Uncertain Exchange Rate Policies and Interest Rate Determination *

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I. Introduction

Significant interest rate differentials persist between countries within the European Monetary System (EMS) despite the alleged fixed exchange rate system.

The relationship between interest rates in Denmark and Germany is a case in point, cf. fig. 1. During the period 1983.1 to 1991.4 the difference in interest rates has been close to 5 %, while the difference in inflation between the two countries has been around 2 %. Thus the interest rate differential exceeds by some 3 % that implied by the uncovered interest rate parity condition supposing that exchange rate expectations are determined by inflation differentials.[1] The excessive interest rate differential may reflect either that market participants currently expect a devaluation higher than 2 % or a price for the uncertainty perceived by the market of the Danish exchange rate policy.

The Danish government has since the autumn 1982 pursued a fixed exchange rate policy. This marks a difference to the previous policy regime where discrete devaluations were undertaken to solve the two problems of unemployment and current account deficits. The government taking over in late 1982 emphasized that the exchange rate would not be used to that end in the future, and the announced policy was to maintain a fixed exchange rate within the EMS. This policy shift helps explain the dramatic fall in interest rates in Denmark in 1982 - 83 (see *Andersen* and *Risager* (1988) for

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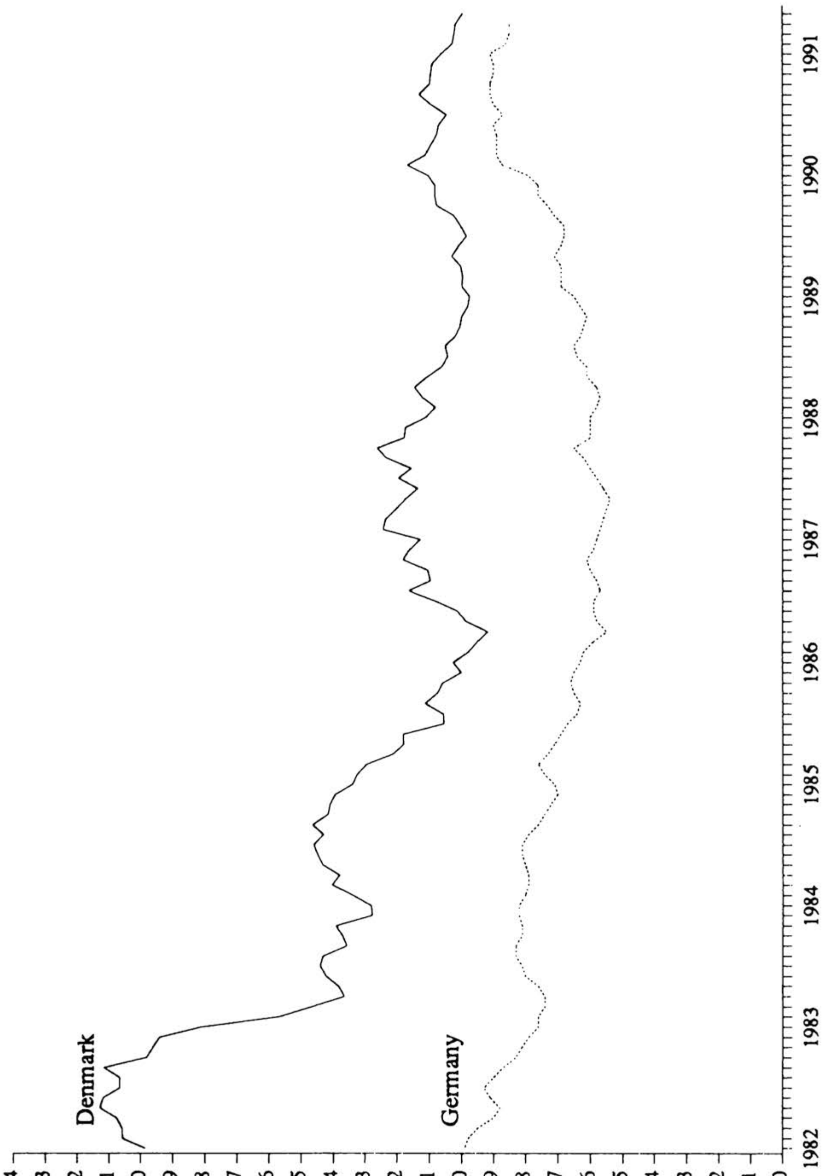
[1] During the period from 1967 to 1991 the average annual inflation differential between Denmark and Germany was 4.5 % and the Danish krone was on average devalued by 3.5 % relative to D-mark.



