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ABSTRACT

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Sunk costs of entry create a wedge between the real exchange rate for which a foreign exporter enters the domestic market, and that for which he exits. On the macroeconomic level, heterogeneous cost structures make the number of entry and exit thresholds approach a continuum: any movement of the real exchange rate beyond its historical peak triggers some entry or exit. A sufficiently large appreciation followed by an equivalent depreciation (a 'cycle') could hysteretically affect the trade volume, because some exporters enter and stay. This paper investigates whether trade-volume hysteresis indeed occurs during such cycles, by testing for structural breaks in the constant term and the real exchange rate elasticity of the import volume in a standard import-volume specification. Binomial tests indicate that constant-term breaks have the sign predicted by hysteresis theory significantly more than 50% of the time. Breaks in the real exchange rate elasticity, on the other hand, have the 'reverse' sign in significantly more than half of the cases.

Key words: Hysteresis, Trade volumes, Real exchange rate cycles, Recursive coefficient estimations
JEL codes: D57, F19, F31, F41

SAMENVATTING

Handelsvolumehysterese: een onderzoek met geaggregeerde data

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Wanneer een buitenlandse exporteur sunk costs voorziet bij intreding van de binnenlandse markt, zal hij voor een andere reële wisselkoerswaarde intreden dan uittreden. Op het macroeconomische niveau zorgen heterogene kostenstructuren ervoor dat het aantal in- en uittreeddrempels een continue verdeling benadert: iedere beweging van de reële wisselkoers voorbij een historische piek leidt dan tot enige in- of uittreding. Een voldoende grote appreciatie, gevolgd door een depreciatie van gelijke orde (een 'cyclus') zou tot handelsvolumehysterese kunnen leiden, omdat sommige exporteurs intreden maar niet uittreden. Onderzocht wordt of er inderdaad hysterese optreedt tijdens zulke cycli, door te toetsen op breuken in de constante term en de reële wisselkoerselasticiteit in een standaard importvolumespecificatie. Uit binomiale toetsen blijkt dat de breuken in de constante significant vaker dan 50% van de tijd het teken hebben dat overeenkomt met de voorspellingen van de hysteresetheorie. Daarentegen hebben breuken in de reële wisselkoerselasticiteit het 'omgekeerde' teken in significant meer dan 50% van de gevallen.

Trefwoorden: Hysterese, Handelsvolumes, Reële wisselkoerscycli, Recursieve coëfficiëntsschattingen
JEL codes: D57, F19, F31, F41

1 INTRODUCTION

- Cessante causa cessat effectus[1]

Hysteresis is the name given to an effect which remains after its cause has been removed. In a hysteretic process a positive and a negative shock of the same order will bring about a lasting consequence. In recent years hysteretic properties have been attributed to an increasing number of economic phenomena. Examples are unemployment hysteresis and domestic-production hysteresis[2]. However, this paper deals with one specific type of economic hysteresis: trade-volume hysteresis, caused by changes in the real exchange rate. That is, the real exchange rate movements present the cause, which, after having been reversed, can still have lasting consequences for trade volumes.

In short, the main reason that this could occur, is because a foreign exporter has to take into account certain sunk costs when entering into the domestic market, such as advertising expenditure. Once they are made, however, these costs cease to influence the exporter's decision-making process. An exporter will continue to export to the domestic market, as long his operating profit is nonnegative. Moreover, his (foreign-currency) profits are a positive function of the real exchange rate. Therefore, the real exchange rate that induces entry lies above that which forces exit. A real exchange rate appreciation may cause entry into the domestic market by a foreign exporter, which is not undone after an equivalent depreciation.

This type of trade hysteresis has also attracted previous theoretical and empirical research. Yet, most of the empirical work focuses on one period in one country: the 1980's in the US. But hysteresis in trade volumes, if it is found, can be interpreted as a general economic phenomenon. Its existence need not be restricted to a few 'exceptional' observations. That is why it seems important to broaden the research set, and conduct an investigation covering a larger set of countries. Our sample includes sixteen countries, fourteen EU-members plus the US and Japan, and covers the three decades since the end of Bretton Woods. *Our goal is to qualitatively test for hysteresis-induced structural breaks in the import-volume equation during periods of real exchange rate swings.*

In the next section we look at the theoretical foundations of trade-volume hysteresis. We start at the firm level, explaining the main insights from the seminal articles of Baldwin and Krugman (1989) and

[1] If the cause ceases to exist, so does the consequence (Grootwoordenboek der Nederlandse Taal, 1992, p. 3578).

[2] For the former see Phelps (1972), Blanchard and Summers (1986) and Belke and Göcke (1997), and for the latter Cross (2000).

Dixit (1992). Then we can go on to develop an understanding of trade-volume hysteresis on an aggregate, macroeconomic level, where the process undergoes a qualitative change. These foundations allow us to build our own simple model of trade-volume hysteresis, which generates testable implications. The issue of foreign direct investment (as a 'substitute' for trade flows) is covered at the end of this section.

The third section provides an overview of the existing empirical literature. In the fourth section we will subsequently be ready to develop our own empirical methodology. We define five distinct 'steps': defining the import-volume specification; identifying cycles of the real exchange rate; running the recursive coefficient estimations; making binomial tests to see if the signs of structural breaks correspond to the predictions of hysteresis theory; and checking the robustness of the results to alternative specifications. At each step along the way we discuss the results we obtain in applying our method. The last section concludes, points out some possibilities for future research and briefly touches upon some welfare implications, although the overall focus of this paper remains purely qualitative.

2 DEFINITION AND THEORY OF TRADE-VOLUME HYSTERESIS

What exactly is trade-volume hysteresis? As we shall see, the answer depends on the level of aggregation. Although the basic idea is the same, the concept itself takes on a different form when we move from the firm level, to the sectoral level, and finally to the macroeconomic level. For this reason, this section is separated into different parts. First, we analyse the single firm's reaction to real exchange rate swings. Then we move on to the multi-firm level, aggregating firms into sectors, and later sectors into the macroeconomy. The eventual goal of this section is to develop a simple model that will generate empirically testable implications. Beforehand, however, we need to define two concepts that will prove crucial in the theory of trade-volume hysteresis: sunk costs and the real exchange rate.

2.1 Sunk costs and the real exchange rate

According to Pindyck and Rubinfeld (1998, p. 207), a sunk cost is an expenditure that has been made and cannot be recovered. It follows that sunk costs should not play any role in a profit-maximising firm's decision-making process after they have been made, since they can no longer influence the net present value of its projects. Yet, in this paper we only look at one particular type of sunk costs: *sunk costs in trade*. A foreign exporter that engages in an advertising campaign to enter the domestic market, for instance, is incurring sunk costs that are related to trade. But a firm that makes a sunk investment in custom-made equipment in order to start producing a new variety in its domestic market, is incurring sunk costs that are unrelated to foreign trade. As we shall see, only sunk costs *in trade* matter for trade-volume hysteresis[3].

Examples of possible sunk costs in trade include: marketing, R&D, distribution networks, build-up of reputational capital, expenditures on market research, and product design change (Baldwin and Krugman, 1987 and 1989). Additionally, one could perhaps also think of top management's time expenditure in setting up foreign operations, investment in trade-specific human capital, and buying a trading license as sunk costs in trade.

[3] For an example of sunk costs in *domestic production* relating to 'domestic-production hysteresis', see Cross (2000).

Our definition of the real exchange rate is as follows:

$$R = \frac{p^D}{e * p^F} \tag{1}$$

where p^D is the domestic price level in domestic currency, p^F is the foreign price level in foreign currency, and e is nominal exchange rate, defined as units of domestic currency per unit of the foreign currency. Thus, in this definition an increase in the nominal exchange rate means a depreciation of the domestic currency. At the same time R is defined such that an increase implies a real appreciation of the domestic currency. Although these definitions might at first glance seem confusing, they are consistent with most of the existing literature, which will prove useful[4].

2.2 **The microeconomic theory**

This section deals with the theory of trade-volume hysteresis at the most disaggregated level: the firm level. We look at firms that are potential or current players in international trade. For the moment we do not consider foreign direct investment, so that the firms can simply be termed ‘exporters’. For simplicity, we consider foreign exporters entering the home market: they conduct all sales on the home market by producing abroad and then selling the goods domestically.

2.2.1 *Baldwin and Krugman’s model*

How does a foreign exporter make a decision about entry (or exit) of the home market? This question is actually comprised of two separate problems: *whether* it is optimal to enter, and if it is, *when* is the optimal moment to do so. This section primarily deals with the first issue, while section 2.2.2 addresses the second. Both issues are obviously related to the firm’s profit-maximisation objective. The exporter will want to maximise the discounted value of all expected future cash flows. Following in the footsteps of Baldwin and Krugman (1989), let us therefore define a profit function[5]. We must do so for three distinct states, namely: no entry into the home market; new entry into the home market; and continuation of operations in the home market after entry has already occurred. Each of these states is comprised of three elements: the revenue, the variable costs and the sunk costs of entry. We shall explain each of these in turn.

4 Moreover, in the coming analysis we assume for simplicity that firms face the same changes to their ‘own’ real exchange rate as the country’s overall real exchange rate.

5 We follow Baldwin and Krugman (1989) in terms of the theoretic intuition, although our exposition is quite different.

What happens if the firm does not enter the home market? Obviously, there will be neither domestic revenue then, nor any costs. Thus the profit function is simply zero in this case. Now, consider first-time entry into the home market. How should we model the revenues made by the exporter? Revenue is simply the amount of sold goods times their price. Call the sales output Q. Each good is sold for a price p^D in *domestic currency*. But the exporter's profit function should be defined in its own (foreign) currency. Hence, we must correct the price for the prevailing nominal exchange rate, e, which is defined in domestic currency per foreign currency. The revenue can thus be written down as: $(p^D / e)Q$. Now, setting p^F equal to one, and assuming for the moment that it is constant, we can, for simplicity of exposition, rewrite the revenue function as: $R * Q$, where R is the real exchange rate.

The next part of the profit function is the variable costs. Let us assume constant marginal costs, c, expressed in foreign currency, so that the variable costs can be written as $c * Q$. Now, we turn to the last and crucial part of the profit function: the sunk costs of entry. For intuitive understanding, we can imagine that to enter the domestic market the exporter must engage in an advertising campaign. These costs of entry, S, are sunk, since they cannot be recouped if the exporter were ever to exit. Therefore, the complete one-period profit function for an entering foreign exporter is:

$$\Pi = (R - c)Q - S \qquad (2)$$

Having determined this, we can ask ourselves what happens in the last state: the continuation of operations after entry has already occurred. Nothing changes in the revenues, nor in the variable costs. But the sunk costs of entry do no longer play a role, because entry has already happened. In this case, therefore:

$$\Pi = (R - c)Q \qquad (3)$$

Table 1 One-period profit function of the foreign exporter

State	Profit function
No entry	$\Pi = 0$
Entry	$\Pi = (R - c)Q - S$
Continuation	$\Pi = (R - c)Q$

Returning to our initial question, that is, *whether* a foreign exporter will enter the domestic market, we now have the tools to make this question more concrete. After all, the values of c and S are given. Let us assume for the moment that Q is given too[6]. At this point, we can see that Π is a positive function of R. The question thus becomes: *for which R will the exporter decide to enter*. The exporter will enter for $\Pi > 0$ or $R > (S / Q) + c$. We can define a value of R, say R_N, for which entry will occur:

$$R_N = (S / Q) + c \tag{4}$$

Now, let us relax the assumption that Q is given. In fact, a foreign exporter will increase his sales volume on the domestic market after an appreciation. To make the exposition simple, we define Q's function as follows:

$$Q = \alpha + \beta(R - R_N) \tag{5}$$

Here α is a constant, which represents the sales volume at which the exporter enters, that is, the value of Q when $R = R_N$. Clearly, $\alpha > 0$. Also, $\beta > 0$, because the further R passes R_N, the more the exporter will sell. But since at $R = R_N$, $Q = \alpha$, we can say that:

$$R_N = (S / \alpha) + c \tag{6}$$

The next step is to look at the possibility of continuation: for which R will the exporter not continue to export if it was already in domestic market last period? In a one-period setting, the exporter would only exit if $R < R_X$ (R for which exit will occur). Setting $\Pi = 0$ we obtain:

$$R_X = c \tag{7}$$

Here we reach an important conclusion: since $(S / \alpha) + c > c$, it follows that $R_N > R_X$. The real exchange rate that prompts entry is higher than that which forces exit. The reason is that in order to enter the exporter requires compensation for both the variable costs *and* the sunk costs of entry, whereas to continue operations he only requires compensation for his variable costs. Of course, we have only looked at a one-period framework. In a multi-period framework the 'new entry' and 'continuation' scenario's differ only in the first period. In any case, $R_N > R_X$ will still hold, as we can

[6] This would imply that the exporter's supply is completely inelastic with respect to the price (R). We will relax this assumption shortly.

show more formally. The exporter will enter, when the Net Present Value of entry (NPV_{ENTRY}) is equal to or greater than zero:

$$NPV_{ENTRY} = \sum_{t=0}^{t=T} \left[\delta^t (R_t - c) Q_t \right] - S \tag{8}$$

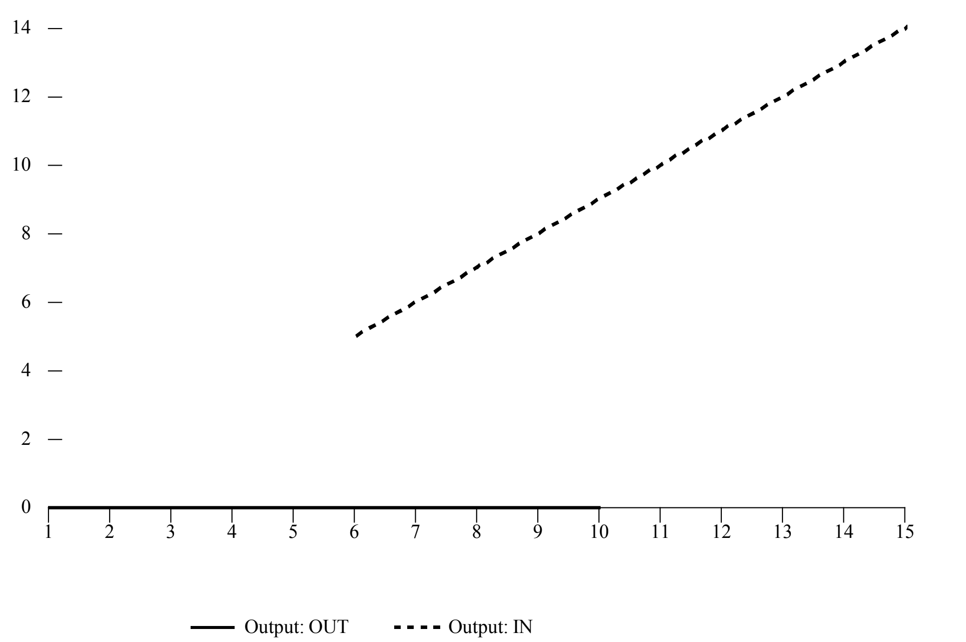
Here δ stands for the (constant) discount factor, where $0 < \delta < 1$. Note, moreover, that Q_t remains a function of R_t. It is possible, therefore, to find a value of R_t for which $NPV_{ENTRY} = 0$. This is R_N. Now, let us define R_X. This is the value of R_t for which the NPV of an exporter who is already in the market, is zero (we call his NPV: 'NPV_C', where subscript c denotes 'continuation'). Below this value, he will exit. We define NPV_C as follows:

$$NPV_C = \sum_{t=0}^{t=T} \left[\delta^t (R_t - c) Q_t \right] \tag{9}$$

Clearly, for any R_t: $NPV_{ENTRY} < NPV_C$. This means that the value of R for which $NPV_{ENTRY} = 0$, must be *higher* than the value of R for which $NPV_C = 0$. That is, $R_N > R_X$.

