation in the central bank's decision-making process, which causes the agents' endogenous inflation expectation to decline. At the same time, an increase in this variance boosts expected deviations of planned money growth from agents' conditional expectation of money growth. Central bank credibility declines, and consequently a higher output loss results from a given disinflation. Thus, when the central bank experiences a greater variance of innovations to its employment objective, *lower* expected inflation is associated with *higher* output losses from disinflations.

Comparing these two examples indicates that the net relationship between expected inflation and output losses from disinflations depends on underlying parameters that simultaneously influence both variables. Hence, taking into account policy credibility considerations yields a theoretically ambiguous relationship between observed values of expected inflation and the sacrifice ratio.

The indirect policymaker reputation channel

Barro and Gordon ([8]) investigated how a monetary authority might establish an anti-inflation reputation to limit the inflationary bias of discretionary policymaking. Backus and Driffill ([2],[3]) famously pursued this idea within an explicit dynamic-game-theoretic reputational model. In their model, a central bank known to have a tough anti-inflation stance can credibly commit to low (or zero) inflation and thereby ensure that the output cost of a disinflation will be very low (and potentially zero). Backus and Driffill contemplate central banks that are either tough or weak in their anti-inflationary stances and also consider private sectors that are tough or weak in terms of giving in on adjustment of their inflation expectations and settings for the nominal wage rate.

Backus and Driffill ([3]) consider a special case of their reputational model in which the central bank is tough and the private sector is weak. They verify that actual and expected inflation and the output loss from a disinflation both fall toward zero, so that *lower* expected inflation is associated with a *lower* sacrifice ratio. They find that in the case of a weak central banker but a tough private sector, both expected inflation and the output cost of disinflating are high, so that *higher* expected inflation is associated with a *higher* sacrifice ratio. Thus, these two reputational cases imply a positive association between expected inflation and the sacrifice ratio.

The indirect macroeconomic variability channel

Considerable evidence—see Taylor ([27]), for example—indicates that reduced inflation volatility owing to diminished aggregate demand variability is directly associated with lower mean inflation, reduced inflation forecast errors, and decreased inflation expectations. In addition, the theory of optimal length of nominal contracts developed by Gray ([21]) indicates that a reduction in aggregate demand variability reduces optimal contract length. To the extent that greater policy credibility reduces volatility of aggregate demand, the degree of nominal wage and price stickiness should decrease.

Thus, as noted by Gray and Kandil ([22]), greater macroeconomic stability and increased wage and price flexibility can simultaneously result when policymaking reduces aggregate demand volatility. This insight yields the final indirect channel through which inflation expectations can be related to the sacrifice ratio. On the one hand, greater macroeconomic stability brought about by a more credible policy process implies both lower inflation volatility and hence mean inflation. On the other hand, the enhanced stability of aggregate demand associated with greater policy credibility also reduces nominal contract length and thereby boosts the flexibilities of wages and prices and tends to reduce output losses resulting from disinflations. Taken together, this final policy credibility channel thereby yields a positive relationship between expected inflation and the sacrifice ratio. This last channel operating through the policy credibility process thereby suggests that *higher* expected inflation potentially could be associated with a *higher* sacrifice ratio, thereby implying a positive relationship between the two variables.

Summary

Economists typically appeal to wage and price rigidities to rationalize the observation of output losses that accompany disinflations, which, since Ball's ([4]) original contribution, have been measured with sacrifice ratios. If we were to limit ourselves solely to this basic explanation for the observation of positive sacrifice ratios, we would predict that higher expected inflation accompanying an increased actual mean inflation rate would be associated with a lower sacrifice ratio. That is, we would anticipate observing an estimated negative relationship between expected inflation and the sacrifice ratio in the available data.

