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What determines the sacrifice ratio? A quantile regression approach

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Abstract

This paper investigates the determinants of the sacrifice ratio in the OECD economies using a quantile regression framework. We show that the relationship is characterised by asymmetries that standard approaches are unable to capture.

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1. Introduction

Disinflationary episodes are generally accompanied by contractions in output, often measured in terms of the sacrifice ratio – calculated as the sum of output losses over the disinflation (Ball, 1994). Indeed, Ball argues that disinflations may even be the major cause of recessions in developed economies. Given this perception, research on the determinants of the sacrifice ratio has flourished over the last two decades.

Rather than calculating the sacrifice ratio by estimating a Phillips curve we follow most of the literature and focus on reduced forms and on disinflationary episodes. As Ball (1994) points out, estimating Phillips curves constrains the output-inflation trade-off to be the same during episodes of increasing as those of decreasing inflation.

The empirical literature on the sacrifice ratio generally uses OLS to analyse its determinants. Doing so embodies the underlying assumption that the estimated coefficients are evaluated when the level of the sacrifice ratio is at the mean of the distribution conditional on its explanatory variables. This paper takes the current literature one step further by considering the asymmetry of the responses of the sacrifice ratio across quantiles. OECD evidence on sacrifice ratios using annual data typically range from -1.6 to 22 and there is no reason to believe that the response of the sacrifice ratio at the mean should be the same as the response at the tails of the distribution. It is therefore worth exploring whether the behaviour of the sacrifice ratio to the covariates differs at different points of its distribution.

In this paper we use a quantile regression approach and focus on the same determinants of the sacrifice ratio as in Gonçalves and Carvalho (2009). The starting point is the following equation

$$SR_i = \alpha + \beta\pi_{0,i} + \gamma\frac{1}{d_i} + \delta b_i + \theta Transp_i + \epsilon_i \tag{1}$$

Where π_0, d, b and $Transp$ are initial inflation, number of quarters under disinflation (so $1/d$ denotes speed), the average central government debt to GDP during the disinflationary episode and a monetary policy transparency index, respectively. The choice of variables is motivated by Ball (1994) with the initial level of inflation expected to have a negative influence on the grounds that a higher level of inflation leads to a reduction in the degree of nominal rigidities, following Ball et al. (1988).

For all four variables we find significant asymmetries that are not captured by OLS.[1]

2. The sacrifice ratio and quantile regression

The methodology follows Ball (1994), with disinflations being identified as periods when trend inflation falls by more than two percentage points from peak to trough. A peak (trough) occurs during the quarter in which trend inflation is higher (lower) than in both the previous and the following four quarters. To determine the output losses from disinflation, we assume that output is equal to its potential level both at the start of the disinflation and also four quarters after the end of the disinflation, with trend output assumed to grow log-linearly. The output costs arising from the disinflation are then measured by summing the log-deviations of output from its trend over the disinflation, while the sacrifice ratio (SR) is measured as the output cost divided by the change in inflation brought about by the disinflation.

Much of the empirical evidence on the sacrifice ratio has relied on OLS and the major results to date are that both the speed of the disinflationary process and the rate of inflation at the beginning of the disinflation have a negative effect on the sacrifice ratio. The first factor is consistent with the argument put forward by Sargent (1981) that a 'cold turkey' approach yields a credibility despite the potential benefits from 'gradualism' in the presence of Fischer or Taylor contracts. At the same

[1] We also considered the effect of inflation targeting on the sacrifice ratio. However, we found its role to be insignificant across all quantiles, consistent with the findings in Brito (2010) and in Mazumder (2012). The results are available from the authors on request.

time, a high starting rate of inflation is likely to lead to a lower degree of nominal rigidities and therefore a lower sacrifice ratio (Ball et al., 1988). To this set of variables – originally considered by Ball (1994) – both Gonçalves and Carvalho (2009) and Brito (2010) included a role for the debt-GDP ratio and an index on central bank transparency computed by Stasavage (2003). The rationale for including debt as a determinant of the sacrifice ratio can be attributed to the potential lack of credibility of the disinflation, while transparency is strongly correlated with the degree of central bank independence, which is generally negatively related to the sacrifice ratio. There are several reasons why transparency and central bank independence are likely to result in a higher sacrifice ratio. Beyond issues of credibility, a more independent central bank is likely to engage in a less opportunistic approach and to react more aggressively to inflation regardless of the circumstances and independent central banks are likely to deliver lower inflation rates so that greater nominal rigidities will prevail.

