15 Foreign lending under limited enforcement

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Introduction

It is widely recognized that the well-established principle of sovereign immunity poses an additional risk for lenders of international capital. The lack of any notable collateral and the absence of a supranational institution with a recognized authority to enforce loan contracts limit lending to sovereign states. Assuming participants in international capital markets are rational, any sovereign loan contract must therefore be self-enforcing.

Several studies have indicated that credible sanctions against arbitrary defaults, implicit in the nature of the debtor/creditor relationship, can explain positive sovereign debt.[1] In an influential paper, Eaton and Gersovitz (1981) focus on the threat of exclusion of a defaulter from further borrowing. In their model, foreign borrowing cushions consumption from shocks to income so that a greater *variability* in export earnings increases the option value of access to credit markets thus diminishing the risk of a default. Bulow and Rogoff (1989) show, however, that if a defaulter can enter into outside financial agreements, the threat of exclusion from future borrowing alone will not support foreign lending. In a more recent study, Kletzer and Wright (2000) demonstrate that in a repeated borrowing/repayment game, if the defaulters of today can become defaultees of the future, then positive lending can be sustained without recourse to any exogenous punishments even with outside financial options. In general, incentive-constrained consumption loans are inefficient since they cannot provide for complete consumption smoothing.

For a developing economy, foreign borrowing is desirable not only because it enables consumption smoothing, but more significantly because it can free investment from constraints due to limited domestic sources of savings. For growth, the *level* of exports matters as well: exports facilitate imports of investment goods for which domestic substitutes usually do not exist. Hence, the prospect of losing valuable export markets may also work as a strong deterrent against an arbitrary default. Consequently, the extent of a debtor's dependence on creditor markets for exports becomes strategic. While building up an export presence in creditor markets is a signal of future willingness to repay debt, an expansion in the home goods market can be construed as a sign of potential recalcitrance. Thus, investment and lending decisions are strategically intertwined, distorting incentives for investment and creating opportunities for inefficiencies to arise.

For instance, in a two-period stochastic model, Aizenman (1991) assumes default sanctions in the form of a terms-of-trade deterioration and shows that in the presence of default risk and limited enforcement, investment subsidies to open sectors may be optimal. Nonetheless, investments in the open sectors are lower than full-commitment levels, resulting in an inefficiently small degree of openness.[2] But the two-period assumption is unnecessarily restrictive, since by assumption it excludes dynamic adjustment paths. A more serious drawback is that, without some stickiness in capital stocks, the assumed form of sanctions – a terms-of-trade deterioration – lacks credibility. A defaulter, anticipating an imminent worsening in the terms of trade, can rapidly divest the export capital and use the proceeds for consumption and investment in the import-competing sector, and thereby avoid any default costs. In models with limited enforcement, some *irreversibility* in capital stocks is essential for the credibility of sanctions. As such, we believe it may constitute one of the key identifying principles in foreign lending for export-oriented investment projects.

Admittedly, the full weight of the irreversibility assumption would be felt more acutely in a general stochastic environment where, given an adverse shock of sufficient magnitude, default would be optimal in equilibrium. In an uncertain world with irreversible investments, a debtor is best advised to keep his default option open. That is, in order to avoid inordinate potential default costs, less openness of the economy will be desirable. In a world of certainty such as we shall consider, irreversibility is still needed. Otherwise, the credibility of the lending equilibrium under the threat of trade sanctions is questionable.

The literature on sovereign debt has shown that, in the absence of an outside authority to enforce loan agreements, endogenous commitment mechanisms are likely to arise to mitigate, but not fully reverse, the welfare loss due to the lack of enforcement. This paper focuses on one such commitment mechanism, export-led growth, and also quantifies the welfare loss stemming from limited enforcement. We develop a model of a two-sector open economy that underscores the strategic nature of investment activities and foreign lending. In contrast to its predecessors, however, exports are not domestically consumed, and sector specific capital stocks are *locked-in* so that the threat of trade restrictions is credible. In the absence of full enforcement, the model emphasizes the commitment value of investment activities and shows how export-led growth can be supported as a second-best policy.

We study a self-enforcing lending scheme in which a debtor's repayment *resources* never fall below the default alternative at any point in time. We show that this strategy boils down to setting target debt/export ratios. Using these target debt/export ratios, we are able to derive analytical results that explicitly show the nature and the extent of the inefficiencies caused by limited enforcement. For instance, if a borrower's pure time preference exceeds the world interest rate, then the long-run productive capacities in the export and the home goods sectors depend also on the severity of creditor sanctions. More specifically, the marginal product of capital in the export sector is now bounded from above by the domestic pure time preference, as in autarky (no enforcement) and from below by the world interest rate, as in full integration (full enforcement). The size of the home goods, on the other hand, depends both on preferences and the available sanctions. If the home and the foreign goods are gross substitutes, then the home goods sector expands with limited sanctions.

When the pure time preference and the world interest rate are equal, so too is the marginal product of export capital in the long-run, regardless of how limited the sanctions are. The size of the home goods sector, however, is still inversely related to the potential sanctions. Ultimately, to the degree the home goods are poor substitutes for foreign goods, the future consumption is discounted heavily, and the potential sanctions are low, the welfare cost of limited enforcement will be substantial.

Finally, using a wide range of parameter values, we use genetic algorithms to optimize numerically the repayment program constrained by target debt/export ratios, thereby demonstrating the extent of inefficiencies due to limited enforcement.

The balance of the paper is organized as follows: Section 2 discusses the model, its justification, and the long-run analytical results. The simulation results are provided in Section 3, while conclusions are summarized in Section 4.

