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

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# WORKING PAPER

**Abstract** - Conclusions favourable to flexible exchange rates typically accord with expected utility theory in ignoring the costs that exchange rate uncertainty generates for governments, central banks, firms and unions in: (i) choosing among available acts; and (ii) existing until learning the outcome of the chosen act. Allowing for these costs involves the stages of knowledge ahead framework, Pope (1983, 1995, 2005). A laboratory experiment suggests that (i) and (ii) together outweigh the advantages of having a flexible exchange rate as an additional instrument for managing a country's employment, interest rate, price level and international competitiveness goals

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## Overview

Some see our currently flexible exchange rates as desirable since they afford a nation's official sector an additional macroeconomic instrument for dealing with shocks introduced by demand and supply factors and unreasonable unions. Other economists find current exchange rate variations a curse to be curbed, eg with better international financial architecture, Kenen (2001), or a Tobin tax, or to be partially eliminated by joining the currency of one's major trading partner, eg Courchene (1999a, 1999b, 1999c), or even to be entirely eliminated by a single world money, eg Mundell (1961, 2003). For flexible exchange rates have their costs. They introduce exchange rate uncertainty, raise transactions costs and much else.

Empirically estimating whether the extra official instrument of exchange rate flexibility is worth its cost is hampered by many recognized factors. It is also hampered by a little recognized factor, use of expected utility theory. Under this theory (or any of its standard rank dependent generalizations), the future: 1, begins with a decision over a given choice set; and 2, is as if decisionmakers parachute from making a risky choice into certainty. This pair of abstractions excludes most exchange rate uncertainty effects. It excludes what are here termed (i) Manne-Janis uncertainty in making a good choice out of our available acts;[1] and (ii) Keynesian uncertainty during the interim between making a decision under risk/ uncertainty and learning its outcome.[2] The stages of knowledge ahead framework of Pope (1983, 1995, 2005) allows more reasonable decision procedures that take into account the benefits and costs of the Janis-Manne and Keynesian uncertainties (i) and (ii) experienced prior to learning the outcome of risk taking.

Our laboratory experiment is designed to obtain insights on the effects of eliminating exchange rate uncertainties without needing to exclude effects (i) and (ii). It also designed to free us from some of the data limitations that econometric estimates of exchange rate uncertainty face when not even implicitly using an expected utility approach. Our findings suggest that eliminating exchange rate uncertainty improves the performance of the government and the central bank in achieving their objectives for employment, the interest rate, the price level and international competitiveness. These results contrast with widespread concerns that introducing the EURO would loosen union discipline, increase nominal wages and worsen employment and inflation while at the same time robbing the official sector of a countervailing macro instrument. Rather our results suggest that (i) and (ii) – uncertainties in choosing among acts (strategies), and uncertainties in interim between action and learning the outcome – involve a set of costs that together outweigh gains from the official sector having an extra macroeconomic instrument.

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[1] See eg Janis and Manne (1977).

[2] See eg Walsh (1994, pp56, 62-66).

Part 1 gives a brief summary of the evolution of theorising and empirical findings on exchange rate management. Part 2 describes our experimental set-up. Part 3 presents our results.

**1.1 The Demise of the Clean Float Equilibrium Argument**

In the Bretton Woods era, amongst those who saw variable, preferably "clean" or "freely" floating exchange rates as desirable, a prime argument was that floating exchange rates would be "equilibrating". A "clean" or "freely" floating exchange rate is defined as one in which the country's central bank gears its monetary management exclusively to domestic goals (typically an inflation goal), and completely ignores any potential impact its monetary policy might have on the exchange rate, eg Carew (1985). While such a definition is widespread, it is internally inconsistent: any domestic goal, inflation or employment or …) will be indirectly affected by the exchange rate via export and import effects impinging on domestic prices and employment. The notion of a "free" float in short stems from closed economy modeling imperfectly translated over into an open economy setting.

