Economics Department

Of Sticks and Carrots

Incentives and the Maastricht Road to EMU

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Of Sticks and Carrots:

Incentives and the Maastricht Road to EMU

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ABSTRACT

This paper interprets the Maastricht convergence criteria as an incentive mechanism that offers entry into European Monetary Union (EMU) as an uncertain reward for candidate countries' convergence efforts. Similarly, under the 'stability pact' agreed at the Dublin summit in December 1996 countries risk penalties for insufficient discipline inside EMU. The paper suggests a partial trade-off between the entry conditions and the stability pact. Both incentive devices should be designed jointly in order to achieve Maastricht's twin objectives of a *single* currency for a large enough group of countries and a *stable* currency, i.e. based on sufficient and durable convergence.

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1. Introduction

Europe's ambition to install Economic and Monetary Union (EMU) before the end of the millenium has provoked great controversy among policymakers and within the economics profession. Two issues can be distinguished, first *whether* EMU is a desirable project to undertake and second *how* best to achieve it. This paper focusses on the second problem. The transition strategy originally envisaged by the fathers of the Maastricht treaty, like the drive for EMU itself, was a product of the experience with the European exchange rate mechanism (ERM) in the 1980s and early 1990s. Since 1987 central parities of the participating currencies had no longer been adjusted, inflation and interest rates had been converging for some time. The philosophy behind the "Maastricht road to EMU", therefore, invoked a smooth transition to monetary union by a further gradual hardening of the ERM and strengthening of the convergence process. The transformation of an ever closer "quasi-EMU", where control of monetary policy was still nominally in the hands of national authorities, to full-blown monetary union would then appear to be a small and logical final step.

The exchange rate based approach to EMU was blown to pieces by the exchange rate crises of 1992-93. Since then, in the absence of any meaningful exchange rate constraint or institutionalized policy co-ordination, the burden of organizing European Monetary Union has almost exclusively fallen on the convergence criteria. It is therefore important to explore whether the Maastricht criteria are an adequate, or perhaps even superior, substitute for the ERM in providing national policymakers with the right incentives for continuing convergence and securing EMU. In view of the the "pact for stability and growth" agreed in Dublin in December 1996 it is equally important to understand how such a pact could supplement, alter, or replace the entry conditions. Section two examines the Maastricht criteria's incentive effects on individual countries in the run-up to EMU (or under a the stability pact within EMU). Section three explores how the criteria (the stability pact) might be chosen optimally by a designer interested in convergence and (perhaps) also in EMU coming about.

In order to understand the various roles that the criteria have to play "post-ERM" in the transition to EMU, it is instructive to briefly recall the principal reactions to the crisis of 1992-93. One such reaction was that the crisis had demonstrated that EMU was premature and had to be delayed until economies had converged much further. Another view, on the contrary, held that the crisis showed that EMU had to be introduced quickly, otherwise countries would start to diverge again and EMU would never happen (De Grauwe, 1994, 1995). A third viewpoint was that the crisis said nothing about EMU, but had only shown that the ERM was unstable in the presence of liberalized capital flows (Portes 1993). The answer would therefore be to protect

the ERM against speculative attacks (Eichengreen and Wyplosz 1993). Fourth, the crisis had demonstrated that the ERM, the convergence process and EMU itself could not survive as long as control rested exclusively with national policymakers. Therefore already ahead of EMU there had to be institutions, e.g. an upgraded European Monetary Institute, that provide for effective policy co-ordination (Artis 1994). Fifth, on the contrary, the collapse of the ERM had been a blessing in disguise (Haller 1994) *because* it had destroyed the illusion of convergence and co-ordinated policies. Durable and credible convergence would have to be built "bottom-up" and by national efforts only.

In essence all the above statements can be traced back to the early debate between the "economist" and the "monetarist" approaches to monetary union, which is a version of the "chicken and egg" problem: must convergence precede monetary union or will (only) the irrevocable locking of exchange rates produce durable convergence? In other words: should institutional innovations (like the ERM or EMU) be no more than the expression and final outcome of common policies, or should they be the instrument to induce such common policies in the first place? The Maastricht criteria[1] can be seen as a compromise between both views. By making EMU conditional on prior convergence they attempt to secure favourable initial conditions before embarking on the single currency. By making entry of individual countries dependent on convergence and by setting a firm final deadline for the start of EMU in 1999, the criteria also provide the instrument and incentives to actually induce the desired convergence.

This suggests that the Maastricht treaty is best understood as a simple incentive contract[2]. It offers a "carrot", i.e. the reward of EMU entry, and a "stick", in the form of the convergence criteria that impose costly adjustment on individual countries which however is regarded as necessary and desirable for the success of EMU. This paper seeks to explore how the criteria operate in providing convergence incentives. It does not go into the debate about whether the induced convergence is sensible nor does it have much to say about whether the precise criteria selected in the treaty provide the right "stick" to enforce the desired behaviour. In Winkler (1995 and 1996a) it is argued that the criteria are best interpreted as indicators of (past, present and future) credibility. In stage two of EMU, candidate countries are asked to demonstrate their stability orientation before joining and then co-determining the (expected and actual) performance of the new single currency. Winkler (1996b)

[1] The criteria call for inflation and interest rates to be within 1,5 percentage points of the the three best performers and for membership of the exchange rate mechanism (ERM) for at least two years without devaluation on own initiative. The fiscal criteria stipulate a deficit of at most 3% and a public debt of at most 60% in relation to the candidate's GDP. See Buiter et al (1993) and Bini-Smaghi et al. (1994) for discussions.

[2] See Hart and Holmström (1987) for an introduction to contract theory.

suggests that the criteria represent an imperfect and incomplete contract since important variables (say, "stability culture" or "sound public finances") are not observable, verifiable or contractible directly. However, by structuring the sequence of actions and the procedures for the decisions governing the transition to EMU, by creating deadlines and institutions, the treaty still can provide effective instruments for achieving its twin objectives: organizing convergence and the launch of EMU (Winkler 1996c).

In order to make sense as entry conditions for EMU the convergence criteria must satisfy two requirements. First, the behaviour they induce in stage two must have lasting and beneficial effects on stage three. This could be the case either because convergence is desirable *per se*, e.g. by rendering economies more similar or flexible, or (as argued above) because information about countries' willingness and ability to sustain stability oriented policies is revealed, which in turn is a condition for durable success of EMU. Second, the criteria must be seen to address inefficiencies, for example from time inconsistency problems of national monetary policies, political deficit biases of fiscal policy or externalities from uncoordinated policies across countries. Concentrating on the latter, the Maastricht criteria serve their purpose if they can induce desirable actions that would otherwise not be undertaken. In particular the criteria are important if producing convergence and credibility for EMU has public good features, i.e. if it requires individual sacrifice for the common good. One example is fiscal consolidation to the extent that it lowers inflation expectations and long term interest rates in EMU for the benefit of all participants. More generally, any adjustment that renders Europe's economies, institutions and preferences more homogenous will reduce potential conflicts and losses from centralizing monetary policy in EMU and thereby enhance its stability.

