IMF Working Paper

Spreading Currency Crises:
The Role of Economic Interdependence

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IMF Working Paper

Research Department

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Authorized for distribution by Kenneth Rogoff

August 2002

Abstract

We analyze in this paper how the mutual dependence of private sector expectations in different countries on one another influences the stability of fixed exchange rate regimes. The crisis probabilities of countries trading with one another are interdependent because wage setters react to an imminent loss of international competitiveness stemming from an increase in the crisis probability of a trading partner. If a currency crisis in one country is perceived to be increasingly likely, the probability of devaluation of its trading partners' currencies to restore their international competitiveness rises as well. Thus, not only actual devaluations but also an increasing crisis probability may trigger currency crises elsewhere. We show that not only fundamental weaknesses but also spontaneous shifts in market sentiment may play a role in precipitating currency crises.

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1. INTRODUCTION

The spread of currency crises is a hotly debated topic among international economists. Two main explanations have gained prominence in the literature (Masson, 1999). First, economic interdependencies between two economies may be the reason why a currency crisis in one country is transmitted to another. Starting from trade or financial links, a currency crisis spreads to other countries because the crisis affects other countries' fundamentals through their economic linkages. Consider trade links. The crisis-induced devaluation of one country's currency leads to a deteriorating trade balance and thus a reduction in output and employment in other countries. Thus, the stability of the fixed exchange rate systems of bilateral trade partners, as well as of competitors for export markets will be reduced.

Second, (pure) contagion may be responsible for the simultaneous occurrence of currency crises. Contagion refers to the phenomenon of a crisis in one country triggering crises elsewhere in the world without a corresponding shift in fundamentals. Crises spread contagiously if they lead to shifts in market sentiment for which there is no conceivable fundamental reason. A crisis in one country may be understood as an indicator of equally severe problems in others that are perceived by international capital markets as being in a similar macroeconomic position, or the crisis may lead to a reassessment of existing information about other countries. This may result in a changing attitude toward several countries and precipitate a massive capital outflow that is unrelated to their fundamental situations. Calvo (1999), Kodres and Pritsker (1998), and Lagunoff and Schreft (1999) analyze theoretically this explanation for the transmission of crises.

In this paper, we concentrate on the first approach to explain contemporaneous currency crises. Recent related papers by Corsetti, Pesenti, Roubini and Tille (2000) and Loisel and Martin (2001) have examined this problem. Corsetti and others rely on a choice-theoretic framework and assess the welfare effects of competitive devaluations on the basis of individual utility functions. In their model, a crisis in one country does not necessarily reduce the welfare of its trading partners. They stress that trade partners profit from a welfare-enhancing improvement in their terms of trade. Under certain circumstances, the improvement in the terms of trade dominates the welfare loss resulting from the loss of international cost competitiveness. Corsetti and others further show that the crisis transmission via trade links depends on the existence of bilateral trade between the periphery countries. If countries trade bilaterally—that is, they are not only linked with one another through the competition in common export markets—they are more likely to refrain from a devaluation to restore their international competitiveness.

Loisel and Martin (2001) present a micro-founded, second-generation model. In their deterministic model, currency crises are only possible when countries are not in equilibrium. The policymaker devalues in order to increase the national market share in a monopolistically competitive sector. The incentive to abandon the fixed exchange rate stems from the loss of competitiveness and the reduction in domestic firms' profits if the private sector demands higher wages in anticipation of a crisis. This circular logic gives rise to the possibility of multiple equilibria and self-fulfilling crises. The probability of

simultaneous self-fulfilling crises in the periphery countries grows with the strength of the trade links. Loisel and Martin then examine whether policy coordination—that is, selecting the best Nash equilibrium if multiple equilibria exist, or cooperating with the periphery countries—defined as the maximization of the sum of the periphery countries' welfare by a supranational authority—are suitable measures to reduce the probability of contemporaneous self-fulfilling currency crises. Both coordination and cooperation help to limit the zone where simultaneous self-fulfilling crises can develop. However, international policy coordination may also introduce a new channel for the international transmission of currency crises. Coordination raises the mutual dependence of the periphery countries' fundamentals on one another. As the credibility of international policy coordination depends on the fundamentals of both periphery countries, an agreement to attain the Pareto-dominant Nash equilibrium might lose its credibility if a crisis in one country leads to a sufficiently strong deterioration in the other countries' fundamentals.

We present a model that adds a further cornerstone to the existing literature by concentrating on the previously neglected issue of how the interdependencies of private sector expectations in different countries may contribute to the spreading of foreign exchange market turmoil. In contrast to the papers by Loisel and Martin (2001) and Corsetti and others (2000), we do not examine how a currency devaluation carried out by one country influences the incentives of the policymakers in other countries to maintain a fixed exchange rate. Instead we focus on the mutual dependence of private expectations in the periphery countries. To do this, we start from an increase in the crisis probability in one periphery country and analyze its impact on the stability of the fixed exchange rate system in the second country. Our aim is to investigate how the private sector in periphery country A reacts to an increase in the other periphery country B's crisis probability, and what repercussions this interaction has for optimal monetary policy in A.

In order to focus on strategic interactions, we build our model along the lines of Obstfeld's (1996) and Jeanne's (1997) canonical second-generation currency-crisis models. By extending their approach to a three-country system, we are able to analyze not only the interaction between the policymaker and the private sector in one country—which is the focus of typical second-generation models—but also the interaction between the private sectors in both periphery countries. We show that not only crisis-induced devaluations but also a rising crisis probability exert a beggar-thy-neighbor effect. The rising crisis probability in one country increases the probability of a loss of international competitiveness for its trade partners. The increased probability of an expansionary monetary policy to restore international competitiveness is embedded in private sector expectations and, given a fixed exchange rate, immediately leads to a recessionary situation.

Now three scenarios can be differentiated. First, an increase in country B's crisis probability may impair the stability of country A's fixed exchange rate so much that a crisis is the inevitable outcome. Second, it may have only a negligible effect on the stability of A's exchange rate system, so that a crisis remains very unlikely. In both cases, country A's crisis probability is unambiguously defined. But this need not necessarily be the case. In the third scenario, it is possible for A to enter the zone of multiple equilibria

We present our model in Section II and derive the optimal opting-out clause for the policymaker in Section III. In Section IV the equilibrium condition is derived. Particular attention is paid to the circumstances under which multiple equilibria exist. The interdependencies of the crisis probabilities in our model are further examined in Section V. Section VI concludes.