The model

Consider a small open economy that produces an export, $Q^e = Q^e(K^e)$, and a home good, $Q^h = Q^h(K^h)$. The production technology in each sector is strictly concave. Home goods are only consumed so that $C^h = Q^h(K^h)$ in equilibrium where C^h denotes the consumption of home goods. Sector-specific capital stocks, K^e and K^h, grow over time according to:

$$\dot{K}^e = J^e, \text{ and } J^e \geq 0, \tag{15.1a}$$

$$\dot{K}^h = J^h, \text{ and } J^h \geq 0. \tag{15.1b}$$

where J^e and J^h are the amounts of imported goods invested in the respective sectors, which cannot be undone, i.e. are irreversible.[3]

The accumulation of capital stocks involves installation (or adjustment costs), so that the total resources involved in accumulating capital at the rates specified in equations (15.1a) and (15.1b) are[4]

$$C(J^e) \equiv J^e\left(1 + \frac{z}{2}J^e\right) \tag{15.2a}$$

$$C(J^h) \equiv J^h\left(1 + \frac{z}{2}J^h\right) \tag{15.2b}$$

where z reflects the installation costs, assumed for simplicity to be common to both sectors. The absence of domestic production, irreversibility in capital accumulation and sectoral specificity of investment are adopted in order to highlight the value of investment as a commitment mechanism in the strategic interplay between debtors and creditors in an environment of limited enforcement.

As long as the outstanding debt is below the credit limit, the country has access to the world credit market and can finance its current account deficit by borrowing from abroad:

$$\begin{aligned} \dot{D} &= rD + C^m + J^e + \frac{z}{2}(J^e)^2 + J^h + \frac{z}{2}(J^h)^2 - Q^e, \\ D &\leq \tilde{D}, \end{aligned} \tag{15.3}$$

where D is the outstanding debt, $\dot{D}$ is the rate of gross borrowing and $\tilde{D}$ indicates the credit limit yet to be determined by creditors. Note that the terms of trade is fixed at unity so that borrowing is in terms of foreign goods, with the import of consumption goods being C^m. The parameter r denotes the fixed world interest rate at which the country can borrow as long as it is below its credit limit.[5]

At any point in time, t, given the initial stocks, $K^e(t)$, $K^h(t)$ and $D(t)$, if the debt is repaid, the debtor will then obtain a repayment utility:

$$V^P(K^e(t), K^h(t), D(t), t; \beta, r) = \max_{C^m,\ J^e,\ J^h} \int_t^{\infty} e^{-\beta(\tau - t)} U(C^m, Q^h) d\tau \tag{15.4}$$

where $U(C^m, Q^h)$ is a strictly concave instantaneous utility function and β denotes the fixed pure time preference rate.

Alternatively, the debtor may opt for a default with the certain prospect of collective creditor sanctions of an indefinite duration. These include cutting off future lending and retaliatory measures that will disturb the debtor's normal flow of trade.[6] In this case, a defaulter has to conduct trade on a current basis, $\dot{D} = 0$, and will also come under direct trade sanctions. The external constraint, equation (15.3), then becomes,

$$C^m + J^e + \frac{z}{2}(J^e)^2 + J^h + \frac{z}{2}(J^h)^2 = (1 - \alpha)Q^e \tag{15.5}$$

This parameterization of sanctions is in keeping with the literature on sovereign debt.[7] The 'sanction' or 'enforcement coefficient', $0 \leq \alpha \leq 1$, can be motivated by arguments on various levels. For example, if a wilful default is countered by tariffs on the defaulter's exports in creditor countries, then α is the percentage deterioration in the defaulter's terms of trade so that $\alpha Q^e(K^e(t))$ is the direct default cost flow. Alternatively, if quantity restrictions are in force, then α is the fraction by which exports are reduced implying that the potential default cost flow is the same, namely, $\alpha Q^e(K^e(t))$. At a more general level, α measures the difficulty with which the debtor can shift its trade to alternative markets at favourable terms, and also the severity of trade restrictions it anticipates facing in creditor markets. As such, it parameterizes the dependency of the debtor on the creditor markets for exports and thus the ability of creditors to enforce sanctions.

If the debtor defaults, he will obtain a default utility:

$$V^R(K^e(t), K^h(t), t; \beta, \alpha) = \max_{C^m,\, J^e,\, J^h} \int_t^{\infty} e^{-\beta(\tau - t)} U(C^m, Q^h) d\tau \qquad (15.6)$$

with the same constraints, except now equation (15.5) replaces (15.3).

Having formulated the debtor's problem, we now turn to the determination of the credit ceiling, $\tilde{D}$, by the creditors.

Lending

Lenders recognize the inherent time-inconsistency in extending loans to sovereign countries, but lack the capacity to compute the dynamically incentive compatible loan contracts. Neither they nor the debtor deem the pledges of future investment or loan plans as credible. Furthermore, the creditors are unable to compute the debtor's optimal default policies. Instead, loans are collectively made to ensure that the debtor's interest burden at any time not become too onerous, creating temptation for a default.

Creditors reason that by defaulting the debtor would save the face value of its outstanding debt, $D(t)$, and given its locked-in export capacity, it would at the minimum suffer a default penalty equivalent to the capitalized value of the current default cost, $\alpha Q^e(K^e(t))/r$. They reckon that if the outstanding debt is never allowed to exceed the minimum default penalty, $D(t) \leq \alpha Q^e(K^e(t))/r$, then a potential default can always be averted. Below, Proposition 1 establishes that this lending policy is self-enforcing.

Proposition 1. Assume $\beta \geq r$ and low initial indebtedness so that borrowing is desirable, $\dot{D}(t) \geq 0$. Then the lending policy that sets a target debt to export ratio, $\tilde{D}(t) = \alpha Q^e(K^e(t))/r$, is self-enforcing. Thus, creditors can prevent a default if they insist that the debt to export ratio at any given time $t, D(t)/Q^e(t)$, not exceed a 'vulnerability ratio', α/r.

