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6 Excess Capital Flows and the Burden of Inflation in Open Economies

Mihir A. Desai and James R. Hines Jr.

6.1 Introduction

Access to the world capital market provides economies with valuable borrowing and lending opportunities that are unavailable to closed economies. At the same time, openness to the rest of the world has the potential to exacerbate, or to attenuate, domestic economic distortions such as those introduced by taxation and inflation. This paper analyzes the efficiency costs of inflation-tax interactions in open economies. The results indicate that inflation's contribution to deadweight loss is typically far greater in open economies than it is in otherwise similar closed economies. This much higher deadweight burden of inflation is caused by the international capital flows that accompany inflation in open economies.

Small percentage changes in international capital flows now represent large resource reallocations given two decades of rapid growth of net and gross capital flows in both developed and developing economies. For example, the net capital inflow into the United States grew from an average of 0.1 percent of GNP in 1970–72 to 3.0 percent of GNP in 1985–88. Gross capital flows have also expanded rapidly, as indicated by the growth of international loans from a stock of 5 percent of GNP in industrial countries in 1973 to 17 percent of GNP in 1989 (International Monetary Fund [IMF] 1991). Similarly, the ratio of the stock of foreign direct investment in the United States to U.S. GNP grew from 1.2 percent in 1972 to 7.4 percent in 1990 (Graham and Krugman 1991).

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Inflation rate differences have the potential to reroute much of this international capital because prices inflate at widely different rates around the world. For example, average inflation rates from 1973 to 1989 among OECD countries range from 3.8 percent for Germany to 10.6 percent for the United Kingdom. Variation in inflation experiences is even greater in the developing world, with Malaysia averaging 4.6 percent and Bolivia 206.7 percent during the same period.[1]

The analysis in this paper starts by considering the effects of inflation on saving and investment when governments provide nominal depreciation accounting for tax purposes, firms are able to deduct nominal interest payments, and individual savers are taxed on their nominal interest receipts and capital gains. The model then incorporates open economy considerations, including the taxation of foreign exchange gains and losses, international portfolio capital mobility, and foreign direct investment. The welfare effects of inflation in open domestic and foreign economies are then compared to those in closed economies.

The main finding of this analysis is that inflation in an open economy can generate worldwide reallocations of capital with large associated efficiency consequences. As such, the international dimensions of the effects of inflation are properly considered together with effects that are well known from conventional closed economy analyses. Furthermore, the international effects of inflation-tax interactions suggest that there may be possibilities for efficiency gains through international coordination of monetary and fiscal policies.

Section 6.2 of the paper reviews the effects of inflation in closed and open economies with nominal-based tax systems. Section 6.3 develops an open economy model incorporating inflation-tax interactions and uses the model to analyze the effect of domestic inflation on domestic and foreign interest rates, saving, and investment. Section 6.4 translates the real effects of inflation into efficiency terms in order to contrast its welfare consequences in open and closed economies. Sections 6.5 and 6.6 generalize the model to include consideration of imperfect international capital mobility and foreign direct investment, respectively. Section 6.7 is the conclusion.

6.2 Inflation and Taxation in Closed and Open Economies

Irving Fisher's (1930) hypothesis that nominal interest rates rise by exactly the rate of inflation ($dr/d\pi = 1$, in which r is the nominal rate of interest and π the inflation rate) was once thought to carry the strong implication that inflation does not influence the size of the capital stock because real interest rates and therefore real borrowing costs would not change with inflation. Mundell

1. Data drawn from Romer (1993). These figures represent average annual changes in log GDP, or GNP deflators, from 1973 to 1989.

(1963) and Tobin (1965) dispute this conclusion, noting that inflation could raise the capital intensity of an economy through its effect on the demand for liquidity. As nominal interest rates increase, the cost of holding nominal money balances rises, thereby shifting portfolio demand from money to real capital and putting downward pressure on interest rates ($dr/d\pi < 1$). Subsequent work by Darby (1975) and Feldstein (1976) argues that inflation is likely to have the opposite effect on interest rates ($dr/d\pi > 1$) in realistic settings in which savers pay taxes on interest receipts and borrowers deduct interest payments.

Darby and Feldstein observe that the tax structure is based on nominal values. In particular, nominal interest payments are deductible and nominal interest receipts are taxed. As a consequence, inflation has two countervailing effects. Since lenders are taxed on the pure inflation component of interest rates, higher rates of inflation reduce their after-tax returns. At the same time, borrowers deduct their nominal interest payments, and therefore, higher rates of inflation reduce their after-tax borrowing costs. The net effect of inflation on the real rate of interest depends on the difference between tax rates applicable to savers and borrowers. Darby and Feldstein conclude that nominal rates rise by more than the rate of inflation (the modified Fisher hypothesis, or $dr/d\pi > 1$) and that inflation may influence the size of the capital stock in a closed economy. Even after incorporating liquidity effects, Feldstein concludes that, for plausible parameter values, inflation is likely to depress the capital stock of a closed economy through its interaction with the tax structure. While these initial models are limited by their exclusive consideration of investments that are fully debt financed and tax systems that permit assets to be depreciated at economic rates, the results have been extended to consider alternative means of financing and historic cost depreciation (see Feldstein, Green, and Sheshinski 1978; Feldstein 1983).

Hartman (1979) extends this analysis to open economy settings. In particular, he reconsiders the implication that nominal interest rates rise by more than the rate of inflation. In an open economy with flexible exchange rates and purchasing power parity, Hartman concludes that capital flows will remove any real interest rate differentials caused by interactions between tax systems and inflation. In Hartman's model, inflating countries receive capital inflows that prevent interest rates from rising more than one-for-one with inflation. Howard and Johnson (1982) extend this logic to suggest that the interaction of inflation and taxation could result in *either* a worldwide reallocation of capital as suggested by Hartman *or* a violation of purchasing power parity. More recent investigations focus on ways in which details of tax structure may imply something other than the Hartman result. Sorenson (1986) notes that the differential taxation of exchange gains and losses can generate an outcome in which the inflating country does not receive capital inflows, while Sinn (1991) shows that inflation in countries with tax systems that use historic cost depreciation may also have effects other than those Hartman posits. Bayoumi and Gagnon (1996) suggest that inflation-taxation interactions can explain observed patterns in capital flows between developed countries.

International evidence of the relationship between nominal interest rates and inflation provides tests of these theories. Hansson and Stuart (1986) survey empirical work suggesting that $dr/d\pi$ is close to or less than unity, thereby rejecting the modified Fisher hypothesis. More recent empirical work closely examines certain aspects of this evidence. In particular, Mishkin (1992) analyzes the stochastic trends underlying inflation and interest rates to distinguish between the absence of a short-run Fisher effect and the presence of a long-run Fisher effect.

6.3 A Model of a Small Open Economy with Taxation

In order to assess the effect of interactions between inflation and taxation in open economies, it is helpful to review the reasoning that underlies Hartman's (1979) analysis. This framework is then applied to a more general model of saving and investment in a small open economy.

6.3.1 The Fisher Effect in a Small Open Economy with Taxation

Consider the case of a small open (home) economy. In the notation that follows, foreign variables bear asterisks and domestic variables do not. The expected after-tax net return to foreign lenders ($r_{n,w}$) investing in the small open economy is

$$r_{n,w} = (1 - \theta^*)r + (1 - g^*)\dot{e}^*, \tag{1}$$

in which θ^* is the foreign tax rate on interest receipts from abroad (inclusive of any withholding taxes), r is the home country nominal interest rate, g^* is the foreign tax rate on exchange-rate-related gains and losses, and $\dot{e}^*$ is the anticipated appreciation (in foreign currency) of domestic assets held by foreign lenders. We assume exchange rates to be determined by purchasing power parity (PPP) in the goods market, which implies $\dot{e}^* = \pi^* - \pi$ (in which π^* is the foreign inflation rate).[2] A small open economy must offer foreign lenders an after-tax rate of return equal to returns available elsewhere.[3] Consequently, capital market equilibrium implies that $dr_{n,w}/d\pi = 0$, and differentiating equation (1) with respect to π implies

$$\frac{dr}{d\pi} = \frac{1 - g^*}{1 - \theta^*}, \tag{2}$$

2. While this assumption is fairly standard, it is important to note that the literature suggests that PPP is best understood as a long-run phenomenon. See, e.g., Abuaf and Jorion (1990), Johnson (1990), Frankel (1991), Wei and Parsley (1995), and Froot, Kim, and Rogoff (1995).

3. Strictly speaking, capital market equilibrium requires that risk-adjusted after-tax returns be equalized. In the certainty framework used here, risk considerations are absent and capital market equilibrium requires only that after-tax returns be equalized. Explicit considerations of risk would greatly complicate the model without significantly changing its implications. See, e.g., Gordon and Varian (1989).

in which it is implicit that $d\pi^*/d\pi = 0$. If foreign tax systems treat exchange-rate-related gains and losses in the same way as ordinary income, $g^* = \theta^*$, and the modified Fisher effect fails to hold because $dr/d\pi = 1$.[4]

This mirrors Hartman's (1979) argument and is consistent with much of the empirical work on the relationship between interest rates and inflation. Hartman infers from this analysis that capital is drawn toward inflating economies. The following analysis indicates that Hartman's result is a special case of a broader set of possible outcomes in which inflation alters the worldwide allocation of capital.

Why does the modified Fisher effect fail to appear in an open economy? The result stems from the fact that inflation does not penalize foreign savers in the same way that it does domestic savers. If PPP holds and foreign-exchange-related gains and losses are taxed in the same way as ordinary income, foreign lenders are able to deduct foreign exchange losses created by home country inflation. By contrast, domestic savers are unable to deduct from their taxable incomes the real losses they incur as a result of domestic inflation. As a consequence, the modified Fisher effect fails to appear, and instead interest rates obey the traditional Fisher relationship $dr/d\pi = 1$.

6.3.2 The Impact of Domestic Inflation on Worldwide Saving and Investment

In order to understand the interaction of inflation and taxation in open economies, it is necessary to specify the way that inflation and taxation affect investment and saving. First, consider the role of perfectly anticipated, permanent changes in domestic inflation in altering the incentives to invest domestically and abroad. Inflation affects domestic investment incentives through the use of historic cost depreciation, the taxation of nominal capital gains, and the ability to deduct interest payments. The incentives to invest abroad may also be affected if domestic inflation changes exchange rates or foreign interest rates. In equilibrium, worldwide inflation-induced changes in investment must equal worldwide inflation-induced changes in saving.

Firms invest up to the point at which after-tax marginal returns equal the after-tax marginal cost of funds:[5]

$$(1 - \tau)f' - \delta\pi + b\pi = b(1 - \tau)r + (1 - b)s, \tag{3}$$

in which τ is the statutory corporate tax rate, f' is the marginal product of capital (net of depreciation), δ reflects the nominal nature of depreciation allow-

4. In practice, the capital-exporting countries whose tax systems are described by Commission of the European Communities (1992, 235–303) generally set $g^* = \theta^*$. For the issues that arise when these tax rates differ, see Levi (1977) and Wahl (1989).

Note that the condition $dr/d\pi = 1$ is also consistent with financial arbitrage for domestic savers. If $g = \theta$ and $dr/d\pi = 1$, then domestic inflation reduces equally after-tax returns to investing at home and abroad.

5. This notation follows that of Feldstein et al. (1978).

ances ($\delta = 0$ implies that the tax system uses economic depreciation),[6] and $b\pi$ is the effect of inflation in reducing the value of nominal debt. The right-hand side of equation (3) consists of two terms, the first of which is the after-tax cost of debt, and the second of which is the after-tax cost of equity (in which s is the required payment to shareholders). The firm is assumed to finance a fraction b of marginal investments with debt and a fraction $1 - b$ with equity.

