EXCHANGE-RATE PASS THROUGH, OPENNESS, INFLATION, AND THE SACRIFICE RATIO

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March 13, 2008

Abstract

Considerable recent work has reached mixed conclusions about whether and how globalization affects the inflation-output trade-off and realized inflation rates. In this paper, we utilize cross-country data to provide evidence of interacting effects between a greater extent of exchange-rate pass through and openness to international trade as factors that we find both contribute to lower inflation. The interplay between the inflation effects of pass through and openness suggest that both factors may influence the terms of the output-inflation trade-off. We develop a simple theoretical model showing how both pass through and openness can interact to influence the sacrifice ratio, and we empirically explore the nature of the interplay between the two variables as factors influencing the sacrifice ratio. Our results indicate that a greater extent of pass through depresses the sacrifice ratio and that once the extent of pass through is taken into account alongside other factors that affect the sacrifice ratio, the degree of openness to international trade exerts an empirically ambiguous effect on the sacrifice ratio.

Keywords: Pass Through, Openness, Sacrifice Ratio

JEL Codes: F40, F41, F43

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1. Introduction

Does globalization affect inflation? Romer (1993) found a negative relationship between the degree of openness to international trade and inflation. This sparked a number of theoretical and empirical studies on how openness affects the inflation-output tradeoff and how this relationship is conditioned upon possible interactions of openness and other key aspects of the aggregate economy. Romer suggested that increased trade openness enhances negative terms-of-trade effects resulting from domestic output expansions, thereby reducing the incentive for a central bank to engage in inflationary policymaking, and Lane (1997) proposed that greater trade openness reduces the potential output gains from unexpected inflation in non-traded-goods sectors characterized by imperfect competition and sticky product prices. Furthermore, Karras (1999) argued that greater indexation of nominal wages to unexpected inflation in response to increased trade openness could also reduce the incentive for central banks to inflate.

The explanations provided by Romer, Lane, and Karras imply that the effects of openness on the inflation realizations operate by worsening the terms of the output-inflation trade-off faced by central banks. Temple (2002), however, showed that there is little cross-country evidence that increased trade openness reduces the sacrifice ratio. Daniels, Nourzad, and VanHoose (2005) provided evidence that once the inflation-reducing impact of greater central bank independence is taken into account, there is evidence in cross-country data that increased trade openness actually increases the sacrifice ratio, a result consistent with Rogoff's (2006) suggestion that increased globalization tends to make the Phillips curve shallower. This result, Daniels and VanHoose (2006) argued, is consistent with a view that greater trade openness exposes

imperfectly competitive firms to greater competition, thereby reducing their pricing power and effectively reducing the observed responsiveness of output to changes in the inflation rate.

Nevertheless, Daniels and VanHoose point out that the ultimate effects of increased trade openness on the sacrifice ratio hinge on a number of structural factors likely to vary across countries. Indeed, Neiss (2001) suggests that the effect of openness on inflation becomes more muted, indeed, empirically insignificant, once markups are taken into account. In addition, Bowdler (Forthcoming) finds that the relationship between openness and the sacrifice ratio depends on the exchange-rate regime that is in place, and Cavelaars (2006) suggests that the nature of this relationship likely is influenced by trade costs. Ball (2007) argues that for the United States there is in fact no clear evidence that globalization impinges on the process by which inflation is determined.[1]

This paper investigates the role that the extent of exchange-rate pass through, has in influencing the relationship among trade openness, the output-inflation trade-off, and inflation. Using cross-country data, we show that pass through and openness have interacting effects on the inflation rate. This result suggests that pass through and openness may impinge on inflation realizations by altering the terms of the output-inflation trade-off, which we show is the case in the context of a simple theoretical open-economy model. We then test our theoretical model's predictions about the interplay among pass through, openness, and inflation using cross-country data. We find that there is in fact evidence that the degree of pass through directly influences the sacrifice ratio and impinges on the impact of increased openness on the sacrifice ratio. Specifically, a greater extent of pass through reduces the sacrifice ratio and reduces the effect of openness on the sacrifice ratio. Indeed, our estimates indicate that after taking into account the extent of pass through, the empirical effect of greater openness on the sacrifice ratio becomes ambiguous.

