

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

Working Paper

Prominent Numbers and Ratios in Exchange Rate Determination: Field and Laboratory Evidence

Bonn Econ Discussion Papers, No. 29/2006

Provided in Cooperation with:

Bonn Graduate School of Economics (BGSE), University of Bonn

Suggested Citation: von Hagen, Jürgen; Kube, Sebastian; Kaiser, Johannes; Selten, Reinhard; Pope, Robin (2006) : Prominent Numbers and Ratios in Exchange Rate Determination: Field and Laboratory Evidence, Bonn Econ Discussion Papers, No. 29/2006, University of Bonn, Bonn Graduate School of Economics (BGSE), Bonn

This Version is available at:

<https://hdl.handle.net/10419/22973>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

BONN ECON DISCUSSION PAPERS

Discussion Paper 29/2006

Prominent Numbers and Ratios in Exchange Rate Determination: Field and Laboratory Evidence

by

**Robin Pope, Reinhard Selten, Johannes
Kaiser, Sebastian Kube, Jürgen von
Hagen**

December 2006



Bonn Graduate School of Economics
Department of Economics
University of Bonn
Adenauerallee 24 - 42
D-53113 Bonn

The Bonn Graduate School of Economics is
sponsored by the

Deutsche Post  World Net

MAIL EXPRESS LOGISTICS FINANCE

Friday, 1st December 2006

Prominent Numbers and Ratios in Exchange Rate Determination: Field and Laboratory Evidence [†]

Robin Pope,¹ Reinhard Selten,²
Sebastian Kube,³ Johannes Kaiser,² Jürgen von Hagen⁴

1 Experimental Economics Laboratory, Bonn University; Address: Walter Flex Str 3, 53113 Bonn, Germany
Tels +49-228-731887, +49-228-4462880; Fax +49-228-4462881; Email 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

In the decision-making process, there is a stage when choosers evaluate alternatives. Evaluation is complex especially when it involves the future exchange rate. In the complexity of predicting the future exchange rate, choosers may use prominent numbers and ratios. We furnish field and experimental evidence of major effects on exchange rate determination from prominent numbers and ratios that constitute nominal equalities and historical benchmarks. Theorizing and estimation of exchange rates can be enhanced via SKAT, the Stages of Knowledge Ahead Theory that allows prominent numbers and prominent ratios to be taken into account consistently in constructing decision models.

Key words nominalism, money illusion, unpredictability, experiment, SKAT the Stages of Knowledge Ahead Theory, prominent numbers, prominent ratios, transparent policy, nominal equality, historical benchmarks, complexity, decision costs.

JEL Classification D800, D810, F310, F330

1 Introduction

This paper investigates how alternatives are evaluated. It identifies ways in which prominent numbers and prominent ratios enter the evaluation process and affect exchange rate determination.

The paper's layout is as follows. Part 2 introduces SKAT, the Stages of Knowledge Ahead Theory. It details the four stages through which a chooser progresses after encountering a problem, each stage pertaining to a change in knowledge ahead: stage 1 while the choice set is being discovered; stage 2 while the choice set is being evaluated; stage 3 while the chooser awaits learning the final outcome segment of the chosen alternative; and stage 4 by which stage all risk and uncertainty is resolved and certainty reigns. As our paper focuses on stage 2, the evaluation of alternatives, we take time to explain how EUT, axiomatised expected utility theory, excludes stage 2. We outline efforts made to remedy EUT so as to include stage 2 by (i) a supplementary procedure, namely Savage's clarifying sure-thing principle, and (ii) temporal backwards extension of EUT, and why efforts (i) and (ii) failed. In we detail the necessity of employing SKAT, to consistently include stage 2.

[†] We thank for comments Wulf Albers, and for funding the German National Science Foundation.

Part 3 demonstrates the need to move beyond EUT, to quit ignoring stage 2 and start analyzing how the stage 2 process of analyzing alternatives influences decision procedures. It does so via an account of the difficulties encountered by economists, central bankers and firms who need to predict the exchange rate in order to perform stage 2. Part 4 concerns nominalist heuristics for performing stage 2. It defines these as an excessive focus on some prominent numbers or prominent ratios and gives examples. Parts 5 to 7 concern the evidence of the decisive roles of particular nominalist heuristics in exchange rate determination. Part 8 indicates ways of incorporating these nominalist effects in our qualitative and quantitative investigations of the exchange rate process.

2 SKAT

SKAT, the Stages of Knowledge Ahead Theory, is presented in Pope (1983), and in more detail in Pope (1995) and Pope, Leitner and Leopold (2006). Summaries of the changing terminology for its components over the centuries of decision modeling as dated from Pascal's pioneering work in the 17th century are in Pope 1996/7 and Pope (2001). Just as there are many models within EUT reflecting differences in the decision situation and the choosers' von Neumann Morgenstern utility mapping, so also as illustrated in Pope (1995), multiple models conform to SKAT, reflecting the analogous differences.

Not all models lie within the SKAT umbrella. To be within the SKAT umbrella, the model must meet two criteria. First, it must conform to the pre-requisite of the decision maker facing risk / uncertainty. Second, it must be internally consistent about what the chooser and other relevant parties know at different times. Neither EUT nor its standard rank dependent extensions meet either of these two criteria. To explain these failures of EUT and much non-EUT theorizing to meet the basic standards of constituting a decision theory in the face of risk and uncertainty, we need first to consider what a chooser knows at different stages after encountering a problem until he arrives at certainty.

2.1 Four Epistemic Decision Stages

In reaching a decision, the chooser goes through a series of epistemic stages. To be an epistemic stage, it must be demarcated from the earlier stage and any later stage by a change in the chooser's knowledge. Let us take a firm for our chooser. As the firm solves each stage, something that before was unknown becomes known. If it has a change in its knowledge of the future – it has attained a new stage of knowledge ahead. There are multiple stages as almost hourly something new is learned. Here we outline major stages, major changes in the firm's knowledge ahead.

For the firm each of its decision-making processes begins with a recognition that the future is unknown because it has recognized a problem that may warrant action. When recognition is at an unconscious level, the subsequent steps may also be unconscious. In this paper we consider only decisions reached via a conscious process.¹

Recognition of a problem results in stage 1, research and negotiation to discover at least one available act. When the firm stops its search for alternatives, it has its first change in knowledge ahead – from ignorance of the alternatives, to knowledge of its choice set. It has entered stage 2.

In stage 2 it evaluates those alternatives in order to choose amongst them. After it has evaluated and chosen, it has a second change in knowledge ahead – from not knowing what it will choose to having decided this. It has entered stage 3. If it chose a risky alternative, it still does not know whether that chosen risky alternative will prove lucky.

Finally the firm learns whether it had luck. It thus has had a third change in its knowledge ahead – from ignorance of what will be its luck to full knowledge ahead, to complete certainty. It has entered stage 4, the final stage.

Before stage 4 is reached, there can be a multiplicity of each of the earlier stages, involving sub-acts. In addition Stage 3 may include numerous sub-stages simply because different aspects of the outcome may be learned or because the probabilities of the outcome space may be progressively revised. Choosers also sometimes have scope to revise the original decision, and thus go back to stage 2, or even stage 1. The economists' dictum, ignore sunk costs, if taken literally, can involve endless iterations of stages 1 to 3 so that stage 4 would never arrive with respect to anything. Law suits, human intolerance for nothing ever being learned, and such like factors however, keep real world agents away from implementing the economists' dictum to extreme extents. In many circumstances however, there is none of this moving backwards and forwards as regards stages 2, 3 and 4. Once a decision is struck, beginning stage 3, the chooser sticks with it right through to stage 4 when the risk / uncertainty of that chosen act is resolved. Such is in contrast to stages 1 and 2 where moving backwards and forwards is commonplace until stage 3 is entered, a decision struck.

2.2 Illustration

To illustrate the four decision stages – arising out of three principal changes in knowledge ahead – let our firm have already decided to import an item on credit for which it must later

¹ When the chooser is an organization, the issue of unconscious choice is that of its agent, or a set of its agents, unconsciously choosing. Neuroscience is embryonic on decision making. But much of the recent evidence points to the stages not being too dissimilar to those yielding conscious decisions, and to there being an interaction of the conscious and the unconscious decision stages.

pay the bill denominated in a foreign currency. It recognises the problem of what to do when exchange rates may change before the payment is due. It enters stage 1 of the decision process of ascertaining alternatives.

After the firm's first change of knowledge ahead, it has entered stage 2 – has decided what its alternative acts are. Suppose that it has decided that its alternatives are in three broad categories, Table 1.

Table 1
Firm's Choice Set

Broad Category	Number of Distinct Alternatives in this Category
1 <i>stay out of the foreign exchange market</i> and take what comes as the cost of the imports when the bill falls due.	One
2 <i>"hedge" against its own currency</i> in case this depreciates so that when the bill arrives it would otherwise have to pay more.	Numerous, as it can offer variable amounts of its own currency on the foreign exchange market up to its credit limit in borrowing from its domestic currency credit source, different exchange rate agencies to convert the funds and different ways of investing them in the foreign country.
3 <i>"speculate" on its own currency appreciating</i> and thus deciding to borrow money abroad and bring home.	Numerous, as it can decide to offer variable amounts of the foreign currency on the foreign exchange market, up to the credit limit imposed by its foreign currency credit source, and variable means of executing this and investing the speculative funds at home.

In stage 2 it evaluates these alternatives. When it has completed the evaluation and chosen one of the alternatives in Table 1, it has its second change in knowledge ahead. It now knows its chosen alternative. It has entered stage 3. Suppose it chose to hedge, ie an alternative in category 2. Suppose that within this category it decides to hedge to a limited degree by borrowing half the current value of the import bill in its own currency, converting this sum into the foreign currency for investment in the foreign country until payment for the imported item falls due.

In stage 3 the firm is waiting to learn whether its chosen alternative brings it luck. The alternative chosen brings it luck if it learns that its currency had depreciated at the time the import bill fell due. Stage 3 ends when the firm finally learns this exchange rate, ie has its third change of knowledge ahead. The firm has entered stage 4, the stage of living with the outcome of the risky / uncertain half hedge that it chose.

At the beginning of stage 4, the firm may learn it had luck, that its hedging reduced the cost of the imported good as its own currency indeed had depreciated. It may learn that it had bad luck, that its hedging increased its costs over the alternatives of doing nothing or speculating. After this third change in knowledge ahead its future is certain (as regards this issue). It has full knowledge ahead.

Tables 2 and 3 summarise the evolution of the firm's knowledge ahead. They divide up the firm's future epistemically – in terms of its stages of knowledge ahead.

Table 2
The Firm's Four Main Stages of Knowledge Ahead after Recognising a Problem

<i>Period</i>	<i>Activity Stage</i>	<i>Unknown</i>
1 Pre-Choice Set	Discovering Alternatives	Choice set
2 Pre-Alternative Chosen	Evaluating Alternatives	Chosen alternative
3 Pre-Outcome	Waiting to learn if had luck	Later Outcome Segments of Chosen Act if Act is Risky
4 Post-Outcome	Living with the Now Known Outcome of the Chosen Alternative	Nothing – full knowledge ahead, complete certainty (with respect to that problem)

Table 3
Three Anticipated Changes in Knowledge Ahead ΔK_1 , ΔK_2 and ΔK_3
(for a firm after deciding to import on credit)

ΔK_1	from	Pre-Choice Set	<i>Stage 1</i> : at best probabilistic knowledge of what inquiries and negotiations with banks etc might reveal is in the choice set
	to	Choice set identified	<i>New epistemic period starts, Stage 2</i> : now knows with a probability of 1 the choice set: do nothing, hedge or speculate, and the specific option details of each
ΔK_2	from	<i>pre-choice</i>	<i>Stage 2</i> : at best probabilistic knowledge about what the sub-acts of evaluating the alternatives will yield as a choice
	to	choice made: half hedge	<i>New epistemic period starts, Stage 3</i> : now knows with a probability of 1 that the choice is the half hedge and its specifics as regards risk, uncertainty of whether or not the hedge will turn out to have saved money
ΔK_3	from	<i>pre-outcome</i>	<i>Stage 3</i> : lasting until the exchange rate pertaining when the import payment falls due — only probabilistic knowledge of this future exchange rate and thus of which later segments of the outcome will be learned to be the chosen act's <i>actual</i> later segments of the outcome flow
	to	<i>post-outcome</i>	<i>New epistemic period starts, Stage 4</i> : now knows with a probability of 1 the exchange rate when the import bill falls due and thus the <i>actual</i> later segments of the outcome flow either saved money, or the half hedge increased the cost of the item imported on credit

2.3 Sure Alternatives

In Tables 2 and 3, all the alternatives in Table 1 are assumed to involve uncertainty, risk. For any in Table 1 to have been a sure alternative, our firm would have had to know with certainty the future exchange rate at the time when its import bill falls due for payment. As we shall see in Part 3, there does not seem to be any firm (or economist or central banker or government official) with a warranted belief in such certainty.

