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The Damage from Clean Floats
– from an Anti-Inflationary Monetary Policy*†

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Abstract

The paper traces the dangers in the closed economy perspective of a monetary policy focused on a domestic inflation goal under a clean float. Field evidence of the damage wrought from this perspective is reinforced by that from a laboratory experiment. The laboratory experiment avoids measurement errors to which econometric estimation is subject concerning omitted or inadequately proxied determinants, non-normally distributed errors, inadequate degrees of freedom, false assumptions of temporal independence and false synchronicity in decision response lags to stimuli. Our laboratory experiment also embeds a new theory of exchange rate determination involving the uncontroversial power of *fully* cooperating central banks to *totally* fix the exchange rate. The new model is within a broader theory that includes risk effects normally excluded, SKAT, the Stages of Knowledge Ahead Theory. We use SKAT to analyse outliers in our experimental results, and indicate some new directions and foci for econometric work. Our laboratory results point to the superiority of dollarisation, currency unions, a single world money over even dirty floats that include the exchange rate as an objective in its own right.

Key words outliers analysis, clean float, dirty float, IMF, exchange rate regime, exchange rate volatility, experiment, SKAT the Stages of Knowledge Ahead Theory, monetary policy, transparent policy, exchange rate shocks, central bank cooperation, central bank conflict; beggar thy neighbor.

JEL Classification D80, F31

Format

Parts 1 to 3 delineate the clean versus dirty float approaches to exchange rate management, and our minimal progress via current econometric estimates in understanding of why exchange rates change. These three parts delineate our failure to discern the equilibrating fundamentals underlying *both* the clean float perspective *and* that strand of the dirty float perspective wherein variable exchange rates speed the restoration of equilibrium. Part 4 describes one reason for our having learned so little about equilibrating fundaments, and thus so little about clean floats, and also on whether a dirty float focused on stabilizing the exchange rate is inferior to the guarantee of invariance in the exchange rate via a currency union or a single world money. This

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reason is the omission under expected utility theory – and standard non-expected utility theories – of the risk and uncertainty effects experienced in chronological time. Parts 5 to 7 introduce SKAT, the Stages of knowledge Ahead Theory to consistently include these effects, illustrate the stages with France's central bank's decision process upon learning of the 1993 attack on the French franc, and offer a radically different model of how exchange rates are set. Part 8 presents some field data as evidence of the damage from clean floats. Part 9 describes the obstacles in using either armchair theorising or econometric estimates to progress beyond our simple field data evidence. Parts 10 to 12 detail why a laboratory set-up can offer fresh insights, present our experiment, and its results.

1 The Clean Float

1.1 Its Domestic Price Orientation

The clean float was originally promulgated under the belief that speculation is stabilising and that exchange rates would be far more stable than under Bretton Woods, Kenen (2002). The post world war 2 concept of a clean or freely floating exchange rate is closely connected with Milton Friedman (1953, 1998). It stemmed from a closed economy modelling.

Under a clean float, the country's central bank gears its monetary management *exclusively* to the domestic price level – or as a surrogate, inflation, an arguably inferior goal, Swensson (1999). Initially clean float purists completely ignored any potential impact monetary policy might have on the exchange rate, eg Carew (1985). But the domestic price level will indirectly influence and be influenced by the exchange rate because of the export and import effects of international capital, trade and services flows that impinge on domestic prices and employment, Pope (1986).

1.2 Its Evolution to Partial Open Economy Modelling

The closed economy perspective of clean floaters is changing toward a recognition of some open economy aspects. Some now consider the effects that the exchange rate can have on domestic goals in what is termed the new normative macroeconomic research agenda, Taylor (2001). Today also some clean floaters give exchange rate interventions and associated announcements an instrumental role in attaining price and inflationary goals via signaling. Eg the German central bank explained some exchange rate interventions in defence of the DM as signaling – according to Sam Cross's notes for a US Federal Reserve System meeting (1990). Such signaling is also modeled in so-called rational expectations models of clean floating, eg Svensson (2003), Bernanke, Reinhart and Sack (2004).

The moderate clean floater relegates to a footnote – and the extreme clean floater wholesale ignores – collateral exchange rate damage caused to its own or other economies as regards output, debt and asset transfers. It might be thought therefore that clean floating is only considered viable for small countries without close connections to any other small country as regards trade and capital flows. Under such conditions it

could be that the damage that they may wreak on other countries is minor enough to be ignored. However, as will be seen in sections 1.2 and 1.3 below, clean floating is advocated for big countries, and at times practised by them.

1.3 Evolution in the Implementation of Clean Floats

The details of how to implement a clean float have varied over time. This mirrors monetarists' altered understanding of the impact of money on prices and inflation, and on whether fine-tuning is feasible. There was a fine tuning era of interest rate targeting in the 1960s to early 1970s. Then there was a non-fine tuning era of money stock targeting over roughly the next 15 years. This followed Milton Friedman's 1969 discovery that the lags before money impacts on prices are long and variable, and essentially under a two-year horizon unpredictable. Subsequently, with no new information that money has more predictable and shorter lags, an era has arisen in which the clean float operates via interest rate changes as indicated by price changes. This new clean float era arose from difficulties in relating the money base to price changes, and difficulties in giving a long-term stability rule for interest rate changes equivalent to the Friedman money stock rule. The new clean float era has progressively taken longer perspectives about how interest rates influence prices / inflation. In practical policy and reports of success, a vagueness has entered via words such as the "underlying" inflation rate.

The new era, as noted in the preceding section, also allows a role for exchange rates influencing prices / inflation. The country's exchange rate is *not* a goal in its own right. But it has become for some clean floaters, a recognized instrument for attaining the domestic price / inflation goal. By 2007, there are indications of clean floaters reverting from a focus on interest rates for fighting inflation to Friedman's call to focus only on the money stock, eg Kilponen and Leitemo (2007).

1.4 Advocates for Exchange Rate Stability

The IMF is prominent among today's clean float advocates for attaining exchange rate stability. Eg the IMF applauded Indonesia in 1997 for deciding to quit exchange rate interventions and to adopt clean floating, announcing that this will aid its financial stability. It also advised Poland to simultaneously: 1) make a clean float (in the form of its central bank pursuing exclusively a domestic inflation target); and 2) prepare for admission to the EURO. Admission to the EURO requires that the Polish currency stay within an extremely narrow band for an extended period, much narrower than that historically experienced by Poland. The IMF thus sees such clean floats as ultra stabilizing of exchange rates. Others also advocate clean floats as a means of keeping exchange rates more stable, eg for developing countries, Hausken and Pluemper (2002), Ramiakrishnan and Zalduendo (2006), for east European countries, Orlowski (2004), and for the US itself, Dooroodian and Caporale (2006).

1.5 Control of Monetary Policy

Monetary policy can be split between two or three official sectors. In Australia for instance, there is such a three way split, with the central bank, the treasury and the government all with a say. In the US there is a two-way split, with the Treasury in

charge of exchange rate interventions, and the Federal Reserve Board in charge of the key discount rate. Actual monetary policy can thus conform to a clean float without it being a goal of all distinct authorities.

1.6 Practice of a Clean Float

The clean float perspective sprang from a desire to get the government out of exchange rate management, and indeed to generally minimise its role. Its heyday was thus the heyday of the pro free market movement. This had gathered strength from the late 1970s, and was implemented in most developed countries, including in their exchange rate policies, to a very marked degree in the early 1980s by the major currencies on both sides of the Atlantic.

The pre-eminent example of an extreme clean float is that of Paul Volcker's period as chairman of the US Board of Governors that coincided with Donald Regan, a dedicated clean floater, being at the helm for the US Treasury, a post that Donald Regan held until 1985. Volcker is widely regarded as the saviour of the US economy from the high inflation of the mid 1970s through his persistent control of the US monetary base. Paul Volcker moreover personally avows that he pursued an anti-inflationary goal single-mindedly. Some of his critics felt that he should have compromised to alleviate unemployment in the US. Other critics felt that he should have compromised to mitigate the damage imposed on other countries. See eg his retrospective interviews on his Chairmanship of the US Federal Reserve System made to the US Public Broadcasting System.

1.7 Volcker's Undesired Clean Float

This does not however mean that Paul Volcker sees floating exchange rates as a blessing. It does not even mean that he wanted a clean float. In an interview with Perry Mehrling, Mehrling (2001), Volcker elaborates that he would have liked the US to swallow its national pride and depreciate in 1970 (to cope with its Vietnam War expenditures) instead of breaking up the Bretton Woods Agreement. He further reports that when he instituted a tight monetary policy to seek to curb domestic inflation, it was not his intention that this translated into a clean float policy. He wished the US Treasury to permit the Federal Reserve Board to engage in foreign exchange intervention in order to (partially or wholly) sterilise the exchange rate effects of his monetary policy by selling US dollars on the foreign exchange rate market. The US Treasury however, for years declined to authorise the Federal Reserve Board to intervene in the exchange rate market.

Thus although in the public broadcast, Volcker reports that he felt that in a world of floats, his tight monetary policy was the best for the US *and the rest of the world*, this is not the full story. He would have preferred to keep Bretton Woods, and as a second best, to have a dirty float – only the failure to attain a dirty float prior to 1985 he blames on an uncooperative US Treasury. In 1985, the pragmatic James Baker exchanged posts with Donald Regan and US monetary policy departed from its clean float stance, a departure already sought on the other side of the Atlantic.

Volcker's position that US Treasury intervention could have kept the US dollar steady in the early 1980s while he pursued an ultra tight domestic money policy and Reagan pursued an ultra expansionary fiscal policy whiles across the Atlantic primarily contractionary fiscal policies were pursued, hints at a perspective in which domestic activity and prices are independent of the country's open economy linkages.[1] Volcker therefore seems in this regard to be a product of the imperfect transition of the Friedman school from closed economy prescriptions to open economy prescriptions. However, it might be argued that Volcker has progressed further in seeking to reconcile open economy linkages with domestic monetary policy than many academic advocates of clean floats. He indicates inadequate theoretical back-up from his academic colleagues and Federal Reserve Board research staff on this topic. Thus in a panel discussing exchange rates at the American Economic Association meetings in New Orleans, 2001, he constantly challenged his academic co-panelists, all enthusiastic floaters, to explain what was so good about floats. He reminded them that the associated exchange rate outcomes are unpredictable and thus hard to connect to the academic claims of floats being superior as regards stabilising exchange rates or anything else.

In this paper, we take up one aspect of Volcker's challenge. In taking up that aspect of his challenge, we shall offer a quite new modelling of exchange rate determination to those currently available. Prior to offering this new model, we shall introduce additional details concerning Volcker's experience as Chair of the US Federal Reserve, in identifying some of the stylised facts that we embed in our model.

2 The Dirty Float

Under a dirty float policy, a currency's monetary policy includes the exchange rate as a goal in its own right. Dirty floats take two main forms:

1 The beggar-thy-neighbour form; and
2 The stabilising form.

In this paper we are assessing the evidence on whether dirty floats of the stabilising form do better than clean floats in keeping the exchange rate steady. But it is useful to describe first the beggar-thy-neighbour form of dirty floating in order to dispell general widespread misconceptions about Mundell (1961) and the pertinence of different sorts of shocks for choice of exchange rate regimes, and for understanding exchange rate determination.

2.1 Beggar-thy-Neighbour Dirty Floats via Mundell (1961)

Beggar-thy-neighbour dirty floats were commonplace in the 1930s. A country depreciated to seek to solve one's unemployment problem in the hope that this would boost exports and aid import competing industries. Often soon after another country retaliated with a depreciation. In due course countries decided that a preferable exchange rate regime was the Bretton Woods Agreement. Mundell (1961) attributes the horrors of

[1] It could be derived from attributing a far bigger impact of the *foreign* component of the domestic monetary base on the *exchange* rate than has the domestic component of the monetary base, and there is evidence of its being bigger, but so far as the authors know, no estimates of its being the requisite amount bigger, nor of Volcker having employed such extimates.

the 1930s to the failure to quickly enough make the Bretton Woods agreement and remove floating exchange rates and beggar-thy-neighbour competitive depreciations. He never advocated the dirty floats proposed by scientists who refer to his 1961 model. He rightly complains that he distanced himself from them *in that article*, not merely in his consistent advocacy since of a single world money. He objects to the persistent misinterpretation of his 1961 article by those advocating floating exchange rates. He advocates a single money simply on the grounds that this will reduce transactions costs, eg Mundell (2003).

As Mundell has complained, many use Mundell (1961) to ascertain optimal currency areas. All such usages *in practice* amount to advocating the beggar-thy-neighbour dirty floats of the 1930s. To scientists employing Mundell (1961) and extensions thereof, this may be surprising. We therefore explain un-noticed features of that model – how its denial of the complexity, uncertainty, and risk *experienced in the real world* enables this. Later in Part 4 we shall see how in general, not merely in Mundell (1961) that denial of complexity, uncertainty and risk seems natural under our standard expected utility theory lens, and deflects our attention away from uncertainty effects experienced in real time.

2.1.1 Certainty Despite a Mundell Shock

In the Mundell (1961) set-up, there is a once for all shock, never to be repeated, and nobody ever expects another shock. Ie everybody believes in certainty, always did before the shock, and always does after. This, to put it mildly, is a dubious assumption for deciders being even half way rational. But then, often deciders are irrational, or at least myopic and unduly inward looking. For instance, it did take countries in the 1930s a while to discover that other countries would retaliate and that instead of a certain future, exchange rates were exceedingly uncertain and unpredictable.

However, it is dubious to propose that *in reality as distinct from theory*, a country can use the Mundell (1961) solution more than once. A repeat Mundell (1961) solution requires both countries and all those other countries dealing with them to be rather more myopic and non-anticipatory than is the norm. We notice that exchange rate dealers often sharply increase the country risk premium after an unexpected depreciation. The increase in country risk premium can plausibly be interpreted as a realisation that the country's exchange rate is uncertain, something excluded under the Mundell (1961) model's reliance on certainty. This in turn excludes repeated use of the Mundell (1961) model within the period before forgetting occurs as regards risk premia, and people get lulled into seeing the future as certain. See Allais (1972) and Blatt (1983) for evidence on how long is required for such forgetfulness. Yet scientists employing the Mundell (1961) model to investigate advantages and disadvantages of a currency union, to the authors' knowledge, fail to comment on this matter. Ie they fail to take into account that a country could only ever use the exchange rate once – without the model's assumption of certainty becoming altogether implausible, and its implications correspondingly false.

The model's assumption of certainty before and after the single shock moreover excludes all possibilities of anyone being ignorant about the type of shock and its consequences. This assumption of full knowledge about the shock's type and the shock's consequences

has misled economists in their analysis and policy advice concerning exchange rate regime as shown in section 2.1.2 below.

2.1.2 Certainty in Attaining Instantly the New Equilibrium

In Mundell (1961) everybody in both countries understands where, after the shock, is the new equilibrium. Everyone understands that it is good (with rigid nominal wages) for one of the two countries to depreciate to restore the international level of competitiveness after a special sort of shock. Thus there is no scope for retaliation. Everybody agrees that the single never-to-be repeated exchange rate change is beneficial to both countries and will be instantly implemented. There could not be a case of the country that has appreciated protesting that now its wages are too high, and that as a consequence it is suffering unemployment, losses in export markets and in import competing markets.