The next section provides cross-country empirical evidence of interactions among pass through, openness, and inflation. In light of the fact that the equilibrium inflation rate produced by the actions of central banks depends on the underlying nature of the output-inflation relationship, this interplay among pass through, openness, and inflation suggests interdependent influences of pass through and openness on the sensitivity of output to inflation. Section 3 provides a theoretical explanation for the existence of such interdependence among the impacts of pass through and openness on the output-inflation relationship as measured by the sacrifice ratio. Section 4 utilizes cross-country data on pass through, openness, and other variables relevant to the determination of sacrifice ratios and provides empirical support for predictions forthcoming from our theoretical model. Section 5 summarizes our conclusions.

2. An Empirical Interplay among Pass Through, Openness, and Inflation

Recent studies, such as work by Taylor (2000) and Gagnon and Ihrig (2002) indicate that a significant correlation exists between the degree of exchange-rate pass through and mean inflation and inflation variability. Taylor argues that changes in individual expectations regarding price-setting behavior has led to lower inflation and lower price margins, and, as a consequence, reduced pass through. Gagnon and Ihrig maintain that a greater emphasis on inflation stabilization has led to both lower mean inflation and reduced pass through.

Campa and Goldberg (2005) and Marazzi *et al.* (2005) highlight the microeconomic determinants of pass through. Campa and Goldberg estimate short-run and long-run rates of exchange-rate pass through for a panel of 23 countries. Based on these cross-country panel estimates, they argue that macroeconomic variables such as money growth, inflation, and real GDP play only a minor role in determining the extent of pass through. Campa and Goldberg point instead to shifts in the composition of

imports, specifically from energy to manufacturing as a major contributor to the decline in pass through. Marazzi *et al.* show that, in addition to the change in the composition of imports, the ever-increasing presence of China in U.S. markets may have reduced pass through. They suggest that markets that have experienced the greatest reductions in pass through are those in which China has recorded an increased market share. Marazzi *et al.* further claim that Asian exporters have shown an increased sensitively to exchange rate changes since the 1997 financial crises and that this change corresponds to a decline in U.S. pass through around the same time.

At a macroeconomic level, Flamini (2007) and Adolfson (2007) focus on the design of optimal monetary policy and show that the effectiveness of monetary policy can be conditioned upon the degree of exchange-rate pass through. According to Falmini, pass through is important to monetary policy if the central bank is targeting CPI inflation, and lower pass-though worsens the inflation-output trade off in direct relation to how strictly the central bank targets CPI inflation. Adolfson argues that with incomplete pass-through, an implicit response to pass through via CPI inflation targeting is preferred to monetary policy that incorporates an explicit exchange rate target. Hence, accounting for the degree of pass through can improve monetary policy and thereby reduce mean inflation.

Our objective here is not to add to the debate on the microeconomic or macroeconomic determinants of exchange-rate pass through, or the optimal design of monetary policy in light of partial pass through, rather we are interested in the impact of key variables on the sacrifice ratio and their potential interaction. To explore the potential interplay among exchange-rate pass through and openness as factors influencing inflation outcomes, we examine annual observations for seventeen OECD countries covering the period 1979 through 1999 on consumer price inflation and trade openness as measured by imports as a ratio of GDP. Observations for both variables are from the International Monetary Fund's *International Financial Statistics*. We

augment this data with Campa and Goldberg's (2002, Table 1, page 11) estimates of average long-run exchange-rate pass through to import prices. We also include a measure of central bank independence (CBI). This CBI measure is originally from Franzese (2002) and is a weighted average of legal independence, a characterization of independence based on answers to a survey completed by individual at central banks (Cukierman, 1992), economic independence, political independence (Grilli, *et al.*, 1991), and Bade and Parkin's (1982) index of central bank independence. The pass through and CBI measures are time invariant and vary only across the cross sections. Table 1 contains descriptive statistics and lists the countries in the sample data.[2]

Table 2 reports estimation results for inflation, again based on the annual sample of 17 countries covering the 1979-1999 interval. All regressions are estimated using OLS with panel-corrected standard errors.[3] Model 1 of Table 2 reports the results for the model that includes CBI, openness, pass through, a trend, and a constant, while Models 2 and 3 add interaction terms of openness and CBI, and openness and pass through, respectively.[4] For Model 1 CBI, openness, and pass through have negative and statistically significant effects on inflation. The results for Model 1 show that those countries in the sample with higher CBI and higher pass through generally had lower levels of inflation during the sample period. In addition, greater openness is associated with lower levels of inflation.

