

von Hagen, Jürgen; Kube, Sebastian; Selten, Reinhard; Pope, Robin

**Working Paper**

## Experimental Evidence on the Benefits of Eliminating Exchange Rate Uncertainties and Why Expected Utility Theory causes Economists to Miss Them

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# BONN ECON DISCUSSION PAPERS

Discussion Paper 28/2006

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Eliminating Exchange Rate Uncertainties and  
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by

**Robin Pope, Reinhard Selten, Sebastian  
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Bonn Graduate School of Economics  
Department of Economics  
University of Bonn  
Adenauerallee 24 - 42  
D-53113 Bonn

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## **Experimental Evidence on the Benefits of Eliminating Exchange Rate Uncertainties and Why Expected Utility Theory causes Economists to Miss Them**

Robin Pope,<sup>1</sup> Reinhard Selten,<sup>2</sup> Sebastian Kube<sup>3</sup> and Jürgen von Hagen<sup>4†</sup>

- 1 Experimental Economics Laboratory,  
Bonn University, Walter Flex Str 3, D-53113 Bonn, Germany,  
Tels +49-228-731887, +49-228-4462880; Fax +49-228-446-2881  
<http://webserver.econ1.uni-bonn.de/>, [Robin.Pope@uni-bonn.de](mailto:Robin.Pope@uni-bonn.de)
- 2 Experimental Economics Laboratory, Bonn University
- 3 Department of Economics, University of Karlsruhe
- 4 Institute for International Economics, Bonn University

### *Abstract*

Conclusions favorable to flexible exchange rates typically accord with expected utility theory in ignoring the costs that exchange rate uncertainty generates for governments, central banks, firms and unions in: (i) choosing among acts; and (ii) existing until learning the outcome of the chosen act. Allowing for these involves SKAT, the Stages of Knowledge Ahead Theory, Pope (1983, 1995, 2005), Pope, Leitner and Leopold (2006). A laboratory experiment suggests that (i) and (ii) together outweigh the advantages of having a flexible exchange rate as an additional instrument for managing a country's international competitiveness goal.

**Key Words** exchange rate regime, exchange rate uncertainties, currency union, macro-economic instruments, experiment, SKAT, the Stages of Knowledge Ahead Theory, international competitiveness

**JEL Classification** D800, D810, F310, F330

### **Overview**

Some see our currently flexible exchange rates as desirable since they afford a nation's official sector an additional macroeconomic instrument for dealing with shocks introduced by demand and supply factors and unreasonable unions. In other words, this set of economists believe that the exchange rate helps restore equilibrium and a country's international competitiveness in the face of changing inter-country conditions. Under this belief in the later 1980s and into the 1990s, the US sought to solve unemployment problems and help its export sector by getting Japan to appreciate the yen. Ie the US believed that floating is good as it could have permitted Japan to appreciate and that this would fix up the US's competitiveness position. Under this belief in this millenium the US pressures China to appreciate, ie thinks that flexible exchange rates used to appreciate the Yuan can restore to equilibrium its competitiveness, get it out of its private sector "jobless recovery".

A decade back, this belief that flexible exchange rates are desirable for restoring international competitiveness led to widespread concerns about joining the EURO. There were concerns

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that entering the EURO bloc would loosen union discipline, increase nominal wages and worsen employment and inflation. Thereby it would worsen member countries' international competitive positions – already deemed to be in international disequilibrium due to excessively high EURO wages. Today, this belief is mirrored in campaigns to have Italy quit the EURO, and by others, who accept that the EURO is here to stay, advocating alternative ways of restoring the international competitiveness of some EURO members in particular, or of the EURO bloc as a whole. Restoration of international competitiveness is linked to lowering EURO country wages – ie to the belief that the EURO countries' high level of unemployment relative to the US and Australia and Denmark stems partly from the EURO being over-valued for the whole bloc, and especially for regions like southern Italy and eastern Germany. See eg Sinn (2003, 2005a, 2005b).

Other economists oppose altering exchange rates to restore perceived discrepancies in equilibrium due to perceived deviations from international competitiveness. They deem exchange rate variations a curse to be curbed by various measures. Measures proposed include a willingness to let countries like Japan and China peg their currency to a major trading partner, McKinnon (2005), and a Tobin tax. This belief in exchange rate variations being a curse results in support for joining the currency of one's major trading partner(s), eg Courchene (1999), Courchene and Harris (1999a, 1999b), Cobham (2006), or even having a single world money, eg Mundell (1961, 2003). Those who find flexible exchange rates a curse point to the costs of exchange rate uncertainty or of the additional tiers of transactions involved in currency conversion, or of both. Historical studies identify elimination of exchange rate uncertainty costs as a factor behind the spread of the gold standard, eg Bordo and Rockoff (1996), Obstfeld and Taylor (2003), Meissner (2005).

There are difficulties in estimating whether the extra official instrument of exchange rate flexibility for restoring perceived deviations from equilibrium in international competitiveness is worth these transactions and uncertainty costs. One difficulty is the tendency to theorise and estimate within EUT, axiomatised expected utility theory. This theory excludes earlier stages in the decision process and thereby key uncertainty costs.

Other difficulties include:

*tractability constraints in modeling*

- 2 price and wage stickiness;
- 3 shocks;
- 4 the role of central banks; and
- 5 hedging/forward exchange markets

and

*estimation hurdles as regards*

- 6 getting the correct time spans given changes in the exchange rate regime; and
- 7 separating transactions from uncertainty cost effects.

In this paper, we first elucidate these seven difficulties, and why an experiment offers a fresh insight and in important respects, a means of overcoming them. We then describe our experiment and give our results.

## **1 The Gamut of Risk and Uncertainty Effects**

### **1.1 SKAT**

To trace the cause-effect chains arising from risk and uncertainty, we need to look at the decision procedure demarcated by when each stage of risk and uncertainty is passed. This is the purpose of SKAT, the Stages of Knowledge Ahead Theory, presented in Pope (1983), and in more detail in Pope (1995) and Pope, Leitner and Leopold (2006). Epistemic means knowledge. The chooser enters a new epistemic stage whenever he has a change in his knowledge. In the simplest cases, here illustrated, 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.

For simplicity, let us illustrate with the minimum number of epistemic stages that a chooser could encounter after discerning a problem meriting a decision. This is four stages, and thus involves three times when the chooser learns something new. Let our illustration be a fictional account of the Bank of England after it discerned the 1992 speculative attack on the pound.

The Bank's first stage is to discover what alternatives are available. So at this first stage it is ignorant of its choice set. Suppose it discovered that it could: 1, tighten money; or 2, depreciate at once; or 3, try to ride out the crisis.

Then the Bank has had a change in its knowledge ahead. The Bank knows its choice set. It has entered stage 2. Its task now is to evaluate these three alternatives. It considers the distress to the country of a tight money policy and the opposition it would have to shoulder from some sections of the government and civil service. It considers the distress to the government of an immediate sizable depreciation since under the Maastricht Treaty this would force the UK's exit from the EMS, the European Monetary System. It considers the risk of a massive loss of taxpayers' funds if it seeks to ride out the crisis, but fails to persuade Germany's central bank to intervene enough on its behalf or lower its interest rate. Suppose it decided to try to ride the crisis out.

Then the Bank has had a second change in its knowledge ahead. It knows its choice. It has entered stage 3. It now waits to learn if it has luck. By Black Wednesday it learns that it did not have luck.

Then the Bank has had a third change in its knowledge ahead. It knows the final segment of this outcome flow. It has full knowledge ahead – certainty of the failure from its decision –

and the fallout of a massive loss of taxpayers' funds and asset redistribution both within the UK and between the UK and the rest of the world.

Table 1 summarises the four stages through which the Bank passed, progressively having more knowledge ahead, and by stage 4, certainty – as regards that crisis.

