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Exchange Rate Hysteresis: The Effects of Overshooting and Short-Termism

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The present paper addresses two questions. First, how does exchange rate overshooting affect hysteresis in trade and competitiveness? Second, how does 'short-termism' alter the magnitude of such hysteresis effects? The paper models the dynamic processes of hysteresis in trade and competitiveness in terms of the presence of discrete, asymmetric lump-sum costs of entry, in response to unanticipated foreign policy shocks. The paper produces some important new insights into the role of short run adjustment processes in understanding persistence effects in key macroeconomic indicators.

I Introduction

Hysteresis is when an effect persists after its cause has been removed. Thus, the exchange rate is said to be hysteretic when a temporary shock permanently alters its long run equilibrium. In the present paper, hysteresis in the real exchange rate comes about through there being hysteresis in the trade account, as in Baldwin and Krugman (1989). Trade account hysteresis arises from the existence of sunk costs of entry into sectors producing internationally traded goods. Because this forces a gap between the real exchange rate which triggers entry and that which triggers exit, a single real exchange rate may be associated with multiple trade equilibria. These equilibria are selected according to history: and it is this path dependence that is the very meaning of hysteresis. In the model developed in this paper, the real exchange rate is determined in part by the trade account, therefore if there is trade account hysteresis this will feed through to give exchange rate hysteresis. We call this 'feedback' from the trade account onto the real exchange rate. This is important because hysteresis generates long run policy non-neutrality in models where neutrality is normally observed.

The seminal literature that appeared on hysteresis in the late 1980s, see for example Baldwin (1988), Baldwin and Krugman (1989) and Dixit (1989, 1992), made some simplifying assumptions so that they could make sense of the new ideas they were developing. Often, the exchange rate was determined by autonomous factors, or was itself exogenous. Adjustment to long run equilibrium was assumed to be instantaneous. These two assumptions precluded any examination of the effects of the short run dynamics of the real exchange rate such as 'overshooting' or consideration of the effects of how firms value the future on the magnitude of hysteresis. The present paper seeks to address two questions: how does exchange rate overshooting affect hysteresis in trade and competitiveness, and how does 'short-termism' alter the magnitude of such hysteresis effects?

The first question seeks to extend the traditional literature on hysteresis, for example in Baldwin and Krugman (1989) and Baldwin and Lyons (1994), who assume that adjustment to long run equilibrium is instantaneous. Once we relax this assumption then the short run dynamics of the exchange rate become important determinants of the magnitude of entry and exit and hence hysteresis and its effects.

We can then go further because once we allow adjustment to be non-instantaneous, then how firms value the future becomes a relevant consideration. Thus, if firms are 'short-termist', this may then affect the magnitude of these hysteretic effects.

Two methods of modelling hysteresis have recently received prominence in the literature. The contributions by Baldwin (1988), Baldwin and Krugman (1989), Dixit (1989) and Baldwin and Lyons (1994) explain hysteresis in terms of the presence of discrete, asymmetric lump-sum entry costs, and demonstrate that a change inducing firms to enter a market may be reversed without causing exit. This is the line of analysis adopted in the present paper. An alternative explanation of hysteresis is provided by models with multiple local attractors, where parameter changes lead to equilibrium loss, and reversed changes do not restore the economy to the local equilibrium at the initial state[1].

The present paper shows that 'overshooting' magnifies the effects of hysteresis in trade and competitiveness. The intuition behind this result is straightforward. If there is an unanticipated policy change that causes domestic competitiveness to decline, and hence the profits of importers to rise, then if adjustment is less than instantaneous and there is 'overshooting' of domestic competitiveness, then this may trigger the entry of a foreign firm (importer) that would not have entered had competitiveness not overshot its long run equilibrium level. Because the effect of the entry of the foreign firm feeds back onto trade and competitiveness, causing domestic competitiveness to decline further, an unanticipated policy change of equal and opposite magnitude to the initial policy change that just triggered entry will not trigger exit and trade and domestic competitiveness will not return to their former levels. In other words, a reversal of policy does not lead to a reversal of response. 'Overshooting' has induced hysteresis effects that would otherwise have not occurred.