Nevertheless, Model 1 may overlook a potential interplay between openness, the degree of pass through, and CBI. Consequently, Model 2 includes the interaction of CBI with openness. In this model, openness and CBI are no longer significant, while their interaction is significant, typically an indication that the interaction term is not important to the model. Model 3, therefore, drops the interaction of CBI and openness and adds the interaction of pass through and openness. In this model, CBI, openness, and pass through all have negative and statistically significant estimated effects on

inflation, and the interaction of pass through and openness is positive and statistically significant (p-value of 1.3%).

These results provide some preliminary evidence that there is indeed an interaction between openness and exchange-rate pass through as factors affecting inflation. Of course, the policy actions of central banks are central to determination of the inflation rate, and central banks' policies in turn are conditioned on the terms of domestic inflation-output trade-offs that they face. Hence, the fact that inflation outcomes depend on both openness and exchange-rate pass through suggests that pass through may be a key aspect of the aggregate economy that conditions the effect of openness on the inflation-output tradeoff. To better understand the impact of openness, exchange-rate pass though, and their interaction on the inflation-output trade off, we formally model their interdependence in the next section. The implications of this model will then be empirically tested in the following section.

3. A Model of Interdependence among Pass Through, Openness, and the Sacrifice Ratio

In equilibrium, a nation's inflation rate is determined by two key factors: the preferences of its monetary authority in terms of relative weights on output versus inflation and the country's output-inflation relationship faced by the monetary authority. To examine the effects of pass through on a nation's output-inflation relationship, we adapt the model developed in Daniels and VanHoose (2006) to allow for variations in the extent of pass through. In the model, there are numerous atomistic sectors, indexed *i*. These sectors are distributed uniformly along a unit interval. Each sector contains large numbers of workers and firms, the latter of which produce an identical good, which is differentiated from the goods produced in other sectors. Following Ball (1988) and Duca and VanHoose (2000), we assume an identical price elasticity of demand across sectors for the sake of simplicity and tractability.

A portion, Ω, of firms have workforces that contractually set nominal wages in advance of labor-market clearing. In the remaining fraction, 1-Ω, of firms, spot labor markets determine nominal wages. As shown by Duca and VanHoose (2001) in a closed-economy version of this basic framework with risk-neutral firms and workers facing common aggregate shocks and heterogeneously distributed firm-specific disturbances, Ω typically lies between zero and unity. Its equilibrium value depends on the variability of firm-specific disturbances increases relative to the volatility of aggregate shocks. To focus on the interplay between pass through and openness as factors jointly influencing the output-inflation relationship, we abstract from considerations of disturbances that influence the share of firms with nominal wage contracts by assuming that Ω is an exogenous parameter.

In our model, we abstract from productivity or other shocks that would not influence trend inflation in the standard Barro-Gordon (1983) discretionary-policy framework. The output produced by a given firm in sector i is

$$y_i = \alpha l_i , \tag{1}$$

where y_i is the log of output and l_i is the log of employment at a firm in sector i. The demand for the output of a firm in sector i as a share of aggregate domestic output is

$$y_i - y = -\varepsilon(p_i - p), \tag{2}$$

where $y \equiv \int_0^1 y_i di$ is the log of aggregate domestic output; $p \equiv \int_0^1 p_i di$ is the log of the aggregate domestic price level; and ε >1 is the price elasticity of demand.

Domestic income is determined by the quantity equation,

$$y = m - p, \tag{3}$$

where m is the log of the money stock and where the log of velocity has been normalized at a value of zero. The domestic nation's income-expenditure equilibrium condition (for a derivation of this Cobb-Douglas approximation, see, for instance, Canzoneri and Henderson, 1991, or Bryson, *et. al*., 1993) is given by

$$y = \eta(p^M + s - p) + (1 - \beta)y + \beta^* y^*; \tag{4}$$

where η is the elasticity of desired spending with respect to the real exchange rate; the β and β^*, which are fractions, are home and foreign propensities to import; p^M is the log of the aggregate level of prices charged by foreign producers and invoiced in foreign prices; s is the log of the domestic currency price of foreign currency; and y^* is the log of aggregate foreign output.

