

# DISCUSSION PAPER SERIES

No. 6318

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THE ASIAN DEBT CRISIS: AN  
INTERTEMPORAL MODEL WITH REAL  
EXCHANGE RATE OVERSHOOTING**

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*INTERNATIONAL MACROECONOMICS*



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# **STIGLITZ VERSUS THE IMF ON THE ASIAN DEBT CRISIS: AN INTERTEMPORAL MODEL WITH REAL EXCHANGE RATE OVERSHOOTING**

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Discussion Paper No. 6318  
June 2007

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June 2007

## **ABSTRACT**

### **Stiglitz Versus the IMF on the Asian Debt Crisis: An Intertemporal Model with Real Exchange Rate Overshooting**

This paper develops a real model of financial crisis, and uses it to elucidate the controversy between Joe Stiglitz and the IMF concerning the Asian financial crisis. Borrowers of foreign capital are bound by lending contracts to pay the world rate of return on their borrowing, following an adverse shock; by assumption, they do not default. This is onerous, since the shock makes the marginal product of capital fall to less than the world rate of return, and creates a debt overhang on which interest must be paid. The country faces a choice. It could choose to pay these extra interest obligations on its debt overhang -- a transfer -- in every period, raise taxes in order to meet these obligations, and thereby gradually reduce capital to its new lower level, at which point there would no longer be a debt overhang. We describe this as the 'IMF strategy'. Alternatively the country could choose the 'Stiglitz strategy': it could immediately borrow internationally the sum of all the future interest obligations on its debt overhang, perhaps with the assistance of the IMF. It would need to raise taxes in order to meet the interest costs on that extra borrowing. But the fiscal cost of doing this would be finite and the fiscal costs would be equally spread across time. The short run tax burden would thus be smaller.

We show that balance sheet effects mean that the real exchange rate can greatly overshoot in the IMF strategy, whereas it need not overshoot in the Stiglitz strategy.

That will lessen the 'crisis' aspects of the short run responses to the shock.

JEL Classification: F31

Keywords: debt overhang, financial crisis and fiscal adjustment

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Submitted 06 May 2007

# 1 Introduction

We believe that the 1997 Asian crisis was caused by an opening up of a yield differential between the rate of return required in Asia by international investors, and the marginal revenue product of capital in Asian countries. The revenues of exporting firms weakened (MacLeod and Garnaut (1998), Corbett and Vines (1999), Corbett, Irwin, and Vines (2001)) And there were additional factors at work: estimates of non- performing credit and declining bank share value both speak of poor quality investment decisions in the leadup to the crisis (Burnside, Eichenbaum, and Rebelo (2001)) (also Eichengreen (2003), and McKibbin and Martin (1998)). And as the crisis unfolded a subsidy to investments was removed – in some cases only an implicit subsidy, as described by Krugman (1998), and a risk premium emerged on lending to many of the economies involved (McKibbin and Martin (1998)).

Since the crisis, third-generation currency-crisis models (Krugman (1999)) have argued that this shock caused a ‘crisis’ through balance sheet effects, resulting from borrowing in foreign currency by domestic firms, that resulted from ‘original sin’. As the value of the domestic currency fell in the crisis, the domestic value of the un-hedged foreign-currency liabilities rose relative to firms’ revenues, which as noted above, had been eroded. Resources needed to be transferred abroad to honour the interest obligations on these debts. Third generation models have argued that a crisis occurred because of the large cut in absorption which needed to be made in order to affect this transfer.

This paper – written to appear exactly ten years after the Asia crisis – studies this transfer problem in a much more formal way than has been done far. We use an amended two-sector RBC model to study what happens to a heavily indebted small, open, economy when the price of its exports permanently falls. We show three things.

First, we show that the balance-sheet effects do not depend on a devaluation of the currency. We use a *real* model and show that when a large gap between the marginal revenue product of capital and the world interest rate opens up, this can lead to the need for a large cut in absorption, and so to ‘crisis’. The eroded revenues of firms, and their fixed liabilities, are what cause the “balance sheet effect”. The cause of the crisis is that the required transfer of resources to foreign creditors is *not* adjusted at the same time as the external shock – because international investors have financed the investment by loans rather than – say – by equity finance, and because the obligations attached to these loans are not written down after the crisis.

Second, these balance sheet effects are greatly exacerbated by a ‘debt multiplier’ (Menzies and Vines (2002)). A fall in the price of traded goods, and in the rate of return in the traded goods sector can, in the short-term, lead to an even larger fall in the price of non-traded goods, and so in the rate of return on capital in the non-traded sector. This makes the burden of the transfer *larger* for non-traded-goods producers.

Third, we show that the size of these balance sheet effects depends on the fiscal framework which the government pursues. This last finding enables us to use our framework to explain, and pass judgment on, the controversy which occurred between the IMF (Fischer (2004) ) and Joe Stiglitz (Stiglitz (2002)) about the Asia crisis. Stiglitz argued that the IMF response to the crisis led to a much too contractionary fiscal policy. Fischer, in reply, argued that the IMF was, in fact, following something similar to the Stiglitz strategy. We conclude that there *was* a difference between the strategies: the IMF strategy aimed to raise taxes to as to limit fiscal deficits and force a relatively rapid adjustment. The Stiglitz strategy advocated fiscal shock absorption so as to enable smoothing consumption smoothing which may be important in a world of liquidity-constrained consumers. Our model enables us to compute the intertemporal outcomes for the two strategies, and to compare and welfare-rank these outcomes.

## 2 Stiglitz versus Fischer

Our overall story runs as follows. Owners of capital finance their holdings entirely by foreign borrowing. They are bound by lending contracts to foreign lenders, which oblige them to pay the world rate of interest on their borrowing, even following an adverse shock to the marginal product of capital in the economy being considered. This is a simplification: it ignores any writedowns on loans from abroad, in which lenders bear the loss caused by the reduction in export prices. We do this because that is what happened in the Asian crisis – by and large writedowns were avoided. However, as a benchmark, we compare the results from the Fischer scenario and the Stiglitz scenario with what would happen if loans were instead written down in proportion to the reduction in export prices.

The interest obligation is onerous, it creates a ‘flow debt overhang’ of interest which must be paid each period. In the absence of writedowns, the resulting losses make the firms go bankrupt – making for a clear link between the our yield-differential story and ‘third-generation balance-sheet models’. We assume that the government takes the bankrupt firms, bears the financial burden for their losses, and appoints managers charged with the mandate to minimize the present discounted value of the firms’ losses.

The country then faces a spectrum of choice. We name the two (polar) extremes the ‘Fischer’ (after Stan Fischer, who was at the time the First Deputy Managing Director of the IMF) and the ‘Stiglitz’ strategy.

The ‘Fischer strategy’ consists of the government paying these extra interest obligations on the debt overhang of firms – a transfer of resources abroad – in every period, raising taxes in order to do so. Over time, the managers of the loss-making firms, reduce the stock of capital to a new lower level, at which point there is no longer a debt overhang. The speed of adjustment of the capital stock is constrained by adjustment costs, but it is relatively rapid – as compared with the Stiglitz

strategy. Adjustment is also – in general – accompanied by a substantial overshooting of the real exchange rate. This is because the household sector is taxed a great deal in the immediately post-crisis periods, to enable the government to pay the outstanding interest obligations to foreign lenders. But because the household sector is assumed to be borrowing-constrained, it is unable to smooth its consumption over time, and so the tax leads to negative demand effects on consumption expenditure. That causes the demand for non-traded goods to fall, and so the price of non-tradable goods – i.e. the real exchange rate – falls. This fall in prices causes losses to grow there – which is why there is a more rapid reduction in the capital stock there. This real exchange rate overshoot is a central feature of what happened in many Asian countries: between mid 1997 and mid 1998 the Thai, Korean and Indonesian real effective exchange rates depreciated sharply, only to recover subsequently.

The fall in non traded goods prices causes the wage to fall, thereby reducing the tax base. As a result, the tax rate will need to be further increased, leading to further declines in demand, and in the price of non-tradable goods and wages, *etc. etc.*. This is the ‘debt multiplier’ process analysed by Menzies and Vines (2002).