Suppose however that a firm believed it could predict this future exchange rate with certainty and also all the other features of the future pertinent to its half hedge, then (even if its certainty is unwarranted), it would anticipate its future as containing one less stage and one less change in knowledge ahead than is presented in Tables 2 and 3. Since it has chosen a sure alternative, stage 3 of Table 2 does not exist (is degenerate – of zero duration), and in Table 3, ΔK_2 likewise does not exist – our firm upon choice has leapt from stage 2 to stage 4, experienced ΔK_3 , full knowledge ahead. In summary, to choose a sure alternative is to skip stage 3. To choose a risky alternative – often done because there is no available sure one – is to go through stage 3, a period of positive duration, Pope (1985b).

2.4 Timing Consistency Issues

EUT embodies a false timing simultaneity in what the chooser knows. Thus in the initial full axiomatisation of EUT, von Neumann and Morgenstern (1944, 1947, 1953, 1972) assumes that, upon having chosen an alternative, the chooser will have all the risk resolved simultaneously, at a single future date. This is correct if all the alternatives in the choice set are of a particular sub-set of simple risky acts, in the case of choice of a risky alternative. But EUT includes sure alternatives. In the case of choosing a sure acts, the chooser knows everything earlier – not in the *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 that comprise the outcomes space being simultaneously known and not known. Yet epistemically, with one partial exception discussed in section 2.6 below, EUT's axiomatisation is atemporal.

This results in EUT's internally contradictory definition of risky alternatives – that a risky alternative is a probability mix of sure alternatives, Harsanyi (1977). This EUT definition mirrors the timing inconsistency in von Neumann and Morgenstern. It fails to discern the hallmark of risk – uncertainties or numerical non-degenerate probabilities denoting that the chooser only currently knows something probabilistically that later is anticipated to be learned with full certainty. It is a contradiction in terms to have the concept of a sure alternative – one know at the point of choice combined with the non-degenerate probabilities of a risky alternative, Pope (1985b). This timing inconsistency – this false simultaneity postulate – recurs in all standard rank dependent extensions of EUT such as cumulative prospect theory, Tversky and Kahneman (1992).

A prerequisite for avoiding such false simultaneity postulates is that at the point in time at which the modeling of the chooser's future begins, the chooser is aware that there is

something that he does not know, but will learn at a future date.² In turn this implies a positive time interval prior to the resolution of that risk / uncertainty enters the model – that the chooser’s outcomes flow must begin *before* stage 4 when all the risk / uncertainty will have been resolved. In other words the model must be epistemically time-wise consistent and thus contain a minimum of two distinct *epistemic* periods.

Bear in mind the qualifiers *epistemic* and *epistemically consistent*. 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 the chooser and other relevant parties know at distinct dates. In words, this means that no chooser holds or imputes to other relevant parties simultaneously degenerate and non-degenerate distributions over an outcomes space.

There is a problem of using theories like EUT that lie outside the SKAT umbrella since they embed timing inconsistencies. The problem goes beyond the aesthetics of liking consistency. Timing inconsistencies cause such theories to miss out on key causal chains pertaining to the risks and uncertainties that rational reasonable choosers consider. The remaining sections of this part of the paper illustrate these, and efforts to include what is missed.

2.5 The EUT Outcome Segment

Why EUT embeds timing inconsistencies relates to the fact that it contains only one distinct epistemic period. Utilities (satisfactions) are derived from outcomes. The chooser does not spring into existence in stage 4. The chooser has utilities (costs and benefits) from the beginning of stage 1. There is an outcome flow, with the first segment being in stage 1, the second in stage 2, the third in stage 3, and the fourth in stage 4. (Of course for some decision situations it is worthwhile to subdivide each of these epistemically distinct segments of the outcomes flow into smaller segments).

Its axiomatic base constrains EUT to include in its outcomes flows only the final stage of knowledge ahead, only stage 4 – only the last row of Tables 2 and 3, namely the outcome segments 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

² This is in the simplest risky / uncertain situations – in some more complicated ones, he may merely anticipate in the future having a change in his degree of knowledge of the outcome, and not anticipate ever knowing it fully – eg in cases where the outcome is the truth of a hypothesis that the chooser, a scientist, is investigating, Pope (1988).

segments that occur *after* all risk is resolved, Samuelson (1952a), 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 (1952a).³ Restrictions (i) and (ii) hold also for most extensions of EUT such as cumulative prospect theory. 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 three earlier stages implies that there are no satisfactions and dissatisfactions that should be considered by the chooser before the final era when all uncertainty is past. Thus EUT implies that there are no costs, no benefits in stage 1 of ascertaining the choice set, nor in stage 2 of evaluating each alternative in that choice set, nor in stage 3 of 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. (Stage 3 does not exist – is degenerate (ie of zero duration) – if a sure act is chosen.)

It might be thought that models within EUT can include all stage 4 effects. This however is not the case. The earlier stages 1, 2 and 3 all have historical legacies, ie effects on the chooser in stage 4, Table 4.

Table 4
Historical Legacies in Stage 4 from the Earlier Three Stages

<i>stage 1 that lasts until the chooser stops searching for new alternatives and declares his choice set.</i>	The historical legacies in stage 4 of his sub-acts of searching in stage 1 can include being blamed or praised (fired or promoted) for having failed to negotiate / discover or for having succeeded in negotiating / discovering desirable alternatives. He only experiences most of these historical legacies as late as stage 4 because it is only after the chooser and others notice that other alternatives not in the choice set would or might have been better or worse.
<i>stage 2 that lasts until the chooser stops evaluating the alternatives and makes a choice</i>	The historical legacies in stage 4 of the chooser’s sub-acts of evaluating in stage 2 can include being blamed or praised (fired or promoted) for having evaluated in a way that led to rejection of an alternative that subsequently (by stage 4) the chooser or other relevant parties learn would have been superior or inferior
<i>stage 3 that lasts until the risk / uncertainty in the chosen act is resolved</i>	The historical legacies in stage 4 of going through stage 3 of not knowing whether the chosen risky act’s outcome will be good or bad can include repayment of loans with a risk premium. Lenders charge our firm interest on funds borrowed to hedge or speculate – interest inclusive of a risk premium as the lender does not know for sure that our firm will repay. Our firm will only contingently repay – repay provided it is not bankrupt. Without a stage 3, interest repaid in stage 4 if the outcome is good enough to enable repayment, would be less. It would be a risk-free interest rate. (Risk premia have to be exogenous “somethings” not connected to risk in EUT models.) ⁴

³ See Pope (2004) on the alternative Ramsey version of EUT. His version has the like property of precluding attaching a different utility to an outcome depending on its degree of risk, uncertainty.

⁴ There is a literature of EUT-inspired models seeking to endogenous risk premia and related phenomena. These are valuable contributions, but ones hampered like the EUT-inspired search models by a failure to notice that they in fact contradict the EUT axioms.

For literature on the earlier stages outlined below and for literature on Table 4, see Pope (1995, 1996/7) and Pope, Leitner and Leopold (2006).

2.6 Models of Stage 3 Effects

As we noted in section 2.3, EUT fails to include even stage 3. It is instead as von Neumann and Morgenstern had observed a static, atemporal theory. Kreps and Porteus (1978, 1979) extended EUT to include some temporal features. They axiomatically derive a dated (temporal) version of the atemporal EUT property. They do so in order to obtain results that coincide with what a chooser employing SKAT might reasonably decide taking into account *one* of the stage 3 effects that EUT necessarily omits, namely planning difficulties. The Kreps and Porteus models succeed in making choices that coincide with those made under a rational model of SKAT for a limited sub-set of these planning difficulties. Further, this dated version of EUT has proved too complicated for general understanding or adoption. One recent extension of their approach is Klibanoff and Ozdenoren (2007).

Earlier, Keynes looked into stage 3 experiences of firms. It resulted in his constructing a non-EUT theory based on the risky or uncertain stage 3 that a firm endures when it chooses the risky act of production for investment, and a firm avoids if instead it chooses the safe act (according to his theory), of production for consumption. But Keynes' concern about stage 3 uncertainty effects has attracted only a limited amount of interest. See eg Keynes (1936, 1939) and Walsh (1996, pp52-65).

Von Neumann and Morgenstern had wanted to include stage 3 so as to include a set of satisfactions that they termed by various names including the specific utility of gambling. However they encountered a contradiction that they were unable to solve on this "level", and so left the task to future researchers, (1947, 1953, 1972, pp628-32). Pope (1985b) shows that introducing stage 3 permits the analyst to discern that during this stage the alternative (mutually exclusive) outcomes interact in the mind of the chooser since at this stage the distribution is non-degenerate. That distribution only becomes degenerate at the beginning of stage 4.

2.7 Models of Stage 1

Stage 1, identifying the choice set, has branched in three directions. One is into satisficing models, stop when a good enough alternative has been located, eg Simon (1955). A second is into aspiration-adaptation models, eg Sauermann and Selten (1962), Selten (1998). A third is inspired by EUT, but violates the EUT axioms as it concerns a stage before all risk is passed, these are models in which the search continues until the expected benefits of searching exceed the expected costs. Step 1 identifies some probabilistic benefits and costs of searching in a specified way. Step 2 identifies probabilistic benefits and costs of discovering with more confidence what those original probability distributions were, or of another way of search. This is an endless regress of evaluating more and more the

benefits and costs of search, Simon (1991, 1993). It avoids being an endless regress in actual EUT-inspired search models of stage 1 because (somehow in the unconscious) the searcher is assumed to know that certain formulae correctly capture these expected benefits and costs – and do not themselves require further search, further evaluation.

All three approaches to stage 1, satisficing, aspiration-adaptation and EUT-inspired search models are alike in that their current batch of models assume that stage 2 is non-existent, superfluous. All three assume that the chooser already has an evaluation of identified alternatives, of which to choose.

To see this, consider first the satisficing model of Simon (1955). It makes no distinction as regards the timing or the expense of identifying an alternative and being able to classify that alternative as either satisfactory or unsatisfactory. On locating an alternative, the satisficing firm thus has no need to evaluate it. On locating an alternative it has *simultaneously* and costlessly ascertained whether it is satisfactory.

Likewise in the path-dependent aspiration-adaptation model of Sauermann and Selten (1962) and Selten (1998), our firm would be assumed at every decision time point to have already an order of urgency as regards improvements and as regards retreats in its multiple-dimensional goal. Thus each time a firm completes its search procedure of discovering what is feasible, it has no additional stage 2 evaluation to do. If it discovered that moving up is feasible, it already knows that if it has to choose between different upward directions, which upward directions are higher on its urgency scale. Again, if retreating is all that is feasible, and it does not have to retreat in all dimensions, our firm already knows its retreat urgency scale. It has no need to do a stage 2 evaluation in order to discover its desired advance or retreat steps.

Similarly in the EUT-inspired search models, our firm already has its preference order. In these models often the alternatives are modeled as naturally uni-dimensional. Eg in the labour search theories, the alternatives may be net money amounts probabilistically received under each situation, simultaneously and costlessly evaluated by their expected utilities.

2.8 Literature on Stage 2

Research on evaluating alternatives includes learning, and whether choosers: 1, use integrated maximizing calculations and numerically weight the multiple dimensions of alternatives, eg Cyert and March (1963), Borchering and Winterfeldt (1988), Weber and Borchering (1993), Brandstätter, Gigerenzer and Hertwig (2006), Pope, Leitner and Leopold (2006); 2, edit out common components of alternatives, eg Birnbaum and Navarreté (1998); 3, structure by dominance, eg Huber (1982); 4, form reference points related to some status quo, eg Inder and O'Brien (2003); 5, use prominent numbers (see

section 4.8.2 below); 5 include anticipated risk and uncertainty effects of going through stages 2 and 3 prior to attaining the certainty of stage 4, eg Bell (1981), Pope (1983), Conlisk (1993), Pope (2001); Camille, Coricelli, Sallet, Pradat-Diehl, Duhamel and Sirigu (2004), Pope, Leitner and Leopold (2006).

2.9 Efforts to Include Stage 2 in EUT

With the satisficing and aspiration-adaptation models, there is no bar on extending the approach forwards to stage 2, the evaluation procedure. It is merely a matter that research on this extension is largely in the “planned to be done” basket. By contrast, quite a deal of literature already exists seeks on efforts to supplement or extend EUT so as to take account of stage 2.