Source: Series for long-term interest rates constructed by Danmarks Statistik.

Figure 1: Long Term Interest Rates in Denmark and Germany 1982 - 1991

a detailed analysis). The announced exchange rate policy may not still, however, be credible since the problems of unemployment and current account deficits persist. The sheer announcement of a fixed exchange rate policy is not sufficient to remove the devaluation risk since you should never expect a government to admit that it contemplates a devaluation.

A primary reason for uncertainty about exchange rates is lack of knowledge about policy objectives and strategies, and thus whether discrete devaluations or revaluations are considered as policy instruments. To the extent that policy objectives are unknown to the private sector a risk of exchange rate changes arises. Incomplete information about whether a government is primarily concerned about output or inflation may thus create uncertainty about whether the government adheres to a fixed exchange rate or plans a discrete devaluation, see *Horn* and *Persson* (1988) and *Andersen* and *Risager* (1991). The present analysis extends this discussion by considering the effects on interest rates of changes in both the probability of an exchange rate change and the size of a possible change.

Specifically we consider a managed exchange rate system as we find it in e.g. the European Monetary System. Exchange rates of the currencies participating in this cooperation are pegged but realignments are possible. The aim is to analyse how the possibility of exchange rate changes affect interest rate differences between countries participating in the currency cooperation.

The apparent excessive interest rate differential between e.g. Denmark and Germany also relates to the recent discussion about the benefits of entering a formal monetary union implying the ultimate form of a fixed exchange rate policy. The present analysis shows why this may be of benefit to the small countries participating in such a union in the form of a reduction in expected real rates of interest made possible by a removal of risk premia reflecting the possibility of exchange rate changes.

The paper is organized as follows. The model is developed in section II which also characterizes the portfolio decisions of foreign and domestic investors. Section III gives the equilibrium determination of the domestic rate of interest, and some comparative static results on how this depends on the other variables in the model are derived in section IV. Finally, we have some concluding remarks in section V.

II. Portfolio Decisions

The analysis focuses on the effects of exchange rate risk on the interest rate differential between two countries with perfect capital mobility. Specifically we consider a discrete-time two-asset model in which the portfolio decision problem of investors is whether to invest in domestic securities or foreign securities taking into account the risk arising due to a possible change in the exchange rate. The nominal return on both assets (i and i^*, respectively) is known, but the real rate of return differs due to possible exchange rate changes.

A representative domestic investor is assumed to maximize an utility function defined over the expectation (E) and variance (σ^2) of end-of-period real wealth ($\tilde{W}$).

(1) $$\text{Max } U(E(\tilde{W}), \sigma^2(\tilde{W}))$$

and similarly a representative foreign investor maximizes

(2) $$\text{Max } U^*(E(\tilde{W}^*), \sigma^2(\tilde{W}^*))$$

where a * indicates the corresponding variables for the foreign investor. Object functions like (1) and (2) are standard in the static capital asset pricing model but can be obtained from an explicit dynamic framework when the elasticity of intertemporal substitution is constrained to unity (see *Giovannini* and *Jorion* (1988) and *Giovannini* and *Weil* (1989)).

Domestic investors allocate a fraction λ of their initial nominal wealth, $\bar{W}$, to the foreign security F and a fraction $(1-\lambda)$ to the domestic security, B, i.e.

(3) $$\lambda \bar{W} = \bar{\Theta} F$$

(4) $$(1-\lambda)\bar{W} = B$$

where $\bar{\Theta}$ is the initial price of foreign currency measured in domestic currency. Similarly, the foreign investors allocate λ^* of their nominal wealth, $\bar{W}^*$, to the foreign security, F^*, and a fraction $1-\lambda^*$ to their domestic security, i.e.

