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Abstract.

Considerable recent work has reached mixed conclusions about whether and how globalization affects the inflation-output trade-off and suggests that the ultimate effect of openness on the output-inflation relationship is influenced by a variety of factors. In this paper, we consider the impact of exchange-rate pass through and how pass through conditions the effect of openness on the sacrifice ratio. We develop a simple theoretical model showing how both the extent of pass through and openness can interact to influence the output-inflation relationship. Next we empirically explore the nature of these two variables and their interaction. Results indicate that greater pass through increases the sacrifice ratio, that there is significant interaction among pass through and openness, and—once the extent of pass through is taken into account alongside other factors that affect the sacrifice ratio, such as central bank independence—openness exerts an empirically ambiguous effect on the sacrifice ratio.

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

1. Introduction

Does globalization affect inflation? Romer (1993) found a negative cross-country relationship between inflation and the degree of openness to international trade. 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 suggests that greater openness to trade 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) proposes 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) argues 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, has suggested that there is little cross-country evidence that increased trade openness reduces the sacrifice ratio. Daniels, Nourzad, and VanHoose (2005) propose 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) argue, is consistent with a view that greater trade openness exposes imperfectly competitive

firms to greater competition, thereby reducing their pricing power and effectively increasing the observed responsiveness of output to changes in the inflation rate. Recently, Badinger (2009) has obtained results consistent with this prediction in an analysis of data from 91 countries over the 1985-2004 interval.

Nevertheless, Daniels and VanHoose also 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. Along this same line, 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 (2009) finds that the relationship between openness and the sacrifice ratio depends on the exchange-rate regime that is in place, and Cavelaars (2009) suggests that the nature of this relationship likely is influenced by trade costs. Ball (2006) 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]

A number of recent studies examine the varying degree of exchange-rate pass through among economies and changes in pass-through estimates over time. Taylor (2000), for example, 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 (2004) maintain that a greater emphasis on inflation stabilization has led to both lower mean inflation and a reduced extent of pass through. Based on cross-country panel estimates, Campa and Goldberg (2005) examine the main theoretical arguments explaining cross-country differences and changes over time in exchange-rate pass through. They argue that inflation performance, nominal exchange-rate volatility, and other macroeconomic factors play an important but limited role in influencing cross-country differences in pass through. Campa and Goldberg find that changes in the composition of trade—specifically, a shift to a greater share of manufactures in a country's import bundle—correlates with a

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lower extent of pass through. Marazzi *et al.* (2005) show that, in addition to the change in the composition of imports, the growing importance of Chinese trade may have reduced the extent of U.S. pass through. They suggest that markets experiencing the greatest reductions in the extent of pass through are those in which China has recorded an increased market share. At a macroeconomic level, Flamini (2007) and Adolfson (2007) focuses on the design of optimal monetary policy and shows that the effectiveness of monetary policy can be conditioned upon the degree of exchange-rate pass through. 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 the extent of exchange-rate pass through or regarding the optimal design of monetary policy in light of partial pass through. Instead, this paper investigates the effect of exchange-rate pass through on the sacrifice ratio and the role that the extent of exchange-rate pass through has in influencing the relationship between the degree of openness to international trade and the output-inflation trade-off. We begin by developing a simple theoretical model showing how both the extent of pass through and the degree of openness can affect the sacrifice ratio and how these two factors can also interact to influence the sacrifice ratio. The model illustrates how both factors work through competing channels, which renders their overall impacts on the sacrifice ratio theoretically ambiguous. The model also predicts that a greater extent of pass through either enhances a positive impact or reduces a negative effect of greater openness on the sacrifice ratio. Finally, the model indicates that the overall impact of greater openness on the sacrifice ratio is likely to be indeterminate when considering the competing effects of key characteristics of the economy, including in particular the extent of exchange-rate pass through.

Using cross-country data spanning 20 countries for the period 1975 through 2004, we find that there is in fact evidence that the degree of pass through directly

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influences the sacrifice ratio and impinges on the impact of increased openness on the sacrifice ratio. Specifically, a greater extent of pass through contributes to a higher sacrifice ratio and reduces the negative effect of greater openness on the sacrifice ratio. Additional estimates taking into account the extent of central bank independence indicate that the net effect of greater openness on the sacrifice ratio is ambiguous.

The following section provides a theoretical explanation for interdependence of the effects of a greater extent of pass through and an increased degree of openness on the output-inflation relationship as measured by the sacrifice ratio. Section 3 utilizes cross-country data on the extent of pass through, the degree of openness, and other variables relevant to the determination of sacrifice ratios to evaluate the empirical predictions forthcoming from our theoretical model. Section 4 summarizes our conclusions.