As already explained in section 2.5 above, EUT cannot itself be extended backwards to include stage 2 since this would violate its axioms that restrict the outcomes flow to begin in stage 4. Such a backwards extension would be tantamount to elaborating or redefining the outcomes. Thereby the backwards extension would violate the axiomatic base given EUT’s constraints (i) and (ii) listed in section 2.5 above, Pope (2000). Further, even if one ignores the axiomatic constraints, using an EUT-inspired approach to stage 2 would simply re-introduce – but in a more salient fashion – the difficulties of those EUT-inspired search models of stage 1 (that violate the EUT axioms, and thus lie outside EUT). This is because an EUT-inspired stage 2 would need to involve expected utilities of the costs and benefits of doing a better evaluation. But as already discussed in section 2.7, this is an endless regress. Each set of such expected costs and benefits rests on an earlier set.

While EUT cannot be extended backwards to include stage 2, and while an EUT inspired stage 2 optimising model outside EUT would be subject to the endless regress problem, EUT’s need for a complementary stage 2 model is acute. It is far less plausible to be without a stage 2 process than under the non-optimising approaches of satisficing and aspiration-adaptation models. EUT without a complementary stage 2 model is implausible since under EUT the required knowledge of preferences is more precise and comprehensive than under satisficing and aspiration-adaptation models. EUT’s axiomatic base requires the evaluation of each alternative to be:

Condensable to a Single Dimension;

Numerically Precise – mappable into a *single utility number*, with the set of numbers unique apart from scale and origin; and

Comprehensive in

extent – there must be an evaluation of every *conceivable* alternative, not merely of every *actual* alternative, and

depth – each alternative must comprise chronological sequences of alternatives *to the end of the chooser’s life*.

The chronological depth condition stems from the admission of Samuelson and Savage that EUT gives implausible choices if repeat choices are permitted within a lifetime, Samuelson (1952b), Savage (1952b, 1954).

The technicalities of how a chooser could already instantly costlessly know his preferences over any infinite set, let alone know these with a reduction of his multiple goals to a single dimension with such precision and chronological depth has been a matter of interest. Supporters of EUT resort to a black box hypothesis of saying that somehow this happens unconsciously in the brain. EUT critic, de Neufville (1983), describes this EUT assumption of instant costless access to preferences so that zero evaluation of alternatives is required, as “look in a book” utilities. Black (1986) demonstrates that such EUT preferences would be beyond the capacity of any academic, even if the academics’ preferences to the end of his life simply pertained to ranking all the books in a small bookstore. Savage (1954, 1972) has admitted that EUT is too complex to use even for planning a picnic.

It has been easy to overlook how precise and comprehensive is the EUT preference condition, and thus to miss the force of the point being made by de Neufville, Black and Savage. It has been easy to overlook because economists typically formulate decision situations in which all the multiple dimensions of a book’s appeal to an individual, all the multiple dimensions of a firm’s goals rest unmodelled, and all the chronological depth complexity is non-existent. Instead economists have focused on situations in which the chooser’s outcomes flow is assumed to be already a univariate net monetary amount and chronological depth is almost a non-issue either because the chooser lives to eternity in an ultra simple ergodic world,⁵ or because the model ignores the EUT constraint of a single-for life choice, and concerns a one-off choice over a small world segment of the future.

The possibility of a small world variant of EUT was introduced by Savage. He hoped that appeal to a small world would make EUT more practical. But he consigned operationalising the notion of a small world to future researchers. He reported that he had found the matter of defining a small world compatible with the axioms too difficult, Savage (1954, 1972).

The small world that Savage failed to operationalise was not Savage’s only effort to address the obvious need for stage 2, for procedures for evaluating alternatives. His other effort was to go outside EUT and complement it with a different stage 2 procedure. To this end

⁵ The term was developed by the Moscow School of Probability in 1935. Ergodicity implies that samples drawn from past and current data furnish statistically reliable forecasts since economic time series are stationary. For critiques of EUT usage of the ergodicity assumption, see Davidson (1984, 1988, 1991, 1993, 1996).

he constructed what he described as an “extra logical loose” clarifying procedure, Savage (1954, 1972). He called it the sure thing principle.

The construction arose because at a Paris conference in 1952, Allais alerted him to the major issue of stage 2, of evaluating outcomes so as to have preferences, under EUT. Savage was startled to discover that his joint pair of choices to simple questions from Allais violated EUT. Savage concluded that he wished to obey EUT, but that he had made an error in stage 2, and wrongly evaluated the alternatives. He constructed his unaxiomatised sure thing clarifying principle to supplement / precede use of EUT. Friedman and Savage (1952) found the principle so enlightening that “the Greeks must surely have had a name for it”, the authors are unaware of its evidence of use in practice by firms. It is not invariably “clarifying” in the manner that Savage anticipated, Hagen (1972). Whenever it does “clarify”, it does so by truncating the probability distribution and generating an illusion of certainty. It clarifies by enticing the chooser to select an alternative because it is guaranteed, when in fact it is risky, Pope (1991). So the principle is irrational, something to be avoided by any sensible firm in its stage 2 evaluation process. Indeed it is doubly irrational for one like Savage wishing to obey EUT, since those axioms impose the condition that a person is indifferent between whether an outcome is risky or sure – a natural condition to impose when under EUT the only segment of the outcome flow included is that after all risk is passed, thus excluding considering of anything being risky, Pope (1991).

There is also the issue that the sure thing principle is at a level of generality that gives our firm no assistance in its particular evaluation task. Our firm has to evaluate exceedingly complex alternatives relative to the trivial social gambling alternatives that Allais posed to Savage. In Allais’ pair of alternatives, already the exact probabilities of all the outcomes were known.

By contrast our firm, with the choice set of Table 1, has to choose between the three broad categories: 1, do nothing; 2, hedge; and 3 speculate. Our firm needs to consider whether it seems more likely that its own currency will significantly appreciate or more likely that it will significantly depreciate. This is a daunting part of reaching a decision, costly and dangerous. It lacks the props of Savage in 1952 in choosing amongst Allais’ alternatives, the props of knowing *precisely* all the probabilities that are pertinent. Instead in stage 2 our firm has to *discover* what probabilities or qualitative likelihoods it should put on different directions and extents to which the exchange rate might move in order to get to first base in its evaluation process. This difficult process mirrors many other decision situations in which, stage 2, the evaluation process, is costly in emotional and material resources, Janis and Mann (1977), Simon (1991, 1993).

3 Difficulties in Stage 2 – in Predicting the Exchange Rate

How then should our firm perform its stage 2 evaluation of alternatives when this involves seeking to probabilistically predict the pertinent exchange rate? We shall devote the entire next part of the paper to the issue. Part 3 is devoted to illustrating the difficulties of our firm, and thus any chooser – whether a government a central bank, another firm or an individual – in making these predictions. We do so because stage 2 has been so trivialized or overlooked that it is easy for economists to miss the benefits of considering stage 2 in depth, and including it in their exchange rate analyses.

3.1 Fundamentals

Our firm might look to economists to help them predict which way and to what extent the pertinent exchange rate will move. Economists' theories of exchange rate determination have gone through at least four successive generations, Krugman (2001), Cheung and Dan Friedman (2005). They fail to perform better than a random walk if the exchange rate being predicted was averaged over a period of under one to two years – when tested out of sample on the next spate of exchange rate crises, eg Meese and Rogoff (1983), Krugman (1993), Pagan (1993), Chinn, Cheung and Pascual (2005), Alquist and Chinn (2006). Yet these theories had already been revised / replaced after earlier crises. We need now to await crises to ascertain if the latest generation fit out of sample better than a random walk.

The concept of an efficient market is one in which numerous EUT competitive profit maximizers use all available information in an efficient manner, Fama (1965). The concept has been applied to exchange rate markets. It has led some to contend that it is futile to attempt exchange rate predictions beyond accepting what the market gives as the forward rates, since these markets are efficient, eg Hu (1999), and that findings of inefficiency stem from using inappropriate tests, eg Wang and Jones (2002).

But the Fama concept of market efficiency is not a concept of the exchange rate simply being unpredictable, as hinted by the woes of economists' successive generations of exchange rate modeling. The Fama concept is an outcome of “rational” maximization of expected profits generated in the form of an equilibrium by a sufficient number of EUT agents. In turn this means that any contention that the exchange rate market is efficient is bedeviled by the question of what is the equilibrium that the market so efficiently hovers around, Levich (1989).

This equilibrium is unspecifiable until we identify the “fundamentals”. The “fundamentals” remain elusive until we can ascertain that our latest generation exchange rate theories really hold out of sample. Currently we have the situation where a test can find exchange rate markets “efficient” over time and across countries – but with the dilemma that the “fundamentals” are contradicted – that the signs of key “fundamental” relations are the reverse of those posited, eg Rapp and Sharma (1999).

In light of economist's failures to discern fundamentals, some economists continue to use the terms of an "overvalued" and "undervalued" currency to describe some theoretical equilibrium whose particulars are yet to be discovered. Others have altered the denotation of these words to reflect our failure to establish robustly details of equilibria. Eg Cobham (2006) defines these terms simply with respect to where the exchange rate had established itself for some earlier period.

3.2 Business Economists

Firms have access also to exchange rate predictions of business economists. After any sizable exchange rate change, many business economists speak of the change as correcting an over or undervaluation. In they use the language of "fundamentals" and connote that the sizable change was something that they had predicted.

Occasionally a journalist writes up the success record of a business economist who professes to understand the fundamentals and to use them in predicting exchange rates: it is shocking, worse than a random walk. But then such surveys cover less than a handful of business economists' predictions, and one cannot be certain that the analysis was representative of even that business economist. Perhaps if one had full access to all his predictions, one might discover that there were other predictions omitted from the journalist's analysis, that showed the particular business economist more often correct.

3.3 Technical analysts

A growing proportion of exchange rate dealer firms ignore fundamentals and sell predictions based instead on what has come to be termed technical analysis. This can include standard heuristics such as Sharpe and Treynor ratios and Jensen's alphas. It 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 predictions based on some variants of technical analysis have attractive statistical properties, eg Neely (1997), Osler (2000, 2003). But, as with the economists' models based on fundamentals, any technical analysis model faces the hurdle of being demonstrated to be robust out of sample. Moreover the hurdle is higher than barely beating the random walk. The public sector and firms engaged in real and financial imports and exports require models yielding a far higher level of predictability than this if they are to efficiently plan, and avoid massive losses - and a far longer time horizon than that for which technical analysis has attractive properties.⁶

⁶ Even as regards past data, there have been few efforts to compare the success of technical analysis and fundamental approaches in exchange rate predictions - there seems to be insufficient scientists with a mutual respect of both approaches to invest the effort in making such a statistical comparison.

3.3 Firm Failures

Firms also have access to confidential exchange rate models. These are not readily amenable to robustness checks by academics, so we judge them by our incomplete media information about the exchange rate profits and losses of those using these confidential sources. This information hints at firms lacking access to reliable exchange rate predictions, even when they are giant multinationals.

Firm losses on their foreign exchange accounts come often from efforts to hedge against exchange rate changes. Hedging for an extended period ahead is expensive, complex and not available to small firms, McKinnon (2005). The terms are mostly confidential, so that it must be hard for the firm's agents to even discern what is the relevant future's price for one's particular firm looking at its range of future dates that matter, even if it accepted the efficient market hypothesis. Further, all government inquiries of which the authors are aware, report market power in exchange rate spot and forward deals. Small firms seek to avoid being caught in one of these bubbles, and larger ones seek to avoid causing one of them. This adds to the complexity of their evaluations of each hedging and speculation alternative.