2. Single Country Convergence Incentives

This section explores how the convergence criteria in the Maastricht treaty can serve as an incentive device by making entry into EMU conditional on satisfying certain minimal conditions[3]. In *equation 1* the criteria can be seen to determine $p(E)$, which is the probability (or perhaps the timing) of a country's accession to EMU, as a function of convergence effort (E). E only concerns the extra Maastricht-induced component of convergence, i.e. abstracts from the convergence effort that a country would find in its *own interest* to undertake in preparation for EMU in the absence of

[3] The framework is as in Dornbusch's (1991) model of exchange rate based stabilization in developing countries. Similar problems arise in the design of optimal disinflation (Agénor 1993) and the reform process in Eastern Europe (e.g. Dewatripont and Roland 1992).

the entry conditions[4]. For the Agent this *extra* convergence is costly with increasing marginal costs. The higher β, the more painful it is for a country to pursue rigid fiscal and monetary policies or unpopular reforms in preparation for EMU. The (discounted) net benefit, i.e. the "reward" from joining EMU in stage three (such as transaction costs savings, credibility gains or political prestige) is denoted by T.

$$U = p(E)T - \frac{\beta}{2}E^2 \tag{1}$$

In the absence of uncertainty $p(E)$ will be a two-valued function; it will be equal to one if all the criteria are satisfied and zero if not. In this case a country will undertake the required mimimum level of convergence if the (discounted) benefits of EMU exceed the costs of convergence. However, uncertainty in relation to the Maastricht conditions arises from two principal sources. First, it is unclear ex ante how strictly the criteria will be interpreted, what other factors might determine the entry decision and whether EMU will happen at all. Moreover, some of the criteria are relative performance measures, i.e. depend on the behaviour of other countries. Second, there is forecasting uncertainty concerning the economic conditions which affect convergence success and there is instrument uncertainty regarding how the convergence measures that are taken will impact on the target variables. On both counts uncertainty can be seen to intervene between convergence effort and convergence success as measured by the criteria. The presumption is that convergence effort is not or cannot be contracted for directly.

Therefore, more specifically, entry to EMU will be granted if convergence exceeds some threshold value M, the Maastricht criteria. In *equation 2* fulfilment F of the entry conditions depends on convergence effort E, but also on a random term θ. The marginal "productivity" of effort with respect to the relevant target variables, i.e. the effectiveness of convergence measures taken, is measured by α. From this we can derive an expression for the probability of success $p(E)$ for some distribution function $f(\theta)$, in *equation 3*.

$$F = \begin{cases} 0 & if \quad \alpha E + \theta < M \\ 1 & if \quad \alpha E + \theta \geq M \end{cases} \tag{2}$$

$$p(E) = p(\theta \geq \psi) = \int_{\psi}^{\infty} f(\theta)\, d\theta \qquad where\ \psi \equiv M - \alpha E \tag{3}$$

[4] Otherwise T would also have to be modelled as a function of E. Here we are only interested in the additional effects from the convergence criteria, which could also be seen to counter domestic political distortions, such as myopia by governments or electorates, that might prevent countries to undertake adjustments even if they are in their own (long-term) interest.

A country faced with the Maastricht threshold M and a prospective reward from EMU of size T maximizes *equation 1* with respect to E, which yields the first order condition for optimal effort E^*. For a maximum, the second order condition in Appendix A must also be satisfied.

$$E^* = \frac{\partial p}{\partial E}\frac{T}{\beta} \equiv -f(\psi)\frac{\partial \psi}{\partial E}\frac{T}{\beta} \equiv f(\psi)\frac{\alpha T}{\beta} \tag{4}$$

With convergence costly and reward uncertain, optimal convergence effort will not guarantee entry into EMU. The probability of success can be obtained by substituting the optimal convergence effort into *equation 3*. We summarize the comparative statics properties of the model in Proposition 1.

PROPOSITION 1: Optimal convergence effort E^* is increasing in T, decreasing in β. A higher M increases effort for $f'(\psi)>0$, otherwise it reduces effort. The effect of changing α is negative for $f'(\psi)>0$, positive otherwise. The corresponding equilibrium probability p^* is always increasing in T and α, decreasing in β and M.

Proof: see Appendix A.

The results for T and β are straight-forward. If the rewards from EMU increase (or the costs of convergence decrease) on the margin, then both the optimal convergence effort and the probability of success go up. For $f'(\psi)>0$ tightening the convergence criteria (raising M), will lead to an increase in effort. The impact on the entry probability is always negative. For the productivity parameter α the impact on effort is again ambiguous. For $f'(\psi)>0$, effort will be increased in response to tougher entry conditions, but falls in response to higher productivity, say, as economic conditions become more favourable.

Proposition 1 describes the comparative statics around a local maximum. With a distribution function of infinite range the existence of an interior solution is assured, but there may be more than one (local) maximum and altering parameters may then cause a shift in the global maximum. Appendix B gives sufficient conditions for a unique maximum in the case of the normal distribution.

Leaving aside the complications of possible multiple solutions to equation 4, what can we learn from this model about the debate on the interpretation of the Maastricht criteria? A (credible) *tightening of the criteria*, all else equal, leads to increased convergence effort (as long as $f'(\psi)>0$), but always a lower probability of success. From this perspective the Bundesbank's and the German supreme court's insistence on a strict interpretation of the criteria can be useful in sustaining convergence incentives. However, if the aim of the criteria is to induce a high degree of convergence but also to allow a decent probability of entry the conditions must be set such as to trade-off the two effects optimally. The *impact of a recession* on convergence incentives can operate through three channels in our model. If it makes

the convergence targets look further away it is equivalent to raising M. If recession makes any given level of effort more painful (e.g. unpopular or economically costly) it increases β; if it makes convergence results harder to obtain, for given effort, it lowers α. *Political uncertainty* about the EMU project or doubts about its benefits will lower the expected rewards from EMU (T) and thereby reduce both effort and the probability of success. This explains why countries only start to undertake serious convergence programmes as the 1999 deadline draws closer and prospects for EMU look more certain. It also explains why countries like Italy, who hope to gain most from EMU, are willing to use the Maastricht criteria to impose considerable sacrifices, while for countries with a low or negative T (like the UK) the incentive effects of the criteria will be minimal or non-existent.

The Role of Uncertainty

In trying to model convergence incentives we have stressed that either the link from convergence effort to convergence success or the interpretation of the Maastricht criteria is uncertain. This seems to be an accurate description of the actual situation confronted by countries trying to meet the entry conditions. However, the degree of uncertainty can vary or can be made to vary. It is interesting to note that there has been little concerted effort to clarify the ambiguities in the wording of the criteria or to clarify their application, apart from the obvious unilateral attempts to push for stricter or laxer interpretations. The convergence reports issued by the EMI and the Commission as part of a "dry-run" in 1996, foreseen in the Treaty in order to determine whether EMU could go ahead at a starting date earlier than the 1999 deadline, have *not* resulted in more precision and clarification with respect to the criteria. Even though such reports are not binding they might have important commitment value. In terms of our model the main effect of any such clarification of the criteria would have been a reduction in uncertainty and perhaps an adjustment of some of the parameters, notably M. The question that arises immediately, is whether the Commission and the EMI were wise in avoiding such a reduction of uncertainty.

There are three principal reasons why a degree of vagueness may actually be beneficial. First, imprecision ex ante, may ex post allow for a response to shocks that could not have been foreseen or contracted for originally. It thus preserves flexibility. Secondly, it opens up the possibility of mutually beneficial renegotiation, perhaps involving issue linkage across unrelated areas. However, if the EMU entry decision is left to intergovernmental bargaining the ex ante convergence incentives can suffer (cf. Winkler 1996c). This paper addresses the third case for preserving uncertainty about the criteria, which can actually have a *positive* effect on convergence incentives. Intuitively, as long as there is some hope that the application of the criteria in 1998 may be lax, even countries who are far from satisfying them will

continue their effort and not give up. Conversely, even countries that are well within the Maastricht limits will not sit back as long as some uncertainty remains.