Arguments that a "freely" floating exchange rate equilibrates are today less frequently heard. This has not been primarily through a recognition of the mix-up of open and closed economy thinking in notions of a "free float" relating to equilibrium, but from a growing appreciation of five other considerations. First, the equilibrating arguments stemmed from theorizing lacking a stock demand for currencies, and more people have come to view this as flawed, that demand for currencies also has an asset –stock– dimension. Second, what constituted the equilibrium to be achieved by exchange rate variation was rather routinely defined as a zero current account balance, and this too progressively more have come to be recognised as flawed: for decades some countries continue with a negative current account balance, either because so attractive to foreign investors (eg Australia), or because a reserve currency and making greater earnings on their foreign investments than do foreigners investing with them (eg the US). Third exchange rates have changed far more frequently in the last 35 years than was imagined by those advocating an end to Bretton Woods, Kenen (2002b), and the changes have been in ways hard on common sense grounds to describe as equilibrating anything. Fourth, theoretical models of exchange rate variations as equilibrating have not performed out of sample better than a random walk when the observation units are less than two year averages, Pagan (1993). Each new exchange rate crisis generates a new generation of theorizing on equilibrating "fundamentals", that explain ex post, but get replaced with another generation when the next crisis appears, Cheung and Friedman (2005). Fifth, from the empirical evidence, it is hard to establish that countries attempting "free" floats have fared better, been closer to an equilibrium path, than those pursuing very "dirty"

floats, even pegging their exchange rates, von Hagen and Zjiou forthcoming. There is case studies evidence of "dirty" floaters and peggers faring better in global or regional disequilibrium downturns, Vernengo and Rochon (2002).

## 1.2 The Retention of the Extra Instrument Argument

But while advocacy of flexible exchange rates as equilibrating has declined, rather few support Mundell in advocating a shift to a single world currency, or even advocate a revival of Bretton Woods, or the imposition of a Tobin tax. Much of the hesitancy to move in these directions stems from a concern that countries lose a macroeconomic instrument. This argument for the nationalistic right to use exchange rate is in essence an argument for using variable exchange rates as they were repeatedly used in the 1930s. This is in a beggar-thy-neighbour manner of attempting to export elsewhere unemployment, and occasionally in a beggar-thy-neighbour manner of attempting to export elsewhere inflation. In each case, the exchange rate change is expressed euphemistically – as avoiding importing unemployment, importing inflation.

When the argument is put bluntly, and with the recognition of its repetitive nature, its anti-social and at best negative sum game nature at the international level is apparent. However, the argument is not normally expressed in its repetitive form. Instead, it is typically analysed as a single event that befalls a single economy in the whole world, with no other country ever doing anything in retaliation, or in the future. This is because the situation is typically analysed as in Mundell (1961).

In the Mundell 1961 world, which in turn builds on Swan (1952), only one country *once* ever faces a shock. That shock is unanticipated. There are no shocks ever after, so moving the exchange rate once to adjust for a shock generates no future exchange rate uncertainty – no risk of other countries "retaliating" or "adjusting to avoid damage" as they do in actuality. Since in this Mundell world there are no capital flows either (as accords almost with that era of highly restricted capital movements), there is a new equilibrium to reach, and there can be circumstances of sticky nominal wages in which the exchange rate is a simple swift mechanism for getting to the new equilibrium. As noted in the perceptive survey of kenen (2002b), rather little attention has been paid to the work of Flemming and Mundell with models including capital flows. These render exchange rate variation more problematic, even in the case of the world only ever facing one shock and thus one exchange rate change ever.

## 1.3 Hedging Misunderstandings

Reluctance on the part of many economists to believe that there could be uncertainty costs is through misunderstandings of 1, what hedging costs, and 2, what hedging can accomplish. First, as regards costs, there is lack of ready availability of so-called hedging for small firms over the

extended time horizons involved in trade and direct investment. Over relevant time horizons, for these small firms, hedging costs can be massive, for all purposes infinite.

Second, it is not feasible to hedge both ways: we can hedge against either an appreciation or a depreciation but not against both. In popular (non-rational parlance), where one may/will import, hedging is when with a risk of the home currency depreciating, one pays a fixed sum to avoid this risk. In popular (non-rational parlance), speculation is when there is a risk of our currency appreciating, one borrows foreign currency to convert into home currency. But for a "rational" economist looking at opportunities foregone, there is no necessary difference in the riskiness or speculativeness of these two behaviours. If one fails to so-called hedge and there is a depreciation, one may be at a competitive disadvantage vis-à-vis other importers and fail to survive, but so also if there is an appreciation and one failed to so-called speculate.