In the long run, however, this ‘debt-overhang’ problem goes away with the Fischer strategy: the parts of the capital stock which became extra-marginal after the adverse shock are gradually removed, and so the debt abroad is reduced. As a result, debt overhang gradually goes away, and, as a result, the need for a tax on workers disappears. That is, the overhang, the tax, and the demand effects that depress the price of the non-tradable good, are all short-run phenomena.

The ‘Stiglitz strategy’ attempts to avoid the extreme sort-run adjustment implicit in the Fischer strategy. In our formalisation of the Stiglitz strategy we suppose that the country immediately borrows internationally an additional amount equal to the sum of (i) *all of* the future interest obligations on its debt overhang and (ii) all of the adjustment costs that it needs to pay to reduce its capital stock to the new lower long run level which it is appropriate for the country to have after the shock. (Since it is difficult to access private lending during an event like the Asian crisis, such extra lending might have to come from the IMF, although the actual identity of the lender is of no analytic consequence, providing the funds can be obtained somehow, at the going world interest rate. ) This extra borrowing implies a higher present discounted value of all taxes levied into the future, in order to meet the interest costs on the extra borrowing. In the long run, however, just as in the Fischer strategy, the parts of the capital stock which became extra-marginal after the adverse shock are gradually removed, and so the debt abroad is reduced. A point is reached where the returns on capital exactly cover the interest costs on the loans attached to that capital. But in this strategy there remains a need for *some* tax on workers – to cover the interest on the *extra* loans which the Stiglitz strategy has required, which we assume remain outstanding for ever. But in this strategy the taxes are equally spread across time and

are small. They are not – as in the Fischer strategy – concentrated in the period immediately after the shock, when – in the Fischer strategy – they are large. The short-run impact on real national income (and hence demand) would thus be smaller, possibly much smaller.

We also show that, in the Stiglitz strategy, the real exchange rate need not overshoot. This is because this alternative tax strategy enables the household sector to spread its consumption losses over time, cushioning demand. Although the households cannot, by assumption, themselves do consumption smoothing, the government, if it pursues the Stiglitz strategy, effectively does this for them. That lessens the ‘crisis’ aspects of the short run responses to the shock. But in this strategy, the tax increases which occur, although they are small, are permanent, and that lowers the long-run equilibrium level of consumption.

In the paper (and sometimes in reality) countries – even if they do not default, or write down debts – are not confined in their choices to only the IMF or Stiglitz strategies. We set up the model so that the share of the overhang financed by taxation is a parameter, allowing for a mix between taxation and borrowing (equivalently, allowing for budget deficits of different sizes, financed by overseas borrowing). In the final section of the paper, we investigate the choice of this parameter according to two criteria. First, it is chosen to smooth consumption, in which case a large degree of borrowing occurs for reasonable discount rates. Alternatively, it is chosen so as to minimise the present discounted value of firms’ losses, in which case almost no borrowing occurs. Thus, the model suggests that the IMF strategy – in which there is no extra borrowing by governments after the crisis – comes at the issue of debt resolution from the vantage point of a government wanting to minimise the losses of the bankrupt firms that it has taken over. By contrast the model suggests that the Stiglitz strategy is one which takes the side of consumers – attempting to smooth their consumption in the face of the downturn in revenue and enabling them to avoid large, short-lived reductions in consumption immediately after the downturn begins.

The paper is organised as follows. In the next section we set up the model and outline the two different scenarios. In Sections 4 we provide an analytical description of the long-run and short-run responses to the shock in Fischer scenario and the Stiglitz scenario, and we compare them both with what would emerge in the writedown scenario. The dynamics of adjustment for these cases, which result from simulations of the model, are presented in Section 5. Section 6 concludes.

### **3 The Model**

The model is a variant of the standard a two-good/two-factor Heckscher-Ohlin (HO) model of an open economy (Jones (1956)). This is adapted to capture three important things about the Asia-crisis economies: the model (i) identifies an important non-traded goods sector and (ii) includes

the possibility of capital accumulation and (iii) treats capital accumulation as entirely financed by borrowing from abroad. (See Menzies and Vines (2002) and Devarajan and Lewis (1990) and Devarajan, Lewis, and Robinson (1993)). And on capital borrowed by firms see a whole spate of recent CGE models. )

The economy contains two sectors, producing exportables, non-tradeables. The household sector, as in the HO model, also only consumes two kinds of goods: non-tradables and importables.<sup>1</sup> As in the HO model there is no intertemporal substitution on the part of consumers: they exactly spend their income in each time period. Our reason for assuming this is that it seems a good first approximation to assume that households in emerging market economies are predominantly borrowing-constrained.

We study the intertemporal accumulation of capital by producers, subject to adjustment costs. All capital is financed by borrowing from abroad by domestic producers, they must pay interest on this borrowing. They do this at an exogenous *world* rate of interest. (There is no risk premium. ) At any point of time the producers' borrowings of capital are fixed – and thus their stock of capital is fixed – but over time they adjust their holdings of capital to the desired levels, at which the marginal rate of return on capital is exactly equal to the world rate of interest at which they can borrow.

### 3.1 Setup

We use the subscript  $x$  for all variables for the exportables sector, the subscript  $m$  for variables relating to importables, and subscript  $n$  for variables relating to the non-tradable sector.

Output in the two sectors is given by a Cobb-Douglas production function

$$Q_x = K_x^{\alpha_x} L_x^{1-\alpha_x}, \tag{1}$$

$$Q_n = K_n^{\alpha_n} L_n^{1-\alpha_n}. \tag{2}$$

There is an inelastic supply of labour. Labour is mobile between sectors and the total amount of it is fixed:

$$L_x + L_n = \bar{L}. \tag{3}$$

The model is a real model, and all prices are expressed in terms of importables. We define the

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<sup>1</sup>This setup is the simplest way of producing what is still essentially a two-good treatment of an open economy, but one in which one of the goods is non-tradeable, something which we need in order to be able to discuss the loss in real income associate with the transfer problem in an interesting way. If we instead assumed that the country produces only one good, as in Krugman (1999), the country's exports of this good would have to be imperfect substitutes for foreign goods (i.e. exporters would have to face a downward-sloping demand curve. This may be a good starting point for analysis of an OECD country. But it is not a sensible starting point in which to begin thinking about an emerging market (Muscatelli, Shrinivasan, and Vines (1992), and Athukorala and Riedel (1994), and in Currie and Vines (1995)).

terms of trade ( $s$ ) and the real exchange rate ( $q$ ) as follows:

$$s = \frac{P_x}{P_m}, \quad q = \frac{P_n}{P_m}.$$

In this paper we aim to study the effects of a *permanent* fall in the price of exportables. We now describe the components of the model by discussing the three sets of actors in the model: consumers, producers, and fiscal policymakers. This will enable us to discuss the economy-wide outcomes of adjustment to this permanent shock.

### 3.2 Consumers

Workers consume a basket of nontradables and importables. The (instantaneous) utility of workers is given by

$$C = \ln(C_n^\theta C_m^{1-\theta}). \quad (4)$$

Consumers choose  $C_n$  and  $C_m$  optimally at each point in time, subject to the *static* budget constraint, which states that household consumption is equal to disposable income,  $Z$ , since by assumption consumers cannot borrow. This fact that consumers are liquidity constrained is a key feature of the model. We will discuss the determination of household disposable income  $Z$  in detail below.

$$C_m + qC_n = Z. \quad (5)$$

The Lagrangian for this problem is:

$$\mathcal{L} = \ln(C_n^\theta C_m^{1-\theta}) + \lambda(C_m + qC_n - Z) = \theta \ln C_n + (1 - \theta) \ln C_m + \lambda(C_m + qC_n - Z), \quad (6)$$

with first-order conditions:

$$\frac{\partial \mathcal{L}}{\partial C_n} = \frac{\theta}{C_n} + \lambda q = 0, \quad (7)$$

$$\frac{\partial \mathcal{L}}{\partial C_m} = \frac{(1 - \theta)}{C_m} + \lambda = 0. \quad (8)$$

Solving this system and using the expenditure function we obtain the consumer demand equations for the two goods<sup>2</sup>:

$$C_m = (1 - \theta) Z, \quad (9)$$

$$C_n = \frac{\theta}{q} Z. \quad (10)$$

The shock to export prices is going to make  $Z$  fall. Our purpose will be to show how  $C_n$  and  $C_m$  fall in response to this and the consequences of this for utility over time.