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

The literature on discretionary policymaking suggests that a nation's equilibrium inflation rate depends crucially on 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 a greater extent of pass through on a nation's output-inflation relationship, we consider an adaptation of the model developed in Daniels and VanHoose (2006). 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

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wages in advance of labor-market clearing. In the remaining fraction, 1-Ω, of firms, spot labor markets determine nominal wages.

In our 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 index of prices charged by domestic firms; and $\varepsilon >1$ 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 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; 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 incorporate the extent of exchange-rate pass through into the model 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 an index of the prices charged by foreign firms invoiced in terms of the foreign currency, 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. In this latter situation, 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^*, consistent with producer-currency pricing. With no pass through, $\gamma = 0$, consistent with local-currency pricing.

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 index are exogenous and equal to a normalized level of unity, so that y^* and p^* equal zero.

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

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

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

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

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

Hence, this nominal wage rate, which is the wage actually paid in sector i if it is among the share, 1-Ω, 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:

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

Thus, output of firms in sectors without wage contracts responds ambiguously to an increased degree of pass through. This ambiguity can be understood by considering the direct and indirect effects of variations in the extent of pass through. The direct effect of a greater extent of pass through occurs via an increase in consumer price inflation as a consequence of higher prices of imported goods. The indirect effect of an enlarged

degree of pass through takes place via a change in the real exchange rate, which affects domestic output by altering relative prices. In equation (9), a greater extent of pass through increases the magnitude of γ and thereby raises the demand for domestic output and thus non-contracting firms' demand for labor. Hence, the indirect effect of an increased degree 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 imported 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, the direct effect results in a contrasting negative dependence on the magnitude of γ. This effect operates 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 a larger degree of 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, $w_i^c = \overset{\wedge e}{w_i}$. Hence, from (6) and (1), the output of a firm with wage contracts is

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

Because wages are fixed in this sector, pass through affects output only through the indirect, real-exchange-rate channel, through which output at firms with wage contracts unambiguously responds positively to an increased extent of pass through. The demand for output of domestic firms depends positively on the real exchange rate; that is, in logs, an increase in the differential between the exchange-rate-adjusted index of prices charged in domestic markets by foreign firms and the index of domestic firms'

prices pushes up the demand for domestic output. Consequently, a greater degree of pass through boosts the real exchange rate and raises the derived demand for labor by domestic firms. 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 index of domestic firms' prices yields

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

Under imperfect competition, there are no firm-level supply curves and no aggregate supply relationship. Consequently, the expression in (11) is the slope of the relationship between the aggregate output of profit-maximizing price-setting firms and the overall level of prices set by these firms. If markets are sufficiently non-competitive, it is feasible for this slope to be negative, because profit-maximizing firms with considerable monopoly power seek to restrain output substantially in order to boost prices. Hence, computed solely with respect to an increase in the index of domestic firms' prices, 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 prediction forthcoming from this model is that, with respect to the index of domestic firms' prices, an increase in the extent to which the nation's economy is open to international trade boosts the sacrifice ratio. This is so because greater openness renders desired expenditures on domestic output less sensitive to variations in aggregate domestic income, which makes each firm's profit-maximizing price less

responsive to a change in aggregate domestic output. As a consequence, in a more open economy, greater variations in output will be observed for given variations in the index of prices charged by domestic firms.

Differentiating (11) with respect to γ yields

$$\frac{\partial(\partial y/\partial p)}{\partial \gamma} = \alpha\left(\frac{(1-\Omega)\lambda(\alpha+\varepsilon-\alpha\varepsilon)\beta\varepsilon - [\lambda(\alpha+\varepsilon-\alpha\varepsilon)+\Omega\varepsilon]\eta}{\alpha+\varepsilon-\alpha\varepsilon}\right)$$, 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, a greater extent of pass through makes the index of prices charged in domestic markets by foreign firms less sensitive to variations in the real exchange rate brought about by changes in prices charged by domestic firms, which makes the demand for domestic output less sensitive to variations in the index of domestic firms' prices. Thus, a larger degree 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 index of domestic firms' 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 an increased degree of 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 market-clearing sectors. A rise in γ boosts the direct effect operating through the $\beta\varepsilon$ coefficient in the output expressions for output of market-clearing firms in (9) that was noted above, thus enhancing the

impact that greater openness has on prices charged by domestic firms and their effects on domestic output. Thus, an enlarged degree of pass through enhances the positive effect of a greater degree of openness the sacrifice ratio.