Differentiating both sides of equation (3) with respect to inflation, and taking b to be unaffected by inflation,[7] yields

$$(4) \qquad (1 - \tau)\frac{df'}{d\pi} = (\delta - b) + b(1 - \tau)\frac{dr}{d\pi} + (1 - b)\frac{ds}{d\pi}.$$

In order to simplify this expression, it is useful to impose the condition that equilibrium net after-tax returns to holding debt and equity are equal:

$$(5) \qquad (1 - \theta)s - c\pi = (1 - \theta)r - \pi,$$

in which c is the tax rate on inflation-induced capital gains. The left-hand side of equation (5) consists of after-tax real returns to equity holders, whose share values appreciate at the rate of inflation but who incur tax obligations at rate c on such appreciation; the right-hand side of equation (5) is the after-tax real return to holding a one-period bond.[8] This specification yields a value of s high enough to imply that firms should generally prefer debt to equity finance because interest payments are deductible and shareholders care only about net returns. Hence, the assumption that b takes a fixed value less than unity is based on considerations, such as bankruptcy, that are omitted from the model.

The shape of the production function determines the extent to which changes in f' translate into changes in investment, K. This relationship is defined locally as $dK \equiv -\gamma\, df'$ (with $\gamma > 0$ for concave functions). Similarly, $dK^* \equiv -\gamma^*\, df'^*$. Differentiating equation (5) to obtain an expression for $ds/d\pi$, substituting the result into equation (4), and using the result that $dr/d\pi = 1$ generates expressions for changes in domestic and foreign investment:

$$(6) \qquad \frac{dK}{d\pi} = -\gamma\left[\frac{\delta - b}{1 - \tau} + b + \frac{(1 - b)(c - \theta)}{(1 - \tau)(1 - \theta)}\right],$$

6. In this formulation, the tax system provides economic depreciation allowances in the absence of inflation, but after-tax values of these allowances erode at rate δ with inflation. Actual depreciation schedules tend to be fixed in nominal terms, generating positive short-run values of δ. Over long periods of time, however, governments may adjust depreciation schedules in response to prevailing inflation rates, thereby reducing δ. Auerbach and Hines (1988) offer evidence of such long-run adjustment for the United States in the postwar period.

7. Optimal choices of b are generally functions of π (and other parameters) rather than fixed values. From the envelope theorem, however, it is appropriate to take b as fixed in calculating the effect of small changes in π on the cost of capital.

8. Eq. (5) is an arbitrage condition for domestic savers, implicitly ruling out the possibility that foreigners are marginal investors in domestic equities (and that domestic savers invest marginal funds in foreign equities). The model assumes that international investment takes the form of debt rather than equity contracts. This assumption, which is consistent with available evidence, is discussed further in sections 6.5 and 6.6.

(7) $$\frac{dK^*}{d\pi} = -\frac{\gamma^*}{1 - \tau^*}\frac{dr^*}{d\pi}(1 - b^*\tau^*).$$

Equations (6) and (7) express the inflation-induced changes in capital demand to which it is then possible to match inflation-induced changes in the supply of capital.

Domestic saving is a function of the after-tax real rate of return to domestic savers:

(8) $$r_n = (1 - \theta)r - \pi,$$

in which θ is the personal tax rate on interest receipts. The after-tax real rate of return to foreign savers is

(9) $$r_n^* = (1 - \theta^*)r^* - \pi^*,$$

in which θ^* is the foreign tax rate on interest receipts. Using equations (8) and (9), it is possible to translate changes in inflation into changes in domestic and foreign saving:

(10) $$\frac{dS}{d\pi} = -\theta\frac{dS}{dr_n},$$

(11) $$\frac{dS^*}{d\pi} = \frac{dS^*}{dr_n^*}\frac{dr^*}{d\pi}(1 - \theta^*),$$

in which dS/dr_n denotes the responsiveness of domestic saving to the after-tax rate of return. It is then possible to use the world capital account identity $dK/d\pi + dK^*/d\pi \equiv dS/d\pi + dS^*/d\pi$ to determine $dr^*/d\pi$ and the worldwide capital reallocations that accompany inflation.[9]

Consider first the case in which domestic and foreign firms finance marginal investments exclusively with debt. Suppose in addition that domestic and foreign personal and corporate tax rates are all equal ($\theta = \tau = \tau^* = \theta^*$) and that depreciation allowances reflect economic depreciation ($\delta = \delta^* = 0$). Define the parameter ψ to equal the ratio of the size of the rest of the world's economy to the size of the home economy. Taking behavioral responses to be proportional to economic size, it follows that $\gamma^* = \psi\gamma$ and $dS^*/dr_n^* = \psi\ dS/dr_n$. Equating inflation-induced changes in world capital demand to inflation-induced changes in world capital supply yields

(12) $$\frac{dr^*}{d\pi} = \frac{1}{\psi}\left(\frac{\tau}{1 - \tau}\right),$$

(13) $$\frac{dK}{d\pi} = \gamma\frac{\tau}{1 - \tau} = -\frac{dK^*}{d\pi},$$

9. In imposing this identity, the domestic and foreign economies are taken to have single sectors. This formulation abstracts from distortions created by inflation-induced subsidies to certain assets, such as owner-occupied housing.

$$(14) \qquad \frac{dS}{d\pi} = -\tau\frac{dS}{dr} = -\frac{dS^*}{d\pi}.$$

In this special case of 100 percent debt finance, economic depreciation, and all tax rates equal, there is a reallocation of capital but no worldwide reduction in saving and investment. Equation (13) implies that domestic investment increases with inflation and is offset exactly by reduced foreign investment. Similarly, equation (14) indicates that domestic saving is reduced by an amount exactly equal to that by which foreign saving increases. Capital flows to the inflating country from the noninflating rest of the world, which confirms the basic Hartman (1979) result. Note that the mechanism by which this takes place is one in which domestic inflation raises the foreign nominal interest rate, thereby generating capital exports from the noninflating rest of the world to the inflating domestic economy. Moreover, the degree to which domestic inflation affects the foreign nominal interest rate is determined by the relative sizes of the domestic and world economies.

It is useful to consider the effect of alternative tax regimes in which depreciation allowances decline in value as inflation rises ($\delta > 0$), those in which tax rates differ ($\theta \neq \theta^*$), and cases in which firms are financed at least in part by equity ($b < 1$ and $b^* < 1$). In these more general cases, the inflating home economy is described by equations (6) and (10). Note that equation (10) indicates that domestic saving declines with inflation because the behavior of domestic savers is influenced by inflation-induced reductions in real after-tax interest rates. Equation (6) suggests that investment can increase with inflation, as in the special case above, but might alternatively fall with inflation if governments offer historic cost depreciation allowances and if marginal investments are financed in part by equity. Equation (6) further implies that $d^2K/d\pi\, db < 0$ and $d^2K/d\pi\, d\delta < 0$. These inequalities suggest that both the extent to which firms rely on equity finance and the extent to which inflation erodes the present value of depreciation allowances are responsible for reduced domestic investment at higher rates of inflation.

Equations (7) and (11) present results for the rest of the world. Changes in foreign saving and investment depend on the impact of domestic inflation on foreign interest rates. Equating world inflation-induced supply and demand changes, and imposing $dr/d\pi = 1$, produces a modified expression for $dr^*/d\pi$:

$$(15) \qquad \frac{dr^*}{d\pi} = \frac{1}{\psi}\left[\frac{\theta\frac{dS}{dr} - \gamma\left(\frac{\delta - b}{1-\tau} + b + \frac{(1-b)(c-\theta)}{(1-\tau)(1-\theta)}\right)}{\frac{dS}{dr}(1-\theta^*) + \frac{\gamma}{1-\tau^*}(1-b^*\tau^*)}\right].$$

The sign of $dr^*/d\pi$ in equation (15) is indeterminate but can be easily evaluated in the case in which capital gains are taxed at ordinary income rates ($c = \theta$) and saving and investment elasticities are equal ($\gamma = dS/dr$). In this case, there are two alternatives, which are summarized in table 6.1.

Table 6.1 **Summary of Influence of Domestic Inflation on Worldwide Interest Rates, Saving, and Investment**

	A $\delta < b\tau$		B $\delta > b\tau$		
				Foreign	
	Domestic	Foreign	Domestic	$\theta > (\delta - b\tau)/(1 - \tau)$	$\theta < (\delta - b\tau)/(1 - \tau)$
Interest rate	$\frac{dr}{d\pi} = 1$	$\frac{dr^*}{d\pi} > 0$	$\frac{dr}{d\pi} = 1$	$\frac{dr^*}{d\pi} > 0$	$\frac{dr^*}{d\pi} < 0$
Saving	$\frac{dS}{d\pi} < 0$	$\frac{dS^*}{d\pi} > 0$	$\frac{dS}{d\pi} < 0$	$\frac{dS^*}{d\pi} > 0$	$\frac{dS^*}{d\pi} < 0$
Investment	$\frac{dK}{d\pi} > 0$	$\frac{dK^*}{d\pi} < 0$	$\frac{dK}{d\pi} < 0$	$\frac{dK^*}{d\pi} < 0$	$\frac{dK^*}{d\pi} > 0$

Note: Interest rates, inflation, saving levels, and investment are denoted by r, π, S, and K, respectively. Foreign variables are denoted with an asterisk, τ denotes the domestic corporate tax rate, θ denotes the domestic personal tax rate on interest income, b denotes the fraction of investment financed by debt domestically, and δ denotes the degree of historic depreciation accounting for tax purposes (where $\delta = 0$ corresponds to economic depreciation). The above calculations assume that the domestic tax rate on interest income equals the domestic tax rate on capital gains ($\theta = c$) and a nonnegative elasticity of saving with respect to the real rate of return ($\eta_{S_r} > 0$).

Panel A of table 6.1 outlines the results when $\delta < b\tau$. If $\delta < b\tau$, foreign nominal interest rates rise with domestic inflation, foreign investment declines, and foreign saving rises. Inflation reduces domestic saving by lowering the after-tax domestic real interest rate and increases domestic investment because the benefits of nominal interest deductibility outweigh the tax costs imposed by historic cost depreciation. Consequently, capital flows from the noninflating rest of the world to the inflating country. The case in which $\delta > b\tau$ is outlined in panel B and is somewhat more complex. If $\delta > b\tau$, domestic saving *and* domestic investment decline with inflation because the tax penalties associated with historic cost depreciation exceed the benefits of nominal interest deductibility. Signs of the effects of inflation on foreign nominal interest rates, saving, and investment then depend on more detailed parameter values.

The intuition for the effects of τ, δ, and b is fairly straightforward. As firms use more debt or pay taxes at higher statutory rates, they benefit from the ability to deduct nominal interest payments—so inflation can stimulate domestic investment. On the other hand, to the degree that the tax system provides something other than economic depreciation allowances, higher rates of inflation raise the cost of capital and discourage investment. In cases in which $c \neq \theta$, the sign of $dr^*/d\pi$ depends as well on elasticities of capital supply and demand.