Table 1  
The Four Main Stages of Knowledge Ahead After Encountering a Crisis

| <i>Stage</i> | <i>Activity</i>   | <i>Unknown</i>  |
|--------------|---|---|
| 1            | Discovering Alternatives                                    | Choice set  |
| 2            | Evaluating Alternatives                                     | Chosen alternative  |
| 3            | Experiences while waiting to learn if had luck              | Last Outcome Segment  |
| 4            | Living with the Now Known Outcome of the Chosen Alternative | Nothing – full knowledge ahead, certainty (with respect to that crisis) |

Note: Stage 3 is irrelevant, since of zero duration if a sure alternative is chosen

There are literatures on each stage, eg for stage 1 satisficing and aspiration-adaptation models, Simon (1955), Sauermann and Selten (1962), Selten (1998), for stage 2 difficulties in performing such evaluations, Janis and Manne (1977); and heuristics used, Cyert and March (1963), Huber (1982), Montgomery and Svenson (1983), Weber and Borchering (1993), Brandstaetter, Gigerenzer and Hertwig (2006) and Pope, Leitner and Leopold (2006, chapter 14), for stage 3, the effects of uncertainty on firms engaged in investment as distinct from production delineated in Keynes (1936), as noted in Walsh (1994, pp. 56, 62-66), and in effect extended in Pope (1983, 2004, 2005), and for stage 4, all standard decision models. For stage 4 there are also non-standard decision models that consider risk effects from the preceding decision stages like disappointment that the previously possible better final outcome segment did not occur, Bell (1981) and financial effects like being fired for it being discovered in stage 4 that in stage 1 the CEO had chosen the wrong act (rejecting the Norwegian government's offer of what later proved to be the most lucrative north sea oil field, Hagen (1985), and having to repay more interest because of the risk endured in stage 3 by the lender involved a risk premium interest surcharge, Pope (2005).

## 1.2 Timing Consistency Issues

Von Neumann and Morgenstern deemed that nice effects in stage 3 of thrills and nasty effects of fear in not knowing the chosen act's outcomes have a big influence on choice. They had sought to develop a decision theory broader than EUT, axiomatised expected utility theory, so as to include anticipated thrills, fears and so forth. But they encountered a contradiction and so left the task of finding the higher level that overcomes this contradiction to future researchers, (1947, 1953, 1972, pp628-32).

The contradiction, it turns out, arises because EUT embodies a false timing simultaneity in what the chooser knows. Von Neumann and Morgenstern realised that EUT is epistemically static – ie contains only a single stage of knowledge ahead – and so could not cope with

people learning new information at multiple dates in the future. But they thought that nevertheless EUT could model the simplest class of risky choices for stage 4 as follows. Upon having chosen any alternative, the chooser will at a single date in the *future* know everything. A single *future* date at which the chooser knows everything – has full knowledge ahead – is feasible if as they assumed, the set of risky alternatives is restricted to ones where everything is learned at a single identical date.

But the axioms only derive the EUT property by including sure alternatives. In the case of choosing a sure alternative, the chooser knows everything *earlier* – not in the immediate future, which is *after* the point of choice, rather *simultaneously with choice*. This renders it infeasible to model risky and sure choices *together* in a theory that permits only a single epistemic period. Doing so introduces the contradiction of probabilities of the mutually exclusive set of outcomes being simultaneously known and not known. Using SKAT introduces the higher level and overcomes the contradiction. SKAT has multiple epistemic periods, ie multiple stages of knowledge ahead, Pope (1985a). The probabilities that are non-degenerate in stage 3 are degenerate in stage 4 since this is a later stage in the chooser's degree of knowledge ahead.

To be within the SKAT umbrella, it is not sufficient for a model to divide up the chooser's future into numerous *chronologically* distinct future periods. To be within SKAT, the periods must be *epistemically* distinct – demarcated by changes in knowledge. To be within SKAT, any probability distributions over pertinent outcome spaces must be *epistemically consistent*. In other words, the model must not violate other axioms (assumptions) in the system about what it assumes that the chooser and other relevant parties know at distinct dates. Hence unless it builds in an assumption that the chooser or another relevant party is schizophrenic, it must not simultaneously impute to anyone simultaneously degenerate and non-degenerate distributions over the outcomes.

### 1.3 The EUT Outcome Segment

Positive and negative satisfactions (utilities) are derived from outcomes. In turn this means that if a segment of the outcome flow is excluded under a theory, then so also are excluded the satisfactions deriving from that segment of the outcome flow and (probabilistic) knowledge of it. EUT's axiomatic base constrains it to include in its outcomes flows only stage 4, namely the outcome segment that will occur *after* all risk and uncertainty will be in the past. This is because EUT's axiomatic implications include: (i), a restriction of the outcome flow to those segments that occur *after* all risk is resolved, Samuelson (1952), and (ii), a restriction that each of these post risk segments must be evaluated “as if certain”, even though uncertain at the point of choice, Friedman and Savage (1948), Samuelson (1952).<sup>1</sup> Restrictions (i) and (ii) hold also for most extensions of EUT such as cumulative prospect theory.<sup>2</sup>

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<sup>1</sup> See Pope (2004) on the alternative Ramsey version of EUT which has the like property of precluding attaching a different utility to an outcome depending on its degree of risk, uncertainty.

<sup>2</sup> Many scientists inadvertently violate the extreme epistemic constraints of EUT, and thus construct epistemically inconsistent models termed EUT. But in fact such models lie outside both SKAT and EUT.



EUT's omission of the Bank's outcomes segments and thus utilities in the three earlier stages implies the following. The Bank has no satisfactions before the final era when all uncertainty is past. Thus EUT implies that there are no costs, no benefits in stage 1, ascertaining the choice set, nor in stage 2, evaluating each alternative in that choice set, nor in stage 3, in enduring or enjoying the period of risk / uncertainty after choosing and prior to learning whether the lucky outcome has ensued from the risky act chosen.

It might be thought that models within EUT can at least include all the Bank's stage 4 effects. This however is not the case. The earlier stages 1, 2 and 3 have legacies. Table 2 illustrates them with a fictional account.

Table 2  
Legacies for the Bank of England in Stage 4 from Earlier Stages 1, 2 and 3<sup>3</sup>

#### *stage 1 Discovering Alternatives*

*As regards reputation*, the Bank has the minus of criticism that it should have discovered a wider range of alternatives including a Tobin tax and seeking to get the Maastricht Treaty overturned so as to permit capital controls, dual exchange rate schemes, crawling pegs, big depreciations for EMS members, Eichengreen, Wyplosz, Branson and Dornbusch (1993), Vernengo and Rochon (2000).

*As regards the welfare of its stakeholders*, the Bank has the minus of lower welfare by not considering these alternatives in that it exited from the EMS and is out of the EURO today as there is reasonable evidence that the capital controls at least would have worked for quite a period, and saved the British taxpayers not only their large loss in September 1992, but also the increase in the country's risk premium for an extended period from being perceived as depreciation prone.

#### *Stage 2 Evaluation of the Alternatives identified*

*As regards reputation*, the Bank has the minus of not having chosen its identified alternative of immediate depreciation, but instead to ride it out. This criticism has extra bite in that some, eg Cobham (2002, p90), contended that it should not have been in the situation of facing a crisis – that the Bank provoked the crisis by its soft interest rate policy when it was unrealistic that it could pressure Germany's central bank to follow suite and lower its rate.<sup>4</sup>

*As regards the welfare of its stakeholders*, it has the minus of lower welfare from the additional funds plunged in the unsuccessful effort to avoid depreciation

#### *Stage 3 Awaiting Resolution of the Risk / Uncertainty*

*As regards its emotional state*, the Bank has the minus of disappointment that Germany's central bank might have been more cooperative and that one of the UK politicians might have been more diplomatic in the period when such cooperation could not have been ruled out.

*As regards the welfare of its stakeholders*, the Bank has the minus of the higher risk premia now due for payment arising out of the turmoil before Black Wednesday

### **1.4 Idiosyncratic Influences on the Exchange Rate**

Not everything in our above account of the Bank of England is fictional. Factual aspects of our account include the non maximising way that the Bank went about stage 2, its evaluation task, Cobham (1994, 2002 and 2006). The Bank did not for each alternative: a) specify each possible outcome flow  $o_i$ , b) give each  $o_i$ , a utility; c) give each  $o_i$ , a probability, c) compute that alternative's expectation; and then choose the alternative for which this expectation was the maximum. Instead the Bank retained multiple dimensions in how it viewed its goals and its costs of attaining these.

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<sup>3</sup> For literature on Table 4 pertaining to other decision situations, see Pope (1995, 1996/7) and Pope, Leitner and Leopold (2006).