Sacrifice ratios examined by Ball (1994) and other authors typically are computed using CPI inflation rates, which incorporate effects of exchange-rate variations as well as changes in the index of prices of domestic firms. Thus, sacrifice ratios also typically reflect variations in real 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 but is more likely to be negative for a sufficiently large value of ε, 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 $\dfrac{\partial(\partial y/\partial s)}{\partial \beta} = -\dfrac{(1-\Omega)\alpha \lambda \varepsilon \gamma}{\lambda(\alpha + \varepsilon - \alpha \varepsilon) + \varepsilon} < 0.$ Consequently, in contrast to the

positive impact that a greater degree of trade openness has on the sacrifice ratio via the domestic price channel, increased openness has a negative effect on the sacrifice ratio via the real-exchange-rate channel, and this negative impact of openness is enlarged with a greater extent of pass-through (a higher value of γ).

Could the negative effect of greater openness generated through the domestic real-currency-depreciation channel more than offset the positive openness effect operating through an increase in the index of prices at domestic firms? Potentially, the answer is yes. If exchange-rate overshooting is commonplace, for example, then a rise in the nominal exchange rate could exceed an increase in the domestic price index. If the degree of overshooting is regularly sufficiently large, then the net effect of openness

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on the sacrifice ratio could be negative—*if* the degree of pass through is also sufficiently large.

To summarize, the impacts of both an increased degree of openness and a greater extent of exchange-rate pass through on the sacrifice ratio operate through opposing direct and indirect channels. The direct, domestic-price channel yields a positive impact on the sacrifice ratio, and the indirect, real-exchange-rate channel yields a negative sacrifice-ratio effect. Of course, on net the overall effects of an increased degree of openness and a greater extent of pass through operating via both channels simultaneously is ambiguous. Furthermore, the overall effect of greater trade openness is conditioned on interactions among the degree of openness and other key characteristics of the economy, in particular the extent of exchange-rate pass through. The theoretical importance of accounting for such interactions may help to explain why Daniels *et al.* (2005) and Bowdler (2009)—who fail to consider a role for the extent of pass through—reach opposing conclusions on the effects of a greater degree of openness on the sacrifice ratio. Thus, our empirical work that follows seeks to take into account interactions among all of these variables.

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

The key empirical implications of our theoretical model are as follows:

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

ii) the predicted impact of a greater extent of exchange-rate pass through on the sacrifice ratio is theoretically ambiguous and can only be determined empirically;

iii) if the effect of a greater extent of pass through is empirically significant, an increased extent of pass through enhances (reduces) a positive (negative) effect 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 the extent of exchange-rate pass through, and when these competing effects are considered simultaneously, the overall impact of openness is likely to be indeterminate.

We begin the empirical analysis with the estimates of the sacrifice ratio from Bowdler (2009). These estimates cover the period 1981 through 1998. We extend the data in both directions, estimating the sacrifice ratio from 1975 through 2004. These estimates are consistent with Bowdler (and hence the process of Ball 1994) and are likewise based on data from the International Monetary Fund's *International Financial Statistics*.[2] Trend inflation is measured as average inflation over eight quarters, centered on a given year, so that trend inflation for year *t* is the average over the last two quarters of year *t*-1 through the first two quarters of *t*+1. A disinflation period is defined as a period in which trend inflation declines by more than 1.5 percent from a peak to a trough. The initial level of inflation is measured at the peak and labeled **Inflation** in the following data tables. The change in inflation from the peak to the trough is labeled **ΔInflation**. The length of each disinflationary period (**Length**) is measured in years. The sacrifice ratio, **SAC**, is the ratio of the reduction trend output to

the associated change in trend inflation for a given disinflationary period. These calculations are made for 20 advanced economies resulting in 69 observations.

We augment this data with a measure of the degree of trade openness, **Openness**. We follow the literature by measuring the degree of openness as the average of the annual ratio of imports to GDP over the entire sample period. This measure is taken from the *World Development Indicators*. For the reasons spelled out by Daniels *et al.* (2005), we also include their measure of central bank independence, **CBI**, derived from Franzese (2002). A measure of the duration of wage contracts, **WDUR**, is taken from Temple (2002), whose original source is Bruno and Sachs (1985). Lastly, we include Campa and Goldberg's (2005) estimates of the extent of nominal exchange-rate pass through, **Pass Through**, elasticity spanning the period 1975 through 2003. We use this measure because, as Campa and Goldberg argue, their elasticity measure has a direct economic interpretation and is the most relevant measure of the impact of exchange rate changes on inflation performance. Specifically, their estimates reflect the impact of a one-percent fluctuation of the nominal exchange rate on import prices, which correspond to prices denoted p^M in the theoretical model presented in the previous section. Hence, a pass-through estimate of 0.62 (the mean value in our sample of countries) implies that a one percent depreciation of the domestic currency would result in a 0.62 percent increase in the import price index of the domestic country. The authors provide both short-run estimates (quarterly pass through) and long-run estimates (annual pass through). We use the latter, because it is consistent with our annual estimates of trend inflation and the sacrifice ratio. Note that the measures of the degree of openness, the level of central bank independence, wage duration, and the extent of pass through are all time invariant. All regression models are ordinary least squares with the various corrections and controls listed below. Descriptive statistics and the countries used in the data set are provided in Table 1.