The magnitude of the effect of domestic inflation on foreign nominal interest rates, expressed in equation (15), can be illustrated by reference to specific parameter values. Table 6.2 presents values of $dr^*/d\pi$ for a range of home country parameters. For purposes of the calculations presented in table 6.2, the home country's economy is taken to represent 9 percent of the world economy ($\psi = 10$).[10] Foreign parameters are fixed at $b^* = 0.5$, $\theta^* = 0.35$, $\delta^* = 0.1$, and $\tau^* = 0.35$. For the base case in the center of table 6.2, a 1 percentage point rise in domestic inflation increases the world interest rate by 0.0091 percent. For the range of home country parameter values considered in table 6.2, the magnitude of the change in the world interest rate accompanying a 1 percentage point change in domestic inflation ranges from -0.0158 to 0.0788 percent for a 1 percentage point change in domestic inflation.[11]

The sensitivity of $dr^*/d\pi$ to home country parameters is evident from the pattern within table 6.2. For example, the greatest values of $dr^*/d\pi$ appear in cases in which corporate tax rates are highest and debt financing most perva-

10. The relevant value of ψ depends on country size. Using the 1993 share of world output as a measure of the relative size of an economy, ψ is 2.8 for the United States, 4.6 for Japan, 11.7 for Germany, 24.0 for the United Kingdom, and 51.4 for Spain. These measures are based on data from World Bank (1995) and IMF (1997). Measures of ψ based on saving or investment differ from these based on GDP. For example, the values of ψ for the United States and Japan are reversed, 4.6 and 2.8, respectively, when ψ is measured on the basis of saving.

11. Strictly speaking, arbitrage in world capital markets implies that $dr/d\pi = 1 + dr^*/d\pi$. While the approximation that $dr/d\pi = 1$ is valid for small open economies, a precise analysis of inflation in a large open economy should incorporate this more accurate value. From a practical standpoint, however, this adjustment is unlikely to make a major difference to estimated welfare costs of inflation, even for large economies such as those of the United States and Japan.

Table 6.2 Sensitivity of $dr^*/d\pi$ to Home Country Parameters

	$\tau = 0.20$ (1)	$\tau = 0.35$ (2)	$\tau = 0.50$ (3)
$b = 1.0$			
$\delta = 0.0$	0.0197	0.0424	0.0788
$\delta = 0.1$	0.0098	0.0303	0.0630
$\delta = 0.2$	0.0000	0.0182	0.0473
$b = 0.5$			
$\delta = 0.0$	0.0098	0.0212	0.0394
$\delta = 0.1$	0.0000	**0.0091**	0.0236
$\delta = 0.2$	−0.0099	−0.0030	0.0079
$b = 0.2$			
$\delta = 0.0$	0.0039	0.0085	0.0158
$\delta = 0.1$	−0.0059	−0.0036	0.0000
$\delta = 0.2$	−0.0158	−0.0158	−0.0158

Notes: Col. (1) presents inflation-induced changes in foreign interest rates when the domestic corporate tax rate, τ, is 20 percent. Cols. (2) and (3) report results for the same calculation when the domestic corporate tax rates are 35 and 50 percent, respectively.

The parameter b denotes the fraction of domestic investment financed at the margin by debt, and δ is a measure of the degree to which depreciation accounting for tax purposes is sensitive to inflation ($\delta = 0$ corresponds to zero sensitivity, or economic depreciation). The calculations take the domestic tax rate on interest income to be equal to the domestic tax rate on capital gains ($\theta = c$). The fraction of foreign investment financed at the margin by debt, b^*, is taken to equal 0.5, and the foreign corporate tax rate, τ^*, is taken to equal 35 percent. The calculations also assume a zero elasticity of saving with respect to the real rate of return ($\eta_{s,r} = 0$) and that the domestic economy is one-tenth the size of the world economy ($\psi = 10$, which roughly characterizes Germany).

The base case is shown in boldface.

sive (inflation thereby generating the largest subsidies to domestic corporate borrowers) and departures from economic depreciation the smallest (inflation thereby imposing the smallest costs of lost real depreciation allowances). By encouraging domestic investment, inflation is responsible for capital movement from the rest of the world to the inflating country—thereby raising foreign interest rates.

The cases in which $dr^*/d\pi < 0$ are those for which inflation reduces domestic saving and domestic investment. If $dr^*/d\pi < 0$, then domestic investment falls by *more* than does domestic saving due to erosion of depreciation allowances by inflation and higher costs of investment funds consisting partly of equity. In such cases, capital flows from the domestic economy to the foreign economy, thereby reducing the foreign interest rate, discouraging foreign saving and stimulating foreign investment. The cases in which $dr^*/d\pi = 0$ consist of situations in which inflation discourages domestic saving and domestic investment equally, thereby requiring no international capital movement in order to maintain capital balances—and, consequently, no change in the foreign interest rate.

In each of these scenarios the underlying logic is the same. First, the ability of foreign lenders to deduct foreign exchange losses forces domestic nominal interest rates to rise one-for-one with inflation. Second, the degree to which domestic inflation penalizes domestic saving relative to domestic investment then determines whether capital enters or leaves the inflating country and the extent to which foreign interest rates are affected.

6.4 Efficiency Consequences of Inflation in a Small Open Economy

A consistent analysis of the efficiency consequences of inflation in open economies includes consideration of the deadweight losses generated by inflation together with the implications of inflation for tax revenue. Higher rates of inflation typically, though not uniformly, generate greater tax revenue while exacerbating tax distortions. Since tax revenue is valuable to governments whose alternative sources of revenue are distortionary, the costs of inflation-induced distortions must be weighed against the benefits of greater tax revenue. Additionally, inflation affects economic efficiency and tax revenue in two ways: through its interaction with the personal income tax and through its interaction with the corporate income tax. Consequently, a consistent welfare analysis has four components: $d\mathrm{DWL}_p/d\pi$, $d\mathrm{DWL}_c/d\pi$, $d\mathrm{REV}_p/d\pi$, and $d\mathrm{REV}_c/d\pi$, where p, for personal, denotes the effect of interactions between inflation and personal income taxes and c, for corporate, denotes the effect of interactions between inflation and corporate income taxes.

This section derives expressions for the home and world welfare effects of inflation in open economies, in the process demonstrating that the world efficiency impact of inflation is a function of disparities between domestic and rest-of-world inflation rates. The revenue impact of inflation in a small open economy is then integrated with deadweight loss considerations to generate overall welfare effects of inflation. The analysis then estimates these effects for realistic cases using a modified version of the methodology employed by Feldstein (chap. 1 in this volume).

6.4.1 Deadweight Loss Due to Inflation-Induced Capital Flows

The efficiency consequences of inflation-induced international capital movements appear even in the very simplified case analyzed earlier. Specifically, consider again the case in which domestic and foreign firms finance their investments entirely with debt ($b = b^* = 1$), domestic and foreign tax systems provide economic depreciation allowances ($\delta = \delta^* = 0$), and all tax rates are equal ($\theta = \tau = \tau^* = \theta^*$). The effect of inflation on the welfare of a small open economy can be decomposed into the effect of inflation on the allocation of consumption and the effect of inflation on the allocation of investment.

It is useful to consider intertemporal consumption distortions in a two-period framework in which individuals save in the first period to finance consumption in the second. In the home country, the after-tax real price of second-period consumption (p_2^a), measured in first-period units, is $p_2^a = 1/[1 + r(1 - \theta) - \pi]^T$, where T is the number of years that elapses between first-period saving and second-period consumption. The before-tax real price of second-period consumption (p_2^b), measured in first-period units, is $p_2^b = 1/(1 + r - \pi)^T$. The difference between these two prices represents the wedge introduced by the tax system and its interaction with inflation.

The effect of inflation on the efficiency of intertemporal consumption is represented by the interaction of inflation-induced compensated changes in demand for second-period consumption with the tax wedge identified above. As always in analyzing tax-induced deadweight loss, it is important to use compensated rather than uncompensated demand schedules; more specifically, as noted by Feldstein (1978), the compensated demand derivative with which the tax wedge is properly interacted is that for second-period consumption rather than that for saving. Denoting the derivative of compensated demand for second-period consumption by dC_2/dp_2^a, the domestic deadweight loss from the consumption reallocation that accompanies a small change in inflation is $-(dC_2/dp_2^a)(dp_2^a/d\pi)(p_2^a - p_2^b)$. Imposing $dr/d\pi = 1$, this deadweight loss can be expressed as

$$(16)\quad \frac{d\mathrm{DWL_p}}{d\pi} = -\frac{dC_2}{dp_2^a}\frac{dp_2^a}{d\pi}(p_2^a - p_2^b) \cong -T\theta\frac{dC_2}{dp_2^a}p_2^a(p_2^a - p_2^b),$$

in which the approximation is valid at low after-tax real interest rates.[12]

Interactions between inflation and the corporate income tax also carry welfare implications. Equations (3) and (5) together imply a value for the marginal product of capital: $f' = r - \pi/(1 - \tau)$. Hence the difference between the marginal product of capital and the pretax real rate of return $f' - (r - \pi)$ equals $-\tau\pi/(1 - \tau)$ in this special case. This negative tax wedge may at first seem paradoxical because, in a world without inflation, the effective tax rate is zero if tax systems provide economic depreciation deductions and marginal investments are financed by debt. The negative effective tax rate reflects that inflation subsidizes investment by increasing deductible nominal interest payments.

The welfare effect of a change in inflation equals the product of any inflation-induced investment change and the difference between the after-tax and before-tax marginal products of capital. Accordingly,

$$(17)\quad \frac{d\mathrm{DWL_c}}{d\pi} = \frac{\gamma\tau^2\pi}{(1 - \tau)^2}.$$

Adding this to the deadweight loss generated by the personal income tax yields[13]

12. Formally, $dp_2^a/d\pi = \theta Tp_2^a/[1 + r(1 - \theta) - \pi]$, which approximates θTp_2^a if the after-tax real interest rate is close to zero.

13. Note that it is appropriate to sum deadweight losses from interactions between inflation and personal taxes and inflation and corporate taxes because the benchmark real rate of interest, $r - \pi$, is common to both calculations. In a closed economy, such a calculation corresponds to measuring the sizes of two pieces that together make up the Harberger triangle. In an open economy the calculation is somewhat more complicated because inflation-induced changes in saving need not equal changes in investment.

$$\frac{d\text{DWL}}{d\pi} = \frac{\gamma\tau^2\pi}{(1-\tau)^2} - T\theta\frac{dC_2}{dp_2^a}p_2^a(p_2^a - p_2^b), \tag{18}$$

which is unambiguously positive. Inflation reduces the efficiency of domestic resource allocation both in consumption, by discouraging second-period consumption that is already penalized by the tax system, and in investment, by encouraging investment that (in the case of pure debt financing and economic depreciation) is already subsidized by the tax system.

In this scenario, inflation improves the quality of resource allocation in foreign countries. Inflation increases foreign saving and reduces foreign investment; since the foreign tax system penalizes saving and subsidizes investment, each of these changes reduces deadweight loss in the foreign country. Specifically, domestic inflation changes foreign deadweight loss by

$$\frac{d\text{DWL}^*}{d\pi} = T\tau p_2^{a*}(p_2^{a*} - p_2^{b*})\frac{dC_2}{dp_2^{a*}} - \frac{\gamma\tau^{*2}\pi^*}{(1-\tau^*)^2}. \tag{19}$$

Note that this expression is independent of ψ, the ratio of the sizes of the rest of the world and the domestic economy. Intuitively, higher values of ψ imply that domestic inflation has a smaller effect on foreign interest rates but that the impact of higher interest rates applies to a larger world economic base, thereby generating an equivalent deadweight loss.