(5) $$\lambda^* \bar{W}^* = \frac{1}{\bar{\Theta}} F^*$$

(6) $$(1-\lambda^*)\bar{W}^* = B^*$$

End-of-period real wealth for domestic investors is

$$\tilde{W} = \Theta^{-1}[R^* \Theta \bar{\Theta}^{-1} \lambda \bar{W} + R(1-\lambda)\bar{W}]$$
$$(7) \qquad = R^* \lambda \bar{W} \bar{\Theta}^{-1} + R(1-\lambda)\bar{W}\Theta^{-1}$$

where $R = (1 + i)$ and $R^* = (1 + i^*)$ are the gross rates of return, a term used interchangeably with the interest rate in the following, and Θ is the end of period price of foreign currency. The foreign interest rate is assumed to be constant.

It is assumed in (7) that the domestic price level varies proportionally with the exchange rate[2] and that the foreign price level is constant and normalized to one (i.e. the domestic price level equals Θ, so $\tilde{W}$ equals nominal wealth times Θ^{-1}). The first assumption can be justified by referring to the fact that unless nominal rigidities prevail somewhere in the economy this property prevails rather generally in open economy macro models (see e.g. *Marston* (1985)). Alternatively, it can be interpreted as an assumption on expectations formation saying that expectations are formed supposing that prices respond one-to-one to changes in the exchange rates.

With a constant foreign price level end-of-period real wealth for foreign investors is

$$(8) \qquad \tilde{W}^* = R\Theta^{-1}\bar{\Theta}\lambda^* \bar{W}^* + R^*(1-\lambda^*)\bar{W}^*$$

The exchange rate in next period is assumed to be determined as

$$\Theta^{-1} = (1+\varepsilon)\bar{\Theta}^{-1}$$

where ε is a stochastic variable distributed as

$$\varepsilon = \begin{cases} 0 \text{ with probability } 0 \leq 1-p \leq 1 \\ e \text{ with probability } p \end{cases}$$

the expected value and variance of ε are

$$E\varepsilon = p \cdot e$$

$$\text{Var}\ \varepsilon = p(1-p)e^2$$

[2] This assumption has the technical attractiveness that it allows us to avoid the socalled *Siegel's* paradox (*Siegel*, 1972) which arises otherwise because domestic investors are concerned about the exchange rate Θ, while foreign investors are looking at the exchange rate Θ^{-1}, and $(E\Theta)^{-1} \neq E(\Theta^{-1})$, see also *Fama* & *Farber* (1979). The general case where domestic prices are not affected proportionally and prices are risky is considered in *Andersen* and *Sørensen* (1990).

There is thus a probability p that the exchange rate changes by $e \cdot 100\,\%$. If e is positive, the currency is revalued, whereas a devaluation implies a negative value of e. The change in the exchange rate e is taken to be exogenous and only restricted to be in the interval precluding that neither the domestic nor the foreign currency becomes (relatively) valueless, i.e. $-1 < e < \infty$. The particular stochastic process assumed here can be motivated by reference to theoretical credibility analysis yielding such a process when there is incomplete information about whether an inflationary or non-inflationary policy is being pursued (see *Horn* and *Persson* (1988) and *Andersen* and *Risager* (1991)).

Combining the ingredients laid out above, it follows straightforwardly that the share of initial wealth placed in domestic securities by domestic investors is

$$1 - \lambda = \frac{R\,(1 + E\,\varepsilon) - R^*}{\varrho\, R^2\, p\,(1-p)\, e^2} \tag{9}$$

where $\varrho = -2\,(\bar{W}/\bar{\Theta})\,U_2/U_1 > 0$ is the relative risk-aversion coefficient for domestic investors assumed to be constant.

Foreign investors find it optimal to invest a share

$$\lambda^* = \frac{R\,(1 + E\,\varepsilon) - R^*}{\varrho^*\, R^2\, p\,(1-p)\, e^2} \tag{10}$$

of initial wealth in the domestic security. The relative risk-aversion coefficient for foreign investors is $\varrho^* = -2\,\bar{W}^*\, U_2^*/U_1^* > 0$ which is also assumed to be constant.

Expression (9) and (10) embodies the symmetry property that if domestic investors place some of their wealth in domestic assets $(1 - \lambda > 0)$ so do foreign investors $(\lambda^* > 0)$, and vice versa if it is optimal to borrow in the domestic securities market.