Due to the number of observations and the nature of the data set, Daniels *et al.*, and Bowdler suggest testing for potential outliers. Therefore, we first test for outliers, running a regression with the sacrifice ratio as the dependent variable and Inflation, ΔInflation, Length, CBI, Openness, and a constant as regressors. We use the DFITS statistics as our criterion for the detection of outliers and, following Maddala (2001), control for the influence of outliers using bounded influence estimation. This approach weights potential outliers by creating a single variable in which all observations whose DFITS statistics is less than or equal to 0.34 are coded as one and all observations whose DFITS statistic is greater than 0.34 are coded with the value of 0.34 divided by the absolute value of their DFTIS statistic.

The Breusch-Pagen / Cook-Weisberg test is used to test for heteroskedasticity, and rejects the null hypothesis of constant variance. Hence, all of the subsequent regression models report robust standard errors. Furthermore, following Caporale and Caporale (2008), we also control for the clustering of error terms at the country level.

Regression Model 1 in Table 2 is a base model that includes standard determinants of the sacrifice ratio; Inflation, ΔInflation, Length, CBI, and Openness. As in Bowdler, the length of the disinflationary period remains a key determinant of the sacrifice ratio. There are, however, important differences. First, the coefficient estimate for CBI is, consistent with Daniels *et al.* (2005), positive and significant. Additionally, Bowdler reports "weak" evidence linking the change in inflation to the SAC, whereas our results are significant at the 1 percent level. More importantly, Bowdler also reports a weak negative correlation between openness and the SAC, whereas our results are significant at the 5 percent level. These differences are likely an outcome of the larger data set (a longer time horizon in both directions) that we employ. Recall that the results of the theoretical model imply that a negative effect of greater openness on the sacrifice ratio results if the indirect, longer-term effect operating through the real-exchange-rate channel predominates over the direct, shorter-term positive impact

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operating through the domestic-price channel. These results are suggestive of an interpretation that—in the context of the more recent data explored here and by Bowdler—the real-exchange-rate exchange rate channel has become empirically more important over time.

Although our main interest is how pass through might condition the impact of openness on the sacrifice ratio, Model 2 drops Openness and adds the Pass Through variable to the base model to consider a potential independent effect. In Model 2, the coefficient estimate for Pass Through is positive and statistically significant at the 6 percent level. Further, its inclusion has little impact on the sign and significance of the other model variables. This result suggests that countries with a greater degree of exchange-rate pass through tend to have a larger sacrifice ratio, consistent with the effects of variations in the extent of pass through operating primarily through the direct, domestic-price channel. Model 3 includes both Openness and Pass Through. The inclusion of both variables lowers the p-value of Openness to 1 percent and the p-value of Pass Through to 4.5 percent. The estimates of this model suggest that a one-standard-deviation increase in the Openness measure results in a 0.37 *decrease* in the SAC, whereas a one-standard-deviation increase in the Pass Through measure results in a 0.27 *increase* in the SAC. These individual effects of Openness and Pass Through on the SAC are illustrated in added-variable plots in Figures 1 and 2. Figure 1 plots the residuals of a regression of Openness (as the dependent variable) on all other model variables against the residuals of a regression of the SAC (as the dependent variable) on all other variables except Openness, thereby isolating the impact of Openness on the SAC. Figure 2 provides the corresponding plot for Pass Through.

Model 4 includes an interaction term between Pass Through and Openness. Our theory suggests that a greater extent of exchange-rate pass through enhances an output expansion generated by a higher price level in nominal-wage-contracting sectors, boosting the positive impact of a greater degree of openness on the sacrifice ratio via the

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direct channel.[3] Consistent with this theoretical prediction, the estimated coefficient on this interaction term is positive and statistically significant. Note that the estimated total marginal effect of Openness on the sacrifice ratio in Model 4 is the sum of the coefficient on Openness plus the coefficient on the Openness-Pass Through interaction term times a given value for Pass Through. Evaluated at the mean value for Pass Through, the total estimated marginal effect of Openness on the sacrifice ratio remains negative and statistically significant. Figure 3 illustrates the total marginal effect of Openness on the SAC, taking into account the interaction with Pass Through. Figure 3 also includes the point estimates for each individual country given in light of each nation's unique measure of Pass Through (plotted on the right-hand axis), along with a histogram of the Pass Through measures (plotted on the left-hand axis). For reference purposes, the individual marginal effect of Openness on the SAC is illustrated by the solid horizontal line.