A study similar to ours is that of Mazumder (2012), who analyses the main determinants of the sacrifice ratio for both OECD and non-OECD economies over the period 1969 to 2009. He finds that for the former – the countries of interest in the present study – the most important variable driving the sacrifice ratio is the speed of disinflation, whereas all the other variables considered, such as the degree of nominal rigidities, the starting level of inflation and openness are not significant across model specifications. Interestingly, the behaviour of non-OECD economies is altogher different since in these countries speed is unimportant and the debt-GDP ratio has a negative effect on the sacrifice ratio. Like the majority of previous research in this area, the results in Mazumder (2012) were obtained via OLS and did not take into account asymmetries of the kind considered in this paper.

The quantile regression technique is used to investigate the relationship between the sacrifice ratio and the independent variables at different points of the distribution of sacrifice ratio. It is useful to compare the quantile regression with the ordinary least square (OLS) technique. Let us first consider a linear model $y_t = x_t'\beta + \varepsilon_t$. Using OLS regression, the parameters of interest

$\hat{\beta}$ measure the responsiveness of y_t to x_t when y_t is located at the mean. In contrast, the quantile regression (QR) technique, first proposed by Koenker and Bassett (1978), estimates the *conditional quantile* of y_t based on x_t, allowing one to learn about $\hat{\beta}$ at different quantiles on the distribution of y_t.

QR estimators have several desirable properties. First, they are more efficient than conventional OLS estimators when errors are not distributed normally; secondly, unlike OLS estimators, QR estimators are more robust to outliers in the data; and thirdly, because a QR estimate can be used to measure sensitivity of the dependent variable — in our case, the sacrifice ratio — to changes in the covariates at different points on the distribution, the method permits us to learn more about how the sacrifice ratio is affected by the explanatory variables when the slope of the Phillips curve is assumed to vary.

In this paper, the following model is fitted to the data:

$$q_\tau(SR_i|\Omega) = \alpha_\tau + \beta_\tau \pi_{0,i} + \gamma_\tau \frac{1}{d_i} + \delta_\tau b_i + \theta_\tau Transp_i \tag{2}$$

where $q_\tau(\bullet)$ is the conditional quantile function evaluated at the τ^{th} quantile; Ω is the information set; $\tau \in (0, 1)$; and $\alpha_\tau \beta_\tau, \gamma_\tau, \delta_\tau$ and θ_τ are the parameters to be estimated at the τ^{th} quantile.

For a fixed value of τ, the parameters $\alpha_\tau \beta_\tau, \gamma_\tau, \delta_\tau$ and θ_τ are estimated via the following minimisation:

$$\min_{\alpha_\tau \beta_\tau, \gamma_\tau, \delta_\tau, \theta_\tau} \sum_{i=1}^{N} \rho_\tau \left(SR_i - \alpha_\tau - \beta_\tau \pi_{0,i} - \gamma_\tau \frac{1}{d_i} - \delta_\tau b_i - \theta_\tau Transp_i \right)$$

where $\rho_\tau(z)$ is the check function given by $\rho_\tau(z) = z(\tau - 1_{[Z \leq 0]})$. The indicator function $1_{[z \leq 0]}$ takes only two values: 1 if $z \leq 0$ and 0 otherwise. Moreover, the check function $\rho_\tau(z)$ imposes different weights on positive and negative residuals. It is worth noting that when $\tau = 0.5$, this is the median estimator.