Once the potential importance of various policy credibility effects is taken into account, however, the predicted sign of this relationship becomes less obvious. Endogenously-determined inflation expectations and the credibility of macroeconomic policymaking, which in turn influences the output losses from disinflations, can move in tandem or in opposing directions, depending on magnitudes of underlying structural parameters. Hence, consideration of influence of the credibility of policies yields an ambiguous prediction for the relationship between expected inflation and the sacrifice ratio. Although dynamic-game-theoretic models of policymaker reputation could be made sufficiently complicated to generate a negative relationship, the implication of accounting for reputational considerations is that expected inflation is more likely to be positively related to the sacrifice ratio. Finally, macroeconomic volatility induced by policymaking, which depends on the overall credibility of the policy process, impinges on the optimal durations of nominal contracts that motivate output losses from disinflations. Taking this channel into consideration predicts a positive relationship between expected inflation and the sacrifice ratio. Overall, taking into account all three indirect channels operating through the macroeconomic policy process yields the prediction of a likely positive sign for the relationship between expected inflation and the sacrifice ratio, although some scope for ambiguity is present.

Overall, taking into account the various channels in combination yields a theoretically uncertain relationship between expected inflation and the sacrifice ratio. Consequently, in the next section we turn to the data for guidance regarding the relationship that actually exists between these two variables.

DATA

Much of our empirical data comes from the meta-study of the determinants of the sacrifice ratio by Daniels, Mazumder, and VanHoose ([12]). These authors derive their sacrifice ratio data from Bowdler ([10]) and extend his data set to cover 1973–2004. The primary data source for that data is the International Monetary Fund's *International Financial Statistics*. Focusing on this dataset, we can directly compare our results with the various models in their study. The data set covers 20 OECD countries for the period 1973 through 2004 for a total of 69 usable observations.[1]

The sacrifice ratio (**SAC**) is the dependent variable in our regression models and is based on the seminal work of Ball ([4]). The sacrifice ratio is measured as the ratio of actual less trend output, to the amount of disinflation during a disinflationary period. Using the centered eight-quarter moving average of actual quarterly inflation, an inflation peak (trough) is a period in which trend inflation is higher (lower) than in the previous two years. A disinflation episode is then defined as a period of time beginning with a peak and ending at a trough, where trend inflation declines by at least 1.5 percent.

To measure trend output, it is assumed that output is at trend at an inflation peak and returns to its trend one year after the end of a disinflationary episode. Trend output is assumed to grow log-linearly between the peak and trough. The numerator of the sacrifice ratio, therefore, is the sum of the differences between trend output, and the log of actual output. The denominator of the sacrifice ratio is simply the amount of disinflation during an episode.

Independent variables begin with the speed of the disinflation as measured by the length (**Length**) of the disinflation episode in years. Peak inflation (**Peak**) is the initial level of inflation at the start of a disinflation episode. The relative inflation loss (**RInfLoss**) is measured as the amount of disinflation over an episode relative to the initial level of inflation at the start of the episode (**Peak**). We use this measure to capture diminishing returns to inflation reductions (e.g., it is likely that the output loss associated with a 2 percent inflation reduction when initial inflation is 10 percent would be smaller than the output loss associated with a 2 percent inflation loss when initial inflation is, say, 3 percent).

The degree of trade openness (**Openness**) follows Romer ([24]) who focuses only in the cross-sectional variance of this measure so as to reduce potential endogeneity. His measure, therefore, is the period-average of the ratio of imports to GDP. Our measure of Central Bank Independence (**CBI**) follows Daniels, Nourzad, and VanHoose ([13]) who employ data from Franzese ([17]). To capture expected inflation (ExpInf), we use the inflation forecasts from various issues of the OECD *Economic Outlook*.[2] Specifically, we use the next-year inflation forecast from the December issue of the *Economic Outlook* immediately prior to a disinflationary episode. This year-ahead forecast is based on the most recent, but incomplete, inflation information. The relative change in expected inflation (**RelΔExpInf**) is simply the difference between the OECD inflation forecast at the end of a disinflationary episode and the measure of expected inflation, **ExpInf**, at the beginning of the episode relative to the level of inflation expectations, **ExpInf**. Hence, the relative change in inflation expectations is consistent with the relative change in inflation, **RInfLoss**.