These hysteretic effects are further magnified if firm behaviour is 'short-termist'. Again the intuition behind this result is easy to see. If profits are falling during the adjustment period, then firms that value present profits relatively highly (a firm with a very high discount rate, a firm whose behaviour is 'short-termist') is more likely to enter than a firm that is relatively 'far-sighted'. Thus, 'short-termism' may encourage entry where none would have occurred if behaviour had been more 'far-sighted'. This extra entry magnifies the hysteresis effects on trade and competitiveness.

The rest of the paper is set out in three sections. Section 1 sets out a micro economic model of import determination incorporating trade account hysteresis in the spirit of Baldwin and Krugman (1989). Section 2 examines the policy implications of 'overshooting' and 'short-termism' on hysteresis in trade and competitiveness, and hence therefore on industrial structure and long-term trade patterns. Section 3 concludes and gives an indication of the likely direction of future research.

II A Micro Model of Import Determination

Suppose that there are two countries, domestic and foreign, and the domestic country is 'small' relative to the foreign country. In the foreign country there are two types of *sectors – non-hysteretic* sectors and *hysteretic* sectors. In the more general case there may be many hysteretic sectors. For simplicity, however, we assume that there is only a single foreign hysteretic sector. In this sector there operates only a single foreign firm[2] which therefore operates as a monopolist in that sector. This monopolist supplies all the goods it produces in this sector to the *domestic* market. The monopolist may, in addition, have commercial interests in the non-hysteretic sectors,[3] but the analysis here assumes that any profits derived from these interests are not used to cross-subsidise its operations in the foreign hysteretic sectors.

As in Baldwin and Krugman (1989), the foreign monopolist decides at the beginning of each time period whether it wishes to operate in the foreign hysteretic sector. If it wishes to enter the foreign hysteretic sector and begin production, it must pay a one-off non-recoverable lump sum entry cost. Once the firm has entered it must pay a maintenance cost in each subsequent period in order to remain in production in its foreign hysteretic sector. If it fails to pay this maintenance cost it must exit the foreign hysteretic sector, and

[1]Roberts and McCausland (1999) present a global analysis of international debt, the trade account, and the exchange rate along these lines. Other examples of this approach to modelling hysteresis can be found in the output model of Evans and Honkapohja (1993) and the model of money demand and inflation by Roberts (1993).

[2]Or a group of foreign firms that act as a single monopolist.

[3]These may be in either country. Assume there are only non-hysteretic sectors in the home country.

it may not then re-enter production at any time thereafter. For firms with low rates of time preference, the entry cost will be relatively unimportant (that is, only maintenance costs are relevant).

The entry cost reflects the cost of entering a new market present in many types of industry. In the retail and service sectors this may be the cost of advertising to establish a brand name. In, for example, oil, or other natural resource extraction, this may take the form of research and development expenditure to locate fresh resources, or the cost of obtaining or bidding for a licence to begin extraction.

If the foreign monopolist is already operating in the foreign hysteretic sector and wishes to continue doing so then it must pay the maintenance cost. If it does not pay the maintenance cost, it must cease production and exit from the foreign hysteretic sector for all time. Exit does not incur any extra cost. The monopolist makes these decisions based on the profit maximising conditions explained in the following text, which depend critically on changes in competitiveness or the real exchange rate.

By contrast, in the non-hysteretic sectors there is a perfectly competitive environment in which entry and exit is free. In these sectors there is a continuous relationship between the real exchange rate and how much is produced. Assume the foreign general price level is the numeraire. The domestic general price level may, of course, vary.