In this Mundell (1961) world, no country would ever need to risk being accused of beggar-thy-neighbour activity in lobbying another country to appreciate or in itself depreciating. In this Mundell (1961) world as in reality, there is an adding up accounting identity. After a shock, each pair of countries recognises and readily agrees whether it is the sort of shock where one country should appreciate, and the other depreciate.

2.1.3 Systematic Bias in Discerning the New Equilibrium

Let us now contrast this academic exercise – in which the accounting identity holds – with what economists tell an actual country to do in an actual situation. The authors have been unable to identify any country other than Singapore that has a body of economists writing in academic journals or advising the government, seeking to have that country's wage level raised because it is excessively competitive in the international arena. Instead the authors find economists advising virtually every land that their country's unemployment woes arise via too high wages.

The notion that, apart from Singapore, every country has suffered a special sort of shock that might be aided by a depreciation is thus untenable. It violates accounting identities. The fair Mundell (1961) model translates in the complexity of the real world into a beggar-thy-neighbour dirty float policy. The complexity of the real world generates uncertainty on just where is equilibrium and just what sorts of shocks have occurred.

Thus US economists see a solution to its jobless private sector recovery from China appreciating, and estimate the trade gains from a Renminbi appreciation. They seem quite promising, Thorbecke (2006). For its part, China seeks to avoid this appreciation as far as is feasible, given its massive unemployment problems. Economists concerned for poor China, worry that it could follow Japan into long-term recession if it yields substantially to US pressure to appreciate, McKinnon (2005). In practice, therefore, in the murky world where nobody knows where the equilibrium is and has only a vague notion of what sort of shocks have occurred, against his wishes, the model of Mundell (1961) is used as a justification for beggar-thy-neighbour procedures. The econometric exercises conducted in that vast branch of research on optimal currency areas, have served as inadvertent buttresses for anti-social behaviour. In practical policy, this massive branch of econometric literature has not merely been futile. It has been

counterproductive in furnishing unwitting support for biased exchange rate interventions in the name of speeding attainment of equilibria.

2.2 Exchange Rate Stabilising Dirty Floats

Advocates of dirty floating to stabilise exchange rates include Keynes. In the early 1940s he proposed a world central bank with more powers than the current IMF. Support for dirty floats with marked intervention to maintain exchange rate pegs has continued to attract supporters, eg Calvo (2000), Calvo and Reinhart (2002), Courchene (1999a, 1999b) and Courchene and Harris (1999) and Wyplosz (2006). In a like spirit, Charles Bean, Executive Director and Chief Economist at the Bank of England, in 2001 at the Royal Economic society conference criticized the European Central Bank for not choosing to use its obviously available intervention powers to intervene and stabilize the EURO, Islam (2001).

Into the 1990s, numerous developing countries floated very dirtily to try to stabilise their exchange rates. This is seen as a wise policy given how international debts can become unmanageable after a depreciation, Eichengreen (2001). But developing countries sometimes became cleaner under pressure from the IMF and the Washington Consensus to liberalise their capital markets.[2] Clear-cut examples of countries with very dirty floats to stabilise their exchange rates today are Japan and China. Another clear-cut example of a dirty float amongst themselves was the decision to seek a European Monetary system in 1979, one that in steps led to 12 European countries joining currencies and adopting the EURO two decades later with a single currency operated under the European Central Bank. In a similar vein other countries have taken the extreme of exchange rate intervention to stabilize exchange rates and eliminated currency differences entirely via government acts of dollarisation or currency unions.

3 Understanding the Exchange Rate

Can we discern from econometric estimates derived from our current theories whether clean or dirty floats better stabilise the exchange rate? Central bankers, despite their well-endowed research departments, bewail their inability to understand embarrassing and undesired changes in their country's exchange rate, eg Cobham (2002a), Bergo (2006). Major multi-nationals go into receivership through exchange rate errors despite access to the top commercial exchange rate experts.

3.1 Equilibrating Fundamentals

Econometric models that incorporate equilibrating fundamentals fail after each new unanticipated exchange rate crisis. The new crisis affords us a new pool of data. The prior theories fitted the earlier quarterly data nicely. But out of sample, those that are publicly available and checked, fail to outperform a random walk unless each data point

[2] Reservations on this pressure have been expressed, eg Polanski (2000) and Stiglitz (2002). Another study, while not estimating separately the exchange rate component of the IMF raft of conditions, finds that obtaining IMF help with its attendant conditions, is damaging to an economy, namely Barro and Lee (forthcoming). Yet other studies conclude that the impact of exchange rate regime on exchange rate stability is ambiguous or country-specific, eg von Hagen and Zhou (forthcoming).

is stretched from being a quarter in duration to a two years in duration, Meese and Rogoff (1983), Krugman (1993), Mussa (1993), Pagan (1993), Chinn, Cheung and Pascual (2005), Alquist and Chinn (2006). Out of each crisis, we acquire new generation theories. For a nice survey of this evolution, see Dan Friedman (2005). Out of sample, some in the latest generation of publicly available ones do better than a random walk, as for instance, via improvements in measuring money stocks, including that reported in Bissoondeeal, Binner and Elger (2006). However it continues to be the case that those available for public evaluation have a minimal degree of explanatory power, Engels et al (2007).

One that employs fundamentals under standard competitive market assumptions but is not available for public evaluation uses Bayesian priors, Putnam and Quintana (1993). It suggests an impressive increment over investing in the S&P 500. However no information is provided on this Bayesian prior enhanced model's degree of predictive power concerning individual exchange rates, or even concerning the set of exchange rates together used in its portfolio management strategy. Thus no evidence is afforded that its possible increment in exchange rate predictive power puts it anywhere near the level of prediction accuracy required to avoid firms going bankrupt. Firms continue to go bankrupt in their hedging mistakes, hinting that even this non-publicly available Bayesian priors technique leaves the economic equilibrating fundamentals unsatisfactorily vague.

3.2 Market Power

Some have ignored the inefficiencies for firms and the official sector in having unpredictable exchange rates, and pointed instead to the possibility that the unpredictability could arise from efficient markets as in Fama (1965) and rational expectations. According to such models numerous EUT competitive profit maximizers use all available information in an efficient manner, and apply it to exchange rate markets, eg Hu (1999), and argue that findings of inefficiency stem from using inappropriate tests, eg Wang and Jones (2002).

One quandary for this efficient markets viewpoint is the systematic and highly significantly wrongly signed parameter estimate in interest parity models whenever the variation has sufficed to get sharp coefficient estimates, Rapp and Sharma (1999). An efficient market ought operate to eliminate not exaggerate arbitrage opportunities. Yet for over five years on end in the 1980s, exchange rate expectations in highly regarded sources moved every quarter in the wrong direction as did the forward rates compared to the subsequent actual spot rates, Frankel and Froot (1987).

A second quandary is that the Fama concept of market efficiency is not a concept of the exchange rate simply being unpredictable. The Fama concept is an outcome of "rational" maximization of expected profits generated in the form of an equilibrium and thus bedeviled by the question of what is the equilibrium that the market so efficiently hovers around, Levich (1989). But it is implausible that equilibrium would be stable or unique given the negative findings with regard to other neoclassical, rational expectations and so

forth modelling. See eg Phelps (1999), Barnett and He (1999), and Sordi and Vercelli (2006).

The third quandary is that people do not instantly know the equilibrium. Instead it is proposed that they can learn it. This, notes Phelps (1999), has the farcical aspect of what are people to learn – which particular economist's should they be learning?

There is in addition to these three quandaries an overwhelming objection to such a Fama-Lucas world. This is the matter raised by Merton (2001) and Soros (1987, 1994, 2003), the matter of market power of key speculators that such models irrationally ignore. Merton attributes Long Term Capital Management's difficulties to a failure to understand this hedge fund's massive market power in its Black Scholes arbitrage opportunities formulae.

Those with even more market power than private participants are the pair of official sectors who issue the pair of currencies. By law under full cooperation the two official sectors fully determine the exchange rate. The short-cut heuristics of economists in doing their modelling to predict exchange rates and perform stage 2 of evaluating alternatives ignore both the important market power of major speculators, and the overwhelming power of the official sectors when fully cooperating.

3.3 Non-Fundamental Predictions

If one deviates from equations predicting exchange rates on the basis of equilibrating fundaments, the picture is a little rosier. Technical analysis seeks to identify upper and lower barriers beyond which it is unlikely that an exchange rate will move, barriers at which it is predicted that there will be exchange rate turbulence, reversals of trends. The predictions can involve the judgment in discerning the patterns, in which case it is sometimes termed chartism. Or the predictions can be mechanical, the product of fixed statistical rules.

Short range out-of-sample predictions based on some publicly available variants of technical analysis have attractive statistical properties, eg Osler (2000, 2003). But again the degree of explanatory power is low. The gross inefficiency for firms and for the official sector in their joint inability to understand exchange rate changes remains drastic.

In summary, there is room for a radical change in understanding and modelling exchange rate determination. Before offering this, we explain why we also need to ground our radically different focus for understanding exchange rate changes in a different decision theory from that of EUT, axiomatised expected utility theory, and most non-EUT theories.

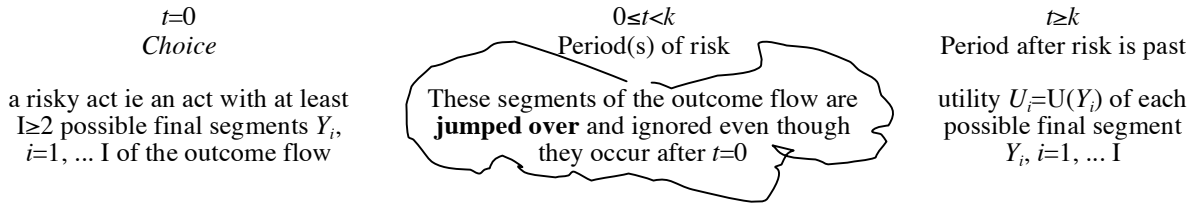
4 Risk Effects and Expected Utility Theory

EUT, axiomatised expected utility theory, when consistently applied, excludes attributing utility to any segment of the outcome flow that occurs before all risk and uncertainty is past, Samuelson (1952), and that remaining segment of the outcome flow must, as Friedman and Savage (1948) put it, be evaluated "as if certain". This is not a promising

basis for discerning the operation of exchange rate markets. Small wonder that scientists dissecting Mundell (1961) focus on numerous dubious features of the model, but few on its assumptions of certainty discussed in Part 2 above. Ie few focus on its doubtful feature that the exchange rate is certain as nobody before and nobody after the exchange rate change (to restore equilibrium after a shock) ever expects there to be another exchange rate change.

Figure 1 depicts how, under EUT and its standard rank dependent generalisations such as cumulative prospect theory, each outcome is a timewise indivisible outcome segment beginning *later* than choice t=0 – at t=k, *after* all risk is past, Pope (1983, 2005).

Figure 1
The Jump Through of the Prior Periods of Uncertainty to Certainty
that occurs under EUT and its Standard Rank Dependent Generalisations



EUT's ignoring of risk in mapping outcomes Y_i into utilities can be seen from the right hand column of Figure 1 where the probability distribution – that denotes the chooser's degree of risk, ie of knowledge ahead – does *not* affect the U_i's. V, the utility U(V) of a risky choice is,

$$U(V) = \sum_{i=1}^{I} p_i \, U(Y_i) \qquad (1)$$

atemporal aggregation weight **outside time** — anticipated utility of outcome Y_i **within time**

Nothing that is anticipated to be happen in the future in reality – ie *within time* – concerning risk that can impact on utility, is in EUT's equation (1). The only way risk enters is *atemporally*, in how probabilities concerning the mutually exclusive outcomes aggregated to attain a single overall value of the alternative. Under EUT the atemporal aggregation rule is simple probability weights. Under cumulative prospect theory and other standard rank dependent generalisations, the atemporal aggregation rule is a more complex (de-) cumulative probability function, but still no real time risk effects are included as the anticipated utility mapping is identical to that of equation (1).

See Appendix 1 on the numerous attempts to remedy this omission and why each attempt fails. See Pope (2005, 2006) on why EUT cannot include more than one period, even after all risk is passed. See Pope (2000) and Pope and Selten (2007) on how including in the utility mapping any risk effects anticipated to be experienced – ie anticipated to occur in future time periods – precludes deriving EUT's representation theorem.

5 SKAT, the Stages of Knowledge Ahead Theory

5.1 The Pre-Outcome Period

Keynes had been interested in financial effects of uncertainty that fall on the investor following a decision to invest, Walsh (1996, pp52-65). Von Neumann and Morgenstern had recognized that EUT missed out on some emotional uncertainty effects such as excitement that occur following a decision to gamble socially, ones to which they gave various names including the utility of gambling. They had wished to expand their model to include them, but left the task to future researchers as they could not solve a contradiction that they encountered "on this level", (1947, 1972, pp428-432). To include choosers' anticipations of these uncertainty effects meant admitting that choosers were affected by the distribution, ie by an interdependence between the different possible outcomes. But, asked von Neumann and Morgenstern, when each outcome in the distribution is mutually exclusive, how can a chooser be affected by their interdependence?[3]

To get to the higher level where mutually exclusive outcomes can be interdependent (without the chooser being irrational), it is necessary to partition the future epistemically, by stages of knowledge ahead. Upon making a risky choice, the chooser goes through what may be termed a pre-outcome period, a period of uncertainty, of ignorance of the final segment of his outcome flow. During this period, since the risk is still unresolved, there can be an interdependence of the mutually exclusive outcomes in the chooser's mind, Pope (1985a). The chooser can hate or love the excitement of the tension created by wondering whether the good or bad outcome will occur, ie created by the *interdependence* of the good and bad outcome – created by the non-degenerate probability distribution over the outcome space. Later, at the beginning of what may be termed the post-outcome period, the chooser learns the result of his choice, ie the later segment(s) of his outcome flow, has attained certainty. But through historical legacy there may remain effects of the prior uncertainty.

SKAT, the Stages of Knowledge Ahead Theory, dissolves the von Neumann and Morgenstern contradiction, and integrates earlier work on emotional risk effects with that on planning efficiencies via risk effects. It allows us to identify other material and financial risk effects, to delineate the mutually exclusive cause effect chains that choice of an alternative would unleash – and to avoid conflating these anticipations with atemporal weights used to aggregate these mutually exclusive cause effect chains.

5.2 Primary and Secondary Satisfactions

It was partly to help alleviate confusions on what satisfactions EUT excludes, that Pope (2001) introduced the terminology of secondary satisfactions, and its counterpart,

[3] In the language of quantum physics for which von Neumann had constructed an axiomatisation ten years earlier, they termed this interdependence a complementarity.

primary satisfactions. Choice between alternatives depends on future satisfactions – future real time experiences– *as anticipated at the time of choice*. Primary satisfactions can be positive or negative (dissatisfactions). They stem from *knowledge-ahead-independent* sources of satisfactions *as anticipated at the time of choice*, ie satisfactions reaped from the current outcome segment that are independent of having known ahead what this outcome segment would be. Primary satisfactions from the outcome segment, occurring after all conceivable risk is past, are included in EUT. If as EUT and most non-EUT theories do, we limit ourselves to:

(i) the sub-set of primary satisfactions that will be reaped after all risk is past,

(ii) cases where the utility scale and post risk outcomes are both inherently univariate – not with irreducible multiple dimensions,

then utility is itself univariate and can be mapped in a plane against the post-risk outcome segment. The utility shape is concave if there is diminishing marginal utility from primary satisfactions, linear if there is linear marginal utility from primary satisfactions, and convex if there is increasing marginal utility from primary satisfactions, as in Friedman and Savage (1948) diagrams.[4]

Secondary satisfactions are the counterpart to primary satisfactions, the complementary class of satisfactions from primary ones. Secondary satisfactions can be positive or negative. They stem from *knowledge-ahead-based* sources of satisfactions *as anticipated at the time of choice*. They are termed secondary since they derive from primary satisfactions, not because they are necessarily less important. Often they are more important. Since in the case of secondary satisfactions, utility derives from its riskiness or certainty, it is infeasible to trace out the secondary satisfactions function on a plane with outcomes on the other axis. Multiple other dimensions (axes) will in general be needed to capture the various aspects of risk whose bound at one end is certainty.