So what happens for any R in between R_N and R_X? If the exporter is not in the market, he will not enter. If he is in the market, he will not exit and, as usual, the supply (Q) becomes positive a function of the price (R). We can visualise this using Figure 1 (source: Baldwin and Krugman, 1989, p. 641):

Figure 1 Exporter output as a function of R



In this graph, the dotted line shows how the firm's export sales relate to the value of the real exchange rate *after* it has entered the domestic market. The straight line represents the firm's (zero) export volume when it has *not entered* or has *exited* the domestic market. For any $R > 10$, the exporter is certainly in the market (dotted line). In this figure, $R_N = 10$. For any $R < 6$, the exporter is certainly out of the market (straight line): $R_X = 6$. But for $6 < R < 10$, the foreign exporter's sales could follow either the dotted or the straight line. Whether or not the exporter is in the market will *depend upon the past path of the real exchange rate*. The exporter is *in* the market if R has been greater than 10 and at no subsequent point smaller than 6. If, on the other hand, R has at some subsequent point been smaller than 6, or has never been greater than 10, then the exporter is *out* of the domestic market.

How does all this relate to trade-volume hysteresis on the firm level? Imagine a potential exporter who is currently not exporting to the home market, and at $t = 0$, $R = 8$. At $t = 1$, R rises to 11, that is, it passes the *hysteresis-threshold level* of 10 (R_N)[7]. The exporter enters. At $t = 2$, R then returns to 8, but the exporter remains in the market. The cause (change in R) reverts to the initial point, but what happens to the consequence (the export volume)? At $t = 0$, $Q = 0$. At $t = 2$, $Q > 0$. Therefore, even though the cause disappears, the consequence *lasts*. We are observing a hysteretic process, wherein a real exchange rate appreciation followed by a depreciation of the same magnitude, has ceteris paribus (no more change in R) *permanently* altered the trade volume. From the home country's point of view, the import volume of this particular good has lastingly increased.

Without explicitly mentioning so, we have actually only discussed one particular type of trade-volume hysteresis: supply-side trade-volume hysteresis in the presence of sunk costs of entry. This type is also the one that we will discuss in the rest of the paper, but it is not the only one that could theoretically exist. On the supply side, Göcke (2001) has suggested the possibility of "experience-curve" induced trade-volume hysteresis: during a domestic-currency appreciation a foreign exporter enters the home market, and by doing so acquires a higher level of experience. This allows the exporter to produce against lower costs than before. Thus, upon returning to the initial value of R the exporter might not be forced to exit, thereby inducing trade-volume hysteresis. Alternatively, a theoretical case can also be made for demand-side hysteresis. Göcke (2001) suggests, for example, that if consumers have incomplete information about the quality of goods and are risk averse, only a sufficiently large price decrease will induce them to switch products. During an appreciation some consumers could switch to imported goods, but a depreciation back to the initial point might not cause consumers to completely switch back to their old consumption patterns.

[7] $(R_N - R_X)$ is called the 'hysteresis band'.

Finally, let us note that it does not matter whether the change in the real exchange rate occurs through a sudden jump, or whether it is caused by a series of positively autocorrelated small shocks (Baldwin and Lyons, 1994, p. 12). All that is relevant, is whether R has crossed a hysteresis threshold or not.

2.2.2 *Dixit's option value*

Now we turn to the second issue: the timing of entry. When a foreign exporter recognises a potential new export possibility in the home market, which currently seems sufficiently profitable ($NPV_{ENTRY} > 0$, $R > R_N$) should he enter immediately? Employing the framework of the previous section, we would believe the answer to be affirmative: why wait and lose positive profits? In fact, in the previous section we made the implicit assumption that the exporter was able to perfectly anticipate the exchange rate path, and base his entry decision upon this perfect foresight: he would be certain about the NPV after entry. But what happens when we introduce exchange rate uncertainty? What if exporting may seem currently profitable, but upon a greater subsequent depreciation than foreseen, it will turn out not to be? Suddenly the one-period framework, in which exchange rate uncertainty is indeed irrelevant, starts to *qualitatively differ* from the multi-period framework in which the exporter is exposed to exchange rate risk.

Dixit (1989 and 1992) has expanded trade-volume hysteresis theory by including the effects of exchange rate uncertainty. Here we will follow his reasoning. Firstly, we should understand that for time to matter to an exporter's entry decision, the opportunity to enter must not disappear if not taken directly. If it would, there would of course be no point in waiting. Secondly, because there are sunk costs of entry, reversing an entry decision is costly (from an ex-ante point of view). Now waiting can have positive value, because it brings more information about R: *if R has risen far above R_N (and R_X), the possibility that an entry decision will have to be reversed becomes smaller*.

We can now witness a trade-off: waiting has the benefit of more knowledge about the development of the real exchange rate, but it has the cost of temporarily forgoing profits earned if entry would have occurred. Logically, if R is only slightly above R_N, very few profits are being lost by not entering, so that the waiting benefit will dominate. If R has risen far above R_N, the opposite will hold. Thus, we can already see that when there is exchange rate uncertainty the real exchange rate for which entry will occur, say R_U, will exceed the value of R for which entry would occur in the absence of exchange rate uncertainty, R_N.

What about exit? Imagine R is just slightly below R_X ($NPV_C < 0$) and that due to uncertainty the exporter does not know whether R will continue to decrease, stay where it is, or turn back up again. If he exits and at some subsequent point in the future R appreciates sufficiently (over R_U) for him to want to re-enter, he will have to incur all sunk costs once more. The benefit of waiting is thus the possibility to avoid incurring these costs again. If he does not exit, on the other hand, he will have to continue making an operating loss for as long as $R < R_X$. This is the cost of waiting. As long as $(R_X – R)$ is relatively small, however, the benefit of waiting will dominate, just as with the entry option, so that the crossing of R_X will not trigger exit. The exit trigger under uncertainty, call it R_D, will lie below R_X. *Therefore, exchange rate uncertainty widens the hysteresis band from* $(R_N - R_X)$ *to* $(R_U – R_D)$.

Dixit (1992) formalises this idea using option theory. The decision process of an exporter considering entry now closely resembles that of an investor owning a call option. The Present Value of his cash flows after entry (NPV_C) is like an 'underlying asset', which can be obtained against 'exercise price' S. We could, therefore, call the option $f(NPV_C, S)$. The profits he forgoes each period are like a 'dividend'. Since he can exercise at any given moment, he holds the equivalent of an American call option on a dividend-paying stock. Like an option too, the greater the exchange rate uncertainty, the greater the value of the option, because of the unlimited upside and bounded downside potential[8]. Using this idea, we can see that immediate entry has a new opportunity cost: the loss of the option to wait. Incorporating this back into Baldwin and Krugman's framework, the value of the option could be seen as an additional sunk cost of entry. Hence, we can write the new entry threshold as:

$$R_U = R_N + f(NPV_C, S) \qquad (10)$$

An option analogy for the exit option has not previously been developed, however, so we have attempted to do so ourselves. It too, can be seen as an American call. The benefit of exercising the exit option is the Present Value of the *negative profit stream* that would have occurred, if the exporter would not have exited (since $R < R_X$). This is like an 'underlying asset'. The 'dividend' is the negative profit incurred each period. The cost of exiting is the possibility that the exporter will want to re-enter again at a later stage, paying S once more. This is equivalent to 'buying' a new entry option. That is, the 'exercise price' of the *exit option* is $f(NPV_C, S)$. Hence, we can write the new exit threshold as:

$$R_D = R_X – g(PV(\text{negative profits}), f(NPV_C, S)) \qquad (11)$$

8 The effect of exchange rate uncertainty on the *option value* should not be confused with any direct effect of exchange rate uncertainty on *trade flows*. There is a large *distinct* literature on the direct relation between exchange rate uncertainty and trade flows. See, for example, Cushman (1983 and 1988), IMF (1984) and Coes (1981).

Except in a few cases where we mention option values explicitly, however, we abstract from them during the rest of the paper. The reason is that their inclusion would complicate the analysis, while only reinforcing the basic intuition. Nevertheless, it is useful to keep in mind that option values widen the hysteresis band, so that any conclusions based on the concepts of R_N and R_X, would have only been qualitatively 'strengthened' when using R_U and R_D instead.

2.3 **The macroeconomic theory**

The end goal of this paper is to test for the existence of hysteresis in *national* trade volumes. So far, however, we have only considered hysteresis at the firm level. As will become clear, the steps from the individual firm, to the sector, to the macroeconomy involve qualitative changes in the hysteretic process. After analysing these steps, we can formalise the ideas into a simple model, which will allow us to understand what we ought to look for empirically.

2.3.1 *Trade-volume hysteresis*

In the previous section we considered the firm level, so let us now take the next step up to the sectoral level. We assume that all exporters in a given sector produce the same, single good. The following analysis draws on the work by Baldwin and Krugman (1989), although the exposition is different. Let us assume there are two countries, Home and Foreign. Imagine also that there are two exporters, A and B, which differ from each other in their cost structures, which may be either in their variable costs of production, c, or in their sunk costs of entry, S, or in both.

We start by introducing heterogeneity in the variable costs, while keeping S equal across the firms. Let us say $c_A < c_B$. In all other respects the exporters are completely equal, so any difference in profitability arises solely from differences in the variable costs. From equation (8) we can see that for any R_t: $NPV_{ENTRY(A)} > NPV_{ENTRY(B)}$. It follows that $R_{N(A)} < R_{N(B)}$. Equivalently, from equation (9) it becomes clear that $R_{X(A)} < R_{X(B)}$. The firm with the lower variable costs (A) has both a lower entry threshold *and* a lower exit threshold. Therefore, when two exporters differ in their variable costs and in nothing else, on the sectoral level there will be two entry triggers and two exit triggers. Expanding to a setting with many more firms inside a sector, *we obtain a situation of multiple thresholds*.

Now, let us turn to the second case: the two exporters have exactly the same variable costs, but they differ in their sunk costs of entry. Say, $S_A < S_B$. Again, we can see from equation (8) that $NPV_{ENTRY(A)} > NPV_{ENTRY(B)}$, so that $R_{N(A)} < R_{N(B)}$. Yet, in this case nothing happens to the exit threshold.

As becomes clear from equation (9), the sunk costs of entry do *not* play a role in the exit decision[9]. Hence, $R_{X(A)} = R_{X(B)}$. When two exporters differ in their sunk costs and in nothing else, on the sectoral level there will be two entry triggers. Expanding to a setting with many more firms inside a sector, *we obtain a situation of multiple entry thresholds*. We can generally conclude that when we aggregate heterogeneous individual firms into a sector, we move from a situation with only one entry threshold and one exit threshold, to a situation with multiple thresholds (of both kinds). Since there are now more thresholds 'spread out in the R-space, any given movement of R is more likely to cross *some* firm's threshold for entry or exit.

What happens when we aggregate from the sectoral level to the bilateral trade-flow level? Now that we realise how heterogeneity in variable and sunk costs influences the number of thresholds, the next step of aggregation is fairly straightforward. Clearly, export sectors will differ among each other in both the required sunk costs of entry and in their comparative advantage relative to domestic firms[10]. Therefore, the multiplicity in thresholds will become even greater when aggregating to the bilateral trade-flow level. Differences between industries may well even be so great, that some exporters' entry triggers will lie *below* others' exit triggers. Aggregating to the multilateral level simply takes the same idea one step further: there will be many more sectors still, and many more exporters, so that *the number of thresholds would start to approach a continuum, in which even for the smallest movements of R some thresholds of entry or exit are passed* (Göcke, 2001).