The media reports to us firm errors in their hedging and speculation moves. Around the beginning of this millennium for instance, the giant multinational in zinc extraction, Pasmenco, sought to hedge its Australian operations. It sought to hedge against the anticipated appreciation of the Australian dollar against that of the US – zinc being sold in the international market at US prices. It purchased an exotic derivative for this purpose. It however failed to consider quite how unpredictable exchange rates are under our current theories. Instead of appreciating at that time, the Australian dollar sank rapidly and drastically against the US dollar. The conditions of the purchased exotic were such that the company's liabilities rapidly exceeded its assets, forcing reconstruction. This is not an isolated case. Consider Long Term Capital Management's misprediction of the Ruble-USD exchange rate.⁷

3.4 Official Sector Failures

The official sector of a country has other confidential means of predicting exchange rate changes not available to the private sector. But their methods do not yield them reliable predictions of the exchange rate either as many of them admit. Central bankers bewail the

⁷ Beware of the hindsight bias in which everyone sees that Pasmenco was a fool in the exotic derivative it used in its attempt to hedge. In this context, one needs to bear in mind that Enron did not collapse solely through fraud. It collapsed partly also through the complexity and uncertainty of exotic derivatives being quite beyond the evaluation capacity of Enron employees (and most others).

inability of their research departments to furnish reliable exchange rate predictions, eg Jarle Berge (2006), and Deputy Governor of the Norwegian central bank, Roy Bridge (1998) then Governor of the Bank of England. This was not a one-off problem of the Bank of England, rather an enduring problem of being startled by sterling's exchange rate changes and never, not even retrospectively, succeeding in understanding them. See for instance the illuminating summaries of its Monetary Policy Committee minutes and other public sources concerning the mystification of the Bank of England on why sterling so dramatically appreciated 1996-8, then dipped, and why it had another dip in 2003, Cobham (2006). Paul Volcker, former Chair of the US Federal Reserve System, finds the unpredictability even by 2001, a ground for abandoning floats.⁸

Government treasuries (who via interest rate swap deals and so forth, acquire international currency / short term debt) suffer the same lack of access to reliable theories with reliable predictions on future exchange rates. Thus at about the same time that Pasmenco went into reconstruction, the Australian treasury incurred losses on its international portfolio at the beginning of this millennium, losses borne by the general taxpayer. The losses were so massive that the country's central bank deterred a parliamentary proposal to have the interest rate swaps liquidated on the grounds that the sums involved would likely cause a massive depreciation of the Australian dollar.

In summary, the matter of evaluating alternatives in a choice set, where the evaluation involves prediction of future exchange rates, is non-trivial. Organisations like central banks and large multinationals have little in the way of cash constraints on buying predictions from the top international academics and other sources. Yet even these entities have public records of making grave errors stemming from faulty exchange rate predictions.

4 Nominalism

Our firm has to evaluate in order to choose to do nothing, or to hedge, or to speculate. In this complex situation of needing to predict a future exchange rate in order to choose amongst its alternatives, what evaluation procedure might our firm adopt? We have shown in Part 2 that EUT cannot itself help, as stage 2, evaluating alternatives, lies outside its axioms. We have also shown that EUT-inspired approaches to stage 2 in the form of procedures that might complement EUT while distinct from EUT, namely the maximizing expected benefits minus costs approach to evaluation, and Savage's clarifying sure thing principle would be positively harmful for our firm. In Part 3, we have shown that our firm lacks a robust verified means of obtaining a probability distribution over the outcomes

⁸ On 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 when the associated exchange rate outcomes are unpredictable.

space of where the pertinent exchange rate might lie when its import bill falls due. It can resort to nominalism in forming this probability distribution, or in forming some qualitative counterpart of such a probability distribution.

4.1 The Concept

Nominalism we define as undue attention to prominent numbers and ratios – undue according to some economists. Now every theory abstracts, ie pays less attention to some numbers and ratios than would a less abstract theory that includes more of the cause-effect chains and more details on how each chain operates. All instances of decision-making, including those of scientists in constructing, using, testing and estimating theories exhibit nominalism. We cannot have a theory of what causes what without abstracting. What we term nominalism in this paper thus can also be termed abstraction.

There is however a distinction in connotation. The term abstraction has no generally accepted connotation of praise or blame in economics. It has often a neutral connotation. It has often a positive connotation, eg when scientists assert that abstraction is the essence of good theoretical and empirical work. It can have a negative connotation, as when scientists find some particular piece of theorizing so abstract that it “throws out the baby with the bathwater”. Einstein, quoted in Allais (1984) made such a criticism. Allais was quoting Einstein, since he wished to alert his EUT colleagues to the issue that EUT might be elegantly simple in its abstractness, but too simple to be useful for scientific purposes.

The term nominalism by contrast to the term abstraction, has *consistently* the negative connotation. We economists use nominalism to refer to instances in which *we ourselves* (as superior decision makers) *look down* on others who abstract inappropriately – who failed to consider as many factors as we deem pertinent. We also use nominalism to refer to instances in which we know that *other economists* would *condemn* decision makers for having inappropriately abstracted – even if we ourselves refrain from judging whether the abstraction was inappropriate, or even praise it.

4.2 The Rationality Issue

Keynes in 1936 gave centre stage to one form of nominalism, namely trade union leaders’ attention to the money wage number without equal attention to the associated cost of living number, in his *General Theory*. There are overtones of irrationality in Keynes terming this instance of nominalism “money illusion”. He did however argue that it was a sensible strategy for the trade union leaders. It was sensible due to aggregation effects from the wage bargaining outcomes of its different trade unions.

We likewise refrain from describing nominalism as *necessarily* unreasonable or irrational. There may be the sorts of aggregation effects that Keynes identified. Further, nominalism has the virtues that it saves on evaluation costs in ways not accounted for yet in most of our theorizing. We cannot avoid being nominalist. We are “guilty” of it whenever we theorise.

No theory includes all relevant number relations. Any theory abstracts and assumes some numbers move together when in fact they do not. Sometimes such nominalism captures the essential stylized features of the economy and renders understanding, robust predictions and policy advice. Sometimes it fails, and yields the reverse.

Nor can choosers making decisions outside economic research and policy work refrain from being nominalists. Thus issues concerning rationality can only be those of identifying when *more* nominalist techniques are superior to *less* nominalist ones, and of identifying among alternative nominalist technique that exhibit roughly the same level of abstraction, which are the superior ones. The answers will depend on the specifics.

4.3 Nominalism in the “Real” Variable Concept

There are of course numerous instances in which being more nominalist yields inferior decisions, inferior understandings and predictions. We give but two examples. Both have the irony that a nominalist short cut is given the positive connotation of being superior because paying attention to two numbers, not merely one, and as a consequence are called real, as distinct from nominal. Both however *in some situations* yield inferior decisions and inferior understandings compared to some less nominalist analyses.

4.3.1 The Real Interest Rate

The real interest rate is defined as the interest rate less the rate of inflation. It is a nominalist short-cut. There are numerous anticipated rates of inflation that might be used to deflate an interest rate. Each is highly controversial as it involves anticipations, and assumes that there is some particular set of prices whose future movement matters for all borrowers and lenders. The Australian Treasury for instance found on its investigations that introducing the nominalist short-cut of a real interest rate into economic incentives in taxation would be counter-efficient. But economists seeking the simplicity of tractable models, ignore such findings, ie ignore most of the variables and thus numbers that matter for borrowers and lenders, and rather routinely take the nominalist short-cut and analyse with “real” interest rates.

4.3.1 The Real Exchange Rate

The real exchange rate denotes the nominal exchange rate divided by either a traded goods price index; a consumer price index; a wage index; a wholesale price index, and also by various other domestic price indices. These diverse price indices typically move in markedly different ways. But it is quite common in both theoretical and empirical studies employing a “real” exchange rate to not even mention which particular price index was used to generate the “real” exchange rate. The nominalist practice of analyzing with “real” exchange rates thus ignores many other pertinent numbers. It ignores distinctions between prices for intermediate goods such as imports, exports, the prices for final consumer goods,

and the price of labour, and the disproportionately high use of importable and exportables by a country's import-competing sector.

As with "real" interest rate analyses, the defence is that it is less nominalist and thus more informative than simply using the nominal exchange rate. This however is not necessarily the case. The nominalist short-cut of analyzing the tradeable sector as if there were only one price deflator for all inputs and outputs of the import and export sector and the other complementary and competing sectors of the economy can yield false conclusions.

Analyses employing the nominalist "real" exchange rate yield the conclusion that the import competing local manufacturing sector benefits from exchange rate depreciations – and the IMF advice that countries seeking to expand local manufacturing ought depreciate. But for countries Australia, and some developing countries, this depreciation decision arising out of nominalist real exchange rate modeling is the wrong one to take. It contracts the local manufacturing sector, the reverse of the typical IMF goal, in countries where the export sector is primarily commodities (agricultural, mining and so forth) and exporters have expenditure-smoothing capacities. Commodities face wild price fluctuations and comprise primarily fixed costs. Expenditure from the export sector accordingly conforms to the Smithies-Friedman theory of insensitivity to short run profit fluctuations, Smithies (1945), Friedman (1957). The net effect is that the import competing local manufacturing sector whose costs are primarily importables and exportables, contracts markedly with depreciations (which raise costs but not demand), expands markedly with appreciations, Pope (1981, 1985a, 1987), Pope and Selten (2000).

4.4 Money Illusion

Evidence for nominalism can be found in the field and in the laboratory. As regards money illusion, there is qualitative field corroboration, eg Fisher (1929). There is econometric corroboration, eg estimates of the Australian consumption function, Johnston and Looker (1979). There is questionnaire corroboration over a range of hypothetical consumption and investment decisions, eg Shafir, Diamond and Tversky (1997). There is corroboration from laboratory experiments, eg Fehr and Tyran (2001), Mekvabishvili (2006).

4.5 Base Illusion

Some rank countries as having been more successful on the basis of growth rate number. They make no allowance for whether the country was in a recession or a boom in the earlier period taken as the base number. (Central Banks are also prone to present and analyse data in such a change format!) Such nominalism can yield copy-cat fluctuations in economic regimes. When one country is at the top of the league (often simply because in the base

period it had been performing badly), the other countries try to copy its industrial structure, attributing all its growth success to these industrial features. Thus when corporatist continental Europe and Japan were growing faster than English speaking countries, there was interest in changing the business environment in English speaking countries toward in the longer term investment perspective and the less hierarchical workplace structures of these countries and their lower percentage of managers, especially a lower percentage of managers from non MBA-style backgrounds. When later the US and the UK had growth spurts (after severe slowdowns), interest heightened in deregulating Japan and continental Europe so as to mirror the business environment in English speaking countries. Less nominalist economists warn against excessive copy-cat behaviour. They warn that undue attention is being paid to short-run growth rates in the countries growing fast. They warn that that ignores attention to other numbers, namely whether the base was temporarily unrepresentatively low due to a recession – low due to the country having been relatively undeveloped.

4.6 Inertia

Inertia after price incentives change is justifiable under assumptions of fully “rational” optimizing choosers who have costlessly precisely calculated all the costs of shifting to a new “equilibrium” and decided that the transactions and other costs exceed the benefits of responding, eg Constantanides (1979, 1986). But such assumptions are unrealistic: most inertia stems from nominal heuristics, from choosers who have limited recognition of the price changes, little knowledge of the transition costs of response, and so forth. Inertia leads them to simply consider the current numbers and number ratios.

4.7 Nominal Equality

When short of a means for progressing toward predictions, nominalism enters much of physics in the form of postulating symmetries between particular numbers, namely between a particular number of entities. In turn these can involve giving numbers to other ratios and quantities predicted (typically not prominent numbers). Symmetries and related aesthetics issues (such as simplicity and elegance) enter formal economic theorizing, Manne and Charnes (1952). In turn these often result in numbers being given to quantities.

Symmetries in the form of identity transforms – equality generators – are widespread in society where there is no clear fixed pie to divide up fairly, eg because of the irreducibly multi-dimensional nature of the pie. Civil, criminal and tax law often treats everyone identically in some dimensions. Organisations often impose identity on all employees as regards matters like working hours, holidays and sick leave. In negotiations, successful agents tend to structure their steps of retreat from their initial demands in a manner that,

among other things, enables in effect a 1:1 exchange of concessions as both parties retreat from their basket of initial demands to the final solution, Tietz (1972, 1982, 1997).

All these equalities involve nominalism in the sense that equality in one dimension generates inequality in other dimensions or from other perspectives. Eg the bargainers do not make equal concessions from every perspective; equality of income after tax would create inequality of effort pre-tax, and inequality of happiness post-tax, since not all have equal capacity to get the same happiness from the same income, and so forth.

4.8 Prominent Numbers

4.8.1 Historical Prominence

Decisive historical events lend prominence to some numbers and result in nominalist benchmarking. Eg typically the public has no precise notion of what prices were the previous week, month or year when inflation is mild and so operate for extended periods of time as if there were no inflation in their budget allocations and the resultant aggregate consumption flows, Johnston and Looker (1979). If however there is a change of currency, the public can remember prices vividly at the historically prominent date of the changeover. They benchmark inflation as the price increase since that changeover price number. The changeover date becomes progressively more distant.