II. THE MODEL

We consider a world consisting of three economies, two of which are small periphery countries (Countries A and B) that peg their exchange rate to the currency of the third, economically large country, the so-called center-country C. We assume that each economy produces only one good and that these goods are imperfect substitutes for one another. The structure of our model is based on typical models of the policy coordination literature, in particular the model of Canzoneri and Henderson (1991). As is usual in the second generation approach to currency crises, we focus on the interaction between the policymaker and the wage setters, ignoring the game between the policymakers in both periphery countries which is the subject of the policy coordination literature. We explicitly only model country A's economy and analyze the effect of a rise in B's crisis probability, which we take as exogenous on the stability of A's fixed exchange rate. All variables are expressed in logs.

We assume that country A produces according to a Cobb-Douglas function.

$$y_{A,t} = (1-\alpha)n_{A,t}, \qquad 0 < \alpha < 1. \qquad (1)$$

$y_{A,t}$ and $n_{A,t}$ are the deviations of output and employment from their natural rates, which we normalize to zero in logs.

The international demand for the good produced in A depends on the real exchange rate between the periphery countries and on the real exchange rate between countries A and C. Furthermore, it is influenced by a stochastic shock $\eta_{A,t}$, which has a continuous probability density function (p.d.f.) that monotonically rises in $[-\infty,0]$ and falls in the interval $[0,\infty]$. The p.d.f. is symmetric around zero, i.e. $f(\eta_{A,t}) = f(-\eta_{A,t}) \; \forall \eta_{A,t}$ (cf. Jeanne, 1997). The goods market of A, therefore, is in equilibrium if equation (2) holds.

$$y_{A,t} = \delta q_{A,t} + \varepsilon(q_{A,t} - q_{B,t}) - \eta_{A,t}, \qquad \delta, \varepsilon > 0. \qquad (2)$$

The real exchange rate $q_{i,t}$ is defined as:

$$q_{i,t} = s_{i,t} + p_{C,t} - p_{i,t},$$

(3)

so that a rising (real) exchange rate $s_{i,t}$ ($q_{i,t}$) means a (real) devaluation. $p_{i,t}$, $i = A, B, C$ are the product prices.

We further assume that the price of country B's good $p_{B,t}$ is predetermined. Moreover, the center country C leaves its monetary policy unchanged and $p_{C,t} = 0$ $\forall t$.

Money market equilibrium is given by the Cambridge equation:

$$m_{A,t} - p_{A,t} = y_{A,t},$$

(4)

where $m_{A,t}$ is the money supply in country A. Aggregate employment can now be derived from the competitive firms' profit maximization problem. The labor demand is extended until the marginal product of labor equals the real wage, which is defined as the nominal wage $w_{A,t}$ minus the product price.[2]

$$-\alpha n_{A,t} = w_{A,t} - p_{A,t}.$$

(5)

Using (1), (4) and (5) we can now calculate the aggregate employment as,

$$n_{A,t} = m_{A,t} - w_{A,t}.$$

(6)

Trade unions and firms enter into wage negotiations before the random shock is drawn and money supplies are set. The trade unions aim at setting the nominal wages so that all union members will be employed if no shock hits. In this case employment reaches its natural rate, i.e. $n_{A,t} = 0$.[3] Thus, the nominal wage is set equal to the expected money supply, $w_{A,t} = E_{t-1} m_{A,t}$ (Canzoneri and Henderson, 1991). Wage setters are contractually obliged to supply whatever quantity of labor firms demand at the negotiated wage after the money supplies are set. Now, aggregate employment $n_{A,t}$ and the producer price level $p_{A,t}$ can be expressed as a function of the realized and the expected money supply.

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[2] Actually profit maximization requires: $\ln(1-\alpha) - \alpha n = \hat{w} - p$. For notational simplicity we define $w = \hat{w} - \ln(1-\alpha)$.

[3] More formally, wage setter minimize $E_{t-1}(n_{A,t})^2 = E_{t-1}(m_{A,t} - w_{A,t})^2$. Thus, we employ a quite simple objective function for the trade union. The reason is of course the intention to keep the model tractable. A comprehensive analysis of the economics of the trade union can be found in Booth (1995).

$$n_{A,t} = m_{A,t} - E_{t-1}m_{A,t}.$$ (7)

$$p_{A,t} = \alpha m_{A,t} + (1-\alpha)E_{t-1}m_{A,t}.$$ (8)

III. THE OPTIMAL OPTING-OUT CLAUSE

The policymaker minimizes the loss function:

$$L_{A,t} = (n_{A,t} - k_A)^2 + \theta_A(p_{A,t} - p_{A,t-1})^2 + \chi C_A, \qquad \theta_A > 0.$$ (9)

The policymaker's employment target exceeds the natural rate, which is assumed to be zero;[4] k_A is the difference between both. If the policymaker opts out of the fixed exchange rate system he has to bear a fixed personal cost of realignment, C_A, representing the loss of political reputation or credibility. χ is a dummy variable, which is equal to one if the prevailing exchange rate system is abandoned and to zero if the policymaker continues to fix the exchange rate.

To facilitate further calculations we consider the change in the product price level (GDP deflator) as a policy target, instead of the consumer price index, and assume that $p_{A,t-1} = 0$. The policymaker's loss function can thus be expressed as follows:

$$L_{A,t} = (m_{A,t} - E_{t-1}m_{A,t} - k_A)^2 + \theta_A(\alpha m_{A,t} + (1-\alpha)E_{t-1}m_{A,t})^2 + \chi C_A.$$ (10)

If the policymaker decides to devalue, the money supply will be

$$m_{A,t}^{flex} = \frac{(1-\alpha(1-\alpha)\theta_A)E_{t-1}m_{A,t} + k_A}{1+\alpha^2\theta_A}.$$ (11)

The case of a flexible exchange rate is denoted by the superscript "flex". Equation (11) is the policymaker's reaction function. It tells how the policymaker should optimally set the money supply for given market expectations if monetary policy is not subordinated to an exchange rate target. Employment, in this case can now easily be calculated:

$$n_{A,t}^{flex} = \frac{k_A - \alpha\theta_A E_{t-1}m_{A,t}}{1+\alpha^2\theta_A}.$$ (12)

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[4] That is, the policymaker cares about all workers and not just the unionized insiders.

so that the value of the policymaker's loss function is:

$$L_{A,t}^{flex} = \frac{\theta_A}{1+\alpha^2\theta_A}\left(E_{t-1}m_{A,t} + \alpha k_A\right)^2.$$ (13)

In second generation type models a currency crisis is interpreted as a rational policy decision of the policymaker who compares the social loss under a fixed exchange rate with the value of the loss function under a flexible exchange rate. If the loss under a fixed exchange rate exceeds the loss of the optimal monetary policy according to the policymaker's reaction function (11) by an amount greater than C_A, the policymaker will rationally decide to abandon the fixed exchange rate. A currency crisis therefore reflects the policy decision in favor of the optimal autonomous monetary policy. Before the condition steering the change of the exchange rate system can be derived, the value of the loss function for the continuation of the exchange rate peg must be computed.