To illustrate this intuition, we compare our model above with the results obtained in the absence of uncertainty, i.e. with $\theta=0$ in *equation 2*. Then the probability of entry $p(E)$ and the optimal convergence effort become just two-valued functions, which can be expressed in terms of a critical value $\overline{T}$, as the minimum reward from EMU that just compensates for complying with the Maastricht criteria.

$$p(E)=\begin{cases}0 & \text{if} \quad \alpha E < M \\ 1 & \text{if} \quad \alpha E \geq M\end{cases} \tag{5}$$

$$E^{**}=\begin{cases}0 & \text{if} \quad T < \overline{T} \\ \dfrac{M}{\alpha} & \text{if} \quad T \geq \overline{T}\end{cases} \qquad \text{with} \quad \overline{T}=\frac{\beta(E^{*})^{2}}{2}=\frac{\beta M^{2}}{2\alpha^{2}} \tag{6}$$

We can compare these results to those obtained earlier and summarize in Proposition 2, assuming $f(\psi)>0$ for infinite range.

PROPOSITION 2: Optimal convergence effort E^{**} will be greater for the model with uncertainty for

$$\begin{aligned} T &< \overline{T} \quad \textit{always} \qquad (\textit{recall } \overline{T}=\frac{\beta M^{2}}{2\alpha^{2}}) \\ T &= \overline{T} \quad \textit{never} \\ T &> \overline{T} \quad \textit{iff} \quad T > \frac{2}{f(\psi^{*})M}\overline{T} \quad \textit{and} \quad \psi^{*}(E^{**})<0 \quad \textit{global max.} \end{aligned} \tag{7}$$

Proof: see Appendix A.

Again, Appendix B gives sufficient conditions for uncertainty generating higher convergence effort at large enough T in the case of the normal distribution. The results in Proposition 2 confirm our earlier intuition. "Hopeless cases", for whom the convergence mandated exceeds the benefits under certainty and who thus give up, can be induced to undertake convergence effort under uncertainty. "Safe cases" (for high enough T) again exert higher effort under uncertainty, that keeps them on their toes, while they would be content to just meet the entry conditions under certainty. In the intermediate range for T convergence incentives are weakened, rather than sharpened by uncertainty. This is the usual result one would expect for incentive schemes more general than the simple Maastricht threshold contract. Clearly, introducing uncertainty first of all reduces the (expected) reward from satisfying the criteria and thus reduces the amount of convergence countries are willing to undertake. The result that uncertainty could lead to higher effort can arise only if the threshold M is either set "too high" to be worth the corresponding effort under

certainty or sufficiently "too low" in that only part of the effort a country would be willing to undertake is extracted by the treaty. In other words the assumption is that in the absence of uncertainty M could not be set "optimally" by a Principal interested in maximizing convergence. This may be because he is not allowed to discriminate among individual countries (i.e. has to set the *same* threshold for everybody), it may be because he lacks precise knowledge of countries' objective functions or, finally, because *M* cannot be determined unilaterally by the Principal but is determined from various other considerations apart from maximizing overall effort. All of these are features of the Maastricht treaty which could render the criteria second-best even in the absence of shocks, ambiguities and contractability problems.

If the Commission, the EMI or European governments decide to resolve the residual ambiguities in the criteria and if economic uncertainty recedes as the deadline draws near, our model predicts that only those countries that are close to fulfilling the criteria will intensify their efforts, all others will slacken off. Hence if the aim is to maximize both convergence and entry probabilities it may be a good idea to remain vague about how the criteria will in the end be applied and thus to keep hope and incentives alive for the greatest possible number of member states. However, to be effective, entry probabilities must clearly reflect convergence effort, and while not contractable directly, this effort may perhaps be observable. If countries come to believe that the entry decisions will be taken purely or primarily on "political" grounds, obviously convergence incentives are lost. Thus the model provides an answer to the criticism of the criteria that argues that either they will be useless because they will be overridden politically or that they will be harmful because they cannot possibly be met. We argue that it is precisely the uncertainty about the flexibility and interpretation of the criteria that renders the criteria useful and beneficial as a compromise between the two extreme cases[5].

Finally, we should note that we have only compared our uncertainty model with the benchmark deterministic model. The effect of increasing uncertainty (say, the variance) within the model will depend on the characteristics of the distribution function. We can, however, imagine a mean-preserving spread that increases uncertainty, i.e. redistributes probability weight from the centre to the tails. Near the centre of the distribution $f(\psi)$ decreases and E^* will go down (from *equation 4*), whereas along the tails the opposite is true. In other words, raising uncertainty

[5] The leaked statements by German finance minister Waigel before a parliamentary committee in the summer of 1995, where he asserted that Italy would not be in the first group joining EMU "and they know it", provides an instructive episode. The press report caused a severe market reaction against the Lira and Italian bonds. From the perspective of this model, not because the markets necessarily had had a much more optimistic view on Italian entry probabilities, but rather because certainty would destroy Italian convergence incentives.

increases convergence incentives where the probability of entry is already very high (or very low), whereas in the middle range the opposite holds. Appendix B shows the effect of increasing the variance for the case of the normal distribution[6].

Credibility Feedback

The public's (market's) expectation of a country's EMU entry probability p^e could itself feedback into the actual probability of success p. For example, the market's expectation of EMU could lead to lower inflation expectations and lower interest rates, i.e. a smaller interest burden in the budget and perhaps higher confidence and growth. Both should reduce budget deficits and in turn increase the likelihood of meeting the Maastricht criteria. *Equation 3* then becomes

$$p(E) = p(\theta \geq \psi) = \int_{\psi}^{\infty} f(\theta)\, d\theta \qquad where\ \psi \equiv M - \alpha E + \tau(1 - p^e) \tag{8}$$

Here the formulation is in terms of a negative feedback τ on the perceived probability of failure $(1 - p^e)$. The more markets expect a country to be excluded from EMU, the more difficult it becomes to meet the criteria. If market expectations are treated as given, note that the negative feedback is equivalent to an increase in M and the comparative statics results in Proposition 1 apply. A higher probability of non-EMU therefore leads to increased (compensating) convergence effort but to a smaller probability of success. Exogenous shifts in expectations in particular can be used to model changes in market sentiment with respect to the risk of the EMU project falling apart altogether. However, reductions of EMU's fortunes that are independent of any individual country's convergence effort, are captured in the expected (discounted) benefits from EMU, i.e. correspond to a lower T in our model. In this case, therefore, convergence incentives and EMU probability are unambiguously reduced.

Returning to the country and convergence specific component of market expectations, as long as the latter are treated as exogenous, every level of market confidence will correspond to a different optimal convergence effort from the first order condition in (*4*). However, if market expectations are formed rationally they should (at least on average) reflect the true probability of EMU entry. Under rational expectations $p=p^e$ and the policymaker should take the credibility feedback into account when optimizing. This modifies his first order condition as follows.

[6] We have explored the effects of uncertainty under the assumption of risk neutrality. If agents are risk averse there will be a welfare loss from increasing uncertainty and risk aversion will by itself affect the incentives to converge.