This may certainly be an interesting theoretical discussion, but what does it really mean for trade-volume hysteresis? Whereas at the firm level only large changes in R could induce firm entry or exit, at the highest macroeconomic level *any* change in R induces entry or exit. Relating this back to trade volumes, we can see that at the firm level only for *certain* full cycles of R (return to initial point) the exporter's sales volume will have been altered (by entry or exit)[11]. On the other hand, at the macro level *any* full cycle of R will, ceteris paribus, have lastingly altered the total sales volume of the foreign exporters - or, equivalently, the domestic import volume - (Amable et al, 1994). For example, an appreciation and subsequent equivalent depreciation of R will induce some exporters in some sectors from some countries to enter and remain, despite the return to the initial point of R. This has

[9] At this point, however, including the option value *does* make a difference in the intuition. This is because the value of the exit option *increases*, when S increases: avoiding future re-entry becomes more valuable. Technically, we can see from equation (11) that S↑, f↓, g↑, R_D↓. Hence, since $S_A < S_B$, it follows that $R_{D(A)} > R_{D(B)}$.

[10] A comparative advantage of one trade sector against another is the inter-sectoral 'equivalent' of the differences in variable costs among individual firms inside a sector.

[11] By a 'full cycle' (often shortened to 'cycle') of R, we mean an appreciation of R followed by an equivalent depreciation (or vice versa). This should *not* be confused with the concept of 'business cycles', where a full cycle means the completion of a 'sine-curve'. If R would move according to a sine-function, what we call a 'full cycle' would be half a sine-curve.

prompted some authors to call macroeconomic trade-volume hysteresis ‘strong hysteresis’, because heterogeneity qualitatively enriches the hysteretic process. Firm level hysteresis is then termed ‘weak hysteresis’[12].

So far, however, we have only regarded a *single* full cycle of R. That is, R has always been constant, suddenly it shows one full-cycle swing, returning and subsequently remaining at the initial point. What happens when we allow R to be constantly ‘in cycle’? Imagine initially ($t = 0$) $R = 100$. Subsequently ($t = 1$) it increases to 110 and ($t = 2$) drops back to 100. In a macroeconomic setting, some exporters enter, but do not exit. But now ($t = 3$) R increases to 105 and then ($t = 4$) depreciates back to 100. What happens to the trade volume at ($t = 4$)? It is exactly the same as before the second cycle (at $t = 2$), because whichever exporter would enter during an appreciation to 105, would certainly already have entered during an appreciation to 110.

After the new highest point is set ($t = 2$), only an appreciation *beyond* that highest point will induce new entry. Hence, only a cycle that passes that highest point, would induce trade-volume hysteresis. Equivalently, a cycle of R will only lead to *exit* of foreign exporters, if it crosses the *lowest* point that R has ever reached. These highest and lowest points historically set by R are called: *the dominant extrema of the real exchange rate*[13]. Therefore, we can say that *in a process of ‘strong hysteresis’, trade-volume hysteresis is only induced by R crossing a dominant extremum during its cycle* (Amable et al., 1994).

In order for the idea of hysteresis triggered by the crossing of dominant extrema to hold completely, however, we have to assume no creation of new market sectors over time. Imagine a Japanese semiconductor producer who is considering entry into the US market in 1993. Will he really care about a dominant extremum established in 1975, when neither he nor his industry existed? He might well decide to enter at a value of R *below* R_{MAX}. Of course, in the cross-industrial aggregate, the creation of individual new sectors is at least partly ‘diversified away’. But in this paper we abstract from this issue, assuming no new market creation[14].

[12] See Amable et al. (1994 and 1995), Göcke (2001), Piscitelli et al. (2000) and Dannenbaum (1998).

[13] Mathematically, the maximum since the time origin is called the ‘supremum’, and the minimum the ‘infimum’. In this paper we use the terms ‘positive dominant extremum’: R_{MAX}; and ‘negative dominant extremum’: R_{MIN}.

[14] In fact, we are also implicitly assuming that technological change does not affect the cost structures of exporters in *existing* sectors. If it would, the exporters may decide to exit/enter at points below/above the dominant extrema. In reality, therefore, the usefulness of the extrema concept ‘erodes’ over time.

There is also another reason why macroeconomic hysteresis can be considered ‘stronger’ than firm level hysteresis. At the firm level the *magnitude* of the R-swing is irrelevant, beyond the point that it passes a threshold. *But at the macroeconomic level, conditional on a dominant extremum having been crossed, the larger the R-swing, the greater the magnitude of the hysteretic effect*. The reason is that for every marginal increase (decrease) in R beyond a dominant extremum, some additional entry (exit) thresholds are being crossed (Amable et al., 1994).

Incidentally, it can now also be seen why it is so important to look at full R-cycles, rather than only a one-sided change in R. After all, even in a non-hysteretic process an appreciation will bring about greater foreign export volume, irrespective of dominant extrema being crossed. But then *upon return* to the initial value of R, export volume would also return to its initial point. Therefore, *during* the appreciation it is not really possible to determine whether trade-volume hysteresis is taking place, but *after completion of a cycle*, there can be no doubt. This is different from the firm-level situation, in that for one firm *during* the appreciation beyond a hysteresis trigger, a ‘jump’ can be witnessed from ‘no export sales’ to ‘export sales’. In the macroeconomic process the individual ‘jumps’ are invisible, since they get ‘smoothed out’ in the aggregate: *macroeconomic hysteresis is not a jump process*.

Table 2 Summary of aggregation results

Level of aggregation	Firm	Sector	Multilateral
Number of entry (exit) triggers	1	Multiple	Approaching continuum
What causes trade-volume hysteresis?	R-cycle passing the threshold	R-cycle passing at least one threshold	R-cycle passing dominant extremum of R
“Grade” of hysteresis	‘Weak’	‘Moderate’	‘Strong’

2.3.2 *Feedback into the real exchange rate*

So far, we have assumed that the real exchange rate is an exogenous factor *causing* change in the trade volume. But, of course, in economic reality the value of R is itself determined by many economic factors, and cannot simply be seen as given. In particular, trade flows *themselves* influence the real exchange rate. In the vein of Baldwin and Krugman (1989) and Ljungqvist (1994), let us therefore try to take a step in the direction of a general-equilibrium framework by dropping the assumption of an exogenous real exchange rate. To do this, we start by imposing certain dynamics on R. Firstly, we assume that R is stationary around a long-run equilibrium, R_{EQ}. R can deviate from R_{EQ} in the short run, but in the long run it returns toward R_{EQ}. Secondly, R_{EQ} is a function of the trade account (TA)[15]. We define R_{EQ} as the value of R for which $TA = 0$.

Let us develop a simple example. Initially, Home has a zero trade-account balance versus Foreign. The initial R, call it R_I, is currently also the equilibrium R, R_{EQ}. Now imagine that something causes an appreciation in R. We could say, for example, that there is a large capital inflow. Furthermore, R appreciates beyond the positive dominant extremum, R_{MAX}. This causes new entry by foreign exporters. Next, the capital inflow reverses itself, so that R returns to R_I. Does $R_I = R_{EQ}$ still hold? Let us see what has happened to the trade account. We can define it as:

$$TA = X - M = (p_X * q_X) - (p_M * q_M) \qquad (12)$$

Where p stands for price, q for volume, and X and M denote export and import. What has changed in this equation between the beginning and the return to the initial point (the cycle)? Trade-volume hysteresis implies that q_M has shifted to a higher level through foreign entry[16]. Therefore, now at R_I, $TA < 0$. To restore $TA = 0$, R has to depreciate beyond R_I. In other words, R_{EQ} has shifted downward. *A real exchange rate appreciation beyond a dominant extremum, brings about a shift in the long-run equilibrium real exchange rate for which balance is restored in the trade account*. This process can be termed *real exchange rate hysteresis* (Ljungqvist, 1994, p. 387). A capital inflow (or some other cause) brings about a real exchange rate appreciation, but after the cause is removed R does not return to its previous level, but over time depreciates to its new, lower equilibrium.

Interestingly enough, considerable attention in the literature has also been devoted to the concept of *trade-account hysteresis*[17]. As we have seen in the above analysis, if there is trade-volume hysteresis, a real exchange rate appreciation can lower the real equilibrium exchange rate. Adjustment back down to R_{EQ} and $TA = 0$ would then take longer than if trade-volume hysteresis would not exist. However, the long-term *level* of the trade account has not been lastingly altered, it just takes more time to reach it. *But this is not hysteresis, merely persistence* (Piscitelli et al., 2000).

[15] We are assuming equivalence of the trade account and the current account, and thereby implicitly abstracting from international trade in services and interest payments, which are part of the current account, but not of the trade account (Pilbeam, 1998, pp. 34-36).

[16] For simplicity, we abstract from the decrease in q_X which will have occurred through exit of domestic exporters from the foreign market. Including it would only reinforce the conclusions, however.

[17] See McCausland (2000), Lawrence (1990), Göcke (2001) and Wang (1995).

Table 3 Summary of trade-hysteresis types

Type of trade hysteresis	Meaning	Conditions for existence
Trade-volume hysteresis	Appreciation and subsequent equal depreciation of R leave trade volumes at changed levels.	Nonzero sunk of costs of entry in trade.
Real exchange rate hysteresis	Capital inflow (or other cause) and subsequent equal capital outflow lower R_{EQ}, because of altered trade volumes.	R has a long-run equilibrium, which is influenced by the trade account.
Trade-account hysteresis	Changed R_{EQ} causes slower adjustment to balance.	(Flawed) interpretation of hysteresis as persistence.

2.3.3 *Conditional stationarity*

We now have the necessary tools to start developing our own model of trade-volume hysteresis. In this section we start out by modelling the real exchange rate dynamics. In the next section we integrate these dynamics into a model of trade-volume determination. Let us start out, however, by visualising the type of path followed by the real exchange rate, according to the ideas developed in the previous section. In Figure 2 (next page) the dominant extrema of R initially lie at 110 and 90, while the equilibrium real exchange rate that brings about a zero trade-account deficit is at 105. R evolves around 105, but at some point appreciates over the positive dominant extremum to 112 (now, of course, 112 becomes the new positive dominant extremum). This triggers entry of foreign exporters, so that $TA = 0$ would be reached at a more depreciated real exchange rate: R_{EQ} becomes 100. Over time R depreciates to its new equilibrium, around which it is once more stationary. This new steady state lasts for as long as R does not again move beyond a dominant extremum. *The real exchange rate is stationary around its (constant) equilibrium, as long as the condition $R_{MIN} < R < R_{MAX}$ holds*. We could thus name these real exchange rate dynamics "conditional stationarity".

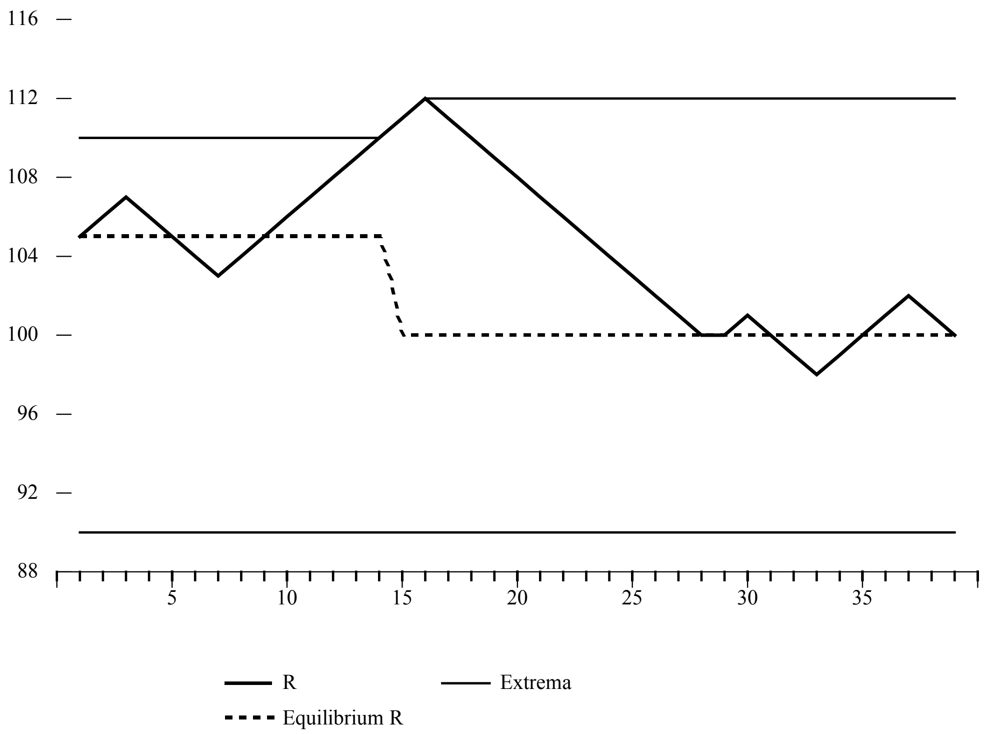
Proceeding to the next step, we can ask ourselves how we can best model such a process. As a starting point, we use an adapted version of Katzner's (1993, p. 325) algebraic definition of stationarity. Later, we will add to it the element of 'conditionality':

$$X_t = R_t - R_{EQ} \tag{13}$$

and

$$X_t = \theta X_{t-1} + \varepsilon_t \tag{14}$$

Figure 2 Real exchange rate path



Where X_t stands for the deviation of R from its long-run equilibrium, and we assume that $X_0 = 0$. All ε_t's are independently distributed, random variables with $E(\varepsilon_t) = 0$ and $Var(\varepsilon_t) = \sigma^2$. Moreover, we assume that $0 < \theta < 1$, so that any shock (ε_t) to X_t fades out over time, and R_t returns toward to R_{EQ}.