We model exchange-rate pass through along the lines of Adolfson (2007). We assume that the aggregate level of prices charged by foreign producers, measured in foreign currency units, p^M, may deviate from the level of prices that would prevail with full pass through, which is the foreign price level denoted p^*. If the extent of pass through is incomplete, however, producers respond to exchange-rate changes that lead to deviations between the foreign price and the price of the domestic good in foreign currency units and, therefore, p^M deviates from p^*. Let $1 - \gamma$ denote the extent to which foreign producers adjust the price, in foreign currency units, that they charge in response to these deviations from the price of the domestic good due to changes in the nominal exchange rate, so that

$$p^M = p^* + (1 - \gamma)(p - s). \tag{5}$$

Thus, under full pass through, $\gamma = 1$, and the foreign price is equal to p^*.

If we were to specify analogous structural relationships for a foreign nation, the result would be a two-country framework in which y^* and p^* would be treated as fully

endogenous variables. In order to concentrate on a basic open-economy setting with the potential for incomplete pass through, we assume that foreign output and the foreign price level are exogenous and equal to a normalized level of unity, so that y^* and p^* equal zero.

Using (1) in the profit function, $P_iY_i - W_iL_i$, yields the labor demand function for a firm i (with the intercept suppressed because it plays no role in our subsequent analysis):

$$l_i^d = \frac{-\varepsilon(w_i - p) + \eta\gamma(s - p) + (1 - \beta)(m - p)}{\alpha + \varepsilon - \alpha\varepsilon}, \tag{6}$$

where w_i is the log of the nominal wage for the firm.

Workers can consume both domestically produced output and foreign-produced goods. Consequently, labor supply to firms depends on the real wage computed in terms of the overall price workers pay for a basket of both domestic and foreign goods, where the consumer price index is $(1 - \beta)p + \beta(p^M + s)$ and $\lambda > 0$ is the labor supply elasticity:

$$l_i^s = \lambda\left[w_i - (1 - \beta\gamma)p - \beta\gamma s\right]. \tag{7}$$

For firms with or without nominal wage contracts, the full-information, market-clearing wage satisfies (5) and (6) simultaneously and equals

$$\hat{w}_i = \frac{[\lambda(\alpha + \varepsilon - \alpha\varepsilon)\beta + \eta]\gamma(s - p) + (1 - \beta)(m - p)}{[\lambda(\alpha + \varepsilon - \alpha\varepsilon) + \varepsilon]}. \tag{8}$$

Hence, this nominal wage rate, which is the wage actually paid in sector i if it is among the share, $1-\Omega$, of sectors without nominal wage contracts, depends positively on the extent of pass through. Substitution of (8) into either (6) or (7) and the result into (1) yields output of a noncontract firm with market-clearing (mc) wages:

$$y_i^{mc} = \alpha\lambda\left(\frac{(\eta - \beta\varepsilon)\gamma(s - p) + (1 - \beta)(m - p)}{[\lambda(\alpha + \varepsilon - \alpha\varepsilon) + \varepsilon]}\right). \tag{9}$$

Thus, output of firms in sectors without wage contracts responds ambiguously to increased pass through. This ambiguity can be understood by considering the direct and indirect effects of pass through. The direct effect of pass though occurs via an increase in consumer price inflation as a consequence of higher prices of imported goods. The indirect effect of pass though takes place via a change in the real exchange, which affects domestic output by altering relative prices. In equation (9), greater pass through increases the magnitude of γ, thereby raising the demand for domestic output and hence non-contracting firms' demand for labor. Hence, the indirect effect of pass through is a positive dependence of output on the magnitude of γ operating through the η coefficient in the first term of the numerator of the ratio within parentheses in (9). At the same time, however, an increase in the extent of the direct effect of pass through boosts the level of prices of foreign goods, which raises the consumer price index, induces a decline in labor supply, and thereby tends to reduce employment and output in sectors with market-clearing wages. Thus, direct pass through results in a contrasting negative dependence on the magnitude of γ operating through the $\beta\varepsilon$ coefficient in the first term of the numerator of the ratio within parentheses in (9). On net, therefore, the impact of greater pass through on output of non-contracting firms is indeterminate.