This sort of nominalism has entered public perception of whether the EURO's introduction caused a price spurt. There indeed was such a spurt in the prices of some items. But the extent of the spurt and the range of items whose prices leapt (in those countries that failed to impose a price freeze) became exaggerated in people's perceptions, partly through a historical benchmarking form of nominalism. The public lacked comparable precision in their notions of how much prices had risen per week, year, triennium prior to the introduction of the Euro. Implicitly the public put that prior inflation rate number at zero in reaching their inference that the arrival of the Euro notes and coins has been inflationary, for Germany, Brachinger (2006), and in other countries that introduced the EURO, eg Cestari (2006), Marques (2006). When lacking such historical benchmarks of prior price numbers, provided that price changes do not show a dramatic systematic trend, there is evidence that firms also look at prices in levels, not in rates of change, Pope (1981, 1985a, 1987).

4.8.2 Prominence in the Numbers Themselves

Prominent numbers are those used more often than others. Which numbers are prominent depends (a) on culture, religion and scientific understanding as these determine which numbers are lucky, or sacred or have fiduciary power, (b) on the number system including whether it has a base of four, ten, or a unique reference value of the decision problem, and

(c) on the range within which numerical responses are selected. The restriction of attention to prominent numbers and prominent ratios – ie ignoring other numbers and ratios – can yield constancies, propensities to hover around some numbers and ratios, and equilibria in systems.

Prominent numbers are those used more often than others. Which numbers are prominent depends (a) on culture, religion and scientific understanding as these determine which numbers are lucky, or sacred or have fiduciary power, (b) on the number system including whether it has a base of four, ten, or a unique reference value of the decision problem, and (c) on the range within which numerical responses are selected.

Albers reached this set of conclusions from examining how in laboratory experiments participants used numbers. He extended prominence theory to a theory of perception and evaluation of numerical responses when monetary amounts, probabilities and time is involved, including theories of the evaluation of lotteries, and fairness in two person conflicts. He and others have found experimental evidence supporting the Albers Prominence Theory. It explains some laboratory data better than prospect theory or standard game theory Albers (1998b, 2001), Keser and Vogt (2000). Albers has also located field evidence, the clustering of German stock market prices, Albers (2001).

Also in English-speaking countries, in lay usage, the prominence structure of responses predicted by the Albers Prominence Theory has been found to be widespread. A team from the universities of Nottingham and Birmingham, found that numbers in contingent market evaluations asked of the lay public exhibit choice of the Albers prominent numbers, Whynes, Phillips and Frew (2005). Another team from the universities of East Anglia and Durham found that the tendency to choose the logarithmic Albers prominent numbers is more marked for health interventions and self-complete surveys than in face-to face interviews, Covey and Smith (2006). Joint work by the two teams, using questionnaires on students validated three key predictions of Albers' Prominence Theory, Whynes et al forthcoming.

5 Field Evidence of Nominalism in Exchange Rate Determinations

5.1 Exchange Rate Contracts

Nominalism enters exchange rate determination through the tendency to write international debt contracts in nominal exchange rate terms. Such nominalist fails to take into account the country locations of those engaging in the contract, the set of countries in which the lent funds will be spent, and the set of countries in which the borrower will subsequently spend the contingently repaid loan. It ignores the divergently moving pertinent price levels and

exchange rates should influence the exchange rate contract terms. (Economic modelling nearly always is only one step less nominalist – it tends to consider only the subsequent exchange rate cum price level of a single country.

5.2 Inertia

Pope (1981, 1985a, 1987) found evidence that import competing firms made their decisions on the basis of *current* relative prices, including on the *current* exchange rate. They did not employ less nominalist procedures of looking at the bigger range of numbers required to make decisions on past trends or prior fluctuations in either the exchange rate or in other pertinent relative prices.

5.3 Mythical Benchmarking

Money is fiduciary, as too are exchange rates. What generates trust, usage in a currency pertains to beliefs in a maintained order, in what are the fixed connections between numbers. As understanding of the world changes, previously conceived connections get condemned as mythical, as laughably nominalist.

Often opinion is mixed on what is mythical, what is real. Thus international investors hire chartists, and partially base their decisions on their advice, and chartist theories employ prominent number ratios and other connections between numbers. Many economists and others laugh at usage of such techniques, so that while they must have some impact on exchange rates, the over impact may be modest.

But when understandings are reasonably widespread, their impact on exchange rate can be decisive. We give but one example. Two widely used currencies in antiquity were gold and silver. The exchange rate of gold to silver remained for centuries roughly 13:1. This pertained to what today we might see as the mythical association of gold with the sun and the moon of silver with the moon and a scientific understanding of harmonies between celestial and earthly relationships. The sun takes one year for a cycle through the ecliptic where the moon completes 13 such cycles in this time. This exchange rate was maintained via the incentives for the production of gold and silver. This could be maintained for extended periods given the fiduciary role of any currency, and by many trusting / believing in the ratio of 13:1 being the natural harmony – the equilibrium. This prominent ratio of 13:1 has been one of the most enduring and decisive exchange rate determinants in history.

Prominent number ratios did not disappear from exchange rates with modern astronomy. Nor did they disappear with strains on the bimetallic gold-silver currency system due to massive new mineral discoveries altering their relative costs of production more than marginally. One continuing form of prominent number ratios is historical benchmarking.

5.4 Historical Benchmarking

Prominent numbers have been interpreted as determining whether an exchange rate would be politically feasible, enforceable, stable, or with a likely trend path. Thus a stumbling bloc to the early resumption of the gold standard after World War 1 – given the costs of the war to Britain and her consequent indebtedness to the US – was the following. Britain had suspended conversions of the pound into gold during the war. She wished to return to the gold standard soon afterwards, but found that the historically prominent number ratio, the pre-war ratio of the pound to gold was too high a ratio at which to return. The other key countries' central bankers, however, considered that a resumed gold standard with the pound at any other exchange rate to gold could not be credible. They thus virtually forced the delay in when Britain “went back on gold” until 1925, and forced her going back at that historically prominent number ratio. In turn, since that historical benchmark was inappropriately high, Keynes campaigned for Britain to go off the gold standard. Britain's departure from the gold standard ensued within a few years. Thus one can interpret that particular historically prominent number as causing a delay in the effective resumption of the gold standard, of causing the British pound exchange rate of the mid 1920s, and causing Britain's depreciation of her currency a few years later. This was an instance of a high exchange rate for the British pound being pressured on the United Kingdom. See eg Keynes (1971-88), Howson (1975), Earley (1976), Pope D and Pope R (1980), and Butkiewicz (2005a, 2005b).

Central banks after the demise of Bretton Woods, several countries retained a historical exchange rate from prior to the demise, or from some subsequent important date. Let us give two examples where the motivation of the unilaterally linking country, so far as we can glean from public information, has related to the promotion of exports. Austria maintained seven Austrian shillings to the DM essentially until the introduction of the EURO. Recently China settled on maintaining a historical benchmark of the Yuan to the USD, and only less than a year back, weakened this.

In other instances historical benchmarking stems neither from the credibility issues as Britain's return to the gold standard in 1925, nor from helping trade flows. Rather it stems from a country's citizenry's national pride and concerns about terms of exchange altering the distribution of wealth (and cost of imports). The most recent instance of this was East Germany. The exchange rate on unification with the west was set on a nominal equality basis, at 1:1 for prices, wages and savings blow a particular level, depending on one's status. Nothing else was deemed politically feasible, even if some argued this high value for the East German currency relative to that of West Germany would hinder East

Germany's economic catch-up. Savings above the designated limit moreover faced an exchange rate of 2:1 (two Marks to one DM), so here we have one more example of a prominent number ratio in the exchange rates employed in forming the re-united Germany.

5.5 Prominence in the Numbers Themselves

5.5.1 In Administered Exchange Rates

Prominent numbers often determine the exchange rate of a new currency introduced. Thus when the DM was introduced it was set at the round number of 4 DM to a USD. When it was decided that this was too high a value for the DM, the devaluation was another prominent number, a 5% devaluation. Likewise prominent numbers, not percentages with numerous decimal points, determined the size of other exchange rate changes during the Bretton Woods era. Prominent numbers continue to determine changes in pegs for those countries continuing on pegs or returning to pegs today.

5.5.2 In Speculation

Consider the technical analyst's prediction tools of a lower bound "support" through which a falling exchange rate is unlikely to lastingly pierce, instead on hitting this, likely to reverse, and of an upper bound "barrier" that an exchange rate is unlikely to lastingly surpass, instead on hitting it, likely to reverse. These lower and upper bounds tend to prominent numbers. In speculative exchange rate dramas, "breaking the barrier" of round numbers are headline news. Much interest was expressed when the Euro initially slid below 1:1 with the US dollar, and when it later rose above that nominal equality of 1:1. A US survey found that by 1996-7, usage of prominent number barriers and other forms of technical analysis had risen to be the main exchange rate prediction tool of 30% of exchange rate operators, Cheung and Chinn (2001). A British survey found that for predictions of under a week, technical analysis predominates, Taylor and Allen (1992). From a study of six technical analysis firms over 1996-8, Osler (2000, 2003) found that exchange rate dealers' attractions to the prominence of round numbers for these chartist "supports" / "barriers may be the cause of the clustering observed in currency stop-loss and take-profit orders. Thus relatedly she found some statistical support for the predictions furnished by this set of chartists / technical analysts on what sets exchange rates.

Osler's findings, however, like the media reports, pertain primarily to the ultra short run, durations of up to 15 days, with the focus on shorter durations of up to five days – not to any longer term enduring impact of the exchange rate over the period of concern to those involved in importing and exporting goods and services or longer term capital flows. There is a prevailing view that prominent number could not matter over these longer range horizons of a year plus would rest solely on fundamentals.

5.5.3 In Central Bank Rates

Official interest rates influence the exchange rate. In settings these, proportionate prominent numbers are the norm. This can be seen for instance in citations from FOMC archival notes of the US Federal Reserve, King and Goodfriend (2005). It can also be seen in the citations from the MPC minutes of the Bank of England, Cobham (2006). Market determined interest rates reported from these meetings are non-prominent numbers. But officially set interests rates are proportionate prominent numbers. The officially set rates rose or fell typically by 0.5% if a big change was selected, or by 0.25% if a small change was selected.

5.6 Nominalism a Missing Link?

Does nominalism have overall systematic effects on floating exchange rates – in particular effects sufficiently enduring to matter for those involved in importing and exporting goods and services, and in capital movements concerned with returns over this intermediate time horizon? We might seek to infer this from the exchange rate prediction success of economists' public access theories of exchange rate determination. These theories ignore stage 2 of the decision process, and thus the role of nominalism. So if they predict well with robust statistical properties, it would seem that prominent numbers and nominalism only enter exchange rate determination episodically. As described in Part 3 above, we lack out of sample evidence that even the latest generation theories predict well. There is thus a possibility that the unreliability stems partly from omission, or inappropriate methods of inclusion, of the phenomenon of prominent numbers and nominalism effects.

However a leap to the conclusion that the unpredictability of exchange rates directly relates to their omission of nominalism is to ignore other issues that might explain the unpredictability. First these theories also omit stages 1 and 3 of the decision process. Second these theories are estimated as if exchange rate regimes and numerous other influences were stable for sizable periods, when in fact these influences were changing frequently. Third it could be that there is nothing systematic to be discerned in exchange rate movements, as argued under the efficient markets hypothesis.

6 Laboratory Experiment

A laboratory experiment allows for changes in the stages of knowledge ahead. Where there is sufficient time in a single experiment, it can allow for all stages, including stage 1 of discovering via research and negotiation, the choice set of each agent with a specific role, eg as the government, the central bank, a firm, a wage bargainer. Where experimental participants cannot be kept for this long, our case, the laboratory set-up fixes the choice set

of participants in each role, ie cannot investigate stage 1. But it can investigate the risk and uncertainty effects of the later stages 2, 3 and 4.

A laboratory experiment allows us to hold the exchange rate regime and other influences constant so that the estimates are not bedeviled by violations of the “other things constant” assumption in seeing whether the resultant exchange rate is white noise, as under the efficient market hypothesis. It thus lends insight on whether and how prominent numbers and prominent number ratios enter exchange rate determination in a more general and systematic manner than the specific ways identified in Part 4 – and enter it over the medium term time horizon involved for international trade in goods and services and the associated medium term horizon capital flows.

Our design seeks to capture corporatist union-influenced continental Europe. Output prices are determined in a domestic Cournot market with five firms in each country, 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 their exchange rate targets, and we vary the degree of transparency.

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 complexities that generate the phenomenon of prominent numbers and nominalism. 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). It is perhaps the most complex experiment performed in an economics laboratory other than those on the Sinto market, Becker and Selten (1970), Becker et al (2006). More complex experiments have been conducted in psychology laboratories on economic decision making, eg Dörner, Kreuzig, Reither and Stäudel (1983) and MacKinnon and Wearing (1983).