Next, we can express X_t in terms of only θ and ε_t . For example, at $t = 10$, $X_{t+10} = \theta X_{t+9} + \varepsilon_{t+10}$; but then $X_{t+9} = \theta X_{t+8} + \varepsilon_{t+9}$, so that $X_{t+10} = \theta(\theta X_{t+8} + \varepsilon_{t+9}) + \varepsilon_{t+10}$. The further you look back, the more discounted becomes the past X in the determination of the current X. Algebraically: $X_t = \theta^t X_0 + \sum_{n=1}^{t} \theta^{t-n} \varepsilon_n$. But since we assume that $X_0 = 0$:

$$X_t = \sum_{n=1}^{t} \theta^{t-n} \varepsilon_n \tag{15}$$

This is as far as Katzner's (1993) definition will take us. Here we start to develop our own model, by adding the element of hysteresis. We know from section 2.4.2 that when a cycle of R_t crosses a dominant extremum, R_{EQ} will shift. Let us first, therefore, define a cycle mathematically. When the sum of all (discounted) shocks to R_t is zero (that is, when $X_t = 0$), R_t must be back where it began. Thus, a cycle is completed when:

$$\sum_{n=1}^{t} \theta^{t-n} \varepsilon_n = 0 \tag{16}$$

Moreover, R_{EQ} can now change over time, so that we can rewrite equation (13) as:

$$X_t = R_t - R_{EQ,t} \tag{17}$$

Where:

$$R_{EQ,t} = R_{EQ,0} + h_t \tag{18}$$

Here h_t is a hysteresis factor, which is equal to zero as long as no dominant extremum has been crossed. That is, as long as no hysteretic shifts in the equilibrium real exchange rate take place: $R_{EQ,t} = R_{EQ,0}$. Since hysteresis is not a jump process, however, we can not say that *at the moment* that a dominant extremum is crossed h_t changes value. What we can say with certainty is that $h_T \neq 0$ at a point in time T when $\sum_{n=1}^{T} \theta^{T-n} \varepsilon_n = 0$, if at some point between 0 and T, R_t has been greater than R_{MAX} *or* at some point has been less than R_{MIN}[18]. More specifically, if for some $t < T$, $R_t > R_{MAX}$, then $h_T < 0$. This means that $R_{EQ,T} < R_{EQ,0}$ (the equilibrium has shifted downward, due to foreign entry). If for some $t < T$, $R_t < R_{MIN}$, then $h_T > 0$. In this case: $R_{EQ,T} > R_{EQ,0}$. Finally, if for all $t < T$, $R_{MIN} < R_t < R_{MAX}$, then $h_T = 0$. Then, of course: $R_{EQ,T} = R_{EQ,0}$.

2.3.4 *A simple model of trade-volume hysteresis*

In the previous section we formalised the concept of real exchange rate hysteresis. We can now incorporate this into a simple model of trade-volume hysteresis, which we develop in this section. First, we define a trade-volume specification, which will be discussed in more detail in section 4.1:

18 We assume that R_t will not between 0 and T have passed *both* extrema, since inclusion of this possibility gives no further insight, but does complicate the analysis. Moreover, empirically we will define R-cycles in such a way that double-sided extrema crossings are not possible, see section 5.1.

$$Q_{M,t} = \alpha + \beta R_t + \gamma Y_t + u_t \tag{19}$$

Here $Q_{M,t}$ is the import volume, α is a constant, and u_t is a white-noise variable with $E(u_t) = 0$ and $Var(u_t) = \sigma^2$.

This specification is still lacking a hysteretic factor, however. As it is written now, an appreciation and equivalent depreciation would always bring the import volume back to the initial point. Therefore, we introduce a hysteretic factor, say s_t, which can model the change in $Q_{M,t}$'s level for a R-cycle crossing a dominant extremum:

$$Q_{M,t} = \alpha + \beta R_t + \gamma Y_t + u_t + s_t \tag{20}$$

We assume that s_0 is zero. Furthermore, we know that a R-cycle crossing a positive dominant extremum will lead to foreign entry into the domestic market, in which case: $s_t > 0$. Conversely, we know that at the end of a R-cycle that has crossed R_{MIN}, the import volume will be lower than initially: $s_t < 0$. More formally, using equation (16) we can say that at a point in time T when $\sum_{n=1}^{T} \theta^{T-n} \varepsilon_n = 0$, if for some $t < T$, $R_t > R_{MAX}$, then $s_T > 0$; if for some $t < T$, $R_t < R_{MIN}$, then $s_T < 0$; and if for all $t < T$, $R_{MIN} < R_t < R_{MAX}$, then $s_T = 0$.

The most important step left to take, is to make R_t endogenous. After all, in the long run R_t evolves around $R_{EQ,t}$. $R_{EQ,t}$, in turn, is influenced the trade account, which is in part determined by the trade volumes. We could simply write $R_t(Q_{M,t})$. But we can be more precise than that. Taking together equations (15), (17) and (18), we obtain:

$$R_t = \sum_{n=1}^{t} \theta^{t-n} \varepsilon_n + R_{EQ,0} + h_t \tag{21}$$

Since $R_{EQ,0}$ is given, the only right-hand side variable that can be influenced by the trade account is h_t. Hence, $h_t(Q_{M,t})$. This actually makes perfect sense. A R-cycle crossing R_{MAX} shifts up $Q_{M,t}$, so that a balanced trade account can only be achieved for a lower equilibrium R: $h_t < 0$. The greater the hysteretic increase in the import volumes, the larger the downward shift in h_t necessary to bring about

TA = 0. Yet, the extent to which $Q_{M,t}$ shifts upward in turn depends on s_t, so that we could also say $h_t(s_t)$: R_t's hysteretic factor is influenced by $Q_{M,t}$'s hysteretic factor. Here $(\partial h_t / \partial s_t) < 0$. But, to complete the 'circle', the extent to which s_t increases depends on the extent to which R_t has crossed R_{MAX} (the more individual entry thresholds are crossed the higher is s_t). This means that s_t is in fact a function of $\sum_{n=1}^{t} \theta^{t-n} \varepsilon_n$. *R_t and $Q_{M,t}$ are thus jointly determined in this model.*

To make things yet slightly more complicated, even Y_t can not properly be seen as an exogenous variable. After all:

$$Y = C + I + G + X - M \tag{22}$$

But $X - M = TA$, so that Y_t can *temporarily* respond to shifts in ($Q_{M,t}$). After all, these shifts can change the time it takes to reach $TA = 0$ once more: the distance between R_t and $R_{EQ,t}$ widens after the crossing of a dominant extremum. Because trade-*account* hysteresis does not exist, however, a shock to Y_t can only be considered *persistent*, not *lasting*. An appreciation beyond R_{MAX} would, for example, temporarily cause a trade-account deficit. For as long as it lasts $Y_t < Y_N$, where Y_N is the 'natural' rate of output.

Now turning briefly to the empirical relevance of this model, we can ask ourselves what happens if we run an OLS-regression on (19). We see from (20) that the constant term in (19) actually includes the hysteretic factor, s_t. Hence, anytime that a R-cycle crosses a dominant extremum, the constant term will change: *there will be a structural break in the constant term whenever trade-volume hysteresis occurs*.

Yet, it is not only in the constant term that structural breaks could occur. Baldwin (1998a) argues that in a trade-volume specification, such as a logarithmic version of (19), hysteresis could also cause structural breaks in β. To see this, we need to let go of the assumption that all firms in a sector produce the same good. Imagine that each firm produces a different variety. Hence, consumers can substitute between different varieties. From microeconomics we know that *the larger the number of varieties, the higher the price elasticity of demand*. A cycle of R_t which crosses a positive dominant extremum, triggers entry of new foreign exporters. Since the total number of suppliers (domestic + foreign) in an industry rises, the number of varieties increases, and the industry demand curve will become more elastic. From the Home country's point of view, the import volume becomes more sensitive to changes in the domestic prices. *A R-cycle crossing R_{MAX} increases the domestic-price elasticity of the import* *volume*. But since p^D is the numerator of R_t, when running an OLS-regression of *ln*($Q_{M,t}$) on *ln*(R_t), this effect would show up as an increase in *ln*(R_t)'s coefficient: *there would be a structural break in the real exchange rate elasticity of the import volume*.

2.4 **Foreign direct investment**

Until now we have been looking at foreign exporters who produce abroad and then ship their goods to the domestic market. But in reality foreign firms have an alternative way of entering the domestic market: foreign direct investment (FDI). Instead of shipping goods to the domestic market, the foreign firm can set up a domestic plant and produce the goods locally. As Kulatilaka and Kogut (1996, p. 15) point out, FDI can be seen as a substitute for trade flows. What does this imply for trade-volume hysteresis? Imagine that at a given value of R_t that triggers entry for certain foreign exporters, these exporters are indifferent between entering through 'trade flows' or through FDI. Say, half of them will choose to enter through 'trade flows' and half through FDI. What changes? Qualitatively speaking, nothing. When there is a R-cycle crossing these exporters' entry trigger, import volume will still be larger than initially. But the increase will be *quantitatively* less pronounced, because half of them enter through FDI, which does not form part of the import volume. Rather FDI-flows are accounted for through the capital account.

Since our empirical investigation merely tests for the *existence* of trade-volume hysteresis, however, as long as the qualitative impact is not lost through FDI, we are not really concerned about the quantitative impact. But the above example is not necessarily realistic. Can we think of an example in which also the qualitative impact of trade-volume hysteresis would be lost through FDI? The only thinkable possibility is that *all* entry through trade flows would be substituted by entry through FDI. Nevertheless, even in this extreme case not the entire qualitative impact would be lost. True, there would no longer be a structural break in the constant term of the import-volume specification. After all, the import-volume *level* does not respond anymore to a R-cycle crossing a dominant extremum. But the *responsiveness* of $Q_{M,t}$ to R_t still changes as before. Why? The number of suppliers on the domestic market increases through FDI-entry, just as it did through 'trade-flow' entry. Thus, the number of varieties increases and the domestic industrial demand curves become more elastic. Each existing "trade-flow" type exporter would face a less steep demand curve: *there would still be a structural break in the real exchange rate elasticity of the import volume.*

3 OVERVIEW OF THE EMPIRICAL LITERATURE

Before proceeding to our own research, let us first have a look at the prior empirical investigations conducted in the field of trade-volume hysteresis. Rather than providing an exhaustive enumeration of all previous work, we will point out the main lines of the different approaches used. The first choice the researcher faces, is the level of aggregation that he wishes to use in his investigation. The discussion in section 2 would seem to indicate that a higher level of aggregation is preferable, but not all authors agree with this view.

Campa (2000) argues, for instance, that hysteresis may be of much greater quantitative importance on the firm level than on the macroeconomic level. The reason is that the increase in aggregate trade volume due to one exporter's entry or exit is negligible. He develops a firm-level test, based on the notion that if hysteresis exists, an exporter is more likely to be in the market today, if he was already in the market a year ago. This is because an 'inside' firm does not have to incur sunk costs of entry, like an 'outside' firm that wants to enter. If a dummy variable for 'being inside' is significantly positive in an export-supply specification, trade-volume hysteresis on the firm level cannot be disproved, Campa argues. Indeed, Campa finds evidence of 'exporter-status persistence'.

Although we cannot but agree with Campa's claim that trade-volume hysteresis might be *quantitatively* stronger on the firm level than on the macroeconomic level, in *qualitative* terms the opposite may be true. It could well be, for example, that during Campa's seven year sample only very few of the individual firms he looked at actually saw the passing of an entry or exit threshold. Since on the firm level we do not know where an individual threshold lies, we can not know *when* we should expect it to be crossed. On the macroeconomic level, however, we can solve the timing issue: *any* crossing of a dominant extremum of R should trigger trade-volume hysteresis.

Parsley and Wei (1993) take an intermediate position between the firm and the sector: they conduct a commodity-level test. Their idea is that the effect on trade volumes of a depreciation following successive depreciations should be different from the effect of a depreciation following successive appreciations. The reason is that firms' hysteresis triggers are more likely to be crossed when exchange rate movements are positively correlated. Based on their results they reject the hysteresis hypothesis. Since they only look at six commodities, however, it is again well conceivable that no thresholds at all were crossed during the sample period. This is *especially* so since they select commodities with relatively large sunk costs: from section 2.3.1 we know that exporters with larger sunk costs have *wider* hysteresis bands. If no thresholds were crossed, one would not observe any asymmetrical effects of depreciations.

Feinberg (1992) chooses the sectoral level for his empirical investigation. He asks whether after a dollar appreciation less American exporters remain in each export sector. His finding is that, indeed, a dollar appreciation leads to exit of American exporters from foreign markets, increasing sectoral exporter concentration. Moreover, he concludes that this effect is weakest in high sunk-cost sectors, which he takes as evidence for trade-volume hysteresis. In our view, this research presents a good example of the problems associated with 'one-sided tests' rather than 'full-cycle tests'. After all, irrespective of sunk costs, it is not surprising that some American exporters exit from foreign markets during an appreciation. The question is whether they *return* to that market after *an equivalent depreciation*. If they do, there is no hysteresis[19].

At the macroeconomic level, the best known test is Baldwin and Krugman (1987)[20]. They use the real effective exchange rate of the dollar and multilateral trade flows, thereby 'achieving' maximum aggregation. They estimate a trade-volume specification, adding a step-dummy variable beginning in the month that R reached its (positive) peak. Subsequently, they test whether this dummy is significantly positive. If it would be, they would take it as evidence of a structural break in the constant term induced by trade-volume hysteresis. However, the dummy is not statistically significant.

In our opinion, however, this test is rather crude to base conclusions upon. Firstly, *not every peak of R should induce trade-volume hysteresis*. Baldwin and Krugman do not check whether this peak of R actually lies above the positive dominant extremum. If it does not, there is no reason it should induce hysteresis. Secondly, even if the peak does lie above R_{MAX}, there is no reason to assume that the structural break in the constant term must occur *at the peak*. As discussed in the tenth paragraph of section 2.3.1, macroeconomic hysteresis is not a jump process: the shift occurs gradually during the cycle. Their sample period may well end before the end of the R-cycle, so that the possible shift in the trade-volume level is not completely captured by the dummy. Moreover, they do not test for structural breaks in the coefficient of the real exchange rate, which, as we saw in section 2.4, may occur even when there is no structural break in the constant term. Lastly, their sample consists of only one decade in one country, which seems rather limited to be able to draw general conclusions about hysteresis.