Proof: Note that the repayment and default programs are essentially the same except for the external constraints, (15.3) and (15.5). Indeed, if $\dot{D}(t) - rD(t) + \alpha Q^e(K^e(t)) = 0$, for all t, then $V^P(K^e(t), K^h(t), D(t), t; \beta, r) = V^R(K^e(t), K^h(t), t; \beta, \alpha)$ for all t because both programs have identical utility functionals and equal resources. Suppose $rD(t) - \dot{D}(t) \leq \alpha Q^e(K^e(t))$ for all t. Then $V^P(K^e(t), K^h(t), D(t), t; \beta, r) \geq V^R(K^e(t), K^h(t), t; \beta, \alpha)$ for all t as both programs start with the same initial capital stocks, $K^e(t)$ and $K^h(t)$, and have identical utility functionals. That is, so long as the net debt service is less than the default cost, the debtor has more resources under the repayment program, and therefore, is better off servicing the debt. Since $\dot{D}(t) \geq 0$, if $rD(t) \leq \alpha Q^e(K^e(t))$ for all t, then $V^P(K^e(t), K^h(t), D(t), t; \beta, r) \geq V^R(K^e(t), K^h(t), t; \beta, \alpha)$ for all t. Thus, Proposition 1 follows.

At first blush, this lending policy may appear overly restrictive since creditors have ignored new lending ($\dot{D}(t) \geq 0$) as a repayment resource in their default calculus. In fact, lending will not be unduly restricted. This is because, in a world of certainty, default can be optimal only after all available credits are exhausted. Thus, when weighing the costs and benefits of a default, it is reasonable to assume that credits have been used up.

Long-run analytical results

Despite their widespread use by international credit institutions as measures of creditworthiness and their practical appeal, to our knowledge, an analysis as to the welfare costs of debt/export ratios on growth has not been addressed. The following analytical results should therefore be of interest both for their empirical relevance, and for the fact that debt/export ratios themselves have a rational foundation as we have demonstrated. We summarize our long-run results as propositions.

Proposition 2. Suppose that creditors adopt the lending policy $\tilde{D} = (\alpha/r) Q^e(K^e)$. Reconsider the repayment program described by equations (1) to (4), now constrained by $D(\tau) \leq (\alpha/r)\, Q^e(K^e(\tau))$:
Given sufficiently low stocks of initial debt and export capital, *if* $\beta > r$ and $0 \leq \alpha \leq 1$, then the long-run credit constraint, $\tilde{D} = (\alpha/r)\, Q^e(K^e)$, is binding where export capital, $\hat{K}^e$, satisfies:

$$\frac{\partial Q^e}{\partial \hat{K}^e} = \frac{\beta r}{r(1-\alpha)+\alpha\beta}.$$

If $\beta = r$ *and* $0 \leq \alpha \leq 1$, then in the long-run, the credit constraint does not bind, though in transition it may have, and the marginal productivity in the export sector is independent of sanctions; namely, $\partial Q^e/\partial \hat{K}^e = \beta = r$.

Given a sufficiently small initial home goods sector and also a sanction rate, α, if $\beta \geq r$, then the long-run capital stock in the home goods sector is determined by both sanctions and preferences:

$$\frac{\partial U}{\partial \hat{C}^m}\beta = \frac{\partial U}{\partial Q^h(\hat{K}^h)}\frac{\partial Q^h}{\partial \hat{K}^h}.$$

Proof: Note that the debtor faces an optimal growth problem with an additional target debt/export constraint. Kamien and Schwartz (1981) provide a set of necessary conditions for optimal control problems with bounded state variables. These involve a new definition of the Hamiltonian, now appended with the total differential of the state variable constraint and an accompanying multiplier which is non-increasing when the constraint is binding and a constant but not necessarily zero during a free interval. In our problem, H, the current valued Hamiltonian is:

$$
\begin{aligned}
\mathrm{H} = {} & U(C^m, Q^h) + \mu\left[rD + C^m + J^e + \frac{z}{2}(J^e)^2 + J^h + \frac{z}{2}(J^h)^2 - Q^e(K^e)\right] \\
& + \lambda^e J^e + \lambda^h J^h + \phi\left\{\alpha(\partial Q^e/\partial K^e)(J^e/r) - [rD + C^m + J^e + \frac{z}{2}(J^e)^2\right. \\
& \left. + J^h + \frac{z}{2}(J^h)^2 - Q^e(K^e)]\right\}
\end{aligned}
$$

For optimality, the following first order conditions are necessary:

$$\frac{\partial U}{\partial C^m} = \phi - \mu \tag{15.7}$$

$$J^e = \frac{1}{z}\left\{\frac{\lambda^e + W^1 + \dfrac{\phi\alpha}{r}\dfrac{\partial Q^e}{\partial K^e}}{\phi - \mu} - 1\right\} \tag{15.8}$$

$$J^h = \frac{1}{z}\left\{\frac{\lambda^h + W^2}{\phi - \mu} - 1\right\} \tag{15.9}$$

where λ^e, λ^h, and μ are the respective co-state variables for $\dot{K}^e$, $\dot{K}^h$, and $\dot{D}$. The variable, ϕ adjoins the time-differentiated credit constraint, $(\alpha/r)(\partial Q^e/\partial K^e) \cdot \dot{K}^e - \dot{D}$. Optimal policies will satisfy (15.7)–(15.9) as well as the 'complementary slackness conditions' $W^1 \geq 0$, $J^e W^1 = 0$, and $W^2 \geq 0$, $J^h W^2 = 0$.

Equation (15.7) prescribes the optimal consumption of foreign goods while (15.8) and (15.9) indicate the rates of investment in each sector. Notice that the marginal utility of imported goods consumption is $\phi - \mu$ whereas in the absence of credit constraint it would have been onlyμ. Hence the opportunity cost of borrowing is now higher, discouraging consumption. The term $(\phi\alpha/r)(\partial Q^e/\partial K^e)$ appearing in the numerator in equation (15.8) captures the beneficial effect of investment in the export sector on the credit constraint. Thus, the presence of the credit constraint tilts the optimal composition of investment in favour of the export sector relative to a decentralized borrowing or when the credit constraint is altogether absent.