Total demand for domestic securities can thus be written

$$\begin{aligned} D &= (1-\lambda)\,\bar{W} + \lambda^*\,\bar{\Theta}\,\bar{W}^* \\ &= \frac{R\,(1 + E\,\varepsilon) - R^*}{R^2\, p\,(1-p)\, e^2} \left[\frac{\bar{W}}{\varrho} + \frac{\bar{\Theta}\,\bar{W}^*}{\varrho^*} \right] \end{aligned} \tag{11}$$

One notices that there is a possibility that total demand for domestic securities is not increasing in the domestic rate of interest (R) since

$$\frac{\partial D}{\partial R} \gtreqless 0 \;\text{ if }\; 2\,R^* \gtreqless R\,(1 + E\,\varepsilon) \tag{12}$$

This ambiguity arises although investors get a higher expected return on domestic securities when the interest rate increases, because the uncertainty on the return obtainable on these securities increases too. When R is low the effect of a higher expected return dominates the uncertainty effect, but when R is high the uncertainty effect is dominating. To understand this trade off, it is important to note that the expected income from holding domestic securities is always increasing in the interest rate (i.e. $\partial(R \cdot D)/\partial R = R^* [R^2 p(1-p)e^2]^{-1} \cdot [\bar{W}/\varrho + \bar{\Theta}\bar{W}^*/\varrho^*] > 0)$.

From (11) it follows that

$$\lim_{R \to 0} D = -\infty$$

$$\lim_{R \to \infty} D = 0$$

Combining this fact with (12) allows us to draw the total demand function for domestic securities as in figure 2.

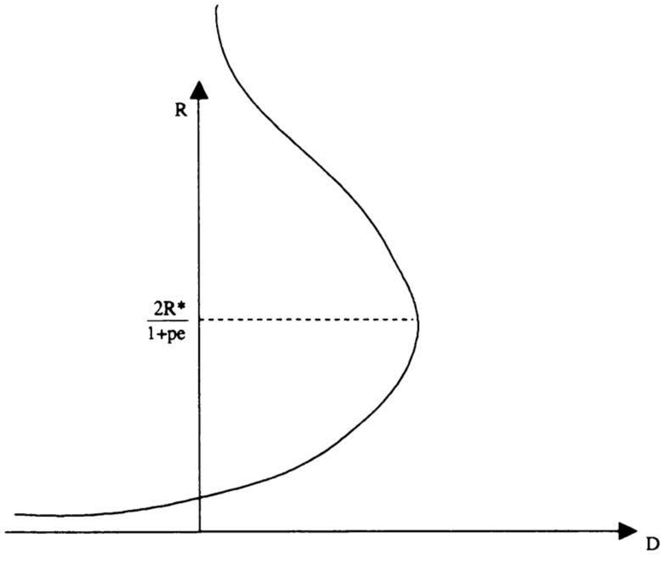


Figure 2: Demand for domestic securities

III. Determination of the Domestic Rate of Interest

We employ a small open economy assumption wrt. to financial markets in the sense that the foreign variables are taken to be given independently of domestic variables. Conditions abroad affect the domestic economy but the economy is too small to have any influence on market conditions abroad. Specifically, this means that we do not consider the equilibrium condition for the foreign securities market but take R^* as a constant.[3]

The equilibrium condition for the domestic securities market can now be written

$$S = D(R) \tag{13}$$

where $S(> 0)$ is the supply of domestic securities assumed to be constant.

Solving for the equilibrium value of the domestic rate of interest we find that it has a quadratic form which implies that we can have two, a unique, or no equilibria values for the domestic interest rate. Figure 3 illustrates the possible equilibrium configurations, where we with a supply S_I have two equilibria (A and B), with a supply S_{II} have a unique equilibrium (C) and with a supply S_{III} no equilibrium exists.