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<sup>2</sup>This pair of consumer demand equations is as simple as it is because of (i) the assumption of Cobb-Douglas preferences, and (ii) the ruling out of intertemporal borrowing by consumers.

### 3.3 Producers

Firms are normally owned by consumers. But when the crisis happens they all go bankrupt and are then taken over by the government. Firms normally maximise the present discounted value of profits, which are equal to revenues, minus payments of wages and of interest on payments for capital, minus payments of adjustment costs, which are quadratic in the level of investment (or in the level of disinvestment). After the crisis the government puts managers in charge of the bankrupt firms, who pursue the same objective as before (except that this now becomes minimising the present discounted value of losses). Capital consists of importables, and all of adjustment costs involve purchases of importables.<sup>3</sup> At each instant in time, producers in each sector choose labour input so that the marginal product of labour is equal to the own-product real wage. Capital cannot be moved instantaneously since it is assumed – as already noted – to have convex costs of adjustment. But, subject to these adjustment costs, firms adjust the stock of capital over time so as to maximise the present discounted values of profits. We will study the effects of a *permanent* fall in the price of exportables. This this will result in a new optimal lower level of capital in both sectors. This will mean that, at each point in time, firms choose the amount of capital they want to (un-) install.

#### 3.3.1 Exportables

For exportables, the profit maximisation problem can be written in real terms (*i. e.* expressed in terms of importables) as

$$\max_{L_x, I_x} \left( \Pi_x = \int_{t=0}^{\infty} e^{-rt} (sQ_x - wL_x - rK_x - J_x) dt \right). \quad (11)$$

The installation cost of one unit of investment good is taken as

$$J_x = \frac{\phi}{2} \frac{I_x^2}{K_x}. \quad (12)$$

With no capital depreciation, the capital accumulation equation is:

$$\dot{K}_x = I_x, \quad (13)$$

where  $I$  is the number of capital good units which are installed or removed. Formula (12) can be solved with respect to  $I_x$  to obtain the constraint

$$\dot{K}_x = I(K_x, J_x). \quad (14)$$

Therefore, the Hamiltonian for the exportable producer's problem is (with  $\eta_x = e^{-rt}\psi_x$ ):

$$\mathcal{H} = e^{-rt} (sK_x^{\alpha_x} L_x^{1-\alpha_x} - wL_x - rK_x - J_x) + e^{-rt}\psi_x I(K_x, J_x).$$

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<sup>3</sup>This restriction is made for simplicity. See Kuralbayeva and Vines (2006) for a similar model which does not make this restriction.

The first order condition with respect to labour yields the labour demand equation:

$$L_x = \left( \frac{s(1-\alpha_x)}{w} \right)^{\frac{1}{\alpha_x}} K_x. \quad (15)$$

The first order conditions with respect to investment spending  $J$  lead to the following equations:

$$\frac{\partial \mathcal{H}}{\partial J} = -e^{-rt} + e^{-rt} \psi_x I_J(K_x, J_x) = 0, \quad (16)$$

$$\frac{\partial \mathcal{H}}{\partial K} = e^{-rt} (\alpha_x s K_x^{\alpha_x-1} L_x^{1-\alpha_x} - r) + e^{-rt} \psi_x I_K(K_x, J_x) \quad (17)$$

$$= -\dot{\eta} = -e^{-rt} \left( \dot{\psi}_x - r\psi_x \right),$$

$$\frac{\partial \mathcal{H}}{\partial \eta_x} = I(K_x, J_x) = \dot{K}_x, \quad (18)$$

where we need to impose  $K_x(0) = K_0$  and  $\psi_x(\infty) < \infty$ .

We can simplify this system. We solve formula (12) with respect to  $I_x$ :

$$I_x = \sqrt{\frac{2K_x J_x}{\phi}}, \quad (19)$$

so we obtain formulae for its derivatives:

$$I_K = \sqrt{\frac{J_x}{2\phi K_x}} = \frac{I_x}{2K_x}, \quad I_J = \sqrt{\frac{K_x}{2\phi I_x}} = \frac{K_x}{J_x}. \quad (20)$$

The system thus becomes

$$I_x = \psi_x K_x, \quad (21)$$

$$\dot{\psi}_x = -\alpha_x s K_x^{\alpha_x-1} L_x^{1-\alpha_x} + r + \psi_x \left( r - \frac{I_x}{2K_x} \right), \quad (22)$$

$$\dot{K}_x = I_x. \quad (23)$$

The first equation from system (21)-(23) yields  $I_x$ :

$$\psi_x K_x = I_x, \quad (24)$$

which can be substituted in the two dynamic equations of the same system to obtain a simultaneous pair of Riccati-type differential equations, whose behaviour will depend on the (endogenous) value of  $L_n$  :

$$\dot{\psi}_x = -\alpha_x s K_x^{\alpha_x-1} L_x^{1-\alpha_x} + r + \psi_x \left( r - \frac{\psi_x}{2} \right), \quad (25)$$

$$\dot{K}_x = \psi_x K_x. \quad (26)$$

Additionally, the (de-)installation cost can be written as:

$$J_x = \frac{\phi I_x^2}{2K_x} = \frac{\phi \psi_x^2 K_x}{2}. \quad (27)$$

We also need the steady state values which can be obtained from system (21)-(23):

$$\psi_x = 0, \quad (28)$$

$$r = \alpha_x s \left( \frac{L_x}{K_x} \right)^{1-\alpha_x}, \quad (29)$$

$$I_x = 0. \quad (30)$$

### 3.3.2 Nontradables

For the nontradable sector, the profit maximisation condition can be stated as:

$$\max_{L_n, I_n} \left( \Pi_n = \int_{t=0}^{\infty} e^{-rt} (qQ_n - wL_n - rK_n - J_n) dt \right). \quad (31)$$

The installation cost of one unit of investment good is taken as

$$J_n = \frac{\phi}{2} \frac{I_n^2}{K_n}. \quad (32)$$

Similar to the tradable sector, the Hamiltonian can be written as (with  $\eta_x = e^{-rt}\psi_x$ ):

$$\mathcal{H} = e^{-rt} (qK_n^{\alpha_n} L_n^{1-\alpha_n} - wL_n - rK_n - J_n) + e^{-rt}\psi_n I(K_n, J_n).$$

The first order conditions with respect to labour yields the labor demand in the nontradable sector:

$$L_n = \left( \frac{q(1-\alpha_n)}{w} \right)^{\frac{1}{\alpha_n}} K_n \quad (33)$$

The first order conditions with respect to investment spendings  $J$  lead to the following equations:

$$\frac{\partial \mathcal{H}}{\partial J} = -e^{-rt} + e^{-rt}\psi_n I_J(K_n, J_n) = 0, \quad (34)$$

$$\frac{\partial \mathcal{H}}{\partial K} = e^{-rt} (\alpha_n q K_n^{\alpha_n-1} L_n^{1-\alpha_n} - r) + e^{-rt}\psi_n I_K(K_n, J_n) \quad (35)$$

$$= -\dot{\eta} = -e^{-rt} \left( \dot{\psi}_n - r\psi_n \right),$$

$$\frac{\partial \mathcal{H}}{\partial \eta_n} = I(K_n, J_n) = \dot{K}_n, \quad (36)$$

where we need to impose  $K_n(0) = K_0$  and  $\psi_n(\infty) < \infty$ .