The costate variables μ, λ^e, and λ^h evolve according to,

$$\dot{\mu} = \mu(\beta - r) + \phi r \tag{15.10}$$

$$\dot{\lambda}^e = \lambda^e\beta + (\mu - \phi)\frac{\partial Q^e}{\partial K^e} - \phi\alpha\frac{J^e}{r}\frac{\partial^2 Q^e}{\partial (K^e)^2} \tag{15.11}$$

$$\dot{\lambda}^h = \lambda^h \beta - \frac{\partial U}{\partial Q^h(K^h)} \frac{\partial Q^h}{\partial K^h} \tag{15.12}$$

$$\phi \geq 0,\ (\dot{\phi} - \beta\phi) \leq 0,\ (\dot{\phi} - \beta\phi)[(\alpha Q^e/r) - D] = 0, \tag{15.13}$$

with the transversality conditions

$$\lim_{\tau\to\infty} e^{-\beta(\tau-t)}\mu D(\tau) = \lim_{\tau\to\infty} e^{-\beta(\tau-t)}\lambda^e K^e(\tau) = \lim_{\tau\to\infty} e^{-\beta(\tau-t)}\lambda^h K^h(\tau) = 0 \tag{15.14}$$

From equation (15.10) notice that when $\beta = r$, for $\dot{\mu} = 0$, $\phi = 0$, that is the credit constraint is non-binding at that point, although it may have been previously. Consider first the export sector. Assume sufficiently low initial indebtedness and export capital so that an interior solution obtains in the steady state. Setting J^ein equation (15.8) to zero implies

$$\lambda^e + \frac{\phi\alpha}{r}\frac{\partial Q^e}{\partial \hat{K}^e} = \phi - \mu. \tag{15.15}$$

Next, taking the time derivative of (15.15), substituting $\dot{\mu}$ and $\dot{\lambda}^e$ from (15.10) and (15.11), and then replacing $\beta\lambda^e$ in the resultant expression from (15.15) yields

$$\left(\frac{\alpha}{r}\frac{\partial Q^e}{\partial \hat{K}^e} - 1\right)(\dot{\phi} - \beta\phi) - (\phi - \mu)\left(\frac{\partial Q^e}{\partial \hat{K}^e} - r\right) = 0. \tag{15.16}$$

In steady state, $\dot{\phi} = \dot{\mu} = 0$, so that $\phi r = \mu(r - \beta)$. Substituting these relationships into (15.16) yields

$$\frac{\partial Q^e}{\partial \hat{K}^e}[\alpha\beta + r(1-\alpha)] - \beta r = 0.$$

from which the first result in Proposition 2 immediately follows.

Next, turn to the home goods sector. Assume sufficiently small initial stocks and sanction rate so that the desired consumption profile of imported goods is not declining. Consequently, the irreversibility constraint does not bind, so that $W^2 = 0$. Setting J^h to zero in (15.9) and combining with (15.7), implies $\lambda^h = \partial U/\partial \hat{C}^m$. Setting $\dot{\lambda}^h = 0$ in (12) and substituting $\lambda^h = \partial U/\partial \hat{C}^m$ yields the second result in Proposition 2.

Proposition 2 shows that the long-run marginal productivity in the export sector varies between the world interest and the domestic pure time preference rates, depending on the rate of enforcement. If no sanctions can be brought to bear upon a debtor, $\alpha = 0$, then the financial autarky results in, $\partial Q^e/\partial \hat{K}^e = \beta$. With full enforcement ($\alpha = 1$), on the other hand, perfect capital market integration leads to a convergence, $\partial Q^e/\partial \hat{K}^e = r$.

Note that in a more general stochastic environment a sufficiently large shock will trigger a default and thus sanctions in equilibrium. Consequently, the debtor's investment plans will have to cover this contingency as well. With default as a real possibility, the long-run sectoral mix as indicated by Proposition 2 would not be optimal. In order to plan for such an eventuality, and not to regret having invested so much in the export sector to bear such heavy default costs, the debtor will invest relatively less in the export sector than prescribed by Proposition 2. In other words, with irreversible investments in an uncertain environment the debtor will always keep its default option open.

Proposition 3, below, summarizes the sensitivity of the long-run equilibrium to the rate of enforcement as well as making more precise the role preferences play. Assuming an interior steady state and taking home and foreign goods to be gross substitutes, we may state

Proposition 3. If $\beta > r$, then in the long-run:

$$\frac{\partial \hat{K}^e}{\partial \alpha} \geq 0, \ \frac{\partial \hat{D}}{\partial \alpha} > 0, \ \frac{\partial \hat{C}^m}{\partial \alpha} < 0, \ \frac{\partial \hat{K}^h}{\partial \alpha} < 0,$$

If $\beta = r$, the above qualitative results are still valid, with $\partial \hat{K}^e / \partial \alpha = 0$.

Proof: From Proposition 2, $\hat{K}^e$ solves,

$$\frac{\partial Q^e}{\partial \hat{K}^e} = \frac{\beta r}{r(1-\alpha)+\alpha\beta}. \tag{15.17}$$

Assuming that the debt/export and the vulnerability ratios are equal in the long-run, $\hat{D}$, satisfies,

$$r\hat{D} = \alpha Q^e(\hat{K}^e). \tag{15.18}$$

The long-run foreign goods consumption is given by,

$$\hat{C}^m = Q^e(\hat{K}^e) - r\hat{D}. \tag{15.19}$$

Finally, the home goods capital stock in the long-run is obtained from,

$$\frac{\partial U}{\partial \hat{C}^m}\beta = \frac{\partial U}{\partial Q^h(\hat{K}^h)} \frac{\partial Q^h}{\partial \hat{K}^h}. \tag{15.20}$$