Table 2 provides a correlation matrix for all the independent variables. The key variables of interest for this study are **Peak**, **RInfLoss**, **ExpInf**, and **RelΔExpInf**. Among the four variables, the only statistically significant pairwise correlations are between **Peak** and **ExpInf**, which have a positive correlation that is statistically significant at the 5 percent level, and between **Peak** and **RInfLoss** which have a negative correlation that is statistically significant at the 10 percent level.

Table 2. Correlation matrix between independent variables

	Length	**Peak**	**RInfLoss**	**Openness**	**CBI**	**ExpInf**	**RelΔExpInf**
Length	1						
Peak	0.041	1					
RInfLoss	0.523***	−0.200*	1				
Openness	−0.005	−0.017	−0.097	1			
CBI	−0.053	−0.317***	0.105	−0.032	1		
ExpInf	0.080	0.808***	−0.100	0.081	−0.220*	1	
RelΔExpInf	−0.003	−0.177	−0.055	0.167	−0.106	−0.107	1

1 *** denotes significance at the 1 percent level, ** at the 5 percent level, * at the 10 percent level.

EMPIRICAL MODEL AND RESULTS

We turn to our main empirical analyses, in which we regress the sacrifice ratio on various determinants that are considered standard in the literature. Aside from the length of disinflationary episodes, the amount of disinflation is also frequently included in typical sacrifice ratio regressions, such as in Ball ([4]). As stated in the previous section we define relative inflation loss as the amount of inflation loss divided by inflation at the onset of an episode, where this transformed variable has lower correlations with the other regressors. Hence, in Model 1 of each table of results reported below, we use a fairly typical specification of regressing the sacrifice ratio on a constant, trade openness, the length of the disinflation episode, and the relative inflation loss. Because of the correlation between **Peak** and **ExpInf**, we first add **Peak** (initial inflation). As noted by Ball ([4]), theory suggests that the sacrifice ratio should be lower with higher initial inflation.[3] Hence, we expect this variable to have a negative relationship with the sacrifice ratio.

We next add to the first model the interaction between the length of the episode and **Peak** (Model 2), where we test to see whether initial inflation matters when considered alongside the speed of disinflation. In Model 3, we employ the Daniels et al. ([13]) model that tests central bank independence, while Model 4 modifies this slightly by adding the interaction between central bank independence and initial inflation.

In subsection 4.1 that follows, we focus on evaluating the evidence concerning the fundamental issue of what the data tell us about the actual relationship between the level of the expected inflation rate and the sacrifice ratio vis-à-vis conflicting predictions of the alternative theories discussed in Section 2. In subsection 4.2, we seek to delve more deeply into how other independent variables that might affect the sacrifice ratio affect nature of this relationship. In addition, we explore empirically the potential of differential sacrifice-ratio effects of the *level* of inflation expectations vis-à-vis *changes* in inflation expectations that have not generally been addressed explicitly in the theoretical literature.

Results for initial inflation and for the level of expected inflation

The results for our four basic regression models and focusing separately on peak inflation and expected inflation can be seen in Tables 3 and 4, respectively, in which we utilize pooled OLS with robust standard errors (clustered at the country level). As is well documented in the literature, in all four columns of Table 3, we see that the length of a disinflationary episode is a positive and statistically significant determinant of the sacrifice ratio. In other words, longer disinflations are costlier in terms of more lost GDP. This, in turn, is what motivates the idea of 'cold-turkey' disinflation, for which fast reductions in the level of trend inflation are often encouraged. In all specifications we find that trade openness is a negative and significant determinant of **SAC**, as argued in Daniels et al. ([13]), in which in a more open economy, a real depreciation causes the price of foreign goods and services to rise proportionately faster than that of domestic goods and services, causing higher inflation. Indeed, a real depreciation which raises domestic firms' costs leads to a larger increase in domestic prices for any rise in domestic output. While relative inflation loss in Table 3 always produces the expected negative sign, we never obtain statistical significance for this variable. In Models 3 and 4, we find the coefficients on central bank independence to be positive but not a statistically significant determinant of the sacrifice ratio. In Models 1 and 3 (models without an interaction term), the coefficient on **Peak** is negative and statistically significant, in line with *a priori* expectations. In Models 2 and 4, the total effect of **Peak** is negative and statistically significant.