Assume that the foreign firm is a monopoly producer in its sector and that it faces a demand function in the domestic country of the form

$$I = \left(\frac{p_I}{p}\right)^{-\alpha} \quad \alpha > 1 \tag{1}$$

giving an inverse demand function of the form

$$\frac{p_I}{p} = I^{-\frac{1}{\alpha}} \tag{2}$$

where p_I is the price of imports and p is the domestic general price level. The typical foreign firm chooses a level of production to maximise a time separable operating profit function (which, in the absence of depreciation on capital, is equivalent to maximising the expected value of profits over time) of the form

$$\pi = \frac{p_I I}{s(\mu, \beta, l, r^*)} - QI \quad \pi_s < 0, s_\mu < 0, s_\beta > 0, s_l > 0, s_{r^*} > 0 \tag{3}$$

where π are operating profits, s is the nominal exchange rate defined as the price of foreign currency in domestic currency terms, μ takes a value of 1 if the foreign monopolist is operating in the foreign hysteretic sector, and zero if the foreign monopolist is not operating in the foreign hysteretic sector, β represents a positive external trade shock, l and r^* reflect domestic and foreign monetary policy, respectively, I is the volume of production (domestic imports) and Q is the unit variable cost in the foreign hysteretic sector. Assume marginal costs are constant. Note that these profits are the profits only of that firm's particular operation in the domestic country in foreign currency terms, not the profits of its world operation as a whole.

Solving the firm's maximisation problem gives an equilibrium profit function of the form

$$\pi = \left(\frac{Q}{\alpha - 1}\right)^{1-\alpha} (\alpha c)^{-\alpha} = \psi(\alpha c)^{-\alpha} \tag{4}$$

where $c \equiv s/p$ is the domestic economy's real exchange rate.

The equation of motion of the representative foreign firm's profits in the foreign hysteretic sector is given by the linear adjustment process

$$\pi(t+u) = \tilde{\pi}(\infty) + [\pi(t) - \tilde{\pi}(\infty)]e^{-\rho_s u} \tag{5}$$

where $\tilde{\pi}(\infty)$ are long run profits, that is profits evaluated at the long run equilibrium real exchange rate, $\pi(t)$ are profits evaluated at the instant an external shock (or policy) hits the system using the value of the real exchange rate immediately after the 'jump' onto the saddle path, and ρ_s is the *absolute* value of the stable root, interpreted here as the speed of adjustment.

The expected present value function for the firm is

$$V(t) = \int_0^\infty e^{-\delta u}\pi(t+u)du \tag{6}$$

where δ is the rate of time preference or 'subjective discount rate' of foreign firms, which, for analytical convenience is assumed to be independent of the domestic interest rate. Substituting equation 5 into equation 6 yields

$$V(t) = \int_0^\infty \left[e^{-\delta u}\tilde{\pi}(\infty) + e^{-(\delta+\rho)u}(\pi(t) - \tilde{\pi}(\infty))\right]du \tag{7}$$

Thus

$$V(t) = \frac{\tilde{\pi}(\infty)}{\delta} + \frac{\pi(t) - \tilde{\pi}(\infty)}{\delta + \rho_s} \tag{8}$$

A firm will enter if the expected present value of being 'in' $(V_I - M/\delta)$ less the expected present value of being 'out' (V_U) exceeds the cost of entry, N. A firm will exit if the expected present value of being 'out' (V_U) exceeds the expected present value of being 'in' $(V_I - M/\delta)$. Clearly $V_U = 0$, and $V_I = V|_{\mu=1}$ which will henceforth be written as $V_{I(1)}$.

The exit and entry boundary conditions are defined as

$$\begin{aligned} &exit: V_I - M/\delta = V_U \to V_{I(1)} - M/\delta = 0 \\ &entry: V_I - N = V_U \to V_{I(1)} - N = 0 \end{aligned} \tag{9}$$

where N is the lump sum cost of entry, M is the maintenance cost payable each period to remain in production, and the expected present value functions are as defined above.