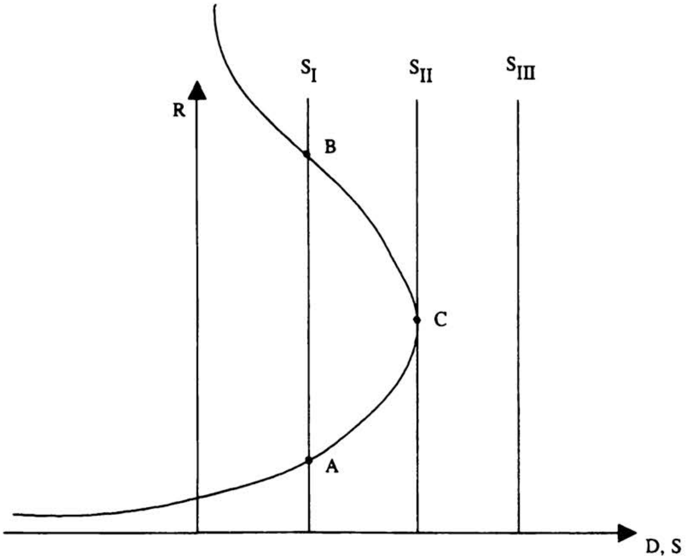


Figure 3: Equilibrium in the domestic securities market

[3] Could also be interpreted as reflecting an infinitely elastic supply of foreign bonds at R^*. In *Andersen* and *Sørensen* (1990) it is shown that the model also can be interpreted as a general equilibrium two-country model.

In the following we proceed under the assumption that an equilibrium exists and we shall moreover restrict attention to stable equilibria, that is, a normal tatonnement process is assumed such that the domestic interest rate decreases if the domestic securities market is in excess demand and vice versa. Comparing the equilibria in figure 3 shows that A is stable whereas B is unstable. This implies that $\partial D / \partial R > 0$ in any stable equilibrium.

Considering the qualitative implications of an uncertain exchange rate policy we find that

$$R(1 + E\varepsilon) > R^* \tag{14}$$

which should be compared to the uncovered interest parity condition which emerges as a special case of our model when the exchange rate policy is known with certainty (p equal to zero or one) or agents are risk neutral, i. e.

$$R(1 + E\varepsilon) = R^* \tag{15}$$

In comparing (14) and (15) we must conclude that if a small open economy has an uncertain exchange rate policy it implies that interest rates are higher than if the exchange rate policy would have been known for sure. The difference in interest rates between certainty and uncertainty reflects a risk premium since investors are risk averse. The intuition is that we are essentially analysing the pricing of an asset with an uncertain real return (viz. the domestic security) relative to an asset with a certain real rate of return (viz. the foreign security). This explains why the domestic security always carries a premium above the expected exchange rate change relative to the foreign security when investors are risk averse. Rewriting (13) to obtain an expression for the risk premium we find

$$R\,(1 + pe) - R^* = SR^2\, p\,(1 - p)\, e^2 \left[\frac{\bar{W}}{\varrho} + \frac{\bar{\Theta}\,\bar{W}^*}{\varrho^*} \right]^{-1} \tag{16}$$

More uncertainty concerning the exchange rate (i.e. var $\varepsilon = p(1 - p)e^2$), and a higher domestic interest rate, increases the uncertainty concerning the real return on domestic securities, and this explains why the risk premium is increasing in $R^2 p(1 - p)e^2$. Moreover, we see that more risk averse investors increase the risk premium, and so does a higher supply of domestic securities relative to the level of domestic and foreign wealth.

Nevertheless, the complexity of the RHS of (16) shows that the conventional econometric practice of modelling risk premia as a constant deviation from the uncovered interest parity condition has little theoretical foundation.

IV. Comparative Static Results

In this section we consider the effects on the domestic rate of interest if there is a marginal change in one of the exogenous variables. The analysis relates to stable equilibria, i.e. $\partial D / \partial R > 0$.

(i) A change in the supply of domestic securities.

An increase in the supply of domestic securities leads to a higher interest rate, i.e.

$$\frac{\partial R}{\partial S} > 0$$

This result is also easily seen from figure 3.

(ii) A change in the foreign interest rate.

A higher level of interest rates abroad leads unambiguously to a higher domestic rate of interest

$$\frac{\partial R}{\partial R^*} > 0$$

(iii) A change in risk aversion.