The same terms appear (with opposite signs) in both equations (18) and (19), thereby suggesting that world welfare might not be affected by inflation. While it is true that domestic inflation reduces deadweight loss in the rest of the world, it does not follow that this reduction is of the same magnitude as the positive impact of inflation on deadweight loss in the home country. This can be illustrated by adding equations (18) and (19) and imposing equality between the tax and behavioral patterns of the two countries other than their inflation rates (so that, for example, $r^* - \pi^* = r - \pi$):

$$\begin{aligned}\frac{d(\text{DWL} + \text{DWL}^*)}{d\pi} &= \frac{\gamma\tau^2}{(1-\tau)^2}(\pi - \pi^*) \\ &\quad + T\tau\frac{dC_2}{dp_2^a}[p_2^{a*}(p_2^{a*} - p_2^{b*}) - p_2^a(p_2^a - p_2^b)].\end{aligned} \tag{20}$$

Inspection of equation (20) verifies that $d(\text{DWL} + \text{DWL}^*)/d\pi = 0$ when $\pi = \pi^*$, since the first term on the right-hand side is zero, as is the second term, by virtue of the equalities $p_2^a = p_2^{a*}$ and $p_2^b = p_2^{b*}$. This is a sensible result, since the foreign and domestic economies are identical when $\pi = \pi^*$, making the world equivalent to a large closed economy. Darby (1975) and Feldstein (1976) show that inflation does not reduce the welfare of a closed economy with debt-financed investments and economic depreciation because inflation does not change after-tax real interest rates and borrowing costs.

In order to characterize the global welfare properties of inflation, it is useful to differentiate both sides of equation (20) with respect to π:

$$\frac{d^2(\text{DWL} + \text{DWL}^*)}{d\pi^2} = \frac{\gamma\tau^2}{(1-\tau)^2} + T^2\tau^2\frac{dC_2}{dp_2^a}$$

$$(21) \qquad \left\{\frac{1}{\psi}\left[(p_2^{a*})^{1+1/T}p_2^{b*} + \frac{p_2^{a*}(p_2^{b*})^{1+1/T}}{1-\tau} - 2(p_2^{a*})^{2+1/T}\right]\right.$$

$$\left. + \left[(p_2^a)^{1+1/T}p_2^b - 2(p_2^a)^{2+1/T}\right]\right\}.$$

The first term on the right-hand side of equation (21) is positive, and since $dC_2/dp_2^a < 0$, the second term is also positive if the expression in braces is less than zero. In evaluating the sign of this expression, it is useful to note that $p_2^a > p_2^b$, $p_2^{a*} > p_2^{b*}$, and, if $\pi > \pi^*$, $p_2^a > p_2^{a*}$ while $p_2^b > p_2^{b*}$. As a result, an upper bound of the absolute value of the expression in braces can be obtained by evaluating the expression if $p_2^a = p_2^b = p_2^{a*} = p_2^{b*}$:

$$(22) \qquad \frac{d^2(\text{DWL} + \text{DWL}^*)}{d\pi^2} \geq \frac{\gamma\tau^2}{(1-\tau)^2}$$

$$+ T^2\tau^2\frac{dC_2}{dp_2^a}(p_2^a)^{2+1/T}\left[\frac{1}{\psi}\left(\frac{1}{1-\tau} - 1\right) - 1\right].$$

The term in brackets on the right-hand side of equation (22) is less than zero as long as $\tau < \psi/(1 + \psi)$. Since the rest of the world is taken to be large relative to the inflating economy, this condition is equivalent to the realistic case of tax rates less than 100 percent. Consequently, both terms on the right-hand side of equation (22) are positive, and $d^2(\text{DWL} + \text{DWL}^*)/d\pi^2 > 0$.

Figure 6.1 depicts the relationship between deadweight loss and inflation differences. The $d(\text{DWL} + \text{DWL}^*)/d\pi$ schedule is upward sloping and takes a value of zero at $\pi = \pi^*$. Accordingly, as is evident from the figure, $d(\text{DWL} + \text{DWL}^*)/d\pi$ takes the same sign as $\pi - \pi^*$. The deadweight loss function is also nonlinear in π, generally taking a convex form (as pictured).

Equation (20) indicates that the aggregate welfare cost of domestic inflation depends on existing disparities between national inflation rates. In the scenario under consideration, greater domestic inflation improves world welfare if the rest of the world has a higher rate of inflation.[14] Conversely, if the domestic inflation rate exceeds the world inflation rate, higher domestic inflation reduces world welfare. The international reallocations that accompany inflation stem

14. It is worth emphasizing that this result depends on the values of relevant parameters. There exist scenarios in which higher domestic inflation reduced world welfare, even though world inflation rates exceed the domestic rate.

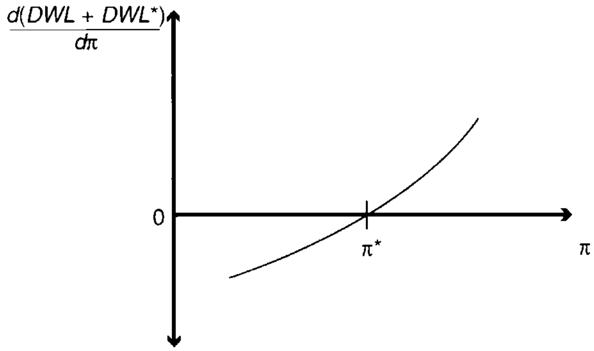

Fig. 6.1 World welfare and inflation disparities

Note: The figure depicts the relationship between disparities in inflation rates ($\pi - \pi^*$) and the effect of inflation on world welfare. It is evident from the figure that $d(\text{DWL} + \text{DWL}^*)/d\pi$ takes the same sign as $\pi - \pi^*$.

from the fact that foreign lenders deduct exchange losses when calculating their taxable incomes. Domestic inflation increases nominal interest rates by the same amount that it reduces expected exchange gains of foreign lenders. Consequently, domestic inflation does not generate any additional tax liabilities for foreign lenders. But domestic lenders, who are taxed on their nominal interest receipts without any adjustments for inflation, face lower after-tax real interest rates and therefore save less as inflation rises. Domestic corporations deduct nominal interest payments and therefore invest more at higher rates of inflation. As a result, capital flows from noninflating countries to inflating countries.

These international capital reallocations are costly because they imply that too little saving and too much investing take place in inflating countries relative to noninflating countries. It is noteworthy that the nonzero deadweight loss derivative in equation (20) appears in a scenario—one in which firms finance their marginal investments with debt and governments provide depreciation allowances that do not erode with inflation—in which inflation would not generate deadweight loss if the economy were closed. All of the deadweight loss described in equation (20) comes from international capital movements and associated effects.

In the more general case in which governments provide historic cost depreciation and investments are financed at least in part by equity, the expression for the component of deadweight loss generated by personal taxation is unchanged from equation (16). The expression for the component of deadweight loss generated by corporate taxation does, however, change, as the expressions for the preexisting tax wedge and inflation-induced change in domestic investment become somewhat more complicated. Taking $c = \theta$ for simplicity, the domestic deadweight loss due to interactions between inflation and corporate taxation systems is

$$(23)\qquad \frac{d\mathrm{DWL}_c}{d\pi} = \frac{\gamma}{(1-\tau)^2}\{(\delta - \tau b)[r\tau(1-b) + \pi(\delta-\tau)]\}.$$

This expression can be understood as the product of the investment response, represented by $\gamma(\delta - b\tau)/(1-\tau)$, and the preexisting distortion, represented by $[r\tau(1-b) + \pi(\delta-\tau)]/(1-\tau)$. Relative values of δ and $b\tau$ dictate whether inflation encourages or discourages domestic investment. The sign of the preexisting distortion indicates whether effective tax rates are positive or negative. Their product determines whether deadweight losses are positive or negative. For example, if the effective tax rate is positive and inflation discourages domestic investment, equation (23) is positive. If the effective tax rate is negative and inflation encourages domestic investment, equation (23) is again positive.

Expressions for foreign deadweight loss in the general case are slightly more complicated than that in equation (19). Deadweight losses generated by interactions between inflation and foreign corporate and personal taxes are

$$(24)\qquad \frac{d\mathrm{DWL}_p^*}{d\pi} = T\frac{dr^*}{d\pi}(1-\theta^*)p_2^{a*}(p_2^{a*} - p_2^{b*})\frac{dC_2^*}{dp_2^{a*}},$$

$$(25)\qquad \frac{d\mathrm{DWL}_c^*}{d\pi} = \frac{\gamma^*}{(1-\tau^*)^2}[r^*\tau^*(1-b^*) + \pi^*(\delta^*-\tau^*)]\frac{dr^*}{d\pi}(1-b^*\tau^*),$$

where $dr^*/d\pi$ is as represented in equation (15).

6.4.2 The Revenue Impact of Inflation

Inflation rates influence tax collections, which in turn have welfare implications since alternative sources of tax revenue are generally distortionary. The impact of inflation on the present value of personal income tax revenue is

$$(26)\qquad \frac{d\mathrm{REV}_p}{d\pi} = \frac{dp_2^a}{d\pi}C_2 + (p_2^a - p_2^b)\frac{dC_2}{dp_2^a}\frac{dp_2^a}{d\pi}.$$

The first term in equation (26) reflects revenue obtained by changing the price of retirement consumption, while the second term reflects the revenue effect of changes in retirement consumption, holding its price constant. In general, the sign of equation (26) is indeterminate. The impact of inflation on corporate tax revenue is similarly

$$(27)\qquad \frac{d\mathrm{REV}_c}{d\pi} = \frac{df'}{d\pi}K - [f' - (r-\pi)]\frac{df'}{d\pi}\gamma.$$

In order to unify the analysis of deadweight loss and revenue effects of inflation, it is necessary to assign a shadow value to government revenue equal to

$1 + \lambda$, in which a value of $\lambda > 0$ reflects the deadweight loss that accompanies alternative sources of tax revenue. Accordingly, the overall effect of inflation on social welfare is

$$(28) \qquad \frac{d\mathrm{SW}}{d\pi} = \lambda\frac{d\mathrm{REV}}{d\pi} - \frac{d\mathrm{DWL}}{d\pi},$$

where SW denotes social welfare.

6.4.3 Estimation of the Welfare Impact of Inflation

In order to estimate magnitudes of equation (28) it is helpful to use the empirical framework sketched by Feldstein (chap. 1 in this volume). Interactions between inflation and the personal income tax generate deadweight loss given by

$$(29) \qquad \frac{d\mathrm{DWL}_{\mathrm{P}}}{d\pi} = -(p_2^{\mathrm{a}} - p_2^{\mathrm{b}})\frac{dC_2}{dp_2^{\mathrm{a}}}\frac{dp_2^{\mathrm{a}}}{d\pi},$$

where

$$\frac{dp_2^{\mathrm{a}}}{d\pi} = T\left[1 - \frac{dr}{d\pi}(1 - \theta)\right]p_2^{\mathrm{a}}\frac{1}{1 + r(1 - \theta) - \pi}$$

and T is the number of years in a period. Equation (29) can be transformed into a direct analogue of Feldstein's equation (4):

$$(30) \qquad \frac{d\mathrm{DWL}_{\mathrm{P}}}{d\pi} = (p_2^{\mathrm{a}} - p_2^{\mathrm{b}})\left(\frac{1}{p_2^{\mathrm{a}}}\right)^2\frac{dp_2^{\mathrm{a}}}{d\pi}S_2(1 - \eta_{Sp} - \sigma),$$

in which S_2 is saving in preretirement years, η_{Sp} is the uncompensated elasticity of saving with respect to the price of retirement consumption, and σ is the propensity to save out of exogenous income. Further manipulation yields an expression that is easily calibrated. Taking $\eta_{Sp} = 0$, $\sigma = 0.12$, and $S_2 = 0.09\mathrm{GDP}$,[15] equation (30) becomes

$$(31) \qquad \frac{\mathrm{dDWL}_{\mathrm{P}}}{d\pi} = (p_2^{\mathrm{a}} - p_2^{\mathrm{b}})\left(\frac{1}{p_2^{\mathrm{a}}}\right)^2\frac{dp_2^{\mathrm{a}}}{d\pi}(0.0792\mathrm{GDP}).$$

In order to evaluate this expression, it is useful to assume that 30 years elapse between periods and to consider the case that $r = 0.07$, $\pi = 0.02$, and $\theta = 0.35$ in a small open economy in which $dr/d\pi = 1$. Under these assumptions, $d\mathrm{DWL}_{\mathrm{p}}/d\pi = 0.4115\mathrm{GDP}$, which is similar to estimates reported by Feldstein (chap. 1 in this volume).[16]

15. This value of preretirement saving is derived by linking preretirement saving with national income account measures of personal saving as in Feldstein (chap. 1 in this volume).