3. Empirical Evidence

We use the dataset considered in Gonçalves and Carvalho (2009) and Brito (2010). It consists of annual data for all the thirty OECD economies covering the period 1980-2006, with trend inflation is defined as a centred, nine quarter moving average of consumer price inflation.[2]

Quantile	α	β	γ	δ	θ
0.1	1.23	-0.11	-32.18	0.01	0.79
	(-0.37,3.18)	(-0.16, -0.05)	(-84.59, -9.88)	(-0.02, 0.03)	(0.21, 2.61)
0.2	5.80	-0.29	-37.94	0.02	0.43
	(-0.57, 7.83)	(-0.36, 0.03)	(-73.91, -16.29)	(-0.03, 0.04)	(0.06, 1.81)
0.3	7.06	-0.34	-41.92	0.02	0.44
	(2.05, 7.49)	(-0.35, -0.05)	(-63.64, -31.54)	(-0.03, 0.04)	(0.34, 1.39)
0.4	7.61	-0.34	-42.70	0.01	0.55
	(2.81, 8.61)	(-0.38, -0.17)	(-58.05, -28.84)	(-0.03, 0.06)	(0.19, 0.88)
0.5	8.09	-0.40	-49.1	0.02	0.83
	(3.35, 11.23)	(-0.59, -0.16)	(-58.71, 4.35)	(-0.02, 0.09)	(0.43, 1.10)
0.6	8.69	-0.51	-37.85	0.04	0.83
	(3.63, 14.39)	(-0.79, -0.25)	(-62.76, 21.73)	(-0.03, 0.14)	(0.10, 1.29)
0.7	8.48	-0.63	-2.09	0.07	0.69
	(3.19, 18.84)	(-0.86, -0.15)	(-63.57, 21.48)	(-0.00, 0.15)	(-2.34, 1.22)
0.8	11.87	-0.7	10.16	0.11	-0.55
	(6.62, 25.74)	(-0.94, -0.26)	(-81.86, 24.90)	(0.03, 0.13)	(-2.73, 1.06)
0.9	19.06	-0.68	-3.22	0.08	-1.63
	(9.83, 25.56)	(-0.97, -0.52)	(-31.21, 47.96)	(0.06, 0.18)	(-5.95, 0.87)

Note: 90% confidence intervals in parentheses

Table I: Quantile regression results.

Table I reports the results from estimating equation (2), revealing evidence of asymmetric behaviour in the sacrifice ratio. To understand whether there is statistically significant evidence of asymmetric evidence across quantiles it is best to focus on the figures below showing the estimated coefficients. If the lower bound of the 90% confidence interval at the bottom quantiles – the shaded area in the figures – differs from the upper bound of the confidence interval at the top quantiles we then have evidence of asymmetric behaviour.

[2] We therefore exclude those countries that joined the OECD in 2010.

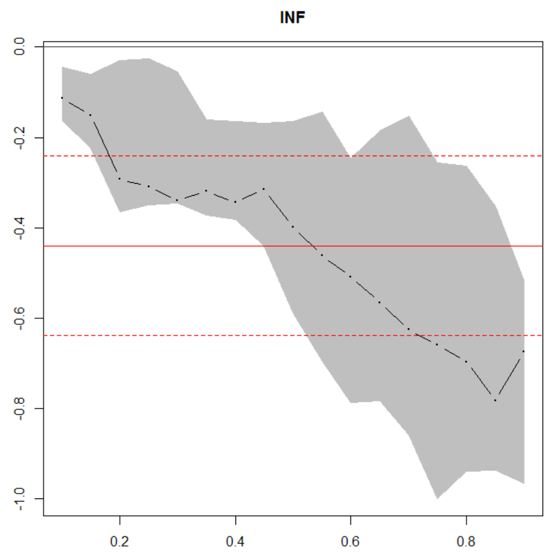

Figure 1: Coefficient on the initial rate of inflation.
Note: The shaded area denotes the 90% confidence interval; the horizontal straight line represents the OLS estimate, with its 90% confidence interval shown by the dashed lines.