Differentiating (15.16), (15.17), (15.18) and (15.19) and assuming home and foreign goods to be gross substitutes, we obtain the qualitative responses summarized in Proposition 3:

$$\frac{\partial \hat{K}^e}{\partial \alpha} = -\frac{\beta r(\beta - r)}{(r+\alpha(\beta-r))^2 \dfrac{\partial^2 Q^e}{\partial (\hat{K}^e)^2}} \geq 0,$$

$$\frac{\partial \hat{D}}{\partial \alpha} = \frac{1}{r}\left[Q^e + \alpha \frac{\partial Q^e}{\partial \hat{K}^e}\frac{\partial \hat{K}^e}{\partial \alpha}\right] > 0,$$

$$\frac{\partial \hat{C}^m}{\partial \alpha} = -Q^e + (1-\alpha)\frac{\partial Q^e}{\partial \hat{K}^e}\frac{\partial \hat{K}^e}{\partial \alpha} < 0,$$

$$\frac{\partial \hat{K}^h}{\partial \alpha} = \frac{\dfrac{\partial \hat{C}^m}{\partial \alpha}\left[\dfrac{\partial Q^h}{\partial \hat{K}^h}\dfrac{\partial^2 U}{\partial \hat{C}^m \partial \hat{C}^h} - \beta \dfrac{\partial^2 U}{\partial (\hat{C}^m)^2}\right]}{\beta \dfrac{\partial^2 U}{\partial \hat{C}^m \partial \hat{C}^h}\left(\dfrac{\partial Q^h}{\partial \hat{K}^h} - \dfrac{\partial^2 U}{\partial (\hat{C}^h)^2}\left(\left(\dfrac{\partial Q^h}{\partial \hat{K}^h}\right)^2 - \dfrac{\partial^2 Q^h}{\partial (\hat{K}^h)^2}\dfrac{\partial U}{\partial \hat{C}^h}\right)\right)} < 0.$$

Proposition 3 establishes that a stronger enforcement will support a larger debt and openness in equilibrium. Since increased inflows also finance foreign consumption and investment in the home goods sector, indebtedness will grow more than exports so that foreign consumption falls in the long-run. Furthermore, as shown in the proof of Proposition 3, if foreign and home goods are gross substitutes, the home goods consumption drops as well. Dynamic inefficiency in the home goods sector occurs in the opposite direction. Namely, lower sanctions lead to an inefficiently large home goods sector. The upshot of the comparative static exercise is that limited enforcement also limits openness. These results are intuitive and also verified by our numerical experiments.

Finally, to conclude our analytical inquiry, and also to better appreciate how the locked-in export capital serves as a commitment mechanism, compare the long-run export capacity had investments been irreversible with the capacity when they could be undone. Had the debtor been able to disinvest after a default, the long-run capital stock in the export sector would have satisfied, $\partial Q^e/\partial \hat{K}^e = \beta/(1-\alpha)$. Clearly, a defaulter would have preferred to have a much smaller export capacity than the one it got locked into. Thus, the capacity created in the export sector under the lending regime, $D(t)/Q^e(K^e(t)) \leq \alpha/r$, is "too high" should the debtor default. As such, this "excess capacity" provides the guarantee to the creditors that their loans will be repaid.

Simulations of transition paths

Since the purpose of our numerical experimentation is to discover how limited enforcement impacts equilibrium paths, we approximate the repayment and default programs with a low, $\alpha = 0.1$, and a high enforcement, $\alpha = 0.8$, rates. The equilibrium paths are also affected by the relative magnitudes of the pure time preference and the interest rates so that the experiments are run with $\beta = r$ and $\beta > r$. Altogether, four cases are considered.[8]

In order to control for the effects of technology and tastes on the experiments, we assume symmetry in production technologies and preferences over domestic and foreign goods. The economy is assumed initially to be almost closed with no outstanding foreign liabilities and a relatively small export sector. Parameter values and functional forms are discussed in the Appendix. Figures 15.1 and 15.2, and Table 15.1 summarize our numerical findings.

Notice that in a loose enforcement regime where the borrower is allowed to hold a debt stock about 1.25 times its exports, $\alpha = 0.1$, the credit limit binds around the tenth quarter (after the first time period) and remains so thereafter. Once the credits tighten, the creditors allow gross lending to grow at the same rate as exports and also start extracting a fixed fraction, $\alpha = 0.1$, of the debtor's exports as interest payments.

As shown in Figures 15.1 and 15.2, the debtor starts with no foreign debt and a relatively low export capacity, and quickly accumulates both. The home goods