Model 5 drops the interaction of Pass Through and Openness and controls for a potential interplay between CBI and Openness, as suggested by Daniels *et al*. Once this interaction is taken into account, the coefficient estimate for Openness is no longer statistically significant. This finding is consistent with the more recent results of Bowdler as well as the theoretical model presented here.[4] Models 3 and 4 suggest that the overall impact of openness on the sacrifice ratio depends on interacting structural parameters of the macroeconomy. Once the full scope of such interactions is taken into account, the impact of Openness on the sacrifice ratio becomes ambiguous.

Though not considered in the theoretical model, Model 6 drops the interaction of Pass Through and Openness and controls for a potential interaction between CBI and Pass Through. Daniels *et al.* (2005) suggest that greater CBI leads to greater nominal wage contracting and, therefore, a larger sacrifice ratio. Greater CBI and greater nominal wage contracting would also leave less scope for exchange-rate pass through to independently exert a positive influence on the sacrifice ratio. This conclusion suggests

a negative coefficient estimate for the CBI-Pass Through interaction term. The estimate of the interaction term is indeed negative and statistically significant, providing some empirical support for this argument.

In addition to the empirical models summarized in Table 2, we also examined the role of wage contracting by considering a model that includes the wage duration measure described above (WDUR) and interactions of that measure with the Pass Through measure. The coefficient on the wage duration variable in this revised model turns out to be positive but not statistically significant, and the coefficient on the interaction term is insignificant. The only impact of including the wage duration in the model is to reduce the level of significance for the Pass Through measure (the p-value for this revised model turns out to be slightly outside standard levels of significance for a two-tailed test). Including the wage duration measure (from Temple 2002), which exhibits little variation across the sample of countries and does not cover the full sample of countries (omitting Ireland, Norway, Portugal, and Spain), reduces the sample size to 55 observations. Hence, we do not take our results as indicating that there is no interaction with the extent of pass through or other key structural characteristics and the degree of wage contracting. Rather, we see further study of the importance of the degree of nominal wage rigidity as a conditioning factor to be a potentially important path for future research.

A model that omitted potential outliers was also considered by using a standard threshold for the DFITS statistic of 2 times the square root the number of independent variables (k) divided by the number of observations (n), $2 \cdot (k/n)$. Based on this threshold, we identify two outliers, Finland (1989-1996, also identified as an outlier by Bowdler), and Italy (1977-1978, which was not included in Bowdler's sample). For these two observations, Finland had an exceptionally large sacrifice ratio (10.529, which is more than two standard deviations greater than the mean), and Italy exhibited a very large drop in inflation of 13.57 percent over only a one-year disinflationary period. These

results are provided in Table 3 which indicates that standard measures of model fit were lower under this approach and that there were no noteworthy differences in the sign and significance of our variables of interest.

Finally, Bowdler suggests the impact of the degree of openness and its interaction with the level of central bank independence may have changed along with monetary-policy making after 1980. In light of this suggestion, we also introduced a single dummy variable to evaluate the effect of our inclusion of the earlier sample period, coding years 1975 through 1980 as one and all subsequent years as zero. The coefficient estimate for this variable was statistically insignificant, and its presence had no impact (other than to reduce the p-value on both Openness and Pass Through) on our general conclusions.

4. Conclusion

Considerable recent work has reached mixed conclusions about whether and how globalization affects the output-inflation relationship. In this paper, we have explored the implications of a simple theoretical model allowing for the variations in extent of exchange-rate pass through and the degree of trade openness to exert simultaneous impacts on the output-inflation trade-off. This model predicts that both factors should have interacting effects on the sacrifice ratio. Examination of the interaction among measures of the degree of openness, the extent of pass through, the level of 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 increases 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 tends to have an empirically indeterminate 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 relationship. In light of the numerous structural factors that can impinge on the potential relationship between the degree of openness and the sacrifice ratio, it may be appropriate for future studies of this relationship to focus attention on evidence revealed from time-series data from individual countries instead of cross-country data.