19 Other commodity-level tests include Martinez-Zarzoso (2001) and Rogers and Jenkins (1995). Other examples of tests at the sectoral level are Dannenbaum (1998) and Yerger (1999).

20 For other examples of tests at the macroeconomic level, see Baldwin (1988a and 1988b), Blecker (1992), Giovanetti and Samiei (1996), Hickok, Hung, and Wulfekuhler (1991), Kim (1991) and Chionis (2002).

4 RESEARCH METHODOLOGY AND EMPIRICAL RESULTS

In this section we discuss the method that we developed to test for trade-volume hysteresis and the results we obtain in applying it. We divide our method into five distinct 'steps'. Firstly, we define an import-volume specification, which we estimate using OLS for all sixteen countries in our sample[21]. Secondly, we identify the cycles of the real exchange rate that cross dominant extrema. During these cycles we would expect to see breaks in the constant term and the real exchange rate elasticity of the import volume, as argued in section 2.3.4. Thirdly, therefore, we test for structural breaks in these coefficients, using recursive coefficient estimations. Finally, we use binomial tests to see whether the breaks we find have the signs predicted by hysteresis theory. If significantly more than 50% of the breaks have a sign corresponding to the prediction of hysteresis theory, we conclude that trade-volume hysteresis cannot be considered irrelevant for the explanation of coefficient breaks during R-cycles. Afterwards, we try out some different specifications, to check the robustness of the results.

4.1 **Running the regressions**

Our first step is to specify and estimate the import-volume equation. We choose the following specification:

$$ln(Q_{M,t}) = \alpha + \beta\, ln(R_{t-1}) + \gamma\, ln(Y_{t-1}) + \varepsilon_t \qquad (23)$$

Here $Q_{M,t}$ stands for a country's multilateral import volume at time t; R_{t-1} is that country's real effective exchange rate at time t-1; and Y_{t-1} is the real GDP at time t-1. The one-period lag in both explanatory variables is simply the result of determining the best specification by trial-and-error. On average, this one-lag specification yielded the highest R^2 and the most significant coefficients of R and Y[22]. Moreover, especially in the case of R, it would seem logical that it would take some time until foreign exporters adjust their supply in response to a price change. Also, we choose to write the equation in logarithmic form. This has the advantage that it allows us to speak of *elasticities* instead of simply coefficients. For example, β is now the real exchange rate elasticity of the import volume. We

[21] The sixteen countries in our sample are: The Netherlands, West-Germany, France, Italy, Belgium, Denmark, Ireland, Spain, UK, Sweden, Finland, Austria, Greece, Portugal, US and Japan. The sample period is 1970-2001. We use annual data. For an overview of the data sources and the performed transformations, see Appendix A.

[22] Use of the Akaike info criterion yielded similar results.

know that it is possible to make theoretical predictions about changes in this elasticity during periods in which trade-volume hysteresis occurs[23].

Because we are using an equation in levels, however, we need to check for cointegration to avoid running spurious regressions. First, we test to see if Q_M, R and Y are integrated of the same order, by using ADF-tests on the variables themselves. All variables from all countries are I(1) with the sole exception of the British R, which is I(0). Next, we apply ADF-tests to check whether the regression residuals posses a unit-root. These tests are performed with automatic lag selection up to eight lags. Moreover, they are performed without an intercept and a deterministic trend, because, as Hayashi (2000) argues, the inclusion of such terms in residual stationarity tests is unnecessary. The outcomes of these tests are reported in the final column of Appendix B.

Only for one country – Sweden – do we actually observe non-stationary residuals. Yet, even this case can be 'solved' quite simply. By plotting the Swedish regression residuals, it becomes clear that the last observation is a rather extreme outlier. If we re-estimate the equation without the year 2001, the residuals do become stationary at 5% significance. In addition, we use Jarque-Bera tests to see whether the regression residuals are normally distributed. They are normally distributed in all cases except Sweden (at 5%). Thus, it would seem we have a reasonable statistical basis to justify the use of our empirical specification.

The coefficient estimates from the OLS-regressions and their t-statistics are reported in Appendix B. If a coefficient does not have the expected sign, it is shaded. If either β or γ differs insignificantly from zero, the t-statistic is shaded. For both β and γ the expected sign is positive, since an appreciation and a higher income should both lead to a greater import volume. In fact, for γ we would even expect a value greater than unity, because world trade has grown faster than world income during our sample period. The constant term does not have an expected sign.

From Appendix B several things become apparent. All constant terms are either insignificant or significantly negative. Y's coefficient is always significantly positive and greater than unity, as expected. The only exception is Italy, where γ is just below one[24]. The results for β, however, are considerably more "problematic": five countries (Italy, UK, Austria, Greece and Portugal) do not have

23 We cannot use an error-correction type specification, because the hysteretic shifts occur in the *level* of the import volume. The effect on $\Delta\ln(Q_{M,t})$ would only be temporary. We would no longer know *when* to look for structural breaks in the coefficients, because at the end of a R-cycle the effect of a level shift on the growth rate may already have passed away.

24 When we include a time-trend, however, $\gamma > 1$ for only seven countries (out of sixteen).

significantly positive β's. Two countries (Austria and Greece) even have a significantly *negative* β, which means that a real exchange rate appreciation *decreases* the import volume. The reason for this may well be multicollinearity between R and Y. The correlation coefficients between these two variables are high: for example, 0.83 for the UK and –0.66 for Greece[25]. Moreover, performing Granger-causality tests, we find that Y 'dominates' R.

Irrespective of the cause, however, when the coefficient of the real exchange rate is not significantly positive, it is quite uncertain what value we can attach to the results about hysteresis that we subsequently find. After all, the theory of trade-volume hysteresis is *constructed* upon the effects of change in R. For this reason we report the results of our final binomial tests in two forms: one including all countries and another excluding the five 'problem' countries (Appendix D).

4.2 **Identifying real exchange rate cycles**

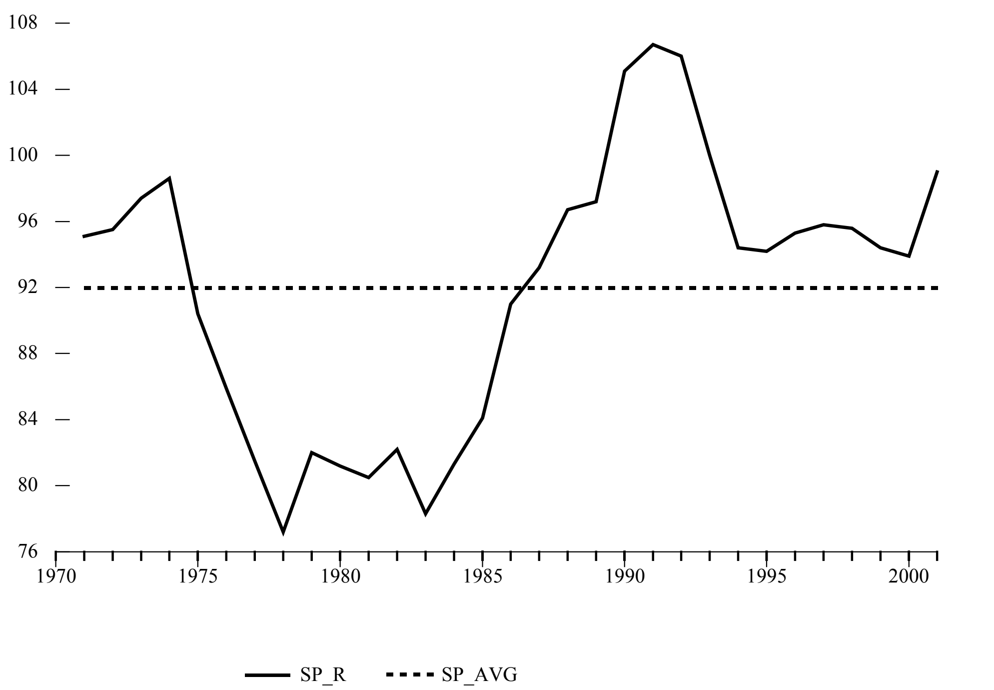
In identifying R-cycles we need to establish a reference point: at what value of R does a cycle start and end? From any given 'starting point' of R, a cycle crossing a dominant extremum would be expected to induce lasting foreign entry or exit, thereby causing hysteresis. Hence, we can choose our reference point purely from a practical point of view. We do not want a reference value that is hardly ever crossed, because that makes it hard to define 'cycles'. For this reason it seems logical to take the average value of R during the sample period as a reference point. Per definition the average is a 'central' point, so that it will be crossed relatively often during the sample period.

The concept of dominant extrema works relatively well for our sample period, moreover, since 1970-2001 exactly covers the post-Bretton Woods era. Before 1970 nominal exchange rates were virtually fixed against the dollar, while inflation differentials were low. This implies low real exchange rate variance. It seems very likely, therefore, that any dominant extremum of R established post-1970 will lie beyond the dominant extremum of pre-1970.

[25] In the British case (positive correlation) the 'capital-account' causation probably dominates: an increase in domestic GDP brings about a greater capital inflow, which causes an appreciation of R. On the other hand, for Greece (negative correlation) the 'current-account' causation may dominate: an increase in domestic GDP leads to greater imports, which increases the demand for foreign currency, bringing about a nominal depreciation and a decrease in R.

Let us exemplify our cycle selection using the graph of Spain's real exchange rate:

Figure 3 Spain's real exchange rate



The above graph plots both the value of R in every year, and the average of R over the entire sample period. How would we ideally define a cycle? As *a period starting at R_{AVG} (average) during which a dominant extremum of R is crossed and ending upon the return to R_{AVG}.* The period 1975-1987 conforms exactly to this description, for example. It starts at R_{AVG} in 1975, establishes a new negative dominant extremum in 1978, and returns to R_{AVG} in 1987. We call this period the second cycle. The first cycle runs from the beginning until 1975, and the third cycle from 1987 until the end.

It is immediately obvious, however, that the first and the last cycles are not quite as 'pretty' as the second one, because they either do not start or do not end at R_{AVG}. Nevertheless, they do both cross a (positive) dominant extremum, and they do both 'touch' R_{AVG} at least once. Laying the reference point higher than the average might allow us to define three 'ideal' cycles, but this would impose an arbitrariness in the cycle selection that we would wish to avoid. Rather, for the first and last cycles, we broaden our definition of a cycle: *a period starting and/or ending at R_{AVG}, during which a dominant extremum is crossed.* This definition, therefore, allows for a departure from the 'full-cycle approach' in some cases. In fact, in the extreme it becomes a 'one-sided approach', as employed in prior research: during the 'cycle' there is only a movement in one direction, without any offsetting movement in the opposite direction. Even so, if from our point of view the previously used one-sided approach is only a 'worst-case' scenario in our cycle-identification process, then our approach unambiguously involves an 'improvement'[26].

In total we identify 41 cycles for the sixteen countries, as can be seen in the second column of Appendix C. This means that on average a country has 2.6 cycles of 11.7 years length.

4.3 **Recursive coefficient estimations**

We know from section 2.3.4 that hysteresis theory predicts positive structural breaks in both the constant term (α) and the real exchange rate elasticity of the import volume (β), for a R-cycle crossing a positive dominant extremum (and vice versa for a cycle crossing a negative dominant extremum). As for the real-income elasticity of the import volume (γ), hysteresis theory makes no predictions. Now that we have defined the cycles, the next step is to see what actually happens to the coefficients during those cycles.

How do we compare the value of a coefficient, say α, at the beginning of a cycle with its value at the end? Basically, we need to calculate the value of α at two different points in time. Say, we have defined a cycle from 1980 until 1990. First, we run an OLS-regression from 1970 until 1980 and note the value we obtain for α. Next, we run an OLS-regression from 1970 until 1990. We now have two values of α at different points in time that we can compare. This technique is called *recursive coefficient estimations*. To perform a formal test for a structural break, however, it is not sufficient to only know the value of α. We also need to calculate the standard errors of the coefficient estimates. Once we have those, we can test whether $\alpha_{1980} \neq \alpha_{1990}$ by seeing if α_{1980} lies outside the 95% confidence interval of α_{1990}. That is, if $\alpha_{1980} < \{\alpha_{1990} - 2{*}s.e.(\alpha_{1990})\}$ or $\alpha_{1980} > \{\alpha_{1990} + 2{*}s.e.(\alpha_{1990})\}$, then we reject the hypothesis that $\alpha_{1980} = \alpha_{1990}$.

Yet, we have not taken into account the fact that we are using a one-period lag in R. If the real exchange rate cycle ends in 1990, the cycle's effect on the import volume will end only in 1991. Therefore, for a cycle from 1980 till 1990, we conduct the following tests:

26 In the cases of Austria and Portugal – two of the 'problem countries' – after an upward peak in the early seventies, the real effective exchange rate follows a constant downward path. Here it seems quite pointless to use the R_{AVG}, since it is crossed only once. Therefore, we choose to use a different cycle definition in these two particular cases. The first reference point is the 'starting value' of R in 1970: the first cycle ends upon return to this starting point. The second cycle is completely 'one sided', only downward.

