9-1-2013

Exchange-rate Pass Through, Openness, and the Sacrifice Ratio

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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 examine how pass through conditions the effect of openness on the sacrifice ratio. We develop a simple theoretical model showing how the extent of both 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 statistically significant interaction between 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 fails to exert an empirically robust effect on 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 et al. (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 inconsistent with Rogoff's (2006) suggestion that increased globalization tends to make the Phillips curve steeper. 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. Badinger (2009) has obtained results consistent with this prediction in an analysis of data from 91 countries over the 1985–2004 interval. Recent work has added other elements that can impinge on the relationship between trade openness and the sacrifice ratio: political

regime (Caporale and Caporale, 2008), progressivity of income taxation (Daniels and VanHoose, 2009a), capital mobility (Daniels and VanHoose, 2009b), labor-market structures (Bowdler and Nunziata, 2010), reliance on imported commodities in production (Pickering and Valle, 2012).

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.[2] One contribution of this paper is to provide a new motivation for why the effects of greater openness on the sacrifice ratio might be theoretically ambiguous. Our explanation focuses on an interplay between the degree of openness and the extent of exchange-rate pass through within a direct price-level effect and an opposing indirect exchange-rate effect on the sacrifice ratio. In addition, the paper seeks to determine the net effects of this interplay by utilizing empirical measures of the degree of openness and the extent of pass through.

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 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) 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. 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 influences the sacrifice ratio and impinges on the impact of increased openness on the sacrifice ratio.

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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 not empirically robust. Lastly, we consider the role of wage contracting in the economy as a factor conditioning the impact of exchange-rate pass through on the sacrifice ratio. We find that the effect of pass through on the sacrifice ratio remains positive, is statistically significant, and increases with a greater extent of wage contracting as measured by union density.

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).

2.1. Theoretical model

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, $1 - \Omega$, of firms, spot labor markets determine nominal wages.

As a simplification, we restrict the analysis to wage stickiness as the only potential source of nominal rigidities in a portion of our model economy's sectors, rather than including as well a potential role for price stickiness. In reality, of course, as recently documented by Gwin and VanHoose (2012), there are real-world sectoral variations in the degrees of stickiness of *both* wages *and* prices, and in principle we could consider a more complicated model allowing for both sources of nominal rigidities. As we demonstrate below, however, allowing for nominal rigidities arising solely from wage stickiness is sufficient to generate several interrelationships among variables and to yield contrasting effects of these variables on a nation's sacrifice ratio. Including additionally a role for sticky prices undoubtedly would introduce additional channels through which openness and pass through might affect the sacrifice ratio, but at a substantial cost in terms of model complexity. Consequently, we eschew consideration of varying degrees of price flexibility across sectors, which might be a fruitful avenue of future research.

In our framework, the output produced by a given firm in sector *i* is

$$\gamma_i = \alpha \mathrm{I}_i,$$

(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

$$\gamma_i - \gamma = -\varepsilon(\rho_i - \rho),$$

(2)

where $\gamma \equiv \int_0^1 \gamma_i \mathrm{d}i$ is the log of aggregate domestic output; $\rho \equiv \int_0^1 \gamma \rho_i \mathrm{d}i$ 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,

$$\gamma = m - p$$

(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, see, for instance, Canzoneri and Henderson, 1991; or Bryson et al., 1993) is given by

$$\gamma = \eta(\rho\mathrm{M} + s - \rho) + (1 - \beta)\gamma + \beta^*\gamma^*$$

(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.

2.2. Incorporating micro-foundations of exchange-rate pass through

We incorporate the extent of exchange-rate pass through into the model along the lines of Campa and Goldberg (2005). We denote by p^M an index of prices charged by foreign producers in the import market (measured in foreign currency units), which equal a markup, mu^*, over the marginal costs of foreign producers, mc^*, such that:

$$\rho\mathrm{M} = mu^*(\gamma) + \gamma mc^*,$$

(5)

where γ is a parameter measuring the extent of pass through equal to unity under full pass through versus zero under zero pass

through. The markup is assumed to be a function of prices (expressed in foreign currency units) charged by competing domestic producers, $p - s$, and an index measure of fixed effects across the aggregate economy, ϕ:

$$mu * (\gamma) = \phi + (1 - \gamma)(p - s).$$

(6)

The marginal costs of foreign producers are equal to prices charged by foreign producers in the foreign market, $p*$. These prices depend on wages in the foreign market, $w*$, and on demand conditions in the foreign market, captured by foreign income, $y*$. Marginal costs of foreign producers, therefore, are expressed as

$$mc *= \varphi w * + \varphi y *.$$

(7)

Hence, prices charged by foreign producers in domestic import markets are

$$pM = \phi + (1-\gamma)(p-s) + \gamma(\varphi w^* + \varphi y^*)$$

(8)

With the index of fixed effects normalized to unity (so that the log of this index, ϕ, equals zero), and using $p*$ in equation (7), the index of prices charged by foreign producers in the domestic import market can be more conveniently expressed as

$$pM = (1 - \gamma)(p - s) + \gamma p^*.$$

(9)

This index of prices indicates that under domestic-currency pricing—that is, zero pass through—$\gamma = 0$, and $p^M = p - s$. Under producer-currency pricing or full pass through, $\gamma = 1$, and $p^M = p^*$. With incomplete pass through, $0 < \gamma < 1$. Along the lines of Campa and Goldberg, this price index allows pass through to depend on underlying structural elements such as industry structure and competition.