PROPOSITION 3: The introduction of a (negative) credibility feedback under rational expectations gives rise to a credibility multiplier with respect to the original first order condition. Optimal effort becomes as in *equation 9* below. The effect of an increase of the feedback parameter τ on optimal effort is ambiguous, whereas the probability of success is unambiguously increased.

$$E^* = \frac{\partial p}{\partial E}\frac{T}{\beta} \equiv f(\psi)\frac{\alpha T}{\beta[1-\tau f(\psi)]}; \qquad 1-\tau f(\psi) > 0$$
$$\frac{\partial E^*}{\partial \tau} > 0 \quad for \quad f'(\psi) > 0, \qquad \frac{\partial p^*}{\partial \tau} \quad \text{ambiguous} \tag{9}$$

Proof: see Appendix A.

That the impact of the feedback parameter on effort can go either way is intuitive. On the one hand, it provides an extra incentive for convergence to the extent that increasing (1-*p*) is equivalent to raising *M*. On the other hand, the feedback multiplier effect means that less convergence effort is necessary to achieve any given improvement in the probability. Increasing feedback, however, unambiguously increases the probability of success.

Speculative attacks would be an obvious example for a high feedback parameter τ, which punishes any deterioration in EMU entry prospects immediately and severely. If such attacks are treated as exogenous they simply lead to a reduction in the likelihood of entry, even though increased effort will partially compensate. A change in market sentiment will thereby lead to an actual deterioration of entry prospects. This could serve as a simple illustration or short-hand for the possibility of multiple equilibria, when expectations influence convergence incentives. However, with rational expectations the model as it stands produces a unique solution. When the policymaker takes the feedback into account he has an extra incentive to increase his entry probability and thus to avoid punishment by the markets. Under rational expectations our model therefore illustrates positive incentive effects from the threat of speculative attacks that will discipline policymakers. The "sticks" and "carrots" provided by the markets thereby complement and reinforce the role the incentive effects of the Maastricht criteria. Again, Italy is a good example of a country that was first punished and then, in the summer of 1996 in particular, rewarded by the markets.

So far we have interpreted the model as applied to the incentive effects of the Maastricht entry conditions. The same framework can also be used to analyze the basic features of the stability pact for stage three of EMU. Then fiscal discipline (*E*) is needed to reduce the risk of incurring penalties (*T*) if deficits exceed the Maastricht threshold (*M*) in the face of economic shocks (recessions). The logic is as

before, including the potential benefits of uncertainy in sustaining discipline across a heterogenous group of countries and circumstances and also with respect to the credibility feedback. The latter derives from the fact (anticipated by the markets) that fines that are actually imposed would exacerbate fiscal problems further. Therefore, once the probability of fines becomes significant, market reactions could well accelerate and aggravate the crisis. Again, this should lead rational countries to be even more careful ex ante in the presence of credibility feedbacks.

3. Contract Design

In section 2 we examined convergence incentives under uncertainty from the perspective of an individual country confronted with the Maastricht criteria. In this section we explore the design problem faced by a "Principal" wishing to design an optimal performance contract[7] for countries seeking entry into EMU (the "Agent"). The Principal represents the interest of countries with high domestic monetary credibility who are concerned about loss of reputation and price stability in EMU. The Principal, most easily thought of as Germany or the Bundesbank, prefers that convergence and credibility be established by national effort prior to admission into EMU. For Agent countries, on the contrary, the whole point of EMU is to gain credibility more cheaply, so they prefer convergence inside EMU, if at all. Consider the following specific objective functions for the Principal and Agent, respectively.

$$V(P) = p(E)\cdot(\bar{T}_P - S) + \omega E \tag{10}$$

$$U(A) = p(E)\cdot(\bar{T}_A + S) - \frac{\beta}{2}E^2 \tag{11}$$

The first term in both equations captures the expected net benefits from EMU, where p (as before) reflects the probability and timing of EMU, as a function of the Agent's convergence efforts. The second terms capture the benefits and costs of convergence, respectively. The Principal cares about convergence and we adopt a simple linear formulation, where ω is the marginal utility of convergence[8]. For the Agent's utility we return to the general formulation of *equation 1*, except that we distinguish two components of the benefits from EMU: the non-rival net benefits $\bar{T}_A$ ($\bar{T}_P$ for the Principal) with the best example being transaction costs savings in EMU, and a rival component S, which shifts costs and benefits across the contracting

[7] Walsh (1995) has suggested incentive contracts to influence central banks' conduct of monetary policy.

[8] There are two possibilities: the Principal might be interested in convergence *per se* (as assumed here) or he cares about it only if EMU happens. Winkler (1996c) explores the effect of that distinction.

parties. This component primarily reflects net transfers of sovereignty, broadly defined. This has a formal and a material aspect, i.e. the transfer of decision rights to European institutions and the difference this transfer makes to national welfare. We assume that EMU represents a net transfer of sovereignty (S) from the Principal to the Agent, the extent and conditions of which are subject to the provisions of the Maastricht treaty and, of course, will also depend on the actual policies pursued by the future ECB[9].

One example would be the choice of monetary policy instruments of the ECB (e.g. reserve requirements), whether they are more conducive to an Anglo-Saxon or continental style financial system. Another example is the stability pact agreed in Dublin (discussed later on) to the extent that it shifts costs of EMU by reducing the risks to price stability but increases the risks and costs of countries with debt and deficit problems. The extent to which the ECB was modelled on the Bundesbank that, as a concession, went beyond what other countries might have found desirable is also reflected in S. While parts of the costs and benefits of pooling sovereignty are non-rival, there is also a rival component reflected in S. This is most evident from the perspective of the hard-EMS in the late 1980s and early 1990s, when the ERM countries largely followed Bundesbank policy, which was still almost exclusively orientated towards domestic objectives. With this benchmark there is a clearcut transfer of sovereignty (and associated economic costs and benefits) from Germany to its partner countries simply because of the expansion of the policy domain in EMU. This is so even if the ECB was to have German preferences and even more so if European preferences were to differ. As for the rival benefits, therefore, the closer EMU is shaped in the German image, the smaller S.

The provisions for stage three of EMU (S) and the entry conditions $p(E)$ are the two parameters of the Maastricht treaty that can be used by the Principal to influence the Agent's incentives. The maintained assumption, of course, is that effort cannot be contracted over directly, that is it may not be observable, verifiable or enforceable by the Principal. As in a standard Principal-Agent problem we assume that only convergence results can be contracted over and that the latter will be the result of effort and a random variable as in section two.

There are therefore basically two options for the design problem, restricted to the Maastricht parameters in *equations 10* and *11* , i.e. make either p or S (or perhaps

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[9] One can distinguish conceptually the welfare loss (or gain) from centralization *per se*, i.e. the loss of differentiated national policy options, from the distribution of these losses across countries. The latter depend not on the total adjustment EMU requires but on the *direction* of convergence, i.e. *to* which (whose) economic parameters, institutional and policy choices convergence takes place. Given that a *common* policy regime is adopted, S denotes the distance from the common framework or policy that would be preferred nationally.

even both) a function of convergence effort, where the other variable can either be taken as given by the Principal (case *a*), be chosen together with the incentive parameter (case *b*) or turn into the choice variable if the incentive mechanism is already pre-determined (case *c*). As is often done in the Principal-Agent literature, we look at linear contracts for illustration[10]. We first look at the Maastricht criteria as an incentive device, i.e. $p(E)$ and subsequently investigate the option of designing a contract (e.g. the stability pact) such that the (rival) benefits of EMU become a function of convergence $S(E)$.