We restricted the complexity to what was teachable to advanced economics students for them to play it within a day, and analyzable with a game theoretic benchmark of an incomplete equilibrium. This incomplete equilibrium involves the non-co-operative Cournot solution for final output, and a Nash bargaining equilibrium in the nominal wage rate solution. This equilibrium in an incomplete mode was constructed for the design by Reinhard Selten. 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.

There are two countries (the limit of our laboratory space of 18 seats, 9 for each country), each with its own currency, symmetric in every respect. 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 that are used in fixed proportions to produce a homogenous final good sold in a Cournot market, with nominal demand set by the government. 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 can hedge or speculate 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.

6.1 Central Bank Intervention

If the two central banks have the identical aim for the exchange rate, they determine it. It is, as in reality, only in the case of conflicts between central banks / lack of co-operation that firms have an influence on the resultant exchange rate. In the case of central bank conflict, each central bank intervenes to support its exchange rate aim. It automatically intervenes up to a set multiple, ζ_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. It automatically intervenes up to a set multiple, ζ_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.

6.2 Official Sector Tasks and Instruments

The government sets nominal expenditure. The central bank sets its interest rate and announces its target price for the next period (not the current period), and its exchange rate aim. With these four instruments, as in real life, the official sector has seven goals: 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; and 7, avoiding unduly high employment. 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 5, including the real life issue of a higher penalty for too little employment than for too much.

Table 5: Official Sector Objectives

<u>Variables</u>	
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
<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, $i = 1..5$. The b_i are positive constants, set respectively as 6, 6, 3, 3, 0.02 and 0.01
<u>Official Sector Objective function</u>	
$B = b_0 - b_1 \left(\frac{p_+}{p} - 1 \right)^2 - b_2 \left(\frac{q}{p} - 1 \right)^2 - b_3 (r - r_0)^2 - b_4 \left(\frac{m}{em^*} - 1 \right)^2 - b_5 \left(\frac{e}{f} - 1 \right)^2$ $- b_6 \max\{L_a - L, 0\} - b_7 \max\{L - L_b, 0\}$	

6.3 The Private Sector

After the official sector has set and announced its four targets, in each country the union and employer representative bargain over nominal wages. These are the only players who can communicate within a round. Their communications are in the form of computer entered text messages, wage offers and demands public to all. These are thus the only players for whom there are series of numbers, in the forms of offers and counter offers and associated words, *within* a round. The union representative's payoff is real wages measured as nominal wages deflated by the announced official sector target price, while that of the employer representative, is the profit of the firms deflated by nominal expenditure. A strike ensues if after the set time allowed of 10 minutes, an agreement had not been reached. Then both negotiators receive zero pay. In the case of a strike, there is an institutionally set minimum wage that is a fixed proportion of the target price, and firms

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

Once the wage rate is announced for both countries, firms decide 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. The currency market then sets the period's exchange rate. Next the consumer market sets the consumer price, followed by firms paying for last period's imported materials, and profits flowing to the firm's owners.

6.4 Rounds Interdependent, 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 20 times by the same participants, with a lunch break, typically after the 8th round. A session was a sequence of 20 rounds

The rounds of a single session are interdependent, having in each successive round the same people and some common history. The first round 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 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, 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.

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. To the contrary, 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 according to their task achievement. Their 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.

7 Results

7.1 The Move of the Exchange Rate Toward 1:1

Play started in round 1 of each session in equilibrium. Starting in equilibrium, if nominalism does not operate, and standard game theory holds, we should anticipate no change in the exchange rate throughout the 20 periods. We should also expect no change if under two heuristics that choosers might employ in stage 2 of evaluating their alternatives and the likely future exchange rate, namely inertia and historical benchmarking (since the opening exchange rate is the only striking historical event). A session with no changes in the exchange rate was not observed however. In every session the exchange rate changed.

The actual exchange rate is determined in this experimental set-up by decisions of the participants in the manner explained above in section 6.1, in effect the *ratio* of currency offers made by the firms and central banks of each currency. Participants' choices of prominent numbers (by nominal equality or by historical benchmarking or by the mechanisms described in section 4.8.2 above) do not yield a prominent number for the exchange rate since this is the ratio of two sums of prominent numbers. But participants' choices swayed by such forms of nominalism can cause the exchange rate to move in a particular direction.

As measured by e , the number of unit of home currency needed to buy one unit of foreign currency, from the perspective of one country, in the starting equilibrium the exchange rate was 1.4. Thus e , from the perspective of the other country, its partner in trade and capital flows, was the inverse of this, namely 0.7143. The exchange rate has the lower bound of zero but no upper bound. The rule of Albers for finite rangers cannot be applied. One cannot select the 3 to 5 most prominent numbers among the positive integers.

For a pair of countries viewing their exchange rates as respectively 1.4 and 0.7143, what then becomes prominent when the upper bound does not exist? One possibility is that inertia or historical benchmarking takes centre stage, with the exchange rate being regarded as equally likely to go up or down, so that player have a tendency not to alter the initial exchange rate. The other possibility is that nominal equality takes centre stage, with 1:1 becoming the prominent ratio for the exchange rate.

If the nominal equality of 1:1 did not exert any attraction, and instead the exchange rate changes involved random fluctuations, we should anticipate the final exchange rates to be equally likely to lie above or below the original exchange rates. This however was not the case. In each of the nine sessions, the exchange rate had moved in the direction of 1:1 by the last period, the 20th session. See Table 6, where all exchange rates are expressed from the perspective of country A, ie as beginning at 1.4.

Table 6
Exchange Rate Progression toward 1:1

<i>Exchange Rate Aim</i>	<i>Public Knowledge</i>						<i>Known only in the Official Sectors</i>		
<i>Session</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>
Start in equilibrium	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
20 periods later	1.2	1.14	1.2	1.12	1.19	1.01	1.39	0.96	1

Using the binomial exact test statistic, the probability of this uniform decline being by chance – and not due to nominalism – is 0.002, one-tailed, details in the Appendix. The results thus reveal the pronounced influence of the prominent nominal equality ratio of 1:1 on exchange rate determination. On superficial inspection it seems that players selected Albers-style prominent numbers for all its prices and quantities. But there are altogether over 6,300 final number choices, and many times more in tentative number choices within rounds.

It will be an interesting future project to investigate whether the Albers Prominent Numbers Theory holds for firm choice of production quantities that have specific upper and lower bounds. It will be also an interesting future project to do two things. First extend his theory with a nominal equality / fairness benchmark with potentially nominalist traits, to the majority of these other prices and quantities that lack specific upper and lower bounds. Second see for which roles the extended theory holds.

Despite the marked trend toward the nominal equality of 1:1, apparently aided by both firm and official sector anticipations in this direction, predicting the exchange rate eluded firms. They predicted its changes no better than a random walk, Kaiser and Kube (2005). This accords with reality, insofar as we can glean it from the incomplete records of firm failures in their exchange rate predictions reported in Part 3 above.

7.2 Effect of Transparency in Central Bank Exchange Rate Aim

Consider now where along the spectrum from the initial exchange rate of 1.4:1 to the nominal equality of 1:1 countries had moved by the 20th round. The transparency or otherwise of central bank exchange rate aims seems to play a role.

7.2.1 The Non-Transparent Situation

In sessions 7, 8 and 9, the central bank exchange rate aims of the two countries are veiled from the private sector wage bargainers and firms. In this veiled condition, the outcomes are extreme. Either there is virtually no movement toward 1:1, session 7. Or full

movement to 1:1, session 9, or even “overshooting, session 8. In the additional complexity therefore participants may be interpreted as focusing their attention on either of two simple exchange rate prediction heuristics – inertia, or moving fully to the symmetric 1:1 exchange rate.

7.2.2 The Transparent Situation

In sessions 1 to 6, the exchange rate aims of the two central banks are public knowledge. In this transparent and less complex situation, there is less of a polarization. The move from the initial exchange rate of 1.4:1 in the direction of nominal equality with 1:1 is typically intermediate. Let us divide the distance between 1 and 1.4 into four quarters, and term the two middle segments “intermediate”. Then in five of the six sessions the exchange rate on the 20th round lies in the intermediate segment. The outlier is session 6 which moved virtually the full distance to the prominent number 1:1.

7.2.3 Polarisation and Transparency

We may then hypothesise that non-transparent exchange rate aims generates more polarization. We can test this against the null hypothesis that the degree of transparency of the exchange rate aim has no impact on polarization as measured by the proportion of exchange rates in the intermediate segment of exchange rates between the initial exchange rate of 1.4 and the symmetrically prominent 1:1 exchange rate – ie as the proportion lying in the range of 1.1 to 1.3. The probability of the null hypothesis that the non-transparent condition derives from a population with no greater a propensity for distribution outside this intermediate segment than for the transparent condition is under 5% on fisher’s exact one-tailed test, details in the Appendix. This hints that either nominalism or another rule of thumb, staying put, plays an even bigger role when the complexity, and thus uncertainty, in the situation rises.

8 Conclusions and Modelling Implications

Decision makers, including those who set exchange rates, need to evaluate alternatives. This evaluation is stage 2 in the four stages through which decision makers progress after encountering a problem. It is a stage that EUT, axiomatised expected utility theory, excludes, and as traced in Part 2 of this paper. In this part we also traced how, despite numerous efforts to find an evaluation principle complementary to EUT, including Savage’s clarifying sure thing principle, it has proven elusive to combine an evaluation stage with EUT. In Part 3 we surveyed the extreme difficulties of economists, central bankers, governments and firms in predicting exchange rates and thus performing stage 2, evaluating alternatives.

This paper employed a consistent framework for integrating stage 2 into decision models, namely models within SKAT, the Stages of Knowledge Ahead Theory, Pope (1983, 1995) and Pope, Leitner and Leopold (2006). Within this theory, we could recognize the necessity for new decision models that incorporate the heuristics that economists themselves and others employ in performing stage 2. We have concentrated in this paper on nominalistic heuristics.

In Part 4 we traced the use of nominalism by all decision makers, including academic economists in performing stage 2. We showed that the matter is not one of nominal processes being avoided, as this is both impractical and contrary to the scientific spirit of abstracting in order to discern more major causal effects. As economists, our job is to recognize the role of nominalist heuristics in all our analyses, whether descriptive or prescriptive. It is our task to discern when our own or other's nominalism is excessive for the purpose at hand, and should be replaced by a richer, less abstracted modeling of cause-effect chains. We identified different sorts of nominal heuristics employed in decisions that economists study.

In Parts 5 to 7 we presented field and experimental evidence on how a range of nominalist heuristics affect exchange rates. Below we summarise these findings and indicate how they may assist in future investigations of exchange rates – may assist a little in increasing understanding of exchange rate changes, and less certainly assist a little in reducing the unpredictability of exchange rates.

8.1 Nominalism via Prominence in the Numbers Themselves

Administered changes in actual exchange rates are limited to prominent numbers, section 5.5.1 above. Speculators take an active interest in prominent numbers, section 5.5.2 above. Prices and quantities set by participants that enter the actual exchange rate process such as central bank administered interest rates are also limited to prominent numbers, section 5.5.3 above. Likewise in our laboratory set-up, the numbers chosen by participants for quantities and prices that enter the exchange determination were prominent numbers.

Econometric estimates in other areas have been enhanced from recognizing that variables have assume values that are discontinuous over the real number line. Likewise theorizing and econometric estimation of exchange rates might thus benefit from imposing prominent number restrictions on administered exchange rates, and on some of the determinants of floating ones. It might also benefit from investigating prominent numbers as speculative attractors, repulsors, and investigating Albers Prominence Theory for ascertaining what numbers are prominent.

8.2 Nominalism via Inertia

Pope (1981, 1985a, 1987) found in field data in the complex situation of a variable exchange rate, the nominalist benchmark of inertia in exchange rate expectations comes into play, as also for some other relative prices that enter exchange rate determinations, section 5.2 above. Changes in production were based on the current exchange rate, not on extrapolating past exchange rate trends. In our experimental set-up, for the reasons given in section 7.1, it is infeasible to distinguish the inertia effect from either the game theoretic equilibrium exchange rate being an attractor, or the attractor being another form of nominalism, namely historical benchmarking. One however of these three effects – likely inertia – operated substantially, in that in one session by the final 20th round, the exchange rate had hardly moved, and that in most other sessions, it had moved only an intermediate distance to the attractor of the prominent nominal equality ratio of 1:1.

This suggests that there is room for a re-investigation of the common practice of assuming that expectations not pertaining to “fundamentals” are based on past trends. In complex environments without marked steady trends, an inertia attractor may be worth investigating for exchange rates along with the other attractors identified in this paper and summarized in sections 8.3 and 8.4 below.