Using the expression for investment spending

$$J_n = \frac{\phi I_n^2}{2K_n} = \frac{\phi \psi_n^2 K_n}{2} \quad (37)$$

we come to the following system of Ricatti-type differential equations, which describes the evolution of  $K_n$  and  $\psi_n$ :

$$\dot{\psi}_n = -\alpha_n q K_n^{\alpha_n-1} L_n^{1-\alpha_n} + r + \psi_n \left( r - \frac{\psi_n}{2} \right), \quad (38)$$

$$\dot{K}_n = \psi_n K_n. \quad (39)$$

This system is not closed as we need to define  $L_n$ .

In the steady state:

$$\psi_n = 0, \quad (40)$$

$$r = \alpha_n q \left( \frac{L_n}{K_n} \right)^{1-\alpha_n}, \quad (41)$$

$$J_n = 0. \quad (42)$$

### 3.3.3 Summary

We now can summarise our discussion so far about producers. Profit maximisation leads to (i) choices about labour inputs at each point in time, and (ii) choices about the evolution of capital over time.

We can summarise all of what we have discussed about the evolution of capital over time by writing the following four dynamic equations for the evolution of the capital stock in each of the two sectors, and dynamic equations for the evolution of two co-states, each costate corresponding to the capital stock in that sector. These equations are

$$\dot{\psi}_x = -\alpha_x s \left( \frac{\bar{L} - L_n(K_x, K_n, \psi_x, \psi_n)}{K_x} \right)^{1-\alpha_x} + r + \psi_x \left( r - \frac{\psi_x}{2} \right) \quad (43)$$

$$\dot{K}_x = \psi_x K_x \quad (44)$$

$$\dot{\psi}_n = -\alpha_n s \frac{(1-\alpha_x)}{(1-\alpha_n)} \left( \frac{K_x}{\bar{L} - L_n(K_x, K_n, \psi_x, \psi_n)} \right)^{\alpha_x} \frac{L_n(K_x, K_n, \psi_x, \psi_n)}{K_n} + r + \psi_n \left( r - \frac{\psi_n}{2} \right) \quad (45)$$

$$\dot{K}_n = \psi_n K_n \quad (46)$$

Note, however, that these equations depend upon the inputs of labour in each of the sectors,  $L_x$  and  $L_n$  at each point in time. They thus cannot be solved until this allocation of labour between sectors is pinned down. This allocation will clearly depend on the firms' choice of labour inputs at each point in time. But firms choices will depend, at any point in time on the wage rate  $w$  and the relative price  $q$  which rules at that point in time. And, since the labour market and non traded goods markets must clear – it will also depend on consumer demand for non-tradeables, which will – as we have seen – depend on consumers' real income. That will, in turn, depend upon the fiscal closure of the model which will determine how much taxes are raise in order that the interest payments outstanding on the debt overhang are financed – which (given that there is no default) they must be.

We thus now turn to write down rules for fiscal closure, and show how they differ as between the Fischer case and the Stiglitz case.

### 3.4 Fiscal Closure

After the collapse of the price of exportables, firms suffer losses, because they have to pay a fixed rental rate on capital – equal to the world rate of interest times the value of capital – even although the marginal revenue product of capital has fallen in the export sector because of the shock. The new optimal level of capital which firms desire will be lower than before; firms are assumed able to return their capital abroad and pay off their international debt by doing so, but they need to pay adjustment costs in order to do this.

After the crisis, when the firms make losses, we assume that the government takes over both their decision making (by appointing managers with a mandate to maximize profits) and also takes over the obligation to meet the losses, and so to not default on foreign interest obligations. Included in the firms' losses are not just the need to pay interest on the overhang of capital, but also the need to pay the adjustment costs – which they must pay in order to move to the new lower optimal level of capital. We assume that the government will fund these obligations by means of raising taxes – the Fischer strategy – or borrowing – the Stiglitz strategy, or by some combination of both of these methods.

Let us define the *net* return on capital in the each of the two sectors,  $r_x^*, r_n^*$ , as the marginal revenue product on capital, *net* of any adjustment costs which are to be paid because the holdings of capital are being adjusted. Thus

$$r_x^* = \alpha_x s \left( \frac{L_x}{K_x} \right)^{1-\alpha_x} - \frac{J_x}{K_x} \quad (47)$$

$$r_n^* = \alpha_n q \left( \frac{L_n}{K_n} \right)^{1-\alpha_n} - \frac{J_n}{K_n} \quad (48)$$

We define the *flow* debt overhang  $\Omega$ :

$$\Omega = (r - r_x^*) K_x + (r - r_n^*) K_n \quad (49)$$

The flow debt overhang is the sum of the interest owed on capital-in-place plus adjustment costs minus the marginal value products of capital-in-place ( $r_x K_x$  and  $r_n K_n$ ). That is, the overhang includes adjustment costs paid by the firms, who have borrowed capital, in order to adjust its stock to the desired level. Obviously, the flow debt overhang  $\Omega$  is also equal to the losses of firms – firms have a debt overhang precisely because they cannot cover their interest obligations and needs for adjustment costs, after they have paid wages.

We now come to the closure rule. As noted, we assume that the government bails out firms. Every period, it must pay out the flow debt overhang,  $\Omega$ , i. e. rental payments to foreign owners of capital *plus* the adjustment costs incurred by firms in adjusting the stock of capital that firms rent, *minus* the marginal revenue product of capital. The government finances these payments from two sources. A constant proportion  $\gamma$  of  $\Omega$  is financed by taxation on wages, at tax rate  $\tau$ .

We could let the fraction  $\gamma$  vary from period to period, but to simplify, we treat the parameter  $\gamma$  as constant in all time periods. Thus,

$$\gamma\Omega = \tau w\bar{L}, \quad (50)$$

or, solving for the tax rate,

$$\tau = \tau[\gamma] = \frac{\gamma\Omega}{w\bar{L}}, \quad (51)$$

which implies that  $\tau = \Omega/(w\bar{L})$  (the Fischer strategy) and that  $\tau = 0$  (the Stiglitz strategy).

Once the proportion,  $\gamma$ , is given, the government will need to cover the remaining proportion  $(1 - \gamma)$  of the flow debt overhang by borrowing. We let  $D$  be the size of the present discounted value of all of this future borrowing.  $D$  is given by

$$D = \int_{t=0}^{\infty} e^{-rt}(1 - \gamma)\Omega dt. \quad (52)$$

To make the problem as simple as possible we impose the following financing rule on the government – at each point in time it must pay interest, at rate  $r$ , on the sum  $D$  into a ‘fiscal future fund’ from which the flow debt overhang is paid in every period. By construction, if the government follows this rule, that fund will be exactly solvent. We assume that this burden is levied as an ‘interest-tax’ on consumers at each point in time. In sum in our setup the government, following the crisis, is given one and only one degree of freedom – the choice of which, once chosen, will hold at all future points in time. When  $\gamma = 1$  (the Fischer case) there is no delay in adjustment – all costs of flow debt overhang are immediately met by taxes on consumers. When  $\gamma = 0$  (the Stiglitz case) there is maximum delay – all costs of flow debt overhang, in all future periods, are borrowed and consumers only pay interest on this borrowing. The real income of consumers is thus given by the following simple expression

$$Z = (1 - \tau)w\bar{L} - rD. \quad (53)$$

## 4 Analytical Discussion of Outcomes following the Shock

### 4.1 The Long Run

#### 4.1.1 The Writedown case, and the Fischer Strategy

In the case of writedowns, and in the Fischer strategy, the debt overhang disappears in the long run. This means that change in prices following the fall in export prices is then very simple to compute. In the long run capital is internationally mobile. In comparison with the standard Heckscher-Ohlin model, two endogenous returns  $w$  and  $q$  are determined, *ceteris paribus*, by one exogenous world price  $s$  and one exogenous world rate of return ( $r$ ).