Multiplying[4] through by δ gives the exit and entry boundary conditions as

$$\begin{aligned} &exit: \ \delta V_{I(1)} - M = 0 \\ &entry: \ \delta V_{I(1)} - \delta N = 0 \end{aligned} \tag{10}$$

Thus, writing $\delta V_{I(1)}$ as $X_{I(1)}$, from (8) we obtain

$$X_{I(1)} \equiv \delta V_{I(1)} = \tilde{\pi}_{(1)}(\infty) + \frac{\delta\left[\pi_{(1)}(t) - \tilde{\pi}_{(1)}(\infty)\right]}{\delta + \rho_{(1)}} \tag{11}$$

where $\rho_{(1)} = \rho_s|_{\mu=1}$, $\pi_{(1)} = \pi|_{\mu=1}$. To address our first question of how 'overshooting' affects hysteresis, we shall need to know how the X function in (11) behaves with respect to $\rho_{(1)}$, and, to address our second concern of how 'short-termism' affects hysteresis, we shall also need to know how the X function in (11) behaves with respect to δ. These partial derivatives depend on the sign of the term $[\pi_{(1)}(t) - \tilde{\pi}_{(1)}(\infty)]$. This depends on whether profits are increasing or decreasing as the system adjusts to long run equilibrium. From equation 4

$$\left[\pi_{(1)}(t) - \tilde{\pi}_{(1)}(\infty)\right] = \psi\alpha^{-\alpha}\left[{c'_{(1)}}^{-\alpha} - \tilde{c}_{(1)}^{-\alpha}\right] \tag{12}$$

where c' is the real exchange rate immediately after the policy change, $\tilde{c}$ is the long run equilibrium real exchange rate and $c'_{(1)} = c'|_{\mu=1}$, $\tilde{c}_{(1)} = \tilde{c}|_{\mu=1}$ and $\psi = \left(\frac{Q}{1-\alpha}\right)^{1-\alpha}$ as defined in equation 4. If the real exchange rate falls during the adjustment period to long run equilibrium, then $c'_{(1)} > \tilde{c}_{(1)}$, and therefore $c'_{(1)}{}^{-\alpha} < \tilde{c}_{(1)}^{-\alpha}$, thus making the expression in (12) negative.

It is straightforward to show[5] then that the X function in (11) with respect to $\rho_{(1)}$ is positive and concave, approaches $\tilde{\pi}_{(1)}(\infty)$ as $\rho_{(1)} \to \infty$, and becomes invariant to $\rho_{(1)}$ in the long run. Similarly, the X function in (11) with respect to δ is negative and convex, approaches $\tilde{\pi}_{(1)}(t)$ as $\delta \to \infty$, becoming invariant to δ in the long run.

Conversely, if the real exchange rate rises during the adjustment period to long run equilibrium, then $c'_{(1)} < \tilde{c}_{(1)}$, therefore ${c'_{(1)}}^{-\alpha} > \tilde{c}_{(1)}^{-\alpha}$, thus (12) then becomes positive.

Likewise it is then again straightforward to show that the X function in (11) with respect to $\rho_{(1)}$ is negative and convex, approaches $\tilde{\pi}_{(1)}(\infty)$ as $\rho_{(1)} \to \infty$, and becomes invariant to $\rho_{(1)}$ in the long-run. Similarly, the X function in (11) with respect to δ is positive and concave, approaches $\tilde{\pi}_{(1)}(t)$ as $\delta \to \infty$, becoming invariant to δ in the long run. We shall now use these properties of the X function to analyse policy effectiveness and the associated persistence effects when there is hysteresis in trade and competitiveness. Specifically, we are interested in whether real exchange rate 'overshooting' and 'short-termist' firm behaviour may exacerbate policy effects to the extent that hysteresis effects are magnified. To do this we must have some understanding of how various policies might affect the behaviour of the real exchange rate, and it is to this issue that we now turn.