The Maastricht Criteria

As in the more explicit model of section two, the Maastricht criteria are seen to govern candidate countries' probability to join EMU as a positive function of their convergence effort. In order to affect convergence incentives and the likelihood of EMU the Principal may be able to influence one or more of the Maastricht parameters in the following ways.

1a) Contract $\{p(E)=m_pE\}$

If entry probability is a linear function of convergence effort, the Principal chooses the marginal effort incentive with respect to entry probability m_p in order to maximize (*10*) subject to the Agent's first order condition obtained from maximizing (*11*).

$$\underset{m_p}{Max} \quad V(P) = m_p E(\overline{T}_P - S) + \omega E \qquad s.t. \quad E^*(A) = \frac{m_p}{\beta}(\overline{T}_A + S) \qquad (12)$$

Solving the Principal's first order condition we obtain, assuming $S>\overline{T}_P$ for a maximum:

$$m_p{}^* = \frac{\omega}{2(S - \overline{T}_P)}, \qquad E^* = \frac{\omega(S + \overline{T}_A)}{2\beta(S - \overline{T}_P)} \qquad if \quad p(E) = m_p{}^* E^* \le 1 \qquad (13a)$$

$$else: \quad \overline{m}_p{}^* = \sqrt{\frac{\beta}{S + \overline{T}_A}}, \qquad \overline{E}^* = \frac{1}{m_p{}^*} \qquad and \quad \overline{p}(E) = \overline{m}_p{}^* \overline{E}^* = 1 \qquad (13b)$$

Note that we restrict the entry probability to lie between zero and one, and if this constraint becomes binding the values for optimal incentives and effort are given by

[10] This implies that without any effort the entry probability is zero, and with sufficient effort EMU can be assured; say, countries with debt and deficits below 60% and 3 % cannot be excluded. Realistically, some uncertainty will always remain and the linearity of incentives should at most be treated as a rough approximation for a relevant range.

(*13b*). From (*13a*), in choosing optimal m the Principal, in the case of $S>\overline{T}_P$, trades off the loss from increasing the likelihood of (costly) EMU against the gains from convergence. The optimal marginal incentive (m) is higher the more the Principal cares about convergence (ω) and the smaller his net loss from stage three of EMU. On the margin, Germany will be less inclined to reward convergence the less relevant and important it is to herself (say, if there are one-off budget manipulations) and the more concerned its population is about losses from EMU. The resulting optimal effort in *equation 12a* is increasing in ω and the Agent's reward from stage three; decreasing in β and the Principal's net loss from EMU. In the case of a net benefit, i.e. if $S<\overline{T}_P$ there is no conflict and therefore the Principal will maximize $p=1$, with m given from (*13b*). Contract *1a* can best be seen to model a post-treaty setting, where the Maastricht provisions have already been fixed the features of stage three (as captured by S, $\overline{T}_P$ and $\overline{T}_A$), but give the Principal leeway to impose his interpretation of the convergence criteria.

1b) Contract $\{p(E)=m_pE,\ S\}$

If the Principal can choose both m_p and S, we can assume that he picks S low enough to render EMU beneficial to himself. In that case he would want to maximize the probability of EMU and then trade off m and S optimally, given that constraint.

$$\underset{m_p,S}{Max} \quad V(P) = m_pE(\overline{T}_P - S) + \omega E$$

$$s.t. \quad E^*(A) = \frac{m_p}{\beta}(\overline{T}_A + S) \qquad and \qquad mE = 1 \tag{14}$$

$$m_p{}^* = \frac{2\beta}{\omega}, \qquad E^* = \frac{\omega}{2\beta} \qquad S^* = \frac{\omega^2}{4\beta} - \overline{T}_A \tag{15}$$

Unlike in *equation 13* the two parties' net gains/losses from stage three do not appear in the expressions for the incentive intensity (m) and optimal effort E. The effort induced here is lower than in the previous problem, at least in the case where the probability constraint is not binding. Intuitively, given that EMU is no longer costly to him, he will prefer to increase both EMU gains and convergence via m, which through the probability constraint implies a lower optimal effort. Note also that the optimal S in *equation 15* may turn negative. Contract *1b* captures a situation (e.g.at the Maastricht negotiation table), where the Maastricht criteria are determined together with the rules governing stage three of EMU, such as central bank independence for example. Alternatively, the model can apply to a renegotiation or amendment of those features (i.e. via the stability pact) and the entry conditions together. If the Principal is allowed to set both parameters, by shaping stage three in

his favour he can be more generous on the convergence criteria. In this way EMU can be secured and the convergence effort required from the Agent will be lower than in the previous case, where the Principal can only rely on the criteria.

1c) Contract { S}

In this case the Principal can only choose S, whereas the incentive mechanism (i.e. m_p) is already in place and predetermined (perhaps by other players). This situation might reflect a post-treaty setting, where the convergence criteria are already in place but some residual decisions concerning EMU are still to be taken and additional incentives, e.g. the stability pact could perhaps be imposed. We solve:

$$\underset{S}{Max} \quad V(P) = m_p E(\bar{T}_P - S) + \omega E$$

$$s.t. \quad E^*(A) = \frac{m_p}{\beta}(\bar{T}_A + S) \tag{16}$$

$$S^* = \frac{1}{2}\left[\frac{\omega}{m_p} + (\bar{T}_P - \bar{T}_A)\right] \qquad E^* = \frac{\omega}{2\beta} + m_p \frac{\bar{T}_P + \bar{T}_A}{2\beta} \tag{17}$$

Again, the optimal effort induced by the Principal is higher than in the case where he has two incentive instruments at his disposal (*1b*). The optimal S will be higher, i.e. the Principal will make concessions on stage three of EMU, the more he cares about convergence (ω) and the weaker are the incentives already in place (m). S could turn negative, however, if the Principal's non-rival benefits from EMU are sufficiently below the Agent's. In such a situation the Principal, rather than offering an extra reward for convergence, would instead ask for additional concessions which would weaken EMU's attractiveness to the Agent and hence his convergence incentives. The stability pact could be an example of such a reverse transfer.

The Stability Pact

The proposal for a "stability pact" to complement Maastricht was first put forward by the German finance minister Theo Waigel in late 1995 and calls for automatic sanctions in the form of fines for any breach of the fiscal criteria in stage three of EMU. In December 1996 the Dublin summit reached agreement that countries that violate the deficit criterion would have to supply an interest-free deposit of up to 0.5% of GDP (depending on the extent of the transgression), which would be transformed into a fine if the deficit persists. However the sanctions are not applied automatically, as in the original German proposal, but are decided by qualified majority vote by the Council of Ministers. In particular, in the event of a severe recession (a contraction of more than 0.75% of GDP) sanctions may be waived. The

motivation for the stability pact was the fear that countries that had great difficulty to converge in stage two, even under the threat of exclusion from EMU, may be even less likely to do so once that extra incentive has vanished. On the other hand the costs of convergence (here the parameter β) should be lower in stage three, if interest rates and inflation come down for those countries, and therefore convergence may be easier to achieve inside EMU.