Pegging the exchange rate entails the loss of monetary policy autonomy. Using equations (2) and (4) and assuming that $s_A^{fix} = 0$, we can calculate the money supply that the policymaker has to set in order to maintain the fixed exchange rate:

$$m_{A,t}^{fix} = (1-\alpha)(1-(\delta+\varepsilon))\beta E_{t-1}m_{A,t} - \varepsilon\beta\left(s_{B,t} - p_{B,t}\right) - \beta\eta_{A,t},$$ (14)

with $\beta \equiv \dfrac{1}{1-\alpha(1-(\delta+\varepsilon))}$. The superscript "fix" refers to the fixed exchange rate case. Now employment and the price level, which is identical to the inflation rate due to our assumption that $p_{A,t-1} = 0$, can be derived:

$$n_{A,t}^{fix} = -(\delta+\varepsilon)\beta E_{t-1}m_{A,t} - \varepsilon\beta\left(s_{B,t} - p_{B,t}\right) - \beta\eta_{A,t}.$$ (15)

$$p_{A,t}^{fix} = (1-\alpha)\beta E_{t-1}m_{A,t} - \alpha\varepsilon\beta\left(s_{B,t} - p_{B,t}\right) - \alpha\beta\eta_{A,t}.$$ (16)

The resulting value of the loss function is:

$$L_{A,t}^{fix} = \left((\delta+\varepsilon)\beta E_{t-1}m_{A,t} + \varepsilon\beta\left(s_{B,t} - p_{B,t}\right) + k_A + \beta\eta_{A,t}\right)^2 +$$
$$\theta_A\left((1-\alpha)\beta E_{t-1}m_{A,t} - \alpha\varepsilon\beta\left(s_{B,t} - p_{B,t}\right) - \alpha\beta\eta_{A,t}\right)^2.$$ (17)

The policymaker will stop defending the fixed exchange rate and resort to the optimal monetary policy according to his reaction function if the following condition is fulfilled:

$$L_{A,t}^{fix} - L_{A,t}^{flex} > C_A.$$ (18)

It follows that a currency crisis is precipitated if $\eta_{A,t} > \overline{\eta}_{A,t}$. The threshold $\overline{\eta}_{A,t}$ is defined as follows:[5]

$$
\overline{\eta}_{A,t} = \frac{z_A}{\beta} \left[\alpha(1-\alpha)\theta_A - (\delta+\varepsilon)\beta E_{t-1}m_{A,t} - k_A \right] - \varepsilon\left(s_{B,t} - p_{B,t}\right)
$$
$$
+ \frac{1}{\beta}\sqrt{z_A\left[z_A\left(v_{A,t} - \alpha\theta_A u_{A,t}\right)^2 - \left(v_{A,t}\right)^2 - \theta_A\left(u_{A,t}\right)^2 + \theta_A z_A\left(x_{A,t}\right)^2 + C_A\right]},
$$

(19)

with $v_{A,t} \equiv (\delta+\varepsilon)\beta E_{t-1}m_{A,t} + \varepsilon\beta\left(s_{B,t} - p_{B,t}\right) + k_A$, $u_{A,t} \equiv (1-\alpha)\beta E_{t-1}m_{A,t} - \alpha\varepsilon\beta\left(s_{B,t} - p_{B,t}\right)$,

$x_{A,t} \equiv E_{t-1}m_{A,t} + \alpha k_A$ and $z_A \equiv \dfrac{1}{1+\alpha^2\theta_A}$.

As in all other second generation models, the prevailing exchange rate system is state contingent. For a shock that is higher than the devaluation threshold $\overline{\eta}_{A,t}$, i.e. $\eta_{A,t} > \overline{\eta}_{A,t}$, giving up the fixed exchange rate and resorting to an expansionary monetary policy to counteract the negative employment effect of the demand shock is the optimal policy. Otherwise defending the fixed exchange rate is the dominant strategy.

IV. MULTIPLE EQUILIBRIA AND SELF-FULFILLING CRISES

A. Definition of Equilibrium

In second generation models the expectations of the private sector and the optimal policy decision of the policymaker are mutually dependent on each other. For an equilibrium, market expectations must be rational given the policymaker's behavior and the policy decision must be optimal given private expectations. This interdependence may give rise to more than one equilibrium. If multiple equilibria exist, the optimal opting-out rule of the policymaker is not unambiguously defined for given economic fundamentals. Sudden shifts of market sentiment can alter this optimal opting-out rule although the fundamentals remain unchanged. Self-fulfilling crises, however, cannot occur for any level of the economic fundamentals. Sufficiently weak fundamentals that undermine the stability of a fixed exchange rate without impairing it so much that a crisis is the inevitable outcome are a necessary precondition for multiple equilibria. Following Jeanne (1997), the economic preconditions that enable sudden shifts in private expectations to precipitate a currency crisis will be explicitly derived from the model.

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[5] We only consider the case of a devaluation of the previously fixed exchange rate. Revaluations are assumed to be not possible at all.

Assuming that giving up the fixed exchange rate always entails a devaluation - i.e. revaluations are not possible at all - the probability of a currency crisis in country A in period t+1 is equal to the probability of a shock $\eta_{A,t+1} > \overline{\eta}_{A,t+1}$. We will denote the crisis probability that wage setters rationally form in period t by $\mu_{A,t}$.

$$(20)$$

$$\mu_{A,t} = \mu_{B,t} \operatorname{Prob}\left(\eta_{A,t+1} > \left(\overline{\eta}_{A,t+1}\Big|s_{B,t+1} = s^{flex}_{B,t+1}\right)\right) + \left(1 - \mu_{B,t}\right)\operatorname{Prob}\left(\eta_{A,t+1} > \left(\overline{\eta}_{A,t+1}\Big|s_{B,t+1} = s^{fix}_{B}\right)\right)$$

$$= \mu_{B,t}\left(1 - F\left(\overline{\eta}_{A,t+1}\Big|s_{B,t+1} = s^{flex}_{B,t+1}\right)\right) + \left(1 - \mu_{B,t}\right)\left(1 - F\left(\overline{\eta}_{A,t+1}\Big|s_{B,t+1} = s^{fix}_{B}\right)\right).$$