2.3. The determinants of exchange-rate pass through

As stated earlier, our objective is not to add to the debate on the determinants of exchange-rate pass through, and so in our model we treat *γ* as exogenous. Nonetheless, it is important to keep in mind the theoretical determinants of pass through when implementing our empirical analysis, which employs the elasticity estimates of Campa and Goldberg.

Beginning with industry characteristics, Dornbush (1987) uses an industrial-organization approach to model the potential impact of exchange rate changes on import prices. He argues that, given wage costs in both the exporting market and in the importing market, the degree of price adjustment depends on three different aspects: product substitutability between domestic output and foreign output, the degree of market integration with the world market, and market organization or the degree of competition. The elasticity of domestic prices to exchange rate movements increases with greater competition among firms in the importing market (relatively homogeneous products and a large number of domestic firms such that price taking behavior results) and with an increase in the number of foreign firms relative to the number of home firms. Recent empirical work by Bhattacharya et al. (2008) shows considerable variation in the degree of pass through across U.S. industries.

Numerous authors, including Campa and Goldberg (2005), argue that the composition of a nation's import basket may affect the degree of exchange-rate pass through. Specifically, the import basket of most advanced economies shifted away from a large share of energy and a small share of manufactures (less than 50 percent) to a smaller share of energy and larger share of manufactures (over 75 percent). This would influence pass through if there is greater competition among exporters in the manufactures sector as compared to the energy sector as the shift would heighten the elasticity of import demand. Bergin and Feenstra (2009) extend this analysis, showing that the change in the U.S. import basket from energy to manufactures further led to an increase in imports from China. They argue that the shift to imports from China, which pegs the domestic

currency to the U.S. dollar, made U.S. imports less sensitive to exchange rate movements.

At a more macro level, Taylor (2000) argues that changes in the inflation environment to lower average inflation reduced the pricing power of firms and thereby resulted in lower exchange-rate pass through. Devereux and Yetman (2010) extends this approach within a sticky-price model, concluding that pass through increases with average inflation but at a declining rate. There are a number of authors whose empirical results support the hypothesis that the inflation environment affects pass through, including Takhtamanova (2010), Gagnon and Ihrig (2004), and Shintani et al. (2012). Others [Adolfson (2007) and Engel (2008) for example] consider a potential feedback in that the degree of pass through affects the transmission of exchange rate movements into domestic prices and, therefore, may condition monetary policy and the resulting inflation level.

Recent empirical studies also indicate that other structural characteristics may condition pass through. Gust et al. (2010), on the one hand, claim that an increase in trade openness raises the responsiveness of exporters to competitors' prices and therefore reduces pass through. An and Wang (2011), on the other hand, argue that a higher import share *increases* pass through, along with higher inflation, monetary policy variability, smaller country size, and exchange-rate persistence.

As noted above, the purpose of this paper is not to weigh in on the empirical determinants of exchange-rate pass through. Instead, it is to understand if cross-country differences in pass through may affect the sacrifice ratio. Nonetheless, the literature described above raises possible collinearity and endogeneity issues that should be considered in our empirical work in Section 3.

2.4. Exchange-rate pass through and output

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. Thus, y^* and p^* equal zero, and β^* in equation (4) becomes irrelevant to the analysis.

Using anti-logged versions of equation (1), (2), (3), (4) and (5) in the profit function, $P_iY_i - W_iL_i$, substituting the normalizations $Y^* = 1$ ($y^* = 0$) and $P^* = 1$ ($p^* = 0$), and working out the first order condition for L_i yields the log-linear labor demand function for a firm i (with the intercept suppressed because it plays no role in our subsequent analysis):

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

(10)

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 $(1 - \beta)p + \beta(pM + s)$ and $\lambda > 0$ is the labor supply elasticity:

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

(11)

For firms with or without nominal wage contracts, the full-information, market-clearing wage satisfies (10) and (11) simultaneously and equals

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

(12)

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 (12) into either (10) or (11) and the result into (1) yields output of a noncontract firm with market-clearing (*mc*) wages:

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

(13)

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 (13), 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 (13). 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 (13). 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, $w_i^c = \hat{w}_i^e$. Hence, from (10) and (1), the output of a firm with wage contracts is

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

(14)

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.