Secondary satisfactions stemming from a limited degree of knowledge ahead destroy the axiomatic base of EUT, and most non-EUT theories. Whether secondary satisfactions stemming from certainty – full knowledge ahead – are excluded from EUT, depends on the version of EUT. These are excluded under the Ramsey version, included (also illusory ones) under the Friedman and Savage version, Pope (2004).

One example of a negative material secondary satisfaction is the planning inefficiency of a central bank not knowing whether its attempt to hold out against speculators will succeed. If it knew it would fail it would not waste any taxpayer dollars in interventions on the exchange rate market seeking to defend its currency. If it knew it would succeed, it would not damage its economy by raising interest rates or in other ways restricting domestic credit. It is its limited degree of knowledge ahead of whether it will succeed that results in its "half-way" measures because it does not know what will ensue and thus must inefficiently invest with a bet each way.

Another example of a material negative secondary satisfaction is that from a loan and its associated risk premia. This is a secondary satisfaction since the loan size and its

[4] In that paper, primary satisfactions are what Friedman and Savage term the EUT utilities, being unaware that there might be certainty effects captured by their version of EUT, and recognizing that EUT excludes from its utilities sources of satisfactions based on a *limited degree of knowledge ahead.*

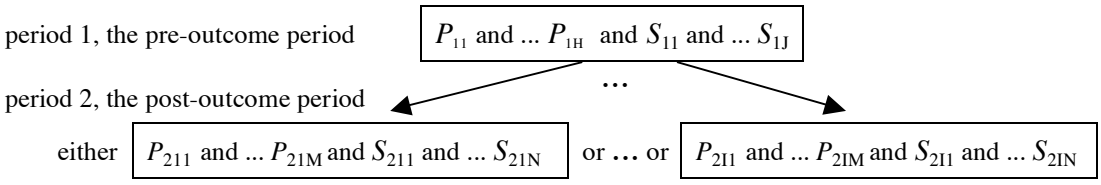
repayment cost inclusive or any risk premium interest surcharge depends on degree of knowledge ahead – namely the probability of repayment. Exchange rate depreciation risk for the borrower's domestic currency adds to these negative secondary satisfactions for the borrower by increasing a) the risk of default and thus risk premium, and b) the repayment liability if solvent.

An example of a mixed emotional and material secondary satisfaction is blame when a risk turns out badly. Its emotional component is the affect. Its financial component is the loss of income or promotional prospects in the case of official sector executives moved sideways or with their powers relegated to another branch.

5.3 SKAT from the Point of Choice

Let all the risk be completely resolved at a time in the future that the chooser, a central bank, knows exactly at the time of choice time t=0. Then its future at time t=0 contains just two stages of knowledge ahead, just two epistemic periods, one pre-outcome period (before it learns the final segment of its outcome flow), and one post-outcome period, when it will have learned this final segment of his outcome flow. The SKAT decision maker takes into account primary satisfactions P_{1h}, $h = 1, \ldots H$ and secondary satisfactions S_{1j}, $j = 1, \ldots J$ anticipated in period 1, the *pre*-outcome period, and primary satisfactions P_{2mi}, $m = 1, \ldots M$ and secondary satisfactions S_{2ni}, $n = 1, \ldots N$ anticipated in period 2, the *post*-outcome period if outcome segment i occurs, $i = 1, \ldots I$. See Figure 2 and Table 1.

Figure 2
The Anticipated Cause-Effect Chains from Choosing an Alternative



In Figure 2, note the "and's" of the pre-outcome period anticipated satisfactions denoting simultaneity. In the *post*-outcome period, if the act is risky (the case if I, the number of outcomes perceived as possible, is ≥2), only some satisfactions are anticipated to hold simultaneously – only those pertaining to the same outcome i. Satisfactions pertaining to *different* outcomes i, $i = 1, \ldots I$ are *mutually exclusive* – are a matter of *either* those of i=1, *or* those of ... , *or* those of i=I. The epistemic partitioning of Figure 2 is necessary in order to lay out the anticipated cause effect chains and identify effects are simultaneous (the "and's") and which are mutually exclusive (the "or's"), something not consistently achieved in either temporal EUT or in atemporal EUT or in its standard rank dependent generalisations.

Table 1
Example of Aggregation to Form an Overall SKAT Value of an Alternative
for a Central Bank with Numerical: Aggregation Weights, Satisfactions and Likelihoods

Pre-outcome Period 1 Total Satisfactions: $V_1=V_{1P}+V_{1S}$

Primary Simultaneous

$$V_{1P}=\sum_h^H a_h\ P_{1h}$$

atemporal weight **outside time** — primary satisfaction **within time**

Secondary Simultaneous

$$V_{1S}=\sum_j^J b_j\ S_{1j}.$$

atemporal weight **outside time** — secondary satisfaction **within time**

Post-outcome Period 2 Total Satisfactions: $V_2=V_{2P}+V_{2S}$

Primary Simultaneous under outcome *i*

$$V_{2Pi}=\sum_m^M c_m\ P_{2mi}$$

atemporal weight **outside time** — primary satisfaction **within time**

Total Primary: Non-Simultaneous of i=1, ... I

$$V_{2P}=\sum_i^I p_i\ V_{2Pi}$$

atemporal weight **outside time** — secondary satisfaction **within time**

Secondary Simultaneous under outcome *i*

$$V_{2Si}=\sum_n^N d_n\ S_{2ni}$$

atemporal weight **outside time** — primary satisfaction **within time**

Total Secondary: Non-Simultaneous of i=1, ... I

$$V_{2S}=\sum_i^I p_i\ V_{2Si}$$

atemporal weight **outside time** — secondary satisfaction **within time**

Overall Value: under SKAT: $V=V_1+V_2=V_{1P}+V_{1S}+V_{2P}+V_{2S}$; under EUT: $V=V_{2P}$

Note

1 EUT excludes $V_1=V_{1P}+V_{1S}$ and also excludes V_{2S}. The exclusions of these three sets of satisfactions under EUT can be seen to have nothing to do with the aggregation rule to use probabilities as the atemporal weights for mutually exclusive outcomes since this SKAT central bank also weights mutually exclusive alternatives by their probabilities.

2 The aggregation weights for the different primary and secondary satisfactions simultaneously anticipated in the pre- and post outcome periods and are respectively a_h and b_j, c_m and d_n. The aggregation weights for mutually exclusive anticipated are satisfactions the probabilities of their occurrence p_i, and the aggregation weights for total satisfactions in each of these periods are *e* and *f*. The weights are unrealistic since a real central bank lacks numbers for satisfactions and probabilities and thus has no use for numerical weights.

From Table 1 it can be seen that the SKAT central bank requires atemporal aggregation rules for amalgamating all these satisfactions that he has listed in Figure 1 into an overall value of that particular alternative. It needs the overall value either in order to assess whether that alternative is good enough (if he is a satisficer), or to compare with those other alternatives in the choice set that he considers warrant analysis. Unlike in Table 1, however, the aggregation steps are almost invariably conducted qualitatively. This is because normally the aggregation, like the satisfactions themselves, is of a qualitative form, and follows algorithmic procedures of sequentially considering sources of satisfactions, often with a satisficing component, choosing an alternative when it yields enough satisfaction. It is however, easier to see the fundamental difference between SKAT and EUT via Table 1. Here we unrealistically impute to our SKAT central bank numerical satisfactions and weights (for linearly separable satisfactions) and a probability to each possible outcome and use of these probabilities as his atemporal weights for aggregating these mutually exclusive outcomes to form its overall value of an alternative. Table 1 thereby highlights the three sets of satisfactions that EUT omits – even in the case of and numerical probability weights for the atemporal aggregation of the mutually excusive satisfactions. These three omitted

sets are: primary satisfactions in the pre-outcome period, secondary satisfactions in the pre-outcome period, and secondary satisfactions in the post-outcome period.

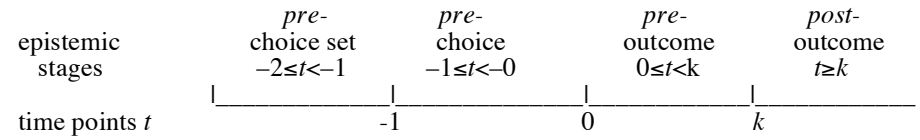
5.4 Four Epistemic Stages

The process of decision making starts before the point of choice at which EUT begins and at which each alternative V is evaluated in Table 1. There are at least two prior stages. See the first two rows of Table 2 and the first two columns of Figure 3.

Table 2
Four Epistemic Stages upon Encountering a Problem at Time t=-2

Stage	*Duration*	*Period*	*Knowledge*
1	$-2 \le t < -1$	pre-choice set:	prior to identifying the choice set
2	$1 \le t < -0$	pre-choice:	prior to choosing an act within the choice set
3	$0 \le t <$ k	Pre-outcome	prior to learning the outcome of the chosen alternative
4	$t \ge k$	post-outcome:	knowing the outcome of the chosen alternative

Figure 3
The Future Divided Epistemically – by *Changes in Knowledge Ahead*



Note:
1 The name of the first three periods starts with "pre-" and then states an aspect of the future that the person will not yet have learned, namely in stage 1 the choice set, in stage 2 the choice, in stage 3 what will be the outcome of the choice, a stage that is degenerate, of zero duration, if the choice is a sure act, as then the chooser knows at the point of decision t=0 the outcome, ie in this case t=0=k. If instead the choice is a risky act, stage 3, like the other periods, is of positive duration, ie t=k>0. The last stage starts with "post", and then states the aspect of the future the person that the chooser by then have learned, namely the final segment of the outcome flow.
2 Each time point denotes a *change in knowledge ahead*, with one previously unknown aspect having become known, and the start of a new epistemic period that last until the next change in knowledge ahead.
3 In the case of choosing a sure act, the outcome of the chosen act is already known. Thus for sure acts the time points t=0 and t=k coincide – are simultaneous – and the duration of the pre-outcome period is zero. It is only for risky acts that the time points t=0 and t=k fail to coincide – are non-simultaneous – so that the pre-outcome period of positive duration. The false simultaneity postulate in von Neumann and Morgenstern (1944, 1947, 1953 and 1972), leading to their contradiction, had two prongs. Prong a) was to explicitly set k to be simultaneous for *all* acts in their explanation of their axiomatisation. Such simultaneity is incompatible with the theory including both sure and risky acts, when these are distinguished from each other by whether there is full or merely limited knowledge ahead of the outcome at t=0. Prong b) was to implicitly set k=0 for *both* risky and sure acts in the atemporal axioms (ones lacking any epistemic division of the future from the point of choice).

Each of the first three stages ends with a *change in knowledge ahead* about a different matter. Stage 1 is over since the choice set, previously unknown, has been discovered. Stage 2 ends since the choice, previously unknown, has been made. Stage 3 ends, since the final outcome segment of the outcome flow, previously unknown unless this stage is degenerate as a sure act was chosen, has been learned. After encountering a problem, there are typically a vast number of stages as new things are learned, almost minute-by-minute. The reduction to only four epistemic stages in Table 2 and Figure 3 is because these portray an especially simple case where each change in knowledge is from ignorance about some future happening – ie at best probabilistic knowledge of what that happening may turn out to be, to certainty about that happening – to that risk being completely resolved.

All that von Neumann and Morgenstern and EUT include is stage 4, the period that begins upon learning the outcome of the chosen act (and that lasts indefinitely in our

simple scenario, not being followed by any other change in knowledge ahead). As can be seen from Figure 1, EUT ignores the period of discovering alternatives and evaluating them. It assumes that the chooser can instantly and costlessly know the choice set, evaluate in a maximising way each of the available alternatives to choose, and then leap through the period of risk and uncertainty. EUT thus maps into utility only the final segment of the outcome flow that began upon learning of the problem. For the case where the chooser selects a risky act with, at the point of choice, multiple possible outcomes Y_i, i=1, 2, ... , EUT attaches utility only to the outcome flow segment after the chooser has learned which final outcome segment has transpired – and attached utility to this final segment in a knowledge ahead independent way. That is, EUT evaluates each possible as if there never was earlier any risk or uncertainty, as if the future were certain. Thereby it excludes all real time effects of risk and uncertainty in the initial three stages, and also excludes any real time historical legacies of this prior risk and uncertainty in stage 4.

5.5 The Discovery and Evaluation Stages

When EUT skips all stages apart from the final post-outcome one, it assumes that evaluation is costless and timeless and can be a maximising process. Such maximising however is infeasible, even to define and thus impractical to conduct. As Savage (1954) observed, it is beyond our scope, even for a family picnic. Savage sought to solve this practicality issue via maximising under a small worlds assumption. But identifying how it could render EUT practical, he found too difficult a task, and left it to future researchers. To the authors' knowledge, no progress has been made since on rendering small worlds, and thus EUT, practical.

Savage also tried another angle to substitute for explicit maximising, a clarifying sure-thing principle. But this has two shortcomings. First, it cannot be applied in most circumstances. Second where it can be applied it "clarifies" by truncating the probability distribution creating a delusion of certainty, Pope (1991) – ie it is a patently irrational principle.

SKAT, by contrast, permits the outcomes segment to include the evaluation stage and thus the non-maximising techniques that central bankers report using, eg Papademos (2006), and that economists analysing central bank minutes, report that they use, eg Cobham (2006). This is likewise the case for others whose actions influence exchange rates.

6 Illustrating SKAT

Here, let us illustrate SKAT with the minimum four epistemic (knowledge) stages that a chooser could encounter after discerning a problem meriting a decision. Let our illustration be France's central bank in July 1993 upon discovery of a speculative attack on the French franc, an attack whose cause remains to this day controversial. We draw on accounts of this historical episode in Eichengreen and Wyplosz (1993) and Melitz

(1994), information kindly furnished by Massmo Warglien on Italy's exchange rate crisis experience the year before, and of the UK exchange rate experience in the preceding year in Cobham (2001). Despite using these accounts, our illustration is fictional, partly since it is so exceedingly simplified, and partly since it is designed to illustrate SKAT and general issues in exchange rate determination.

Whiles fictional in its specific details, some *general* aspects of our account are factual. We shall draw attention to some of these factual general aspects when commenting afterwards on the four stages, and again when presenting our model of exchange rate determination in Part 6. This illustration helps explain why we have decided to differ so radically from other exchange rate determination models in the following respects.

1 Central bank cooperation or conflict is key to exchange rates.
2 The norm, apart from the early to mid 1980s, is for central banks to have multiple goals.
3 There is a limited circle of people whose decisions have a major impact on an exchange rate, most of who are in the official sector, and amongst whom are personalities, friendships (or enmities) whose idiosyncracies may be decisive.
4 The decision process is primarily qualitative, with no resemblance to the maximisations assumed in theoretical derivations of a central bank reaction function.