Table 3. Sacrifice ratio regressions with peak inflation

	Model 1	**Model 2**	**Model 3**	**Model 4**
Openness	−0.026*** (0.007)	−0.027*** (0.007)	−0.025*** (0.008)	−0.025*** (0.007)
Length	0.545*** (0.097)	1.014*** (0.315)	0.553*** (0.099)	0.549*** (0.100)
RInfLoss	−0.439 (0.676)	−0.722 (0.691)	−0.496 (0.681)	−0.501 (0.681)
Peak	−0.069** (0.027)	0.077 (0.067)	−0.061** (0.028)	−0.033 (0.050)
Length × Peak		−0.034* (0.017)		
CBI			0.826 (0.560)	1.531 (1.367)
CBI × Peak				−0.082 (0.129)
Constant	0.755 (0.635)	−1.018 (1.159)	0.295 (0.632)	0.056 (0.750)
Total effect of Peak		−0.075*** (0.025)		−0.070** (0.032)
Observations	69	69	69	69
R^2	0.375	0.429	0.382	0.384
Adj. R^2	0.336	0.383	0.333	0.324

In Table 4, we repeat this exercise, substituting the level of inflation expectations, **ExpInf** for **Peak**. In cases in which the level of expected inflation is used alone in the sacrifice ratio regression (Models 1 and 3), we find a statistically significant negative coefficient, albeit it with a small magnitude, in which we obtain coefficients in the region of about −0.06. This thus agrees with the side of the theory that argues that higher expected inflation tends to be associated with lower sacrifice ratios. Namely, the nominal wage and price rigidity channel outlined in section 2.1, agrees with this finding, whereby reductions in wage and price stickiness caused by higher rates of output and input price inflation, leads to diminished tradeoffs between reductions in inflation and total output.

Table 4. Sacrifice ratio regressions with expected inflation

	Model 1	**Model 2**	**Model 3**	**Model 4**

Openness	−0.023** (0.008)	−0.023*** (0.008)	−0.023** (0.008)	−0.021** (0.008)
Length	0.534*** (0.101)	0.997** (0.371)	0.546*** (0.103)	0.521*** (0.106)
RInfLoss	−0.189 (0.611)	−0.600 (0.683)	−0.305 (0.619)	−0.262 (0.564)
ExpInf	−0.067** (0.031)	0.107 (0.092)	−0.059* (0.031)	0.034 (0.044)
Length × ExpInf		−0.041* (0.024)		
CBI			1.050* (0.570)	2.652** (1.046)
CBI × ExpInf				−0.254** (0.112)
Constant	0.394 (0.547)	−1.269 (1.192)	−0.122 (0.540)	−0.699 (0.509)
Total effect of ExpInf		−0.078** (0.031)		−0.081** (0.032)
Observations	69	69	69	69
R^2	0.362	0.413	0.374	0.389
Adj. R^2	0.322	0.367	0.324	0.330

In Model 2, we find a negative and significant coefficient for the interaction between length and expected inflation. This tells us that inflation expectations condition the length of disinflationary episodes, which we always find to have a positive effect on the sacrifice ratio. In particular, a negative coefficient for the interaction terms shows that quickly adjusting expectations allows policymakers to pursue reductions in trend inflation all the more aggressively. Also notice that the fit of the model, as seen by the adjusted-R^2, rises substantially—by about 30 percent—when we add the interaction term from Model 1 to get the results seen in Model 2. In this model, we also consider the total effect of expected inflation on **SAC**, by combining the coefficients on the interaction term with expected inflation (assuming length to be equal to its mean value), and we see that the overall impact of expected inflation on output losses of disinflation is negative and statistically significant. Hence, the results for **Peak** and **ExpInf** are very similar across Models 1 and 2.