**Wages, Prices and the Exchange Rate** To solve for the wage, we use the capital-labour ratio implied by the marginal product of capital condition for the export sector and substitute it into the marginal product of labour condition for the export sector. We obtain a result which shows that the wage falls proportionately more than  $s$ .

$$w_\infty = (1 - \alpha_x) (s_\infty)^{\frac{1}{1-\alpha_x}} \left( \frac{\alpha_x}{r} \right)^{\frac{\alpha_x}{1-\alpha_x}} \quad (54)$$

The reason for this is that in the long run the stock of capital is reduced to the point where at the margin the owners of capital do not bear any of the loss caused by the worsened terms of trade. All of the loss must be born by only one factor, labour, whose returns must therefore fall by proportionally more than the worsening of the terms of trade.

Non traded prices  $q$  also fall with  $s$ , for the following reason. For the non-traded sector we use the capital-labour ratio implied by the marginal product of capital condition and substitute it into the marginal product of labour condition for this sector. We obtain an analogous result to that described above, which shows that the wage falls proportionately more than  $q$ .

$$w_\infty = (1 - \alpha_n) q_\infty^{\frac{1}{1-\alpha_n}} \left( \frac{\alpha_n}{r} \right)^{\frac{\alpha_n}{1-\alpha_n}} \quad (55)$$

Putting these two expressions together, and allowing for the fact that the traded goods sector is more capital intensive than the non-traded goods sector, we obtain that  $q$  falls by more than  $s$ .

$$q_\infty = s_\infty^{\frac{1-\alpha_n}{1-\alpha_x}} \frac{(1 - \alpha_x)}{(1 - \alpha_n)} \left( \frac{\alpha_x}{r} \right)^{\frac{\alpha_x}{1-\alpha_x}} \left( \frac{\alpha_n}{r} \right)^{-\frac{\alpha_n}{1-\alpha_n}} \quad (56)$$

Again, what is happening is that in the long run the stock of capital engaged in non-tradeables production is reduced to the point where at the margin the owners of capital do not bear any loss as a result of the reduction in demand for non-tradeables caused by the worsened terms of trade. The price of non-tradable must therefore fall, just so as to compensate for the fall in wage costs caused by the fall in the wage shown in equation (54). But since the non-traded sector is relatively labour intensive, this fall in wage costs cause the prices of non-tradeables to fall by more than the fall in the price of exports.

Notice that equations (54) and (55) do not depend upon the preference parameter  $\theta$ . Thus, this model exhibits the property that the long run price of non-tradeables is independent of demand, which merely allocates labour and output in the way described in the subsection that follows. This kind of feature, that there is a unique mapping from goods prices to factor prices independent of demand, is familiar from standard Heckscher-Ohlin theory, and is a result of the assumption of constant returns to scale in the production functions (1) and (2) for both goods. As we shall see below, this is not true in the short run, when the fixity of capital means that extra output can only be obtained by applying more labour to the fixed stock of capital, incurring diminishing returns. We shall see that in these circumstances there can be demand effects on the real exchange rate,  $q$ .

**Demand, Quantities and Factor Use** In the case of writedowns, and in the Fischer strategy, the long-run solutions for quantities and factor usage follow directly from these prices, using optimal consumption and production choices. The results of these calculations are as follows. (The details of how these results are derived, are discussed in the Section below on the Short Run and we do not repeat those discussions here. )

$$K_{x\infty} = L_{x\infty} (\delta s_0)^{\frac{1}{1-\alpha_x}} \left( \frac{\alpha_x}{r} \right)^{\frac{1}{1-\alpha_x}} \quad (57)$$

$$K_{n\infty} = L_{n\infty} q_\infty \left( \frac{\alpha_n}{r} \right)^{\frac{1}{1-\alpha_n}} \quad (58)$$

$$L_{n\infty} = \theta (1 - \alpha_n) (1 - \tau) \bar{L} \quad (59)$$

$$L_{x\infty} = \bar{L} - L_{n\infty} \quad (60)$$

$$Q_{x\infty} = \left( \frac{K_{x\infty}}{L_{x\infty}} \right)^{\alpha_x} L_{x\infty}. \quad (61)$$

$$C_{n\infty} = \theta w \bar{L} / q \quad (62)$$

#### 4.1.2 The Stiglitz Case

In the case of the Stiglitz strategy, and indeed in any case in which  $\gamma < 1$ , the economy builds up extra debt during the adjustment process. In the long run its real exchange rate must be competitive enough to enable it to pay the interest on this debt, and absorption must be curtailed enough to make room for these payments out of domestic output. The exact details of the outcomes will clearly depend on the amount of debt accumulated, which will depend on the whole dynamic solution to the problem. We can thus not give an analytic discussion of this case, other than noting that it will differ from the Fischer strategy in the way just suggested – a more competitive economy to pay for the required debt interest, and constrained consumption to make room for these payments.

#### 4.2 The Short Run

The decisions by the government about taxing and borrowing which we discussed at the end of the previous section determine consumer real income and thus demand for goods, and labour allocation, at any point in time. In this section, we discuss what happens *immediately* following the shock, in a time period so shortly after the shock that the capital stock has not yet changed.

*Non-traded sector.* From equation (10), and using the fact that everything that is produced in nontradable sector is consumed, i. e.  $C_n = Q_n$ , we have an equation showing the demand  $Q_n$  for non-tradeable goods

$$Q_n = \frac{\theta}{q} Z. \quad (63)$$

Employment in the non-tradeable goods sector  $L_n$  must be such that this demand can be

supplied (see equation (2)):

$$Q_n = \left( \frac{K_n}{L_n} \right)^{\alpha_n} L_n. \quad (64)$$

That, in turn will only be the case if the price of non-tradeable goods  $q$  is such that the marginal product of labour in the non-tradeables sector equals the real wage in terms of non-tradeables (see equation (33)):

$$\frac{w}{q} = (1 - \alpha_n) \left( \frac{K_n}{L_n} \right)^{\alpha_n}. \quad (65)$$

*Production of Exportables.* Output in the exportable sector is determined by factors of production in that sector (see equation (1)):

$$Q_x = \left( \frac{K_x}{L_x} \right)^{\alpha_x} L_x. \quad (66)$$

Employment  $L_x$  is determined such that the marginal revenue product in the exportable sector, is equal to the real wage. That, in turn will only be the case if the price of exportable goods  $s$  is such that the marginal product of labour in the exportables sector equals the real wage in terms of tradeables (see equation (15)):

$$w = s(1 - \alpha_x) \left( \frac{K_x}{L_x} \right)^{\alpha_x}. \quad (67)$$

It is also the case that, for equilibrium in the labour market employment in the exportable sector is, of course, equal to what is not employed in the non-tradeable sector (see equation (3)):

$$L_x = \bar{L} - L_n \quad (68)$$

*Consumption of Importables .* From equation (9), and the definition of  $Z$  we have an equation showing the demand  $C_m$  for importable goods:

$$C_m = (1 - \theta)Z. \quad (69)$$

*Fiscal Closure.* This system is closed by the determination of consumers' income. As shown in equation (53), this depends on fiscal policy:

$$Z = (1 - \tau)w\bar{L} - rD. \quad (70)$$

In order to solve this system we need to determine  $\tau$  and  $D$ . In what follows we will consider three different cases: equity financing, the Fischer rule, and the Stiglitz rule.

### 4.2.1 Enforced Writedowns

If there were enforced writedowns, the fiscal authorities would not pay the flow debt overhang, and so would not need to raise taxes and then we would have  $Z = w\bar{L}$ . The above system of eight equations for  $Q_n, L_n, w/q, C_m, Q_x, L_x, w$  and  $Z$  turns out to be trivially easy to solve in this case, because it falls into three simple components.

First, substitute  $\left(\frac{K_n}{L_n}\right)^{\alpha_n}$  from equation (65) and  $Q_n$  from equation (63) into equation (64) and obtain an equation for  $L_n$  :

$$L_n = \frac{\theta(1 - \alpha_n)}{w} Z = \theta(1 - \alpha_n) \bar{L} \quad (71)$$

In this case  $L_n$  is independent of anything to do with the exportable sector, or with shock to the terms of trade,  $s$ . This is illustrated in the top panel of Figure 1. The upward sloping line is just the *demand* function (63), drawn for the case when the tax rate is zero and after substituting for  $Z = w\bar{L}$ . It shows that the higher is the real wage in terms of non-tradeables, the higher will be then demand for them. This function is as simple as it is partly because the Cobb-Douglas assumption makes the influence of prices particularly simple, and partly because, in this economy after the crisis there are no profits, and so demand is only higher when wages are higher. The downward sloping line is the *supply* function, and shows that the higher is the real wage in terms of non-tradeables the lower will be output of non-traded goods  $Q_n$ , simply because of diminishing returns (65). These two curves together determine  $Q_n$  and  $w/q$ . The solution for  $L_n$ , which we have just given, follows directly from the production function, (64), once the solution for  $Q_n$  has been obtained.