6.1 Stage 1

On facing an unexpected attack on the franc, the Banque must discover available alternatives since it is ignorant of its choice set. Suppose it discovered that it could: raise interest rates; or depreciate at once; or try to ride out the crisis. Then the Banque has had a change in its knowledge ahead. The Bank knows its choice set. It has entered stage 2.

6.2 Stage 2

Its task now is to evaluate these three alternatives, work out which are safe alternatives (with a single known outcome if chosen), and which risky, with more than one possible outcome, and the details of each alternative – vaguely posed initially. How it makes the more precise, the preliminary step in the evaluation process, stems from its goals.

6.2.1 Its Seven Goals

First, there is the goal of becoming part of the EURO bloc. The Maastricht Treaty required exchange rates of EU members entering the EURO bloc to keep within a narrow band. A sizable depreciation would breach this treaty requirement. Both key French political parties want France in the EURO, and so for this reason are against much of a depreciation against Germany. Those French firms that have borrowed in DM on the assumption of a pretty steady exchange rate, and will suffer a sizable increase in indebtedness if their trust in the exchange rate's steadiness proves to have been misplaced. The government and the Banque are also against much of a depreciation in order to maintain French pride. France had joined forces with the UK back in 1989 against Germany's central bank's request to be allowed to markedly appreciate against other countries planning to enter the EURO bloc. The national pride of the French in a strong franc and the like desire of the UK to have a strong pound had (under the rules of an earlier treaty) allowed these two countries to stop Germany from undertaking its

desired appreciation to cope with the inflationary pressures arising out of the integration of east Germany. Already the UK looked foolish, having in 1992 felt forced to stop defending the pound on the "Black Wednesday" of September 1992, and as a consequence having had to quit being in the formal EURO entry process.

There are the Banque's set of roughly six other goals – the matters of 1) prices and inflation low and 2) prices and inflation as forecast, 3) maintaining international competitiveness, 4) keeping interest rates appropriate, 5) keeping employment at a good level, and 6) pleasing the main political parties. At the time of the attack, competitiveness does not indicate a depreciation, and inflation does not indicate an interest rate rise. Indeed the low level of inflation and the sorry state of employment indicates an interest rate drop – and so does the forthcoming election.

6.2.2 The Safe Alternatives of a Big Interest Rate Hike or Depreciation

The Banque considers alternative a), raising interest rate. It concludes that this would need to be sizable to keep the Franc from depreciating below its EURO entry specified lower band, but if sizable, safe. Ie, a sizable interest rate hike would be guaranteed to avoid the franc going outside the agreed exchange rate band and so guaranteed to keep France in the EMS and thus also essentially without any of the undesirable and disruptive wealth redistribution that would accompany a sizable exchange rate change of depreciating below the treaty agreed lower band limit. The Banque considers the distress to the country of a tight money policy when the country is already in depression and the opposition it would have to shoulder from political parties – especially as elections were nearing, and there is no need for a higher interest rate as regards international competitiveness or inflationary forecasts or targets.

The Banque next considers alternative b), the distress to key political parties of an immediate sizable depreciation. A sizable depreciation would be safe. It would be guaranteed to end the speculative pressure. But it would force France's exit from the EMS, and both the main political parties have endorsed entering the EURO bloc.

6.2.3 The Risky Alternative of Seeking to Ride Out the Crisis

Finally, the Banque considers its third alternative, seeking to ride out the crisis. It realises that this has no guaranteed outcome. It considers the downside risk. Failure implies a massive loss of taxpayers' funds plunged in the effort of holding the French franc in the EMS band. It considers the costs of failure to be worse than those of the UK when it had failed nearly a year earlier after attempting to ride out its exchange rate crisis and had been forced out of the EMS. It considers that the cost of failure would be similar to those of the Italian central bank that had also about a year earlier tried to ride out a crisis over an even longer period and yet failed. The Banca d'Italia had by the time it failed, lost essentially all the official sector's foreign reserves, had a massive depreciation and exit from the EMS. There were such drastic debt repercussions for the public sector that government had taken 6% or so of every Italian bank account to bring its public debt back to a manageable level.[5]

[5] The "plunder" just might have been rough justice if bank accounts of the speculators had been swelled by the speculative gains, ie falling more heavily on these than those who had not speculated and thus

The Banque considers the chance of success for itself, considering what differentiates France from the UK and Italian failures. It feels it has a better chance to persuade Erminger, the head of Germany's central bank to intervene enough on its behalf. Erminger sees France as a well-behaved nation in having a lower inflation rate than Germany itself. He has already twice come to her aid in the last year in two other speculative attacks, and the German federal government is dedicated to keeping France in the EURO. The Banque also thinks that even if it does not get sufficient cooperation from Germany's central bank to avoid a depreciation below the amount permitted under the Maastricht Treaty, that France is such an important country for Germany to keep in the EMS, that the treaty terms might be softened so that France does not have to forfeit EMS membership. However, getting the treaty terms softened would require time, so that pursuing this option would involve attempting to ride out the crisis. The Banque realises that it could have: 1, huge luck – no depreciation and no need to keep highish interest rates after to deter a fourth speculative attack; or 2, modest luck, with a bit of a depreciation pushing it below the currently permitted EMS band, but that band being widened to keep it in the EMS and this being maintainable with continuing highish interest rates; or a disaster.

Suppose the Banque decided to try to ride the crisis out. This is because it hopes for more cooperation than the German central bank offered the UK and Italy in their crises nearly a year earlier and enough German federal government support to get the treaty changed if need be. Ie the Banque hopes to get at least the modest luck outcome.[6] Then the Banque has had a second change in its knowledge ahead. It knows its choice. It has entered stage 3.

6.3 Stage 3

The Banque now waits to learn if it has luck. It does not get enough cooperation from Germany's central bank to avoid a drop in the value of the French franc. But it does get enough cooperation that the drop was not catastrophic and it has the luck of being permitted nevertheless to remain in the process planned to lead into the EURO. This is because its lobbying succeeded in getting the EMS band (within which exchange rates must stay) widened. It is in the modest luck category only, having to maintain highish interest rates despite its recessed economy as speculators did get a bit of a reward, and in this sense have saddled France (because of its modest depreciation) with a modest

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had not such large accounts in the aftermath. This raises an interesting issue of a new instrument, that if it had BIS cooperation and WTO endorsement, might enable governments to differentially tax holders of their currency, eg choosing to levy taxes on such holdings only after undesired depreciations of their currencies.

6 Ie the Banque has decided it may have more luck than the Bank of England a year earlier when it had to deal with a speculative attack on the pound, and sought rather than tight money in a severe recession to dare that Germany would avert a depreciation and avert its forced exit the process planned to lead into the EURO. That dare that failed as Germany did not offer enough cooperation. The vain attempt to avoid a severe depreciation failed, costing UK taxpayers billions, and the UK exited from its government's desire to stay in the process planned to lead into the EURO.

increment in the country's risk premium.[7] Then it has had a third change in its knowledge ahead. It knows the final segment of this outcome flow.

6.4 Stage 4 and Summary

The Banque has full knowledge ahead – certainty of the middling success from its decision – and the fallout of some loss of taxpayers' funds and asset redistribution both within France and between France and the rest of the world, plus the fallout of a risk premium to be born into the future of higher interest rates than otherwise for an extended period. Table 3 summarises the four stages through which the Banque passed, progressively having more knowledge ahead, and by stage 4, certainty – as regards that crisis.

Table 3
The Banque's Four Main Stages of Knowledge Ahead After Encountering a Crisis

Stage / Period Outcome Segment	*Activity*	*Unknown*
1 Pre-Choice set	Discovering Alternatives	Choice set
2 Pre Choice	Evaluating Alternatives a) safe option – raise interest rates; or b) safe option – depreciate and exit the EMS; or c) risky option – try to ride out the crisis with three possible outcomes: 1, failure or; 2, modest luck; or 3 huge luck	Chosen alternative
3 Pre-outcome*	Waiting to learn its luck with choice of c)	Last Outcome Segment
4 Post-Outcome	Living with modest luck under its choice of c)	Nothing – full knowledge ahead, certainty

* Irrelevant, as of zero duration, if the Banque had chosen sure alternative a) or b)

6.5 Literature

For stage 1 there are the satisficing and aspiration-adaptation models, Simon (1955), Sauermann and Selten (1962), Selten (1998). There are also critiques of central bankers, arguing that they at times failed to search broadly enough for alternatives, and thus sometimes ended up with a bad decision simply because they failed to notice a good alternative and thus did not include it in the choice set. As regards the UK official sector (where power for interest rates resides with the Bank of England, eg, Cobham (2002a, 2002b).

For stage 2 there is literature on the difficulties in performing such evaluations, Janis and Mann (1977). This research allows us to understand the difficulties of economists described in Part 2 trying to evaluate under real world complexity where is equilibrium within a Mundell (1961) frame. Nearly all economists conclude that nearly every country in the world would be more in equilibrium with a depreciation, implying that at least half misevaluate. Work on the heuristics used in stage 2 include Cyert and March (1963), Huber (1982), Montgomery and Svenson (1983), Weber and Borcherding (1993), Brandstaetter, Gigerenzer and Hertwig (2006) and Pope, Leitner and Leopold-

[7] It could have avoided this by choosing its safe but disagreeable policy – especially disagreeable as preceding elections – of a substantial interest rate hike at the beginning of the speculative attack.

Wildburger (2006, chapter 14). In the exchange rate context, work on the heuristics of real exchange rates as a short cut to tracing the effects of the multiple prices in and economy, have been conducted by two of the authors as discussed in Part 3, work showing that these real exchange rate heuristics yield conclusions concerning exchange rate effects that, for some countries, are the reverse of the actual effects.

There is for stage 3, literature on secondary satisfactions (on uncertainty effects anticipated to be experienced in chronological time) includes the effects of uncertainty on firms engaged in investment as distinct from production delineated in Keynes (1936), as noted in Walsh (1996, pp. 56, 62-66), and in effect extended in Pope (1983, 2004, 2005). In the case of the Banque, the costs of this uncertainty (the negative secondary satisfactions) are the higher than otherwise interest levels and shortage of funds of its stakeholders (through some of them speculating against the French franc).

For stage 4, there is a literature from standard decision models on primary satisfactions. For stage 4 there is also a literature from non-standard decision models that consider secondary satisfactions in the form of risk and uncertainty effects from the legacies of the preceding decision stages. One such legacy of prior risk is disappointment that the previously possible better final outcome segment did not occur, Bell (1981). In this regard the Banque will have been disappointed as it had successfully defended two prior attacks without virtually no depreciation, but thankful that the outcome was not more dire.

Another such legacy of prior risk is being fired when others discover in stage 4 that in stage 1 the CEO had chosen the wrong act of rejecting the Norwegian government's offer of what later proved to be the most lucrative north sea oil field, Hagen (1985). In this respect the Banque did not suffer as much criticism as might have ensued had the depreciation forced it out of the EMS process planned to lead into the EURO.

A third such legacy of prior risk in stage 4 is having to repay more interest because of the risk endured in stage 3 by the lender involved a risk premium interest surcharge, Pope (2005). In this respect the Banque's stakeholders faced less of an increase in risk premia than if France had been forced to exit he process leading to the EURO. Still the Banque had to shoulder the unpleasant legacy of many of its stakeholders suffering a difficult hike in their non-Franc denominated debt repayments out of this unanticipated and moderately successful speculative attack on the currency – an attack that even with hindsight was puzzling economists afterwards, Mélitz (1994). It knows moreover that it will suffer for an extended period from having to subject its stakeholders to higher than otherwise interest rates to ensure that there will not be another speculative attack.

7 An Official Sector Cooperation-Conflict Exchange Rate Model within SKAT

SKAT permits us to start at the *beginning* of this process for the key participants in the exchange rate process. In EUT and its temporal extensions and standard rank dependent generalisation, the decision process starts half way through. In these, a choice can be costlessly and instantly made since each alternative has been costlessly and instantly evaluated via a maximising technique. SKAT, by contrast, allows us to start earlier, and

in starting earlier, recognise the infeasibility, impracticality and non-employment of maximising techniques in choosing an alternative.

7.1 The Key Players

As in any modelling, we must abstract, we thus focus on key players in exchange rate determination, not on those with marginal influence. In exchange rate determination, the key players are the issuers of the currencies, and those who decide how much is to be issued and under what conditions.

A century plus back, these key players were the central banks of the leading power blocs of the UK, Germany, the Austro-Hungarian empire, and to lesser extents those of France and the US. There were in addition the major multinational banks that in many lesser countries issued currency and notes and succeeded (and sometimes failed) to keep these private currencies on the gold standard. A century plus ago therefore, in the determination of many of the exchange rates, the private multinational banks were also key players. That situation however vanished, essentially just before the First World War when many countries instituted central banks and private banks lost their right to issue notes and coins.

Today private bank currencies can be ignored. Each currency area is supervised by an official sector that has the power to:

1 produce in unlimited amounts its own currency and
2 intervene on the foreign exchange market.

For some currencies, powers 1 and 2 both reside exclusively in a central bank, eg for the EURO. For some currencies, eg for the US dollar, there was historically a sharing of these two powers between the central bank and the treasury. For yet other currencies, eg the Australian dollar, there is a sharing of these two powers among three branches of the official sector, the central bank, the treasury and the parliament.

Powers 1 and 2 together imply that for each pair of currencies, total cooperation of the official sectors totally settles the exchange rate. No speculator whether private or a third country's central bank has any scope to deflect the exchange rate over any significant period of time. For an hour or two, there can be some deviation – since one of the central banks may have misestimated the extent to which intervention was required. But apart from these minor transient frictions, the exchange rate is set.

7.2 Behaviour of the Key Players – their "Reaction" Functions

All unwanted exchange rate changes fall on a country from lack of complete cooperation of the two official sectors. In this respect the situation of a modern official is similar to that of the gold standard era. That was not maintained by automatic mechanisms pertaining to how monetary policy influences prices or interest rates or capital flows. Among the major players, it was maintained through all the normal unanticipatable fluctuations in inter-country balances that ensue via the gentlemen's club.[8] Central banks

[8] Among minor players on the world stage who had difficulties staying on the gold standard, official sectors of the big players as well as commercial banks assisted the process, Flandreau (2003).

co-operatively shipped gold and silver and engaged in reverse rediscount rate changes as required, Hooks (2005). Such cooperation is dependent on individual personalities and cultures. It is disrupted by changes in who were the central players and their degree of cooperativeness. The disruption after the First World War (which gave key roles to non-cooperators, the US and France) ended the gold standard, Butkiewitcz (2005a, 2005b). There was a like failure of co-operation for the incipient EURO group in the stances taken by Germany and the UK when unexpectedly needed, precluding at least temporarily, UK participation in the EURO. There was limited cooperation, sufficient to limit the depreciation of the French franc, between the French and German official sectors the following year.

As Paul Volcker reports in an interview, Mehrling (2001), the US exchange rate is also a matter of cooperation among official sectors. He explains that the era of a high dollar in the 1980s ended after the British Prime Minister Margaret Thatcher discussed the matter with Ronald Reagan. Without such cooperation of a personal friendship, Germany's central bank had shortly before tried with insufficient success to unilaterally get the US dollar down via exchange rate market interventions.[9] Margaret Thatcher's friendship with Ronald Reagan achieved the desired cooperation. She informed Reagan that the damage being wrought on other countries (from the roughly doubling of the value of the US dollar and the roughly doubling of world wide interest rates) was unsustainable. Reagan is reported to have understood and agreed. He had also been facing years of complaints from exporters and others affected by the severe prolonged recession in the US.