16. This estimate implies that a 2 percent reduction in inflation produces an efficiency gain of 0.823 percent of GDP per year; Feldstein estimates the gain to be 0.730 percent of GDP per year.

A similar procedure can be used to estimate the revenue consequences of domestic inflation. Equation (26) can be transformed to yield

$$\text{(32)} \qquad \frac{d\mathrm{REV_p}}{d\pi} = \frac{dp_2^a}{d\pi}\frac{1}{p_2^a}S_2\left[1 - (p_2^a - p_2^b)\frac{1}{p_2^a}(1 - \eta_{S_p} - \sigma)\right].$$

Assuming the uncompensated elasticity of saving with respect to the after-tax interest rate to be zero and taking $r = 0.07$, $\pi = 0.02$, and $\theta = 0.35$, it follows that $d\mathrm{REV_p}/d\pi = 0.5100\mathrm{GDP}$. With $\lambda = 0.4$, the overall welfare impact of interactions between inflation and personal income taxes is $d\mathrm{SW_p}/d\pi = -0.2075\mathrm{GDP}$.[17]

The distinguishing difference between inflation-induced deadweight losses in open and closed economies lies in values of $dr/d\pi$ and, consequently, $dp_2^a/d\pi$. In an open economy, $dr/d\pi = 1$ due to arbitrage in the world capital market, while in a closed economy, $dr/d\pi$ varies with the underlying parameters of the economy. The appendix presents an analogous closed economy model for which it derives $dr/d\pi$. Table 6.3 illustrates the difference between closed and open economies by presenting estimates of $dr/d\pi$ in closed economies and using these values to estimate the components of the welfare effect of interactions between inflation and personal income taxes in closed economies: $(d\mathrm{DWL_p}/d\pi)^{\mathrm{closed}}$ and $(d\mathrm{REV_p}/d\pi)^{\mathrm{closed}}$. These values are then used to construct ratios of welfare losses from personal income taxes in open and closed economies.

The first line of table 6.3 evaluates the Feldstein-Darby case of 100 percent debt financing and economic depreciation allowances. The closed economy is not distorted by inflation because the nominal interest rate rises sufficiently to generate no change in the after-tax price of retirement consumption. Since inflation is responsible for deadweight loss in small open economies, the ratio of deadweight losses in open and closed economies, provided in column (7), is infinite. Realistic alternative scenarios with some nondebt financing and departures from economic depreciation offer additional information. The ratio of deadweight losses in open and closed economies varies directly with values of $(dr/d\pi)^{\mathrm{closed}}$. Intuitively, the ratio of deadweight losses in open and closed economies equals unity when $(dr/d\pi)^{\mathrm{closed}} = 1$. If $(dr/d\pi)^{\mathrm{closed}} > 1$, then $(dp_2^a/d\pi)^{\mathrm{closed}} < (dp_2^a/d\pi)^{\mathrm{open}}$, which implies that the efficiency costs of interactions between inflation and personal income taxes are more modest in closed economies than in open economies. Alternatively, if $(dr/d\pi)^{\mathrm{closed}} < 1$, then

17. There is considerable dispute over the correct value of λ for the U.S. economy. Ballard, Shoven, and Whalley (1985) estimate values of λ between 0.17 and 0.56, on the basis of which (in addition to other calculations) many authors use $\lambda = 0.40$ as a baseline for deadweight loss calculations. For considerably higher estimates of λ, see Feldstein (1995).

It is possible to calculate the implied values of λ for the model by comparing marginal tax revenue and marginal deadweight losses as tax rates vary. At baseline parameter values, the model implies $\lambda = 0.22$ if corporate taxes are the marginal source of funds and $\lambda = 0.81$ if personal taxes are the marginal source of funds. Hence, $\lambda = 0.40$ appears to be a reasonable baseline case.

Table 6.3 **Deadweight Loss and Revenue of Domestic Inflation in Open and Closed Economies: Personal Income Taxation**

	$\left(\frac{dr}{d\pi}\right)^{\text{closed}}$ (1)	$\left(\frac{dp_2^a}{d\pi}\right)^{\text{closed}}$ (2)	$\left(\frac{dDWL_p}{d\pi}\right)^{\text{closed}}$ (3)	$\left(\frac{dREV_p}{d\pi}\right)^{\text{closed}}$ (4)	$\left(\frac{dDWL_p}{d\pi}\right)^{\text{open}}$ (5)	$\left(\frac{dREV_p}{d\pi}\right)^{\text{open}}$ (6)	$\frac{dSW_p^{\text{open}}}{d\pi} \Big/ \frac{dSW_p^{\text{closed}}}{d\pi}$ (7)
$b = 1.0$							
$\delta = 0.0$	1.5385	0.0000	0.0000GDP	0.0000GDP	0.4115GDP	0.5100GDP	$-\infty$
$\delta = 0.1$	1.3849	1.3721	0.1174	0.1455	0.4115	0.5100	3.5044
$\delta = 0.2$	1.2313	2.7440	0.2348	0.2929	0.4115	0.5100	1.7524
$b = 0.5$							
$\delta = 0.0$	1.2127	2.9102	0.2490	0.3085	0.4115	0.5100	1.6523
$\delta = 0.1$	1.0917	3.9908	0.3414	0.4321	0.4115	0.5100	1.2049
$\delta = 0.2$	0.9708	5.0711	0.4339	0.5376	0.4115	0.5100	0.9482
$b = 0.2$							
$\delta = 0.0$	1.0761	4.1302	0.3534	0.4378	0.4115	0.5100	1.1643
$\delta = 0.1$	0.9689	5.0886	0.4354	0.5394	0.4115	0.5100	0.9450
$\delta = 0.2$	0.8616	6.0468	0.5173	0.6410	0.4115	0.5100	0.7952

Notes: Col. (1) indicates the responsiveness of nominal interest rates to inflation in a closed economy. Col. (2) presents inflation-induced changes in after-tax prices of retirement consumption in closed economies. Col. (3) presents inflation-induced changes in portions of deadweight losses in closed economies corresponding to intertemporal consumption distortions. Col. (4) presents inflation-induced changes in personal income tax revenues in closed economies. Col. (5) presents inflation-induced changes in deadweight losses in open economies corresponding to intertemporal consumption distortions. Col. (6) presents inflation-induced changes in personal income tax revenues in open economies. Col. (7) presents ratios of changes in domestic welfare arising from intertemporal consumption distortions in open and closed economies.

The parameter b denotes the fraction of domestic investment financed at the margin by debt, and δ is a measure of the degree to which depreciation accounting for tax purposes is sensitive to inflation ($\delta = 0$ corresponds to zero sensitivity, or economic depreciation). The calculations take the domestic tax rate on interest income to be equal to the domestic tax rate on capital gains ($\theta = c$). The domestic inflation rate, π, is assumed to be 2.0 percent, and the nominal interest rate, r, is assumed to be 7.0 percent. The calculations also assume a zero elasticity of saving with respect to the real rate of return ($\eta_{S_r} = 0$) and that the shadow value of tax revenue is 1.4 ($\lambda = 0.4$).

$(dp_2^a/d\pi)^{\text{closed}} > (dp_2^a/d\pi)^{\text{open}}$ and the efficiency costs of interactions between inflation and personal taxes in closed economies exceed those in open economies. In a reference case in which $b = 0.5$ and $\delta = 0.1$, open economies are characterized by 20 percent greater deadweight losses from interactions with personal taxation than are closed economies.[18]

Inflation is responsible for the following deadweight losses through its interaction with corporate taxes:

$$\frac{d\text{DWL}_c}{d\pi} = [f' - (r - \pi)]\frac{df'}{d\pi}\gamma. \tag{33}$$

The associated revenue consequences are

$$\frac{d\text{REV}_c}{d\pi} = \frac{df'}{d\pi}K - [f' - (r - \pi)]\frac{df'}{d\pi}\gamma, \tag{34}$$

where

$$\frac{df'}{d\pi} = \frac{1}{1 - \tau}\left[\frac{dr}{d\pi}(1 - b\tau) - (1 - \delta)\right].$$

In order to calibrate γ, we assume that the economy has a Cobb-Douglas production function and corresponding unit elasticity of capital demand. In order to make the results comparable with the analysis of intertemporal consumption distortions, we further assume the capital stock to be twice the size of GDP.

Distinctions between open and closed economies are reflected in values of $dr/d\pi$ and $df'/d\pi$. In a closed economy with zero uncompensated saving elasticity, inflation does not affect the size of the capital stock. However, in calculating the welfare consequences of inflation, it is important to incorporate the fact that if individuals are compensated for real income changes due to inflation, the size of the capital stock will change. Accordingly, deadweight loss calculations must be performed in a setting in which inflation affects the size of the capital stock in a closed economy—even though the uncompensated saving elasticity is zero. In open economies, the interaction between corporate taxes and inflation generates further distortions through international capital flows. Table 6.4 provides estimates of equations (33) and (34) under different scenarios in a manner comparable to the presentation in table 6.3.

Column (1) of table 6.4 indicates the responsiveness of the marginal product of capital to inflation and, as such, reflects whether investment flows into or out of the inflating economy. The entries correspond to those presented in table 6.1 in that their signs depend on the relative magnitude of δ and the product of b and τ. Column (2) indicates the size of the existing tax wedge, $f' - (r - \pi)$. Signs of entries in columns (1) and (2) of table 6.4 determine the sign of the

18. Auerbach (1978) calculates a value of $\delta = 0.23$ for the U.S. tax system in the 1970s. Subsequent U.S. tax changes have reduced the inflation sensitivity of the present value of depreciation allowances, making $\delta = 0.10$ a reasonable base case.