III Policy Analysis and Implications

The precise specification of the model determining the dynamics of the real exchange rate is not of prime concern to this paper, nor does it drive any of the results. I shall therefore assume that the reader is familiar with the concept of exchange rate 'overshooting' as, for example, presented in Dornbusch (1976). For the purpose at hand I employ a useful extension of the Dornbusch model by Buiter and Miller (1981).

[4] This operation is widely used and does not affect the analysis of the triggers on investment decisions.

[5] The appendix gives a brief sketch of how we determine these properties of the X function in (11).

Because the model is well explained in a great number of texts, here I present only the basic intuition behind the model using the familiar phase-diagram, and give a brief formal description of the derivation of the results in the appendix.

(i) A Macro-Economic Model of Exchange Rate Determination

The extended Buiter and Miller (1981) model with feedback may be summarised by the following linear dynamical system[6]

$$\begin{bmatrix} \dot{c} \\ \dot{l} \end{bmatrix} = \mathbf{A}\begin{bmatrix} c \\ l \end{bmatrix} + \mathbf{B}\begin{bmatrix} \hat{m} \\ (r^* - \dot{p}^*) \\ \mu \end{bmatrix} \qquad (13)$$

where the matrices **A** and **B** are defined in the appendix and c is domestic competitiveness, l is domestic liquidity, $\hat{m}$ is the rate of growth of the domestic nominal money supply, r^* is the foreign nominal interest rate, $\dot{p}^*$ is the foreign inflation rate, and μ is a term representing whether the foreign hysteretic firm is active ($\mu = 1$) or inactive ($\mu = 0$). This system is captured on the familiar phase diagram (Figure 1).

We shall assume that foreign monetary policy takes the form of changes in the foreign nominal interest rate, r^*. The effect of a rise in r^* is to shift the $\dot{c} = 0$ locus upwards (without changing the position of the $\dot{l} = 0$ locus), thereby increasing long run domestic competitiveness and decreasing long run domestic liquidity. This is illustrated on Figure 1. Because the saddle path is upwards sloping, we can see straightaway that the exchange rate 'overshoots' its long run equilibrium.

(ii) The Effects of 'Overshooting

The first question we wish to address is whether 'overshooting' can affect the magnitude of hysteresis effects. Suppose that initially the firm is 'in' (operating in its foreign hysteretic sector). There is an unanticipated foreign monetary contraction (an increase in the foreign interest rate, r^*) at time t. Overall, there is an increase in domestic competitiveness, but the real exchange rate 'overshoots' its long run equilibrium level. Thus, the short run adjustment profile is characterised by a falling real exchange rate along the saddle path. We saw that, because this implies that, from equation 11, profits are rising along the saddle path, this gives the upwards sloping X_ρ locus depicted on Figure 2. Intuitively, the reason for the slope of this locus is not difficult to see. If the adjustment speed is instantaneous then short run profits are identical to long run profits, and there is an increasing divergence between long and short run profits as adjustment becomes slower.

If adjustment to long run equilibrium was instantaneous, that is, there was no 'overshooting' ($\rho_{(1)} \to \infty$), then clearly the firm would remain in production (because $X_{I(1)} > M$). However, if adjustment is less than instantaneous then the firm

[6] The full workings of the model may be obtained as a note from the author.