For atomistic wage setters within the fraction, Ω, of firms in sectors with nominal wage contracts, the contract wage is equal to the expected value of the market clearing wage, $w_i^c = \hat{w}_i^e$. Hence, from (6) and (1), the output of a firm with wage contracts is

$$y_i^c = \frac{-\alpha\varepsilon(\hat{w}_i^e - p) + \eta\gamma(s - p) + \alpha(1 - \beta)(m - p)}{(\alpha + \varepsilon - \alpha\varepsilon)}. \tag{10}$$

Because wages are fixed in this sector, pass through affects output only through the indirect channel, so output at firms with wage contracts unambiguously responds positively to an increased extent of pass through. Because greater pass through raises the level of foreign prices relative to domestic prices and pushes up the demand for domestic output, the demand for labor by domestic firms increases in response to a greater extent of pass through. With nominal wages set by contracts, the result is a rise in domestic employment and hence domestic output.

Firms behave identically, so that $y_i^c = y^c$ for all $i \in [0, \Omega]$, $y_i^{mc} = y^{mc}$ for all $i \in (\Omega, 1]$. It follows that $y = \Omega y^c + (1-\Omega) y^{mc}$. Substituting from (8) and (9) and differentiating with respect to the domestic price level yields

$$\frac{\partial y}{\partial p} = \frac{\Omega\left\{\alpha\left[\varepsilon - (1-\beta)\right] - \alpha\eta\gamma\right\}}{\alpha + \varepsilon - \alpha\varepsilon} + \frac{(1-\Omega)\lambda\alpha\left[(\beta\varepsilon - \eta)\gamma - (1-\beta)\right]}{\lambda(\alpha + \varepsilon - \alpha\varepsilon) + \varepsilon}. \tag{11}$$

Hence, computed solely with respect to an increase the domestic price level, the domestic sacrifice ratio is positive for a sufficiently large value of ε —that is, if the degree of competition is sufficiently high. Differentiating (11) with respect to β yields $\frac{\partial(\partial y/\partial p)}{\partial \beta} = \frac{\Omega\alpha}{\alpha + \varepsilon - \alpha\varepsilon} + \frac{(1-\Omega)\alpha\lambda(\varepsilon\gamma + 1)}{\lambda(\alpha + \varepsilon - \alpha\varepsilon) + \varepsilon} > 0$. Thus, as in Daniels and VanHoose (2006), one central prediction forthcoming from this model is that an increase in the extent to which the nation's economy is open to international trade boosts the sacrifice ratio.

Differentiating (11) with respect to γ yields $\frac{\partial(\partial y/\partial p)}{\partial \gamma} = \alpha\left(\frac{(1-\Omega)\lambda(\alpha + \varepsilon - \alpha\varepsilon)\beta\varepsilon - \left[\lambda(\alpha + \varepsilon - \alpha\varepsilon) + \Omega\varepsilon\right]\eta}{\alpha + \varepsilon - \alpha\varepsilon}\right)$, the sign of which is indeterminate. Note that in this expression, if $\Omega = 1$, so that all sectors of the economy utilize nominal wage contracts, $\frac{\partial(\partial y/\partial p)}{\partial \gamma} < 0$ follows unambiguously. In this special case, greater pass through pushes up the level of prices of foreign goods relative to

domestic goods, which makes the demand for domestic output less sensitive to variations in the domestic price level. Thus, a larger extent of pass through reduces the sacrifice ratio in an all-contracting economy. In the more general case in which $0 < \Omega < 1$, however, the previously discussed conflicting effects of increased pass through on outputs of firms in non-contracting sectors influences the overall responsiveness of domestic output to an increase in the level of domestic prices. As a consequence, in an economy made up of both sectors with nominal wage contracts and sectors with market-clearing wages, the theoretically predicted effect of increased pass through on the sacrifice ratio is ambiguous. Only empirical analysis could determine whether the net effect is positive or negative.

In addition, $\dfrac{\partial\left(\dfrac{\partial(\partial y/\partial p)}{\partial\beta}\right)}{\partial\gamma} = \dfrac{(1-\Omega)\alpha\lambda\varepsilon}{\lambda(\alpha+\varepsilon-\alpha\varepsilon)+\varepsilon} > 0$. A greater extent of pass through further stimulates inflation-induced production in sectors with nominal wage contracts, so more pass through enhances the positive effect of a greater degree of openness on this measure of the sacrifice ratio.