Higher risk aversion measured by the relative risk-aversion coefficient for both domestic and foreign investors leads to a higher domestic interest rate, i.e.

$$\frac{\partial R}{\partial \varrho} > 0$$

$$\frac{\partial R}{\partial \varrho^*} > 0$$

The intuition being that more risk-averse investors require a higher premium to invest in the security with an uncertain real return, viz. the domestic security.

(iv) A change in initial wealth.

Increased initial wealth for both types of investors increases the demand for domestic securities and leads thus to lower interest rates

$$\frac{\partial R}{\partial \bar{W}} < 0$$

$$\frac{\partial R}{\partial \bar{\Theta} \bar{W}^*} < 0$$

(v) A change in the probability for an exchange rate change.

The effect of a change in the probability that the exchange rate is changed is in general ambiguous. This is so since the probability affects both the expectation and variance of the future exchange rate, and the latter is moreover not monotone in the probability p. An increase in p increases the variance for $p < 1/2$ and decreases it for $p > 1/2$.

It is possible to show that

$$\text{sign} \frac{\partial R}{\partial p} = -\text{sign}\,[\text{Rep}\,(1-p) - (R\,(1+pe) - R^*)\,(1-2\,p)]$$

The sign of $\partial R / \partial p$ is unambiguously negative if an increase in p increases the expectation and decreases the variance of the domestic security's real return. This is the case if the probability for a revaluation is higher than one half (i.e. $e > 0$ and $p \geq 1/2$). The sign of $\partial R / \partial p$ is unambiguously positive if an increase in p decreases the expectation and increases the variance of the domestic security's real return. This is the case if the probability for a devaluation is lower than one half (i.e. $e < 0$ and $p \leq 1/2$). In the other cases $\partial R / \partial p$ is ambiguous (i.e. $e < 0$ and $p > 1/2$ or $e > 0$ and $p < 1/2$).

If we consider a devaluation risk, we therefore find that the domestic interest rate unambiguously increases if p increases from a level below $1/2$. Whereas it is ambiguous whether the domestic interest rate increases or decreases if p increases from a level above $1/2$. The influence of p on the interest rate can be summarized by figure 4, where figure 4.I illustrates the case where the interest rate increases continuously in p, and figure 4.II shows that it is also possible that the interest rate decreases when p increases from a level above $1/2$.[4]

The upward sloping dashed line in figure 4 shows how the domestic interest rate would respond to the probability of a devaluation according to the uncovered interest parity condition which arises as the special case of our model when agents are risk neutral. The shaded area in the figures shows thus the excess return arising from risk-aversion. In both figures we find this to be first increasing and then decreasing in the probability p of a devaluation.

[4] This requires that $1 - SRe[(\bar{W}/\varrho) + (\bar{\Theta}\bar{W}^*/\varrho^*)]^{-1}(1-2p) < 0$ which has $p > 1/2$ as a necessary but not sufficient condition.

The findings illustrated in figure 4.II run counter to common sense arguments often found in e.g. the financial press claiming that a more uncertain exchange rate policy in terms of a higher probability for a change in the exchange rate always leads to higher interest differentials. The interest spread needs not to be monotone in the probability p but may be maximal at a value of p less than one.