<sup>4</sup> This critique, Cobham notes, builds on Melitz (1994).

Relatedly, it is factual that the Bank did *not* fully anticipate the effects on all its stakeholders of living through stage 3 – of not knowing whether the Bank would succeed in riding out the crisis. The Bank did *not* compute a probability distribution over the various risk premia to which firms would be subjected during the crisis. Nor did the Bank compute a probability distribution over the legacies of these risk premia after a failure to ride it out in the form of higher loan repayments consequent on the risks taken by those contingently able to repay.

The Bank's disappointment in stage 4 is likewise factual. Nor was this an isolated incident of the Bank facing the unexpected as regards sterling's exchange rate change. Cobham (2006) provides convincing evidence that many of the major exchange rate changes of sterling over the last 20 years came as surprises, as nasty surprises, resulting in disappointment.

In summary, the Bank anticipated some effects on its goal attainment in each stage, and was influenced by these. The Bank missed some effects that outsiders, not caught up in the emotional heat of the moment, discerned at the time. The Bank missed yet other effects that, at least with hindsight bias, bystanders deemed it should have anticipated.

The Bank had multiple goals and thus multiple dimensions to its satisfactions in each stage. The set of anticipated satisfactions that the Bank noticed and missed will be a mix of the Bank's culture, and of the personalities of those holding top Bank posts. Developing tractable and econometrically estimable models within SKAT that capture principal influences in particular decision situations and have some predictive power is desirable but will be a challenging task.

### **1.5 Experiment**

A means of looking at the net effects of all these intricate and idiosyncratic evaluation processes is an experiment, where, unlike in theorizing and econometric estimation from field data, we do not need to impose assumptions on how all this happens. Let us now proceed to see how an experiment addresses some of the other difficulties in gauging whether it is worth having flexible exchange rates in order to redress disequilibria associated with (perceived and actual) changes in international competitiveness.

## **2 Wage Stickiness**

The desire for the extra macroeconomic instrument of varying the exchange rate to restore international competitiveness is intimately related to the notion that wages are sticky. When conditions change – especially for the country needing lower nominal wages – it is deemed quicker and thus less costly to get to a new equilibrium by altering the exchange rate than by getting labour to accept a wage drop. The empirical evidence is abundant on wage stickiness. But we have limited understanding of the precise forms it takes period-to-period. Relatedly, whether all the stickiness constitutes irrational or inefficient disequilibrium behaviour – that ought be countervailed by an exchange rate change – is far from well understood.

Theoretical models become untractable if they take into account many of the factors that cause variations in the extent and functional form of wage stickiness. It would be demanding, to say the least for theoretical models to remain tractable and understandable if they included for instance, the diverse forms that wage stickiness assumes in different organizations depending on their workplace morale and on the evolving notions of what is fair over the business cycle detected in Bewley (1999). In a complex and ever-changing world, different factors grab the attention of wage bargainers at different times, with what grabs attention depending on the particular personalities involved, and their particular cause-effect mental models of the world.

Econometric estimates are limited to assuming constancy in the stickiness over stretches of time. In addition they need to invoke a host of assumptions on linearity in the functional relationships and independence of errors. These assumptions are in reality violated and can at best be partially filtered out by techniques – with each technique adjusting for that violation, but introducing a host of other problems.

A laboratory experiment can overcome both the theoretical tractability hurdle and the above set of econometric hurdles. It can leave the wage bargainers free to exhibit over time a pattern of being sticky and immune to what other price incentives indicate as regards unemployment or overemployment. It can leave the wage bargainers free to learn over time, and to forget over time. It can leave the wage bargainer free to respond to events that are salient to them, and to allow episodes when relativities dominate wage bargaining and other episodes when absolute welfare considerations dominate.

Since each laboratory session comprises a new set of participants who have never played before, it allows scope for how different personalities, with different ways of responding to their monetary incentives and enhancing their monetary incentives interact. Such individual idiosyncracies yielding group dynamics have to be assumed away, replaced by an assumption like homo economicus, in theoretically tractable models. By independent sessions we create independence rather than assuming it. Therefore we can perform non-parametric tests with the sessions as independent observations and avoid unjustified independence assumptions.

### **3 Shocks**

#### **3.1 The Swan-Mundell Never Repeated Shock**

Modelling of shocks and estimating their impact is tricky. The theoretical work dates back to the seminal paper on assignment of objectives and associated instruments to the fiscal and monetary authorities, Swan (1952). His form of analysis was brought to international attention in Mundell (1961), and has remained the prime justification for the exchange rate as an extra instrument. (This is ironic since Mundell himself, on account of transactions costs, in that 1961 article, ridiculed multiple monies, and in effect launched his lifelong campaign for a single world money, and ever deemed his article misunderstood.)

In the Swan-Mundell models, any shock, as the word itself suggests, is unanticipated. There are no shocks ever after, and indeed no probabilistically anticipated changes in the exchange rate ever after. So moving the exchange rate once to adjust for a shock generates no future exchange rate uncertainty – no risk of other countries “retaliating” or “adjusting to avoid damage” as they do in actuality. This assumption – that a shock change in an exchange rate fails to alert decision makers to the reality that in the future there could be other exchange rate changes – characterizes a wide body of theoretical and empirical analysis of shocks since, not only as regards exchange rates, but much else also.

### **3.2 Learning to anticipate shocks**

It is questionable to construe agents as rational who after the first shock in their lives, never expect another one, nor realize that the future exchange rate is uncertain, and thus qualitatively or probabilistically anticipate exchange rate changes. It is also questionable descriptively. It is true that many economists in their modeling took a long time after the demise of Breton Woods to grapple with the possibility of future exchange rate shocks. But at least some of those who actively operate in exchange rate markets, and thus help set exchange rates, after a while start anticipating that there may be future exchange rate changes. Let us give but two examples.

First, in the interwar period, countries successively devalued to improve their international competitiveness. The improvement can only endure of course if the other countries do not retaliate and devalue in turn. In fact others did retaliate. In due course a majority opinion developed of anticipating nasty shocks of reciprocal devaluations from these “beggar-thy-neighbour” attempts of every country to improve its competitiveness at the expense of all the others. The earlier failure to look ahead and to fail to anticipate retaliatory exchange rate changes had ended, and countries sought to end the practice. The compromise, weaker than what Keynes had sought, given US opposition to a strong new system, was Bretton Woods.

Second, let us take a post Bretton Woods example of learning to anticipate exchange rate shocks. At the time of the first shock after entering a new regime of floating after Bretton Woods in 1982 and finding the Australian USD exchange rate stable for a while, there was such naivety of anticipating zero shocks in Australia as the private sector borrowed billions in USD unhedged. The Australian official sector was even more naive. It expanded the money supply in a prelude to an election. There ensued a massive abrupt depreciation. The naivety went and the country’s risk premium leapt. That is to say, foreign exchange dealers and other key parties, understood that there can be exchange rate shocks, that Australia might in the future yet again depreciate.<sup>5</sup>

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<sup>5</sup> Naturally, as in all markets, not everyone had been naive their fingers burned. Some had been wiser, had anticipated the likelihood of exchange rate shocks, and refrained from such unhedged borrowings. The next depreciation is described in Part 4. It too was a shock in the sense that its timing and size could not have been predicted – it arose out of overseas good weather conditions expanding the world grain crops and reducing the price of Australian grain exports.

### **3.3 Maximisers over Ergodic Shocks**

The new generation of exchange rate theorizing has agents who anticipate exchange rate shocks, eg Obstfeld (2001). Here we are appropriately in the world of recognising that the future exchange rate is uncertain. The shocks are inserted in perhaps the only tractable way in a theoretical model. The shocks are inserted as random noise in an ergodic (stationary, self-repeating system).<sup>6</sup> In these models moreover each agent maximises his expected utility. (For these agents therefore there are no shocks in the sense of totally unanticipated events, but probabilistically anticipated ones.) There are thus two key features of such modeling ergodicity and expected utility maximisation.