Null hypothesis$_A$: $\alpha_{1981} = \alpha_{1991}$

Alternative hypothesis$_A$: $\alpha_{1981} \neq \alpha_{1991}$

Rejection region: $\alpha_{1981} < \{\alpha_{1991} - 2*s.e.(\alpha_{1991})\}$ *and* $\alpha_{1981} > \{\alpha_{1991} + 2*s.e.(\alpha_{1991})\}$

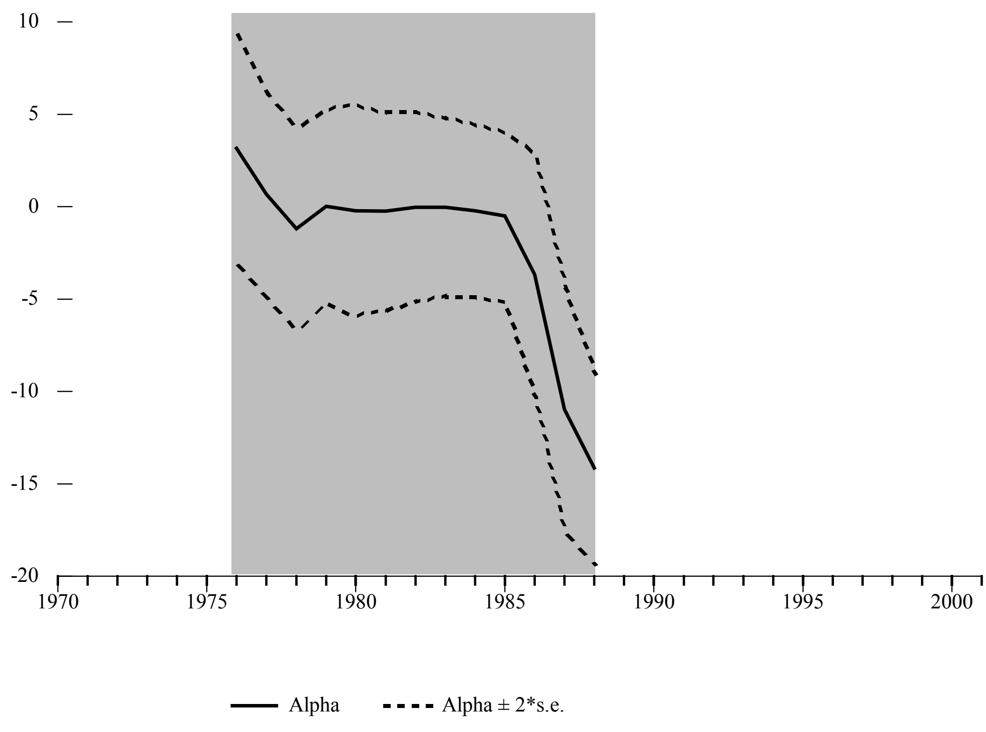
Null hypothesis$_B$: $\beta_{1981} = \beta_{1991}$

Alternative hypothesis$_B$: $\beta_{1981} \neq \beta_{1991}$

Rejection region: $\beta_{1981} < \{\beta_{1991} - 2*s.e.(\beta_{1991})\}$ *and* $\beta_{1981} > \{\beta_{1991} + 2*s.e.(\beta_{1991})\}$

To clarify how recursive coefficient estimations are applied, let us go back to the example of Spain. In Figure 4 we see the recursive estimation of α during the second cycle:

Figure 4 Recursive estimate of alpha (Spain, 2nd cycle)



Clearly, if we compare α_{1988} to α_{1976} , a break occurs. After all, in 1988 the 'α + 2*s.e.'-line lies *below* the solid α-line in 1976. To conduct the test more formally, we can use Table 4, on the next page[27]:

[27] Note from the fourth column in Table 4 that β can temporarily 'dive under' zero during the recursive estimation, even for a country such as Spain that for the entire sample period has a significantly positive β. Because the early estimations are based on relatively few observations, however, we do not consider such a country a 'problem' country.

Table 4 Recursive coefficient estimations – Spain, second cycle.

Year	Alpha	S.e. of alpha	Beta	S.e. of beta
1976	3.17	3.11	-1.03	0.61
1977	0.68	2.77	-0.41	0.43
1978	-1.19	2.74	0.00	0.35
1979	0.03	2.60	-0.24	0.29
1980	-0.21	2.87	-0.29	0.32
1981	-0.24	2.70	-0.27	0.30
1982	-0.02	2.56	-0.31	0.28
1983	-0.03	2.42	-0.31	0.26
1984	-0.22	2.34	-0.27	0.25
1985	-0.50	2.27	-0.26	0.24
1986	-3.66	3.29	-0.01	0.36
1987	-10.97	3.32	0.71	0.39
1988	-14.13	2.59	1.02	0.34

Since 3.17 > {–14.13 + 2*2.59}, we reject the hypothesis that $\alpha_{1976} = \alpha_{1988}$, so that we conclude that a structural break in the constant term has occurred. Equivalently, -1.03 < {1.02 - 2*0.34}, so that $\beta_{1976} \neq \beta_{1988}$.

Of course, the existence of structural breaks in and of itself cannot be considered evidence for the existence of trade-volume hysteresis. Structural breaks, after all, may occur for a variety of reasons. That is why, aside from simply testing whether a break has occurred, we need to note the *sign* of the break and compare it to the *predicted sign* according to hysteresis theory. In the case of Spain's second cycle, for instance, the sign of the break in α is negative, since $\alpha_{1976} > \alpha_{1988}$. The predicted sign is negative as well, because during this cycle a negative dominant extremum is crossed (see Figure 3). So in this case the observed sign of the break corresponds to the predicted sign. We will get back to this in section 4.4.

Appendix C reports for each cycle if breaks were observed in α and in β, and whether or not they had the predicted sign[28]. Let us look carefully at the reported results. One thing that immediately becomes apparent is that many of the α-breaks that we find in different countries occur during the first cycle.

[28] Note that, contrary to Baldwin and Krugman (1987), we *do* find a break in the constant term during the second US-cycle (which also has the predicted sign). The period of this cycle is considerably longer than their sample period though, so that the results are not completely comparable.

Eight out of fourteen breaks (57%) in α occur in the first cycle. The reason for this may well be purely statistical. During the first cycle, the recursive estimations of the coefficients are based on fewer observations, and therefore tend to have a greater variability. As the movements are stronger, it is more likely that we will find a break in this period[29]. Although this statistical issue might cause a *greater number* of breaks to be found in the first cycle, it would not necessarily cause these breaks to have *the predicted sign*. Hence, *even if the timing of the breaks is biased, the comparison of observed versus predicted signs does not have to be*.

Yet, irrespective of whether the signs of the breaks that we find are well explained by hysteresis theory, the *total number* of breaks that we find is far less than 'predicted'. After all, according to hysteresis theory, *every* cycle crossing a dominant extremum ought to cause structural breaks in the import-volume equation. But from 41 cycles, we only observe α-breaks in 14 and β-breaks in 17 cycles. Taken together, one could say that only in 18 of the 41 cycles (44%) do we observe breaks in α and/or β. From a pragmatic point of view one might argue that this is actually not very surprising, since it is perhaps not realistic to truly expect to find a break in every cycle of every country. Nevertheless, strictly speaking this finding is not in congruence with hysteresis theory. On the other hand, it is true that in 14 out of 16 *countries* we do find at least one break, and that the only two in which we do not are Austria and Greece, the 'problem' countries with the significantly negative β's.

Another interesting observation is that breaks in β more often than not have the 'reverse' sign: the opposite of the predicted sign. We will get back to this in section 4.4. Also, it is interesting to note that for quite a few countries 'predicted-sign' α-breaks seem to occur in the same cycle as 'reverse-sign' β-breaks. We will further discuss this 'mirror-image' phenomenon in section 4.5.

4.4 **Binomial tests**

Any structural breaks in coefficients which occur during the three decades in our sample will be picked up by our recursive coefficient estimations. But, as previously remarked, it would be quite inappropriate to simply attribute *every* structural break in α or β to trade-volume hysteresis. For example, if consumer preferences for imported goods relative to domestically-produced goods change over time – say, domestic consumers have a greater propensity to import at any given real exchange

29 On the other hand, the standard errors are higher too in the first cycle, which works in the opposite direction: higher standard errors make it less likely to find a structural break.

rate – one could observe a structural break in α that has nothing to do with hysteresis. The point is, however, that we assume that the effect of change in consumer preferences is completely unrelated to the predictions of hysteresis theory. That is, if hysteresis theory predicts a positive break in α, but in fact another factor like consumer preferences causes the break, we assume that the chance to actually observe a positive break is 50%.

Therefore, to see whether the results we find provide any evidence pointing toward the existence of trade-volume hysteresis, *we need to test if the predicted sign is observed in significantly more than 50% of the actual breaks*. That is, we perform a one-sided binomial test on the following hypothesis:

Null hypothesis$_A$:	*When a break occurs in α, there is at most 50% chance that it is of the predicted sign.*
Alternative hypothesis$_A$:	*When a break occurs in α, there is more than 50% chance that it is of the predicted sign.*

For β-breaks the story is a bit different, however. As can be seen from Appendix C, only 3 out of 17 β-breaks actually have the predicted sign. It does not make much sense, therefore, to test whether *more* than 50% of the breaks have the predicted sign. It could be worthwhile, on the other hand, to perform a test for "reverse-sign" β-breaks. That is, whether significantly *less* than 50% of β-breaks have the predicted sign. We could write down the hypothesis as follows:

Null hypothesis$_B$:	*When a break occurs in β, there is at most 50% chance that it is of the 'reverse' sign.*
Alternative hypothesis$_B$:	*When a break occurs in β, there is more than 50% chance that it is of the 'reverse' sign.*

Appendix D reports the results of the binomial tests (hypotheses 1a and 2). The first part of Appendix D gives the results for all sixteen countries, while the second part shows the outcome when we exclude the five 'problem' countries. Interestingly, the results for α-breaks become more significant when we exclude the 'problem' countries. But even including those countries the null is rejected at 1%. *Bearing in mind that we only find breaks in less than half of all cycles, the results for the* sign *of α-breaks nevertheless seem 'encouraging'*. That is, they conform to the predictions based on hysteresis theory.

The results for β-breaks are much farther from the predicted outcome, however. In fact, the binomial tests reject the 'reverse' null hypothesis. In other words, *significantly more than 50% of β-breaks have the 'reverse' sign*. The significance of these 'reverse' tests is somewhat lower when we exclude the 'problem' countries, but still at least 2.5%. This is a most surprising result. Following the arguments of section 2.3.4, it would mean that a R-cycle crossing a positive dominant extremum triggers new foreign entry, which somehow *decreases* the number of varieties available. This, in turn, *decreases* the domestic price elasticity of the import volume, which causes a *negative* structural break in β.

How can we explain this? Well, we cannot, really. But we might at least go part of the way by introducing an additional factor: domestic firm *exit*. If new foreign entry creates new competition which forces some existing domestic producers to leave the market, the number of varieties would increase less than when these producers would have stayed. At most this would cancel out the β-breaks, however. It would not make them *negative*.

There is nevertheless one rather speculative possibility thinkable that could cause reverse β-breaks. Imagine that currently domestic firms in all sectors have a rather low efficiency compared to the rest of the world. Suddenly there is a large 'wave' of foreign entry, triggered by a R-cycle crossing a positive dominant extremum. This forces change in the domestic economic structure, to increase competitiveness of domestic firms. One could think of large-scale mergers, for instance. If such a change would be sufficiently large, and in the process of becoming more efficient domestic firms specialise in fewer varieties, this effect could theoretically *more than compensate* for the increase in varieties through foreign entry. Breaks in α would not be affected, moreover, since the import volume at the end of the cycle remains at a higher level than at the beginning.

Yet, even this speculative explanation is not theoretically consistent. The reason is that in this particular case, the effect of crossing a positive extremum and that of crossing a negative extremum cannot be considered symmetrical. After all, for a *positive* break in β to occur after the crossing of a *negative* extremum, foreign-exporter *exit* would have to lead to domestic-firm *de-specialisation*. This would have to happen to such an extent that despite foreign-exporter exit, the number of varieties in the market *increases*. This is quite unrealistic, of course[30]. All the same, we are not able to come up with a more convincing explanation for this puzzling phenomenon.

30 Interestingly, however, relatively more 'reverse' β-breaks occur during cycles crossing *positive* extrema than during cycles crossing *negative* extrema. For cycles crossing *positive* extrema 85% of all β-breaks are 'reverse' versus 75% for cycles crossing *negative* extrema.

4.5 **Fixed beta and fixed gamma tests**

The primary part of the empirical discussion has already been completed in section 4.4. Here we describe two 'extra' tests that we perform. The first one is prompted by the curious fact that for quite a few countries 'predicted-sign' α-breaks seem to occur at the same moment as 'reverse-sign' β-breaks. For example, in Appendix C one can see that Spain's first two cycles produce such an outcome: both cycles produce a break in α with the predicted sign, and a break in β with a sign that is opposite to the prediction. This 'mirror-image' phenomenon is observed in eight countries.

What causes this effect? There does not seem to be an intuitive answer. Yet, one might perhaps speculate that 'initially' a break occurs in the responsiveness of the import volume to the real exchange rate, which for some reason has the reverse sign. At the same time, the *level* of the import volume stays constant. Now the constant term 'compensates' for the effect of the β-change on the import-volume level, which shows up as an α-break with the predicted sign. In this case, it would be inappropriate to view α-breaks with predicted signs as evidence for trade-volume hysteresis: α is simply 'following' β, and overall no shift in the import volume actually occurs.

It may be interesting, therefore, to redo the recursive estimations of the constant term, *while keeping β fixed*. At which value do we fix β? Simply at the OLS-regression estimate of β for the entire sample period (which can be found in Appendix B). We rerun the recursive estimations of α, and check once more per cycle if a break occurs, and if so, whether it has the predicted sign. The results are reported in Appendix E. Afterwards, we perform new binomial tests, to check if α-breaks still have the predicted sign significantly more than 50% of the time. The results are reported in Appendix D, under hypothesis 1b. The null hypothesis is still rejected, irrespective of whether we exclude the "problem" countries. In all, the only thing that changes quite strongly is the number of breaks that are found in α, which increases from 14 to 20 for all countries together[31]. We will explain a possible reason for this shortly.

Our second test is to keep γ fixed, and redo the OLS-regressions, recursive coefficient estimations and binomial tests like in the case of the fixed β. This test does not really have a strong theoretical foundation, however. Rather, it can be thought of as a way to 'get a feeling' for the interdependencies between the coefficients. The results are reported in Appendix F and under hypothesis 1c in Appendix D.