Models 3 and 4 of Table 4, however, provides differing results than Models 3 and 4 for **Peak**. When inflation expectations are substituted for initial inflation, the coefficient on **CBI** is positive and statistically significant (albeit at the 10 percent level) in Model 3 and is positive and statistically significant at the 5 percent level in Model 4. Further, the interaction terms between **CBI** and **ExpInf** is negative and statistically significant at the 5 percent level. This latter result indicates that a more independent central bank that embarks upon a tightening of monetary policy, beginning from a high level of expected inflation, is able to lower the output losses incurred during this disinflation episode. In other words, this gives some credence to the rational expectations notion that disinflation can be 'costless' if the central bank makes a credible announcement of their goal of reducing inflation, if one uses central bank independence as a proxy for credibility. This finding is tempered, however, when we consider the total effect of **CBI** on the sacrifice ratio and find it to be an effect that is statistically equal to zero. Similar to the results for Peak, the total effect of expected inflation on the sacrifice ratio (while also including its interaction with central bank independence) is negative and statistically significant.

Further exploration of the empirical relationship among expected inflation, the sacrifice ratio, and other explanatory variables

Our above results indicate unambiguously that, consistent with theories based on nominal stickiness, the empirical relationship between the level of expected inflation and the sacrifice ratio is negative.

These results also suggest, however, that interactions exist among inflation expectations and other independent variables that influence the sacrifice ratio. In the remainder of this section, we seek to explore more fully the nature of these interactions. In the process, we shall demonstrate that the *level* of inflation expectations and *changes* in inflation expectations have individually unique effects on the sacrifice ratio.

First, note that Models 2 and 4 of Tables and indicate that both initial inflation and the level of inflation expectations have a moderating effect on, or condition, the impact of the length of the disinflation period and central bank independence (as captured by the interaction terms). Models 3 and 4, however, indicate that initial inflation and the level of inflation expectations affect the influence of **CBI** on the **SAC** differently. We explore this further by considering mediation effects. That is, do initial inflation and inflation expectations carry the influence of **CBI** on the sacrifice ratio? To do this, we first test and find that: (1) **CBI** statistically significantly affects the **Peak**; (2) **CBI** statistically significantly affects the **SAC** in absences of **Peak**; (3) **Peak** has a statistically significant effect on the **SAC**, and; (4) the impact or coefficient on **CBI** declines with the inclusion of Peak. Following this, results for the Sobel-Goodman mediation test show that the overall coefficient of **CBI** is 1.531 (consistent with Model 4) but that 0.526, or 39 percent, of this total effect is an indirect effect carried by **Peak**. Hence, **Peak** is a mediating variable that carries a statistically significant (*p*-value of 0.023) indirect effect of **CBI** on the **SAC**. This has important policy implications for central banks, which may be able to exploit the tradeoff between inflation and output further if the level of peak inflation is high at the start of a disinflationary episode.

We also test the level of inflation expectations as a mediator. Though it passes the first four tests described above, the indirect effect is not statistically significant (*p*-value of 0.137).[4]

One could easily argue that the way in which expected inflation should be incorporated into a sacrifice ratio regression is by examining the *change* in expected inflation, rather than the *level* of expected inflation, over the course of a disinflation episode. Therefore, in Table 5, we reproduce the previous regressions except with the relative change in expected inflation over the course of the disinflation rather than the level of expected inflation or peak. The results of Models 1 and 3 are similar to the level of expected inflation in that the coefficient on **RelΔExpInf** is negative and statistically significant and the coefficient on **CBI** is positive and statistically significant in Model 3. We also find the relative change in the expected inflation coefficient to be positive in Model 2 of Table 5. Nevertheless, consistent with our results regarding the level of inflation expectations in subsection 4.1, the total effect of the change in expected inflation on the sacrifice ratio remains negative and significant.