### **3.4 Our Non-Ergodic World**

The ergodicity assumption is contrary to the actual way that shocks are generated. They are generated by humans decisions. It is questionable, to say the least, to assume that these take the form of history precisely repeating itself. For accounts of how central banker policy kept changing and not repeating itself, see eg Eichengreen and Wyplosz (1993) and Cobham (1994, 2002, 2006). For accounts of exchange dealers having altered over the years their techniques for attempting to predict the exchange rate, and thus their exchange decisions, see eg Osler (2000, 2003). For examples of firms and governments making decisions that alter the course of history, preclude ergodicity, see Part 4 below.

### **3.5 Our Inability to Maximise**

Since the ergodicity assumption is false as indicated above, the assumption that agents choose on the basis of expected utility maximisation is implausible – the Bank of England with which we illustrated the decision process in Part 1 is no exception in this regard. Rather it reflects the universal human condition. No entity has a capacity to maximise. A non-ergodic world is awesome to probabilistically predict. Participants in the exchange rate market do not have a distribution over the utilities of the outcomes that they seek to maximise. They have a highly time variant perception of whether there will be exchange rate shocks or not, and in which direction these might occur.

In our non-ergodic evolving world, we humans do not maximise. We have to do our evaluations based on other sorts of techniques. We have systematic learning and forgetting patterns about shocks and other exchange rate changes. It takes only about a generation of minor shocks for most participants in a market to forget about the possibility of big shocks, Allais (1972), Blatt (1983). Besides even if at some higher level of aggregation, the world were ergodic, it is far too complex for us to maximize an expectation in the sort of objective impartial overview manner postulated under expected utility theory.<sup>7</sup>

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<sup>6</sup> See footnote 4 above.

<sup>7</sup> This impossibility of maximising was recognised by Savage, granting that EUT was impractical for planning even a picnic. He proposed a short-cut heuristic, a small worlds assumption, but found it too difficult to operationalise, and left this task to future researchers. As an alternative he proposed what he called an “extra logical loose” sure thing principle, Savage (1954, 1972). But the principle turns out to be irrational, to give the mirage of clarifying by generating an illusion of certainty, Pope (1991).

It is sometimes asserted that *unconsciously* people maximise. This assertion has the awkward property that no economist could differ in his policy recommendations from another except by asserting that the other economist's *unconscious* was inferior to his unconscious, and thus failed to maximise whereas his own *unconscious* – without his being able to analyse why or offer *conscious* supportive reasoning – did the maximisation correctly. Let us therefore not take this line that in effect no decision or piece of analysing can be subject to scrutiny as everything is perfect, no errors are ever made. Instead, let us give two examples of economists' own fallible non-maximising pattern of arriving at policy conclusions.

### **3.5.1 Forgetfulness about Exchange Rate Regimes**

First, an example where the focus is more on forgetfulness. In the complexity and confusion of an evolving world, many economists and others of the 1960s and 1970s, forgot the shocks that the floating exchange rate regime had delivered in the interwar period.<sup>8</sup> They yearned for its return, quite forgetting it could usher in exchange rate crises comparable to those of the interwar years, or even worse, Kenen (2002b). Wyplosz (1993, p139) notes the irony involved in the swings pro and anti floats, an outcome of human fallible forgetfulness – inability to maximise.

### **3.5.2 Complexity in Making International Competitiveness analyses**

Second let us take an example of how complexity deprives us economists of a the ability to be expected utility maximisers over any domain relevant for serious economic policy. We should not feel too badly about this, since as noted above in section 1.3, back in the 1950s Savage observed that expected utility theory would be impractical even for planning a picnic.

In the nice simple abstract Swan-Mundell framework, it seems easy to maximize, easy to extend it to obeying expected utility theory. All risk is in the past after the shock. There is none of the murky complexity of an uncertain future. It seems transparent that both countries “ought” to realize that a mutual benefit arose if one country devalued – implying that the other had to revalue. In these models it is crystal clear to all parties what is the shock and what should be done – no scope for a “beggar-thy-neighbour” set of nasty retaliatory exchange rate shocks to be set in train.

In real life, the situation is the reverse. It is so complex, as it was in the interwar period when analysts gradually learned about the nasty retaliation shocks. Today the world seems even more complex and confusing in that the authors are unaware of a single country, other than Singapore, that has ever had a majority of influential economists and policy makers deeming that its wage rate was low enough for international competitiveness.

Instead, virtually every country has the majority of its economists and other policy makers convinced that they are special, that they need others to appreciate (to avoid them having the

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<sup>8</sup> This process was helped by those who had ever favoured floats, those of the Chicago School who out their interpretation of the role of New York grain speculators entering the Chicago grain market in the 1870s, saw all speculation as stabilizing, as creating desirable new equilibria, eg Friedman (1953).

shame of depreciating). We hinted at this in the opening paragraph of this paper – in the example of the US which has a low unemployment rate compared to China, pressuring China to appreciate. Now not every single country in the world can be at a competitive disadvantage because of its high wages relative to the others. There is a situation in which we have to own that economists fail to be able to utility maximize – fail even in drawing conclusions about exchange rate levels.

In these complex situations neither we economists – nor other leading analysts and policy makers – grapple too well with the complexities. We fail to form an objective overview of the situation. In these complex situations, both countries' economists get angry via their opposite partisan Swan-Mundell vision of which way to move the exchange rate in order for the economy to move toward equilibrium. Both are distressed that the opposing country, the offending country, does not recognize their partisan equilibrium notion of how exchange rates should shift.

We economists do not even notice that we fail to aggregate consistently when giving our policy advice on matters that alter exchange rates. This is completely excusable. The world is very complex. Our mistakes in policy advice as an economics profession that is unable to consistently apply the concept of international competitiveness, add to the exchange rate shocks.

### **3.6 Laboratory**

A laboratory set up permits all the exchange rate shocks to be, as in reality, from humans who lack overall maximizing capacities. It permits for the ever fluctuating and evolving perceptions of humans. These could not be incorporated readily into any tractable theory, not even one that modified its random shocks to allow them to become non-ergodic shocks and introduced some learning processes. Shifts in these directions would be interesting in theorizing. An alternative is the laboratory. There all the decisions and thus all the shocks, as in reality, come from individuals, from their differing responses and interactions. The laboratory set-up allows for the complexity of decision making to cloud choices and perceptions and generate the shocks even as we see this happening in historical episodes. It allows us to see whether, when humans make all the decisions in complex situations, the extra instrument of moving the exchange rate really helps to restore international competitiveness after shocks. It allows us to check out the reverse hypothesis, that it renders the situation worse. This reverse hypothesis is hinted at in the ability of economists as a profession, to analyse consistently international competitiveness issues once we step outside the simple Swan-Mundell framework and have to apply the concept in a world muddied by many other complexities.

## **4 The Role of Central Banks**

It is simply a matter of the power of each country's central bank to produce its own currency that ensures that if any two countries agree to co-operate fully and totally defend any given exchange rate between them, no other central bank, and no private agent, can dislodge that exchange rate. Exchange rate changes undesired by one of the central banks come via lack of full co-operation from the other central bank, Eichengreen and Wylasz (1993). In turn this renders all exchange rate changes undesired by one central bank, a matter of less than full co-operation from the central bank of the partner currency.

The conflict or cooperation among central banks is routinely ignored. The reasons are fourfold: statements of central bankers; the clean float focus; the small country focus; the particular reaction functions used in big country models.

### **4.1 Central Banker Statements**

Some central bankers avow their powerlessness to determine the exchange rate. Acting alone this is true. A central bank hardly wishes to advertise that it is failing to obtain co-operation from a brother central bank. Only as a last resort when the conflict has flared to inter-government public rows, is this generally broadcast. Further, while fully co-operating central banks are unassailable, this does not mean that each knows by how much to intervene by the hour, or whether to supplement interventions with public announcements of support, or altering instead its domestic monetary base. These fine details are still in the exploring stage – even 35 years after the end of Bretton Woods. Thus the matter that two central banks that fully committed to each other are unassailable is the situation when viewed with respect to a reasonable stretch of time. There can be a window of a few hours, even days, when the exchange rate between two fully cooperating central banks diverges unintentionally through ignorance on how much and how fast to intervene / do swaps and so forth.