2.5. The sacrifice ratio: comparative statics and ambiguous price versus exchange-rate effects

Most theoretical analyses focus on a nation's sacrifice ratio expressed in terms of a direct relationship between its output and price level. Sacrifice ratios examined empirically by Ball (1994) and other authors, however, 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. Our analysis, therefore, considers both the direct responsiveness of the nation's domestic output to a change in the domestic price level and the indirect output responsiveness to a change in the exchange rate. To highlight the different mechanisms of output responses to the price level versus the exchange rate, we compute the effects on output of changes in each of these variables separately. Firms behave identically, so that $y_i^c = y^c$ for all i ∈ $[0, \Omega\,]$ and $y_i^{mc} = y^{mc}$ for all i ∈ $(\Omega, 1]$. It follows that y $= \Omega y^c + (1 - \Omega)y^{mc}$. Substituting from (12) and (13) and differentiating with respect to the index of domestic firms' price level yields the following expression for the response of aggregate domestic output to a change in the domestic price level

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

(15)

Under imperfect competition, there are no firm-level supply curves and no aggregate supply relationship. Consequently, the expression in (15) 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 (15) with respect to β yields $\partial(\partial y/\partial p)/\partial\beta = (\Omega\alpha)/(\alpha + \varepsilon - \alpha\varepsilon) + [(1-\Omega)\alpha\lambda(\varepsilon\gamma + 1)]/[\lambda(\alpha + \varepsilon - \alpha\varepsilon) + \varepsilon] > 0$. 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 (15) with respect to γ yields $\partial(\partial y/\partial p)/\partial\gamma = \alpha(((1-\Omega)\lambda(\alpha + \varepsilon - \alpha\varepsilon)\beta\varepsilon - [\lambda(\alpha + \varepsilon - \alpha\varepsilon) + \Omega\varepsilon]\eta)/(\alpha + \varepsilon - \alpha\varepsilon))$, 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, $\partial(\partial y/\partial p)/\partial\gamma\partial(\partial y/\partial p)/\partial\gamma < 0$ 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. This result is comparable to Flamini's (2007) finding, in the context of a theoretical framework in which nominal rigidities instead arise from price stickiness and impinge on multiple exchange-rate channels, that greater pass through reduces the responsiveness of the variability of the output gap to the variability of inflation. In Flamini's general-equilibrium model, a monetary authority's utilization of an inflation-targeting procedure induces endogenous responses of agents that yield a net effect of a negative influence of increased pass through on the sacrifice ratio. In our simpler framework, an analogous outcome arises as well through a real-exchange rate effect that exists in the absence of policymaking choices by a monetary authority.

In contrast, if $\Omega = 0$, so that all sectors of the economy have market-determined nominal wages, $\partial(\partial y/\partial p)/\partial \gamma \partial(\partial y/\partial p)/\partial \gamma > 0$. In an open economy, a greater degree of pass through generates an enlarged sensitivity of domestic-market prices to foreign firms' prices and thereby causes domestic output to respond more strongly to changes in the sacrifice ratio. Thus, in an economy in without nominal rigidities, our model yields an outcome contradictory to Flamini's, in which greater pass through induces domestic output to adjust more flexibly in association with a domestic price-level change, resulting in a larger predicted sacrifice-ratio response to domestic price inflation.

It follows then in an economy made up of both sectors with nominal wage contracts and sectors with market-clearing wages (that is, $0 < \Omega < 1$), 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, $\partial((\partial(\partial y/\partial p)/\partial \beta))/\partial \gamma = ((1-\Omega)\alpha\lambda\varepsilon/[\lambda(\alpha + \varepsilon - \alpha\varepsilon) + \varepsilon] > 0$. 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 (13) 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 on the sacrifice ratio expressed only in terms of domestic prices.

In an open economy, however, exchange-rate variations influence consumer prices and consequently impinge on the sacrifice ratio alongside changes in domestic prices. Thus, a full analysis of the sacrifice-ratio implications of greater openness must take into account the responsiveness of the nation's output to a change in the exchange rate. From (13) and (14), differentiating aggregate output with respect to the exchange rate yields

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

(16)

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 $\partial(\partial y/\partial s)/\partial \beta = ((1 - \Omega)\alpha\lambda\varepsilon\gamma/\lambda(\alpha + \varepsilon - \alpha\varepsilon) + \varepsilon) < 0$. 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 on the sacrifice ratio could be negative—*if* the degree of pass through is also sufficiently large.

As in the case of the pass-through influence on the sacrifice ratio operating through the direct effect on output of a variation in the price level, a change in the degree of pass through exerts an ambiguous influence via the indirect, exchange-rate effect. Equation (16) indicates that if $\Omega = 0$, so that nominal wage contracts exist in all sectors of the nation's economy, $\partial(\partial y/\partial s)/\partial\gamma\partial(\partial y/\partial s)/\partial\gamma < 0$, whereas if $\Omega = 1$, so that nominal wages throughout the economy are market-determined, $\partial(\partial y/\partial s)/\partial\gamma\partial(\partial y/\partial s)/\partial\gamma > 0$. These signs are reversed relative to the contracted-wage/flexible-wage cases discussed above with respect to the direct channel operating from the domestic price level to real output. Hence, as is true for the theoretical effects of greater openness on the sacrifice ratio, the influences of increased pass through on the sacrifice ratio operating through the direct price-level and indirect exchange-rate channel are exactly opposed, which yields ambiguous predictions.

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.

3. 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, depending on whether price-level or real-exchange-rate channel predominates, 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, depending on the relative share of the economy with flexible versus contracted nominal wages, and can only be determined empirically;

iii)an increased extent of pass through enhances (reduces) a positive (negative) effect of openness on the sacrifice ratio.