To illustrate the complexities and costs of speculation/hedging, big firms often seek to reduce their costs by using exotic derivates, but sometimes go broke through their hedge intended as a safety net, eg the zinc multinational Pasminco met this fate a couple of years ago. It, like the Australian Treasury, a few years back, was convinced of a rise in the Australian dollar vis-à-vis the US dollar and took measures to protect its stakeholders. In organising the agreement (like the Australian Treasury), it did not consider sufficiently the reverse risk, of instead the Australian dollar at that time depreciating, as happened. Pasminco went into reconstruction, while the Australian Treasury endured inquiries and statements from the national central bank, the Reserve Bank of Australia that were the treasury to seek to unwind its hedge act that had misfired, it might cause a catastrophic drop in the Australian dollar.

Another problem of hedging that typically it must be incomplete. As Kenen notes (personal communication), at the time of hedging, the firm generally does not know how much to hedge. This is because it does not know yet the foreign demand for its good (if exporting), or its own demand (if importing).

### 1.4  Jumping over when Agents are Uncertain

The reluctance of many to believe that there could be uncertainty costs associated with exchange rate changes or anything else is also partly due to the way expected utility theory and its standard generalisations ignore the periods until after the uncertainty is past in the ways described in the overview. As a consequence, under that theory, there are no costs in ascertaining available acts (strategies), none in choosing the best amongst them), and each outcome of each risky act being evaluated is evaluated "as if certain", even though in fact risky, Friedman and Savage (1948). For this to be plausible, and thus for expected utility theory to have an axiomatic base and not be

arbitrary, all the periods considered have to be after the risk is past, Samuelson (1952). Explorings of dropping the assumption of exchange rate certainty – of permitting an anticipation of shocks – within an expected utility framework, thus have to ignore its axiomatic constraint on all the periods being after the uncertainty is passed, eg Obstfeld (2001).

## 1.5    Empiricially Estimating Exchange Rate Uncertainty

There have been explorings of exchange rate uncertainty at the experimental level, which does not impose such a framework, eg Noussair and Plott (1995, 1997), Fisher (2001, 2005), Fisher and Kelley (2000), Cheung and Friedman (2005).  These, like the theoretical studies, can be interpreted as suggestive of uncertainty costs from variable exchange rates.  This is likewise the case in econometric efforts to get at the issue, though here studies have been hampered by the normal data problems: insufficiently long time series to determine trade and capital flow effects. Trade effects of relative price changes such as those emanating from exchange rate changes lag price changes by over a year, Pope (1981), and those of direct capital investment would have even longer lags.  But over the decades needed to get a satisfactory time series, much else will have changed muddying the econometric estimates.  The result has been a concentration on whether day to day or week to week volatility affects trade.  Not surprisingly, the conclusion has been, only modestly.  It could be expected however that such short term volatility influences hot money flows, and on this there is indirect evidence – ultra volatile exchange rates, as was New Zealand's under a "clean" float policy.  The New Zealand currency became in that era the sixth most traded currency in the world.  However, there is to say the least division amongst economists on whether such massive hot money flows are equilibrating speculation or destabilising speculation.

Efforts to judge the trade costs of exchange rate uncertainty by comparing trade within and without currency unions are suggestive of high trade costs, eg Rose (2000, 2004).  But again there are data difficulties as too few sizable countries joined in currency unions (instead most such unions couple one big with one or more ultra tiny countries), and suggestions that cause-effect chain from exchange rate uncertainty to trade reduction is not solely what the regressions capture, but rather also some reverse causation, eg Kenen (2002a).  Further in all the studies, whether theoretical or empirical, of which the authors are aware, a rather limited spectrum of goals of a country's official sector is investigated.

## 2  Our Laboratory Design

### 2.1 Multiple Official Objectives, Centralised Wage Bargaining

Our laboratory experiment abstracts from transactions costs. Our goal is to get a fresh handle on exchange rate uncertainties without the above shortcomings of field data. In designing it, we differed from earlier theoretical and experimental frames for a number of reasons. One was to gauge the impact of variable exchange rates on a representative gamut of the goals of a country. Another was to model centralized wage fixing as occurs in principal EURO countries, as this had been a prime concern of economists in Europe opposed to the EURO's introduction.

### 2.2 Central Banks in Exchange Rate Determination

A third concern in our design was to model the role of central banks in setting exchange rates. A prime reason for the failure of efforts to model exchange rate changes as equilibrating and thus out of sample predictable values, is the crucial role of central bank behaviour, behaviour more complex that standard reactions functions such as the Taylor rule. We the public hear only the fights between central banks that reach the press – that between the central banks of Japan and the US during the nineties, and more recently that between China and both the US and Europe. If central banks agree, there can be no overwhelming private speculation dislodging and exchange rate. To get private speculation "dislodging" an exchange rate is rather a case of one central bank wishing to hold its rate, and the other central banks not deeming the country is following or can be guaranteed to continue to follow, appropriate measures.