Table 6.4 Deadweight Loss and Revenue of Domestic Inflation in Open and Closed Economies: Corporate Income Taxation

	$\left(\frac{df'}{d\pi}\right)^{\text{open}}$ (1)	$f' - (r - \pi)$ (2)	$\left(\frac{d\text{DWL}_c}{d\pi}\right)^{\text{closed}}$ (3)	$\left(\frac{d\text{REV}_c}{d\pi}\right)^{\text{closed}}$ (4)	$\left(\frac{d\text{DWL}_c}{d\pi}\right)^{\text{open}}$ (5)	$\left(\frac{d\text{REV}_c}{d\pi}\right)^{\text{open}}$ (6)	$\frac{dSW_c^{\text{open}}}{d\pi} \Big/ \frac{dSW_c^{\text{closed}}}{d\pi}$ (7)
$b = 1.0$							
$\delta = 0.0$	−0.5385	−0.0108	0.0000GDP	0.0000GDP	0.2956GDP	−1.3725GDP	$-\infty$
$\delta = 0.1$	−0.3846	−0.0077	−0.0001	0.0006	0.1399	−0.9091	−1518.1529
$\delta = 0.2$	−0.2308	−0.0046	−0.0001	0.0012	0.0469	−0.5085	−424.4788
$b = 0.5$							
$\delta = 0.0$	−0.2692	0.0081	0.0002	0.0013	−0.0749	−0.4636	−364.8884
$\delta = 0.1$	−0.1154	0.0112	0.0004	0.0017	−0.0421	−0.1887	−108.3006
$\delta = 0.2$	0.0385	0.0142	0.0006	0.0022	0.0170	0.0599	27.0485
$b = 0.2$							
$\delta = 0.0$	−0.1077	0.0194	0.0007	0.0018	−0.0602	−0.1552	−86.0827
$\delta = 0.1$	0.0462	0.0225	0.0010	0.0022	0.0286	0.0637	28.6728
$\delta = 0.2$	0.2000	0.0256	0.0013	0.0026	0.1352	0.2648	100.3005

Notes: Col. (1) indicates the responsiveness of marginal products of capital to inflation in open economies. Col. (2) presents tax and inflation-induced differences between marginal products of capital and pretax real rates of return. Col. (3) presents inflation-induced changes in portions of deadweight losses in closed economies corresponding to investment distortions. Col. (4) presents inflation-induced changes in corporate tax revenues in closed economies. Col. (5) presents inflation-induced changes in portions of deadweight losses in open economies corresponding to investment distortions. Col. (6) presents inflation-induced changes in corporate tax revenues in open economies. Col. (7) presents ratios of inflation-induced changes in social welfare due to corporate taxation in open and closed economies.

The parameter b denotes the fraction of domestic investment financed at the margin by debt, and δ is a measure of the degree to which depreciation accounting for tax purposes is sensitive to inflation ($\delta = 0$ corresponds to zero sensitivity, or economic depreciation). The calculations take the domestic tax rate on interest income to be equal to the domestic tax rate on capital gains ($\theta = c$). The domestic inflation rate, π, is assumed to be 2.0 percent, and the nominal interest rate, r, is assumed to be 7.0 percent. The calculations also assume a zero elasticity of saving with respect to the real rate of return ($\eta_{S_r} = 0$) and that the shadow value of tax revenue is 1.4 ($\lambda = 0.4$).

impact of inflation on investment efficiency. Common signs indicate either that the effective tax wedge is negative and inflation is associated with greater investment or that the effective tax wedge is positive and inflation is associated with reduced investment. In either of these cases, higher rates of inflation are associated with greater deadweight loss. Given the small size of inflation-induced deadweight loss in the closed economy, the ratio of deadweight losses from corporate taxes in open and closed economies approximates $\pm\infty$. In the base case of $b = 0.5$ and $\delta = 0.1$, the signs of the two components of deadweight loss differ (there is a positive effective tax wedge while higher inflation rates increase investment), so higher rates of inflation reduce deadweight loss.

Table 6.5 summarizes the results of tables 6.3 and 6.4. Note that the ratios in column (5) typically exceed unity and that the deadweight losses due to taxes in open economies range from 0.2006GDP to 1.0522GDP. These values suggest that the efficiency gain from reducing inflation by 2 percent is bounded by 0.40 percent of GDP per year and 2.10 percent of GDP per year. In the base case of $b = 0.5$ and $\delta = 0.1$, the inflating economy experiences 40 percent greater inflation-induced welfare loss when open relative to when it is closed to the rest of the world. In this context, it is noteworthy that the closed economy deadweight losses from inflation, with the exception of the case of all-debt financing and economic depreciation, are not trivial. The results in tables 6.3, 6.4, and 6.5 are not sensitive to the assumption of a foreign inflation rate as equations (30), (32), (33), and (34) are functions of $dr/d\pi$ and not π^*.

Table 6.6 outlines the relevant welfare considerations for the rest of the world. Columns (1), (2), and (3) detail the welfare impact of distortions to intertemporal consumption choices. These results are directly linked to the results on $dr^*/d\pi$ presented in column (2) of table 6.2.[19] Note that when the foreign nominal interest rate rises with domestic inflation ($dr^*/d\pi > 0$), the foreign after-tax price of consumption declines ($dp_2^{a*}/d\pi < 0$) and, consequently, foreign welfare improves. Foreign parameters match the base case of the inflating economy ($b^* = 0.5$, $\tau^* = 0.35$, $\delta^* = 0.1$, and $\theta^* = 0.35$). At these parameter values, there exists a positive investment tax wedge, and signs of the figures in column (4) correspond to the direction of investment flows in response to domestic inflation. Column (7) aggregates the world welfare consequences of inflation in open and closed economies. In the base case, the impact of inflation on world welfare is 49 percent greater when the inflating economy is open than when it is closed.

6.5 Imperfect Capital Mobility

The validity of the assumption that capital is perfectly mobile internationally is frequently questioned on the basis of the persistent correlation between

19. Note that the values of $dr^*/d\pi$ presented in table 6.2 are based on calculations using uncompensated saving elasticities, while the values of $dr^*/d\pi$ used in the welfare analysis are based on calculations using compensated saving elasticities. Implied values of $dr^*/d\pi$ only differ slightly between these two cases.

Table 6.5 Welfare Effects of Domestic Inflation in Open and Closed Economies: Summary Table

	$\left(\frac{dSW_p}{d\pi}\right)^{closed}$ (1)	$\left(\frac{dSW_c}{d\pi}\right)^{closed}$ (2)	$\left(\frac{dSW_p}{d\pi}\right)^{open}$ (3)	$\left(\frac{dSW_c}{d\pi}\right)^{open}$ (4)	$\frac{dSW^{open}}{d\pi} \Big/ \frac{dSW^{closed}}{d\pi}$ (5)
$b = 1.0$					
$\delta = 0.0$	0.0000GDP	0.0000GDP	−0.2075GDP	−0.8446GDP	$-\infty$
$\delta = 0.1$	−0.0592	0.0003	−0.2075	−0.5035	12.0756
$\delta = 0.2$	−0.1184	0.0006	−0.2075	−0.2503	3.8859
$b = 0.5$					
$\delta = 0.0$	−0.1256	0.0003	−0.2075	−0.1105	2.5387
$\delta = 0.1$	−0.1722	0.0003	−0.2075	−0.0334	1.4013
$\delta = 0.2$	−0.2188	0.0003	−0.2075	0.0069	0.9177
$b = 0.2$					
$\delta = 0.0$	−0.1782	0.0000	−0.2075	−0.0019	1.1751
$\delta = 0.1$	−0.2196	−0.0001	−0.2075	−0.0031	0.9588
$\delta = 0.2$	−0.2609	−0.0003	−0.2075	−0.0293	0.9066

Notes: Col. (1) presents inflation-induced changes in social welfare due to personal taxation in closed economies. Col. (2) presents inflation-induced changes in social welfare due to corporate taxation in closed economies. Col. (3) presents inflation-induced changes in social welfare due to personal taxation in open economies. Col. (4) presents inflation-induced changes in social welfare due to corporate taxation in open economies. Col. (5) presents the ratios of inflation-induced changes in social welfare due to personal and corporate taxation in closed and open economies.

The parameter b denotes the fraction of domestic investment financed at the margin by debt, and δ is a measure of the degree to which depreciation accounting for tax purposes is sensitive to inflation ($\delta = 0$ corresponds to zero sensitivity, or economic depreciation). The calculations take the domestic tax rate on interest income to be equal to the domestic tax rate on capital gains ($\theta = c$). The domestic inflation rate, π, is assumed to be 2.0 percent, and the nominal interest rate, r, is assumed to be 7.0 percent. The calculations also assume a zero elasticity of saving with respect to the real rate of return ($\eta_{S_r} = 0$) and that the shadow value of tax revenue is 1.4 ($\lambda = 0.4$).

Table 6.6 **Effects of Domestic Inflation on Foreign Economy and World Welfare**

	$\frac{d\mathrm{DWL}_p^*}{d\pi}$ (1)	$\frac{d\mathrm{REV}_p^*}{d\pi}$ (2)	$\frac{d\mathrm{SW}^*_p}{d\pi}$ (3)	$\frac{d\mathrm{DWL}_c^*}{d\pi}$ (4)	$\frac{d\mathrm{REV}_c^*}{d\pi}$ (5)	$\frac{d\mathrm{SW}_c^*}{d\pi}$ (6)	$\frac{d(\mathrm{SW}^{\text{open}} + \mathrm{SW}^*)}{d\pi} \Big/ \frac{d\mathrm{SW}^{\text{closed}}}{d\pi}$ (7)
$b = 1.0$							
$\delta = 0.0$	−0.3244GDP	−0.4019GDP	0.1636GDP	0.1965GDP	−0.0881GDP	−0.2317GDP	$-\infty$
$\delta = 0.1$	−0.2318	−0.2873	0.1169	0.1404	−0.0630	−0.1656	12.9025
$\delta = 0.2$	−0.1393	−0.1727	0.0703	0.0844	−0.0378	−0.0995	4.1343
$b = 0.5$							
$\delta = 0.0$	−0.1626	−0.2014	0.0820	0.0985	−0.0441	−0.1161	2.8112
$\delta = 0.1$	−0.0701	−0.0869	0.0354	0.0425	−0.0190	−0.0501	1.4869
$\delta = 0.2$	0.0223	0.0276	−0.0113	0.0135	0.0061	0.0159	0.8963
$b = 0.2$							
$\delta = 0.0$	−0.0656	−0.0813	0.0331	0.0397	−0.0178	−0.0469	1.2524
$\delta = 0.1$	0.0268	0.0332	−0.0135	−0.0162	0.0073	0.0192	0.9332
$\delta = 0.2$	0.1192	0.1477	−0.0601	−0.0722	0.0324	0.0852	0.8108

Notes: Col. (1) presents inflation-induced changes in portions of deadweight loss in the rest of the world corresponding to intertemporal consumption distortions. Col. (2) presents inflation-induced changes in personal income tax revenues in the rest of the world. Col. (3) presents inflation-induced changes in foreign welfare arising from intertemporal consumption distortions. Col. (4) presents inflation-induced changes in the portions of deadweight loss in the rest of the world corresponding to investment distortions. Col. (5) presents inflation-induced changes in corporate tax revenue in the rest of the world. Col. (6) presents inflation-induced changes in social welfare in the rest of the world arising from corporate taxation. Col. (7) presents the ratios of inflation-induced changes in world welfare when inflating economies are open and closed.

The parameter b denotes the fraction of domestic investment financed at the margin by debt, and δ is a measure of the degree to which depreciation accounting for tax purposes is sensitive to inflation ($\delta = 0$ corresponds to zero sensitivity, or economic depreciation). The calculations take the domestic tax rate on interest income to be equal to the domestic tax rate on capital gains ($\theta = c$). The domestic inflation rate, π, is assumed to be 2.0 percent, and the nominal interest rate, r, is assumed to be 7.0 percent. The calculations also assume a zero elasticity of saving with respect to the real rate of return ($\eta_{s,r} = 0$) and that the shadow value of tax revenue is 1.4 ($\lambda = 0.4$). Foreign parameters are fixed at $\pi^* = 0$ percent, $b^* = 0.5$, $\delta^* = 0.1$, $\tau^* = 35$ percent, and $\theta^* = 35$ percent.

saving and investment for a variety of countries and the widespread home bias in domestic portfolios.[20] The economic significance of imperfect capital mobility is a matter of some dispute. In the present context, it suggests that capital might not flow in sufficient volume to inflating countries in order to maintain local before-tax real interest rates at world levels. Such a failure to equate real interest rates implies a failure of arbitrage that is consistent with profit-maximizing behavior only if lenders incur some costs associated with international capital flows. In order to examine the implications of imperfect international capital mobility, this section analyzes a model in which such costs are present.