3.1. Dependent variable: the sacrifice ratio

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 procedure of Ball, 1994) and are likewise based on data from the International Monetary Fund's *International Financial Statistics*.[3]

The independent variable of analysis, the sacrifice ratio, SAC, is the ratio of the reduction in trend output to the associated change in trend inflation for a given disinflationary period. 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 length of a disinflationary period is then measured in years and varies from observation to observation. These calculations are made for 20 advanced economies resulting in 69 observations. Table 1 provides

summary statistics for all variables and Table 2 provides a correlation matrix.

Table 1. Descriptive statistics for 20 countries, 1975–2004.[a]

Variable		Mean	Std. Dev.	Min	Max	Observations[b]
	Overall	1.4933	1.7938	−1.1910	10.5290	$N = 69$
SAC	Between		1.0983	0.2895	4.8785	$n = 20$
	Within		1.5011	−1.3359	8.3811	$T = 3.45$
	Overall	4.4783	2.0264	1.0000	11.0000	$N = 69$
Length	Between		1.3109	2.8000	9.5000	$n = 20$
	Within		1.7062	1.7283	9.2283	$T = 3.45$
	Overall	10.5547	6.3224	1.2708	27.5863	$N = 69$
Inflation	Between		4.0753	5.9309	21.7710	$n = 20$
	Within		4.8358	−2.6974	21.8908	$T = 3.45$
	Overall	6.2683	4.1652	1.5288	17.9950	$N = 69$
ΔInflation	Between		2.1370	3.2730	11.0450	$n = 20$
	Within		3.6398	−1.1506	15.2825	$T = 3.45$
	Overall	0.4452	0.1979	0.1505	0.9314	$N = 69$
CBI	Between		0.2153	0.1505	0.9314	$n = 20$
						$T = 3.45$
	Overall	29.4823	12.1045	10.0800	65.6100	$N = 69$
Openness	Between		12.7211	10.0800	65.6100	$n = 20$
						$T = 3.45$
	Overall	0.6512	0.2905	0.1000	1.1300	$N = 65$
Pass Through	Between		0.2833	0.1000	1.1300	$n = 19$
						$T = 3.42105$
	Overall	0.0628	0.0130	0.0458	0.0968	$N = 69$
Concentration	Between		0.0136	0.0458	0.0968	$n = 20$
						$T = 3.45$
	Overall	102.7854	8.5543	76.9583	112.8125	$N = 69$
Propensity	Between		8.3788	76.9583	112.8125	$n = 20$
						$T = 3.45$
	Overall	44.2573	18.4502	9.99	79.42	$N = 69$
Union Density	Between		18.0195	11.77	77.6775	$n = 20$
	Within		6.9735	19.3198	65.4197	$T = 3.45$

[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.

[b]N provides the number of total observations, n the number of cross sections, and T the average number of observations per cross section.

Table 2. Correlation of explanatory variables.

	Length	Inflation	ΔInflation	CBI	Openness	Pass Through	Union Density
Length	1						
Inflation	0.0409	1					
ΔInflation	**0.4134**	**0.8091**	1				
CBI	−0.0534	−**0.3168**	−**0.213**	1			
Openness	−0.0045	−0.0167	−0.0082	−0.0316	1		
Pass Through	0.1346	−0.0194	0.005	0.0376	−**0.2623**	1	
Union Density	−0.1190	0.1873	0.0667	−**0.2482**	**0.2904**	−**0.3086**	1

Correlation coefficients in bold are significant at the 10 percent level.

As shown in Table 1, the sacrifice ratio ranges from a minimum of −1.191 to a maximum of 10.529. The length of each disinflationary period, Length, is one of our independent variables, and ranges from a minimum of one year to a maximum of 11 years. Not only does the length of each disinflationary period vary; so does the number of observations per country. As shown in Table 1, the average number of observations (*T*) per country is 3.45, with a minimum of 2 observations for Germany and Spain to a maximum of 5 observations for Australia. Table 1 also provides the overall standard deviation (1.794) as well as the between (1.098) and within standard deviation (1.501).

3.2. Independent variables

Our independent variables of analysis include those shown to be important by the existing literature. 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 Inflation, ΔInflation, and Length measures vary for each disinflationary period and, therefore, vary both across country and within country. Ball (1994) shows that faster disinflations or the "cold turkey" approach results in a lower loss of output than a gradualist approach. Hence, ΔInflation is expected to have a negative relationship with SAC, while Length is expected to have a positive relationship. Ball's results for the initial level of inflation, Inflation, were insignificant.

For the reasons spelled out by Daniels et al. (2005), we augment this data with their measure of central bank independence, CBI, derived from Franzese (2002). As with openness, CBI does not vary over time and has no within-cross-section variation. Daniels et al. show that greater central bank independence has a positive impact on the sacrifice ratio.

We also include a measure of the degree of trade openness, Openness. Romer (1993) is a key contribution to the literature on the impact of openness on inflation outcomes. Romer argues that equilibrium inflation is lower in more open economies as policymakers have less of an incentive to pursue expansionary policies as the economy becomes more open. In his empirical analysis he considers only the cross-section variation of openness (the average over the sample period) to minimize potential endogeneity between openness and inflation. Instrumental variable analysis provides no evidence that empirical relationship between openness and inflation results from the potential endogeneity. As a result of this work, the bulk of the literature on the impact of openness on the sacrifice ratio follows Romer 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*.