After Maggie Thatcher's conversation with him, the combined set of official (fiscal and monetary) policies in the US altered in a way that the US dollar's value, had returned to its 1980's level by the end of the 1980s, as had interest rates, a change aided by a switch in who was White House Chief of Staff and who was the Treasury secretary. The switch meant that the Treasury was no longer headed by the devout free-floater Donald Regan, but instead by the pragmatic Howard Baker. This episode is thus interpreted as a case of belated cooperation of the official sectors of the UK and the US resulting in a return of the exchange rate between the US and other countries to what a set of influential countries deemed to be the appropriate level. The cooperation, signed in the Plaza Accord (among the big five), went beyond an agreement to stabilise exchange rates henceforth. It involved in effect reversing what had happened over the last three years, involved roughly a doubling of these four exchange rates in this brief span. For Japan moreover, it involved a much faster doubling. Further, Japan, unlike the other "big three), had not had a marked depreciation of its currency in the 1980s, so that the shock

[9] Such was the false belief in free floats, and in the helplessness of central banks at this time, that Dieter Sondermann reports as follows. The general view of exchange rate dealers on the Bundesbank's intervention efforts was that these unilateral moves were counterproductive: they enticed dealers to think that the US dollar's rise really would have no end and via such anticipations, to push the US dollar yet higher. However access to the daily data, and analysis thereof, suggests otherwise, Dominguez and Frankel (1990, 1993). See also Frankel (1985, 1988, 1991, 1996) and Frankel, Bergsten and Mussa (1994). On the other techniques besides intervention for an official sector to unilaterally influence its exchange rate, see Zemin (2007).

for it of its currency almost doubling in value was far greater. By 1987, the big currencies had realised that both appreciations and depreciations and their unpredictability were bad. In the Louvre Accord, they agreed to keep major exchange rates stable. Ie by 1987 there had been complete reneging on the virtues of clean floats, and effort instead to have an informal Bretton Woods with gentlemanly central bank cooperation affecting the stable exchange rates.

7.3 Our Model

Our model in its general form is an extension of that in Pope (1986). It was extended from the single official sector with neutral other central banks, to the game theoretic perspective introduced by Reinhard Selten's inquiry about central bank conflict. It was further refined by Juergen von Hagen's interest in the distinct role of the government's fiscal policy independently of how the central bank as a separate organisation considered should be the stance of fiscal policy and despite the fact that both entities had a shared objective, namely the common good of their stakeholders. This in turn reflects the assignment issue first raised in a seminal paper on how macroeconomic objectives should be split between the treasury and the central bank, Swan (1952, 1953 and 1960). Mundell (1961) discussed this assignment for the case of whether fixed or flexible exchange rates are better.

Our model's key feature is the power of *fully* cooperating official sectors operating currencies, to *fully* set their pairwise exchange rate. By implication, it follows that whatever exchange rate evolves can be expressed in terms of the degree of cooperation between those two official sectors. Cooperation involves:

a) sacrificing other official sector interests and
b) fending off unwanted private sector pressures.

Conversely, the extent to which exchange rate changes are undesired by one of the two official sectors, or even simply unexpected by one or both of them, can be characterised in terms of degrees of conflict between the two official sectors as regards: whether interest rates set assist in stabilising the exchange rate or in moving it to a jointly agreed upon new rate; official sector announcements of their exchange rate goals; official interventions; domestic price and inflation goals.

Using historical episodes as reported by key official sector participants in the exchange rate process, we identified the following.

(i) A few individuals (who control each currency area's official sector), among themselves determine that official sector's degree of cooperation or conflict with the partner official sector.
(ii) These people are human beings who cannot and do not use maximising procedures to reach decisions.
(iii) The personalities of those in these official sector roles with their resultant group dynamics matters – something not captured by assumptions of an unchanging

culture and associated "reaction function" of the particular branch of the official sector.

(iv) Even where the treasury has no power over the issue of notes or coins or over foreign exchange rate interventions, through its fiscal policy, it has an impact on exchange rate determination.

(v) Multiple objectives often enter official sector exchange rate decisions. The clean float conception of monetary policy exclusively geared to a domestic price / inflation goal has been implemented, but over the last two centuries, and also over the recent past, it is more the exception than the rule. Official sector objectives are typically better characterised as comprising at least seven goals, 1) stability of domestic prices, 2) forecastability of domestic prices, 3) appropriate interest rates, 4) national pride in meeting exchange rate objectives, 5) maintaining international competitiveness, 6) avoiding domestic over employment, and yet more important, 7) avoiding domestic underemployment.

Our model thus embeds the following seven causal factors.

1 A pair of official sectors that agree on a desirable exchange rate, and fully cooperate to attain it, set their exchange rate.

2 Incomplete cooperation or conflict between a pair of official sector opens the way for influence of the private sector, but such private sector influence is confined – confined to the range of disagreement between the central banks on where is the exchange rate that each is willing to defend.

3 Official sectors are hierarchical, with one to three top people.

4 These top people use non-maximising techniques – heuristics – in reaching choices.

5 Individual differences in the people at the top of these hierarchies matter.

6 Fiscal policy matters.

7 Each official sector has typically multiple goals.

These seven features render our model radically different from those with reaction functions of maximising central banks, at most a couple of objectives, and no allowance for personalities, friendships, enmities and so forth between personnel heading either the central bank or treasury or parliamentary components of official sectors. Our model differs even more radically from the majority of models of exchange rate determination as these do not include an official sector explicitly at all, considering only "fundamentals" and different sorts of private operators on the exchange rate market. For instance there can be a mix of "informed" traders who employ a specific "fundamentals" model and "uninformed" traders who either seek to copy the informed traders or to employ chartist or other techniques.

As regards the private sector our model is rather standard, namely allotting a role to those firms effecting currency sales for purposes of trade in goods and capital. What makes it non-standard is our recognition of how circumscribed is the role of the private sector. We shall describe a particular version of our model in Part 9 underlying a laboratory experiment. First we offer in Part 7 some simple field evidence, and outline in Part 8 obstacles in going much further than this simple evidence using either an algebraic approach or econometric estimation.

8 Our Field Evidence

There are many countries and thus many exchange rates. Let us be broad brush in our field evidence on whether clean or dirty floating stabilises the exchange rate better. Let us focus on just two trading blocs, namely the US and those who entered the EURO. From 1970 until into this millennium, these two blocs have had the other as the key trading partner.[10] Let us focus on just the exchange rates of these versus the US dollar.

For these countries, the clean floating hey day was the early 1980s. The Plaza Accord of 1985 and the Louvre Accord of 1987 were essentially transatlantic government agreements to undo the exchange rate changes that arose under the clean floats.[11] For the transatlantic bloc, if the clean float viewpoint holds, we might have anticipated that, compared to the 1980s, annual exchange rates would be more volatile in the 1970s, 1990s and in this millennium – as the floats were in these other eras dirtier. The reverse prediction holds under the dirty float viewpoint, namely exchange rate volatilities should be higher in the 1980s.

From Table 4, the clean float prediction is refuted, the dirty float viewpoint supported. The table presents the situation for the biggest three, Italy, France, Germany, and the entire 12 who entered the EURO in 1999. Volatilities are about double in the purer clean float decade. Though not depicted, the remainder of the 12 who formed the Euro likewise suffered volatilities in the 1980s about double those of the 1970s, of the 1990s and in this millennium.

Table 4
Exchange Rate Volatilities

	Italy	France	Germany	EU 12
1970-1980	0.06	0.07	0.07	0.06
1980-1990	0.14	0.14	0.12	0.13
1990-2000	0.07	0.07	0.07	0.07
2000-2005	0.07	0.07	0.07	0.07

The exchange rate volatilities were symmetrised to avoid discrepancies between percentages being affected by which way the exchange rate is expressed, and thus by whether the former or later exchange rate is higher. The symmetrisation was done by taking the average of the absolute percentage increments $|e_t-e_{t-1}|/e_{t-1}$ and $|e_t-e_{t-1}|/e_t$. This average in turn simplifies to $0.5*|(e_{t-1}/e_t - e_t/e_{t-1}|$, where e_t is the exchange rate in year t, the number of units of the European currency needed to buy one USD.

Source of exchange rate data: Matthew Shane, US Department of Agriculture.

This evidence hints that dirtier floats would have softened the worldwide exchange rate jars from the US giving massive tax cuts and sharply increasing its military expenditures in the early 1980s when the other major currencies were being fiscally conservative. It hints at what might have happened if Italy, France, Germany – and above all the US – had pursued dirty floats in the 1980s. It hints that it need not have happened that European countries suffered over that decade a halving then doubling of the value of

[10] In the 1970s and to date, the EURO countries have been the US's most important trading partner. This was also true in the reverse direction until into the current millennium (statistical sources, the US federal Reserve System and the European Central Bank. In terms of capital flows, the other key determinant of exchange rates, it is reasonable to postulate that in both directions, the EURO countries and the US have found the other its key partner.

[11] In these accords, Japan, unwisely and irrationally according to Mundell (2003) and McKinnon (2005), was pressured by the transatlantic alliance to massively appreciate the yen, even though it had had no depreciation vis-à-vis the US dollar over the 1982-5 era.

their currencies vis-à-vis the US dollar. Ours is one interpretation of the shocking 1980s. Ie the exchange rate shocks would have been less marked but for adoption of both the US and the predecessors of the European Central Bank of especially clean floating for the first half of the 1980s. It hints at Japan having been wise when it sought a stably evolving exchange rate with its key trading partner, and at China being wise in seeking this also, as proposed eg in Mundell (2002, 2005).

The reverse interpretation of the shocking 1980s however can be offered – eg that the shocks would have been twice or ten times as big were it not for the rather clean float policies, and that the exchange rate changes would have been far smaller had only all the floats been completely clean. Let us start with two unreasonable – but widespread – grounds for querying our interpretation.

9 Obstacles in Progressing with Algebra and Field Data

9.1 Reverse Interpretations

A reverse interpretation to ours of Part 8 can be drawn using a purchasing power parity model of exchange rates and price determination holding on a quarterly basis. On this model, the European currencies halved then doubled in value against the US dollar in the 1980s because European prices relative to those in the US, doubled and then halved. These exchange rate convulsions caused by the relative price convulsions, would have been even worse but for the clean float policies of both countries keeping relative prices from convulsing even more. But the model's pivotal implication for this era, namely the convulsion of transatlantic relative prices, did not happen. Ie such a reverse interpretation to ours is falsified by a simple fact.

The same simple fact, namely that European prices relative to those in the US, did not double and then halve in the 1980s, falsifies another suggestion. This is the suggestion that there was no greater exchange rate instability in the decade of the 1980s if one uses "real" instead of nominal exchange rates. It is also useful to mention, that "real" exchange rates are heuristics – shortcuts that ignore the multiplicity of prices moving divergently. All theorising and econometrics involves abstractions, ie heuristics, shortcuts. The heuristics of "real" exchange rates at times mislead trade theorists and the IMF in their exchange rate advice, generating sectoral output effects that are the reverse to those intended, Pope (1981, 1985b, 1987) and Pope and Selten (2002). Being humans, we have to use shortcuts in the evaluation stage of making decisions, including decisions on what we conclude would be the impact of an exchange rate on an economy. SKAT, the Stages of Knowledge Ahead Theory, allows us to notice that we economists do not maximise as expected utility assumes. SKAT offers us the opportunity to start modeling economic agents as they are, non-maximisers, who can benefit from admitting that they use heuristics as this aids open-ness to when the evidence points to changing the heuristics – changing our models and estimation techniques.

Grounds for querying our interpretation of Table 3 that cannot be excluded by how relative transatlantic prices in the early relative to the later 1980s, fall into three classes.

1 Did we correctly classify the exchange rate regime in each epoque?
2 Is our conclusion robust when we failed to keep other causal factors constant?
3 Is our conclusion robust when we failed to model the micro-foundations of the economies?

9.2 The Regime Classification

The clean dirty spectrum is multidimensional and thus opens the scope for disagreement on how to weight the diverse components. In addition central bank policy is rarely completely transparent and there are documented instances of policy differing substantially from what is claimed, Alesina and Wagner (2005). Further central bankers have been coy about the degree of dirtiness of their floats for multiple reasons, including concern of fanning speculation, concern at admitting their failures, concern about other central banks and governments disagreeing with their actions.

Another problem here is that practices can diverge because of official sector learning and forgetting with each change in top personnel and each new constellation of external events. This learning and forgetting has resulted in many regime changes over the post Bretton Woods era in nearly every currency area, and in dramatic changes in what the official sector does – while holding its regime constant. The situation is too complex for evident overall systematic learning by all participants however. We have illustrated the difficulties with key players[12] – central bankers and their economist advisers – in preceding parts of this paper, and in Appendix 2.

In summary, getting a superior regime classification of matched periods when both transatlantic partners were adequately clean, and other periods when both were adequately dirty, so as to discern the difference in impact on exchange rate stability, might not turn out to be exist. It could transpire when we complete the analysis, that the only era of a really close match was both clean from 1982 to 1984. That single clean float match, without a matched dirty float era, would not suffice to enable us to infer anything about whether clean or dirty floats better stabilise the exchange rate.

9.3 Other Things Equal

Suppose we did get matched periods for both regimes after our subtler regime classification. We would still feel that the results (whichever way round they turned out) are questionable. This is because we have ignored other causes like the exchange rates of other currency areas and shocks peculiar to each epoch. As regards, shocks, the 1970s decade included the aftermath of the worldwide grain crop failures of 1969-70, and the two OPEC rises of the 1970s. The 1980s coped with President Reagan's fiscal spurt and its aftermath. The 1990s began with the exchange rate crises of northern Europe and ended with those of eastern Europe and south east Asia. This millennium had the shock of the ending of the US decade of private sector expansion. We might wish moreover to list other shocks, to classify them by sorts, demand, supply expenditure switching,

[12] The situation is also difficult when we get to the minor participants in the exchange rate process – those in the private sector importing, exporting goods and capital, and even less direct participants such as those bargaining over wages that affect inter-country competitiveness. Investigations reveal highly idiosyncratic techniques employed in the decision making procedures of each group, and quite a concentration of power rendering individual personalities and their general group dynamics of importance.

aggregate expenditure changing and so forth – in case these sorts have differential impacts on exchange rate stability.

Suppose we succeed in doing this – mastering all the classification difficulties as regards the relative importance of other currency areas and shock types. We would then need to consider lags, as not all these effects of regime, of other currencies and shocks impact within a day. To have enough degrees of freedom, we would by now require a vast data set given how many other currencies there are in the world, and the multiplicity of shock types. But given that some of the lags demonstrably exceed a year, we have only 36 years after the demise of Bretton Woods, and thus lack the data on this count alone. We would need to do some approximations – cutting out what we guess are less important causes to do any empirical estimation.

8.4 The Micro-Foundations

Our conclusion might also be questioned as being too aggregate, lacking specifics on the market structure. Unlike some other exchange rate conclusions, eg those based on Obstfeld (2001), we have ignored the differentiated nature of the products that characterize this inter-country trade. We have left unanalysed the input and output market structures and how these evolved over time. It might for instance matter that the US economy was less oligopolistic than the European market both as regards real sector firms and financial intermediaries, and transatlantic cultural differences in agent's objectives might also matter.