Sacrifice ratios examined by Ball (1994) and other authors, however, are normally computed using CPI inflation rates, which incorporate effects of exchange-rate variations as well as changes in the domestic price level. Thus, sacrifice ratios also typically reflect variations in exchange rates as well. From (9) and (10), differentiating aggregate output with respect to the exchange rate yields

$$\frac{\partial y}{\partial s} = \frac{\Omega\alpha\eta\gamma}{\alpha+\varepsilon-\alpha\varepsilon} - \frac{(1-\Omega)\lambda\alpha(\beta\varepsilon-\eta)\gamma}{\lambda(\alpha+\varepsilon-\alpha\varepsilon)+\varepsilon}. \tag{12}$$

This expression is ambiguous in sign and, therefore, in regard to pass through, although it is more likely to be negative for a sufficiently large value of ε, which is the opposite of the positive effect of a higher domestic price level under this same condition on ε. This

is so because under this condition the predominant effect of domestic currency depreciation is to reduce the real wage rate and hence reduce labor supply and output. Note that the effect of greater openness on the output impact of the exchange rate is given by $\frac{\partial(\partial y/\partial s)}{\partial \beta} = -\frac{(1-\Omega)\alpha\lambda\varepsilon\gamma}{\lambda(\alpha+\varepsilon-\alpha\varepsilon)+\varepsilon} < 0$. Hence, increased openness has a negative effect on the sacrifice ratio via this exchange-rate channel, and this negative impact of openness is enlarged with greater pass-through (a higher value of γ).

Could the negative effect of greater openness generated through the domestic currency depreciation channel more than offset the positive openness effect operating through an increase in the domestic price level? Potentially, the answer is yes. If exchange-rate overshooting is commonplace, then a rise in the exchange rate could exceed an increase in the domestic price level. If the degree of overshooting is regularly sufficiently large, then the net effect of openness on the sacrifice ratio could be negative—*if* the degree of pass through is also sufficiently large. Of course, on net the overall effect of openness on the sacrifice ratio operating simultaneously through opposing domestic price-level and exchange-rate channels is ambiguous.

4. Empirical Evidence on Pass Through, Openness, and the Sacrifice Ratio

The empirical implications of the above theoretical model are as follows:

i) the effect of a greater degree of openness on the sacrifice ratio is theoretically ambiguous and can only be determined empirically;

ii) the effect of exchange-rate pass through on the sacrifice ratio is theoretically ambiguous and can only be determined empirically;

iii) if exchange-rate pass through is empirically significant, an increased extent of pass through has a positive effect on the impact of openness on the sacrifice ratio;

iv) the overall effect of greater openness on the sacrifice ratio depends on key structural characteristics of the economy, such as CBI and pass through, and when these

competing effects are considered simultaneously, the overall impact of openness is indeterminate.

We use the data set made available by Temple (2002) to test the impact of openness on the sacrifice ratio. We augment this data set with the same measures of CBI and pass though described in section 2 above.

We estimate four regression models that include as independent variables our measures of openness, CBI, and pass though, as well as the change in inflation (ΔInflation), the length of each deflationary period (Length), and the initial level of inflation (Inflation). The estimates of the sacrifice ratio (SAC) are originally from Ball (2004). The data cover 64 episodes of moderate inflation for the same seventeen countries as our inflation estimates, but over the time period from 1960 through 1990. Table 3 provides summary statistics on the data set.

Table 4 reports regression results for the sacrifice ratio estimates. Model 1 estimates a base model that includes all of the independent variables but not interaction terms. Based on Daniels *et al.* (2005), this model is tested for outliers using the DFITS, Cook's distance, and Welsch's distance tests. All three tests confirm Spain's deflationary episode of 1979-1989 as an outlier. An unreported dummy variable was used to control for this observation in all four of the models.

In the results for all models reported in Table 4, Length and CBI are positive and statically significant and ΔInflation is negative and significant. The level of inflation, Inflation, is significant only in Model 1. In Model 1, before allowing for any interactions, the estimated effect of Openness on the sacrifice ratio is not significant. The estimated effect of Pass Through is negative and significant, however, suggesting that greater pass through reduces the sacrifice ratio.