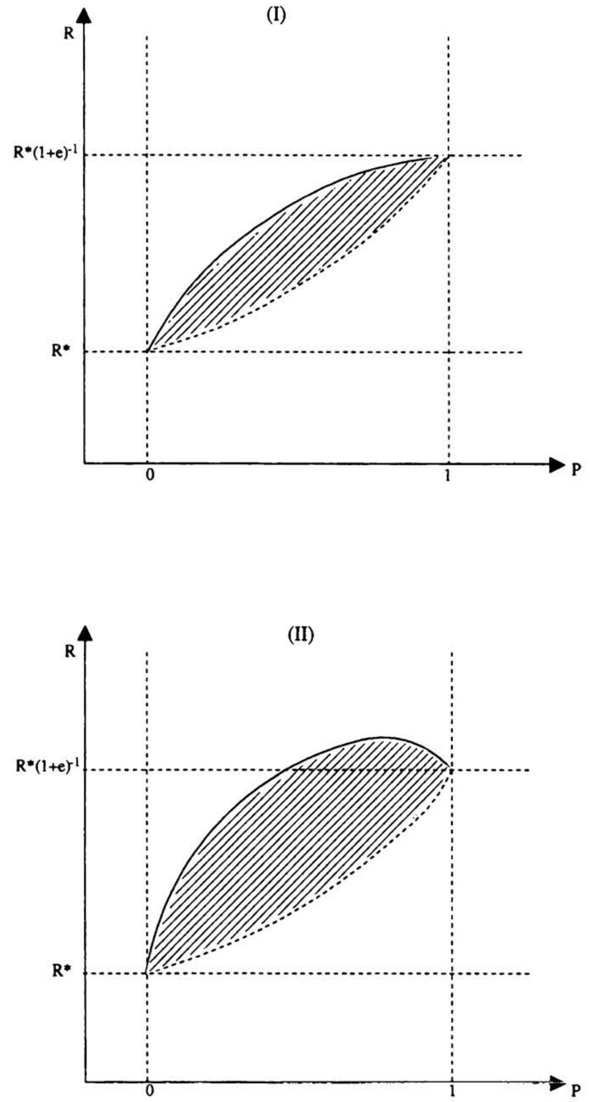


Figure 4: The Dependence of the domestic interest rate on the probability of a devaluation

If credibility of a given exchange rate policy is measured by the probability (p) that an exchange rate change is undertaken, it follows that a monotone relationship between credibility and the domestic interest rate does not necessarily exist. To see this, consider the following scenario where a new government takes over in a context where discrete devaluations have been frequently undertaken in the past, i.e. the private sector perceives to face a situation with $e < 0$ and $p \approx 1$. As part of its stabilization programme the new government announces a fixed exchange rate as a means in a disinflationary policy. The announced exchange rate policy is not credible offhand to the private sector since a government intending to devalue will also claim that it goes for a fixed exchange rate to maximize the gain from a surprise devaluation. Eventually, the new government might succeed in making the fixed exchange rate credible. If p in this process of establishing credibility decreases continuously the interest rate may first increase as a response to the lower probability for a devaluation. At a certain point of time credibility is enhanced so much that the interest rate begins to fall, cf. figure 4.II. The explanation of this possible perverse initial reaction to increased credibility is that the previous policy regime entailing discrete devaluations gave the private sector a relatively stable anchor for its investment planning, namely, the devaluation was expected ($p \approx 1$) and it was subsequently undertaken (no surprises). When the probability of a devaluation falls it may at first create more uncertainty about the future exchange rate and this effect may dominate the effect of a reduction in the expected value of the exchange rate such that interest rate increases in the transition period from an inflationary to a non-inflationary policy regime.[5]

(vi) A change in the possible exchange rate change.

The influence of a change in the possible exchange rate change (e) is also ambiguous in general since it affects both expectations and variance. We find that

$$\text{sign}\ \frac{\partial R}{\partial e} = -\ \text{sign}\ [\text{Rpe}^2 - (R\,(1 + pe) - R^*)\ 2\ e]$$

and therefore

$$\frac{\partial R}{\partial e} < 0 \ \text{ if } \ e \gtreqless 0$$

[5] The theoretical analysis of this transition period based on risk neutrality in *Andersen* and *Risager* (1991) is unaffected by the introduction of risk aversion, since the particular game-theoretic model predicts that the probability of a devaluation remains constant in the transition period.

which is as should be expected since for $e < 0$ an increase in e means a lower potential devaluation which increases the expected return and lowers the variance. Reversely, we can thus conclude that a fall in e implying a larger potential devaluation unambiguously leads to an increase in the domestic interest rate.

(vii) Increasing risk for given expectations.

Since changes in p and e both affect expectations and variances it is natural to ask what the effect would be of an increase in variability for given expectations. This can be done by considering changes in p and e which keep the expected value of the exchange rate change constant, i.e.

$$pe = \text{constant}$$

In this case an increase in e would increase the variance if e is positive and vice versa if e is negative since $\operatorname{Var} \varepsilon = p(1-p)e^2 = (pe)e - (pe)^2$. An increase in e requires thus a fall in p if e is positive and an increase in p if e is negative to keep the expected exchange-rate change pe constant. It is easily verified that

$$\left.\frac{\partial R}{\partial |e|}\right|_{pe\ =\ \text{constant}} > 0$$

An increase in the numerical value of e increases thus the variability of the future exchange rate for a given expected value and this leads to a higher domestic rate of interest.