Table 5. Sacrifice ratio regressions with relative change in expected inflation

	Model 1	**Model 2**	**Model 3**	**Model 4**
Openness	−0.021*** (0.006)	−0.018** (0.006)	−0.021*** (0.006)	−0.021*** (0.006)
Length	0.506*** (0.091)	0.537*** (0.091)	0.524*** (0.094)	0.528*** (0.096)
RInfLoss	0.006 (0.567)	−0.059 (0.577)	−0.159 (0.615)	−0.128 (0.621)
RelΔExpInf	−0.039*** (0.013)	0.031* (0.015)	−0.036** (0.015)	0.015 (0.052)

Length × RelΔExpInf		−0.023*** (0.005)		
CBI			1.220** (0.548)	1.390** (0.646)
CBI × RelΔExpInf				−0.106 (0.114)
Constant	−0.118 (0.500)	−0.238 (0.517)	−0.648 (0.521)	−0.792 (0.562)
Total effect of RelΔExpInf		−0.071*** (0.010)		−0.033* (0.016)
Observations	69	69	69	69
R^2	0.352	0.360	0.369	0.370
Adj. R^2	0.312	0.309	0.319	0.309

Thus, whether we employ the level of expected inflation or the change in expected inflation as an independent variable, we find it has a negative and statistically significant effect on the sacrifice ratio. This tells us that a disinflation that successfully brings down the expected rate of inflation that prevails in an economy is one that has lower costs in terms of output losses.[5]

We also consider whether the change in inflation expectations might carry the influence of **CBI** to the sacrifice ratio in a similar manner as initial inflation. That is, does **RelΔExpInf** serve as both a moderating variable (as shown by the interaction term in Model 4) and a mediating variable? Following the process described above, **RelΔExpInf** is indeed a mediating variable. The total effect (coefficient) of **CBI** on the **SAC** is 1.390 as shown in Model 3 of Table with 10 percent of the effect (0.1309) being a statistically significant indirect effect carried by **RelΔExpInf**. Therefore, the change in expected inflation is a mediating variable, whereas we reported earlier that the level of expected inflation was not. This indicates that central banks are changing the output costs of disinflation through their impact on inflation expectations. In other words, part of the effect on output of reducing the trend inflation rate comes about through changing the expected rate of inflation.

Results for tests for individual or unique effects

To this point, our regressions have considered initial inflation and the relative change in inflation expectations separately and the initial level of expected inflation and the relative change in inflation expectations separately. Tables 6 and 7 provide results when the models include both variables. The results provided in Table 6 show that **Peak** is statistically significant across all models and **RelΔExpInf** is statistically significant in Models 1 and 3, and that the total effect of **RelΔExpInf** is statistically significant in Models 2 and 4. We conclude, therefore, that **Peak** and **RelΔExpInf** have unique effects on the sacrifice ratio.

Table 6. Sacrifice ratio regressions with peak and relative change in expected inflation

	Model 1	**Model 2**	**Model 3**	**Model 4**
Openness	−0.021*** (0.006)	−0.018** (0.007)	−0.021*** (0.006)	−0.021*** (0.006)
Length	0.558*** (0.100)	0.599*** (0.102)	0.562*** (0.101)	0.561*** (0.101)
RInfLoss	−0.610 (0.628)	−0.716 (0.652)	−0.638 (0.638)	−0.655 (0.643)

Peak	−0.082*** (0.024)	−0.085*** (0.025)	−0.077*** (0.025)	−0.077*** (0.026)
RelΔExpInf	−0.051*** (0.016)	0.036* (0.020)	−0.049*** (0.017)	−0.067 (0.056)
Length × RelΔExpInf		−0.029*** (0.007)		
CBI			0.514 (0.570)	0.447 (0.687)
CBI × RelΔExpInf				0.036 (0.124)
Constant	0.909 (0.547)	0.796 (0.581)	0.617 (0.531)	0.681 (0.638)
Total effect of RelΔExpInf		−0.092*** (0.014)		−0.050*** (0.015)
Observations	69	69	69	69
R^2	0.416	0.427	0.418	0.418
Adj. R^2	0.369	0.372	0.362	0.352

Table 7 repeats this exercise, substituting the level of expected inflation, **ExpInf**, for **Peak**. Similar to the results in Table 6, **ExpInf** is statistically significant across all models, **RelΔExpInf** is statistically significant in Models 1 through 3, and the total effect of **RelΔExpInf** is statistically significant in Models 2 and 4. Again we conclude that **ExpInf** and **RelΔExpInf** have unique effects on the sacrifice ratio.