Model 2 includes the interaction of Openness and CBI. Daniels *et al*. argue and show empirically that once the interaction of CBI and Openness is taken into account, Openness and the sacrifice ratio should be positively related, and, additionally, there

should be a negative interaction between Openness and CBI. The results of Model 2 are consistent with their findings.

Model 3 drops the interaction between Openness and CBI and adds the interaction of Openness and Pass Through. Once this interaction is included, the effect of Openness on the sacrifice ratio becomes negative and statistically significant, and the interaction between Openness and Pass Through has a positive and significant effect. In Model 3, the total effect of Openness on the sacrifice ratio is the estimated coefficient on Openness plus the coefficient on the interaction term times the level of Pass Through. For example, evaluating the results of Model 3 at the mean value of Pass Through (from Table 3) yields $\partial SAC/\partial Openness = -0.0395 + 0.0005 \cdot 61.25 = -0.0089$. Although the estimated combined effect is negative, it is not statistically significantly different from zero.

Model 4 includes both interaction terms. The estimated effects of CBI, Pass Through, and both interaction terms on the sacrifice ratio are statistically significant in this model. The estimated effect of Openness on the sacrifice ratio is not, however.

In general, the regression results indicate that there is a negative relationship between pass through and the sacrifice ratio. Daniels and VanHoose (2006) argue that the effect of greater openness on the output-inflation trade off depends crucially on structural factors. The ambiguous estimated effects of Openness on the sacrifice ratio in our various regression models supports this claim by showing that the effect of openness is influenced by factors such as CBI and exchange-rate pass through.

4. Conclusion

Considerable recent work has reached mixed conclusions about whether and how globalization affects the inflation-output trade-off and realized inflation rates. Consistent with most studies of cross-country data, we have found evidence that greater openness and increased central bank independence reduce the mean inflation

rate, but we have also provided evidence that a greater extent of exchange-rate pass through depresses inflation. Furthermore, exchange-rate pass through influences the effect that greater openness has on the mean inflation rate, suggesting the potential for interacting effects of pass through and openness on domestic output-inflation trade-offs.

We have explored a simple theoretical model allowing for the degree of exchange-rate pass through and openness to exert simultaneous impacts on the output-inflation trade-off, and this model predicts that both pass through and openness should have interacting effects on the sacrifice ratio. Examination of the interplay among openness, pass through, central bank independence, and other factors influencing the sacrifice ratio in cross-country data verifies the empirical importance of the predicted interactions. On net, our results indicate that a greater extent of pass through depresses the sacrifice ratio. Furthermore, once the extent of pass through is taken into account alongside other factors that affect the sacrifice ratio, the degree of openness to international trade has a more ambiguous effect on the sacrifice ratio.

Thus, our results suggest that considerable work must be done to better understand whether and how greater openness influences the output-inflation trade-off. In light of the numerous structural factors that can impinge on the potential relationship between openness and the sacrifice ratio, it may be appropriate for future studies of this relationship to focus attention on evidence revealed from data on individual countries instead of cross-country data.

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Table 1

Descriptive Statistics for Panel Data Used to Test Inflation Results
Annual Panel of 17 Countries, 1979-1999[a]

Variable		Mean	St. Dev.	Min	Max	Obs.
Inflation	Overall	4.6768	4.0447	-0.7078	21.2765	357
	Between[b]		1.6871	1.9601	7.9949	17
	Within[c]		3.6977	-2.7456	18.8410	21
CBI	Overall	50.6862	19.5720	15.0495	93.1438	357
	Between		20.1461	15.0495	93.1438	17
	Within		0			21
Openness	Overall	31.6697	15.5028	6.8564	76.0997	357
	Between		15.6081	9.6766	67.2084	17
	Within		3.2262	21.3373	49.4832	21
LRP	Overall	60.3529	30.4477	6	113	357
	Between		31.3408	6	113	17
	Within		0			21

[a] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Sweden, Switzerland, United Kingdom, and United States.
[b] Provides the deviation between cross sections of the average for each individual cross section.
[c] Provides the deviation within a cross section from the average for that cross section, with the overall mean added back in. A zero value for the standard deviation indicates that the variable is time invariant within the cross section.

