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**Working Paper**

## Currency choice for credit contracts and exchange rate regime

Diskussionsbeiträge - Serie II, No. 62

**Provided in Cooperation with:**

Department of Economics, University of Konstanz

*Suggested Citation:* Franke, Günter (1988) : Currency choice for credit contracts and exchange rate regime, Diskussionsbeiträge - Serie II, No. 62, Universität Konstanz, Sonderforschungsbereich 178 - Internationalisierung der Wirtschaft, Konstanz

This Version is available at:

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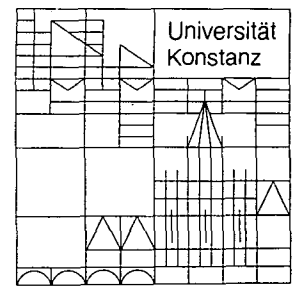
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**Sonderforschungsbereich 178**  
**„Internationalisierung der Wirtschaft“**

Diskussionsbeiträge

Juristische  
Fakultät

Fakultät für Wirtschafts-  
wissenschaften und Statistik

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**Currency Choice for Credit Contracts  
and Exchange Rate Regime**

CURRENCY CHOICE FOR CREDIT CONTRACTS  
AND EXCHANGE RATE REGIME

Günter Franke

Serie II - Nr. 62

A 9 2974 / 88  
Weltwirtschaft  
Kiel  
jf

Mai 1988

CURRENCY CHOICE FOR CREDIT CONTRACTS  
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by

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Introduction

Many papers, cf. Sarnat [1973], Fischer [1975], Liviatan and Levhari [1977], Dumas [1982], analysed investors' choice between non-indexed and indexed bonds for borrowing and lending purposes in a one-currency framework. It was shown that risk averse investors prefer indexed bonds unless non-indexed bonds serve hedging purposes. Another strand of papers, cf. Solnik [1974], Grauer, Litzenberger and Stehle [1976], Stulz [1981], Adler and Dumas [1983], investigates international portfolio choice. It was shown how investors from different countries allocate their wealth to stocks and bonds in various currencies. Adler and Dumas, for example, decompose an investor's portfolio into two components, the first being a universal portfolio, derived from logarithmic utility with constant proportional risk aversion, and the second being an individual hedge portfolio in case of non-logarithmic utility. The first component is the same for all investors since exchange rates and inflation rates do not matter with logarithmic utility. The second component depends on the investor's home currency since exchange rates and the inflation rate in his country determine his purchasing power. The investor's hedge portfolio provides the best protection against the investor's home currency inflation risk. Adler and Dumas estimate the second component for various Western hard currency-countries and find that this component consists mostly of non-indexed bonds, denominated in the investor's home currency. This result depends strongly on the observa-

tion that inflation risk of hard currencies is low so that the purchasing power risk of those bonds is low<sup>1</sup>).

A third strand in the literature, cf. Miles and Stewart [1980], Stulz [1984], Calvo [1985], Melvin [1985], investigates currency substitution. The emphasis in these papers is placed on the consumption services of cash balances, being held in different currencies. Thus, production functions of consumption services become important.

This paper is an extension of the first two strands of literature. It extends the first strand of literature to an international dimension. It gives a much more detailed account of borrowing and lending decisions than the second strand of literature. Investors' currency choice for credit contracts will be analyzed with the lender and borrower living in the same country (intranational lending) or living in different countries (international lending). Credit contracts can be written in various currencies, in indexed or non-indexed form. Thus, there exists competition between various currencies.

As investors are concerned about real returns, not nominal returns, the competitive strength of a non-indexed bond depends on the inflation rates and the exchange rates of the currencies being considered. Thus monetary policies and exchange rate policies determine investors' currency choice.

Currency choice can have far reaching implications for the supply and demand of funds. If inflation risk of a currency is high, then this may drive borrowers and lenders into other currencies so that even intranational lending is done through foreign currencies. If, in addition, foreign currency credit

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<sup>1</sup> The relation between monetary policy and international bond yields has been explored by Stapleton and Subrahmanyam [1981].

contracts are illegal or if the settlement of these contracts is endangered by governmental or central bank interference, then capital flight is stimulated. As a consequence, the international supply of funds will be curtailed.

Currency choice in international lending is equally important. If a contract is denominated in the borrower's home currency, then the borrower's ability to serve his debt does not depend on the availability of foreign exchange. If, however, the contract is denominated in another currency, then problems in the availability of foreign exchange may actually rule out borrowing and thus impede growth of the borrower's economy.