FIGURE 1
Exchange rate overshooting

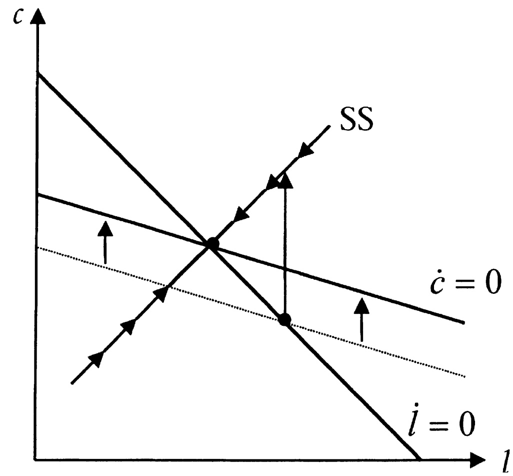
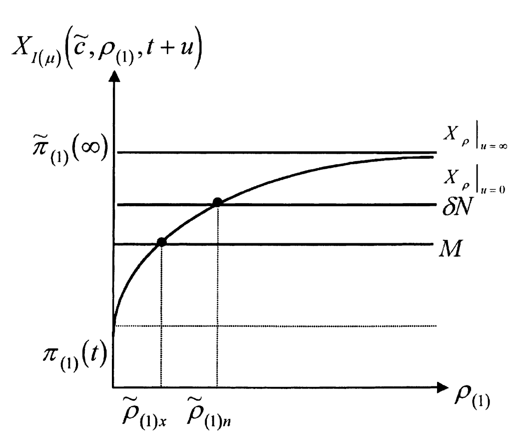


FIGURE 2
Overshooting and hysteresis



may exit. The critical value of ρ below which exit is triggered is depicted as $\tilde{\rho}_{(1)x}$ on Figure 2 (because for $\rho_{(1)} < \tilde{\rho}_{(1)x}$, $X_{I(1)} < M$).

Thus, 'overshooting' magnifies the effects of hysteresis in trade and competitiveness. The intuition behind this result is straightforward. If there is an unanticipated policy change that causes domestic competitiveness to decline, and hence the profits of importers to rise, then if adjustment is less than instantaneous and there is 'overshooting' of domestic competitiveness, then this may trigger the entry of a foreign firm (importer) that would not have entered had competitiveness not overshot its long run equilibrium level. Because the effect of the entry of the foreign firm feeds back onto trade and competitiveness, an unanticipated policy change of equal and opposite magnitude to the initial policy change that just triggered entry will not trigger exit and trade and domestic competitiveness will not return to their former levels. 'Overshooting' has induced hysteresis effects that would otherwise not have occurred.

As time progresses, the X_ρ function flattens, as shown in equation 16 and depicted on Figure 2.

As the X_ρ function in Figure 2 flattens, if the firm originally remained 'in' production, it will continue to produce. However, there is the possibility that if the firm had exited (if $\tilde{\rho}_{(1)} < \tilde{\rho}_{(1)x}$) it may re-enter later (because profits rise as we move down the saddle path). This re-entry possibility is ruled out if $\delta N > \tilde{\pi}_{(1)}(\infty)$.

(iii) The Effects of 'Short-Termism'

The second question to address is whether 'short-termism' exacerbates these hysteretic effects. Because we know now that the short-run adjustment path matters, how firms value their profits along the saddle path becomes a relevant concern. Suppose again that initially the firm is 'in' (operating in its foreign hysteretic sector). There is an unanticipated foreign monetary contraction (a rise in r^*) at time t. Overall, there is an increase in domestic competitiveness but the real exchange rate 'overshoots' its long run equilibrium level. Thus, the short run adjustment profile is characterised by a falling real exchange rate along the saddle path. We saw that, because this implies that, from equation 11, profits are rising along the saddle path, this gives the downwards sloping X_δ locus depicted on Figure 3. The higher δ is, the more heavily the future is discounted, that is, the more 'short-termist' the firms are. The reasoning behind the slope of this locus is that the gap between short and long run profits is lowest the lower the rate of time discounting.