It might also matter how these differences have evolved over the post Bretton Woods era. As regards financial intermediaries for instance, oligopolistic power has been accentuated via mergers and, in some areas, European takeovers (eg of virtually the entire US reinsurance business). Objectives of the key figures in the official sectors changes with reallocations of duties and personnel changeovers and unanticipated events. Should they be modeled via an aspiration-adaptation model such as Selten (1999), or what? Again, in the private, is its behaviour captured as a mix of two sorts of firms as regards international capital and goods flows, one sort prone to hedge their imports, and the other sort prone to speculate such as Kaiser and Kube (2005), or what? This raises the general questions of:

1) goal differences amongst agents;
2) differences amongst agents in beliefs on what attains their goals, and
3) group dynamics arising out of 1) and 2) plus changes in the persons holding key posts.

9.5 An Algebraic SKAT Model

It might seem natural to develop an algebraic model of the exchange rate determination process to overcome the numerous legitimate queries of our interpretation of the field evidence in Table 3. It might seem that the combination of the SKAT umbrella theory and the specifics of exchange rate determination delineated in Part 7 offer the golden opportunity for finally discovering all those "fundamentals" that have eluded us economists over the entire post Bretton Woods era. It might even seem that out of it we can predict exchange rates reasonable periods ahead.

A moment's thought however indicates that attaining a tractable algebraic SKAT model in the genre of Part 7 that yielded any conclusions whatsoever would be an interesting challenge. Consider the matter of modeling how cooperation within a country's official

sector, and between a pair of official sectors, change over time. Consider the matter of including how this is influenced by personality changes in the (often) three branches of each country's official sector, and their associated group dynamics.

Consider what would be involved in the above compared to the difficulties already encountered in our current exchange rate models. Current models typically have two currencies – ie the issue of third currency areas is ignored or one small country. Firms, where modeled, tend to be identical to households, and do not hedge or speculate, ie there are no domestic or international financial intermediaries. Alternatively, firms are implicitly perfectly competitive and of only two sorts, informed and uninformed. Alternatively, the current model has a market structure for labour inputs and market output. In both cases firms / households (contrary to fact) have typically identical univariate objective for which maximisation is feasible to specify and done. These simplifications seem needed for tractability. In summary, SKAT algebraic modeling is worthwhile but awesome in the tractability issues from the need to limit the number of causal factors.

Likewise econometric estimation is worthwhile, but involves even greater difficulties. To get the required constancy it needs numerous data points for every causal factor with responses to that cause held constant. As shown in Appendix 2, there is a freedom of degrees problem even were all data available. The 35 years plus that have elapsed since the end of Bretton Woods is too short to get enough episodes with the needed matched exchange rate regimes across currency areas, since official sector heads who manage these regimes keep trying to learn and improve. They episodically make different responses, as they notice something amiss, or because it is a new person at the top, yielding an overall pattern of learning and forgetting lacking the constancies required for robust econometric estimates of exchange rate regime effects on exchange rates.

10 The Scope for a Laboratory Experiment

A fresh insight can be a laboratory experiment. The laboratory experiment avoids virtually all the above questionings of our above interpretation of the field data. It also goes a long way toward avoiding the tractability issues for theory, and the constancy over time requirements of using field data for estimation. It can specify the markets for inputs, outputs and the exchange rate. It can avoid external currencies that obviously impact, but are infeasible to incorporate in either algebraic models or empirical estimates. It can allow firms to engage in both real and financial international transactions without rendering the model and its associated estimation too cumbersome. It can specify the lag before agents can revise their decisions, and the number of changes that there will be in knowledge ahead that matter to agents, ie for how many periods ahead, unknown exchange rate changes can affect attainment of objectives. It can also specify the objectives of each agent with associated monetary rewards for attainment of that set of objectives. And unlike all other forms of theoretical plus empirical investigation, it can leave those agents free to decide how they will seek to attain those goals. It avoids the falsified maximising assumptions underlying most theory and estimation techniques.

Readers may however feel disconcerted at thinking that laboratory findings can shed light on the real economy, especially when in the form of a direct comparison of field and laboratory exchange rate volatilities. It is worth considering therefore how we see other contributions shedding light. This allows us to see that we make just such direct comparisons in our traditional analysis. This allows us to see that the comparisons process is not different in kind from our other sources of knowledge, each has shortcomings, none is the Holy Grail, but each may shed light. We need to be careful

that we do not discard experimental evidence, when the identical sort of criticism can be leveled at our standard uses of theory and field data.

In this regard, every paper potentially contributes to our accumulated evidence on whether a clean or a dirty float ushers in more stable exchange rates. Each bit of accumulated evidence may support one viewpoint or the other. Or it may support neither, in this case hinting either at the need for more data, or form more complicated viewpoints (theories) on what keeps and exchange rate stable.

Each empirical study, whether employing qualitative or quantitative methods adds evidence. This empirical evidence can never be theory free. Empirical work invokes theories of the market structure, of agent motivations, ways of neutralizing other factors that we could not hold constant, and of rendering interdependent cross sectional or time series data free of their serial correlation, heteroscedasticity and many other features that bedevil using them for estimation and hypothesis testing. Despite all these additional assumptions invoked, empirical work affords us additional evidence not gleanable from armchair theorizing.

Simulations can be of an empirical genre. They are an empirical genre if they insert into theoretical models, parameters and lags obtained from empirical sources such as other econometric or input output studies. Sometimes the empirical component is tenuous and the predictions ensuing implausible. This can occur due to a failure to consider issues such as whether the variables are seasonally adjusted or unadjusted. Failure to do so can yield bad output – some very disturbing simulation results – as uncovered in the critique offered in Zellner and Peck (1973) of the FRB-MIT-PENN model of the US economy.

Again, simulations that are not transparently documented on when parameters are simply assumed result in bad policy advice, including unwarranted complacency on world population growth. Thus in the case of the agricultural sector of the ORANI 1979 general equilibrium model of the Australian economy of Dixon, Parmenter, Powell and Vincent (1979), the aggregate supply elasticity was for decades set at 40 and maybe still is. An elasticity of 40 somewhat accords with popular trade models that assume infinite supply elasticity of exports, and most of this sector's output is exported. But it is a parameter value for which there is zero empirical support. Australia has essentially no scope to expand her aggregate agricultural output, only scope to switch under price incentives, from one agricultural item to another. That this parameter is contrary to all known about Australian agricultural production however has not been transparent to world wide users of the model. It has resulted in CGE models around the world misconstruing the implications of population growth – misconstruing that the growth will be supplied by a massive expansion in Australian food output to feed the world, Pope (1997).

Both the FRB-MIT-PENN model of the US economy and the Orani model of the Australian economy have some parameters and lags informed by empirical evidence, by econometrics and input-output data. When combined with macro-financial-international modules, such simulations yield exchange rate predictions that stem from a mix of assumed and empirically grounded relations.

Other exchange rate simulation models by contrast spring entirely from armchair theorizing. None of the lags and none of the parameters have an empirical base. Such simulations are of a purely theoretical genre of evidence.

Yet even such purely theoretical simulations are deemed to potentially contribute evidence. This is the justification for their production and dissemination. The potential of purely theoretical work contributing is that we warrant the assumptions sufficiently

good approximations to reality, and recognise that in all modeling we must abstract, ie merely approximate reality. If not, we give no role to theory contributing to our knowledge base, Pope D and Pope R. (1972).

Thus in purely theoretical modeling, both sides can and do construct models which they see as evidence for their viewpoint of how exchange rates operate. Inevitably, these stem from their conflicting assessments of what assumptions yield good approximations of the workings of exchange rate markets. For tractability, nearly all theoretical models ignore the multiplicity of agents. They rarely contain an official sector comprising more than one decision maker. They rarely model firms involved in goods and capital flows explicitly. They rarely combine different sorts of markets (eg competitive and oligopolistic) even though stylised facts suggest this. In terms of decision making types, there tend to be a most two, eg one so called rational and one so-called noisy, and so forth. All such simplifications are required for keeping the theory tractable.

Further, as already mentioned at the start of Part 4, there are grounds for being very cautious as to whether anyone has reached first base in theoretical modeling of the actual exchange rate. As shown in the remainder of that part, one reason for this failure is the use of standard theories. These, when applied consistently, exclude nearly all the segments of the outcome flow that matter for the economic agents.

11 Our Laboratory Design

Our laboratory experiment, inclusive of instructions to participants, is in Pope et al (2007). It seeks to capture key features of corporatist union-influenced continental Europe and thus to aid particularly in examining exchange rate determination effects from a continental European perspective. Output prices are determined in a Cournot market with a limited number of firms, while imported materials prices are competitively determined, and wages set via centralized bargaining between an employer and an employee representative. We examine the effects of a dirty float in which central banks automatically intervene to support the exchange rate target, varying the degree of transparency in the manner described at the beginning of section 11.5. Central bank intervention limits are described in section 11.2.

11.1 A Concrete Complex Setting

We make the context concrete to all participants, given the evidence that context affects decisions. The world is complex so that conclusions drawn from simplified set-ups may miss effects, and this matter is especially important when the study concerns uncertainty, since uncertainty itself generates complexities. Our design is a compromise between the complexity of reality, and other constraints, including the number of seats in our laboratory, and the maximum time for which we keep participants in a session (one day). To our knowledge it is the most complex experiment performed in an economics laboratory other than those on the Sinto market, Becker and Selten (1970), Becker, Hofer, Leopold-Wildburger, Pope and Selten (2006). In this market, firms had to choose their range of products, their advertising, investment, and price for every product, taking into account how closeness in quality and price might influence demand, and how demand might be growing over time.

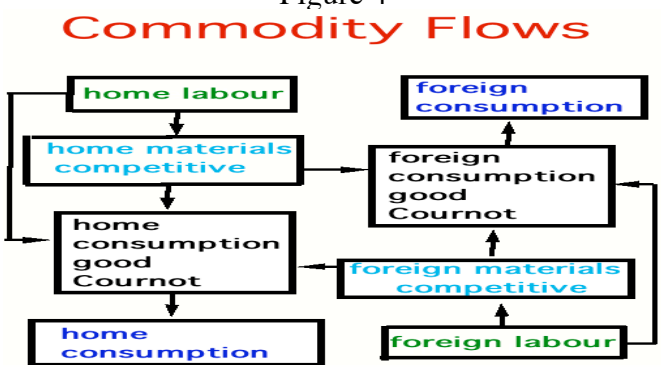
Our set-up is too complex a business game to have a discernible game theoretic solution.[13] Yet more complex experiments have however been conducted in psychology laboratories on economic decision making, eg Dörner, Kreuzig, Reither and Stäudel

[13]Reinhard Selten has constructed (specially for our set-up) a new more realistic game theoretic equilibrium construct to use as a benchmark, that of an incomplete equilibrium, in which players not consider branches that could not yield superior payoffs.

(1983) and MacKinnon and Wearing (1983). To grapple with real world uncertainty costs, we sought as complex a design as was teachable to advanced economics students for them to play it within a day, and also theoretically analyzability with a game theoretic benchmark. While lacking numerous aspects of real world complexity, it is arguably overall closer to reality than any of our current batch of theoretical and econometric models of exchange rate determination. This of course is a tricky judgment to make since reality has so many aspects, and we do not take the view that in every single aspect, there is not one model ever constructed that captures that single aspect better (missing out altogether on numerous others), only that over the entire set of aspects, it could be argued that ours captures more of these in a more adequate manner.

Our set-up has two countries, each with its own currency, symmetric in every respect, and thus suggestive of France and Germany that are of approximately equal economic size, in the days before a currency union was mooted. In each country there is: 1 government, 1 central bank, 1 union representative, 1 employer representative, 5 firms who buy local and imported materials produced under competitive conditions (and thus made by a vast number of firms not represented by players in our laboratory). These imported materials are used in fixed proportions to produce a homogenous final good sold in a Cournot market,[14] with nominal demand set by the government. On these real flows, see Figure 4.

Figure 4



As regards the financial side of real production, firms buy their imports on credit, and must pay for them only next period. They face fixed costs, must produce at least a minimum amount, and face a capacity constraint on the maximum that they can produce. They act as their own financial intermediaries in any hedging or speculating that they do in the current period, prior to its exchange rate being determined, and thus face uncertainty concerning both the current and the future exchange rate. Firm importing and hedging / speculative activity helps determine the exchange rate whenever the two central banks conflict on their exchange rate goals.

11.2 Central Bank Intervention

In the absence of conflict between the two central banks, they set the exchange rate. In the event of a conflict between the exchange rate aims of the two central banks, the amounts of each country's central bank intervention to attain its exchange rate target depends on its import or exports price. It automatically intervenes up to a set proportion, ζ_2, of its export price in the form of selling its own currency, if seeking to depreciate its currency against the wishes of the other central bank, (termed a high aim conflict). It automatically intervenes up to a set proportion, ζ_1, of its import price in the form of

[14] Field and empirical studies reveal that oligopolies with five or more participants have the difficulty attaining systematic collusion, lack of which, broadly speaking characterises corporatist EURO bloc production. The EUC has been helpful in reducing the corporatist, collusive character of Europe over the past decades.

buying the foreign currency, if seeking to appreciate its currency against the wishes of the other central bank (termed a low aim conflict). Since countries have more limited scope to intervene in an effort to appreciate against the wishes of other central banks (this requiring foreign reserves), than in an effort to depreciate (this requiring them only to produce more of their own currency), $\zeta_1 > \zeta_2$. The actual exchange rate ensuing in these conflict situations is the ratio of offers made by both firms and central banks of each currency as long as this ratio is between the exchange rate aims of the two central banks. Otherwise, since the two central banks cooperate if it lies outside the exchange rate aim of either, it is that of the nearest of these two exchange rate aims.

11.3 Official Sector Tasks and Instruments

In addition to the government setting nominal expenditure, the official sector, in the form of its central bank, sets its interest rate and announces its price and exchange rate aim. Thus between its government and central bank, a country's official sector has four instruments of macromanagement. In having only four instruments, it is, as in real life, under-instrumented for meeting goals. In having the official sector short on instruments, we offer reasonable scope for the popular view to be demonstrated that adding an exchange rate change instrument helps macro-management.

The goals are seven: 1 keeping prices steady; 2, meeting its price target; 3, keeping its ideal interest rate; 4, maintaining its ideal level of competitiveness in its cost structure relative to the other country; 5, meeting its exchange rate target (a goal absent in the one currency case; 6 avoiding unduly low employment; 7, avoiding unduly high employment. This latter goal is less important than underemployment, and accordingly is given less weight in the overall objective function. Although the decisions on instruments were allotted (as in most countries) either to the government or the central bank, the payoff was joint: both work for the national good, with penalties for the official sector deviating from each of its goals as in Table 5.