8.3 Nominalism via Historical Benchmarking

Episodically, mythically and historically prominent exchange rate numbers have had decisive effects on actual exchange rates, effects that it was feasible to distinguish from inertia or a notion of the “fundamentals” being in equilibrium. Most of the instances cited in sections 5.3 and 5.4 above, the mythical or historical benchmark was not simply an influence, but virtually totally determined an exchange rate, often for a very extended period.

Including such idiosyncratic effects in exchange rate modelling on any extensive scale would be demanding. Further including them goes against the ambition of many economists to model or estimate “economic” not “historical” causes, and causes that will hold “on average” in the future and did hold “on average” in the past. Economics has had now over a century of seeking to avoid immersion in details and being cataloguers of “accidents of mythology and history”. We have to modify our imperial ambitions as economists of this brand however, and adopt a more eclectic methodological approach however, if we are to incorporate the sort of field evidence identified in this paper.

But when exchange rates were not totally decided by history – in the form of historical benchmarks, there is more scope for combining “on average” theorizing and econometrics with historical effects. Consider instances when an exchange rate enters a floating regime,

or declares a cleaner float regime. At such moments, a historically prominent benchmark comes into existence, the prior one. In theoretical and empirical work embracing such moments, it could be useful to add gravity / attractor terms toward these historically prominent benchmarks and assess if this improves prediction, retrodiction / understanding.

8.4 Prominent Number Ratios

The attraction of some exchange rates to prominent number ratios is indicated by the field evidence, section 5.5.2. It is strongly supported by our laboratory experiment in which the attraction to 1:1 was very highly significant, section 7.1. There is also evidence from our laboratory experiment that polarization in the form of an exchange rate either exhibiting inertia, or moving the full distance to another attractor, is accentuated when central bank exchange rate aims are non-transparent, section 7.2.

The attraction of exchange rates to prominent number ratios is largely ignored in theoretical modelling of exchange rate determination over horizons longer than several days. The corresponding econometric estimates of quarterly and medium to longer term exchange rates typically impose no constraints on numbers chosen, and include no expectation terms pertaining to prominent number ratios. It could be useful to include gravity or attractor terms toward these. Likewise, when a new currency is formed, such as the EURO, there may have been a period when the media focus on whether the exchange rate to the USD was above or below 1:1 had an impact, ie acted (perhaps still acts) as an attractor on the actual EURO-USD exchange rate. This might be checked by ascertaining whether adding such a term enhances the explanatory power of equations during that period.

References

- Albers, Wulf, (1998a), “Foundations of a Theory of Prominence in the decimal System”. Parts I-IV, Institute of Mathematical Economics, University of Bielefeld.
- Albers, Wulf, (1998b), Prospect Theory and the Theory of Prominence as Solutions of the Same Stylised Facts., mimeo, Bielefeld
- Albers, Wulf (2001), “Numerical Decision Processing Causing Stock Price Clustering”, *Homo Oeconomicus*, 18 (2), 77-92.
- Allais, Maurice, (1952), ‘Fondements d’une Théorie Positive des Choix Comportant un Risque et Critique des Postulats et Axiomes de L’Ecole Américaine’, published in 1953 in *Econométrie*, 40, Colloques Internationaux du Centre National de la Recherche Scientifique, Paris, 127-140 and 257-332, translated into English as Allais 1979a. and in English in Allais 1979a, ‘The Foundations of a Positive Theory of Choice Involving Risk and a Criticism of the Postulates and Axioms of the American School’, in M. Allais and O. Hagen (eds), *Expected Utility Hypotheses and the Allais Paradox: Contemporary Discussions of Decisions under Uncertainty with Allais’ Rejoinder*, Reidel, Dordrecht, 27-145.
- Allais, Maurice, (1984), “The Foundations of the Theory of Utility and Risk. Some Central Points of the Discussions at the Oslo Conference”, in O. Hagen and F. Wenstøp (eds), *Progress in Utility and Risk Theory*, Reidel, Dordrecht, 3-131.

- Alquist, Ron and Menzie D. Chinn (2006) Conventional and Unconventional Approaches to Exchange Rate Modeling and Assessment, revised version dated 21 June 2006) of paper presented to the ECB-Bank of Canada workshop on "Exchange rate determinants and impacts," Frankfurt, December 6-7, accessed from http://www.ssc.wisc.edu/~mchinn/alquist_chinn_21jun06.pdf.
- Becker, Otwin and R. Selten (1970), "Experiences with the Management Game SINTO – Market", in *Beiträge zur experimentellen Wirtschaftsforschung* (Contributions to Experimental Economics), **2**, Heinz Sauermann (ed.), Tübingen: J.C.B. Mohr (Paul Siebeck), 136-150,
- Becker, Otwin, T. Feit, V. Hofer, U. Leopold-Wildburger, R. Pope and R. Selten (2006), "Männer schöpfen Märkte besser aus – Empirische Evidenz anhand des Unternehmensplanspiels SINTO-Markt" (Men Create Better Markets – Empirical Evidence of Enterprise Planning from Playing the SINTO Business Game", *Perspektiven der Wirtschaftspolitik* (Perspectives in Political economy), **7** (4), 445-458.
- Bergo, Jarle, (2006), "Cyclical developments, monetary policy and the krone exchange rate", Speech by Deputy Governor Jarle Bergo, Østfold University College, Sarpsborg, 28 September.
- Birnbaum, Michael H. and Juan B. Navarreté, 1998, "Testing Descriptive Utility Theories: "Violations of Stochastic Dominance and Cumulative Independence", *Journal of Risk and Uncertainty*, **17**, 49-78.
- Black, Max, (1986), 'Some Questions About Bayesian Decision Theory', in L. Daboni, A. Montesano and M. Lines (eds), *Recent Developments in the Foundations of Utility and Risk Theory*, Reidel, Dordrecht, 57-66.
- Borcherding, K. and D. von Winterfeldt, 1988. The effect of varying value trees on multiattribute evaluations. *Acta Psychologica* **68**, 153-170.
- Brandstätter, E., G. Gigerenzer and R. Hertwig, 2006 The Priority Heuristic: Making Choices Without Trade-Offs. *Psychological Review*, **113**, 409-432.
- Brachinger, Hans Wolfgang, (2006), "Euro or 'Teuro'?": The Euro-induced Perceived Inflation in Germany", paper presented to the Behavioral Economics and Economic Psychology conference, Paris, July.
- Butkiewicz, JL, (2005a), Governor Eugene Meyer and the Great Contraction. Working paper No. 2005-01, Department of economics, Alfred Lerner College of business & Economics University of Delaware.
- Butkiewicz, JL, (2005b), Eugene Meyer: From Laissez Faire to the Keynesian Revolution, presentation to the Southern Economic Association Meetings, Washington, November.
- Camille, Nathalie, Giorgio Coricelli, Jerome Sallet, Pascale Pradat-Diehl, Jean-Rene Duhamel, Angela Sirigu, 2004, The Involvement of the Orbitofrontal Cortex in the Experience of Regret, *Science*, **304**, 1167-1170.
- Cestari, V, 2006: Memory of Prices and Inflation Perceptions: In the Case of the Changeover from the Lira to the Euro. IAREP – SABE Conference 5-8 July 2006 Paris, France
- Cheung, Yin-Wong, Dan Friedman, 2005, "Speculative Attacks: An Experiment", presentation to the Economics Science Association, Tucson.
- Cheung, Yin-Wong and Menzie David Chinn, 2001, Currency Traders and exchange rate dynamics: a survey of the US market, *Journal of International Money and Finance* **20**, 439-471.
- Cheung Yin-Wong and Dan Friedman (2005), "Speculative Attacks: A Laboratory Study in Continuous Time". Presentation to the Economic Science Association, Tucson
- Chinn, Menzie, Yin-Wong Cheung and Antonio Garcia Pascual, 2005, Empirical Exchange

- Rate Models of the 1990's: Are Any Fit to Survive? *Journal of International Money and Finance* 24, 1150-1175.
- Conlisk, J., 1993. The Utility of Gambling. *Journal of Risk and Uncertainty* 6, 255-275.
- Constantanides, George M, (1979) Multiperiod Consumption and Investment Behavior with Convex Transaction Costs. *Management Science*, 25(11), 1127-1137.
- Constantanides, George M. (1986) Capital Market Equilibrium with Transaction costs. *The Journal of Political Economy*, 94(4), 842-862.
- Covey, Judith and Richard D. Smith, (2006), How Common is the 'Prominence Effect' Additional Evidence to Whynes et al', *Health Economics* 15: 205-210.
- Cyert, R. and J. March, (1963), *The Behavioral Theory of the Firm*, Prentice Hall.
- Davidson, Paul (1984) "Reviving Keynes's revolution", *Journal of Post Keynesian Economics*, 4, 561-575.
- Davidson, Paul (1988) "A technical definition of uncertainty and the long-run non-neutrality of money", *Cambridge Journal of Economics*, 12, 329-337.
- Davidson, Paul (1991) "Is Probability Theory Relevant for Uncertainty? A Post Keynesian Perspective", *Journal of Economic Perspectives*, 5 (1), 129-143.
- Davidson, Paul (1993), "The elephant and the butterfly – Or Hysteresis and Post Keynesian economics", *Journal of Post Keynesian Economics*, 15 (3), 309–322.
- Davidson, Paul (1996) "Reality and economic theory", *Journal of Post Keynesian Economics*, 18 (4), 479-508.
- De Neufville, Richard and H. Munéra, (1983), "A Decision Analysis Model When the Substitution Principle is not Acceptable," in B. P. Stigum and F. Wenstøp, eds., *Foundations of Utility and Risk Theory with Applications*, D. Reidel, Holland, 247-262.
- Dörner, D., Kreuzig, H. W., Reither, F., & Stäudel T. (Eds.). (1983). *Lohhausen. Vom Umgang mit Unbestimmtheit und Komplexität* [Lohhausen. On dealing with uncertainty and complexity]. Bern, Switzerland: Hans Huber.
- Earley, James S, (1976), "Domestic Monetary Management in Britain 1919-1938 by Susan Howson", *Journal of Economic History* 36 (4), 968-969.
- Fama, Eugene F., (1965), "The Behavior of Stock-Market Prices", *Journal of Business*, 38, (1), 34-105.
- Fehr, E; Tyran, J. R. (2001): Does Money Illusion Matter?. *American Economic Review*, 91 , 1239-1262.
- Fisher, Irving (1929): *The Money Illusion*
- Friedman, Milton, and L.J. Savage, (1948), 'Utility Analysis of Choices Involving Risk', *Journal of Political Economy*, 56(4), 279-304.
- Friedman, Milton and L.J. Savage, 1952a, 'The Expected-Utility Hypothesis and the Measurability of Utility', *Journal of Political Economy*, 60 (6), 463-474.
- Friedman, Milton, (1957), "A Theory of the Consumption Function" Princeton University Press, Princeton.
- Hagen, Ole, (1972), 'A New Axiomatization of Utility under Risk', *Teorie A Metoda*, 4 (2), 55-80.
- Harsanyi, John C., 1977, *Rational Behavior and Bargaining Equilibrium in Games and Social Situations*, Cambridge University Press, New York.
- Howson, Susan (1975), "Domestic Monetary Management in Britain 1919-1938", Cambridge University Press, London and New York.
- Hu, Ling, (1999), "Robust tests of foreign exchange market efficiency with empirical evidence from european 92-93 currency crisis", working paper, JEL classification number C22, F31.