### **4.2 Clean Floats**

The second reason why the unassailable power of cooperating central banks gets ignored stems from a semi-closed economy perspective. This yields a policy of advocating clean floats, meaning ones in which the central bank pays zero attention to the exchange rate in using monetary policy to attain domestic goals, eg Carew (1985). A dirty float policy by contrast includes an exchange rate aim in the central bank's basket of goals. Once the international connections are accurately modelled, it becomes obscure what a clean float could mean, since the exchange rate affects in varying degrees all domestic goals. As awareness of this expands, usage of the term clean float has become less frequent.

The most persistent and influential group emanating from the clean float tradition are those who advocate reserving central bank policy for controlling the domestic inflation rate, eg Friedman (1953). This group has evolved away from monetary targeting as practised eg by Paul Volcker in his era as Chair of the US Federal Reserve System, to a focus on interest rates



as the engine of monetary policy. The "twin pillars" of the European Central Bank, suffer regular criticism for not being sufficiently transparently in the clean float tradition of caring only about the EURO inflation rate, eg EurActiv (2006). (Instead this bank has as its second pillar, economic and financial indicators – considerations so broad it can even include exchange rate targetting.)

Any sort of clean float focus – including the modern more sophisticated variant – deflects the adherent from noticing that accidentally, in pursuing exclusively their domestic central bank goals, clean floating central banks are major operators in foreign exchange rate determination. Let us illustrate with an application of Australia's clean float programme of the early 1980s alluded to in section 3.3. In reading the account, be wary of hindsight bias. The misconceptions and changing understandings of the Australian official sector are mirrored in academic writings of this era, and have marked traces still in our understanding as economists – in how we fail as economists to put due weight on central bank co-operation and conflict as critical to the history and theory of exchange rate movements.<sup>9</sup>

The Australian central bank had begun the era of a floating Australian dollar in 1982 embracing the clean float approach, though a clean float approach of a sort Friedman decried – one in which the goal was to boost employment prior to an election via an expansion in credit prior to an election. Its central bank markedly lowered the rediscount rate prior to an election. It accompanied the lowering, with statements to those incredulous inquirers that a government with a floating rate really meant to keep the rate low, that of course as an independent country pursuing a clean float, this was the course. There swiftly followed the depreciation unanticipated by the government.

Thus being a clean floater, and declaring this public in response to inquiries, could not and did not eliminate the Australian central bank's crucial role in affecting the Australian dollar. But the clean float focus had temporarily eclipsed from official thinking this reality. In the complex real world officials were immersed in "reforms" like floating, for which they were hailed as bringing independence to their country's central bank. In this complex situation the Australian officials had misinterpreted an independent free monetary policy as meaning that the central bank's action were irrelevant to Australia's exchange rate.

The Australian central bank then switched six months later in 1983 to being a dirty floater – to having exchange rate aims. It used its now understood power to unilaterally depreciate dramatically for a second time. It took monetary action to abruptly and massively depreciate to aid farmers in the grain export market who were suffering from a drop in world grain prices. A higher grain price in Australian dollars achieved by the depreciation would help the current Australian government get re-elected by these farmers.

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<sup>9</sup> Indeed throughout this paper, readers will notice that we largely refrain from giving examples from ourselves the academic community, in the belief that it is nicer for us to read about mistakes made by officials, not by ourselves. But the officials hire us, selecting primarily those perceived to be the best to help in a country's macroeconomic management – their errors are a mirror of the typical thinking of the economic profession in each era.

Now how did the Australian central bank manage to act unilaterally? The loss in competitiveness that the Australian depreciation imposed on competing US and Canadian grain exporters was not so marked that they effected retaliatory depreciations – or retaliatory subsidies. What thus operated were effects of complexity (much else was concerning the US and Canadian governments) and of Australia being in the grain export market a sufficiently small player that retaliatory depreciations did not ensue.

### **4.3 Small Country Focus**

That Australian deployment of its power to depreciate without retaliation is the mirror image of what entices us economists to overlook the unbeatable, invincible power of co-operating central banks to prevent a country unwillingly depreciating. Our economic modeling has focussed so much on the small country assumption, eg in the speculative literature, that we tend to overlook the scope for central bank co-operation in withstanding speculative attacks. It is true that utterly unlimited support of the partner central bank is rare, arguably non-existent. But last century and up to the 1<sup>st</sup> World War, sufficient support was the norm. The reality is that the gold standard worked via co-operation not via any automatic movement in prices caused by gold flows. It worked in the early 19<sup>th</sup> century via co-operation of France and the Bank of England. It worked later via co-operation of the big four co-operatively varying rediscount rates. It stopped when France was uncooperative in the 1920s, and the US a weak link. See eg Hook (2005), Butkiewicz (2005a, 2005b). In the monetary arrangements of the countries planning to form the inaugural EURO bloc, central co-operation episodically failed, and episodically succeeded, so that in the end some countries exited. But co-operation sufficed to get several countries over crises and into this inaugural EUR bloc, Eichengreen and Wyplosz (1993) and Cobham (1994, 2002, 2006).

### **4.4 Big Country Reaction Functions**

Sometimes we economists do make a big country assumption, and two or more central banks are modeled permitting co-operation and conflict effects to be studied. But here the reaction functions are based on the assumption that the central banks are expected utility maximisers employing (extended) Taylor rules. Such responses bear little resemblance to the motivations and decisions reached according to the minutes of central bank meetings and the other information documented in the references given in Parts 1 and 2 above. For every country, including for the frequently touted independent central bank of Germany, central bankers interact intimately with the government. Which side's view prevails is frequently a matter of personalities and of other political events.

This disjunction between theoretical models with simple fixed utility maximizing reaction functions of central banks on the one hand and the real world's murky complex decision processing is in part natural. What a difficult job, how seemingly impossible to capture this

complex set of considerations under any sort of theoretically tractable reaction function. For the early 1990s, how for instance might one theoretically model the role of Germany's central bank culture and the special personality of its governor, Otmar Emminger. Germany's government under Helmut Kohl was dedicated to the EURO, and to its being adopted by all in the EU. Yet in the run up to the EURO, under the Maastricht Treaty, Emminger managed to get Kohl's government to give it permission to renege on its obligations under that agreement, and so not necessarily support other countries committed to adopting the EURO if they faced a crisis, Eichengreen and Wyplosz (1993, p109). Further there is evidence supporting the hypothesis that the German central bank used this permission to push out of the EURO process those countries that it preferred excluded, Eichengreen and Wyplosz (1993, p111-2). This hypothesis implies that the German central bank's partisan approach to co-operation with EMS members in crisis had a key effect on their exchange rates during these years, and on which countries entered the EURO. Under a variant of this hypothesis asserted eg in Fischer (1993, p137), the German central bank sought to defy the German government and sabotage the move to the EURO altogether.

Hindsight bias might make it seem easy to model this sequence of events and to contend that all knew the power of Germany's central bank, and which countries it favoured. To appreciate that any notion of that this era in exchange rate history was easy to model / predict is only hindsight bias, think of other closely related predictions. Who believed 10 years earlier that the EURO could come about? We could print the names of all the international economists who went in print on its infeasibility, a far longer list than the few who in print declared it might happen. Who in the early 90s could have forecast which countries would survive the crises in exchange rates and political interactions – including Blair letting himself get talked into a EURO referendum – and be the actual set of formative countries constituting the EURO? Like complexities involving a mass of interactions, defy us to build theoretical models of central bank co-operation and conflict. Efforts in this direction would be fascinating. We encourage them. In the meantime, a laboratory experiment offers a fresh handle on the matter.

It allows for the distinctive personalities of those taking on the official and private sector roles to form group dynamics that differ over different sessions because of the different people playing these roles. It permits participants as central bankers to behave as in the theoretical models, namely maximising their set of objectives. It allows for participants to be like the real world central bankers, routinely making bad judgments (at least according to the studies such as Eichengreen and Wyplosz (1993, Cobham (1994, 2002 and 2006)). It can allow for a richer set of central bank objectives than is practical under normal tractability requirements. It can allow for the confusion and complexity that besets all decision makers who influence exchange rate determination, both the official and the private agents.

## 5 Hedging

Another difficulty in theoretical and econometric work on exchange rate determination is what to do about hedging by private firms. Explicitly or implicitly most theoretical and econometric work assumes that this is available. Further, many of these models assume that the forward and spot markets are connected to each other in ways contradicted by the empirical evidence – the hedging is available at a zero transactions charge. (In qualitative field work, the assumption is typically of a positive but minimal charge.)