Second, it must continue to be the case that the marginal product of labour in the exportables sector equals to the real wage in terms of tradeables. This means, following any fall in  $s$ , that the wage  $w$  must fall one for one with the fall in  $s$  (see equation (67)). This is illustrated in the bottom panel of Figure 1. As the price of exports,  $s$ , falls, we shift down the the marginal product in the export sector, the  $MPL_x$  curve, as illustrated. This would cause equilibrium to move from  $\alpha$  to  $\beta$ , if  $q$  were unchanged. However, as explained above,  $q$  falls exactly in line with  $w$ . This shift down takes us exactly to point  $\gamma$ . Firms find it profitable to go on producing the same amount of exportables, even although their price has fallen, because the wage falls by exactly the same amount as this fall in prices.

Third, the demand for imports falls by the same proportion as the fall in export prices. We can see this from equation (69), noting that  $Z = w\bar{L}$ . Ex-post it will be the case that the *quantity*,  $C_m$ , falls in the same proportion as the fall in *revenue*  $sQ_x$ . This is where the adjustment takes place to the terms of trade shock. Although the consumption of non-tradeables is unaffected, that of imports falls. We can say that there is ‘expenditure switching’ in response to the shock – imports fall because imports have become relatively more expensive. The fact that total

consumption – of both tradeables and non-tradeables – falls means that we can also say that there has also been ‘expenditure reduction’ in the face of the shock.

As a result of what we have just shown, we can thus see that it is possible to solve for the short-run equilibrium after the fall in  $s$  – i. e. including for the allocation of labour between sectors in the short run – without knowing anything about the intertemporal solution to the capital-stock adjustment process. There is one-way causation: that capital stock adjustment process is influenced by this allocation of labour, and the dynamics of the real exchange rate, wages, income and consumption is determined by the dynamics of the capital stock, but none of these things influence the short-run allocation.

#### 4.2.2 The Fischer Case

If  $\gamma = 1$  (the Fischer solution) then there are no writedowns, and no intertemporal borrowing by the government. The government simply raises enough taxes to pay the flow debt overhang. Therefore,  $Z = (1 - \tau)w\bar{L}$ , where the determination of  $\tau$  is discussed below. Performing similar manipulations to equations (65), (63) and (64) to those done above, we obtain

$$L_n = \theta(1 - \alpha_n)(1 - \tau)\bar{L} \quad (72)$$

instead of equation (71). Demand for non tradeable goods is reduced because of the increase in taxes which is required to pay for the flow debt overhang.

What happens can be thought about as follows. The size of the tax increase is determined by the amount of debt overhang,  $\Omega$ . To compute this we need to take the seven equations for  $Q_n, L_n, w/q, Q_m, Q_x, L_x, w$  presented above, and the amended equation for  $Z$ , and then add the following three equations for the net return on capital, and the flow debt overhang,

$$r_x^* = \alpha_x s \left( \frac{L_x}{K_x} \right)^{1-\alpha_x} - \frac{J_x}{K_x}, \quad (73)$$

$$r_n^* = \alpha_n q \left( \frac{L_n}{K_n} \right)^{1-\alpha_n} - \frac{J_n}{K_n}, \quad (74)$$

$$\Omega = (r - r_x^*)K_x + (r - r_n^*)K_n, \quad (75)$$

and then use these to compute the tax rate

$$\tau = \frac{\gamma\Omega}{w\bar{L}}, \quad (76)$$

which we would then, of course insert in the equation for  $Z$ . so as to solve the whole system simultaneously.

Suppose for a moment that we could ignore adjustment costs in the calculation of  $\Omega$ . We can write

$$\Omega = \left( r - \alpha_x s \left( \frac{L_x}{K_x} \right)^{1-\alpha_x} \right) K_x + \left( r - \alpha_n s \left( \frac{L_n}{K_n} \right)^{1-\alpha_n} \right) K_n \quad (77)$$

and can then compute how high the tax rate  $\tau$  has to be from the set of twelve equations which we have just described. How this solution works can be understood from the two parts of Figure 1. In the top half of the Figure the increase in the tax rate shifts the demand line to the left, simply because taxes are a deduction from the real wages which accrue to workers. It is thus now the case that  $Q_n$  and  $L_n$  will fall following the shock in the terms of trade,  $s$ , and  $q$  will fall relative to  $w$ , i. e. the real wage  $w/q$  will rise. In the lower part of the Figure we can see what happens another way. Since it is now the case that  $q$  falls more than  $w$  the marginal revenue product of labour in the nontradeables sector now falls more than initial fall in the marginal revenue product of labour in the exportables sector caused by the initial fall in  $s$ . The solution to these equations is discussed in Menzies and Vines (2002), where it is demonstrated that – even ignoring adjustment costs – the output of non-traded goods, the wage and the the price of non-traded goods can fall significantly. As a result of the tax, the demand for the non traded good, and its price will fall. But the wage will also fall. This means that the tax rate  $\tau$  will need to rise by more than would have been necessary if the wage had not fallen. But that higher tax rate will cause a further fall in the price of non-traded goods, and a further fall in the wage, meaning that the tax rate will need to fall yet further. This is why we use the term ‘debt-service multiplier’ in that paper to describe what happens.

Of course to compute the value of  $\Omega$  we do need to allow for adjustment costs. These adjustment costs do two things. First they make the problem worse – they add to the flow debt overhang – firms make losses not just because the return on capital is too low but also because they need to pay adjustment costs in order to reduce their capital stocks, so that losses will be lower in the future. Second, they make the whole problem much more difficult to solve. This is because the size of these adjustment costs in any period depends on the whole intertemporal optimisation (see equations (27) and (37)); the larger they are the larger will taxes have to be, which, in turn affects the outcome of the inter-temporal optimisation. All parts of the solution become jointly determined.

### 4.2.3 The Stiglitz Case

For  $\gamma < 1$  (including the Stiglitz solution in which  $\gamma = 0$ ) then there is intertemporal borrowing to be done by the government and  $Z = (1 - \tau)w\bar{L} - rD$ , where  $rD$  is the interest that must be paid on the borrowing  $D$ . It is important to understand what happens to  $rD$  as the tax rate  $\tau$  falls.

What happens, as  $\gamma$  falls below unity is that – at the margin – a dollar of the flow debt overhang that would have been met by the government by raising taxes is instead met by borrowing. If this dollar of the flow debt overhang would have only lasted for one year, this means that, instead of being due for a dollar of taxes, the private sector will be only due for an interest payment

of a fraction  $r$  of a dollar, where  $0 < r < 1$ , although it will of course have to pay this forever. Of course if the dollar of the flow debt overhang would have lasted forever, a decision to cover one dollar of the flow debt overhang by borrowing forever, rather than by taxing forever, would lead to an increase in the present discounted value of indebtedness of  $1/r$  and so an increase in interest obligations today of  $r$  times  $1/r$  dollars or of one dollar. The point is that the flow debt overhang does not last forever, since firms adjust their capital stock to ensure that it eventually disappears. A conversion of strategy from Fischer to Stiglitz thus lowers the tax burden. Thus, a move from Fischer to Stiglitz means that  $Z$  will rise. The problem of depressed consumption in the short-run, which we discussed for the Fischer strategy, is removed by Stiglitz.