$F(\cdot)$ is the c.d.f. of $\eta_{A,t}$, $F'(\cdot) = f(\cdot)$. Equation (20) shows that the crisis probabilities in the periphery countries A and B depend on each other because monetary policy decisions in B affect the optimal opting-out rule in A and vice versa. Being aware of this interdependence the private sector in A differentiates between the possibility of a currency crisis in B and the possibility that country B keeps on fixing its exchange rate. Therefore, the probability of a currency crisis in A is the sum of these two conditional probabilities weighted with the respective probabilities of their occurrence. The critical realizations of the demand shock $\left(\overline{\eta}_{A,t+1}\Big|s_{B,t+1} = s^{flex}_{B,t+1}\right)$ and $\left(\overline{\eta}_{A,t+1}\Big|s_{B,t+1} = s^{fix}_{B}\right)$ can be derived from equation (19) by imposing the conditions $s_{B,t+1} = s^{flex}_{B,t+1}$ and $s_{B,t+1} = s^{fix}_{B}$.

$$(21)$$

$$\left(\overline{\eta}_{A,t+1}\Big|s_{B,t+1} = s^{flex}_{B,t+1}\right) = \frac{z_A}{\beta}\left[\left(\alpha(1-\alpha)\theta_A - (\delta + \varepsilon)\right)\beta E_t\left(m_{A,t+1}\Big|s_{B,t+1} = s^{flex}_{B,t+1}\right) - k_A\right] - \varepsilon s^{flex}_{B,t+1}$$

$$+ \varepsilon p^{flex}_{B,t+1} + \frac{1}{\beta}\sqrt{z_A\left[z_A\left(v^{flex}_{A,t+1} - \alpha\theta_A u^{flex}_{A,t+1}\right)^2 - \left(v^{flex}_{A,t+1}\right)^2 - \theta_A\left(u^{flex}_{A,t+1}\right)^2 + \theta_A z_A\left(x^{flex}_{A,t+1}\right)^2 + C_A\right]}.$$

$$(22)$$

$$\left(\overline{\eta}_{A,t+1}\Big|s_{B,t+1} = s^{fix}_{B}\right) = \frac{z_A}{\beta}\left[\left(\alpha(1-\alpha)\theta_A - (\delta + \varepsilon)\right)\beta E_t\left(m_{A,t+1}\Big|s_{B,t+1} = s^{fix}_{B}\right) - k_A\right]$$

$$+ \varepsilon p^{fix}_{B,t+1} + \frac{1}{\beta}\sqrt{z_A\left[z_A\left(v^{fix}_{A,t+1} - \alpha\theta_A u^{fix}_{A,t+1}\right)^2 - \left(v^{fix}_{A,t+1}\right)^2 - \theta_A\left(u^{fix}_{A,t+1}\right)^2 + \theta_A z_A\left(x^{fix}_{A,t+1}\right)^2 + C_A\right]}.$$

The conditional rational money supply expectations, $E_t\left(m_{A,t+1}\Big|s_{B,t+1} = s^{flex}_{B,t+1}\right)$ and $E_t\left(m_{A,t+1}\Big|s_{B,t+1} = s^{fix}_{B}\right)$, are the weighted sums of the expectations conditioned on the continuation and the abandonment of the exchange rate pegging in A, respectively, for a given monetary policy in country B.

$$E_t\left(m_{A,t+1}\Big|s_{B,t+1} = s^{flex}_{B,t+1}\right) = \mu_{A,t}E_t m^{flex}_{A,t+1} + \left(1 - \mu_{A,t}\right)E_t\left(m^{fix}_{A,t+1}\Big|s_{B,t+1} = s^{flex}_{B,t+1}\right). \qquad (23)$$

$$E_t\left(m_{A,t+1}\Big|s_{B,t+1} = s^{fix}_{B}\right) = \mu_{A,t}E_t m^{flex}_{A,t+1} + \left(1 - \mu_{A,t}\right)E_t\left(m^{fix}_{A,t+1}\Big|s_{B,t+1} = s^{fix}_{B}\right). \qquad (24)$$

Using equations (21) to (24), an expression for the crisis probability in country A, which must hold in an equilibrium, can be derived from equation (20).

$$
\begin{aligned}
\mu_{A,t} = \mu_{B,t} &\left(1 - F\left(\frac{z_A}{\beta}\left[\left(\alpha(1-\alpha)\theta_A - (\delta+\varepsilon)\right)\beta E_t\left(m_{A,t+1}\big|s_{B,t+1} = s_{B,t+1}^{flex}\right) - k_A\right] - \varepsilon\left(s_{B,t+1}^{flex} - p_{B,t+1}^{flex}\right)\right.\right. \\
&\left.\left. + \frac{1}{\beta}\sqrt{z_A\left[z_A\left(v_{A,t+1}^{flex} - \alpha\theta_A u_{A,t+1}^{flex}\right)^2 - \left(v_{A,t+1}^{flex}\right)^2 - \theta_A\left(u_{A,t+1}^{flex}\right)^2 + z_A\theta_A\left(x_{A,t+1}^{flex}\right)^2 + C_A\right]}\right)\right) \\
+ \left(1 - \mu_{B,t}\right) &\left(1 - F\left(\frac{z_A}{\beta}\left[\left(\alpha(1-\alpha)\theta_A - (\delta+\varepsilon)\right)\beta E_t\left(m_{A,t+1}\big|s_{B,t+1} = s_B^{fix}\right) - k_A\right] + \varepsilon p_{B,t+1}^{fix}\right.\right. \\
&\left.\left. + \frac{1}{\beta}\sqrt{z_A\left[z_A\left(v_{A,t+1}^{fix} - \alpha\theta_A u_{A,t+1}^{fix}\right)^2 - \left(v_{A,t+1}^{fix}\right)^2 - \theta_A\left(u_{A,t+1}^{fix}\right)^2 + z_A\theta_A\left(x_{A,t+1}^{fix}\right)^2 + C_A\right]}\right)\right).
\end{aligned}
\tag{25}
$$

A graphical representation of the equilibrium condition (25) is presented in figure 1. The l.h.s. of equation (25) corresponds to the 45° line as the locus of all equilibria, while the r.h.s., which reflects the crisis perception of the market, is represented by the S-shaped curves V_i. The location of the latter depends on C_A and k_A, the depreciation rate and the conditional price levels of country B in t+1, $s_{B,t+1}^{flex}$, $p_{B,t+1}^{flex}$ and $p_{B,t+1}^{fix}$, and the crisis probability of B, $\mu_{B,t}$. Only points where the curves V_i intersect the 45° line constitute rational expectations equilibria of the model. Figure 1 shows that multiple equilibria may exist.