Over the typical one year plus lag for trade and associated capital movements, the reality is quite different. Until very recently there have not been any publicly listed year plus forward rates. Over such extended horizons, what rates are available are at best available to giant multi-nationals, typically in the form of exotic derivatives. The complexities of these derivatives are hard for anyone to understand, even for a specialist on their production like Enron. This brought Enron into difficulties that could not be covered up by fraud indefinitely and finally pushed this firm out of business.

One complexity is that one cannot fully hedge in both directions in any satisfactory sense. Yet exchange rates are so uncertain, that uncertainty comes in both directions. In popular (non-rational parlance), where one may/will import, hedging is when, with a risk of the home currency depreciating, one pays a fixed sum to avoid this risk. In popular (non-rational parlance), speculation is when there is a risk of our currency appreciating, one borrows foreign currency to convert into home currency. But for a “rational” economist looking at opportunities foregone, there is no necessary difference in the riskiness or speculativeness of these two behaviours. If one fails to so-called hedge and there is a depreciation, one may be at a competitive disadvantage vis-à-vis other importers and fail to survive, but so also if there is an appreciation and one failed to so-called speculate.

Another complexity is that the hedging has to be for a specific amount. We are indebted to Peter Kenen (private communication) for this commonsense observation. At the time the firm should start hedging, it does not yet know how big its export sales will be in foreign currency, or if an importer how well its business will be going, and thus how much it will be importing.

To illustrate the complexities and costs of speculation/hedging, consider how often one reads of firms bankrupted / put into reconstruction through their errors. Long Term Capital Management misestimated the Ruble. Alan Greenspan speedily indicated to the company's underwriters that if they were not helpful in minimising the fallout, the US Federal Reserve System might make life difficult for them. Greenspan thereby can be seen as forestalling the risk of a 1929 style depression ensuing, Davidson (2005).

At about the same time, the giant Pasminco was convinced of a rise in the Australian dollar vis-à-vis the US dollar and took measures to protect the export value of its Australian zinc mines. In organising the agreement, it did not consider sufficiently the reverse risk, of instead the Australian dollar at that time depreciating, as happened. Pasminco went into reconstruction at a point when the receiver was unable to even estimate the billions of liabilities so generated – since some holding the other side of the derivative could wait indefinitely in the hope of yet further falls in the Australian dollar before seeking to cash in. Also about this time, the Australian Treasury had engaged in interest swaps due to its

expectation of an Australian dollar appreciation against the US dollar. When instead the massive depreciation ensued, it endured Parliamentary inquiries and the following testimony in the country's parliament from the country's central bank. If the Treasury were to seek to unwind its hedge act that had misfired, it might cause an altogether catastrophic drop in the Australian dollar.

In summary, in competitive market expected utility theory modeling it is assumed that firms have access to a rational forward exchange rate market, and can hedge with zero transactions costs in doing so. The stylised facts are the reverse. Most firms lack any access to a forward exchange market over the pertinent time span for trade and associated capital flows. The big multinationals can get forward cover for such extended horizons. But the process is so complex as to preclude analysts discerning whether getting forward cover is sensible, let alone a maximizing strategy. A laboratory experiment can avoid the assumption present essentially always implicitly that firms have access to a rational forward exchange rate market, and can purchase this cover at a zero transactions cost.

## **6 The Time Spans**

Trade effects of relative price changes such as those emanating from exchange rate changes lag price changes by over a year, Pope (1981, 1985), and those of direct capital investment would have even longer lags. But over the decades needed to get a satisfactory time series, much else will have changed muddying the econometric estimates, including fluctuations in exchange rate regime for many countries from clean to dirty floating and partially back again. The result has been a concentration on whether day-to-day or week-to-week volatility affects trade. Not surprisingly, the conclusion has been, only modestly.

A laboratory experiment frees us from this problem. We can make the periodisation compatible with the year plus lags that are pertinent. We do not need to model using a periodisation that is, depending on the particular study, between four and 365 times too short for being relevant for trade and associated capital flows. We can also fix the exchange rate regime, and avoid effects of exchange rate regime changes introducing heterogeneity into the degree of uncertainty that agents face. Thereby we can complement other ways being employed to get over the timing and regime change problems such as the gravity models with dummies brought into prominence by Krugman and applied to exchange rate effects in eg Rose (2000, 2004), Kenen (2002a), and Adam and Cobham (2005).

## **7 Transactions Costs**

Mundell (1961) focused on transactions costs as the plank of his arguments against multiple currencies. This has continued to be his focus, eg Mundell (2003). Others have recognized that both uncertainty and transactions costs impede trade and thus are grounds for more stable currencies, even currency unions, eg Adam and Cobham (2005). But in field data we lack more than qualitative means of separating out the two effects. In the laboratory by contrast, we can effectively exclude transactions costs in the sense that we can and do set the exchange conversion costs at zero.

## **8 Our Laboratory Design**

There have already been interesting experiments on exchange rates, eg Noussair and Plott (1995, 1997), Fisher (2001, 2005), Fisher and Kelley (2000), Cheung and Friedman (2005).

Our design differs for numerous reasons. One of these is our desire to examine sticky price behaviour (or its absence) in the context of wage bargaining, as this had been a prime concern of economists in Europe opposed to the EURO's introduction and sticky wages out of the wage bargaining process a lynchpin of the Mundell 1961 model that inspires much of the advocacy of floating exchange rates. A second is our desire to model shocks (supply, demand, expenditure changing, expenditure switching, domestic in origin, foreign in origin) exclusively as in real life, namely from human decisions. A third is our desire to enable central banks to conflict or co-operate, and to model the prime role of central banks in exchange rate determination – including under floats. A fourth is our desire to combine trade and capital flows. A fifth is our desire to mirror as far as possible real world complexity, including the official sector's multiplicity of goals.

### **8.1 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 and Selten forthcoming. More complex experiments have however been conducted in psychology laboratories on economic decision-making, eg Dörner, Kreuzig, Reither and Stäudel (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 analyzable with a game theoretic benchmark.

Despite simplifications, the set-up is sufficiently complex that we are unable to spell out a standard game theoretic solution. We restricted the complexity to what was teachable to advanced economics students for them to play it within a day, and analysable with a game theoretic benchmark of an incomplete equilibrium, designed by Reinhard Selten. It involves the non-cooperative Cournot equilibrium for final output, and a Nash bargaining solution in the nominal wage rate bargaining. The incomplete equilibrium does not specify choices at all information sets and allows a player to neglect those branches of the game which, on being reached by his actions could not improve his payoff, no matter what is assumed about unspecified choices.

### **8.2 The General Set-up**

Our set-up has two countries, symmetric in every respect, and thus suggestive of the UK and Germany, countries that are of approximately equal economic size. This is a matter of interest in that some economists, eg Cobham (2006), keep open the possibility that the UK might find benefits in joining the EURO. Vice-versa, for German industry, having the UK in the EURO is touted as the way to solve many co-ordination and other costs of complexity and uncertainty involved in trade at present.

We perform experiments with and without a currency union. In the two currency case, there is in each country: 1 government, 1 central bank, 1 union representative, 1 employer representative, 5 firms who buy local and imported materials produced under competitive conditions that are used in fixed proportions to produce a homogenous final good sold in a domestic Cournot market, with nominal demand set by the government. Firms face fixed costs, must produce at least a minimum amount, and face a capacity constraint on the maximum that they can produce. In the case of a currency union, the set-up is the same except that there is only one central bank.

### **8.3 Credit, Interest Rate Charges and Opportunities**

There is no cash, reflecting the fact that in advanced countries, only a minimal portion of firm working capital is in this form. Firms operate exclusively on credit up to their credit limit with their home and foreign bank. Firms thus face interest charges on their three inputs for producing physical output, labour, local materials and imported materials. Firms also face interest charges on their borrowings for hedging and speculative capital flows, and reap interest in the other country in which they lodge such borrowed funds. Interest is earned in the same period, and interest due must be paid in the same round. Sums on the foreign account however – debits for imported materials, and credits on capital invested abroad – only get repatriated in the next round.