The government now has to raise only a smaller amount of taxes in response to the flow debt overhang. Performing similar manipulations to equations (65), (63) and (64) to those done above, we obtain

$$L_n = \frac{\theta}{w} (1 - \alpha_n) ((1 - \tau) w \bar{L} - rD) \quad (78)$$

which – because of our above argument – is now much close to what would have been the outcome if there had been debt writedowns.

How this solution will work in the short run can be best understood, again from the two parts of Figure 1. As we have just argued, the overall tax take  $((1 - \tau) w \bar{L} - rD)$  levied on the private sector by the government will now be smaller than it was under the Fischer strategy, and – because of this – the shift to the left in the demand curve will now be much less. It is thus now the case that  $Q_n$  and  $L_n$  will fall much less following the shock in the terms of trade,  $s$ , and  $q$  will fall much less relative to  $w$ , i. e. the real wage  $w/q$  will rise by less. In the lower part of the Figure we can see what happens another way. Since it is now the case that  $q$  falls much less relative to  $w$  the marginal revenue product of labour in the nontradeables sector now falls less than it did Fischer case – this is why the solution for  $L_n$  shows a much smaller fall.

Of course the Stiglitz strategy creates extra borrowing, *forever*, and thus extra interest obligations on the private sector, *forever*. The way we have set up the problem there will be a need to pay these obligations beginning now, and forever. Ultimately consumption will be lower than it is in the Fischer scenario.

Note that the Stiglitz strategy is even more difficult to solve than the Fischer one. This is because it is not just that the size of these adjustment costs in any period depends on the whole intertemporal optimisation, as in the Fischer case. It is now the case that the amount borrowed depends in the solution to the whole problem – which, of course, depends on the amount borrowed.

## 5 Simulation of Dynamic Outcomes

We now plot dynamic outcomes, in the case of a 15 per cent decline in the price of exports.

There are a range of outcomes which we could plot, depending on the parameter  $\gamma$ , which is the share of the overhang covered by tax, with  $1 - \gamma$  covered by foreign borrowing (at the world interest rate,  $r$ ). In this model, consumers are powerless to consumption smooth, as we have already noted, because of liquidity constraints. However, the government can do de facto consumption smoothing on behalf of consumers – it can borrow to fund the flow debt overhang and so needs to tax consumers less in the short run. Of course the government could, in principle, choose a different value of  $\gamma$  for each period; here we study simple fiscal rules in which just one choice is made, about the choice of  $\gamma$ . We first present a qualitative discussion of ‘Stiglitz versus Fischer’ i. e. of  $\gamma = 0$  and  $\gamma = 1$ . We then turn to compute optimal values for  $\gamma$ .

### 5.1 Stiglitz versus Fischer

In Figure 2 we plot the outcomes for key variables when  $\gamma = 0$  and  $\gamma = 1$ . (It is clear that outcomes in the range  $0 < \gamma < 1$  will lie in between the outcomes shown in the figure. )

When there is no debt overhang – as in the case of the writedowns benchmark – there is no short-run squeezing of consumers because no short-run tax increases are needed to fund the flow-debt overhang. This picture is not yet drawn – new computations are needed for it. But it will have the property shown in our discussion above, that the wage, and the price of non-traded good immediately falls by 15 percent. The excess of capital in the two sectors is gradually worked off, and as it does so the price of non-traded goods, and the level of wages, gradually fall to their long run positions. Consumption of the two goods gradually falls as the capital stocks fall.

The Fischer case displays a radically large fall  $Q_n$  and in  $L_n$  due to the tax increases. ( $L_n$  can be found after subtracting  $L_x$  from the total labour force. ) The real exchange rate overshoots, as discussed above. Gradually the economy converges on long run outcomes which have the features discussed in Section 4: prices determined by the fall of export prices, in the light of production conditions and quantities and output factor use as appropriate to this.

The Stiglitz case differs from the Fischer case in the way that we have discussed. There is no large initial fall in  $L_n$  or in  $Q_n$ . The real exchange rate does not overshoot, for reasons discussed above. Gradually the economy converges on long run outcomes which have higher taxes and lower consumption, than the Fischer outcome.

### 5.2 Intertemporal Optimisation

We can study the choice of  $\gamma$  so as to give optimal consumption smoothing – subject to the constraint that  $\gamma$  does not change from period to period. We choose  $\gamma$  to maximise social welfare function, given by

$$W = \int_{t=0}^{\infty} e^{-\lambda t} \ln(C_n^\theta C_m^{1-\theta}) dt, \tag{79}$$

$\lambda$	0.05	0.0625	0.075
$r$	0.05	0.05	0.05
$\gamma_C$	0.86	0.54	0.30
$\gamma_{II}$	0.90	0.95	0.97

Table 1: Optimal Tax Finance

subject to the full dynamic system (43)-(46), and to the equation that defines the labour allocation. For a range of values of the household discount rate we obtain the optimal share of the debt overhang which we denote by taxation,  $\gamma_C$ . The results are presented in Table 1 for different values of the discount rate lambda.<sup>4</sup> The simulations used in order to compute welfare outcomes, so as to determine the optimal value for  $\gamma_C$ , also assume a 15 per cent decline in the price of exports. In carrying out these simulations we also compute the present discounted value,  $V$ , of firm's losses.

$$V = \int_{t=0}^{\infty} e^{-\lambda t} [\Pi_x + \Pi_n] dt$$

Consider first the case in which the discount rate is equal to the world interest rate,  $r = 0.05$  – see column one of the Table 1.

In this case it would be optimal for firms if the government financed 90 percent of the flow debt overhang by taxes on consumers. Interestingly this number is not the value of 100 percent, which is the optimal value that one might initially have expected. This appears to be because a 100 percent tax rate would cause such a big a reduction in consumption that this would be bad for firms. The fall in consumption would excessively depress non-tradable goods prices. (As we have already seen from Figure 2, for  $\gamma = 1$ , there is a large overshoot in the prices of non-tradable goods. ) This would depress profits in the non-traded sector. That would cause firms in that sector to quickly reduce the capital stock in that sector, causing them to incur too-high levels of adjustment costs, too high because the adjustment would have to be reduced in the future. (Recall that these costs are convex in the speed of adjustment. ) This problem would be augmented by fall in the wage which would cause a reallocation of resources to the tradable sector in the short-run. That would in turn induce further inducement to misallocate capital in the short-run, something which would need to be undone in the longer run.

Obviously, in this case it would be optimal for consumers if taxation were used to finance a smaller proportion of the flow debt overhang – only 86 of the flow debt overhang. Interestingly, this number is not much smaller than 90 percent. This is because, even although consumers cannot borrow to smooth consumption, their discount rate, at 0.05 percent, is so low that the

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<sup>4</sup>The optimal value of  $\gamma$  was found numerically, using standard optimisation techniques. The details and MATLAB code are available from the authors upon request.

constraint imposed upon them by having to cut consumption now is compensated for by the fact that they will not spend too much now on non-traded goods. If they did that then this would keep losses in that sector too low and would therefore delay the downwards adjustment of capital in the non-traded sector. That in turn would mean that the economy had borrowed ‘too much’ and so mean that consumption in the future would have to be lower. With a low discount rate of 0.05, consumers would prefer that this did not happen.

With a higher discount rate used in the calculation of social welfare, a move towards debt finance (i. e. towards the Stiglitz scenario) becomes much more attractive to consumers. It is now the case that the constraint imposed upon consumers in the short-term is harder to compensate for by having a higher level of consumption in the future. It is in the interests of consumers for the government to borrow more now, so as to make consumption smoothing possible.

We have already noted, for the various values of  $\gamma_C$  that it is in the interests of firms to force consumers to adjust faster. We can actually instead set out to compute not  $\gamma_C$ , but the value of  $\gamma_C$  which would maximise the present discounted value of firms’ profits. We give this value of  $\gamma$  the label  $\gamma_{\Pi}$ . The entries show, as we might expect, that just as  $\gamma_C$  falls as  $\lambda$  increases,  $\gamma_{\Pi}$  increases.

## 6 Conclusion

We can sum up.