In terms of our model the Stability pact would have three main effects. First, *equations 10* and *11* (or *equations 1-5* in section two) can be applied to incentive issues in *stage three*. Then T ($=S+\overline{T}_A$) would be a negative penalty for the Agent and $p(E)$ the probability that it will be imposed, which is now decreasing in convergence. Countries will be disciplined from *equation 5* or *12* the greater the fines, the more the risk of incurring them depends on their behaviour (m or $p(E)$) and the lower the costs of fiscal austerity (β). Second, the stability pact, therefore, would alter the parameters of the model as applied to *stage two*. In particular, it should reduce the risks to the Principal (raise $\overline{T}_P$ or lower S). This effect can be captured by contract *1c*, where the Maastricht criteria are taken as given, and it should help overcome his reservations over EMU. Likewise, the stability pact would affect the Agent's payoffs from EMU via a lower $\overline{T}_A$ or lower S from the risk of incurring fines in EMU for countries entering EMU with fiscal problems.

Thirdly, the benefits of EMU could become a function of prior convergence, i.e. be written as $S(E)$ in *equation 11*. Thus they could operate in much the same way as the Maastricht criteria and render it in the candidate's own interest to take corrective fiscal action before entering and thereby reduce the risk of incurring penalties in EMU. If fines (at least partly) benefit the Principal, his stage three payoff will then be decreasing in the Agent's convergence[11]. In a literal reading the stability pact would then act as an insurance mechanism for the Principal, who is still interested in convergence but in its absence could now be partially compensated through the fines collected. In the contracts considered below, while S is a function of convergence effort according to the stability stability pact, the probability of EMU entry p is not. This captures a situation close to the 1999 EMU deadline, where altering the Maastricht criteria no longer exerts incentive effects, and p simply denotes how leniently the criteria will be applied ex post.

The introduction of the stability pact, in any of the three ways mentioned, opens the up the possibility for a trade-off, i.e. a relaxation of the entry conditions in return. Such a deal could make everybody better off, as the contracts *1b* and *2b* (below) allow EMU entry for sure (p=1) and require less convergence from the Agent.

[11] Of course, there are also good reasons why the Principal should have a positive payoff from convergence that is *specific* to stage three, as explored in Winkler (1996b).

However, as argued in Winkler (1995), a lax application of the criteria and a large initial EMU will encounter less favourable starting conditions and a lower reputation. Furthermore, the effectiveness of the Waigel penalties is untested and in the case deterrence fails, the actual imposition of the fines will aggravate a fiscal crisis rather than alleviate it. For these reasons the stability pact is at most a partial substitute for the convergence criteria.

2a) Contract $\{S(E)=m_S E\}$

If the (rival) net benefits from EMU are a linear function of convergence effort, the Principal can choose the marginal effort incentive m_S in order to maximize (*18*) subject to the Agent's first order condition, yielding:

$$\underset{m_S}{Max} \quad V(P) = p(\overline{T}_P - m_S E) + \omega E \qquad s.t. \quad E^*(A) = \frac{pm_S}{\beta} \tag{18}$$

$$m_S{}^* = \frac{\omega}{2p}, \qquad E^* = \frac{\omega}{2\beta} \tag{19}$$

The stringency of the stability pact m, e.g. the degree of automaticity of sanctions, is increasing in ω and decreasing in the probability of EMU happening. The optimal effort is the same as in case 1b), when the Principal was able to set the entry probability to one. Here we have the mirror image of this situation. Note that the benefits from EMU may turn negative for the Principal but will be compensated by the gains from convergence.

2b) Contract $\{S(E)=m_S E, p\}$

If the Principal can choose both m_S and p, we can assume that he picks p=1 and then m_S such as to induce optimal effort. This is true because both parameters are perfect substitutes in the Agent's first order condition, whereas not maximizing p would always carry an extra cost to the Principal in terms of his net (nonrival) benefits foregone

$$\underset{m_S, p}{Max} \quad V(P) = p(\overline{T}_P - m_S E) + \omega E \quad s.t. \quad E^*(A) = \frac{pm_S}{\beta} \quad and \quad p = 1 \tag{20}$$

$$m_S{}^* = \frac{\omega}{2}, \qquad E^* = \frac{\omega}{2\beta} \tag{21}$$

Note that the effort induced here is the same as in the previous problem, but now EMU will happen for sure. Renegotiation over both parameters can be beneficial: the Maastricht criteria will no longer be an obstacle to entry, in their place the stability pact serves as an insurance for the Principal.

2c) Contract { p}

Here the Principal can only choose p, whereas the incentive mechanism (i.e. m_S) is already in place and predetermined. Again, this might reflect a post-treaty setting, where the features of EMU are already in place but perhaps the probability of EMU coming about can be influenced by the Principal, either by committing to a stricter or laxer interpretation of the criteria or by varying his policy, eg. monetary policy stance, if that influences entry probabilities.

$$\underset{p}{Max} \quad V(P) = p(\overline{T}_P - m_S E) + \omega E \qquad s.t. \quad E^*(A) = \frac{p m_S}{\beta} \tag{22}$$

$$p^* = \frac{1}{2}\left(\frac{\beta \overline{T}_P}{(m_S)^2} + \frac{\omega}{m_S}\right), \qquad E^* = \frac{1}{2}\left(\frac{\overline{T}_P}{m_S} + \frac{\omega}{\beta}\right) \quad \text{if } p^* \le 1 \tag{23a}$$

$$\text{else:} \quad p^* = 1, \qquad E^* = \frac{m_S}{\beta} \tag{23b}$$

If the only instrument in the Principal's hands is a unilateral definition of the entry conditions he will impose an optimal effort that is greater than in the previous cases. The optimal probability is set to balance the losses that the incentive scheme imposes on the Principal in EMU and his benefits from convergence.

The Optimal Linear Contract

The above contracts, for the various specific contract forms that we imposed, in general do not yield the efficient cooperative effort, which calls for $E=\omega/\beta$. This is due to the contract restrictions, in particular to the absence of side-payments and the impossibility of separating the efficiency of EMU from the efficiency of convergence. It is therefore useful to confront our results with the optimal linear contract that would induce efficient convergence.

With a linear incentive scheme $S(E)=mE+t$; the Principal can pick m in order to provide the efficient intensity of incentives, and he can adjust the constant term t such as to keep the Agent to his participation constraint and appropriate all surplus for himself. This separation of efficiency and distributional issues was not possible in the formulations we looked at so far. Providing incentives was always costly to the Principal (since the utility transfer could not be fully recouped) and this, in general, led him to contract for suboptimal convergence. Recall that, as in the standard Principal-Agent framework, we assume that effort is not observed or contractable directly, so E here should really be seen as the outcome of convergence that can be contracted for.

Optimal Linear Contract $\{S(E)=mE+t\}$

The Principal chooses the contract parameters to maximize (*24*) subject to the Agent's first order condition derived in (*25*) and keeping the Agent to his Participation constraint (*26*):

$$\underset{m,t}{Max} \quad V(P) = \omega E - mE - t \qquad \textit{subject to} \tag{24}$$

$$\underset{E}{Max} \quad U(A) = mE + t - \frac{\beta}{2}E^2 \qquad \Rightarrow \quad E^* = \frac{m}{\beta} \tag{25}$$

$$U(A) \geq \overline{U}(A) = mE + t - \frac{\beta}{2}E^2 = 0 \tag{26}$$

We can substitute the Agent's first order condition into the Principal's objective function and also into the Agent's participation constraint, and assuming that it binds, solve for t in terms of m. This means that via the constant term t the Principal can fully recoup his losses from providing incentives. He therefore can set the intensity of incentives optimally in *equation 27*.

$$m^* = \omega, \qquad S^* = -\frac{\omega^2}{2\beta}, \qquad \Rightarrow \quad E^* = \frac{\omega}{\beta} \tag{27}$$

This, of course, reproduces the standard result that with risk neutrality the Agent should be given full incentives, i.e. made the residual claimant of the fruits of his effort. The Principal is compensated by a lump-sum transfer. This is equivalent to a transfer of ownership regarding the benefits of convergence. With the optimal contract the Principal's concern over convergence is fully internalized by the Agent, whereas the Principal will now be indifferent with repect to convergence effort.