After each currency crisis, the governments of the major countries and monetary advisers gather, pondering how to avoid the next one, and propose "good conduct rules for a country to avoid a speculative attack by having the other central banks assist. But the terms are onerous, rather as with IMF loans for other matters, and controversial, when as yet we cannot model exchange rate changes out of sample better than a random walk. Conflicts thus have arisen, and will continue to arise, between central bank. We wished to model this, the relative strength of the two central banks, and the limited role of private hedging, speculation and trade flows, able only to set the exchange in the range between the conflicting aims of rival central banks. This too, to our knowledge, constitutes a considerable deviation from other theoretical and empirical investigations of the effects of exchange rate uncertainty.

### 2.3  A Concrete Complex Setting

We make the context concrete to all participants, given the evidence that context affects decisions. The world is complex so that conclusions drawn from simplified set-ups may miss

effects, and this matter is especially important when the study concerns uncertainty, since uncertainty itself generates complexities. Our design is a compromise between the complexity of reality, and other constraints, including the number of seats in our laboratory, and the maximum time for which we keep participants in a session (one day). To our knowledge it is the most complex experiment performed in an economics laboratory other than those on the Sinto market, Becker and Selten (1970), Becker, Hofer, Leopold and Selten forthcoming. More complex experiments have however been conducted in psychology laboratories on economic decision making, eg Dörner, Kreuzig, Reither and Stäudel (1983) and MacKinnon and Wearing (1983). To grapple with real world uncertainty costs, we sought as complex a design as was teachable to advanced economics students for them to play it within a day, and also theoretically analyzability with a game theoretic benchmark.

Despite simplifications, the set-up is sufficiently complex that we are unable to determine if it has a standard game theoretic solution. Accordingly Reinhard Selten has devised a new concept of an incomplete equilibrium. This is more realistic than the normal concept in that it does not require a player to investigate branches of the tree (courses of action) that would be unambiguously unprofitable for him. The new incomplete equilibrium concept, being more plausible than the standard concept under which the player investigates all these irrelevant ones, has potentially widespread applications in situations other than exchange rate uncertainty investigations. It is however beyond the scope of this paper to articulate the new concept in detail.

Our set-up has two countries, symmetric in every respect, and thus suggestive of the EURO's two leading countries, France and Germany that are of approximately equal economic size. In each country there is in the two currency case: 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, and thus face uncertainty concerning both the current and the future exchange rate. Their importing and hedging / speculative activity helps determine the exchange rate whenever the two central banks conflict on their exchange rate goals. In such conflicts, the amounts of each country's central intervention to attain its exchange rate target depends on that government's nominal expenditure.

**2.4 Official Sector Tasks and Instruments**

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

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

Table 1: Official Sector Objectives

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<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+ he 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>

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

The notation $\mid x - y \mid_+$ has the meaning $x - y$ for $x > y$ and zero else. $\mid x - y \mid_+$ is the *positive part* of $x - y$.

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## 2.5 The Private Sector

After the official sector has set its four targets and made these public knowledge, in each country the union and employer representative bargain over nominal wages. In this bargaining the union representative's payoff is real wages measured as nominal wages divided by the announced official sector target price, while that of the employer representative, is the average profit of the firms. If after set time allowed of 8 minutes, an agreement had not been reached, there was strike, with both negotiators receiving zero pay, a government set wage, and firms subject to a lower maximum production level and a cut in nominal demand relative to that announced by the government.

Once the wage rate (from bargaining or a strike) was announced for both countries, firms decided on output and on the amounts of a currency (home or foreign) to borrow in order to offer on the

foreign exchange market in order to either hedge, speculate. The currency market then operated, and set the period's exchange rate, followed by the consumer market, determining the consumer price, followed by firms paying for last period's imported materials, and profits flowing to the firm's owners.