- Huber, Oswald, 1982, *Entscheiden als Problemlöser* (Making a decision as solving the Problem), Bern, Huber.
- Inder, Brett and Terry O'Brien, 2003, 'The Endowment Effect and the Role of Uncertainty', *Bulletin of Economic Research*, **55** (3), 289-301.
- Janis, Irving L. and Leon Mann, (1977), *Decision Making: A Psychological Analysis of Conflict, Choice, and Commitment*, Free Press, New York.
- Johnston, H.N. and J.C. Looker, (1979), "Comment on 'Household Saving and Consumption' by R. A. William", in Conference in Applied Economic Research, Reserve Bank of Australia, December.
- Kaiser, J and S. Kube, (2005), "Currency Speculation Behaviour of Industrial Firms: Evidence from a Two-Country Laboratory Experiment", Economics Department, Bonn University Discussion Paper, November
- Keser, Claudia, Bodo Vogt, 2000: Why Do Experimental Subjects Choose an Equilibrium which is Neither Payoff nor Risk Dominant? CHIRANO, Montreal 2000
- Keynes, John Maynard, (1936): "The general Theory of Employment Interest and Money", New York, Harcourt, Brace.
- Keynes, John Maynard, (1939): "Professor Tinbergen's Method", *The Economic Journal*, September, reprinted in 'The Collected Works of John Maynard Keynes', vol. 14, edited by D. Moggridge (1973), London, Macmillan
- Keynes, John Maynard, 1971 – 1988: "The Collected Writings of John Maynard Keynes", ed. D. Moggridge, London, Macmillan for the Royal Economic Society
- King, Robert G. and Marvin Goodfriend, (2005), *Journal of Monetary Economics*, 52 (5): 981-1015.
- Klibanoff, Peter, Ozdenoren, Emre, 2007, "Subjective recursive expected utility", *Economic Theory*, 30 (1), 49-87.
- Kreps, David M. and Evan L. Porteus (1978) 'Temporal Resolution of Uncertainty and Dynamic Choice Theory', *Econometrica*, 46 (1), 185-200.
- Kreps, David M. and Evan L. Porteus, (1979) 'Temporal von Neumann-Morgenstern and Induced Preferences', *Journal of Economic Theory*, 20, 81-109.
- Krugman, Paul 1993, "Recent thinking about exchange rate determination and policy" in A. Blundell-Wignall (ed), *The Exchange Rate, International Trade and the Balance of Payments*, Economic Group, Reserve Bank of Australia, Ambassador, pp. 6–22.
- Krugman, Paul, 2001, "Crisis: The next generation?" paper prepared for Razin conference, Tel Aviv University, March 25 – 6.
- Levich, Richard M, (1989), "Is the foreign exchange market efficient?", *Oxford review of economic policy*, 5(3), 40-60.
- Mackinnon, Andrew J. and Alexander J. Wearing, (1983), 'Decision Making in Dynamic Environments', in B. Stigum and F. Wenstøp (eds), *Foundations of Utility and Risk Theory with Applications*, D. Reidel, Dordrecht, 399-422.
- Manne, Alan S. and A. Charnes, (1952), 'The Strong Independence Assumption--Gasoline Blends and Probability Mixtures', *Econometrica* **20** (4), 665-669.
- Marques, J. F. (2006) : Anchors Away? Price Knowledge and Anchoring Effects, IAREP – SABE Conference 5-8 July 2006 Paris, France
- Mckinnon, Ronald, (2005), *Exchange Rates Under The East Asian Dollar Standard: Living With Conflicted Virtue*, MIT, Cambridge.
- Meese, Richard A., Rogoff, Kenneth, 1983, "Empirical Exchange Rate Models of the Seventies: Do they fit out of sample?" *Journal of International Economics* 14. 3-24.

- Mekvabishvili, Rati, 2006, Money Illusion and Coordination, mimeo, Nottingham University.
- Neely, J. Christopher, 1997, Technical Analysis in the Foreign Exchange Market: A Layman's Guide, September/October *Review*. Reprinted in *The Market Technician*, The Journal of the Society of Technical Analysts March 1998. No.31.
- Osler, Carol, 2000, "Support for Resistance: Technical Analysis and Intraday Exchange Rates", FRBNY Economic Policy Review 6 (2), 53-68.
- Osler, Carol, 2003, "Currency Orders and Exchange-Rate Dynamics: Explaining the Success of Technical Analysis", *Journal of Finance* 58, 1791-1819.
- Pagan, A., 1993, "A Perspective", in Adrian Blundell-Wignall, ed, *The Exchange Rate, International Trade and the Balance of Payments*, Economic Group, Reserve Bank of Australia, Ambassador, 316-325.
- Pope, Robin (1980), (with D. H. Pope), "Domestic Monetary Management in Britain, 1918-1938 by Susan Howson", *Journal of Money, Credit and Banking*, November, 678-682.
- Pope, Robin (1983), "The Pre-Outcome Period and the Utility of Gambling", in B. Stigum and F. Wenstøp (eds), *Foundations of Utility and Risk Theory with Applications*, D. Reidel, Dordrecht, pp. 137-177.
- Pope, Robin E., 1985a, "Revaluations: Help or Hindrance to Australian Manufacturers?", in W. F. Gosling, ed, *Western Pacific Trade*, Input-Output Publishing Company, Suffolk, 75-104.
- Pope, Robin E., 1985b, "Timing Contradictions in von Neumann and Morgenstern's Axioms and in Savage's 'Sure-Thing' Proof", *Theory and Decision*, **18**, 229-261.
- Pope, Robin (1988), The Bayesian Approach: Irreconcilable with Expected Utility Theory? in: B. Munier ed, *Risk, Decision and Rationality*, Reidel, 221-230.
- Pope, Robin (1991), 'The Delusion of Certainty in Savage's Sure-Thing Principle', *Journal of Economic Psychology*, 12 (2), June, 201-241.
- Pope, Robin (1995), "Towards a More Precise Decision Framework, A Separation of the Negative Utility of Chance from Diminishing Marginal Utility and the Preference". *Theory and Decision*, 39 (3), pp. 241-265.
- Pope, Robin E., 1996/7, and forthcoming, 'Debates on the Utility of Chance: A Look Back to Move Forward', *Journal for Science of Research (Zeitschrift für Wissenschaftsforschung)*, **11/12**, 43-92
- Pope, Robin (2000) "Reconciliation with the Utility of Chance by Elaborated Outcomes Destroys the Axiomatic Basis of Expected Utility Theory", *Theory and Decision*, 49, 223-234.
- Pope, R.E., 2001b 'Evidence of Deliberate Violations of Dominance due to Secondary Satisfaction — Attractions to Chance', *Homo Economicus* **XIV**(2) 47-76.
- Pope, Robin (2004), "Biases from Omitted Risk Effects in Standard Gamble Utilities", *Journal of Health Economics*, 25, pp. 695-735.
- Pope, Robin, Johannes Leitner and Ulrike Leopold-Wildburger, *The Knowledge Ahead Approach to Risk: Theory and Experimental Evidence*, Springer Lecture Notes, November 2006.
- Pope, Robin E., 2000, 'Reconciliation with the Utility of Chance by Elaborated Outcomes Destroys the Axiomatic Basis of Expected Utility Theory', *Theory and Decision*, **49**, 223-234.
- Rapp, Tammy A. and Subhash C. Sharma (1999), Exchange Rate Market Efficiency: Across and Within Countries, *Journal of Business Economics* 51, 423-439.
- Samuelson Paul (1952a), "Probability, Utility and the Independence Axiom", *Econometrica*, 20, 670-678.

- Samuelson, Paul, 1952b, letter to Wold mentioned in Wold 1952b.
- Sauermann, H. and Selten, Reinhard, (1962), 'Anspruchsanpassungstheorie der Unternehmung (aspiration-Adaptation Theory for the Firm)', *Zeitschrift für die gesamte Staatswissenschaft* **118**, 577-97.
- Selten, Reinhard (1998), "Aspiration Adaptation Theory, *Journal of Mathematical Psychology*, 42, 191-214.
- Shafir, Eldar, Peter Diamond and Amos Tversky, (1997), 'Money Illusion', *Quarterly Journal of Economics* 112 (2), 341-374.
- Savage, L., 1952a, claim that Wold has missed the point, *Econometrica*, **20** (4), 663-4.
- Savage, Leonard J., 1952b, reply to Wold's rejoinder to Savage 1952a acknowledging the force of Wold's illustrative example and arguments, *Econometrica*, **20** (4), 664.
- Savage, Leonard J., 1954 and 1972, *The Foundations of Statistics*, Wiley, New York.
- Simon, Herbert A., (1955), "A Behavioral Model of Rational choice", *Quarterly Journal of Economics*, **69**, 99-118.
- Simon, Herbert A., (1991), 'Problem Formulation and Alternative Generation in the Decision Making Process, in A. Chikán (ed.), *Progress in Decision, Utility and Risk*, Kluwer, Dordrecht, 77-84.
- Simon, Herbert A., (1993), *Models of My Life*, Basic Books, USA.
- Smithies, Arthur, (1945), "Forecasting Postwar Demand: I", in 'Econometrica 13(1), 1-14.
- Tietz, Reinhard (1972), 'The Macroeconomic Experimental Game KRESKO – Experimental Design and the Influence of Economic Knowledge on Decision Behavior', in Heinz Sauermann ed, *Contributions to Experimental Economics*, volume 3, J.C.B. Mohr (Pasul Siebeck) Tübingen, 267-334.
- Tietz, Reinhard, ed, (1982), *Aspiration Levels in Bargaining and Economic Decision Making*, Springer, Berlin.
- Tietz, Reinhard, 1997, 'Adaptation of Aspiration Levels – Theory and Experiment', in Wulf Albers, Werner Güth, poeter `Hammerstein, Benny Moldovanu, Eric van Damme eds, *Understanding Strategic Interaction: Essays in Honor of Reinhard Selten*, Springer .
- Tversky, Amos and Daniel Kahneman, (1992) 'Advances in Prospect Theory: Cumulative Representation of Uncertainty', *Journal of Risk and Uncertainty*, 5, 297-323.
- US Public Broadcasting System, 2000, "Paul Volcker Interview", accessible on <http://www.pbs.org/fmc/interviews/volcker.htm>.
- Von Neumann, John and Oskar Morgenstern, 1944, 1947, 1953 and 1972, *Theory of Games and Economic Behavior*, Princeton University Press, Princeton, New Jersey.
- Walsh, Vivian (1996), *Rationality, Allocation and Reproduction*, Clarendon Press, Oxford.
- Wang, P.J. and Jones, T. (2002), Testing for Efficiency and Rationality in Foreign Exchange Markets - A review of the literature and research on foreign exchange market efficiency and rationality with comments, *Journal of International Money and Finance*, 21, 223-239.
- Weber M. and Katrin Borchering (1993), "Behavioral influences on weight judgments in multiattribute decision making", *European Journal of Operational Research* 67, 1-12.
- Whynes, David K., Frew, Emma J., Philips, Zoë N., Covey, Judith, Smith, Richard C., 'On the Numerical form so contingent valuations responses', *Journal of Economic Psychology*, forthcoming.
- Whynes, David K., Zoë Philips, Emma Frew, (2005), "Think of a number *any* number?", *Health Economics Letter*, 14, 1191 – 1195, published online 8 June in Wiley InterScience (www.interscience.wiley.com). DOI:10.1002/hecl.1001.

Appendix: The Statistical Tests

A1 The One-sided Direction of Change in the Exchange Rate

The null hypothesis is that any deviation of the final 20th round exchange rate from the inertia attractor of the initial exchange rate is random, and hence is equally likely to be in either direction. The alternative hypothesis is that any deviation from inertia is in the downward direction since due to the attractor of the nominal equality 1:1 exchange rate. Hence the test is one-sided.

We counted how often (0 of 9 times) the final exchange rate was higher than the initial one of 1.4. On a binomial exact test, if the null were correct, this probability is utterly remote, namely 0.001953.

A2 Polarisation in the Exchange Rate

Divide the distance between the two attractors, the initial exchange rate of 1.4 and the nominal equality exchange rate attractor of 1:1, into four segments. Then the two middle segments comprise exchange rates between 1.1 and 1.3. Polarisation is measured by the exchange rate by the final 20th round lying outside the two middle segments. The null hypothesis is that the extent of polarization in the population is independent of transparency concerning central bank exchange rate aims – ie that sessions labeled 1-6 and those labeled 7-9 in Table 6 are homogenous as regards polarization. The alternative hypothesis is that nominalism in the form being attracted more strongly to either one of these two attractors increases in the more complex situation of a lack of transparency concerning the two central banks' exchange rate aims. Hence the test is one-sided. On a Fisher's exact test, the probability that the two sets of sessions are homogenous as regards the extent of polarization is 0.04761905. We computed this as follows.

We constructed the following 2x2 table:

a b
c d

where

a = the number of observations among the first 6 observations for which the final exchange rate lies in [1.1;1.3] = 5

b = the number of observations among the first 6 observations for which the final exchange rate doesn't lie in [1.1;1.3] = 1

c = the number of observations among the last 3 observations for which the final exchange rate lies in [1.1;1.3] = 0

d = the number of observations among the last 3 observations for which the final exchange rate doesn't lie in [1.1;1.3] = 3

Then we calculated the significance level as:

$$\begin{aligned} p &= [(a+b)!(c+d)!(a+c)!(b+d)!] / [a!b!c!d!n!] \\ &= [(5+1)! (3+0)! (5+0)! (1+3)!] / [5!1!0!3!9!] \\ &= (6!3!5!4!) / (5!1!0!3!9!) \\ &= (6!4!) / 9! \\ &= 24 / 504 \\ &= 0.04761905. \end{aligned}$$