Figure 1. Rational Expectations Equilibria
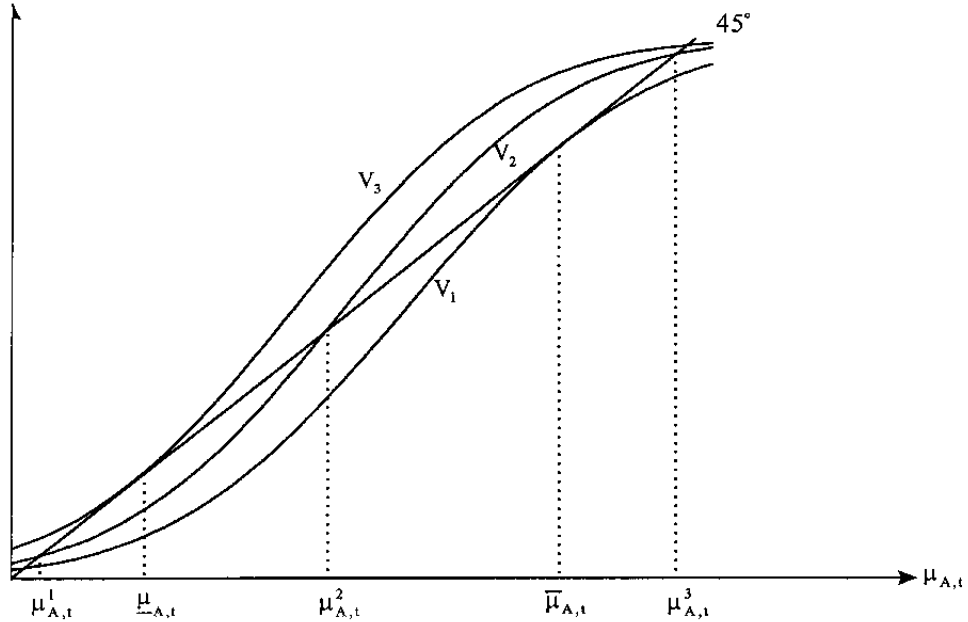
It was implicitly assumed in figure 1 that the graphical representation of the market's crisis perception V_i is monotonically rising in $\mu_{A,t}$. It can be shown, however, that the slope of V_i depends on the parameter constellation, in particular the weight attached to the inflation target in the policymaker's loss function (9).[6]

$$\theta_A \le \frac{\delta + \varepsilon}{\alpha(1-\alpha)}. \tag{26}$$

The slope of V_i will only have a positive sign if condition (26) is fulfilled.

The underlying reason for this result is that a increasing crisis perception by the market leads to a fall in the unconditioned threshold value of the demand shock $\overline{\eta}_{A,t}$, only if condition (26) holds.[7] Since market expectations determine the wage in the following period aggregate employment shrinks if the exchange rate is still pegged. Therefore, the policymaker's incentive to opt out of the fixed exchange-rate system rises and is reflected by a lower devaluation threshold. For the rest of the paper we will assume that equation (26) is fulfilled.

B. Multiple Equilibria and Self-Fulfilling Expectations

Second generation currency crisis models typically have more than one equilibrium (e.g. Obstfeld, 1994, 1996, and Jeanne, 1997). Certain fundamental vulnerabilities are necessary preconditions for multiple equilibria to exist. If the economy is in very good or very bad shape, a unique equilibrium prevails in typical second generation models and the crisis probability is very low or very high, respectively. Multiplicity of equilibria can only arise if the fundamentals enter a middle zone in which sufficiently weak fundamentals prepare the ground for self-fulfilling market spirits. In this case the market expectations are not uniquely determined and may change spontaneously, thereby inducing a shift of equilibrium. Curve V_2 in figure 1 portrays a situation with three equilibria.

The fundamental preconditions for multiple equilibria will be derived in the following (cf. Jeanne, 1997). As the curves in figure 1 show, the multiplicity of equilibria can only arise if the slope of V_i is equal to or exceeds the slope of the $45°$ line in at least one point. This condition can be formulated more formally if we consider that, due to the assumed characteristics of the p.d.f. $f(\cdot)$, the slope of V_i reaches its maximum for $f(0)$.

1.) If

$$\mu_{B,t} z_A \left(\delta + \varepsilon - \alpha(1-\alpha)\theta_A\right)\left(E_t m_{A,t+1}^{flex} - E_t\left(m_{A,t+1}^{fix}\big|s_{B,t+1} = s_{B,t+1}^{flex}\right)\right)f\left(0\big|s_{B,t+1} = s_{B,t+1}^{flex}\right)$$

$$+ \left(1-\mu_{B,t}\right)z_A\left(\delta + \varepsilon - \alpha(1-\alpha)\theta_A\right)\left(E_t m_{A,t+1}^{flex} - E_t\left(m_{A,t+1}^{fix}\big|s_{B,t+1} = s_B^{fix}\right)\right)f\left(0\big|s_{B,t+1} = s_B^{fix}\right) \ge 1$$

holds,

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[6] See the appendix for the derivation of the slope of V_i.

[7] Calculating the first derivative of $\overline{\eta}_{A,t}$ with respect to $\mu_{A,t}$ is very similar to calculating the slope of V_i which is given in the appendix.

the crisis probability is not necessarily uniquely determined. Multiplicity of equilibria may arise depending on the location of V_i.

2.) If

$$\mu_{B,t} z_A \left(\delta + \varepsilon - \alpha(1-\alpha)\theta_A\right)\left(E_t m_{A,t+1}^{flex} - E_t\left(m_{A,t+1}^{fix}\big|s_{B,t+1} = s_{B,t+1}^{flex}\right)\right)f\left(0\big|s_{B,t+1} = s_{B,t+1}^{flex}\right)$$

$$+ \left(1-\mu_{B,t}\right)z_A\left(\delta + \varepsilon - \alpha(1-\alpha)\theta_A\right)\left(E_t m_{A,t+1}^{flex} - E_t\left(m_{A,t+1}^{fix}\big|s_{B,t+1} = s_B^{fix}\right)\right)f\left(0\big|s_{B,t+1} = s_B^{fix}\right) \geq 1$$

does not hold, the crisis probability is uniquely determined. Multiple equilibria cannot arise.