Table 5: Official Sector Objectives

Variables

q	actual price of the home country consumption good
p_+	next period's target price of consumption good
p	current period's target price of consumption good
e	exchange rate, the number of unit of home currency needed to buy one unit of foreign currency and thus as e rises, the home currency depreciates
m	actual price of home materials in home currency
m^*	actual price of foreign materials in foreign currency
r	interest factor (1+ the marginal interest rate)
f	exchange rate aim
B	official sector (government and central bank) objective function
L	actual employment

Parameters

r_0	ideal interest rate, set at 0.05
L_a	minimal acceptable employment, set at 600
L_b	maximum acceptable employment, set at 720
b_i	weight parameters, i = 1... 5. The b_i are positive constants, set respectively as 6, 6, 3, 3, 1, 0.02 and 0.01

Official Sector Objective function

$$B = b_0 - b_1\left(\frac{p_+}{p} - 1\right)^2 - b_2\left(\frac{q}{p} - 1\right)^2 - b_3(r - r_0)^2 - b_4\left(\frac{m}{em^*} - 1\right)^2 - b_5\left(\frac{e}{f} - 1\right)^2$$
$$- b_6 \max\{L_a - L, 0\} - b_7 \max\{L - L_b, 0\}.$$

11.4 Exchange Rate Targeting and Shocks

From Table 5, in the two currency case central banks operate dirty floats. As in the 1961 Mundell model, they can target (manipulate) exchange rates so as to re-equilibrate the economy after shocks. But we shed fresh light on the issue by dropping the assumption of there either only ever being one shock ever, or else (in models that extend Mundell), a set of shocks produced by a random generator and in each case external to the system, as it were from outer space. In such Mundellian models the central bank knows perfectly the source of the shocks, exactly where the new equilibrium is. We replace these false assumptions about shocks and knowledge of the new equilibrium in our laboratory experiment, having instead all shocks generated by the domestic official and private sectors in the two countries. Thus in our laboratory set-up central banks and governments can be as fallible and error-prone as has been the Bank of England in its exchange rate policy according to Cobham (1994, 2002, 2006). In our laboratory set-up, firms as in real life can attempt to make a profit out of exchange rate dealings if they think that one country's central bank has adopted an untenable position as regards its joint choice of exchange rate aim and interest rate relative to the other central bank. Being also fallible, in our laboratory set-up, if firms misjudge the situation, they may lose funds on a grand scale (like Long Term Capital Management), or on a small scale (like some British universities with overseas campuses). Out of this mix of varied fallible moves by members of the private and public sectors in the two countries, our experiment offers a fresh perspective on whether central banks really are able to use the extra instrument of the exchange rate to improve macroeconomic management, to restore equilibrium.

11.5 The Private Sector

Each official sector announces to all in each country its decisions on aggregate nominal expenditure, on the interest rate and its target price for next period. In one treatment each official sector also announces its exchange rate target to all. This might lead to a moderation of exchange rate moves – to the exchange rate staying more toward the middle of the range between the two central bank goals. This could happen as often the interest rate incentive to shift funds will conflict with exchange rate incentive indicated by the official sectors generating either smaller private capital flows or two way counterbalancing flows.

In another less transparent treatment, exchange rate goal information is shared only with the other country's official sector. Here for the firms, the interest rate incentive is unconstrained by exchange rate information from the official sector. Thus private sector capital flows might more often tend to push the exchange rate largely toward the extreme of one central bank's goal, and this might in turn accentuate exchange rate instability.

After each official sector has set its four instruments, and made public knowledge all or three of these, private sector decisions commence. First, in each country, the union and employer representative bargain over nominal wages. The union representative's payoff is real wages measured as nominal wages divided by the announced official sector target price, while that of the employer representative, is the average profit of the firms. If after the set time allowed of 10 minutes, an agreement had not been reached, there was strike, with both negotiators receiving zero pay, a government set wage, and firms subject to a

lower maximum production level and a cut in nominal demand relative to that announced by the government.

Once the wage rate (from bargaining or a strike) was announced for both countries, firms decided on output and on the amounts of a currency (home or foreign) to borrow in order to offer on the foreign exchange market in order to either hedge or speculate. The currency market then operated, and set the period's exchange rate, followed by the consumer market, determining the consumer price, followed by firms paying for last period's imported materials, and profits flowing to the firm's owners.

11.6 Rounds with Interdependencies, Sessions Independent Counterfactuals

A round is the above sequence of decisions and their outcomes played by both the official and private sectors. A round was played by the same participants 20 times, with a lunch break, typically after the 8th period. The first round was preceded by an hour's instruction. The participants were economics students at Bonn University who had passed two or more years of economics, ranging in skill from those in their third year of undergraduate economics up to doctoral candidates. There were six sessions run on 6 different days in 2003 with the exchange rate aims of the two central banks announced to all. An additional three sessions run in 2005, with the exchange rate aims known only to the two central banks. Each of the 9 sessions contained different participants.

By the end of the associated set of experiments, we have almost exhausted our available pool of different willing participants. The sessions were typically on Saturdays, since few participants were available for an entire Monday to Friday weekday. No session had to be abandoned on account of participants becoming bored or too depressed at their earnings prospects to continue for the whole day. Indeed, especially doctoral students often reported how interesting was the experience, and how instructive in macro-international finance. Many participants asked for permission to repeat but were refused. Participants were paid in proportion to their task achievement. Appendix 3 gives the details of how many EURO each participant received for each level of attainment. Participants' earnings varied markedly depending on the session and role. They typically earned between the norm and double the hourly rate students in Bonn obtain in outside casual employment, but some virtually none, and many others more than fourfold the normal rate.

Our nine independent sessions each of 20 periods means that we have a huge advantage over field data with its time series and cross sectional interdependencies. Our field data stem from a single world and a single history, rendering it tricky, to say the least, to decode the effects of the shocks of the 1970s, the 1980s, the 1990s and this millennium. In particular, how do we answer from field data alone that key counterfactual of how would exchange rates have moved in the 1980s under no shocks or smaller or different shocks and a dirty float policy? The laboratory offers us a fresh handle. We have nine sessions of the dirty float, with each with different players, and thus differing propensities to generate shocks, and all our shocks caused by people – as have been

nearly all our field shocks. We have 9 counterfactual worlds to aid us in assessing exchange rate regimes.

11.7 The Round: its Real World Duration Counterpart

11.7.1 The Multiple Actual Decision Frequencies Simplified to a Single One, a Year

In actuality, some types of decisions are made at a far higher frequency than are other decisions. To capture a reasonable proportion the actual differential frequencies requires a highly disaggregate input-output structure identifying the differential production lags of different items used in the production process from bread for sandwiches to steel for mines, from coins in the till, to long term credit, from temporary workers to tenured staff, and so forth. These frequencies however render the modeling so complex, that even in input output studies, differential frequencies are virtually never investigated or modeled. In virtually all theorising and most empirical work, there are not even multiple input-output layers, and even where present, no allowance for differential frequencies of decisions. Our set-up, whilst having two input-output tiers, likewise suffers the shortcoming of setting the frequency of all types of decisions to be identical. We made this compromise with an eye to keeping the game playable as regards participants' understanding and their time needed to make each decision, within a single day when 20 rounds are involved.

Setting all frequencies as in our laboratory set up to be identical has the massive advantage over field empirical data that we avoid all the implicit aggregation assumptions about why the differential frequencies assumed away do not bias the results – implicit since the actual aggregations are too complex to readily start considering. It however sets another question: how does one of our periods relate to actual time flows? We designed it as an approximation to each period being a year.

Our reasoning leading to each period denoting a year started with a lower bound on the duration of each period being investigated via our laboratory technique. We did not wish to model events in time intervals shorter than six months. Shorter durations have limited relevance for the normative issue of exchange regime being investigated for two reasons. First, fluctuations in exchange rates that roughly iron out in a shorter time span have only a modest impact on international trade in goods and services. It is longer lasting adverse changes in the exchange rate that damage international trade. Not surprisingly, most exchange rate studies of the impact of exchange volatility on trade find a minimal effect – not surprisingly since these virtually all use data where the individual observations concern daily, weekly, monthly or quarterly data – not data of a long enough length to be relevant to most trade decisions.

Second, shorter term self-reversing changes in domestic economic activity and relative prices, a government's macro-economic policy smoothes with automatic stabilizers. Of then, frequencies in excess of six months, what is a rough approximation of the lags and their associated flow durations in setting exchange rates that led us to select the year as

the benchmark duration, and design the set-up to very approximately mirror? In taking a year, our thinking stemmed from the evidence described in the following section.

11.7.2 Actual Average Decision Frequencies in Trade

Production varies with a) demand and b) relative prices. The frequencies of actual changes in some components of demand and of relative prices are at least daily. But firms do not respond so rapidly. There is a dearth of information on the actual lags. A source is Pope (1981, 1987) concerning value-added in the Australian manufacturing sector over the period 1950-1980. At that time the estimated average lag of production behind demand was a quarter, and behind relative price changes, five to six quarters.[15]

Lack of data prevented estimating the additional lag of payments, and thus approximately, the foreign exchange market impact, behind changes in production. However nearly all international trade in goods and services is on credit, and the credit to settlement date some two months longer than on domestic transactions, and, while like all credit settlements with a lag sensitive to the business cycle, very roughly in the order of a four month lag from receipt of the imports. This suggests average lags of about two quarters before changes in demand causing changes in goods and services flows to impact on the exchange rate. It hints at an average lag of six to seven quarters before changes in relative prices causing changes in goods and services flows to impact on the exchange rate.

The average of these two markedly different frequencies depends on the variation in trade and goods flows arising from changes in demand compared to those arising from changes in relative prices. Variance in demand is for many countries marked compared to that of changes in domestically determined relative prices, but tiny compared to that from internationally determined relative prices, namely those for commodities (oil, coal, iron ore, agricultural and pastoral products determined in the international market, and so forth), and coming through the role of exchange rate changes altering import and export prices. It thus seems not unreasonable to postulate that the average lag for the two when computed via their variances may be around 5 quarters.

11.7.3 Actual Average Decision Frequencies in Capital Flows

The other components of private sector demand for a country's exchange rate stem from its capital flows. These comprise ones with an extremely short average lag and others with a very long average lag. Hot money, and some portfolio investment, respond in less than a day to alterations in relative interest rate and exchange rates, though there continue to be responses. Direct investment by contrast has typical lags of years between considering an opportunity and deciding on the terms and amount to invest, and then lags of many months, or even years after the deal is finally clinched, before all the capital flows have occurred, both because of the time required to raise the requisite capital,[16] and the typical decision to undertake the direct investment in a sequence of stages with each

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[15] With computerised accounting, and a higher share of the labour force in part-time jobs in some countries (most notably Australia who now leads the world in its proportion of part-time jobs), the average lag in response to demand may have reduced. The lag in response to relative prices however is unlikely to shorten much since responses to relative prices typically requires complex changes in production techniques, and thus only made at annual board meetings and after enough time has elapsed to feel confident that the relative price changes are not temporary bubbles.

[16] In this respect, consider for instance the delays in 2001 that cost Germany's Telecom dearly in cobbering together its EURO funds to transfer for the purchase of US Wireless after all terms of the purchase were finalized. These coincided with an unanticipated drop in the EURO, attributed in the media to a set of massive EURO direct investments (from France and Germany), all in the form of takeovers of US firms. In turn, most of these takeovers were deals clinched prior to the breaking of the US bubble.

stage up to two years apart. The volatility of long-term investment is substantial,[17] but that of hot money is legendary. Splits of capital flows into these two components are tricky, and indeed the capital flows themselves even for many developed countries subject to errors of the order of magnitude of 20%.

There is a presupposition that short term flows are more volatile than at least some long term forms like foreign direct investment, eg Stiglitz (2000). But the authors have been unable to locate a corroborating study. They have instead located studies indicating comparable or even greater instability in long term capital flows compared to short term ones. Eg Fleissig (1971) found the US long-term capital account to be the culprit in that country's contribution to the international severity of the 1930s Great Depression since long term US capital investment abroad shrank dramatically in 1927, 1928 and 1929, while short term flows remained constant. Claessens, Dooley and Warner (1995) study a range of developed and developing countries with data from the early 1970s to the early 1990s. They found that long term flows were often as volatile as short term flows, that it takes as long for a shock to die out in the case of the long term flows as with the short term ones, each with lags of around 16 quarters, and that the long term flows are as least as unpredictable. Singh (2002) offers a range of reasons for anticipating long term capital flows to be as volatile as short term ones. We thus have taken as a working hypothesis that both short and long flows are equally volatile.

When both short and long term capital flows tend to have like autocorrelation properties, it is not too crucial to estimate the shares of short and long term capital flows. The data from Claessens, Dooley and Warner (1995) reveal no average difference, but big differences between countries, eg the UK was almost exclusively long term for their data period but Germany with at least 10% more in short term flows. The statistical results reported in Claessens, Dooley and Warner (1995) point to an average lag of between two and four quarters, depending on whether one looks at their half life estimates or their autocorrelation estimates. Splitting the difference, the average lag discernible from their statistical analysis might be three quarters.

Taking a simple average of our rough estimates of the trade and capital flows average lags, we take our periods as years. We thus use annual exchange rate data in comparing our experimental results on exchange rate volatilities under the set-up of a very dirty automatic intervention institution that includes the goal of maintaining international competitiveness with actual exchange rate volatilities.

12 Results

12.1 Averages

There were no effects that suggest systematic learning over the 20 periods played. This parallels the apparent actual lack of learning in the complex world of floating exchange rates from 1970 to date. See Appendix 3. As economists predicting exchange rates via their models have yet to establish that they have learned to make predictions better than a random walk out of sample in under two years, so also our firms failed to predict the

[17] See preceding footnote for a reported instance of thousands of billions of cycle-sensitive direct investment.

exchange rate changes wrought by their own actions in conjunction with official sectors, Kaiser and Kube (2005).

With no evidence of learning in our complex laboratory set-up designed to mirror real world complexity, we therefore report and analyse here simply the average exchange rate volatility of each session, Table 6. It can be seen that for those laboratory sessions with a less public exchange rate aim, and thus in this sense more dirty float, the average volatility is over double that of the other six sessions. On a non-parametric Mann-Whitney U-test, this is a significant difference at the 5% level. This is suggestive of more transparent dirty floats aiding in exchange rate stabilization.

Table 6

Laboratory Exchange Rate Volatilities with two Currencies and Trading Blocs

Six Sessions with Public Exchange rate aim

Session	1	2	3	4	5	6	Overall
Average per period	.085	0.024	0.033	0.017	0.039	0.030	.038

Three Sessions with Exchange Rate Aims only Known to Other Central Bank

Session	7	8	9	Overall
Average per period	.057	.21	.07	.112

The exchange rate volatilities were symmetrised to avoid discrepancies between percentages being affected by which way the exchange rate is expressed, and thus by whether the former or later exchange rate is higher. The symmetrisation was done by taking the average of the modal absolute percentage increments $|e_t-e_{t-1}|/e_{t-1}$ and $|e_t-e_{t-1}|/e_t$. This average in turn simplifies to $0.5*|(e_{t-1}/e_t - e_t/e_{t-1}|$, where e_t is the exchange rate in period t, the number of units of home currency needed to buy one unit of foreign currency.

Let us now compare the above laboratory volatilities for a two currencies and trading blocs case, with those experienced between two actual sets of currencies and trading blocs – the EURO bloc and the US – since the demise of Bretton Woods, summarised in Table 4, Part 7 above. For the 1970s, 1990s and for the current millennium, the exchange rate volatilities of the EURO countries with the US are in the vicinity of double that of the laboratory dirty float with open exchange rate aims. For the 1980s, the hey-day of clean floating, these countries suffered exchange rate volatilities in the vicinity of four-fold the volatility of the those in the laboratory experiment with their dirty floats. The other epoques were murkier, in between clean and exchange rate stabilising dirty floats given the documented flip-flop changes in regime policies of official sectors depending on whether they perceive it as more urgent to be seen to be exclusively concerned about curbing inflation or attending to other needs of the economy.