[31] The most striking case is that of The Netherlands, which goes from one to four breaks (all predicted sign).

Interestingly, both β-fixing and γ-fixing seems to increase the total number of breaks found and to decrease the timing bias in those breaks. For instance, a glance at Appendix E reveals that a lot more α-breaks are found in second, third and fourth cycles when β is kept fixed. The reason for this may again be purely statistical. When a coefficient is fixed, the OLS-regression can use the same amount of data to estimate a smaller number of (non-fixed) coefficients. At any point in time the standard errors will be lower, so that we are more likely to observe significant results.

5 CONCLUSIONS

In this paper we qualitatively investigate the existence of trade-volume hysteresis on the macroeconomic level. Our sample includes annual, multilateral data from 1970-2001 from fourteen European countries, the US and Japan. On the basis of the insights from hysteresis theory, we test for breaks in the constant term and the real exchange rate elasticity of the import volume in a (cointegrated) import-volume equation. We use recursive estimations to investigate whether the coefficients have a significantly different value at the end of a real exchange rate cycle crossing a dominant extremum.

Although hysteresis theory predicts structural breaks during each R-cycle crossing a dominant extremum, we only observe breaks in less than half of all cycles. Moreover, the breaks in the constant term are mainly located in the first cycle. This is probably attributable to the fact that in recursive estimations the early output is more variable, since it is based on fewer observations. When we fix either the coefficient of the real exchange rate or of the real GDP, and redo the recursive estimations, significance is added to the estimates of the constant term and the timing bias seems to vanish.

Of the breaks in the constant term that we do find, most have the sign predicted by hysteresis theory. Performing binomial tests, we conclude that constant-term breaks have the predicted sign significantly more than 50% of the time. Excluding the five 'problem' countries – countries that do not have a significantly positive real exchange rate coefficient - only reinforces this finding. Moreover, fixing other coefficients does not alter these results. This is the strongest evidence we find in support of hysteresis theory. On the other hand, breaks in the coefficient of the real exchange rate show exactly the opposite behaviour: significantly more than 50% of these breaks have the 'reverse' sign. Again, excluding the five 'problem' countries does not alter this puzzling result.

All in all, our empirical findings regarding trade-volume hysteresis are mixed. *Although we do not find as many breaks as hysteresis theory predicts, its predictive power for the direction of shifts in the import-volume level (constant-term breaks) seems quite strong. The direction of shifts in the real exchange rate elasticity of the import volume, however, is completely contrary to the predictions of hysteresis theory*. Still, in some way one could argue that even for the latter breaks hysteresis theory cannot be thought of as completely irrelevant. There *is*, after all, a strong correlation between the prediction and the outcome, even if it is not in the direction we expected. Perhaps we require further theoretical development to better comprehend the observed effects.

Of course, more empirical work in this field could also shed more light on the remaining questions. Our research would indicate that foremost among these are: Why do breaks in the coefficient of the real exchange rate have the 'reverse' sign? Why do some real exchange rate cycles crossing dominant extrema cause breaks, while others do not? Can we estimate an equation in which the relation between the real exchange rate and the import volume is significantly positive for more countries, but that still allows us to test for hysteresis at the same time? As for our own research methodology, one possible extension is to apply it to *export* volumes as well. This would require replacing the domestic real GDP with the 'foreign' real GDP in the regression equation. For a multilateral test, the 'foreign' real GDP would be a trade-weighted average of the real GDP's of export-destination countries.

Although the focus of this paper is purely qualitative, it may be interesting to briefly look at the possible welfare implications of our findings. Firstly, note that from a global perspective trade-volume hysteresis does not necessarily have any welfare implications at all. Sunk costs of entry may be lost to an individual *firm*, but they are not lost to *society*: another firm gains them as a revenue. As long as no negative externality is associated with these sunk costs, trade-volume hysteresis does not entail any global deadweight loss. An individual country, however, *can* benefit or loose out as a consequence of hysteresis. If the import-volume level can be hysteretically affected by a sufficiently large real appreciation – as our findings on constant-term breaks would indeed indicate - the real equilibrium exchange rate could shift downward (see section 2.3.2). This would mean that the 'depreciation path' back to trade-account balance would be 'lengthened': the country would have to endure a trade-account deficit for a longer time than if hysteresis would not exist.

Viewed from the capital account, this means that the country would have a greater foreign debt to repay, since a prolonged period of capital inflows would have been necessary to support the trade deficit. Hence, countries may wish to avoid relatively large real appreciations that could bring about trade-volume hysteresis. Conversely, countries could try to induce a real depreciation beyond a negative dominant extremum in order to become net creditors, although this would amount to a beggar-thy-neighbour policy.

REFERENCES

Amable, B., J. Henry, F. Lordon and R. Topol, 1994, Strong hysteresis versus zero-root dynamics, *Economics Letters*, 44, 43-47

Amable, B., J. Henry, F. Lordon and R. Topol, 1995, Weak and strong hysteresis: an application to foreign trade, *Economic Notes*, 24.

Baldwin, R., 1988a, Hysteresis in import prices: the beachhead effect, *American Economic Review*, 78, 773-785.

Baldwin, R., 1988b, Some empirical evidence on hysteresis in aggregate import prices, *NBER Working Paper No. 2483*.

Baldwin, R. and P. Krugman, 1987, The persistence of the US trade deficit, *Brookings Papers on Economic Activity No. 1*, 1-43.

Baldwin, R. and P. Krugman, 1989, Persistent trade effects of large exchange rate shocks, *Quarterly Journal of Economics*, 54, 635-654.

Baldwin, R. and R. Lyons, 1994, Exchange rate hysteresis? Large versus small policy misalignments, *European Economic Review*, 38, 1-22.

Belke, A. and M. Göcke, 1997, Cointegration and structural breaks in German employment – an error-correction interpretation, *Jahrbücher für Nationalökonomie und Statistik*, 216, 129-152.

Blanchard, O. and L. Summers, 1986, Fiscal increasing returns, hysteresis, real wages and unemployment, *Harvard Institute of Economic Research Discussion Paper No. 1266*.

Blecker, R., 1992, Structural roots of US trade problems: income elasticities, secular trends, and hysteresis, *Journal of Post-Keynesian Economics*, 14, 321-46.

Campa, J., 2000, Exchange rates and trade: how important is hysteresis in trade?, *IESE Research Paper No. 427*.

Chionis, D., 2002, The hysteretic effects on the real exchange rates, *International Review of Applied Economics*, 16, 451-63.

Coes, D., 1981, The crawling peg and exchange rate uncertainty, in J. Williamson (ed.), *Exchange rate rules, the theory, performance and prospects of the crawling peg*, St. Martin's Press.

Cross, R., 2000, Hysteresis and EMU, *Metroeconomica*, 51, 367-379.

Cushman, D., 1983, The effects of real exchange rate risk on international trade, *Journal of International Economics*, 15, 45-65.

Cushman, D., 1988, US bilateral trade flows and exchange risk during the floating period, *Journal of International Economics*, 24, 317-30.

Dannenbaum, J., 1998, Hysteresis in foreign trade – a new empirical approach, *Jahrbücher für Nationalökonomie und Statistik*, 217, 589-612.

Dixit, A., 1989, Hysteresis, import penetration, and exchange rate pass-through, *Quarterly Journal of Economics*, 54, 205-228.

Dixit, A., 1992, Investment and hysteresis, *Journal of Economic Perspectives*, 6, 107-132.

Feinberg, R., 1992, Hysteresis and export targeting, *International Journal of Organization*, 10, 679-684

Giovannetti, G. and H. Samiei, 1996, Hysteresis in exports, *CEPR Discussion paper No. 1352*.

Göcke, M., 2001, A macroeconomic model with hysteresis in foreign trade, *Metroeconomica*, 52, 449-473.

Grootwoordenboek der Nederlandse Taal, 1992, Van Dale.

Hayashi, F., 2000, *Econometrics*, Princeton University Press.

Hickok, S., J. Hung and K. Wulfekuhler, 1991, An expanded cointegrated model of US trade, *Federal Reserve Bank of New York Research paper No. 9121*.

International Monetary Fund, 1984, Exchange rate volatility and world trade, *Occasional Paper No. 28*.

Katzner, D., 1993, Some notes on the role of history and the definition of hysteresis and related concepts in economic analysis, *Journal of Post-Keynesian Economics*, 15, 323-345.

Kim, Y., 1991, External adjustments and exchange rate flexibility: some evidence from US data, *The Review of Economics and Statistics*, 73, 176-181.

Kulatilaka, N. and B. Kogut, 1996, Direct investment, hysteresis, and real exchange rate volatility, *Journal of the Japanese and International Economies*, 10, 12-36.

Lawrence, R., 1990, US current adjustment: an appraisal, *Brookings Papers on Economic Activity No. 2*, 343-92.

Ljungqvist, L., 1994, Hysteresis in international trade: a general equilibrium analysis, *Journal of International Money and Finance*, 13, 387-399.

Martinez-Zarzoso, I., 2001, Does hysteresis occur in trade? Some evidence for bilateral export flows at a disaggregated level, *International Trade Journal*, 15, 57-88.

McCausland, W., 2000, Exchange rate hysteresis, *The Manchester School*, 68, 113-31.

Parsley, D. and S-J. Wei, 1993, Insignificant and inconsequential hysteresis: the case of US bilateral trade, *The Review of Economics and Statistics*, 606-622.

Phelps, E., 1972, *Inflation policy and unemployment theory*, Norton Publishers.

Pilbeam, K., 1998, *International finance,* Macmillan Press.

Piscitelli, L., R. Cross, M. Grinfeld and H. Lamba, 2000, A test for strong hysteresis, *Computational Economics*, 15, 59-78.

Pindyck, R. and D. Rubinfeld, 1998, *Microeconomics*, Prentice Hall International.

Rogers, J. and M. Jenkins, 1995, Haircuts or hysteresis, *Journal of International Economics*, 38, 339-360.

Wang, Y., 1995, Comparative advantage and hysteresis in trade balance, *International Economic Journal*, 9, 57-76.

Yerger, D., 1999, Exchange rate movements and US import markets: lessons from the 1980's, *International Trade Journal*, 13, 121-56.

APPENDIX A DATA OVERVIEW

Our data-set comprises sixteen countries: all current European Union members, with the exception of Luxembourg, plus the United States and Japan.

Country	*Data type*[32]	*Period*	*Source*[33]
Austria	Real GDP	1970 – 1998	IFS
	Real GDP	1999 – 2001	OECD
	REER	1970 – 2001	DNB
	Import Volume	1970 – 2001	OECD
Belgium	Real GDP	1970 – 1998	IFS
	Real GDP	1999 – 2001	OECD
	REER	1970 – 2001	DNB
	Import Volume	1970 – 2001	OECD
Denmark	Nominal GDP	1970 – 2001	IFS
	CPI	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Volume	1970 – 2000	IFS
	Import Volume	2001	OECD
Finland	Nominal GDP	1970 – 2001	IFS
	CPI	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Volume	1970 – 1997	IFS
	Import Volume	1998 – 2001	OECD
France	Nominal GDP	1970 – 2001	IFS
	CPI	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Volume	1970 – 2000	IFS
	Import Volume	2001	OECD
West-Germany[34]	Nominal GDP	1970 – 2001	IFS
	CPI	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Volume	1970 – 1999	IFS
	Import Volume	2000 – 2001	OECD
Greece	Nominal GDP	1970 – 2001	IFS
	CPI	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Volume	1970 – 1997	IFS
	Import Volume	1998 – 2001	OECD

[32] Abbreviations of data types:
REER - Real Effective Exchange Rate deflated against export prices, weighted against relative trade flows.
GDP – Gross Domestic Product.
CPI - Consumer Price Index.

[33] Abbreviations of sources:
IFS – International Financial Statistics of the International Monetary Funds.
OECD – Organisation for Economic Cooperation and Development, Economic Outlook No. 72.
DNB – The statistical database of De Nederlandsche Bank (Dutch Central Bank).

[34] Both IFS and DNB data for West-Germany are adjusted for unification. For OECD data, see ‘performed data transformations’ below.

Ireland	Nominal GDP	1970 – 2001	IFS
	CPI	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Volume	1970 – 2001	IFS
Italy	Nominal GDP	1970 – 2001	IFS
	CPI	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Volume	1970 – 2001	IFS
Japan	Real GDP	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Volume	1970 – 2001	IFS
Netherlands	Nominal GDP	1970 – 2001	IFS
	CPI	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Volume	1970 – 2001	IFS
Portugal	Nominal GDP	1970 – 2001	IFS
	CPI	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Value in $	1970 – 1993	IFS
	Import Prices in $	1970 – 1993	IFS
	Import Volume	1994 – 2001	OECD
Spain	Nominal GDP	1970 – 2001	IFS
	CPI	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Value in $	1970 – 2001	IFS
	Import Prices in $	1970 – 2001	IFS
Sweden	Nominal GDP	1970 – 2001	IFS
	CPI	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Volume	1970 – 2001	IFS
United Kingdom	Nominal GDP	1970 – 2001	IFS
	CPI	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Volume	1970 – 2001	IFS
United States	Real GDP	1970 – 2001	IFS
	REER	1970 – 2001	DNB
	Import Volume	1970 – 2001	IFS

All data types except Nominal GDP and Import Value are in indices. All import data are multilateral.