In order to derive easily interpretable results, investors are assumed to maximize expected utility of real consumption in a two-date economy with preferences being restricted to  $(\mu, \sigma)$ -preferences. Transaction costs are assumed not to exist. Investors share homogeneous expectations. They have non-marketable assets such as labor income and home currency cash balances for transaction purposes and can trade marketable assets. Credit contracts are specific marketable assets with aggregate demand being zero. These contracts can serve various purposes. They can be used (1) to balance differences in individual time preferences, (2) to reallocate risk of non-marketable assets, and (3) to balance international differences in marketable assets-risk due to exchange rate risk. The important advantage of a  $(\mu, \sigma)$ -based equilibrium is that an investor's portfolio can be split easily into components which relate to these purposes.

The portfolio component for balancing differences in time preferences is always a global minimum variance portfolio (GMVP). This portfolio is bought by the lender and sold by the borrower. It is optimal since it imposes the smallest possible risk on the lender and on the borrower. The expected return of this portfolio is earned by the lender and paid by

the borrower. Borrowing and lending is a zero-sum game in terms of expected returns, but not in terms of risk. Hence a social optimum requires minimal risk of borrowing and lending.

If two citizens of a high inflation risk country write a credit contract, then the GMVP consists only of indexed bonds, denominated in domestic currency. If indexed bonds do not exist, then hard currency bonds, could serve as a substitute. For simplicity, define a hard currency as a currency with a deterministic inflation rate, i.e. without inflation risk. Then a hard currency-bond is a perfect substitute for an indexed, domestic currency-bond if relative purchasing power parity is maintained. Both bonds are risk free in terms of domestic purchasing power.

Hence, without the existence of an indexed bond, a government maintaining purchasing power parity induces its citizens to "currency flight" for balancing differences in time preferences. If the government aims at deterring from such "currency flight", it has to destabilize the real exchange rate or it has to allow the use of indexed bonds.

Now consider international borrowing and lending, i.e. the borrower and the lender domicile in different countries. Then the international global minimum variance portfolio (IGMVP) is derived from a convex combination of the covariance matrices of real asset returns in both currencies. Suppose there exist two countries, the domestic country with high inflation risk and the foreign country with no inflation risk. Then the IGMVP converges to the DGMVP (= domestic GMVP, i.e. the GMVP which is derived only from the covariance matrix in domestic currency) if the domestic country is small relative to the foreign country. The reason is that any shift of specific domestic risks from domestic to foreign investors creates only unsystematic risk in the big foreign country.

Hence international and domestic differences in time preferences are balanced by the same portfolio.

If the domestic country is not small, then the IGMVP is risk free if a hard currency-bond exists and purchasing power parity prevails. Again, a perfect substitute for a hard currency-bond would be a domestic, indexed bond. If purchasing power parity does not prevail, then each bond is risky for citizens of one country. Then the structure of the IGMVP is quite complicated. Some "currency flight" is likely to exist.

The paper is organized as follows. Section I defines the economic setting. Section II analyses the currency choice for lenders and borrowers living in the same country with uncertain inflation. In section III the international currency choice for credit contracts will be analyzed. The fourth section presents some conclusions.

Although the paper is a theoretical one, its results will be linked occasionally to some empirical observations. In order to distinguish these parts, they will be termed "remarks".

## I The Economic Setting

Consider a two date-economy with uncertain inflation. The current (future) date is denoted date 0 (date 1). Every investor maximizes the expected utility of real consumption. His expected utility depends on his date 0 consumption and on the expectation and the variance of real date 1 consumption. There exists only one commodity for consumption whose date 0 price equals 1 in each currency. The date 1 price equals 1 plus the corresponding inflation rate. Every investor has at date 0 an initial endowment of cash and marketable assets with market value  $W_{k0}$ ,  $k$  being the investor index. In addition, his endowment includes non-marketable assets which generate a random real cash flow  $\tilde{W}_{k1}$  at date 1. This cash



flow may include labor income and some exogenously determined domestic currency-cash balance for transaction purposes. The investor's portfolio of non-marketable assets is assumed to be given.

Every investor can trade marketable assets in a competitive market without incurring transaction costs. Short selling is possible. All investors share homogeneous expectations. There exists a given positive supply of securities, issued by firms. In addition, investors can borrow and lend money in various currencies, assuming no default risk and no other settlement risk. Borrowing and lending adds up to zero on an aggregate level. The following notation will be used.