The laboratory results thus hint that when countries float dirty with a transparent exchange rate aim and respond to the normal panoply of domestic objectives as regards prices, interest rates, over and under employment and international competitiveness in determining their exchange rate aims, the resultant exchange rates are likely to be far more stable than when many central banks follow price/inflation clean float policies as has been the case in the last few decades. The results suggest that if central banks have a basket of goals, including international competitiveness, an exchange rate aim, and active intervention, exchange rates would likely have been far steadier. If however the

exchange rate aim is not transparent, the laboratory results thus suggest that the dirty float is significantly worse in stabilizing the exchange rate than when this is public knowledge to all players – not merely a secret among central banks.

12.2 Dispersion, Outliers

Many of us would see an influence for instance for the particular personality of a central banker or a particular president, in actual exchange rate determinations, eg a role for the personalities of US Fed Chairmen Paul Volcker and Alan Greenspan, and for the US President Ronald Reagan. Our theories have difficulty (understatement) in allowing for these differences and when unanticipated, their shock impacts. We need such information about such deviations from central tendency. We live in only one world with one history. Bad luck for the world if we economists advocate policy "reforms" that on average work, only we considered no escape routes if reality proves not to be close to the average, but an outlier on the wrong side.

The dispersion of possible outcomes can pinpoint dangers in reform policies. Attention to dispersion is consistent with SKAT, the Stages of Knowledge Ahead Theory. It is inconsistent with EUT and axiomatised expected utility theory. That theory precludes a concern about dispersion. This point was brought to the attention of the English speaking EUT community in Borch (1969) and Feldstein (1969). Allais mentioned this incompatibility in an *Econometrica* article in 1953, but in French, therefore somewhat inaccessible to many. Its stronger restrictions on when by accident an EUT theory would yield the same conclusion as if variance mattered, are in Schneeweiß (1968a, 1968b, 1973a, 1973b). EUT's focus on expectation, exclusion of dispersion about the expectation, has inhibited economists and the organisations that they influence, from considering outliers, considering dispersion. In turn this has contributed to a lack of concern that an intended reform might not operate as anticipated.

Our statistical significance techniques postulate multiple other worlds. We ought make better use of our standard errors and confidence intervals in our statistical estimates to entertain the notion of dispersion and its dangers in appraising economic policies. SKAT affords us a consistent means of including these considerations in our appraisals of exchange rate regimes.

Experiments offer us yet another angle on dispersion, on outliers, on idiosyncracies arising from individuals and their group dynamics. Virtually nothing else is different in these independent sessions, only the individuals and their group dynamics. Laboratory experiments are a handle on whether the outliers are close to the average, or far away, ie on how dangerous are our "reforms" due to unpredictable and unmodeled idiosyncracies.

Let us therefore, with the umbrella of SKAT, look at the average volatility in each of the nine individual laboratory sessions. Their dispersion is a measure of our degree of uncertainty in drawing policy conclusions due to the role of individual differences or group dynamics. In one of the six sessions where the exchange rate aim was transparent, known to all agents, the average volatility was high, namely that listed as session 1 in Table 2 above. This indicates that transparency on the exchange rate aim aids, but does

not guarantee, the roughly halving of the volatility found to be associated with rendering the float transparent in its dirtiness.

Again, in one of the three sessions with a non-transparent aim, the one that we labeled as session 8 in Table 5, there is an outlier so high as to indicate that under a non-transparent dirty float, the volatility might even be as pronounced as under a clean float. Transparency is often hard to attain, for reasons discussed earlier. This outlier points to countries that seek the benefits of stable exchange rates shifting out of floating altogether. It points to such countries considering dollarisation or currency unions or a single world money, as advocated in eg Alesina and Barro (2001), Courchene (1999a, 1999b) and Courchene and Harris (1999), Rose (2000, 2004), Mundell (1961, 2003).

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Appendix 1
Attempts to deal with Risk Effects Experienced in Chronological Time within EUT

The Coincidence Attempt
Friedman and Savage (1948) argued that although the choices made under EUT ignore risk effects experienced in chronological time, the decisions made under EUT could coincide with those proposed by the older asset theory (in which variance and other measures of dispersion, ie of risk, were included) – if EUT choosers have concave "as if certain" utility functions. They criticised Marschak for not recognising this. Marschak (1950) accepted the criticism, converted to EUT and introduced the following confusing new terminology, taken up in the Arrow-Pratt measures. Ie what is called "risk attitude" in EUT is whether:

(i) the *as if certain* utility function is linear, so called "risk neutral",
(ii) the *as if certain* utility function is concave, so called "risk averse", and
(iii) the *as if certain* utility function is convex, so called "risk loving".

But by the late 1950s it had become more widely known that Friedman and Savage and Marschak were mistaken about the scope of EUT to coincide in its decisions with mean variance models. Borch (1969) and Feldstein (1969) reported that the conditions required for EUT to coincide with a mean variance model are rarely satisfied. Further Schneeweiß (1968a, 1969b, (1972a, 1973b) proved that the conditions in Borch and Feldstein were too weak to attain the coincidence.

Another restriction that does enable EUT to coincide with mean variance models was discovered later. This is if choices concern assets – and the asset market is complete and perfect. But even the financial section of the asset market is far from perfect and far from complete. The coincidence route thus fails to enable EUT to accidentally choose as would a reasonable theory of choice under risk that includes risk effects experienced in chronological time.

The Elaborated Outcomes Attempt
Other ways for EUT to include risk effects experienced in chronological time date back to the early 1950s. One is the proposal to specify the decision situation more fully or to redefine or elaborate the outcomes, eg Samuelson (1952), Markowitz (1959, 1991) and Caplin and Leahy (2001). But these elaborations destroy EUT's axiomatic base and preclude the derivation of its representation theorem in the usual sense, Pope (2000).

The Temporal EUT Attempt
Initially the concern had been about omitted emotional chronological time effects that EUT omits. But by the mid 1950s, it was realised that there were also financial chronological time risk effects that EUT omits. Initially proposals were along the lines of specifying the decision situation more fully. But in due course – since planning involves multiple time periods and an outcome flow with multiple outcome segments – it was realised that atemporal EUT could not include these. Work commenced on constructing new temporal EUT axioms, eg Kreps and Porteus (1978), Caplin and Leahy (2001) and Klibanoff and Oxdenoren (2006). The problem is that an EUT axiomatisation has to derive the mechanical atemporal probability weighting rule. In order to derive it a compound gamble (a mixing) axiom is required of the sort that assumes, as Kreps and Porteus themselves note, that all probabilities are known simultaneously, at the same time. But such a simultaneity postulate contradicts the sequential nature of compound probabilities, Pope (1985). Any such simultaneity postulate precludes getting a non-contradictory set of axioms detailing the actual delays that precede resolution of risk, and blurs the distinction between real time risk effects that must enter the satisfactions (utility) mapping with atemporal aggregation effects that are outside time. Such a false simultaneity postulate precludes understanding the distinction between the chooser's anticipated possible cause effect chains of an act, and how the chooser integrates (aggregates) these into a single value of an act. In the case of temporal EUT, it generates a situation in which sequential risks are assumed to be sequential – with positive delays before being resolved) and *at the same time* assumed to be non-sequential – with delays of a zero duration before being resolved.

Appendix 2
Official Sector Learning and Forgetting About Exchange Rate Regimes

Empirical work requires an exchange rate regime to operate for long enough under one regime, and then for long enough under another, with other important causal factors held constant, or controllable, for us to discern the difference (if any) that the two regimes make to exchange rate stability. For instance, suppose we wanted to measure the effect on exchange rate stability of Volcker's clean float regime versus Greenspan's multiple-goal-influenced exchange rate regime. Then for the US we have around 20 years of data, or somewhat less after we allow for some lags. We have actually far less data, since we need to subtract degrees of freedom for every other causal factor that was operating, and whose values changed over the period, such as various sorts of shocks and gradual predictable structural changes.

We also need to get corresponding data for other countries since an exchange rate involves two currencies. Ie, we need a set of partner currencies, or at least one single partner currency for the US that had exchange rate regimes that changed at roughly the same time. Otherwise we get mixed results from one partner having a clean float and the other not, and our econometric estimation becomes infeasible. Such correspondence held roughly for a few years in the early 1980s when clean floats were especially widespread.

But by the mid 1980s, most countries had the horror of a roughly halving of currencies against the US dollar in which all their roll-over debts were denominated, and a roughly doubling of world wide interest rates, leading to a fourfold increase in their roll-over international debt, virtually all of which was unhedged and denominated in US dollars. No country, not even any rich one, could escape noticing drastic disadvantages in the clean float policy. As reported in Part 7, Germany switched to a dirty float – intervened on the exchange rate market to try to bring down the US dollar, and Margaret Thatcher intervened via a discussion with Ronald Reagan to bring it down.

What this amounts to is that the exchange rate regime keeps changing as the official sector discovers problems with whatever regime it has adopted. This learning causing a regime change thwarts econometric estimation. Econometric estimation needs the regime constant across a pair of countries long enough to estimate the effect of that regime.

It might be thought that this is an isolated instance of being unable to match up regimes in two currencies. It might be thought that we can choose another air of decades in the post-Bretton Woods era, or another pair of countries even for the 1980s and since, that offer alternated symmetric regimes for long enough to perform the econometric estimation. Such however is not the case. While there are world-wide trends of learning and forgetting about the disadvantages and advantages of each sort of exchange rate regimes, constellations of factors relating to the particular countries and the personalities involved, create discrepancies in when major regime changes are adopted, and how much there is of change in the actual regime from quarter to quarter.

The mirror image of the reports of central bankers that they face unpredicted and unwanted exchange rate changes, not merely in the early 1970s but today, is that they are ever trying to learn, but not making systematic progress in learning about exchange rate movements. Somewhat similar comments hold as regards the impact of monetary policy on prices, above all in the short to medium term. As Friedman (1969) had discovered, the lags are long and variable. His discoveries of these long and variable lags are not something that can be estimated econometrically in the least reliably using quarterly data, the norm in econometric models devised to advise central bankers operating clean floats. Econometric estimates require constancy of coefficients for each lag. There has been learning and forgetting over the decades on the length and unreliability of these lags.

All this means that even if we could discover a pair of countries with matched clean float exchange rate regimes sequelled or preceded by matched dirty float regimes, how each country implemented each regime would tend to keep on changing, and not changing in a synchronised way. In this regard, it might be no difficulty for econometric estimation if such learning – and its counterpart of individual and institutional forgetting – has a steady pattern as in some theoretical models of x% learned and y% forgotten per period of some *univariate* instrument applied to some *univariate* goal. Such however is false. Official sectors have multiple instruments of monetary and exchange rate policy, multiple objectives of dirty floats, and the learning and forgetting is of an episodic nature, with indeed no readily discernible systematic trend toward enhanced knowledge. A world of floating exchange rates renders this too complex for official sectors who hire us economists – mirroring we economists' own failure to master the fundamentals of the exchange rate. Below we trace a couple of episodes of the learning and forgetting of the post Bretton Woods era to underline the daunting task of using econometrics that requires constancy to analyse exchange rate regime effects on exchange rate stability.

Consider intervention techniques. When floats began in the early 1970s and since, some official sectors deemed that exchange rates were exclusively demand driven and this continued into the 1980s. Australia's deregulation of the exchange rate was orchestrated and administered under such an extreme neo-Keynesian viewpoint!

Others, of the monetary school, thought that *any* expansion of a country's high powered money base would have like effects on its exchange rate. They thought that selling off some of its domestic debt component to shrink the monetary base would be identical to selling off some of its foreign reserves. That after all is how monetary models depicted it. Any change in the monetary base shrinks domestic money and thus should have a like effect of raising the currency's value. Such neutrality, it was concluded, is far from the case both as regards speed of impact and overall impact. Foreign exchange interventions operate far faster, and arguably more powerfully than do operations on the domestic base. This altered management of both clean and dirty floats in some countries. The learning about this however is far from systematic, in part because it has not entered most economists' theoretical and econometric models, so that new generations of advisers arrive at central banks – each generation has a life of high influence of only perhaps five years.

Even where central bankers choosing a dirty float decide on intervention, there has been little systematic learning on whether announcing the intervention reduces the needed size of intervention and increases its likelihood of success, or has the reverse effect of engendering dangerous and unmanageable speculative moves. The evidence from academic research remains mixed, but tilted to announcing. On the part of some central banks, including the US Federal Reserve and the European Central Bank, the trend is to announced, eg Beine and Lecourt (2006).

But this conclusion, that announced foreign exchange rate interventions are faster and stronger and more reliable than domestic base operations in their impact on the exchange rate, can be interpreted as having a large element of country and time period specificity. This can especially be the case if the operations on the domestic money supply are heralded as being taken without any regard to their exchange rate implications. With such a conjunction, the old-style undifferentiated attention to the monetary base is for

instance a feasible interpretation of the exchange rate impact for Australia at the end of 1982, the beginning of 1983, as follows.

Less than a year after floating, Australia prior to an election in the normal electoral fashion, expanded the base, lowering the domestic interest rate immediately but not causing any immediate increase in inflation. Movers on foreign exchange markets asked is this serious, not about to be reversed tomorrow now that the country has moved this year to a float? The Treasurer stated that it will hold, and the exchange rate promptly depreciated 25% on a trade-weighted basis. The country's risk premium jumped correspondingly.

Some took this as a lesson that Australia ought abandon its clean float policy that could accommodate short term monetary expansions without jeoparidsing its inflation target, and move to a dirty float with the exchange rate itself a goal in its own right. Others found no connection of concern or damage between the country's monetary policy and its exchange rate collapse. Eg the treasurer expressed his pride in the country's new found monetary independence, the prime minister anticipated massive jobs increases from the fortuitous depreciation, and the Treasury employed a quarterly longer term interest rate series in which it detected no jump in the country's risk premium, Pope (1987). A few years later, the exchange rate entered the central bank's goal, ie the float became officially dirty, but since it has exited, ie the float is again officially clean. Should this be classified as:

1 switches in the confusion of floats, or
2 learning followed by unlearning in reverting to a cleaner float, or
3 unlearning followed by learning in returning to the cleaner float?

Finally, suppose that we managed to find a pair of countries that for the requisite eras alternated with both having clean then both dirty of vice versa and both had identical understandings of how to operate their regimes, could we then empirically estimate that effect? The answer is major qualifications. We would then need to consider the matter of other exchange rates impacting on that pair of currencies. But there are so many of these that we use up all our degrees of freedom including them, leaving none over for empirical estimation unless we make assumptions about which to omit. On which to omit we are left to our own judgment since we lack robust models of exchange rate determination to guide us in this regard. Indeed, the problem of third currencies is so tricky and so consumptive of tractability possibilities and degrees of freedom, that few enter theoretical or empirical studies. In these respects too, the laboratory is attractive. It keeps much about the exchange rate regime steady, and excludes entirely the impact of the galaxy of their country currencies. It gives us a fresh insight to complement our empirical work on field data.

Appendix 3
Payoff Conversion formulae

The payoffs in the game itself were expressed for each role in Talers for each point one. The conversion of Talers into Euros was monotonic but not proportional. It varied such that each participant had an identical payoff if all played according to the incomplete game theoretic equilibrium, and was set as follows:

For the government and the central bank 1 Taler for one point
For the union representative, 19,6875 Taler for one point
For the employer representative 50 Taler for one point
For the firms, 250 Taler for one point

The sum in Talers was then converted into EUROs by the following formula:

Sum in Talers between	*Conversion into €*
0 and 60	x
60 and 100	60 + 0.5 (x – 60)
100 and 200	80 + 0.3 (x – 100)
200 and 300	110 + 0.2 (x – 200)
over 300	130 + 0.1 (x – 300)