In the context of EMU we would argue that such a complete internalization of the convergence externality is not easily conceivable. In particular Germany's concern over convergence will not be completely neutralized by the convergence criteria, even though it provides some "insurance". If EMU per se is costly, the conditional Maastricht incentive contract reduces Germany's concern about convergence and in the limit her expected utility could be the same, independent of convergence, as in the optimal contract: if partner countries converge, this raises the probability of having to sacrifice the Bundesbank sooner rather than later (or have its influence diluted by a larger number of countries), but the convergence may make it worth it; if countries don't converge, there are fewer benefits but also smaller expected losses from EMU. In the case of the stability pact the fines provide the Principal with partial compensation for insufficient convergence.

In terms of our model Maastricht can be seen as an efficient treaty if it organized "the sale of the Bundesbank" in terms of three component transactions: the (conditional) transfer of sovereignty from the Principal to the Agent (S) in return for the complete internalization of convergence incentives by the Agent ($P(E)$ or and $S(E)$) *and* a sidepayment (t) that compensates the Principal for providing incentives. The model shows that in order to provide efficient incentives the Principal must be compensated, where the size of the side payment could depend on the bargaining strength. Applying the model to the time when the treaty was prepared and concluded such a sidepayment could have come in terms of concessions to Germany on political union or German unification, to give two popular examples. The various more restrictive contract forms in equations *10-23* above represent Maastricht treaty options in the absence of sidepayments or they describe post-treaty incentives, where only a subset of parameters can be adjusted by the Principal.

4. Conclusion

The paper has tried to examine various incentive effects of the Maastricht treaty, the convergence criteria in particular as well as a the "stability pact". There are several obvious omissions in the analysis (as well as the Maastricht treaty itself). First, we only consider a single Agent and, in general, an optimal contract should be tailored to individual countries. The convergence criteria, however, apply indiscriminately to all applicant countries. Second, with several Agents their behaviour interacts and co-ordination problems can arise. Third, the treaty is not a complete contract, in particular it is not fully state-contingent. This can be an important drawback in the presence of shocks. Fourth, the criteria and the treaty provisions in general may lack credibility, in particular ex ante and ex post incentives can vary. Fifth, with treaty commitment being imperfect, Maastricht represents an ongoing strategic game even after the conclusion of the treaty.

Some of these issues are addressed in companion papers (Winkler 1996b,c,), but as for the present paper, the goal was first to highlight the incentive effects of the treaty provisions in place, and second to argue that these provisions were put there for some reason. The Maastricht criteria are an attempt to induce countries to undertake costly convergence effort prior to entry. On paper and as a first approximation they represent a very simple threshold contract to select countries for EMU as modelled in section two. With uncertainty, the probabability of entry will depend on convergence and will thereby provide incentives. In section three it was shown how for simple linear contracts a greater likelihood of EMU and a lower convergence level can be achieved if the Maastricht criteria are reconsidered together with the provisions for stage three, the stability stability pact, in particular.

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APPENDIX A

The second order condition for a maximum is:

$$U'' = -f'(\psi)\frac{\alpha^2 T}{\beta} - 1 < 0$$

To examine the effects on p^* it is convenient to use the fact that p rises if and only if ψ decreases (from *equation 3*). Rewriting the first order condition (*4*) in terms of ψ and using $\psi = M - \alpha E$ we obtain:

$$f(\psi^*) = \frac{\beta}{\alpha^2 T}(M - \psi^*)$$

$$\Leftrightarrow \quad \psi^* = M - f(\psi^*)\frac{\alpha^2 T}{\beta}$$

See Appendix B for a picture in the case of the normal distribution.

Proof of Proposition 1

Differentiate the first order condition in *equation 4* and the corresponding probability in *equation 3* (using the reformulation above) with respect to the parameter of interest. Assume all parameters strictly positive, $f(\psi)$ strictly positive over the relevant range and effort E, and therefore $(M-\psi)$, nonnegative. Using the second order condition for a maximum we obtain:

$$\frac{\partial E^*}{\partial T} = \frac{f(\psi)\dfrac{\alpha}{\beta}}{1 + f'(\psi)\dfrac{\alpha^2 T}{\beta}} > 0,$$

$$\frac{\partial p^*}{\partial T} > 0 \quad \text{since} \quad \frac{\partial \psi^*}{\partial T} = -\frac{f(\psi)\dfrac{\alpha^2}{\beta}}{1 + f'(\psi)\dfrac{\alpha^2 T}{\beta}} < 0,$$

$$\frac{\partial E^*}{\partial \beta} = -\frac{E^*}{\beta\left[1 + f'(\psi)\dfrac{\alpha^2 T}{\beta}\right]} < 0,$$

$$\frac{\partial p^*}{\partial \beta} < 0 \quad \text{since} \quad \frac{\partial \psi^*}{\partial \beta} = \frac{M - \psi^*}{\beta\left[1 + f'(\psi)\dfrac{\alpha^2 T}{\beta}\right]} > 0,$$

$$\frac{\partial E^*}{\partial M} = f'(\psi)\cdot\left(1 - \alpha\frac{\partial E^*}{\partial M}\right)\cdot\frac{\alpha T}{\beta}$$

$$\Leftrightarrow \quad \frac{\partial E^*}{\partial M} = \frac{f'(\psi)\dfrac{\alpha T}{\beta}}{1 + f'(\psi)\dfrac{\alpha^2 T}{\beta}} > 0 \quad \text{for } f'(\psi)>0, \qquad \frac{\partial E^*}{\partial M} < 0 \quad \text{for } f'(\psi)<0$$

$$\frac{\partial p^*}{\partial M} < 0 \quad \text{since} \quad \frac{\partial \psi^*}{\partial M} = \frac{1}{1 + f'(\psi)\dfrac{\alpha^2 T}{\beta}} > 0$$

$$\frac{\partial E^*}{\partial \alpha} = \frac{f'(\psi)\cdot\left(E + \alpha\dfrac{\partial E^*}{\partial \alpha}\right)\cdot\alpha T + f(\psi)T}{\beta}$$

$$\Leftrightarrow \quad \frac{\partial E^*}{\partial \alpha} = \frac{f(\psi)T\left(1 - f'(\psi)\dfrac{\alpha^2 T}{\beta}\right)}{\beta\left(1 + f'(\psi)\dfrac{\alpha^2 T}{\beta}\right)} > 0 \quad \textit{for} \quad \frac{\beta}{\alpha^2 T} > f'(\psi)$$

$$\frac{\partial p^*}{\partial \alpha} > 0 \quad \text{since} \quad \frac{\partial \psi^*}{\partial \alpha} = -\frac{2f(\psi)}{\dfrac{\beta}{\alpha T}\left[1 + f'(\psi)\dfrac{\alpha^2 T}{\beta}\right]} < 0, \qquad \square$$

Proof of Proposition 2

Recall that under certainty the critical value for T, that makes a country indifferent between complying with the criteria to qualify for EMU and staying out, is given by

$$\overline{T} = \frac{\beta M^2}{2\alpha^2}$$

From *equation 6* under certainty optimal effort is zero for $T<\overline{T}$, whereas with uncertainty (for any continuous distribution function with infinite range) effort is always strictly positive. For $T>\overline{T}$, again comparing the two first order conditions (*4*) and (*6*), we get:

$$\frac{f(\psi)\alpha T}{\beta} > \frac{M}{\alpha} \quad \Leftrightarrow \quad T > \frac{\beta M}{\alpha^2 f(\psi)},$$

which rewritten in terms of $\overline{T}$ yields the condition in (*7*). In terms of the picture in Appendix B the straight line must cut the y-axis below $f(0)$, i.e.

$$f(0) > kM \qquad \text{with} \quad k = \frac{\beta}{\alpha^2 T},$$

as a *necessary* condition for greater effort under uncertainty when the distribution is unimodal and centered on zero. For *sufficiency* we must assure a global maximum for $\psi^*<0$, i.e. kM small enough.