Table 7. Sacrifice ratio regressions with expected inflation and relative change in expected inflation

	Model 1	**Model 2**	**Model 3**	**Model 4**
Openness	−0.019*** (0.006)	−0.014** (0.006)	−0.019*** (0.006)	−0.019*** (0.006)
Length	0.542*** (0.104)	0.588*** (0.105)	0.551*** (0.105)	0.552*** (0.105)
RInfLoss	−0.291 (0.571)	−0.407 (0.585)	−0.378 (0.584)	−0.369 (0.583)
ExpInf	−0.076** (0.027)	−0.082*** (0.028)	−0.069** (0.028)	−0.068** (0.030)
RelΔExpInf	−0.046** (0.017)	0.050*** (0.016)	−0.043** (0.018)	−0.030 (0.066)
Length × RelΔExpInf		−0.032*** (0.006)		
CBI			0.843 (0.583)	0.890 (0.730)
CBI × RelΔExpInf				−0.027 (0.138)
Constant	0.454 (0.489)	0.336 (0.520)	0.0362 (0.488)	−0.006 (0.598)
Total effect of RelΔExpInf		−0.091*** (0.012)		−0.042** (0.018)
Observations	69	69	69	69
R^2	0.395	0.409	0.402	0.402
Adj. R^2	0.347	0.352	0.345	0.334

CONCLUSION

Contemplation of alternative theoretical rationales for a relationship between expected inflation and the sacrifice ratio yields an uncertain net prediction. On the one hand, consideration of nominal wage and price rigidities as the standard motivation for the observation of positive sacrifice ratios leads to a predicted negative relationship between expected inflation and the sacrifice ratio. On the other hand, taking into account the influence of channels emanating from the macroeconomic policy process suggests that a positive relationship between expected inflation and the sacrifice ratio is likely, although some scope for ambiguity is present.

Our generally consistent empirical finding of the existence of a negative relationship between the level of (and changes in) expected inflation and the sacrifice ratio has two important implications. The most obvious of these is that the direct channel linking expected inflation and the sacrifice ratio that operates through the mechanism of wage and price stickiness appears to be more important. The finding of a net negative relationship does not rule out positive effects emanating from the policy channels that theory also indicates should be present. This finding does, however, suggest that these latter policy-based effects are of secondary empirical magnitude.

The second implication of our results derives from the immediately preceding point. As we noted in our discussion in subsection 2.1 of the direct channel linking expected inflation and the sacrifice ratio, traditional theories of wage and price stickiness can generate output losses from disinflations that forward-looking New Keynesian theories typically cannot without reference to imperfect policy credibility. As discussed in subsection 2.2, however, a prediction of a negative relationship between expected inflation and the sacrifice ratio is difficult to glean from a theory that relies on imperfect policy credibility as a basis for output losses to arise from disinflations. Thus, our general finding of a negative relationship in the data calls into question New Keynesian motivations for positive sacrifice ratios that hinge on imperfect policy credibility. More work may be required to render forward-looking New Keynesian models appropriate for analyzing issues relating to output losses generated by disinflations.

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Footnotes

1 Countries include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. The complete data set is available from the authors upon request.

2 We are not aware of alternative measures of inflation expectations that have the comprehensive time and country coverage that the empirical exercise in this paper requires. When such data become available, future research should examine whether our main findings are consistent with these data.

3 The results for peak inflation in Ball ([4]) are not statistically significant. He concludes that this is a result of the collinearity between initial inflation and the inflation loss. Because of the way in which we measure inflation loss, the two variables are not correlated, as shown in Table 2.

4 We also considered whether Peak and ExpInf might be mediators for the length of disinflation. Neither variable passed all four of the tests described above nor had a statistically significant indirect effect. We conclude that the two variables have only moderating effects on Length.

5 Due to the nature and number of data points, the influence of outliers may be an issue. As a robustness test, we estimate a robust regression estimated at the median value. There is no significant difference in sign or significance.

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