Figure 1 shows that, consistent with previous results, the coefficient on initial inflation is negative throughout the distribution of the sacrifice ratio. However, it shows a pronounced increasing effect as the sacrifice ratio becomes larger. In other words, the starting rate of inflation matters the most when the sacrifice ratio is high so that it has an important reducing effect. The rationale is as follows: a high sacrifice ratio can be interpreted as periods or economies where there are large and pervasive nominal rigidities. In these cases, following Ball et al. (1988), a higher rate of inflation will result in fewer nominal rigidities, thereby reducing the sacrifice ratio. By contrast, when the sacrifice ratio is low, as there are fewer nominal rigidities the effect of the initial inflation will be attenuated.

The results for the coefficient on the speed of the disinflation can be found in Figure 2. The previous literature on sacrifice ratios has consistently found speed to reduce the sacrifice ratio and our results do not find evidence of asymmetric behaviour across quantiles, as the shaded areas overlap. However, the coefficient on speed is only significant for low to moderate values of the sacrifice ratio. The confidence interval for the parameter estimated at the 10th and 40th quantiles does not include zero. This can also be seen from the shaded area, located below zero from the

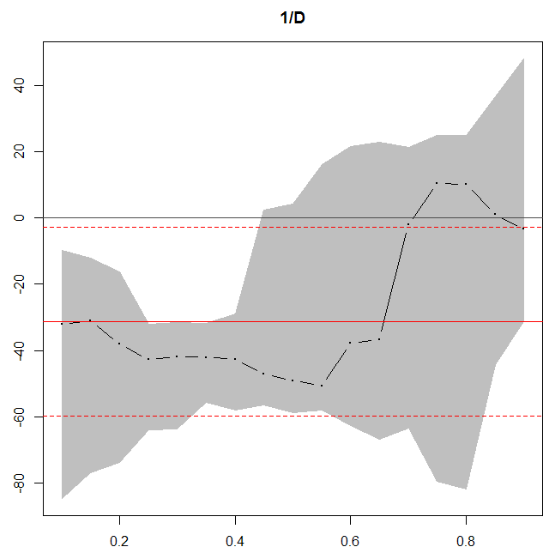

Figure 2: Coefficient on the speed of disinflation.

10th to the 40th quantiles, in Figure 2. As mentioned above, there are two opposing mechanisms that determine how speed affects the sacrifice ratio. First, if credibility is important, a 'cold turkey' approach suggests that the speed of disinflation should reduce the sacrifice ratio. However, in the presence of Fischer or Taylor contracts a gradualist approach may be preferable. The figure indicates that when the sacrifice ratio is low the first channel dominates but that when the sacrifice ratio is high – so that there are many nominal rigidities – speed no longer reduces the sacrifice ratio.

In the case of the debt-GDP ratio, Figure 2 shows as expected the coefficient is positive throughout but only significant when the sacrifice ratio is high, a result that could not be inferred when standard OLS is applied – indeed, this is what Mazumder (2012) finds using annual data. This result is intuitive: if credibility is an important factor in disinflations, this should be most relevant when the sacrifice ratio is high; when it is low there should be few doubts about the policy. To the extent that high debt may represent a challenge for credibility, it should be most relevant for situations when the sacrifice ratio is high. This is indeed what our results indicate.