Provided that the slope of V_i is equal to or exceeds one, the graphical representation of the market's crisis perception intersects the 45° line more than once only if it lies between the curves V_1 and V_3, which graphically limit the zone of multiple equilibria. This condition, derived from figure 1, can be formulated more formally as a restriction for $\mu_{B,t}$, which, among other variables, determines the location of the curves V_i. The lowest crisis probability for B that is still consistent with multiple equilibria, denoted by $\underline{\mu}_{B,t}$, is defined by equations (27) and (28).

$$(27)$$

$$\underline{\mu}_{B,t} z_A\left(\delta + \varepsilon - \alpha(1-\alpha)\theta_A\right)\left(E_t m_{A,t+1}^{flex} - E_t\left(m_{A,t+1}^{fix}\big|s_{B,t+1} = s_{B,t+1}^{flex}\right)\right)f\left(\cdot\big|s_{B,t+1} = s_{B,t+1}^{flex}\right)$$

$$+ \left(1-\underline{\mu}_{B,t}\right)z_A\left(\delta + \varepsilon - \alpha(1-\alpha)\theta_A\right)\left(E_t m_{A,t+1}^{flex} - E_t\left(m_{A,t+1}^{fix}\big|s_{B,t+1} = s_B^{fix}\right)\right)f\left(\cdot\big|s_{B,t+1} = s_B^{fix}\right) = 1.$$

$$(28)$$

$$\underline{\mu}_{A,t} = \underline{\mu}_{B,t}\left(1 - F\left(\frac{z_A}{\beta}\left[(\alpha(1-\alpha)\theta_A - (\delta + \varepsilon))\beta E_t\left(m_{A,t+1}\big|s_{B,t+1} = s_{B,t+1}^{flex}\right) - k_A\right] - \varepsilon\left(s_{B,t+1}^{flex} - p_{B,t+1}^{flex}\right)\right.\right.$$

$$+ \frac{1}{\beta}\sqrt{z_A\left[z_A\left(v_{A,t+1}^{flex} - \alpha\theta_A u_{A,t+1}^{flex}\right)^2 - \left(v_{A,t+1}^{flex}\right)^2 - \theta_A\left(u_{A,t+1}^{flex}\right)^2 + z_A\theta_A\left(x_{A,t+1}^{flex}\right)^2 + C_A\right]}\left.\right)\right)$$

$$+ \left(1-\underline{\mu}_{B,t}\right)\left(1 - F\left(\frac{z_A}{\beta}\left[(\alpha(1-\alpha)\theta_A - (\delta + \varepsilon))\beta E_t\left(m_{A,t+1}\big|s_{B,t+1} = s_B^{fix}\right) - k_A\right] + \varepsilon p_{B,t+1}^{fix}\right.\right.$$

$$+ \frac{1}{\beta}\sqrt{z_A\left[z_A\left(v_{A,t+1}^{fix} - \alpha\theta_A u_{A,t+1}^{fix}\right)^2 - \left(v_{A,t+1}^{fix}\right)^2 - \theta_A\left(u_{A,t+1}^{fix}\right)^2 + z_A\theta_A\left(x_{A,t+1}^{fix}\right)^2 + C_A\right]}\left.\right)\right).$$

V_i is tangent to the 45° line if both equations simultaneously hold, i.e. the slope of V_i is one at $\underline{\mu}_{A,t}$ (equation (27)) and $\underline{\mu}_{A,t}$ constitutes an equilibrium (equation (28)).

The highest crisis probability for B still consistent with multiple equilibria, denoted by $\overline{\mu}_{B,t}$, can be calculated analogously.

$$\text{(29)}$$

$$\overline{\mu}_{B,t} z_A \Big(\delta + \varepsilon - \alpha(1-\alpha)\theta_A \Big) \Big(E_t m_{A,t+1}^{flex} - E_t \Big(m_{A,t+1}^{fix} \Big| s_{B,t+1} = s_{B,t+1}^{flex} \Big) \Big) f\Big(\cdot \Big| s_{B,t+1} = s_{B,t+1}^{flex} \Big)$$

$$+ \Big(1 - \overline{\mu}_{B,t} \Big) z_A \Big(\delta + \varepsilon - \alpha(1-\alpha)\theta_A \Big) \Big(E_t m_{A,t+1}^{flex} - E_t \Big(m_{A,t+1}^{fix} \Big| s_{B,t+1} = s_B^{fix} \Big) \Big) f\Big(\cdot \Big| s_{B,t+1} = s_B^{fix} \Big) = 1.$$

$$\text{(30)}$$

$$\overline{\mu}_{A,t} = \overline{\mu}_{B,t} \Bigg(1 - F\Big(\frac{z_A}{\beta} \big[(\alpha(1-\alpha)\theta_A - (\delta+\varepsilon)) \beta E_t \big(m_{A,t+1} \big| s_{B,t+1} = s_{B,t+1}^{flex} \big) - k_A \big] - \varepsilon \big(s_{B,t+1}^{flex} - p_{B,t+1}^{flex} \big)$$

$$+ \frac{1}{\beta} \sqrt{ z_A \Big[z_A \big(v_{A,t+1}^{flex} - \alpha\theta_A u_{A,t+1}^{flex} \big)^2 - \big(v_{A,t+1}^{flex} \big)^2 - \theta_A \big(u_{A,t+1}^{flex} \big)^2 + z_A \theta_A \big(x_{A,t+1}^{flex} \big)^2 + C_A \Big] } \Bigg) \Bigg)$$

$$+ \Big(1 - \overline{\mu}_{B,t} \Big) \Bigg(1 - F\Big(\frac{z_A}{\beta} \big[(\alpha(1-\alpha)\theta_A - (\delta+\varepsilon)) \beta E_t \big(m_{A,t+1} \big| s_{B,t+1} = s_B^{fix} \big) - k_A \big] + \varepsilon p_{B,t+1}^{fix}$$

$$+ \frac{1}{\beta} \sqrt{ z_A \Big[z_A \big(v_{A,t+1}^{fix} - \alpha\theta_A u_{A,t+1}^{fix} \big)^2 - \big(v_{A,t+1}^{fix} \big)^2 - \theta_A \big(u_{A,t+1}^{fix} \big)^2 + z_A \theta_A \big(x_{A,t+1}^{fix} \big)^2 + C_A \Big] } \Bigg) \Bigg).$$

Sufficient for the multiplicity of equilibria to arise is that the crisis probability of B, $\mu_{B,t}$, lies within the interval $\underline{\mu}_{B,t} \le \mu_{B,t} \le \overline{\mu}_{B,t}$. Outside this interval $\mu_{B,t}$ is either too high or too low to be consistent with multiple equilibria.