As explained in the introduction, evidence on the effect of openness on the sacrifice ratio is mixed. This effect is likely to depend on cross-country structural characteristics, such as CBI and exchange-rate pass through. Hence, to capture cross-country variation in exchange-rate pass through, we include Campa and Goldberg's (2005) estimates of the extent of nominal exchange-rate pass through elasticity spanning the period 1975 through 2003, Pass Through. We use this elasticity measure because, as Campa and Goldberg argue, it has a direct economic interpretation and is the most relevant measure of the impact of exchange rate changes on inflation performance. Note that Campa and Goldberg empirically estimate exchange-rate pass through implementing a variation of equation (8) above

$$p_t = \alpha + \beta_{1e_t} + \beta_2 y_t + \beta_3 w_t + \varepsilon_t,$$

(17)

where w_t is a control variable for exporter costs and y_t is real income of the importing economy.[4] Their estimates reflect the impact of a one-percent fluctuation of the nominal exchange rate on import prices as discussed in the theoretical model presented in the previous section. Hence, a pass-through estimate of 0.65 (the mean value in our sample of countries) implies that a one percent depreciation of the domestic currency would result in a 0.65 percent increase in the import price index of the domestic country.

Campa and Goldberg provide both short-run estimates (the coefficient on the one-quarter lag of the nominal exchange rate) and long-run estimates (the sum of the four-quarter lags of the nominal exchange rate) that result from a regression of import prices on lags of the nominal exchange rate and other controls. We use the long-run estimates, because they are consistent with our annual estimates of trend inflation and the sacrifice ratio. In addition, their pass-through estimates represent average pass through for the sample period (which corresponds with our period of analysis). It is important to point out that Campa and Goldberg consider whether the degree of pass through has declined over time. Based on two different stability tests, they reject stability of short-run pass through for a subset of countries. They are unable to reject stability of long-run pass through, however. Hence, we consider only the cross-section variation in long-run pass through to minimize potential endogeneity between inflation and pass through that might arise if inflation influences exporters' ability to pass through exchange rate changes. In our empirical work below, we test for endogeneity and offer instrument variable (IV) regressions as tests of robustness.

3.3. Empirical model and results

Because the key variable of analysis, the degree of openness, the level of central bank independence, and the extent of pass through are all time invariant, a random effects model is employed. 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 test for outliers by specifying a regression equation 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. Following <u>Maddala (2001)</u>, we control for the influence of outliers using bounded influence estimation.[5]

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

Regression Model 1 in <u>Table 3</u> is a base specification that includes standard determinants of the sacrifice ratio; Inflation, ΔInflation, Length, CBI, and Openness. As in Ball and Bowdler, the length of the disinflationary period remains a key determinant of the sacrifice ratio. There are important differences regarding effects of other variables, however. First, the coefficient estimate for CBI is, consistent with <u>Daniels et al. (2005)</u>, positive and significant. Additionally, Bowdler reports "weak" evidence linking the change in inflation to SAC, whereas our results are significant at the 1 percent level. More importantly, Bowdler also reports a weak negative correlation between Openness and 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 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.

Table 3. Sacrifice ratio estimates for 20 countries, 1975–2004[a] (robust standard errors in second row).

	Model 1	Model 2	Model 3	Model 4	Model 5
Length	0.6915***	0.6587***	0.6654***	0.6662***	0.5989***
	0.1008	0.091	0.0964	0.0969	0.1215
Inflation	0.0409	0.0381	0.0361	0.0361	0.0245
	0.0343	0.0307	0.0346	0.0343	0.1214

	Model 1	Model 2	Model 3	Model 4	Model 5
ΔInflation	−0.2233***	−0.2134***	−0.2150***	−0.2150***	−0.1444
	0.0663	0.0581	0.0636	0.0632	0.0500
CBI	1.4726**	1.4738**	1.4294**	1.3616**	0.7846**
	0.5732	0.5972	0.5196	0.5458	0.4756
Openness	−0.0314**		−0.0266***	−0.0266***	−0.0184***
	0.0125		0.0091	0.0100	0.0067
Pass Through		1.1704*	0.8657**	0.0389*	1.3476*
		0.5961	0.4031	0.0204	0.5655
Constant	5.7812***	4.1804**	5.4072***	5.5768***	5.5768***
	1.602	1.5421	1.485	1.5242	0.7526
Observations	69	69	69	69	69
R-squared[b]	0.6768	0.6581	0.6965	0.6916	0.6224
R-Bar[b]	0.6455	0.625	0.6617	0.6562	0.3941
F	14.63	13.59	12.72	12.62	6.28

[*]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.
[b]Uncentered R^2 and centered R^2 Model 5.