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Table 1

Descriptive Statistics for 20 Countries, 1975-2004[a]

Variable	Mean	St. Dev.	Min	Max	Obs.
SAC	1.417	1.836	-1.851	10.529	69
Inflation	9.986	5.964	1.271	27.586	69
ΔInflation	6.158	4.232	1.529	17.995	69
Length	4.464	1.960	1	11	69
Openness	31.308	14.088	10.08	65.61	69
CBI	0.453	0.196	0.150	0.931	69
WDUR	1.382	0.782	0	2	55
Pass Through	0.617	0.314	0.06	1.13	69

[a] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and United States.

Table 2
Sacrifice Ratio Estimates for 20 Countries, 1975-2004[a]
Bounded Influence Estimation
(Robust Standard Errors in Parentheses)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Length	0.6915***	0.6587***	0.6654***	0.6599***	0.6633***	0.6643***
	0.1008	0.0910	0.0964	0.1063	0.0971	0.0969
Inflation	0.0409	0.0381	0.0361	0.0267	0.0295	0.0305
	0.0343	0.0307	0.0346	0.0375	0.0349	0.0360
ΔInflation	-0.2233***	-0.2134***	-0.2150***	-0.2027**	-0.2074***	-0.2087***
	0.0663	0.0581	0.0636	0.0720	-0.0645	0.0651
CBI	1.4726**	1.4738**	1.4294**	1.3965**	3.6094**	2.8324***
	0.5732	0.5972	0.5196	0.5455	1.5627	0.6522
Openness	-0.0314**		-0.0266***	-0.0582***	0.0094	-0.0267**
	0.0125		0.0091	0.0119	0.0276	0.0094
Pass Through		1.1704*	0.8657**	-0.9089	0.9090**	1.7919***
		0.5961	0.4031	0.5604	0.4241	0.4510
PT·Openness				0.0538***		
				0.0164		
CBI·Openness					-0.0758	
					0.0548	
CBI·PT						-2.1474**
						0.8515
Constant	5.7812***	4.1804**	5.4072***	6.7422***	4.4495***	4.8563***
	1.6020	1.5421	1.4850	1.7476	1.4111	1.4206
Observations	69	69	69	69	69	69
R-squared	0.6768	0.6581	0.6965	0.7164	0.7004	0.7013
R-Bar	0.6455	0.6250	0.6617	0.6786	0.6605	0.6615
F	14.63	13.59	12.72	16.93	11.39	12.23

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

[a] All models control for clustering at the country level.

Table 3
Sacrifice Ratio Estimates for 20 Countries, 1975-2004[a]
Omitted Outliers Estimation
(Robust Standard Errors in Parentheses)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Length	0.6286***	0.6233***	0.6177***	0.6089***	0.6177***	0.6177***
	0.1228	0.1282	0.1223	0.1259	0.1240	0.1222
Inflation	0.0626	0.0659	0.0611	0.0548	0.0610	0.0572
	0.0510	0.0531	0.0519	0.0544	0.0538	0.0538
dInflation	-0.1948*	-0.1995*	-0.1921*	-0.1813	-0.1920*	-0.1878*
	0.1003	0.1016	0.1011	0.1059	0.1039	0.1025
CBI	1.0491*	1.0748*	1.0233*	0.9942*	1.0761	2.1175***
	0.5391	0.5257	0.4932	0.5273	1.4167	0.2943
Openness	-0.0205***		-0.1760***	-0.0322***	-0.0167	-0.0176***
	0.0059		0.005	0.0074	0.0242	0.0051
PassThrough		0.6988**	0.4849**	-0.3380	0.4859**	1.2070***
		0.3015	0.2299	0.4514	0.2301	0.3212
PT·Openness				0.0247**		
				-0.0099		
CBI·Openness					-1.1435	
					0.8151	
CBI·PT						-1.6749**
						-0.5894
Constant	-0.7854	-1.8568***	-1.1178*	-0.5502		-1.5738***
	0.6074	0.6118	0.6110	0.7768	-1.1436	0.4577
					0.8151	
Observations	67	67	67	67	67	67
R-squared	0.4698	0.4530	0.4797	0.4863	0.4797	0.4843
R-Bar	0.4254	0.4082	0.4180	0.4254	0.4709	0.4231
F	21.34	13.52	15.37	28.81	17.75	33.71

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

[a] All models control for clustering at the country level and omit Finland (1989-1996) and Italy (1977-1978) as outliers.