This sufficiency condition can be interpreted as a condition with respect to the present employment level in A. Due to the interdependence of the crisis probabilities of the periphery countries, a variation of $\mu_{B,t}$ directly influences the level of aggregate employment in A. An increasing $\mu_{B,t}$ is reflected in rising wages in A because the increasing probability of a crisis-induced shift in international demand in favor of Country B makes an expansionary monetary policy reaction by A more likely. A variation in $\mu_{B,t}$ leads to changing market expectations concerning the optimal opting out for country A's policymaker and therefore results in varying wages in A. To enter the zone of multiple equilibria, a fundamental vulnerability in the form of sufficiently high unemployment must exist. This fundamental weakness prepares the ground for self-fulfilling shifts in market sentiment, i.e. self-fulfilling crises cannot occur under arbitrary circumstances. That certain fundamental weaknesses are a necessary precondition for sudden shifts in market expectations is a typical feature of second generation models with multiple equilibria (cf. Jeanne, 1997, and Obstfeld, 1996).

If the multiplicity of equilibria arises, given fundamentals are consistent with more than one devaluation threshold that governs the optimal opting out of the fixed exchange rate system, and therefore, with more than one crisis probability of country A. A self-fulfilling currency crisis is precipitated when market expectations shift away from a superior equilibrium with an only modest crisis probability and coordinate on an inferior equilibrium where the crisis probability is much higher. Now a currency crisis can only be avoided if the shocks hitting country A are very favorable. Arbitrary sunspots can trigger such a shift in market expectations.

V. Interdependence of Crisis Probabilities of the Periphery Countries

The model, thus far, shows that the crisis probabilities in the periphery countries are linked with each other. The probability of a currency crisis in country A depends on the crisis probability of country B and vice versa. Bearing this in mind we can now ask how an increasing crisis probability in one of the periphery countries affects the stability of the fixed exchange rate in the other periphery country.

$$(31)$$

$$\frac{\partial \mu_{A,t}}{\partial \mu_{B,t}} = F\left(\frac{z_A}{\beta}\left[(\alpha(1-\alpha)\theta_A - (\delta+\epsilon))\beta E_t\left(m_{A,t+1}\big|s_{B,t+1} = s_B^{fix}\right) - k_A\right] + \epsilon p_{B,t+1}^{fix}\right.$$

$$\left. + \frac{1}{\beta}\sqrt{z_A\left[z_A\left(v_{A,t+1}^{fix} - \alpha\theta_A u_{A,t+1}^{fix}\right)^2 - \left(v_{A,t+1}^{fix}\right)^2 - \theta_A\left(u_{A,t+1}^{fix}\right)^2 + z_A\theta_A\left(x_{A,t+1}^{fix}\right)^2 + C_A\right]}\right)$$

$$- F\left(\frac{z_A}{\beta}\left[(\alpha(1-\alpha)\theta_A - (\delta+\epsilon))\beta E_t\left(m_{A,t+1}\big|s_{B,t+1} = s_{B,t+1}^{flex}\right) - k_A\right] - \epsilon\left(s_{B,t+1}^{flex} - p_{B,t+1}^{flex}\right)\right.$$

$$\left. + \frac{1}{\beta}\sqrt{z_A\left[z_A\left(v_{A,t+1}^{flex} - \alpha\theta_A u_{A,t+1}^{flex}\right)^2 - \left(v_{A,t+1}^{flex}\right)^2 - \theta_A\left(u_{A,t+1}^{flex}\right)^2 + z_A\theta_A\left(x_{A,t+1}^{flex}\right)^2 + C_A\right]}\right) > 0.$$

Equation (31) makes clear that higher instability in one of the periphery countries—in our case country B—is transmitted to the other periphery country, A, via the existing economic links between both. Not only a devaluation in country B—as shown by Corsetti et al. (2000) and Loisel and Martin (2001)—but also the imminent loss of country A's international compatibility weakens A's exchange rate system. The market anticipates that the willingness of the policymaker in A to defend the fixed exchange rate against adverse shocks shrinks if country B devalues and the increasing probability of this case is reflected in private expectations. This, in turn, leads to a reduction in the employment rate and thus, the negative effect of a currency crisis in B for the stability of country A's fixed exchange rate materializes before country B actually devalues.

How much the stability of A's fixed exchange rate is impaired depends on how much $\mu_{B,t}$ increases and on the ex-ante strength of A's fundamentals. Starting from a very low and unique crisis probability in country A, several scenarios can be differentiated. First, an increase in $\mu_{B,t}$ can have a negligible effect on A's crisis probability. Although the greater instability of B's fixed exchange rate spreads, it does not touch A's situation significantly, i.e. the number of equilibria is unchanged. Secondly, one can imagine that country A is pushed into the zone of multiple equilibria by an increase in $\mu_{B,t}$ ($\mu_{B,t}$ lies between $\underline{\mu}_{B,t}$ and $\overline{\mu}_{B,t}$).

Now we have a completely different situation. The stability of A's exchange rate is significantly impaired. Sunspots can now trigger a currency crisis in A. Thirdly, A's crisis probability may be pushed to a level beyond the zone of multiple equilibria ($\mu_{B,t} > \overline{\mu}_{B,t}$). Now already very weak shocks are sufficient to bring about a currency crisis. A's crisis probability now exceeds $\overline{\mu}_{A,t}$.

The ex ante stability of country A's exchange rate system, i.e. the position of A before country B's crisis probability changes, depends on its fundamentals. In our model k_A is the fundamental variable that determines the vulnerability of country A to a spreading currency crisis originating in country B. The greater the (positive) deviation of the policymaker's employment target from the natural employment level, the more fragile A's exchange rate system is. Adverse shocks now cause higher deviations of the realized employment from its target and thus lead to a stronger reduction in the policymaker's willingness to tolerate these shocks. The threshold $\bar{\eta}_{A,t}$ shrinks. Given a high value of k_A —reflecting a socially very inefficient natural employment rate due to distortions in the goods or labor market—very weak shocks that would only have had minor effects otherwise can now have severe consequences. In this sense the domestic fundamentals are of chief importance for a country's vulnerability to the spill-over effects of a currency crisis.

Depending on the size of the shocks, full-blown currency crises in both countries are as equally possible as no crisis in either of the two periphery countries. In addition, we may have the case that only one periphery country slides into a crisis, while a crisis in the other one can be avoided. It may be possible that country B, where the turmoil started, succeeds in preventing a crisis, while the stability of country A's fixed exchange is so badly impaired by B's increasing crisis probability that a currency crisis is only a matter of time.

The model implies that, despite ex-ante sound fundamentals, currency crises may occur if economic interdependences between countries are taken into consideration. Even if the economic policy is consistent with the exchange rate goal, spill-over from other countries can weaken a fixed exchange rate so much that a currency crisis can hardly be avoided. Nevertheless, good economic policy unambiguously strengthens a country's resistance to crisis spill-overs.