If the firm has a subjective discount rate of $\delta > \tilde{\delta}_x$, it will exit from the foreign hysteretic sector (become 'inactive'), because, for these rates of time preference, $X_{I(1)}(\tilde{c}_{(1)}, \delta, t) < M$. Conversely, if the firm has a subjective discount rate of $\delta < \tilde{\delta}_x$, it will remain 'active' (continue operating in the foreign hysteretic sector) because, for these rates of time preference, $X_{I(1)}(\tilde{c}_{(1)}, \delta, t) > M$. Clearly, it is the 'far-sighted' firms (those with relatively low rates of time preference) that remain in production, and the 'short-termist' firms (those with relatively high rates of time preference) that will exit. The intuition is again straightforward. Profits are rising as we move down the saddle path. Firms with 'short-termist' behaviour cannot wait for the higher profits that will occur in the future, and so will exit. Only 'far-sighted' firms will find it advantageous to remain.

As time progresses the X_δ function flattens, as shown in equation 19 and depicted on Figure 3, becoming horizontal in the long run.

An illuminating result may be discovered if we had considered instead the effect of an unanticipated foreign monetary expansion (a fall in r^*) that takes effect at time t. This yields the upwards sloping X_δ locus depicted in Figure 4.

If the firm has a subjective discount rate of $\delta < \tilde{\delta}_n$, it will enter and hence become 'active' (operating in the foreign hysteretic sector) because, for these rates of time preference, $X_{I(1)}(\tilde{c}_{(1)}, \delta, t) > \delta N$. Conversely, if the firm has a subjective discount rate of $\delta > \tilde{\delta}_n$, it will stay 'out', that is, it will remain 'inactive' (not operating in the foreign hysteretic

FIGURE 3
Short-termism and hysteresis

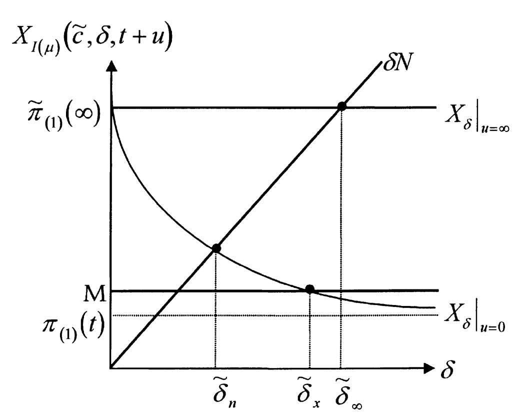
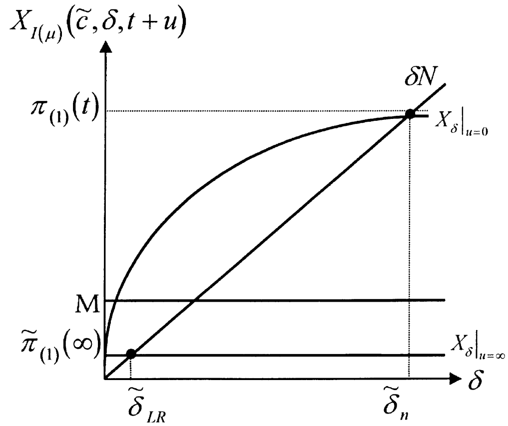


FIGURE 4
Scaling effects



sector), because, for these rates of time preference, $X_{I(1)}(\tilde{c}_{(1)}, \delta, t) < \delta N$.

This behaviour is counter-intuitive. One would expect that, because profits are falling as we move up the saddle path towards the new long run equilibrium, a 'far-sighted' firm would not choose to enter under these circumstances because it realises that in the long run, profit levels would not be sufficient to justify entry. Only firms that are 'short-termist' would choose to enter because they are interested only in short run profits, which are relatively high on the first section of the saddle path.

The explanation for this is that δ is not only capturing the effect of time discounting, but also has a general scaling effect on profits. When we were moving down the saddle path, the discounting effect and the scaling effect were working in the same direction. Here, the two effects are working in opposite directions. The scaling effect is outweighing the discounting effect, leading to the counter-intuitive result.