For $T=\overline{T}$ a country would never choose higher effort because uncertainty reduces the expected payoff. Since by definition, under certainty it had been just indifferent, therefore a lower effort level will be chosen. In fact the country would prefer no effort to the certainty effort. □

Proof of Proposition 3

In the case of credibility feedback the derivative of the probability with respect to effort becomes

$$\frac{\partial p(E)}{\partial E} = \frac{\partial}{\partial E}\int_{\psi}^{\infty} f(\theta)\, d\theta \equiv -f(\psi)\frac{\partial \psi}{\partial E} \equiv -f\left[M - \alpha E + \tau(1-p)\right]\cdot\left(-\alpha + \tau\frac{\partial p}{\partial E}\right)$$

$$\Leftrightarrow \quad \frac{\partial p}{\partial E} - \tau\frac{\partial p}{\partial E} f(\psi) = \alpha f(\psi) \quad \Leftrightarrow \quad \frac{\partial p}{\partial E} = \frac{\alpha f(\psi)}{1-\tau f(\psi)}. \quad \square$$

and, differentiating the first-order condition (*9*),

recalling $\psi \equiv M - \alpha E + \tau(1-p)$, with $f \equiv f(\psi)$ for brevity

$$\frac{\partial E^*}{\partial \tau} = \frac{[1-\tau f]f'\left(-\alpha\frac{\partial E^*}{\partial \alpha} + (1-p)\right) + f\left[f + \tau f'\left(-\alpha\frac{\partial E^*}{\partial \alpha} + (1-p)\right)\right]}{[1-\tau f]^2}$$

$$\Leftrightarrow \quad \frac{\partial E^*}{\partial \tau}\cdot\frac{\beta[1-\tau f]^2}{\alpha T} = f'\left(-\alpha\frac{\partial E^*}{\partial \alpha} + (1-p)\right) + f^2$$

$$\Leftrightarrow \quad \frac{\partial E^*}{\partial \tau} = \frac{f'(1-p) + f^2}{\frac{\beta[1-\tau f]^2}{\alpha T} + \alpha f'} \qquad > 0 \quad for \quad f' > 0$$

since

$$\frac{\partial \psi^*}{\partial \tau} = -\alpha \frac{\partial E^*}{\partial \tau} + (1-p) \qquad > 0 \quad if \quad \frac{\partial E^*}{\partial \tau} < 0, \quad \text{ambiguous otherwise}$$

$$\Rightarrow \quad \frac{\partial p^*}{\partial \tau} = \frac{-f}{1-\tau f} \cdot \frac{\partial \psi^*}{\partial \tau} \quad < 0 \quad if \quad \frac{\partial E^*}{\partial \tau} < 0, \quad \text{ambiguous otherwise} . \square$$

APPENDIX B

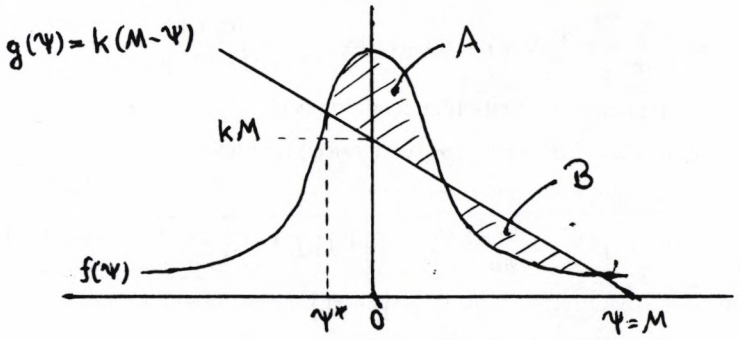
The Example of the Normal Distribution

With the first order condition in equation 4 expressed in terms of ψ we can write

$$f(\psi) = \frac{\beta M}{\alpha^2 T} - \frac{\beta}{\alpha^2 T}\psi \quad \equiv g(\psi) \qquad \text{where } k \equiv \frac{\beta}{\alpha^2 T} \text{ denotes the (negative) slope}$$

We can illustrate the solution graphically in the case of the normal distribution, i.e. with

$$f(\psi, 0, \sigma^2) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2\sigma^2}\psi^2\right], \quad \text{with} \quad \psi = M - \alpha E \text{ and } k \equiv \frac{\beta}{\alpha^2 T}$$



Existence of an interior solution is assured if the straight line cuts the distribution function from below at least once. This will be the case as long as $f(\psi)$ is continuous and positive over the relevant range. Then a corner solution with zero effort (i.e. $\psi = M$) can be ruled out since $U'(M)>0$, i.e. $f(\psi)>0$.

However, there may be more than one local maximum. In the case of the normal distribution there could be one or two, as in the picture above. Then the high effort maximum (low ψ)will be the global optimum as long as area A exceeds area B as in the picture. For small enough M and small enough k there will be a unique high effort maximum. For large enough M and k there will be a unique low effort solution (Utility is strictly decreasing in M and k).

A sufficient condition for a unique maximum is satisfied if the slope of the straight line is steeper than that of the normal distribution at the point of inflection of the normal distribution (i.e. at σ). Otherwise M must be small enough to always keep the straight line below the distribution function, i.e.:

$$M - \psi < f(\psi)\frac{\alpha^2 T}{\beta} \qquad \text{if} \quad f'(\sigma) < -\frac{\beta}{\alpha^2 T}$$

The effect of uncertainty on effort

The effect on optimal effort of increasing the standard deviation of the normal distribution (mean preserving spread) is given by:

$$\frac{\partial E^*}{\partial \sigma} = \frac{\psi^2 - \sigma^2}{\alpha\sigma\left(\dfrac{\beta\sigma^2}{\alpha^2 T f(\psi)} - \psi\right)} \quad > 0 \quad \textit{for} \quad \psi^2 > \sigma^2, \quad (\leq 0 \text{ otherwise})$$

$$\text{using } f'(\psi) = -\frac{\psi f(\psi)}{\sigma^2}$$

$$\text{then } \frac{\beta\sigma^2}{\alpha^2 T f(\psi)} - \psi \quad > 0 \quad \Leftrightarrow \quad \frac{\beta}{\alpha^2 T} + f'(\psi) \quad > 0$$

which always holds from the second order condition for a maximum.

Therefore, optimal effort rises in response to an increase in uncertainty for $\psi^2 > \sigma^2$, i.e. along the tails. This, because in this region greater uncertainty raises the marginal benefit (probability of success) for given effort.

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