Interest rates thus affect firm decisions in the standard ways. Higher interest on borrowed funds deters production and borrowing for hedging and speculation. But inter-country interest differentials entice capital flows. In their hedging or speculating in the current round, face uncertainty concerning both the current exchange rate, and because of the lag in the repatriation of profits on a firm's foreign account, the future exchange rate.

### **8.4 Exchange Rate Determination**

We impose a dirty float regime. If the two central banks have the identical aim for the exchange rate, they determine it, as in reality. In the case of central bank conflict, each central bank intervenes to support its exchange rate aim. Each bank automatically intervenes up to a set multiple,  $\zeta_1$ , 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. Each bank automatically intervenes up to a set multiple,  $\zeta_2$ , of its import price in the form of buying the foreign currency, if seeking to appreciate its currency against the wishes of the other central bank. 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 currency offers made by the firms and central banks of each currency. However if this ratio is outside the range set by the two central bank exchange rate aims, the central banks cooperate in keeping it at the nearest of their two exchange rate aims. It is in the common interest of both central banks to join forces to this extent against the firms.

## 8.5 Official Sector Tasks and Instruments

In addition to the government setting nominal expenditure for this round, the official sector, in the form of its central bank, sets its interest rate for this round and announces its price goal for next round and in the case without a currency union, its exchange rate goal for this round. 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.

Thus the goals were seven in the two currency case: 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. The specific penalties for the official sector deviating from each of its goals in our set-up were as in Table 3.

Table 3: Official Sector Objectives

|  |  |
|--|--|
| <u>Variables</u>   |  |
| $q$  | actual price of the home country consumption good  |
| $p_+$  | next period's goal for the price of consumption good   |
| $p$  | current period's goal for the 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  |
| <u>Parameters</u>  |  |
| $r_0$  | 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, $i = 0 \dots 5$ . The $b_i$ are positive constants, set respectively as 5, 6, 6, 3, 3, 1, 0.02 and 0.01                         |
| <u>Official Sector Objective function</u>  |  |
| $B = b_0 - b_1 \left( \frac{p_+}{p} - 1 \right)^2 - b_2 \left( \frac{q}{p} - 1 \right)^2 - b_3 (r - r_0)^2 - b_4 \left( \frac{m}{em^*} - 1 \right)^2 - b_5 \left( \frac{e}{f} - 1 \right)^2 - b_6 \max\{L_a - L, 0\} - b_7 \max\{L - L_b, 0\}$ |  |

## 8.6 Exchange Rate Targetting and Shocks

From Table 3, 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 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 unwittingly by the domestic official sector, and sometimes wittingly, sometimes unwittingly by the private sector. 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. We get a fresh perspective on whether dirty floating central banks can target their exchange rates in the way hypothesised in the model of Mundell 1961 – and in modern expected utility extensions thereof populated by EUT maximisers.

### **8.7 The Private Sector**

After the official sector has set its four targets and made these public knowledge, in each country the union and employer representative bargain over nominal wages. In this bargaining 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 profit of the firms deflated by nominal expenditure. If after the set time allowed of 10 minutes, an agreement had not been reached, there was strike, with both negotiators receiving zero pay. In strike periods there is an institutionally set wage, and firms are 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, speculate. In making their decisions the firms face two credit limits, one from their domestic bank and one from the foreign country's bank. Their credit limits are multiples of respectively the domestic and the foreign wage rate. Following their decisions, the currency market 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.

### **8.8 Exchange Rate Impacts**

When the exchange rate changes, this alters directly: a) the cost of imported materials; and b) any profits or losses from having invested local currency abroad – from having hedged

against a depreciation of the home currency); or c) any profits or losses from having invested foreign currency at home – from speculating on an appreciation of the home currency. Hence the exchange rate impacts *directly* on the economy via its impact on trade and capital flows, and *indirectly* on the economy via wage bargaining responses altering the costs of a firm's non-traded inputs (direct labour inputs, and indirect labour inputs via domestic materials that embody labour). Since private sector decisions have to be made *before* learning this period's exchange rate, and since profits are only repatriated from abroad at next period's exchange rate, private sector decisions are influenced by two anticipated changes in the exchange rate, those from: (i) last period to this period; and (ii) this period to next period.

## **8.9 Periods, Sessions, Independence**

A period is the above sequence of decisions and their outcomes played by both the official and private sectors. A period was played by the same participants 20 times, with a lunch break, typically after the 8<sup>th</sup> period. The first period was preceded by over 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 twelve such sessions run on 12 different days in 2003. Each of the 12 sessions contained different participants. Six of the sessions had two currencies. Six had only one currency, and only one central bank. This allowed us a comparison of the situation with and without a currency union. There is interdependence between periods in a single session: participants are influenced by what happened last period. This means that we do not have 12 times 20 = 240 independent observations. The interdependence of successive periods means that we have only 12 independent observations, so that only strong effects are detectable. The sessions were typically on Saturdays, since few participants were available for an entire Monday to Friday weekday. Participants were paid in accord with their task achievement.

## **9 Results**

In each session, we started play in the initial period in equilibrium, though not announcing this to participants. That is, if people recognized the exchange rate fundamentals and behaved as prescribed by the incomplete equilibrium solution, under the dirty float regime imposed, the exchange rate would float for all 20 periods at its initial rate.

### **9.1 Disequilibrating Exchange Rate Changes**

The rationale for flexible exchange rates is that these allow a rapid return to equilibrium if wages are sticky and there was a shock, and that in the absence of shocks, exchange rates are stable. But despite starting off in equilibrium, in a system with no external shocks and in this sense no grounds for exchange rate changes, in every session at least one central bank sometimes altered its exchange rate aim. Thus in every session, contrary to much standard theory, exchange rate changes can be described as not equilibrating, rather destabilizing. This accords with other experimental findings that EUT and game theory (which uses that axiomatic base also), is descriptively invalid, Selten (1997), and that assuming EUT yields biased estimates, Pope (2004).

### **9.2 Better Performance of the Central Bank under a Currency Union**

The exchange rate instability damaged governments and central banks in their goal achievement. This can be seen from the payoffs of participants acting as central bankers and

governments. Without a currency union, on average these each earned 74€ for the day. But with a currency union, government players earned 80€ and central bank players 85€. Performance as regards its various individual goals and their statistical significance is itemised in Table 4.

Table 4: Performance of the Official Sector

| <i>Penalties <math>B_i</math> for Falling Short of the Official Sector's Goals 1, 2, 3, 4, 6 and 7</i> |              |                 |              |               |                               |              |              |              |   | <i>Overall Success</i> |
|--|--------------|-----------------|--------------|---------------|-------------------------------|--------------|--------------|--------------|---|------------------------|
| Goals:   | stable aim   | Prices as aimed |              | Interest Rate | International Competitiveness | Employment   |              |              | $5 - B =$                               |                        |
| Currency   | $B_1$        | $B_2$           | $B_1+B_2$    | $B_3$         | $B_4$                         | too low      | too high     | $B_6+B_7$    | $5 + B_1 + B_2 + B_3 + B_4 + B_6 + B_7$ |                        |
| <b>Union</b>   |              |                 |              |               |                               |              |              |              |   |                        |
| 1  | -0.06        | -0.39           | -0.45        | -0.00         | -0.00                         | -0.83        | -0.18        | -1.01        | 3.09                                    |                        |
| 2  | -0.02        | -0.12           | -0.14        | -0.00         | -0.00                         | 0            | -0.16        | -0.16        | 4.56                                    |                        |
| 3  | -0.02        | -0.20           | -0.22        | -0.13         | -0.01                         | -0.01        | -0.33        | -0.34        | 4.07                                    |                        |
| 4  | -0.05        | -0.20           | -0.25        | -0.00         | 0                             | 0            | -0.34        | -0.34        | 4.16                                    |                        |
| 5  | -0.07        | -0.13           | -0.20        | -0.00         | -0.01                         | 0            | -0.07        | -0.07        | 4.53                                    |                        |
| 6  | -0.01        | -0.26           | -0.27        | -0.13         | -0.00                         | -0.79        | -0.03        | -0.82        | 3.51                                    |                        |
| <i>average of 1-6</i>  | <i>-0.04</i> | <i>-0.22</i>    | <i>-0.25</i> | <i>-0.04</i>  | <i>-0.00</i>                  | <i>-0.27</i> | <i>-0.19</i> | <i>-0.46</i> | <i>3.99</i>                             |                        |
| <b>Two Currencies</b>  |              |                 |              |               |                               |              |              |              |   |                        |
| 7  | -0.09        | -0.46           | -0.55        | -0.04         | -0.22                         | -0.13        | -1.09        | -1.22        | 2.43                                    |                        |
| 8  | -0.01        | -0.15           | -0.17        | -0.00         | -0.09                         | -0.03        | -0.21        | -0.23        | 4.35                                    |                        |
| 9  | -0.02        | -0.12           | -0.14        | -0.01         | -0.28                         | 0            | -0.24        | -0.24        | 4.19                                    |                        |
| 10   | -0.11        | -0.36           | -0.47        | -0.00         | -0.87                         | -0.64        | -0.01        | -0.64        | 2.55                                    |                        |
| 11   | -0.03        | -0.21           | -0.24        | -0.02         | -0.45                         | -0.07        | -0.13        | -0.20        | 3.85                                    |                        |
| 12   | -0.06        | -0.11           | -0.17        | -0.01         | -0.27                         | -0.01        | -0.62        | -0.63        | 3.76                                    |                        |
| <i>average of 7-12</i>   | <i>-0.05</i> | <i>-0.24</i>    | <i>-0.29</i> | <i>-0.01</i>  | <i>-0.36</i>                  | <i>-0.14</i> | <i>-0.38</i> | <i>-0.53</i> | <i>3.52</i>                             |                        |
| permtest   |              |                 |              |               |                               |              |              |              |   |                        |
| upper tail   | 0.23         | 0.40            | 0.37         | 0.78          | 0.001                         | 0.72         | 0.16         | 0.38         | 0.11                                    |                        |
| lower tail   | 0.77         | 0.60            | 0.63         | 0.22          | 0.999                         | 0.28         | 0.84         | 0.62         | 0.89                                    |                        |