The most convenient way to introduce the model of imperfect capital mobility is to specify the reaction of domestic interest rates to inflation. Specifically, suppose that

$$\frac{dr}{d\pi} = 1 + \mu, \tag{35}$$

in which μ is a free parameter that is zero if capital is perfectly mobile internationally and is nonzero if capital mobility is limited by some kind of transactions cost. The value of μ takes the same sign as the value of $dr/d\pi - 1$ in an otherwise equivalent closed economy. Of course, μ is not a choice variable but instead a function of transactions costs as well as the supply and demand conditions for world capital. For the moment, it is useful to take μ to be a given parameter that represents costs associated with information gathering or a reduction in return attributable to gains from diversification.[21]

The effect of domestic inflation on domestic saving is then no longer represented by equation (10), instead becoming

$$\frac{dS}{d\pi} = \frac{dS}{dr}[(1 - \theta)(1 + \mu) - 1] = \frac{dS}{dr}[-\theta + \mu(1 - \theta)]. \tag{36}$$

In a similar manner, the effect of domestic inflation on domestic investment becomes a function of μ. Combining equations (4), (5), and (35) yields

$$\frac{dK}{d\pi} = -\gamma\left[\frac{\delta - \beta}{1 - \tau} + b - \frac{(1 - b)(c - \theta)}{(1 - \tau)(1 - \theta)} + \frac{\mu(1 - \tau b)}{1 - \tau}\right]. \tag{37}$$

20. On the saving-investment correlation, see Feldstein and Horioka (1980) and Frankel (1991). French and Poterba (1991), Tesar and Warner (1994, 1995), and Cooper and Kaplanis (1994) provide evidence of the home bias phenomenon. These studies assess possible causes of limited international diversification—such as high transactions costs or the desire to hedge against deviations from PPP—and reject these hypotheses.

21. Note that this specification of the transactions costs associated with international capital mobility does not parallel the "iceberg" models of international trade but rather posits that transactions costs are current instead of capital costs. Furthermore, the costs are assumed to be tax deductible—which is sensible if, for example, the costs take the form of payments to market analysts or reduced risk-adjusted returns.

Equilibrium in the capital market requires equality of world inflation-induced capital supply and capital demand changes, which in turn requires that equation (15) be modified in the presence of imperfect capital mobility to

$$\frac{dr^*}{d\pi} =$$

$$(38)\quad \frac{1}{\psi}\left[\frac{(\theta-\mu(1-\theta))\dfrac{dS}{dr}-\gamma\left(\dfrac{\delta-b}{1-\tau}+b+\dfrac{(1-b)(c-\theta)}{(1-\tau)(1-\theta)}+\dfrac{\mu(1-\tau b)}{1-\tau}\right)}{\dfrac{dS}{dr}(1-\theta^*)+\dfrac{\gamma}{1-\tau^*}(1-b^*\tau^*)}\right].$$

This value of $dr^*/d\pi$ in turn determines $dK^*/d\pi$, $dS^*/d\pi$, and the welfare effects associated with the behavioral responses.

Comparing equation (36) with equation (10), (37) with (6), and (38) with (15), it is clear that the introduction of imperfect capital mobility limits the reduction in domestic saving and the change in domestic investment associated with inflation. Furthermore, imperfect capital mobility reduces the effect of domestic inflation on the world interest rate. This analysis of capital immobility is comparable with the closed economy analysis of Feldstein (1976). In the context of economic depreciation, equal tax rates, and all-debt financing ($\tau = \theta$, $b = 1$, and $\delta = 0$), μ is bounded between 0, for perfectly mobile capital markets, and $\tau/(1-\tau)$, for closed economies. When $\mu = \tau/(1-\tau)$, the economy is effectively closed, and as a result, domestic saving and investment are unaffected by inflation.

Imperfect international capital mobility introduces two other potentially important differences to the welfare analysis of inflation. The first is that inflation may have a first-order effect on the terms at which a country can borrow and consequently may be responsible for income redistribution between foreigners and domestic residents. The second is that the transactions costs associated with international capital mobility must be incorporated into the welfare analysis since inflation that reallocates capital internationally is responsible for these additional costs.

The real rate of interest paid on borrowing by the home country is $r - \pi$, so the effect of inflation on the home country's real borrowing cost is $dr/d\pi - 1 = \mu$. As the home country borrows net capital equal to $K - S$ from the rest of the world, a small change in domestic inflation is responsible for a wealth transfer from home country residents of an amount equal to $\mu(K - S)$. Foreign lenders do not receive all of this amount, however, since the return on their inframarginal lending rises by $(dr^*/d\pi)(K - S)$. The parameter μ differs from $dr^*/d\pi$ due to the deadweight losses that accompany saving and investment distortions as well as the adjustment costs incurred as a result of inflation-induced changes in net international lending.

Putting these pieces together, the impact of inflation on domestic welfare is in part given by equations (16) and (23), properly modified to incorporate the behavioral effects described by equations (36) and (37). In addition, if the home country is a capital importer, domestic residents lose $\mu(K - S)$ with every unit change in inflation. Hence the effect of inflation on welfare in the home country is given by

$$\begin{aligned}\frac{d\text{DWL}}{d\pi} = {} & \frac{\gamma}{(1-\tau)^2}[\delta - \tau b + \mu(1 - \tau b)][r\tau(1-b) + \pi(\delta - \tau)] \\ & -T[1-(1+\mu)(1-\theta)]p_2^a \frac{dC_2}{dp_2^a}(p_2^a - p_2^b) + \mu(K - S),\end{aligned} \tag{39}$$

in which the last component, $\mu(K - S)$, represents a wealth transfer and not inefficiency.

In order to examine the impact of imperfect capital mobility on the welfare of the rest of the world, it is necessary to specify the costs associated with imperfect capital mobility. The equilibrium condition is that small changes in inflation in a small open economy cannot affect net-of-adjustment-cost real rates of return available to foreign lenders. Hence, it must be the case that marginal adjustment costs equal the difference between real rates of return at home and abroad, $(r^* - \pi^*) - (r - \pi)$, and the change in adjustment costs for which a small change in inflation is responsible equals

$$\left(\frac{dK}{d\pi} - \frac{dS}{d\pi}\right)[(r - \pi) - (r^* - \pi^*)]. \tag{40}$$

The reduction in foreign welfare that accompanies a domestic inflation is in part given by equations (24) and (25), properly modified to incorporate equation (38). In addition, foreign residents gain an amount after adjustment costs equal to

$$\mu(K - S) - \left(\frac{dK}{d\pi} - \frac{dS}{d\pi}\right)[(r - \pi) - (r^* - \pi^*)]. \tag{41}$$

Additional restrictions on the form of adjustment costs permit equation (41) to be further simplified. Consider, for example, the case of quadratic adjustment costs, in which $\mu = \zeta(\pi - \pi^*)$. This specification implies that $(r - \pi) - (r^* - \pi^*) = (\mu/2)(\pi - \pi^*)$, so the inflation-induced income transfer to foreigners, net of adjustment costs, is

$$\mu\left[(K - S) - \left(\frac{dK}{d\pi} - \frac{dS}{d\pi}\right)\frac{\pi - \pi^*}{2}\right]. \tag{42}$$

For small values of μ and π, $dK/d\pi$ and $dS/d\pi$ are unaffected by π, and $K - S \cong (dK/d\pi - dS/d\pi)(\pi - \pi^*)$. Imposing this approximation implies that half of the income transfer to foreigners is lost in transactions costs, and the net welfare gain for foreign residents from domestic inflation is given by

$$\begin{aligned} \frac{d\mathrm{DWL}^*}{d\pi} &= T\frac{dr^*}{d\pi}(1-\theta^*)p_2^{a^*}(p_2^{a^*}-p_2^{b^*})\frac{dC_2^*}{dp_2^{a^*}} \\ &+ \frac{\gamma^*}{1-\tau^*}[r^*\tau^*(1-b^*)+\pi^*(\delta^*-\tau^*)]\frac{dr^*}{d\pi}(1-b^*\tau^*) \qquad (43) \\ &-\frac{\mu}{2}(K-S), \end{aligned}$$

in which the last piece, $(\mu/2)(K - S)$, is the income transfer to foreigners, and $dr^*/d\pi$ is given by equation (38). Imperfect capital mobility has an indeterminate effect on world welfare. There are important scenarios in which imperfect capital mobility reduces inflation-induced capital reallocations and associated deadweight losses. At the same time, however, capital immobility reflects transactions costs for which inflation may be partly responsible. As a result, the net welfare effects of inflation-tax interactions with imperfect capital mobility are case specific.

6.6 Foreign Direct Investment

The analysis to this point considers investments that are financed through a combination of equity held by domestic residents and debt that may be held by either domestic or foreign residents. Consequently, the only form in which international investment is undertaken is by cross-border portfolio lending. There are at least two other important possibilities. The first is cross-border individual investing in equities. International investment seldom takes this form, and as Gordon (1986) notes, the effect of inflation on equilibrium capital flows with cross-border equity holdings is unlikely to differ significantly from the effect of inflation when international capital flows are limited to portfolio investments. Consequently, little realism is lost by abstracting from the ability of investors to hold foreign equities.

The second important alternative possibility is that some foreign investments are undertaken by domestic firms with controlling interests in their foreign operations. Foreign direct investment of this type may have different financial characteristics than local operations in foreign countries and typically receives different tax treatment from home countries.[22] It is, however, important to note that foreign direct investments almost uniformly receive the same tax treatment from host countries as do local firms. Consequently, the significance of foreign direct investment to the effect of inflation on international capital flows and associated welfare costs is that its financing may differ from

22. See Hines (1997) for a review of the practice and effect of taxing foreign direct investment.

the financing arrangements of local firms. Given the small size of foreign direct investment relative to portfolio capital flows and the modest difference between its incentives and those of portfolio investors, treating all cross-border investment as portfolio flows offers a reasonable approximation to a complete treatment of cross-border investment.

6.7 Conclusion

The results reported in this paper indicate that there are important efficiency implications of the international dimensions of inflation-tax interactions. In particular, inflation in one country can generate sizable international capital flows with attendant changes in domestic and foreign welfare. The central mechanism for these flows is the ability of foreign savers to convert the inflation component of their nominal interest receipts into a foreign exchange loss, while domestic savers do not have the ability to do so. As a consequence, inflation discourages domestic saving and encourages domestic investment by reducing the after-tax rate of return, and foreign saving must finance the resulting difference.[23] The translation of these capital flows into efficiency terms indicates that inflation-tax interactions yield distortions of possibly much greater magnitude in open economies than they do in closed economies. In part, this difference reflects the greater mobility of capital in an open economy and the larger deadweight loss that therefore accompanies any given tax-induced distortion.

This analysis of inflation-tax interactions in open economies departs from the earlier work of Hartman (1979) in three ways. The first is to note that capital need not flow to inflating countries, since the direction of capital flow depends on the details of an inflating country's tax system. The second is to stress the related idea that as a consequence of these flows, domestic inflation influences world interest rates. Even though the size of a small economy's effect on world interest rates is barely perceptible, the resulting welfare effect may be quite large because the world interest rate influences an extremely large base of capital. The third departure is to measure the impact of inflation-induced capital flows on economic welfare at home and in the rest of the world.