Although our main interest is how pass through might condition the effect of openness on the sacrifice ratio, Model 2 drops Openness and adds Pass Through 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. Furthermore, 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.[6] The estimates of this model suggest that a one-standard-deviation increase in **Openness** results in a 0.37 *decrease* in the SAC, whereas a one-standard-deviation increase in Pass Through results in a 0.27 *increase* in the SAC. These individual effects of Openness and Pass Through on SAC are illustrated in added-variable plots in Figs. 1 and 2. Fig. 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 SAC (as the dependent variable) on all other variables except Openness, thereby isolating the impact of Openness on SAC. Fig. 2 provides the corresponding plot for Pass Through.
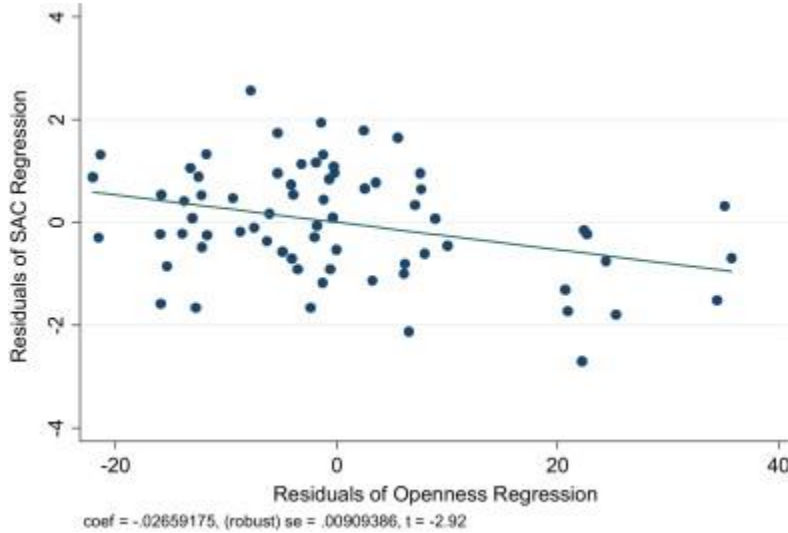

coef = -.02659175, (robust) se = .00909386, t = -2.92

Fig. 1. Individual marginal effect of openness.

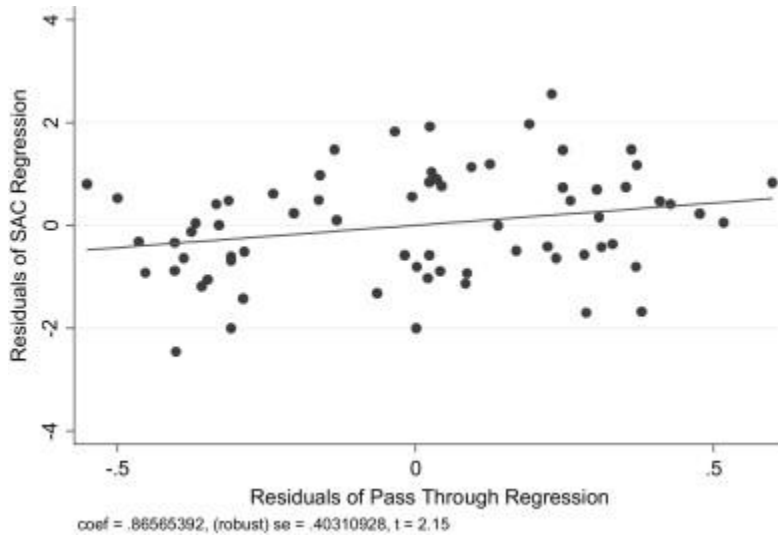coef = .86565392, (robust) se = .40310928, t = 2.15

Fig. 2. Individual marginal effect of pass through.

Models 4 and 5 address the potential for endogeneity between exchange rate pass through and inflation. Model 4 takes a very simple approach and uses the rank order of the pass through estimates across the countries in the sample as an instrument. The results differ

only slightly from Model 3 in that the *p*-value for Pass Through (using the rank) rises to 0.072.

Model 5 is motivated by the fact, discussed in section 2, that the composition of a nation's import bundle may be an important factor in explaining exchange-rate pass through into import prices, especially the rise in the share of manufactured goods in the import basket. Following this argument, we use two different measures of the structure of a nation's trade to instrument for exchange-rate pass through. The first measure is the value of a concentration index of merchandise imports centered on the year 1995. The measure is a Herfindahl–Hirschman index of the degree of market concentration normalized to value ranging from zero to one, with one indicating maximum concentration. The concentration variable and a description of its construction is available through *UNCTAD STAT*. It is assumed that increased market concentration reflects a greater share of manufactured goods within merchandise imports, which, according to Campa and Goldberg, results in reduced pass through.

The second measure of trade structure is the average value for the country's import propensity score for manufactured goods, available from the *Structural Analysis Database* (STAN) of the OECD. This measure shows the country's imports for manufactured goods, relative to its total imports, divided by manufactured goods imports of the 23 OECD countries relative to the 23 OECD countries' total imports. It is benchmarked at 100 so that values above 100 indicate that the country tends to have a "high propensity," relative to the OECD, to import manufactured goods. A higher propensity to import manufactured goods is assumed to result in reduced pass through. Although both variables show a positive correlation with Openness, they also display a negative correlation (and with a greater correlation coefficient) with Pass Through.[7]

Table 3 provides the results of Model 5's Two-Stage-GMM IV regression using the concentration index and propensity score as instruments for pass through. The results show only a slight change, with the significance level for ΔInflation rising slightly above 10 percent ($p = 0.106$). Using this model, we first test the potential endogeneity of the pass through variable. Based on the *C* statistic (difference-in-Sargan statistic), we are unable to reject the null

hypothesis that Pass Through is exogenous. Continuing with the diagnostics of the IV regression, the Angrist–Pischke multivariate F test of excluded regressors indicates that the two instruments are jointly significant at the 1 percent level in the first-stage regression, and the Kleibergen–Paap LM statistic rejects under-identification of the first-stage regression. The Cragg–Donald Wald F statistic for the Weak-Identification test is 17.64, falling between the 10 percent and 15 percent Stock-Yogo critical values. These results fail to provide evidence that potential endogeneity is likely to be the source of the positive and significant result for Pass Through on the sacrifice ratio.