Table 2

Inflation Estimates

Annual Panel of 17 Countries, 1979-1999

(Panel-Corrected Standard Errors in Parentheses)

	Model 1	Model 2	Model 3
Constant	14.1649** 1.1445	12.9017** 1.1436	15.1059** 1.2154
Trend	-0.4486** 0.0487	-0.4481** 0.0487	-0.4464** 0.0488
CBI	-0.0408** 0.0105	-0.0171 0.0131	-0.0419** 0.0106
Openness	-0.0240** 0.0084	0.0186 0.0197	-0.0507** 0.0168
Pass Through	-0.0286** 0.0046	-0.0271** 0.0044	-0.0427** 0.0067
CBI x Openness		-0.0009* 0.0004	
Pass Through x Openness			0.0004* 0.0002
Observations	357	357	357
Number of Countries	17	17	17
R^2	0.5607	0.5620	0.5636
Wald X^2	129.86	130.98	168.26

+ Significant at 10% level, * significant at 5% level, ** significant at 1% level, for two-tailed test.

Table 3

Descriptive Statistics for Data Used to Test Sacrifice Ratio Results

Variable	Mean	St. Dev.	Min	Max	Obs.
SAC	0.7751	1.0432	-0.8558	3.9174	64
Inflation	8.4781	4.2109	1.27	18.4	64
ΔInflation	4.9220	3.1740	1.52	13.86	64
Length	2.9531	1.7406	1	10	64
Openness	29.9609	13.0382	9.3	58.8	64
CBI	0.4871	0.2014	0.1505	0.9314	64
Pass Through	61.25	30.1515	6	113	64

Table 4

Sacrifice Ratio Estimates[a]

(Robust Standard Errors in Parentheses)

	Model 1	Model 2	Model 3	Model 4
Constant	-0.5776 0.6886	-3.3632** 1.0536	0.5084 0.787	-2.2328+ 1.2619
Length	0.3318** 0.1099	0.3001** 0.1077	0.3365** 0.109	0.3069** 0.1068
Inflation	0.0796+ 0.0452	0.064 0.0405	0.068 0.0447	0.0564 0.0404
ΔInflation	-0.1575* 0.068	-0.1371* 0.0654	-0.1326+ 0.0695	-0.1195+ 0.068
Openness	-0.0079 0.0092	0.0912** 0.03	-0.0395* 0.0161	0.0566 0.0376
CBI	2.3030** 0.6389	7.5750** 1.7814	2.1425** 0.6169	6.9297** 1.9058
Pass Through	-0.0071+ 0.0042	-0.0033 0.0037	-0.0234** 0.0078	-0.0164* 0.008
CBI x Openness		-0.1957** 0.0628		-0.1764* 0.0665
Pass Through x Openness			0.0005* 0.0002	0.0004+ 0.0002
Observations R^2	64 0.4281	64 0.5036	64 0.4683	64 0.5278

+ Significant at 10% level, * significant at 5% level, ** significant at 1% level, for two-tailed test.

[a] All models control for Spain's deflation of 1977-1987 as an outlier.

FOOTNOTES

[1] Another branch of the literature exploring the relationship among globalization, output-inflation trade-offs, and inflation focuses on the impact of increased capital mobility. Recent examples of work in this area include Gruben and McLeod (2002, 2004), Razin and Yuen (2002), Loungani, Razin, and Yuen (2001), and Razin and Loungani (2005). The extent to which trade openness and capital mobility exert independent effects on the output-inflation trade-off and inflation has been examined in recent work by Badinger (2007) and Daniels and VanHoose (2007).

[2] Although we have only 21 years of data, we considered the unit root properties of the data. The unit-root tests include a constant, trend, and one lag of the dependent variable. Based on the Levin, Lin and Chu t-statistic for panel data, we were able to reject a common unit root process for inflation and trade openness. The remaining three variables are time invariant within the individual cross sections.

[3] Because CBI and pass through are constant values across time for each country, we cannot estimate a fixed-effects model.

[4] We also tested each model with year dummies included. The only noticeable change in our results was that the coefficient on openness in Model 2 became marginally significant (p-value of 8.7 percent).