VI. CONCLUSION

Economic links between countries are a key culprit in the transmission of currency crises. The most prominent among them are trade links, which have been found to be highly significant for the crisis transmission in numerous empirical studies (cf. Eichengreen and Rose; 1999, Forbes and Rigobon, 1999; Glick and Rose, 1999; and Kaminsky and Reinhart, 2000). Against this background, we analyzed in this paper how the mutual dependence of private sector expectations in different countries influences the stability of fixed exchange rate regimes. The crisis probabilities of countries trading with one another are interdependent, because wage setters react to an imminent loss of international competitiveness stemming from an increase in the crisis probability of a trading partner. If a currency crisis in one country is perceived to be increasingly likely, the probability of currency devaluations by its trading partners to restore their international competitiveness rises as well.
How much the stability of other countries' fixed exchange rates is impaired depends on the soundness of the fundamentals that determine their ex ante vulnerability and on the increase in the crisis probability of the country where the turmoil started. Although policymakers cannot protect their exchange rate systems against the spillovers of exchange rate troubles of a trading partner, they are able to minimize the consequences by pursuing an economic policy in line with the exchange rate system.

In our model, crises spread because they exert a negative effect on other countries' fundamentals and thus provide an incentive for their policymakers to maintain a fixed exchange rate. Our model does not rely on an exclusively fundamental explanation, though. Spontaneous shifts in market sentiment may also play a role in precipitating currency crises. The necessary precondition for this case, however, consists in a fundamental weakness that makes a country sufficiently vulnerable to arbitrary expectational shifts. This fundamental vulnerability is exposed when an increasing crisis probability of a trading partner leads to an increase in the country's unemployment rate via the interdependence of private sector expectations. Thus, the fragility of one country's exchange rate peg prepares the ground for a self-fulfilling currency crisis in another country.

Derivation of the Slope of V_i

$$\frac{\partial V}{\partial \mu_{A,t}} =$$

$$\mu_{B,t} z_A\left(\delta + \varepsilon - \alpha(1-\alpha)\theta_A\right)\left(E_t m_{A,t+1}^{flex} - E_t\left(m_{A,t+1}^{fix}\big| s_{B,t+1} = s_{B,t+1}^{flex}\right)\right) + \frac{z_A}{\beta}\frac{\partial E_t\left(m_{A,t+1}\big| s_{B,t+1} = s_{B,t+1}^{flex}\right)}{\partial \mu_{A,t}}$$

$$\left\{z_A\left[z_A\left(v_{A,t+1}^{flex} - \alpha\theta_A u_{A,t+1}^{flex}\right)^2 - \left(v_{A,t+1}^{flex}\right)^2 - \theta_A\left(u_{A,t+1}^{flex}\right)^2 + \theta_A z_A\left(x_{A,t+1}^{flex}\right)^2 + C_A\right]\right\}^{-\frac{1}{2}}$$

$$\left[z_A\left(v_{A,t+1}^{flex} - \alpha\theta_A u_{A,t+1}^{flex}\right)\beta\left(\delta + \varepsilon - \alpha\theta_A(1-\alpha)\right) - v_{A,t+1}^{flex}\beta(\delta+\varepsilon) - \theta_A u_{A,t+1}^{flex}\beta\left(1-\alpha + \theta_A z_A x_{A,t+1}^{flex}\right)\right]$$

$$+\left(1 - \mu_{B,t}\right)z_A\left(\delta + \varepsilon - \alpha(1-\alpha)\theta_A\right)\left(E_t m_{A,t+1}^{flex} - E_t\left(m_{A,t+1}^{fix}\big| s_{B,t+1} = s_B^{fix}\right)\right) + \frac{z_A}{\beta}\frac{\partial E_t\left(m_{A,t+1}\big| s_{B,t+1} = s_{B,t+1}^{flex}\right)}{\partial \mu_{A,t}}$$

$$\left\{z_A\left[z_A\left(v_{A,t+1}^{fix} - \alpha\theta_A u_{A,t+1}^{fix}\right)^2 - \left(v_{A,t+1}^{fix}\right)^2 - \theta_A\left(u_{A,t+1}^{fix}\right)^2 + \theta_A z_A\left(x_{A,t+1}^{fix}\right)^2 + C_A\right]\right\}^{-\frac{1}{2}}$$

$$\left[z_A\left(v_{A,t+1}^{fix} - \alpha\theta_A u_{A,t+1}^{fix}\right)\beta\left(\delta + \varepsilon - \alpha\theta_A(1-\alpha)\right) - v_{A,t+1}^{fix}\beta(\delta+\varepsilon) - \theta_A u_{A,t+1}^{fix}\beta\left(1-\alpha + \theta_A z_A x_{A,t+1}^{fix}\right)\right]$$

In the following we focus on the third and sixth line of the above equation and show that they are equal to zero. After rearranging we get:

$$\left[v_{A,t+1}\beta\left(z_A\left(\delta + \varepsilon - \alpha\theta_A(1-\alpha)\right) - (\delta+\varepsilon)\right) - \beta u_{A,t+1}\left(\alpha\theta_A z_A\left(\delta + \varepsilon - \alpha\theta_A(1-\alpha)\right) + \theta_A(1-\alpha)\right) + \theta_A z_A x_{A,t+1}^{flex}\right]$$

Taking into account that we defined $\beta \equiv \dfrac{1}{1-\alpha\left(1-(\delta+\varepsilon)\right)}$ after equation (14) we have:

$$-z_A\theta_A\left(\alpha v_{A,t+1} + u_{A,t+1} - x_{A,t+1}\right).$$

It can easily be seen that the expression in brackets equals zero if the definition of $v_{A,t+1}, u_{A,t+1}$ and $x_{A,t+1}$ is taken into consideration so that we finally arrive at:

$$\frac{\partial V}{\partial \mu_{A,t}} =$$

$$\mu_{B,t} z_A\left[\delta + \varepsilon - \alpha(1-\alpha)\theta_A\right]\left[E_t m_{A,t+1}^{flex} - E_t\left(m_{A,t+1}^{fix}\big| s_{B,t+1} = s_{B,t+1}^{flex}\right)\right]f\left(\cdot\big| s_{B,t+1} = s_{B,t+1}^{flex}\right) +$$

$$\left(1 - \mu_{B,t}\right)z_A\left[\delta + \varepsilon - \alpha(1-\alpha)\theta_A\right]\left[E_t m_{A,t+1}^{flex} - E_t\left(m_{A,t+1}^{fix}\big| s_{B,t+1} = s_B^{fix}\right)\right]f\left(\cdot\big| s_{B,t+1} = s_B^{fix}\right)$$

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