- $C_{kt}$  = real consumption of investor  $k$  at date  $t$ ;  $t = 0, 1$ ;  
 $y_{ki}$  = amount invested by investor  $k$  in marketable asset  $i$ ,  
 $i \in I_1 \cup I_2 \equiv I$ ;  $\underline{y}_k = (y_{ki}) =$   
column vector of  $y_{ki}$ ,  $i \in I$ ;  
 $I_1$  = index set of securities, issued by firms;  
 $I_2$  = index set of types of credit contracts;  
 $\hat{Y}_i$  = exogenous supply of type  $i$ -securities; this supply is  
defined in terms of currency units and therefore  
depends on the pricing of assets;  $\hat{\underline{Y}} = (\hat{Y}_i)$ ;  
 $\hat{Y}_i > 0$  for  $i \in I_1$ ;  
 $\hat{Y}_i = 0$  for  $i \in I_2$ ;  
 $\tilde{r}_i$  = random gross real return of asset  $i$ ,  $i \in I$ ;  $\tilde{\underline{r}} = (\tilde{r}_i)$ ,  
 $r_i$  = expected gross real return of asset  $i$ ,  $i \in I$ ;  
 $V$  = covariance matrix of real returns of marketable  
assets;  
 $\sigma_{ki}$  =  $\text{cov}(\tilde{W}_{k1}, \tilde{r}_i)$  = covariance between investor  $k$ 's real  
endowment and the real return of asset  $i$ ,  $i \in I$ ,  
 $\underline{\sigma}_k = (\sigma_{ki})$ ;  
 $\underline{e}$  =  $|I|$ -dimensional column-unit vector;  
 $U_k$  = investor  $k$ 's expected utility of consumption.

$$U_k = U_k [C_{k0}, E(\tilde{C}_{k1}), \sigma^2(\tilde{C}_{k1})]. \quad (1)$$

Consumption has to satisfy the budget constraints

$$C_{k0} = W_{k0} - \underline{e}' \underline{y}_k \quad (2)$$

$$\tilde{C}_{k1} = \tilde{W}_{k1} + \tilde{\Gamma}' \underline{y}_k \quad (3)$$

Equations (1) - (3) imply that  $U_k$  is a function of the investor's portfolio  $\underline{y}_k$ .  $U_k$  is assumed to be strictly quasi-concave in  $\underline{y}_k$ .

## II Currency Choice of Domestic Investors

### 1 Derivation of Optimal Portfolios and Equilibrium

First consider the following situation. The domestic and the foreign capital market are completely segmented. Domestic [foreign] investors have no access to the foreign [domestic] capital market. This does not rule out that some securities, issued by foreign firms, are traded in the domestic market. In any case, domestic investors can write enforceable credit contracts with each other in various currencies.

First the optimal portfolio of a domestic investor will be derived. The first order condition for asset  $i$  is given by

$$U_{k0} = [\delta U_k / \delta E(\tilde{C}_{k1})] r_1 + 2[\delta U_k / \delta \sigma^2(\tilde{C}_{k1})] [V_i \underline{y}_k + \sigma_{k1}], \quad i \in I; \quad (4)$$

with  $U_{k0} \equiv \delta U_k / \delta C_{k0}$ .

$V_i$  denotes the row vector of covariances between returns of marketable assets and the return of marketable asset  $i$ .

For notational convenience, define the marginal rates of substitution

- $U_{k0} / 2[\delta U_k / \delta \sigma^2 (\tilde{C}_{k1})] \equiv U_k^{0\sigma}$ ;
- $[\delta U_k / \delta E(\tilde{C}_{k1})] / 2[\delta U_k / \delta \sigma^2 (\tilde{C}_{k1})] \equiv U_k^{\mu\sigma}$ .

Then equation (4) can be rewritten as

$$U_k^{0\sigma} = U_k^{\mu\sigma} r_1 - V_i \cdot \underline{y}_k - \sigma_{k1} ; i \in I, \quad (5)$$

or in matrix notation,

$$- U_k^{0\sigma} \underline{e} + U_k^{\mu\sigma} \underline{r} - \underline{\sigma}_k = V \underline{y}_k. \quad (6)$$

Aggregation across all investors yields in equilibrium

$$- U^{0\sigma} \underline{e} + U^{\mu\sigma} \underline{r} - \underline{\sigma} = V \hat{\underline{y}} \quad (7)$$

Dropping the index k means aggregation across all investors. Equation (7) determines the expected gross real returns of all marketable assets. If a risk free asset exists, then its return equals  $U^{0\sigma} / U^{\mu\sigma} \equiv U^{0\mu}$ , the marginal rate of substitution between consumption at date 0 and expected consumption at date 1. In general,  $U^{0\mu}$  is the expected return of an asset whose return is uncorrelated with the return on a portfolio of all marketable and non-marketable assets.