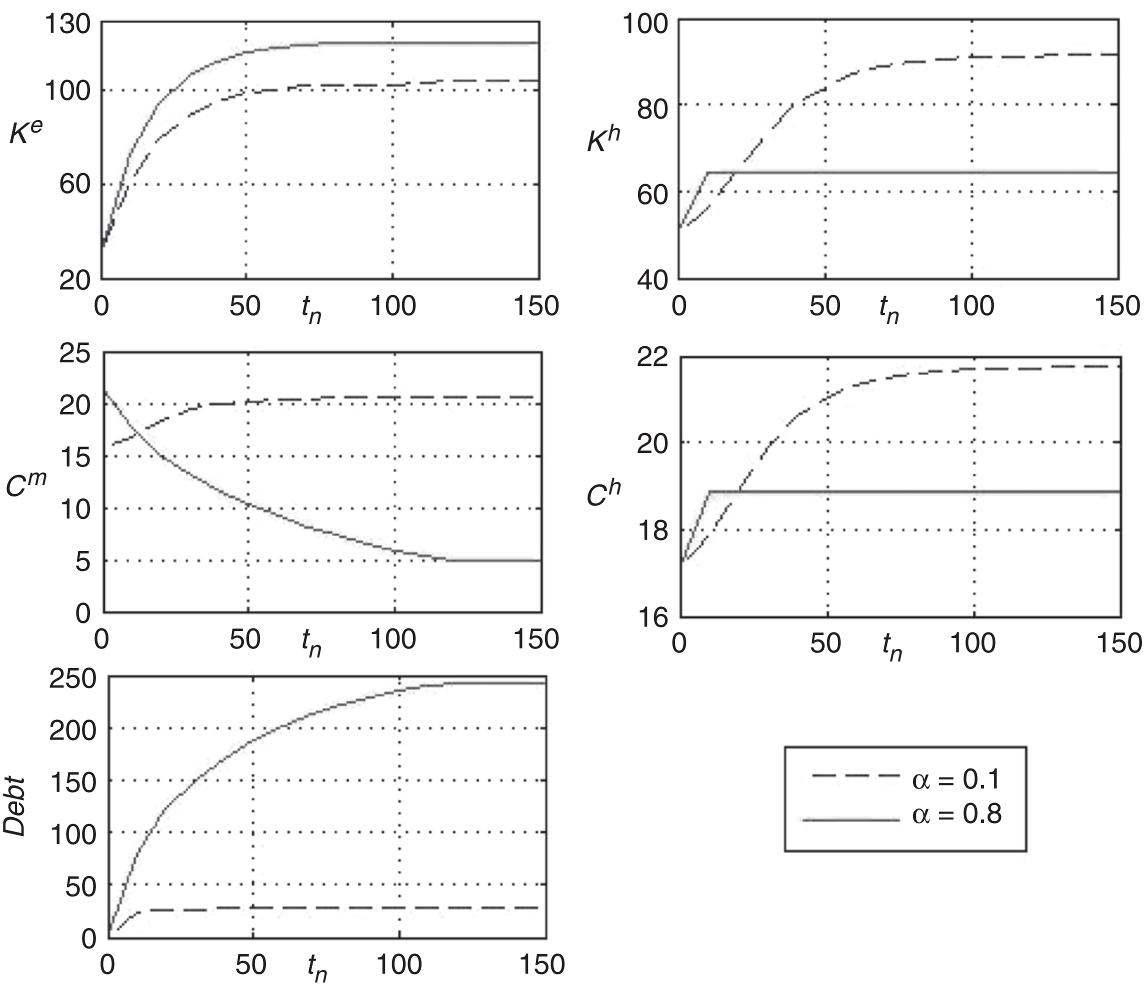

Figure 15.1 Capital, consumption and debt paths ($\beta > r$).

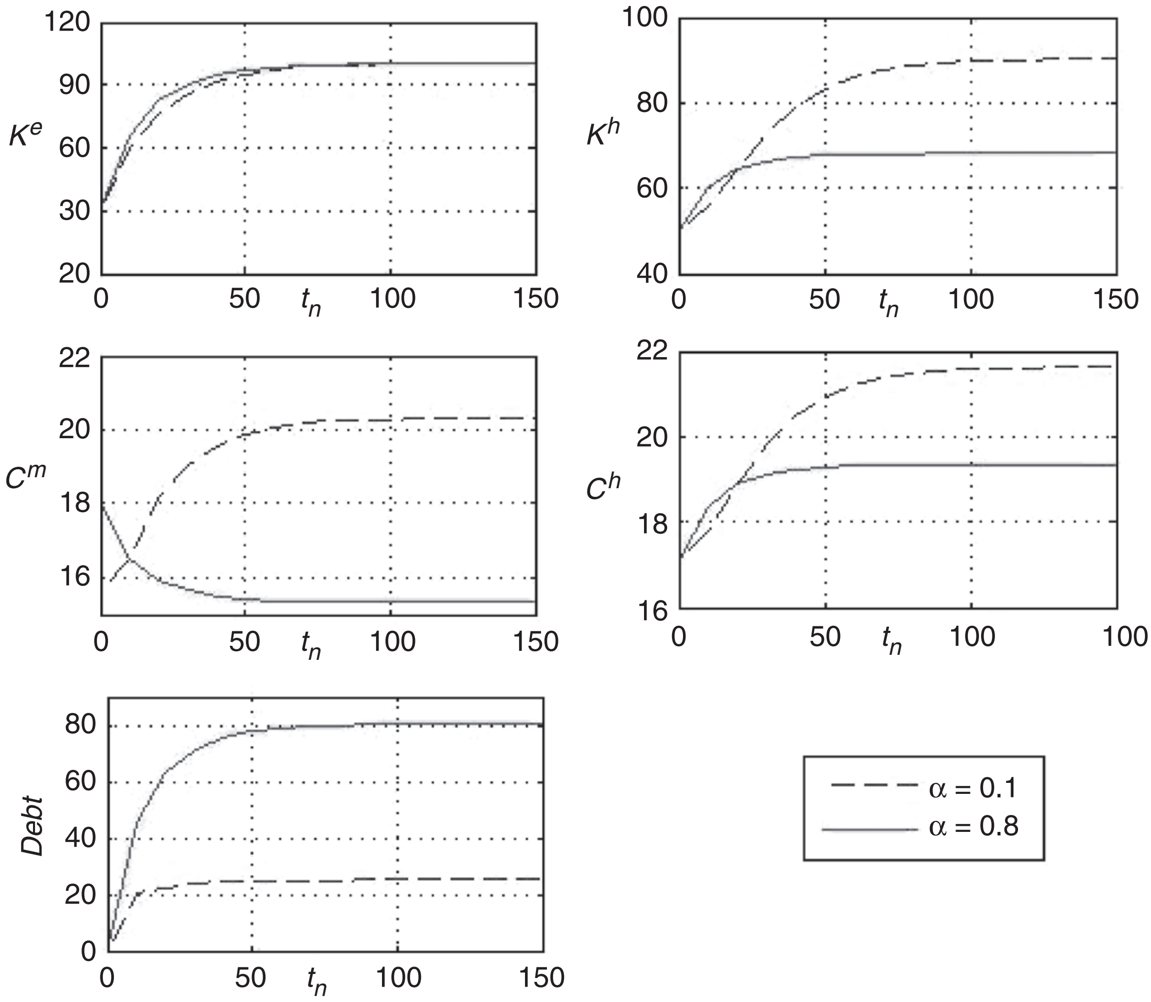

Figure 15.2 Capital, consumption and debt paths ($\beta = r$).

sector expands as well, albeit, at a slower pace. If $\beta > r$ and $\alpha < 1$, credit constraints eventually bind and remain tight thereafter. That is, for some t, $D(s) = \tilde{D}(s)$ for all $s \geq t$.