The maximum payoff attainable by the official sector was 5. For  $B_i$ ,  $i = 1, \dots, 7$ , the symbol  $B_i$  denotes the term of the public sector goal function  $B$ , of Table 3 with the coefficient  $b_i$ , ie the penalties for shortcomings in meeting the individual goals,  $B_1$  of stability of price aim,  $B_2$  of the conformity of actual price with the price aim,  $B_3$  of the interest rate being at its desired level,  $B_4$  of competitiveness being maintained,  $B_6$  of employment being too low, and  $B_7$  of employment being too high. In each  $B_i$  denotes a subtraction from goal attainment. In calculating the overall success of the official sector, presented in the last column, there were no subtractions of penalties for failing to attain the exchange rate target. This was because this target,  $B_5$ , is absent in the case of a currency union. So there is some merit in making the assessment of the improvement in official sector objectives net of this additional burden borne in the non-currency union situation.

Sessions labeled 1 to 6 were with a currency union; sessions labeled 7 to 12 were without a currency union.

### 9.2.1 Statistical Tests

The payoffs of participants acting as central bankers and governments denote the official sector performance in each session. The null hypothesis is that these payoffs are identical with and without a currency union. In choosing statistical tests of whether the null is confirmed by chance, we restricted ourselves to non-parametric tests. These avoid assumptions on the functional forms of distributions.

#### The Perm Test

We performed a permutation test. Under this test we check whether the higher average payoff of the official sector with a currency union could be due to chance as follows. We

have 12 averages of official sector payoffs, six from the sessions with a currency union, and six without. We make each possible combination of those 12 sessional average sorted into two sets of six. We weight each combination by the number of permutations that would give that combination. For this total set of permutations, we compute the probability of getting the average at least as high as was the case with the currency union if the two populations were homogeneous. This probability is shown as the upper perm tail number in Table 4 for each individual official sector goal, and for the overall official sector performance. Conversely the probability shown in the lower tail is 1 minus this magnitude, ie the probability of getting a lower average than was the case with the currency union if the two populations were homogeneous.

### **Outliers**

The perm test is sensitive to outliers. To see this, let us take an extreme case in which there is a single ultra ultra large payoff for the official sector in one single currency session. This can yield the finding that the currency union is better for macroeconomic management even if the five other currency union sessions had lower average payoffs for the official sector than did the six sessions without a currency union. It is therefore desirable to do also a second (in some sense weaker) non-parametric test that is independent of the absolute payoffs for those cases found to be significant, to do a test that simply looks at the payoff ranking.

### **The Mann-Whitney U-test**

The Mann-Whitney test looks at the actual ranking of the payoffs from all 12 sessions and compares these with the other possible rankings. It ranks the 12 payoffs. It then computes the number of times in this ranking each of the six instances of the official sector's average payoff with a currency union is preceded by an average official sector payoff without a currency union. It then sums these and obtains a number. Let us term this  $n_{wu}$ . It also does the analogous sum for the non-currency union case, and obtains a lower number. Let us term this  $n_{nu}$ . It then constructs the set of all possible rankings and uses this to calculate the probability of getting the number  $n_{wu}$  as high as observed if indeed the two samples are randomly drawn from a homogenous population.

### **Two Tail Significance Levels**

The null hypothesis is that the exchange rate regime is irrelevant to public sector performance. In testing whether a currency union improves or detracts from official sector performance, we used 2-tailed significance levels. We do this because a 1-tailed test would fail to take into account that the two opposing hypotheses held by economists, one being that a currency union would worsen this performance due to inability to use the exchange rate to rectify some sorts of competitiveness shocks, and the other that a currency union would improve it by eliminating exchange rate uncertainty.

### **9.2.2 The Results**

As regards the six individual official sector goals remaining also with a currency union, the major gain from a currency union proved to be in the attainment of  $b_4$ , its competitiveness level. The improvement in competitiveness was significant at less than 1/2% level on the non-parametric permutation test. As this is sensitive to outliers, we also conducted a non-

parametric Mann-Whitney U-test under which it also proved significant at less than ½% level. Restoring international competitiveness is the grounds for having a flexible exchange rate, an extra instrument for managing the economy. Our results disconfirm this.

The currency union improved performance on attainment of all official goals except  $B_3$ , attaining its interest rate goal, and  $B_6$ , avoiding too little employment. However, on the official sector's pair of employment goals,  $b_6+b_7$ , the currency union's performance was superior. That is, with a currency union, prices were steadier and better predicted, the country came closer to its sum of employment goals, and there was an overall improvement over the whole basket of goals. However none of these other improvements in individual goal attainment or that in overall goal was statistically significant.

The results suggest that even when the official sector is short of instruments, having three less than its number of goals, it is better for it to lose its exchange rate instrument – even when as in most sessions, the exchange rate instability is minor. In a complex environment, adding even minor additional uncertainty of exchange rate changes reduces attainment of the government's set of price and employment goals.

The costs of this additional uncertainty lie outside expected utility theory. These costs stem from uncertainties in choosing among acts (strategies), and uncertainties in the interim between action and learning the outcome. The results indicate that we need a non-optimising approach to decision making compatible with SKAT, the Stages of Knowledge Ahead theory that adequately describes how humans cope with the complexity of the real world. This allows us to incorporate the benefits and costs prior to the period modeled in expected utility theory. These prior periods are when complexity takes its toll. Our findings accord with the complexity tolls of information overload in making predictions, Marey (2006), and in executives taking action, Omodei et al. (in press). The complexity toll gets overlooked when our chronological welfare analysis begins, as under expected utility theory, upon learning the outcome of risk taking, ie begins after the risks and uncertainties are in the past.

Our findings accord with the descriptive material furnished by ourselves and the other studies cited in this paper revealing that evaluating alternatives in a complex world is a big and costly stage in the whole decision process. It has been shown that evaluating alternatives is far too difficult a procedure for central bankers, governments, firms and their economic advisers to execute in the costless, instantaneous and maximising manner assumed under expected utility theory. Our findings accord with the hypothesis that the complexity of evaluating alternatives in the real world (as distinct from in simple abstract models) has deceived us as an economics profession. It has yielded inconsistent economic policy advice to diverse different countries on improving their competitiveness positions via maintenance of a floating rate to deal with shocks. Our findings tell against the continued use of maximising models under the expected utility theory umbrella that skip over all the tolls of complexity and uncertainty in evaluating alternatives and how this affects the decisions made.

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