We next consider the interactions of Openness, CBI, and Pass Through using the original Pass Through variable. Model 6 of Table 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 direct channel.[8] 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 6 is the sum of the coefficient on Openness plus the coefficient on the Openness-Pass Through interaction term, PT·Openness, 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. Fig. 3 illustrates the total marginal effect of Openness on SAC, taking into account the interaction with Pass Through. Fig. 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 SAC is illustrated by the solid horizontal line.

Table 4. Sacrifice ratio estimates for 20 countries, 1975–2004[a] (robust standard errors in second row).

	Model 6	Model 7	Model 8	Model 9	Model 10
Length	0.6599***	0.6633***	0.6643***	0.6694***	0.6712***
	0.1063	0.0971	0.0969	0.0996	0.0959

	Model 6	Model 7	Model 8	Model 9	Model 10
Inflation	0.0267	0.0295	0.0305	0.0263	0.0147
	0.0375	0.0349	0.0360	0.0356	0.0391
ΔInflation	−0.2027**	−0.2074***	−0.2087***	−0.2060***	−0.1940**
	0.0720	−0.0645	0.0651	0.0648	0.0693
CBI	1.3965**	3.6094**	2.8324***	1.6341***	1.3285**
	0.5455	1.5627	0.6522	0.4667	0.4733
Openness	−0.0582***	0.0094	−0.0267**	−0.0301***	−0.0297***
	0.0119	0.0276	0.0094	0.0085	0.0071
Pass Through	−0.9089	0.9090**	1.7919***	1.0244**	−1.2289
	0.5604	0.4241	0.4510	0.3836	0.7983
Union Density				0.0118**	−0.0236*
				0.0053	0.0182
PT·Openness	0.0538***				
	0.0164				
CBI·Openness		−0.0758			
		0.0548			
CBI·PT			−2.1474**		
			0.8515		
PT·Union Dens.					0.0522***
					0.0182
Constant	6.7422***	4.4495***	4.8563***	4.8108***	6.6061***
	1.7476	1.4111	1.4206	1.3297	1.4772
Observations	69	69	69	69	69
R-squared	0.7164	0.7004	0.7013	0.7073	0.7237
R-Bar	0.6786	0.6605	0.6615	0.6683	0.6816
F	16.93	11.39	12.23	15.32	23.01

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

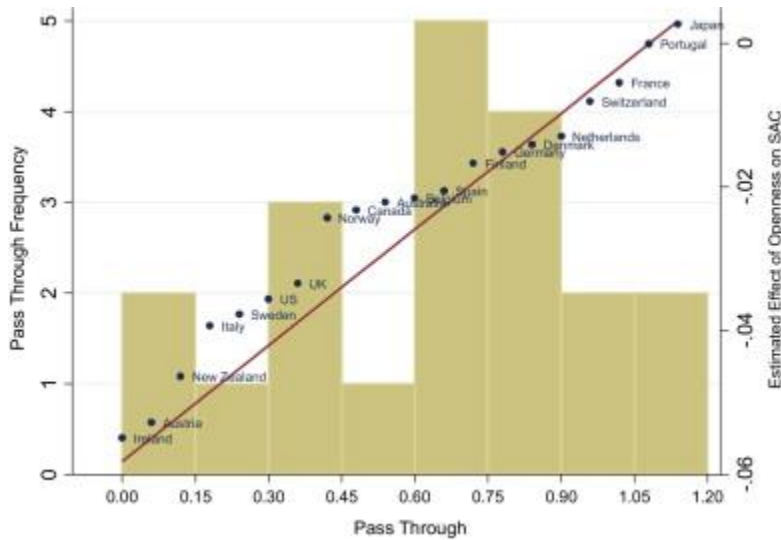[a]All models control for clustering at the country level.

Fig. 3. Estimated total marginal effect of openness on SAC.

Model 7 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 theoretical model presented in Section 2 and with the more recent results of Bowdler.[9] Models 6 and 7 suggest that the overall impact of openness on the sacrifice ratio depends on interacting structural parameters of the macroeconomy. Once the full scope of these interactions is taken into account, the impact of Openness on the sacrifice ratio is not statistically robust.

Model 8 explores a potential interaction between CBI and Pass Through by including this interaction and dropping the pass-through-openness interaction. Daniels et al. (2005) suggest that greater CBI leads to greater nominal wage contracting and 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 Tables 3 and 4, we also examined how the extent of wage contracting within the economy conditions the effect of exchange-rate pass through on the sacrifice ratio. This is motivated by both the theoretical model of Section 2 and the recent work of Nickell et al. (2005) and Bowdler and Nunziata (2010). In a study of unemployment in OECD countries, Nickell et al. find that changes in several labor market institutions (benefits, trade union density, wage coordination, employment protection laws, and labor taxes) explain approximately 55 percent of the rise in unemployment that occurred in Europe over a thirty-five year period. Bowdler and Nunziata consider how labor market characteristics affect the sacrifice ratio and conclude that a negative relationship exists between wage coordination and sacrifice ratios of OECD countries.