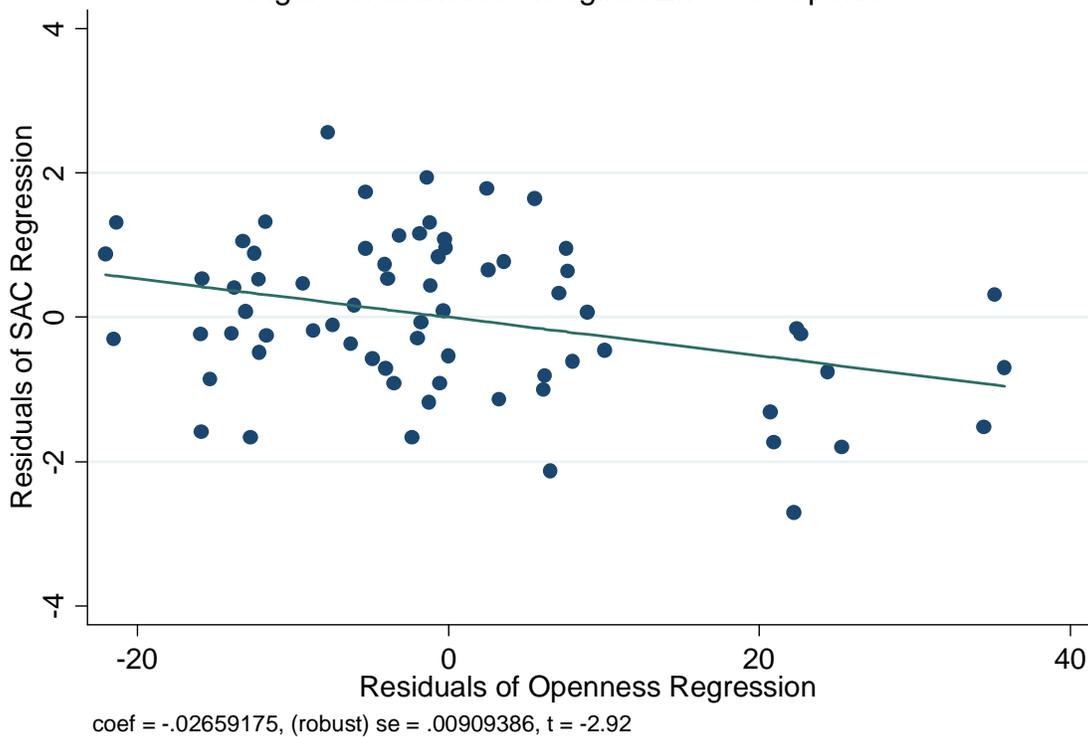Figure 1: Individual Marginal Effect of Openness