V. Concluding Remarks

The almost universally observed deviations from the uncovered interest parity condition has led to substantial interest in explaining this as a result of risk aversion. The present analysis which explicitly focuses on the importance of risk aversion of the pricing of securities in an explicitly formulated equilibrium framework shows that considerable complexity goes into the risk premium.

The present analysis has focused directly on the effects on financial markets of an uncertain exchange rate policy. This relates to the theoretical and empirical literature in which implications for interest rates of incomplete knowledge on policy objectives are addressed, see *Andersen* and *Risager* (1988) and *Christensen* (1989). It turns out that whether a change in the expected exchange rate change is driven by a change in the probability for an exchange rate realignment or a change in the possible exchange rate change has qualitative different implications for interest rate determination. Spreads between domestic and foreign interest rates can thus be influenced in different ways which makes it difficult to infer from changes in spreads to changed credibility of an announced exchange rate policy.

An important conclusion of this analysis is that the interest rate of a small open economy (small in the sense that the price level is proportional to the exchange rate) has a positive risk premium relative to the interest rate of a big open economy (big in the sense that the price level is not affected by the exchange rate) if the exchange rate policy is uncertain. An uncertain exchange rate policy produces thus an excessive real rate of interest which suggests a possible gain from a credible fixed exchange rate policy to a small economy. The present study is partial which precludes an analysis of the implications of the monetary autonomy gained by an uncertain exchange rate policy making domestic and foreign securities imperfect substitutes. An interesting question for future research is thus to analyse whether the gain on monetary autonomy is sufficient to outweight the costs of a higher real-rate of interest.

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Zusammenfassung

Ungewisse Wechselkurspolitiken und Zinsfestsetzung

Wir untersuchen, wie ungewisse Wechselkurspolitiken die Zinsdifferenzen zwischen Ländern beeinflussen, die einem gelenkten Wechselkurssystem angehören. Es wird gezeigt, daß der Zinssatz in einer kleinen offenen Volkswirtschaft gemessen an dem Zinssatz einer großen offenen Volkswirtschaft immer einen positiven Risikozuschlag aufweist. Dieser Beitrag untersucht die komplexe Abweichung von der aufgedeckten, von positiven Risikozuschlägen implizierten Zinsparitätsbedingung. Es erweist sich insbesondere, daß der Zinssatz mit dem jeweiligen Abwertungsumfang steigt, daß die größere Wahrscheinlichkeit einer Abwertung den Zinssatz jedoch nicht unbedingt steigen läßt, da die Erwartungen und Abweichungen sich in verschiedene Richtungen bewegen können.

Summary

Uncertain Exchange Rate Policies and Interest Rate Determination

We analyse how an uncertain exchange rate policy affects interest rate differences between countries participating in a managed exchange rate system. It is shown that the interest rate of a small and open economy always has a positive risk premium relative to the interest rate of a big and open economy. The paper explores the complex deviation from the uncovered interest rate parity condition implied by positive risk premia. Specifically, it turns out that the interest rate is increasing in the potential size of a devaluation, but a higher probability of a depreciation does not necessarily increase the interest rate, since expectations and variances may be affected in different directions.

Résumé

Politiques incertaines de taux de change et détermination des taux d'intérêt

Nous analysons comment une politique incertaine des taux de change influence les différences de taux d'intérêt entre les pays participant à un système de taux de change contrôle. Les auteurs montrent que le taux d'intérêt d'une petite économie ouverte a toujours une prime de risque positive par rapport au taux d'intérêt d'une large économie ouverte. L'article examine la déviation complexe de la condition de parité du taux d'intérêt à découvert, impliquée par des primes de risque positives. Il apparaît spécifiquement que le taux d'intérêt s'élève avec la mesure potentielle d'une dévaluation, mais une probabilité plus élevée de dépréciation ne fait pas nécessairement augmenter le taux d'intérêt, puisque les attentes et les variances peuvent être influencées dans différentes directions.