Increased enforcement speeds up the adjustment process and allows debtor to shift consumption to earlier periods. Since, the home goods are only consumed, the rapid initial growth in the home goods sector indicates the borrower's impatience to attain the long-run consumption level. Furthermore, since the home goods sector shrinks with a stronger enforcement in the long-run, adjustments run their due course faster.

In a tight enforcement regime, larger initial inflows also finance higher consumption of foreign goods while exports are still low. When the debtor's desire to consume in the present is strong, $\beta > r$, and severe sanctions are in force against a default, $\alpha = 0.8$, the time profile of foreign goods consumption starts to decline. If $\beta = r$, as in Figure 15.2, consumption shifting is less desired so that time profiles become more balanced and increase monotonically. In this instance, earlier capital inflows largely finance investment in both sectors.

When $\beta = r$, the long-run productive capacity in the export sector is *independent* of the severity of sanctions as also witnessed in the simulations of the next section.

Table 15.1 Comparison of lending strategies

			$\beta = 0.09,\ r = 0.08$							$\beta = r = 0.09$		
α	N	t_n	$K^e_{t_n}$	$K^h_{t_n}$	D_{t_n}	$C^m_{t_n}$	$C^h_{t_n}$	$K^e_{t_n}$	$K^h_{t_n}$	D_{t_n}	$C^m_{t_n}$	$C^h_{t_n}$
	0	0	30.00	50.00	0.00	15.86	17.08	30.00	50.00	0.00	15.61	17.08
	1	10	60.88	55.96	23.10	16.62	17.87	60.09	55.52	20.42	16.50	17.81
	2	20	78.74	64.08	25.60	18.37	18.86	76.22	63.98	22.46	18.12	18.85
	3	30	89.39	73.16	26.93	19.33	19.89	86.07	72.60	23.58	19.04	19.82
	4	40	94.85	79.94	27.58	19.82	20.60	91.93	78.92	24.21	19.57	20.50
	5	50	99.59	84.03	28.12	20.22	21.02	95.15	83.18	24.55	19.86	20.93
	6	60	100.48	87.28	28.22	20.31	21.34	97.11	85.83	24.75	20.03	21.20
0.1	7	70	101.87	88.79	28.38	20.42	21.49	98.76	87.43	24.91	20.17	21.36
	8	80	102.32	89.86	28.43	20.46	21.59	99.37	88.62	24.98	20.22	21.47
	9	90	102.54	90.45	28.45	20.48	21.65	99.73	89.29	25.01	20.26	21.54
	10	100	102.57	90.76	28.46	20.49	21.68	99.94	89.68	25.03	20.27	21.57
	11	110	103.29	90.81	28.53	20.54	21.68	100.07	89.91	25.05	20.29	21.60
	12	120	103.86	91.01	28.60	20.59	21.70	100.15	90.04	25.05	20.29	21.61
	13	130	103.88	91.29	28.60	20.59	21.73	100.19	90.12	25.06	20.30	21.62
	14	140	103.88	91.42	28.60	20.59	21.74	100.22	90.17	25.06	20.30	21.62
	15	150	103.88	91.49	28.60	20.59	21.75	100.23	90.20	25.06	20.30	21.62
	Welfare: 338.177							Welfare: 336.576				
	0	0	30.00	50.00	0.00	21.33	17.08	30.00	50.00	0.00	18.00	17.08
	1	10	73.40	64.17	79.85	17.50	18.87	65.82	59.90	45.37	16.50	18.36
	2	20	94.44	64.17	121.73	14.99	18.87	82.19	64.29	62.62	15.92	18.88
	3	30	105.91	64.17	149.88	13.10	18.87	90.51	66.32	70.91	15.65	19.12
	4	40	112.44	64.17	170.82	11.57	18.87	94.93	67.26	75.21	15.50	19.23
	5	50	116.24	64.17	187.36	10.28	18.87	97.32	67.71	77.53	15.42	19.28
	6	60	118.46	64.17	200.91	9.16	18.87	98.63	67.92	78.80	15.38	19.30
0.8	7	70	119.66	64.17	212.17	8.17	18.87	99.36	68.01	79.50	15.36	19.31
	8	80	120.12	64.17	221.50	7.30	18.87	99.76	68.06	79.89	15.34	19.32
	9	90	120.12	64.17	229.24	6.54	18.87	99.98	68.08	80.11	15.33	19.32
	10	100	120.12	64.17	235.57	5.86	18.87	100.10	68.09	80.23	15.33	19.32
	11	110	120.12	64.17	240.15	5.27	18.87	100.17	68.10	80.29	15.33	19.32
	12	120	120.12	64.17	242.43	4.85	18.87	100.21	68.10	80.33	15.33	19.32
	13	130	120.12	64.17	242.43	4.85	18.87	100.23	68.10	80.35	15.32	19.32
	14	140	120.12	64.17	242.43	4.85	18.87	100.24	68.10	80.36	15.32	19.32
	15	150	120.12	64.17	242.43	4.85	18.87	100.25	68.10	80.37	15.32	19.32
	Welfare: 342.946							Welfare: 337.303				

Depending on the initial size of the export sector and α, the credit limit may or may not bind. If the initial export capital and the rate of enforcement are sufficiently large, as per our numerical exercises with $\alpha = 0.8$, the credit limit will not bind at all so that no loss of efficiency ensues. Otherwise, (e.g., $\alpha = 0.1$) the credit constraint will eventually bind and remain tight thereafter. Since, in the long-run, all marginal investment opportunities will have been completely exhausted, the value of extra credit will be nil. In this instance, limited enforcement will be costly because, restricted foreign lending will slow down adjustments and will also lead to an inefficiently large home goods sector. As different from the export sector, the size of the home goods sector in the long-run is also affected by the preferences over the two goods.