## 2.6 Rounds, Sessions, Independence

A round is the above sequence of decisions and their outcomes played by both the official and private sectors. A round was played by the same participants 20 times, with a lunch break, typically after the 8th period. The first round was preceded by an hour's instruction by Sebastian Kube on details of the game giving participants practice on acts. Sebastian Kube also programmed the experiment and the monitor viewed by two of the authors during the experiments, and made the statistical computations requested of the other authors for analyzing afterwards the experiments. The participants were economics students at Bonn University who had passed two or more years of economics, ranging in skill from those in their third year of undergraduate economics up to doctoral candidates. There were twelve such sessions run on 12 different days in 2003. Each of the 12 sessions contained different participants. Six of the sessions had two currencies. Six had only one currency, and only one central bank. This allowed us a comparison of the situation with and without a currency union. There is interdependence between rounds in a single session: participants are influenced by what happened last period. This means that we do not have 12 times 20 = 240 independent observations. The rounds interdependence means that we have only 12 independent observations so that only strong effects are detectable. The sessions were typically on Saturdays, since few participants were available for an entire Monday to Friday weekday. Participants were paid in proportion to their task achievement.


## 3  Results

In each session, we started play in the initial round in equilibrium, though not announcing this to participants. There were no random shocks in our set-up. As is largely the case in reality, any change, any shock of the system would arise from a human decision. The set-up allowed for aggregate demand shocks (by the foreign government), expenditure switching shocks (by the foreign central bank) and supply shocks (by the wage setters and the home and foreign firms.

### 3.1 Disequlibrating Exchange Rate Changes

Despite starting off in equilibrium, there was no session in which at least one central bank did not choose to alter its exchange rate aim. Thus in every session, contrary to standard theory, exchange rate changes were not equilibrating, rather destabilizing. This accord with other experimental findings that axiomatised expected utility theory, and game theory which uses that axiomatic base also, is descriptively invalid, Selten (1997), and that assuming expecting utility theory yields biased estimates, Pope (2004).

The degree of exchange rate instability varied markedly from session to session indicating the importance of individual players and the infeasibility of predicting exchange rate changes. Treating each round as a year plus, in one session the instability of the exchange rate mirrored that of the inter-war period and the post-Bretton Woods era, as these are computed in Eichengreen (1995). In other sessions the instability was less, down to 1/100th of this level.

The lesser instability may relate to having only two countries, and thus only two central banks to agree on their exchange rate policy. In the early gold standard era, there were only two players, England and France, who helped each other out, France helping out Britain in the earlier 19th century, then vice versa in the 1830s. In the later 19th and early 20th century there were essentially only four players, these two and the Prussians and the Hapsburgs. In such a small gentleman's club, co-operation would have been easier than in the inter-war and post Bretton Woods eras of vast numbers of central banks. A second reason for the lesser exchange rate instability may pertain to the central bank goals being so transparent in our set-up – more transparent than is the norm.

A third reason for the lesser exchange the lesser instability may pertain to how the official sector's competitiveness goal was modeled (and thus the official sector paid). This was with symmetric penalties for being too cheap or too dear relative to the other country. Apart from Singapore, no country to the authors' knowledge has pushed up wages at home declaring it wishes to be a high labour cost country. Instead, many German economists bewail the EURO, feeling that German labour is too expensive, and the cause of its slow-down, and that a German currency depreciation would do the trick. In a similar spirit some see the EURO as bad for Italy – that it should depreciate against Germany to alleviate southern Italian unemployment. Again the US and Europe ask China to depreciate as they feel that their labour is too expensive relatively causing unemployment, while China is loathe to appreciate, considering its hidden unemployment too high. In short most countries have an asymmetric preoccupation with being too dear and causing unemployment, few have a like preoccupation not to be too cheap, "giving their output away for a song".

Despite the exchange rate changes being on average small compared to those actually experienced under floating rates, the instability damaged governments and central banks in their goal achievement. This can be seen from the payoffs of participants acting as central bankers and governments. Without a currency union, on average these each earned 74 EUR for the day. But with a currency union, government players earned 80 EUR and central bank players 85 EUR. For the central banks, this improvement was weakly significant (11% level on a 2-tail permtest). Further the more variable their exchange rate was, the worse central bank goal achievement, and this was also weakly significant (11% level on a 2-tail test).