In the theoretical model presented in Section 2.5, exchange-rate pass through exerts an ambiguous influence on the sacrifice ratio, depending on the extent of wage contracting in the economy, represented by the parameter Ω in the theoretical model, and on the opposing effects of pass through operating through the direct domestic-price and the indirect exchange-rate channels. The comparative statics of the model for the all-contracting economy imply that an enlarged degree of pass through operating through the direct domestic-price channel results in a larger sacrifice ratio, while operating through the indirect exchange-rate channel it results in a lower sacrifice ratio. Opposite conclusions hold for the economy without nominal rigidities.

Daniels et al. (2006, page 984) contend that union density is the best proxy measure of the share of firms with nominal wage contracts. Hence, Model 9 of Table 4 includes Union Density (from Visser, 2009), which covers our full sample and, as shown in Table 1, varies over country and time. Consistent with Bowdler and Nunziata (Table 3, Model 4), the relationship between Union Density and the sacrifice ratio is positive, indicating that the sacrifice ratio is increased in economies with greater wage contracting; however, in contrast to Bowdler and Nunziata, it is also significant at the 5 percent level in our model. Model fit improves with the inclusion of this variable and Pass Through remains positive and significant.

Model 10 of Table 4 adds the interaction of Pass Through and Union Density. This model suffers from multicollinearity, so the significance level for the individual effects of Pass Through and Union Density fall just outside of the 10 percent and 5 percent level respectively while the two individual effects along with their interaction term are jointly significant (with a *p*-value of less than 1 percent). [10] Evaluated at the mean value for Union Density, the total effect of Pass Through is positive, statistically significant, and increasing with greater Union Density, as predicted by the model if pass through operating through the indirect exchange-rate channel more than offsets the effect operating through the direct domestic-price channel. These results suggest that further study of the importance of the degree of nominal wage rigidity as a conditioning factor may be a potentially useful path for future research.

We also consider a model that omits potential outliers. We assume a standard threshold for the DFITS statistic of 2 times the square root of 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. The results provided in Table 5 indicate that standard measures of model fit were lower under this approach and that there were no noteworthy differences in the signs and significance levels for the variables of interest.

Table 5. Sacrifice ratio estimates for 20 countries, 1975–2004.[a] Omitted Outliers Estimation (robust standard errors in second row).

	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
ΔInflation	−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***

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	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
Pass Through		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
		−0.7854	−1.8568***	−1.1178*	−0.5502		−1.5738***
Constant	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.

The introduction of the euro is an important structural element that may influence the effects of CBI, openness, and pass through on the sacrifice ratio as well as their interactions. There were two euro-member nations that experienced a disinflation episode after the introduction of the euro: Ireland in 2001 and Portugal in 2001. Dropping these two observations from Model 3 had no substantive effect on our results. Country size may also be an element that plays an important role in our results. To consider this possibility, we included in Model 3 a dummy variable that assumes a value of unity for those nations for which 2004 real GDP (measured in U.S. dollars and from the *OECD Main economic Indicators*) was below the median value for the group included in our analysis. This variable was not statistically significant; its only important effect on the results was to reduce the *p*-value of the estimated coefficients on Openness and Pass Through.

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 policymaking after 1980. 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 implication (other than to reduce the *p*-value on both Openness and Pass Through) for 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 effects 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, the extent of wage contracting, 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 elements 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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[2]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 and Gruben and McLeod, 2004, Razin and Yuen (2002), Loungani et al. (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 (2009) and Daniels and VanHoose (2009b).

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

[4]More specifically their regression equation is: $\Delta p_t^j = \alpha + \sum_{i=0}^{4} \alpha_i^j \Delta e_{t-i}^j + \sum_{i=0}^{4} b_i^j \Delta w_{t-i}^j + c^j \Delta y_t^j + \vartheta_t^j$, and e is the domestic currency price of foreign currency. Their estimates of short-run pass through is given by the first-quarter estimate of a, while the estimate of long-run pass through is the sum of the four-quarter estimates of a.

[5]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.

[6]A VIF table is generated for Model 3 to check for potential multicollinearity. No individual score exceeds 10 and the total score is not significantly different from unity and so multicollinearity does not appear to be a problem.

[7]We also considered as potential instruments the size of the economy measured by real GDP in U.S. dollars, exchange rate volatility measured both as the annual average of the monthly standard deviation of the nominal exchange rate and as estimated by a GARCH process, and the percentage of imports originating from South East Asia. None of the three proved to be worthwhile instruments in this application.

[8]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.

[9]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.

[10]The overall VIF score rises from approximately 2 for Model 9 to over 5 for Model 10 and the individual VIF scores for Union Density and Pass Through are approximately 10. The pairwise correlation coefficients for Union Density in Table 2 also indicate the possibility and potential sources of multicollinearity.