<u>Performed data transformations</u>

- Direct data on Real GDP for the whole sample period was only available for Belgium, Japan, the US and Austria, with base year 1995. Therefore, we calculated the Real GDP for the other countries as follows:

$$\left[\frac{GDP_t}{CPI_t} \bigg/ \frac{GDP_{1995}}{CPI_{1995}} \right] * 100$$

- For Portugal and Spain no direct data on import volumes were available. However, we did obtain data on trade *values* and trade *prices*, both expressed in US dollars. We used these to calculate the import-volume time-series in the following manner (V stands for import value, and P for import prices):

$$\left[\frac{V_t}{P_t} \bigg/ \frac{V_{1995}}{P_{1995}} \right] * 100$$

- For the Real GDP of Austria and Belgium, and for the import volumes of six countries, the IFS datafile does not reach 2001. In those cases we used OECD data to complete the sample. To make the data comparable we added the OECD data to the IFS data in terms of percentage change:

$$Q_t^{IFS} = \left[\frac{Q_t^{OECD} - Q_{t-1}^{OECD}}{Q_{t-1}^{OECD}} + 1 \right] Q_{t-1}^{IFS}$$

Here Q stands for the import volume, and the superscript indicates the data source. The starting point for the formula is the last year for which IFS data are available.

APPENDIX B REGRESSION RESULTS

Significance levels are reported as t-statistics in parentheses below the coefficients. The critical t-value at 5% significance is 2.05. Unexpected results are shaded.

Country	Coefficients: Constant term	Coefficients: *R's coefficient*	Coefficients: *Y's coefficient*	R^2	Stationarity of residuals
Netherlands	-1.63 (-0.36)	0.94 (3.19)	1.74 (11.08)	0.944	Yes, but at 10%
Germany	-2.49 (-1.50)	0.78 (2.57)	1.73 (13.75)	0.953	Yes
France	-4.36 (-1.29)	0.87 (2.08)	1.80 (8.95)	0.972	Yes
Italy	-4.42 (-2.91)	0.57 (1.39)	0.96 (8.45)	0.907	Yes
Belgium	-2.11 (-3.39)	0.28 (3.12)	1.86 (25.51)	0.976	Yes
Denmark	-2.51 (-1.82)	0.63 (4.54)	1.25 (8.94)	0.875	Yes
Ireland	-1.87 (-1.07)	0.38 (2.22)	1.32 (30.57)	0.990	Yes
Spain	-14.16 (-16.50)	0.81 (3.76)	2.73 (34.26)	0.984	Yes
UK	-5.03 (-7.62)	0.02 (0.11)	2.17 (17.12)	0.966	Yes
Sweden	-2.97 (-1.29)	0.87 (2.17)	1.36 (9.33)	0.860	No
Finland	-3.49 (-2.86)	0.43 (3.13)	1.36 (6.36)	0.821	Yes
Austria	1.82 (1.44)	-0.79 (-4.51)	1.45 (13.31)	0.984	Yes
Greece	-3.34 (-1.59)	-0.97 (-3.04)	1.94 (15.26)	0.950	Yes
Portugal	1.49 (0.80)	-0.30 (-0.72)	1.70 (19.27)	0.990	Yes
US	-2.86 (-2.31)	0.38 (2.21)	1.80 (18.98)	0.944	Yes
Japan	-5.03 (-11.61)	1.05 (7.70)	1.04 (15.90)	0.976	Yes

APPENDIX C RECURSIVE ESTIMATIONS

Country	*Cycles of R*	*Break in α?*	*Predicted sign?*	*Break in β?*	*Predicted sign?*	*Remarks (all cycles)*
Netherl.	1.1970-1979	Yes	Yes	Yes	No	1. 1st and 3rd cycle
	2.1979-1990	No	-	No	-	break in Y's coefficient.
	3.1990-1995	No	-	No	-	
	4.1995-2001	No	-	No	-	
West-	1.1970-1979	No	-	No	-	1. 2nd cycle break in
Germany	2.1979-2001	No	-	Yes	Yes	Y's coefficient.
France	1.1970-1982	Yes	Yes	Yes	No	
	2.1982-1988	No	-	No	-	
	3.1988-2001	No	-	No	-	
Italy	1.1970-1980	Yes	No	Yes	Yes	1. Twice a break in Y's
	2.1980-1993	No	-	No	-	coefficient.
Belgium	1.1970-1982	Yes	Yes	Yes	Yes	1. Twice a break in Y's
	2.1982-2001	No	-	Yes	No	coefficient.
Denmark	1.1970-1979	No	-	No	-	
	2.1979-1987	No	-	Yes	No	
Ireland	1.1970-1974	No	-	No	-	1. 1st cycle break in
	2.1974-1988	Yes	Yes	Yes	No	Y's coefficient.
	3.1988-2000	No	-	No	-	
Spain	1.1971-1975	Yes	Yes	Yes	No	1. In all cycles breaks
	2.1975-1987	Yes	Yes	Yes	No	in Y's coefficient.
	3.1987-2001	No	-	No	-	
U.K.	1.1971-1977	No	-	No	-	1. 3rd cycle break in
	2.1977-1984	Yes	Yes	Yes	No	Y's coefficient.
	3.1984-2001	Yes	No	No	-	
Sweden	1.1970-1981	Yes	Yes	Yes	No	1. 1st and 3rd cycle
	2.1981-1989	No	-	No	-	breaks in Y's coefficient
	3.1989-2001	No	-	No	-	
Finland	1.1970-1992	Yes	Yes	No	-	1. Breaks in Y's coef.
	2.1992-2001	No	-	No	-	in both cycles.
Austria	1.1970-1976	No	-	No	-	
	2.1976-2001	No	-	No	-	
Greece	1.1970-1986	No	-	No	-	1. Breaks in Y's coef.
	2.1986-2001	No	-	No	-	in both cycles.
Portugal	1.1970-1975	Yes	Yes	Yes	No	
	2.1975-2001	No	-	Yes	No	
U.S.	1.1970-1972	n.a.	n.a.	n.a.	n.a.	1. 3rd cycle break in
	2.1972-1987	Yes	Yes	Yes	No	Y's coefficient.
	3.1987-2001	No	-	No	-	
Japan	1.1970-1974	No	-	Yes	No	1. 2nd cycle break
	2.1974-1988	Yes	Yes	Yes	No	in Y's coefficient.
	3.1988-2001	No	-	No	-	
Total	41 cycles	14 breaks	12 pred. sign	17 breaks	3 pred. sign	

APPENDIX D BINOMIAL TESTS

I. Binomial tests (one-sided)

Hypothesis 1a : When a break occurs in the constant term, there is at most 50% chance that it is of the predicted sign.
Alternative Hypothesis: When a break occurs in the constant term, there is more than 50% chance that it is of the predicted sign.

Question: If the chance of observing the predicted sign would be 50%, what would be the probability of observing the predicted sign 12 times or more in a sample of 14?
Answer: 0.007
Outcome: Reject Hypothesis 1a at the 1% significance level.

Hypothesis 1b (fixed beta) : When a break occurs in the constant term, there is at most 50% chance that it is of the predicted sign.
Alternative Hypothesis: When a break occurs in the constant term, there is more than 50% chance that it is of the predicted sign.

Question: If the chance of observing the predicted sign would be 50%, what would be the probability of observing the predicted sign 15 times or more in a sample of 20?
Answer: 0.021
Outcome: Reject Hypothesis 1b at the 2.5% significance level.

Hypothesis 1c (fixed gamma) : When a break occurs in the constant term, there is at most 50% chance that it is of the predicted sign.
Alternative Hypothesis: When a break occurs in the constant term, there is more than 50% chance that it is of the predicted sign.

Question: If the chance of observing the predicted sign would be 50%, what would be the probability of observing the predicted sign 17 times or more in a sample of 23?
Answer: 0.017
Outcome: Reject Hypothesis 1c at the 2.5% significance level.

Hypothesis 2 : When a break occurs in R's coefficient, there is at most 50% chance that it is of the "reverse" sign.
Alternative Hypothesis: When a break occurs in R's coefficient, there is more than 50% chance that it is of the "reverse" sign.

Question: If the chance of observing the "reverse" sign would be 50%, what would be the probability of observing the "reverse" sign 14 times or more in a sample of 17?
Answer: 0.007
Outcome: Reject Hypothesis 2 at the 1% significance level.

II. Binomial tests excluding "problem" countries (one-sided)

Hypothesis 1a : When a break occurs in the constant term, there is at most 50% chance that it is of the predicted sign.
Alternative Hypothesis: When a break occurs in the constant term, there is more than 50% chance that it is of the predicted sign.

Question: If the chance of observing the predicted sign would be 50%, what would be the probability of observing the predicted sign 10 times in a sample of 10?
Answer: 0.001
Outcome: Reject Hypothesis 1a at the 0.5% significance level.

Hypothesis 1b (fixed beta) : When a break occurs in the constant term, there is at most 50% chance that it is of the predicted sign.
Alternative Hypothesis: When a break occurs in the constant term, there is more than 50% chance that it is of the predicted sign.

Question: If the chance of observing the predicted sign would be 50%, what would be the probability of observing the predicted sign 14 times or more in a sample of 16?
Answer: 0.002
Outcome: Reject Hypothesis 1b at the 0.5% significance level.

Hypothesis 1c (fixed gamma) : When a break occurs in the constant term, there is at most 50% chance that it is of the predicted sign.
Alternative Hypothesis: When a break occurs in the constant term, there is more than 50% chance that it is of the predicted sign.

Question: If the chance of observing the predicted sign would be 50%, what would be the probability of observing the predicted sign 13 times or more in a sample of 17?
Answer: 0.025
Outcome: Reject Hypothesis 1c at the 2.5% significance level.

Hypothesis 2 : When a break occurs in R's coefficient, there is at most 50% chance that it is of the "reverse" sign.
Alternative Hypothesis: When a break occurs in R's coefficient, there is more than 50% chance that it is of the "reverse" sign.

Question: If the chance of observing the "reverse" sign would be 50%, what would be the probability of observing the "reverse" sign 11 times or more in a sample of 13?
Answer: 0.011
Outcome: Reject Hypothesis 2 at the 2.5% significance level.

APPENDIX E RETESTING WITH A FIXED BETA

		without fixed beta		with fixed beta	
Country	*Cycles of R*	*Break in α?*	*Predicted sign?*	*Break in α?*	*Predicted sign?*
Netherlands	1. 1970 - 1979	Yes	Yes	Yes	Yes
	2. 1979 - 1990	No	-	Yes	Yes
	3. 1990 - 1995	No	-	Yes	Yes
	4. 1995 - 2001	No	-	Yes	Yes
France	1. 1970 - 1982	Yes	Yes	Yes	No
	2. 1982 - 1988	No	-	No	-
	3. 1988 - 2001	No	-	Yes	Yes
Ireland	1. 1970 - 1974	No	-	No	-
	2. 1974 - 1988	Yes	Yes	Yes	Yes
	3. 1988 - 2000	No	-	No	-
Spain	1. 1971 - 1975	Yes	Yes	No	-
	2. 1975 - 1987	Yes	Yes	Yes	Yes
	3. 1987 - 2001	No	-	Yes	No
Sweden	1. 1970 - 1981	Yes	Yes	Yes	Yes
	2. 1981 - 1989	No	-	Yes	Yes
	3. 1989 - 2001	No	-	Yes	No
Portugal	1. 1970 - 1975	Yes	Yes	No	-
	2. 1975 - 2001	No	-	Yes	Yes
U.S.	1. 1970 - 1972	n.a.	n.a.	n.a.	n.a.
	2. 1972 - 1987	Yes	Yes	No	-
	3. 1987 - 2001	No	-	Yes	Yes
Japan	1. 1970 - 1974	No	-	Yes	Yes
	2. 1974 - 1988	Yes	Yes	No	-
	3. 1988 - 2001	No	-	No	-
Total (all 16)	41 cycles	14 breaks	12 pred. sign	20 breaks	15 pred. sign

APPENDIX F RETESTING WITH A FIXED GAMMA

		without fixed gamma		with fixed gamma	
Country	*Cycles of R*	*Break in α?*	*Predicted sign?*	*Break in α?*	*Predicted sign?*
Netherl.	1.1970-1979	Yes	Yes	Yes	Yes
	2.1979-1990	No	-	No	-
	3.1990-1995	No	-	No	-
	4.1995-2001	No	-	Yes	No
West-Germany	1.1970-1979	No	-	No	-
	2.1979-2001	No	-	No	-
France	1.1970-1982	Yes	Yes	Yes	Yes
	2.1982-1988	No	-	No	-
	3.1988-2001	No	-	Yes	No
Italy	1.1970-1980	Yes	No	Yes	No
	2.1980-1993	No	-	No	-
Belgium	1.1970-1982	Yes	Yes	Yes	Yes
	2.1982-2001	No	-	No	-
Denmark	1.1970-1979	No	-	Yes	Yes
	2.1979-1987	No	-	Yes	Yes
Ireland	1.1970-1974	No	-	No	-
	2.1974-1988	Yes	Yes	Yes	Yes
	3.1988-2000	No	-	No	-
Spain	1.1971-1975	Yes	Yes	Yes	Yes
	2.1975-1987	Yes	Yes	Yes	Yes
	3.1987-2001	No	-	No	-
U.K.	1.1971-1977	No	-	Yes	No
	2.1977-1984	Yes	Yes	Yes	Yes
	3.1984-2001	Yes	No	No	-
Sweden	1.1970-1981	Yes	Yes	Yes	Yes
	2.1981-1989	No	-	Yes	No
	3.1989-2001	No	-	Yes	Yes
Finland	1.1970-1992	Yes	Yes	Yes	Yes
	2.1992-2001	No	-	Yes	No
Austria	1.1970-1976	No	-	No	-
	2.1976-2001	No	-	Yes	Yes
Greece	1.1970-1986	No	-	No	-
	2.1986-2001	No	-	No	-
Portugal	1.1970-1975	Yes	Yes	Yes	Yes
	2.1975-2001	No	-	Yes	Yes
U.S.	1.1970-1972	n.a.	n.a.	n.a.	n.a.
	2.1972-1987	Yes	Yes	No	-
	3.1987-2001	No	-	No	-
Japan	1.1970-1974	No	-	Yes	Yes
	2.1974-1988	Yes	Yes	Yes	Yes
	3.1988-2001	No	-	No	-
Total	41 cycles	14 breaks	12 pred. sign	23 breaks	17 pred. sign