Ultimately, a tighter enforcement, as captured by a higher α, reduces the effective opportunity cost of foreign borrowing. The borrower not only invests and consumes more in the present, but also invests relatively more in the export sector and consumes more of the imported goods. To the extent home goods can substitute for foreign goods with ease, as assumed in our exercises, the loss of welfare due to the lack of enforcement is limited. Otherwise, with a wide margin between the domestic time preference and the world interest rate, the welfare cost can be substantial.

Finally, we note that a target debt/export ratio is a credible lending policy as it aligns the debtor's ex ante and ex post incentives. *Ex ante*, it imparts to a potential borrower the *ability* to borrow contingent on its investment and trade policies; *ex post*, it measures the creditworthiness as the *willingness*, due in part to the borrower's past investment decisions, to service a given level of debt.

Concluding remarks

In the absence of conventional legal and institutional structures, participants in international loan markets have incentives to develop alternative relational mechanisms to provide support for the contingency needs of loan transactions. Specifically, in an environment of limited enforcement, investment decisions and long-term debtor/creditor relationships become strategically interlocked.

Creditors may set a target debt/export ratio to keep a debtor's interest burden below a certain fraction of its exports so that servicing debt does not become too onerous triggering a default. Within the repudiation/retaliation framework, this fraction can be construed as a measure of the severity of creditor sanctions that may come about in various guises. Thus, the upper bound on the debt service gains a special meaning as the potential default cost. We show that, under the assumptions of our model, target debt/export ratios generate self-enforcing trajectories of debt should a default ever be entertained as an option.

Borrowers, on the other hand, may deliberately alter their investment patterns to increase their vulnerability to potential creditor sanctions to attract increased foreign capital. To the extent investments are irreversible, when present governments commit to export-led growth, they also limit the possibilities for future governments to re-optimize. A large export sector which has been financed by foreign debt is then a 'firm pledge' not to default, for the costs of a default have increased as well.

The inefficiencies arising from the lack of enforcement, however, cannot completely be done away with. Lending under limited enforcement is too restricted to support an efficient foreign and home goods mix. By and large, the trade sector is relatively too small. To the degree the home goods are poor substitutes for foreign goods, the future is discounted more heavily domestically than by the rest of the world, and the potential sanctions are low, the welfare cost of limited enforcement can be substantial.

Appendix: Genetic simulations with target debt/export ratios

Throughout our exercises, we assume identical sectoral production functions, $Q^i(K^i) = a(K^i)^b$, $i = e, h$. Consumption preferences are represented by $U(C^m, C^h) = (C^m C^h)^\gamma$, which is symmetric in the two goods. Two enforcement regimes exist: a low $\alpha = 0.1$ and a high $\alpha = 0.8$. Other parameter values are:[9] $a = 3.57146$, $b = 0.4$, $\gamma = 0.5$, $z = 0.05$, $r = 0.08$, $\beta = 0.09$, $K^e(0) = 30$, $K^h(0) = 50$, and $D(0) = 0$. When $\beta = r$, the same parameter values are used with the exception, $\beta = r = 0.09$.

Assuming both programs become stationary at some arbitrary date T, we discretize the repayment and default programs using the time aggregation method proposed by Mercenier and Michel (1994) to ensure that the discrete models have the same steady-states as their continuous analogs. In time aggregation, we assume 15 periods with a dense equally spaced gridding of the time horizon $T = 150$, which is sufficient to capture convergence.

In all of our numerical experiments, we use the genetic operators in the public domain *GENESIS* package by Grefenstette (1990) on a *SUN SPARC-1000* running

```
procedure Debt/Export GA;
begin
 i = 0; /* Generation counter */
 initialize K^e(i), K^h(i), D(i); /* Initial population of K^e, K^h and
                                      D paths */
 n = 0;  t_n = 0;
 evaluate K^e_{t_n}, K^h_{t_n}, D_{t_n};
 n = n + 1;  t_n = t_{n-1} + 10;
   evaluate K^e_{t_n}, K^h_{t_n}, D_{t_n};
   check D_{t_n}/Q^e_{t_n} ≤ α/r
   repeat until (t_n = T)
 i = i + 1;
   select new population K^e(i), K^h(i), D(i);
   crossover and mutate K^e(i), K^h(i), D(i);
   n = 0;  t_n = 0;
   evaluate K^e_{t_n}, K^h_{t_n}, D_{t_n};
   n = n + 1;  t_n = t_{n-1} + 10;
     evaluate K^e_{t_n}, K^h_{t_n}, D_{t_n};
     check D_{t_n}/Q^e_{t_n} ≤ α/r
     repeat until (t_n = T)
 repeat
 until(terminal condition);
 end;
```

Solaris 2.5. In a typical run, we use a *population size* of 50 a *crossover* rate of 0.60, a *mutation* rate of 0.03, and a generation number of 200,000.

Using these parameter configurations, we approximate the repayment program by genetic algorithms. Genetic algorithms are powerful general purpose optimization tools in irregular and complex search spaces. A drawback, however, is the lack of any obvious and generally accepted method of dealing with constraint violations. Given that repayment program is heavily constrained by target debt/export ratio, irreversible investments as well as non-negativity restrictions this difficulty may seem especially troubling. Nonetheless, we successfully incorporate constraint violations into fitness evaluations by way of severe penalties. The following is a sketch of the algorithm.

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