Lastly, the results of transparency on the sacrifice ratio can be found in Figure 4. Whilst

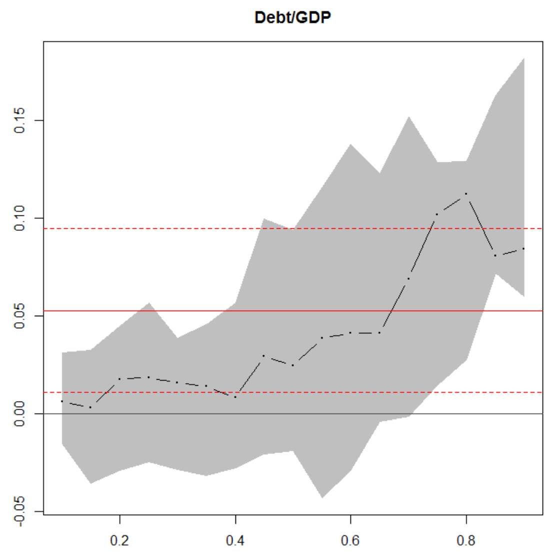

Figure 3: Coefficient on the debt-GDP ratio.

Gonçalves and Carvalho (2009) found transparency to be insignificant our results indicate that this is the case only when the sacrifice ratio is high.[3] For low to moderate levels of the sacrifice ratio the effects are positive and significant. It is worth noting that although Chortareas et al. (2002) found transparency to have a negative impact on the sacrifice ratio this was only the case when the latter was computed using unemployment; in terms of output losses their results also indicated that the coefficient on transparency is insignificant. Our results therefore expand on the existing literature by highlighting the fact that the lack of a clear relationship between transparency and the sacrifice ratio occurs when the latter is near the top of its distribution. To understand these results one has to bear in mind that transparency and central bank independence are highly correlated; the move towards a greater number of independent central banks in recent decades has moved hand in hand with greater transparency (Crowe and Meade, 2008). There are two ways in which the degree of central bank independence-transparency should affect the sacrifice ratio: via private sector expectations of monetary policy actions and by the way it actually implements policy. Our results suggest that when the sacrifice ratio is high central bank institutional structure has no effect on the sacrifice ratio so that more independent central banks do not only behave similarly to those

[3] As with speed, our results do not find the coefficient on transparency to be asymmetric across quantiles.

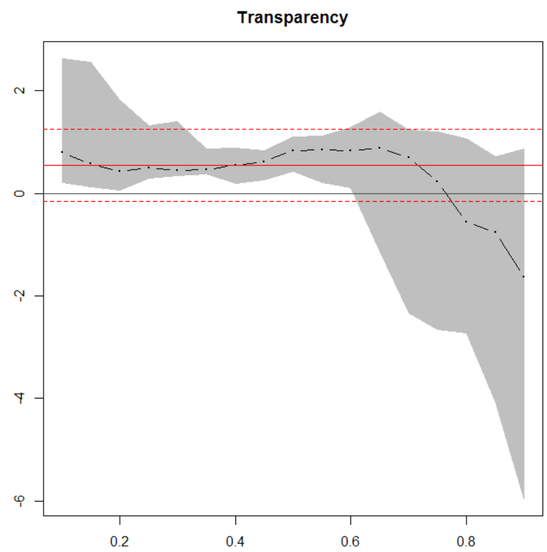

Figure 4: Coefficient on transparency.

that are less independent, but that such a similarity is expected. By contrast, when the sacrifice ratio is low, greater transparency increases the output costs of disinflation. It is well known that the degree of central bank independence is positively correlated with the sacrifice ratio (Fischer, 1996), but in our sample this only occurs when the sacrifice ratio is low to moderate. In such circumstances, as suggested above this is indicative of a greater – in terms of the sacrifice ratio, excessive – aggressive reaction towards inflation under more independent central banks.

4. Conclusion

We try to explain the variation in a sample of sacrifice ratios during disinflations using a quantile regression framework. We find strong evidence of asymmetric responses of the sacrifice ratio across its distribution. The starting rate of inflation always reduces the sacrifice ratio but its effect is much more important when the sacrifice ratio is at the right tail of its distribution. The speed of disinflation, often regarded as an important determinant of the sacrifice ratio, is insignificant for moderate to high levels of the sacrifice ratio, whereas the debt-GDP ratio has a positive effect on the sacrifice ratio, but only when the latter is at the right tail of its distribution.

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