## 3.2 Better Performance of the Official sector under a Currency Union

Table 2: Improvement in Attainment of Official Sector Objectives under Currency Union

|  | b1 | b2 | b3 | b4 | b6 | b7 | Overall Attainment |
|---|---|---|---|---|---|---|---|
| average WCU1 | -0.06 | -0.4 | -0.00 | -0.00 | -0.87 | -0.19 | 3.5 |
| average WCU2 | -0.02 | -0.1 | -0.00 | -0.00 | 0 | -0.17 | 4.7 |
| average WCU3 | -0.02 | -0.2 | -0.14 | -0.02 | -0.01 | -0.35 | 4.3 |
| average WCU4 | -0.06 | -0.2 | -0.00 | 0 | 0 | -0.36 | 4.4 |
| average WCU5 | -0.07 | -0.1 | -0.00 | -0.01 | 0 | -0.07 | 4.7 |
| average WCU6 | -0.01 | -0.3 | -0.14 | -0.00 | -0.83 | -0.03 | 3.7 |
| average NCU1 | -0.09 | -0.5 | -0.04 | -0.228 | -0.13 | -1.15 | 2.9 |
| average NCU2 | -0.01 | -0.2 | -0.00 | -0.09 | -0.03 | -0.22 | 4.5 |
| average NCU3 | -0.02 | -0.1 | -0.01 | -0.29 | 0 | -0.26 | 4.3 |
| average NCU4 | -0.12 | -0.4 | -0.00 | -0.91 | -0.67 | -0.01 | 2.9 |
| average NCU5 | -0.03 | -0.2 | -0.02 | -0.47 | -0.07 | -0.14 | 4.0 |
| average NCU6 | -0.06 | -0.1 | -0.01 | -0.28 | -0.01 | -0.65 | 3.9 |
| | | | | | | | |
| permtest upper tail | 0.23 | 0.40 | 0.78 | 0 | 0.73 | 0.16 | 0.11 |
| permtest lower tail | 0.77 | 0.60 | 0.22 | 1 | 0.28 | 0.84 | 0.89 |
| | | | | | | | |
| u-test z-value | 0.64 | -0.16 | 0.32 | 2.88 | 0.56 | 0.64 | 1.12 |
| | | | | 1%-level | | | 11% level |

WCU*i*: with currency union, session *i*; NCU*j*: no currency union, session *j*;

*b1*: steadiness of price target; *b2*: fulfilment of price target; *b3*: attainment of interest rate target; *b4*: maintenance of international competitiveness; *b6*; avoidance of underemployment; *b7*: avoidance of overemployment.

Note The columns denote subtractions from goal attainment. In calculating the overall attainment for the central bank, presented in the last column, there were no subtractions of its penalties for failing to attain its exchange rate target. This was because this target, b5, is absent in the case of a currency union so that there is some merit in making the assessment of the improvement in official sector objectives net of this additional burden borne in the non-currency union situation.

From Table 2, as regards the six individual official sector goals remaining also with a currency union, the major gain in a currency union proved to be in the attainment of *b4*, its competitiveness level. The improvement in competitiveness was highly significant (1% level on a 2-tail perm test). The currency union improved performance on attainment of all official goals bar that of *b2*, having the predicted price equal to the actual price of the consumer good, (and in this case the disimprovement was trivial). That is with a currency union, prices were steadier, the interest rate was closer to its ideal the competitive level better maintained, and employment

had less of a problem of being either too low or too high. However none of these other improvements in goal attainment was statistically significant.

In addition, nominal wages were some 10% lower in the case of the currency union. The results thus suggest that fears of unruly unions, resulting in rampant inflation and unemployment difficulties if the EURO were introduced were unfounded. The results suggest rather that even when the official sector is short of instruments, having three less than its number of goals, it is better for it to lose its exchange rate instrument – even when as in most sessions, the exchange rate instability is minor. In a complex environment, adding even minor additional uncertainty of exchange rate changes reduces attainment of the government's set of price and employment goals.

The costs of this additional uncertainty lie outside expected utility theory. These costs stem from uncertainties in choosing among acts (strategies), and uncertainties in interim between action and learning the outcome. The results afford indirect evidence that we need the stages of knowledge ahead framework of Pope (1983, 1995, 2005). This allows us to incorporate the benefits and costs of prior to the period modeled in expected utility theory. These prior periods are when complexity takes its toll. Our findings accord with the complexity tolls of information overload in making predictions, Marey (2006), and in executives taking action, Omodei et al. (in press). The complexity toll gets overlooked when our chronological welfare analysis begins, as under expected utility theory, upon learning the outcome of risk taking, ie begins after the risks and uncertainties are in the past.

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