IV Conclusions

The present paper addressed two questions. First, how does exchange rate overshooting affect hysteresis in trade and competitiveness, and second, how does 'short-termism' alter the magnitude of such effects. The paper modelled the dynamic processes of hysteresis in trade and competitiveness in terms of the presence of discrete, asymmetric lump-sum entry costs, and demonstrated that a change inducing firms to enter a market may be reversed without causing exit.

The analysis began by considering a tightening of foreign monetary policy (increasing domestic competitiveness) that would not 'normally' be of sufficient magnitude to trigger exit were adjustment to long run equilibrium instantaneous. However, when adjustment is less than instantaneous, in the short run, the relevant real exchange rate for a firm making an exit decision is the real exchange rate along the 'saddle path' leading to long run equilibrium. The paper shows that real exchange rate 'overshooting' may mean then that exit does now occur. Furthermore, the paper demonstrates that this exit is more likely the more 'short-termist' firm behaviour is. The conclusions therefore are that, in general, 'overshooting' and 'short-termism' magnify hysteretic effects in trade and competitiveness.

APPENDIX

A brief sketch outlining the properties of the X function in (11)

$$\frac{\partial X_{I(1)}}{\partial \rho_{(1)}} = \left(\frac{\delta}{\delta + \rho_{(1)}}\right)\frac{\partial \pi_{(1)}(t)}{\partial \rho_{(1)}} - \frac{\delta\left[\pi_{(1)}(t) - \tilde{\pi}_{(1)}(\infty)\right]}{\left(\delta + \rho_{(1)}\right)^2} \tag{14}$$

$$\frac{\partial^2 X_{I(1)}}{\partial \rho_{(1)}^2} = \left(\frac{\delta}{\delta + \rho_{(1)}}\right)\frac{\partial^2 \pi_{(1)}(t)}{\partial \rho_{(1)}^2} + \frac{2\delta\left[\pi_{(1)}(t) - \tilde{\pi}_{(1)}(\infty)\right]}{\left(\delta + \rho_{(1)}\right)^3} \tag{15}$$

$$\frac{\partial}{\partial u}\left(\frac{\partial X_{I(1)}}{\partial \rho_{(1)}}\right) = \frac{\delta}{\left(\delta + \rho_{(1)}\right)^2}\frac{\partial \pi(u)}{\partial u} < 0 \tag{16}$$

$$\frac{\partial X_{I(1)}}{\partial \delta} = \frac{\rho_{(1)}\left[\pi_{(1)}(t) - \tilde{\pi}_{(1)}(\infty)\right]}{\left(\delta + \rho_{(1)}\right)^2} \tag{17}$$

$$\frac{\partial^2 X_{I(1)}}{\partial \delta^2} = \frac{-2\rho_{(1)}\left[\pi_{(1)}(t) - \tilde{\pi}_{(1)}(\infty)\right]}{\left(\delta + \rho_{(1)}\right)^3} \tag{18}$$

$$\frac{\partial}{\partial u}\left(\frac{\partial X_{I(1)}}{\partial \delta}\right) = \frac{\rho_{(1)}}{\left(\delta + \rho_{(1)}\right)^2}\frac{\partial \pi(u)}{\partial u} > 0 \tag{19}$$

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Although the professional economist will not be satisfied with the scope and depth of the economic analysis, the discursive style may be attractive to the general reader. Even then, the execution is not beyond criticism. There is some repetition; and the division of material into chapters and sections is occasionally strange. (Did the authors spend enough time coordinating their respective inputs?) Also, the now-flourishing debit cards are not treated until the final chapter, added almost as a postscript.

Clearly, the authors have a deep knowledge of the industry. (They report (p. xiii) that they have worked with Visa since 1991, and they acknowledge Visa 'for providing encouragement, financial support and many helpful comments'.) Of course, close knowledge can make it harder to see how to explain things to the beginner.

In short, in respect of both content and exposition, the book does not add to the stature of its authors.

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