The paper does not analyze certain consequences of inflation. The analysis does not include estimates of the lump-sum income redistributions that accompany unanticipated changes in inflation, nor does it include the effects of possible disruptions to import and export markets that may react sluggishly to real exchange rate changes. The one-sector model does not capture distortions created by subsidizing specific assets, such as owner-occupied housing. In addition, the analysis considers only permanent changes in inflation rates. Transitory inflation changes current costs of holding assets without necessarily

23. Desai (1997) offers evidence that this open economy result may explain the empirical regularity, noted by Romer (1993), that more open economies have lower inflation rates.

changing future costs, thereby generating deadweight losses that differ from those analyzed in the paper. The analysis does not incorporate any of the costs associated with the credibility of future monetary policy for which inflation may be responsible and abstracts entirely from the macroeconomic effects of inflation.

In spite of these omissions, the results in the paper identify an important possible motivation for monetary and fiscal policy coordination between countries. The welfare consequences of domestic inflation are greatly amplified if the home country's inflation rate exceeds world levels and are reduced as inflation rates are equalized across countries. It may not, however, be in the perceived interest of all countries to harmonize their inflation rates because deviations from a common inflation rate may improve the welfare of deviating countries at the expense of others. As an empirical matter, countries typically select different inflation targets. The point of this paper is to explore the welfare consequences of such heterogeneous inflation experiences in open economies. The results indicate that the effects of inflation in open economies may be far more dramatic, both for home countries and for the world, than are the equivalent welfare effects of inflation in closed economies.

Appendix

The purpose of this appendix is to identify the closed economy model that is the basis of the welfare comparisons presented in section 6.4. Using the same notation introduced earlier in the paper, capital market equilibrium in a closed economy implies that any inflation-induced saving changes are matched exactly by inflation-induced investment changes:

$$\text{(A1)} \qquad \frac{dS}{d\pi} = \frac{dK}{d\pi},$$

which in turn implies

$$\text{(A2)} \quad \frac{dS}{d\pi}\left[\frac{dr}{d\pi}(1-\theta) - 1\right] = -\gamma\left\{\frac{dr}{d\pi}\frac{1-b\tau}{1-\tau} - \left[\frac{(1-b)(1-c)}{(1-\tau)(1-\theta)} - \frac{\delta - b}{1-\tau}\right]\right\}.$$

This equality implies an effect of inflation on nominal interest rates in a closed economy:

$$\text{(A3)} \quad \left(\frac{dr}{d\pi}\right)^{\text{closed}} = \frac{\dfrac{\gamma}{1-\tau}\left[\dfrac{(1-b)(1-c)}{1-\theta} - \delta + b\right] + \dfrac{dS}{dr}}{\dfrac{dS}{dr}(1-\theta) + \dfrac{\gamma(1-b\tau)}{1-\tau}}.$$

In order to identify the distortions associated with the interaction of inflation and personal taxation in a closed economy, equation (A3) can be used to indicate the effect of inflation on the after-tax price of retirement consumption:

$$\text{(A4)}\quad \left(\frac{dp_2^a}{d\pi}\right)^{\text{closed}} = T\left[1 - \left(\frac{dr}{d\pi}\right)^{\text{closed}}(1 - \theta)\right]p_2^a \frac{1}{1 + r(1 - \theta) - \pi}.$$

Similarly, the distortions associated with the interaction of inflation and corporate taxation in a closed economy depend on the effect of inflation on marginal products of capital:

$$\text{(A5)}\quad \left(\frac{df'}{d\pi}\right)^{\text{closed}} = \frac{1}{1 - \tau}\left[\left(\frac{dr}{d\pi}\right)^{\text{closed}}(1 - b\tau) - (1 - \delta)\right].$$

The values of $(dp_2^a/d\pi)^{\text{closed}}$ and $(df'/d\pi)^{\text{closed}}$ implied by equations (A4) and (A5) can then be used to determine the relevant welfare components of the effect of inflation—as in $d\text{DWL}_p/d\pi$ in equation (31), $d\text{DWL}_c/d\pi$ in equation (33), $d\text{REV}_p/d\pi$ in equation (32), and $d\text{REV}_c/d\pi$ in equation (34)—in a closed economy.

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Comment Jeffrey A. Frankel

The paper by Mihir Desai and James Hines is a welcome contribution to knowledge at the intersection of international finance and tax analysis, an understudied area that we international economists have largely left to the public finance people by default. One might suppose that the major lessons here have to do with international differences in tax rates. But as I read this literature, the public finance economists have concluded, correctly, that interaction of the tax parameters with international differences in inflation rates and interest rates can dwarf the effects of the simple tax differences. The Desai-Hines paper concludes that inflation in open economies reallocates capital internationally, with large adverse implications for efficiency. The result that inflation might be more harmful in an open economy than a closed economy would be an example of the "theory of the second best": eliminating one distortion (capital controls) is not necessarily good if there exist other distortions (taxes and inflation). The surprising aspect of the model is that capital can flow into the inflating country.

The approach follows Hartman (1979), an open economy version of the analysis of the effect of inflation on nominal interest rates. The Feldstein-Darby (closed economy) answer to that question was that the nominal interest rate rises *more* than the increase in the inflation rate, a nonneutrality. The reason is that savers demand no less: otherwise they would suffer a loss in the after-tax real rate of return. But what does it mean that savers demand no loss? What would they substitute into if the after-tax real rate of return were to fall?

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In closed economies, the answer is that they would save less or else shift into real assets. But these are not perfect substitutes. For example, in the 1970s, the after-tax real return was in fact negative. Savers were simply not able to protect themselves.

In an open economy, there is another, potentially more complete, escape: savers can take their money abroad. Does this then give us the Feldstein-Darby result (the "modified" or "tax-adjusted" Fisher effect)? Not necessarily: savers are also taxed on their foreign earnings, and the foreign inflation rate is not directly relevant to the domestic resident's purchasing power. The effect, rather, comes indirectly, via the foreign interest rate and exchange rate. In Hartman's open economy model, the Feldstein-Darby effect apparently vanishes because world capital markets apparently tie down the real interest rate. We are back to neutrality (the "traditional" Fisher effect).

Desai and Hines advance the analysis substantially by working out the inflation interactions of three kinds on nonneutralities: capital gains on exchange rate changes, the tax deductibility of nominal interest payments, and nominal depreciation allowances. This analysis is more complete than the earlier approaches.

I would like to raise a question about the fundamental framework, in which real interest rates would be equalized in the absence of tax factors. We know that real interest rates are not in fact equalized internationally. (Mishkin 1984 is one among many references cited in Frankel 1991.) U.S. real interest rates were above Japanese real rates in the 1980s, for example, and the same is probably again true now. Consider two possible explanations: imperfect capital mobility, defined as an observed discrepancy between the nominal interest differential and the expected rate of depreciation of the domestic currency, and a failure of purchasing power parity (PPP), defined as a discrepancy between the expected rate of depreciation of the domestic currency and the expected inflation differential.

Desai and Hines consider the imperfect mobility case in section 6.5, so let us begin there. They cite evidence of home bias in equity holdings, though I would rather cite the Feldstein-Horioka evidence on correlations between national saving and investment, and other evidence on the failure to equalize rates of returns. They have the Feldstein-Darby effect reemerging, presumably because savers can take their money abroad. The nominal interest rate rises by more than the inflation rate, with the difference denoted by μ. But μ is simply assumed: I would rather it be derived. This could be done by modeling the international flow of capital (or the stock of foreign holdings, in a portfolio balance model) as a function of the differential in expected returns. One must be careful to recognize that the decision of a resident about what assets to hold depends on how he or she is taxed on domestic versus foreign assets (not on the tax rate paid by domestic residents versus foreign residents). This means that under certain circumstances, tax rates can drop out, as can inflation rates.

Desai and Hines do it right for the case of perfect capital mobility. But the analysis is not shown for the case of imperfect capital mobility, so one cannot judge.

The authors do not consider the implications of the possible failure of PPP. Not surprising for public finance economists, but I as a macroeconomist tend to think in such terms. Some examples can illustrate why I think this macroeconomic dimension could be important. Consider a monetary expansion. The idea behind the Desai-Hines approach is that the inflation rate rises, leading to a large increase in the nominal interest rate and a capital inflow. But in monetary expansions I can recall (Japan in the late 1980s), interest rates fell, and capital flowed out, not in. In monetary contractions I can recall (the United Kingdom in 1979, the United States in 1980–82, Germany in 1991), interest rates rose, and capital flowed in, not out.

The interaction of the tax and macroeconomic effects could be modeled. Equation (1) is still right; but the expected rate of change of the exchange rate could be specified in either of two ways. It could be given by the change in the relative price of traded goods versus nontraded, as in the long-term postwar trend in the yen brought about by rapid Japanese productivity growth. Alternatively, the exchange rate could be expected to move in the direction of a long-term real equilibrium from which it has temporarily overshot, as in the Dornbusch overshooting model. The outcome would likely be that monetary expansion is associated with a low real interest rate, real depreciation of the currency, and net capital outflow, rather than a high real interest rate and net capital inflow.

The ready defense of the Desai-Hines model (and the other internationalized work of public finance economists) is that they are talking about the long run and that deviations from PPP disappear in the long run. It should be noted, however, that the short run can last longer than one thinks. The period over which a country's real interest rates can be high or low for pure monetary reasons can easily be as long as the period over which its tax parameters remain at a particular setting.

I agree with the paper's bottom line, that inflation can have bigger effects in an open economy than a closed one. But I am inclined to think it is because savers can take their money *out* of the country, rather than in.

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Discussion Summary

In response to the discussant's remarks, *Jim Hines* stated that he would like to remind the participants that he is not completely unaware of what international economists think, as his wife teaches international finance. When he first told her about this paper, she said, "You have got to be kidding." International economists think of at least six different channels through which inflation can affect capital flows, of which the inflation-tax interaction is the last. Whereas this may be justified for countries with very high inflation rates, for well-functioning economies Hines suggested that the inflation-tax interaction may play a prominent role.

Laurence Ball wondered whether it is possible to resolve empirically the question of the effect of inflation on capital flows, noting the recent paper by Bayoumi and Gagnon. The authors responded that Bayoumi and Gagnon look at OECD countries and assert that, empirically, capital flows are related to inflation in the same way that is predicted in the Desai-Hines model. However, the empirical evidence is not conclusive because it is difficult to control for the many other factors that influence capital flows.

Alan Auerbach asked the authors to clarify how it is possible that as capital flows get less elastic (as measured by the parameter μ) the deadweight loss increases. The authors responded that there are already distortions when capital flows are impeded in the initial situation. They presume that this is the source of the increase in deadweight loss.

Glenn Hubbard asked for an explanation of the parameter ψ in the Desai-Hines calculations. The authors responded that the parameter ψ is the ratio of the size of the rest of the world to the domestic economy, and this ratio is assumed to equal 10 in the simulations. A bigger ψ means that the effect of disinflation in the domestic economy on the world real interest rate is smaller but it will affect a larger world capital market. These opposing effects make the influence of ψ on the inflation effect on world welfare theoretically ambiguous.

Benjamin Friedman noted that the springboard for the analysis is the fact that a foreign lender can deduct from taxation the expected exchange rate depreciation caused by inflation in the domestic country. What happens if foreign countries also change their inflation rate? The authors responded that the welfare effects in the open economy case really depend on inflation differentials. If all countries inflate at the same rate, the analysis is the same as the closed economy analysis, assuming that tax systems are the same in all countries.

Andrew Abel inquired whether, in reality, one is taxed for transactions in the forward currency exchange market. The authors responded that after the Tax Reform Act of 1986, nominal exchange rate gains are taxed at the same rate as other interest income. Hence, in the model's notation, $\theta = g$. Most foreign countries try to do the same.

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