The IMF strategy, if implemented in the way described in this paper, carries in its wake the prospect of exchange rate overshooting. We have described this both analytically and using simulations in Sections 4 and 5. As we have shown, the Stiglitz strategy can avoid this.

In addition we have been able to compute welfare. We have shown that the IMF strategy comes at the issue of debt resolution from the vantage point which closely approximates to that of a policy-maker who wished to minimize the losses of firms, whilst the Stiglitz strategy is much closer to that which sought to maximise the welfare of consumers, by allowing them to consumption smooth, particularly if their welfare is computed with even moderately high discount rates. In computations not shown here, we have in fact shown The IMF strategy can be very costly for consumers, costing them around 15% of the net present value of their consumption for a discount rate of 7.5 per cent and a terms of trade shock of 15 per cent.

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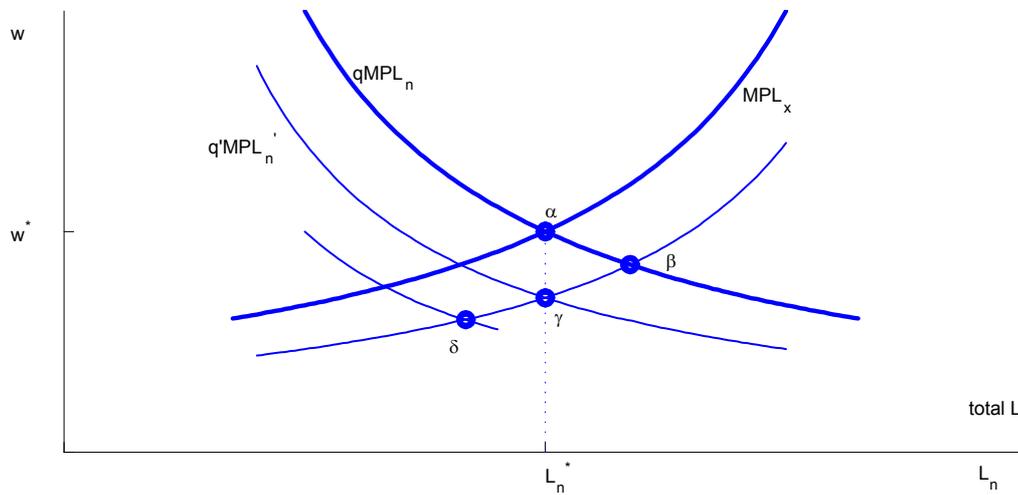
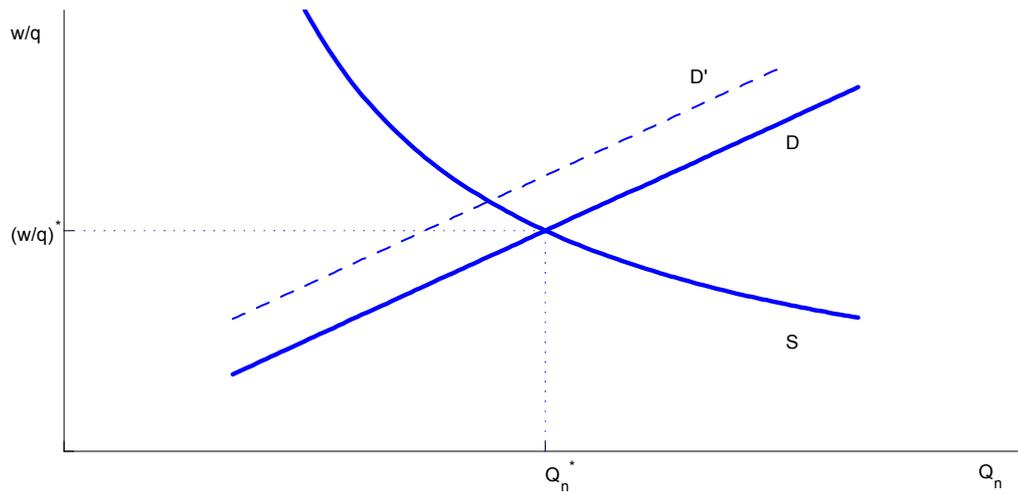


Figure 1: Enforced Writedowns.

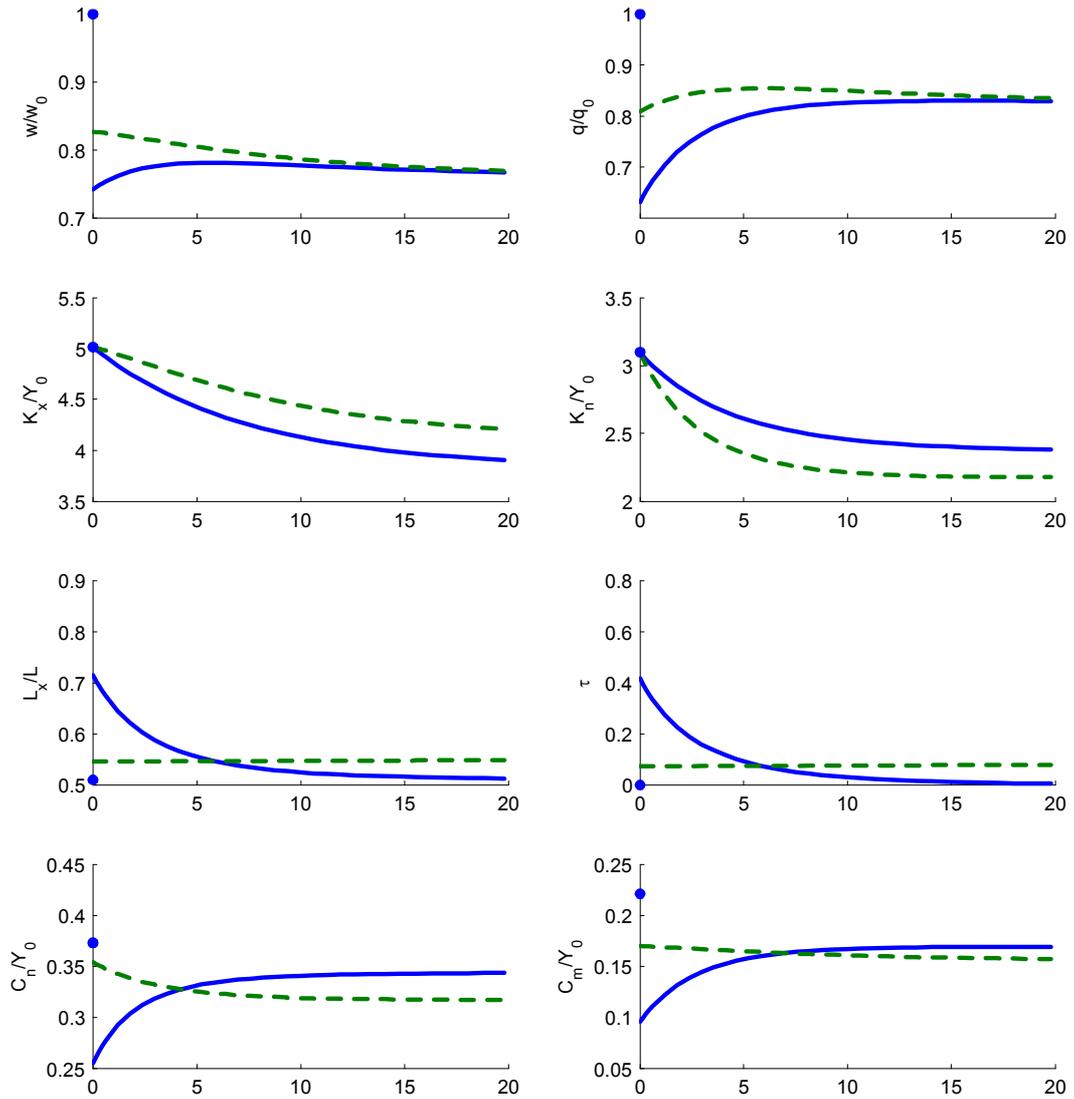


Figure 2: Dynamic Path. Solid line denotes the IMF case and dashed line denotes Stiglitz case.