coef = -.02659175, (robust) se = .00909386, t = -2.92

Figure 2: Individual Marginal Effect of Pass Through

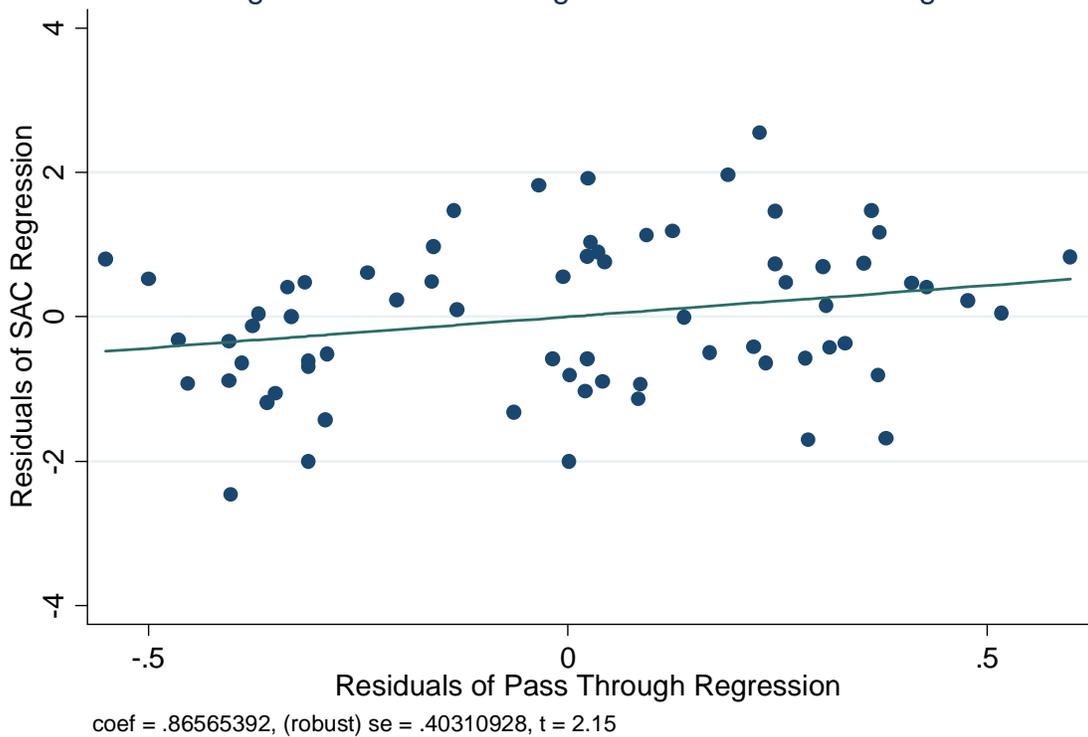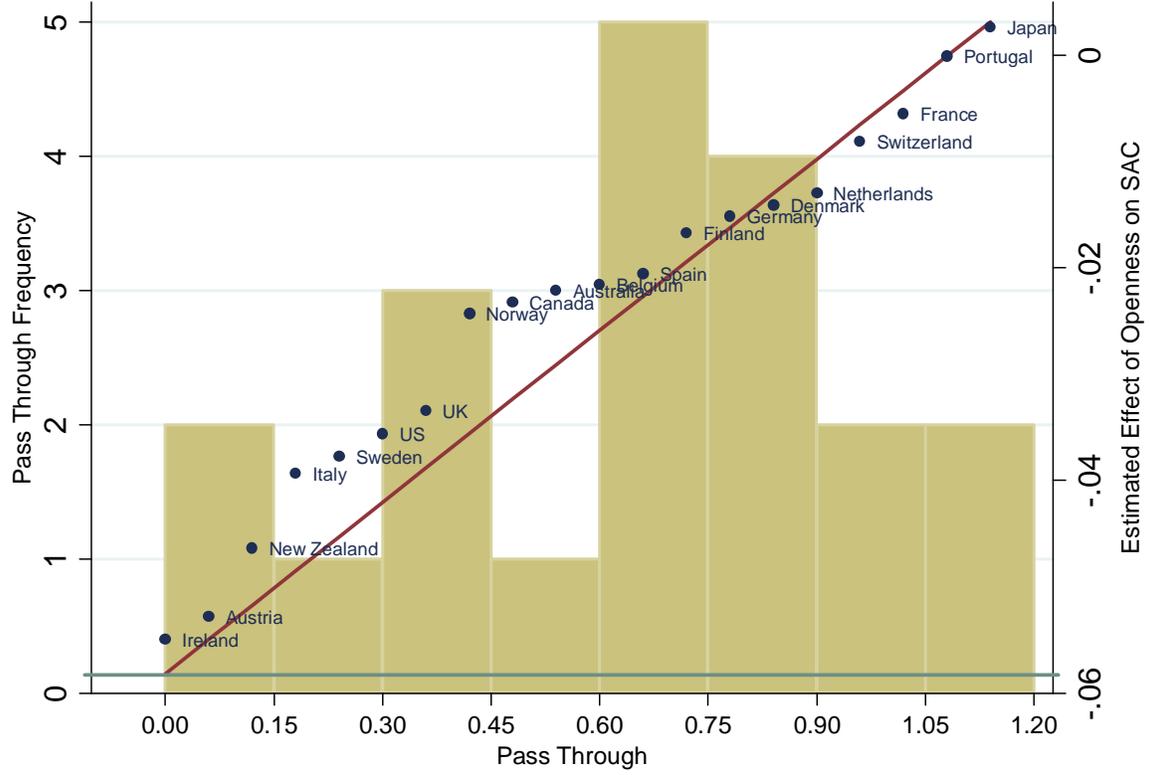coef = .86565392, (robust) se = .40310928, t = 2.15

Figure 3: Estimated Total Marginal Effect of Openness on SAC

FOOTNOTES

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[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 (Forthcoming) and Daniels and VanHoose (Forthcoming).

[2] Sacrifice ratio data is available from the authors upon request.

[3] In this model the total marginal effect of Pass Through is the sum of the coefficient on Pass Through plus the coefficient on the interaction term times a given level of Openness. At the mean value of openness and the mean value plus one standard deviation, the total marginal effect of pass through is positive and statistically significant. At the mean value for Openness minus one standard deviation, the total marginal effect of Pass Through is positive but not statistically significant. For countries with relatively low levels of Openness (slightly more than the mean minus one standard deviation), the total marginal effect of pass through on the sacrifice ratio turns negative.

[4] In this model, the total marginal effect of Openness on the sacrifice ratio is the sum of the coefficient on Openness plus the coefficient on the interaction term times a given value of CBI. Evaluated at the mean value for CBI and the mean value plus one standard deviation, the total impact of openness is negative and statistically significant. At the mean value for CBI minus one standard deviation, the total marginal effect of Openness is negative but not statistically significant.