In order to analyse the currency choice for credit contracts, suppose first that a risk free asset does not exist and V is non-singular. Substitute  $\underline{r}$  from equation (7) in equation (6) and obtain after some manipulation

$$\underline{y}_k = \alpha_k \hat{\underline{y}} + \Gamma_k V^{-1} \underline{e} + V^{-1} (\alpha_k \underline{\sigma} - \underline{\sigma}_k), \quad (8)$$

with

$\alpha_k \equiv U_k^{\mu\sigma} / U^{\mu\sigma}$  being a measure of investor k's risk tolerance relative to aggregate risk tolerance;  $\sum_k \alpha_k = 1$ ;

$\Gamma_k \equiv \alpha_k U^0 \sigma$  being a measure of investor k's time preference minus average time preference;  $\sum_k \Gamma_k = 0$ .

Equation (8) shows that in equilibrium an investor's portfolio is composed of three components. First, the investor buys the fraction  $\alpha_k$  of the market portfolio which is defined by the securities, issued by firms. Credit contracts between investors are not included in the market portfolio since they add up to zero on an aggregate level.

Second, differences in individual time preference are balanced by trading the DGMVP (domestic global minimum variance portfolio)  $V^{-1}\underline{e}$ . The structure of this portfolio is given by the solution of  $\text{Min } \underline{y}'V\underline{y}$ , subject to  $\underline{e}'\underline{y} = 1$ . The intuition behind this result will be explained in the next section.

As  $\sum_k \Gamma_k = 0$ , selling and purchasing the DGMVP adds up to zero on an aggregate level. Therefore the DGMVP is the vehicle for borrowing and lending.

The third portfolio allocates the risk of non-marketable assets optimally across investors. This portfolio has a structure, however, which differs among investors. This is not surprising since different investors hold different non-marketable assets. By definition, the risks of non-marketable assets are not tradable. Therefore investors have to look for some other device to allocate the risks of these assets optimally across investors. This is done by some side bets among investors. The optimal side betting portfolio of investor k,  $\underline{y}_k^*$ , is the solution to

$$\text{Min } \underline{y}_k' V \underline{y}_k + 2\underline{\sigma}_k \underline{y}_k + \sigma^2 (\tilde{W}_{k1}), \text{ subject to } \underline{r}' \underline{y}_k = c_k$$

and the equilibrium condition  $\sum_k \underline{y}_k^* = \underline{0}$ .

$\underline{r}^*$  is an expected return vector to be derived from the side betting equilibrium. The objective function says that the variance from the initial endowment and the side betting portfolio has to be minimized. The first constraint is the usual expected return constraint, the second states that side betting must add up to zero on the aggregate level. Hence the optimal side betting portfolios are mean-variance efficient.

Disregarding the equilibrium condition, the solution is given by

$$2 [V \underline{y}_k^* + \underline{\sigma}_k] = \tau_k \underline{r}^* \quad (9)$$

with  $\tau_k$  being the Lagrange multiplier. As investor  $k$ 's marginal rate of substitution between risk and return is  $2U_k^{\mu\sigma}$ , replace  $\tau_k$  by  $2U_k^{\mu\sigma}$ . Aggregate equation (9) across all investors and obtain, taking into account  $\sum_k \underline{y}_k^* = \underline{0}$ ,

$$\underline{\sigma} = U^{\mu\sigma} \underline{r}^* \quad (10)$$

Equation (10) shows that non-marketable assets have implicit expected returns in the side betting equilibrium which are proportional to their covariances with marketable assets. Recall  $U_k^{\mu\sigma}/U^{\mu\sigma} = \alpha_k$ . Then substitution of  $\underline{r}^*$  in equation (9) from equation (10) proves that investor  $k$ 's optimal side betting portfolio for allocation of non-marketable asset risk is

$$\underline{y}_k^* = V^{-1}(\alpha_k \underline{\sigma} - \underline{\sigma}_k).$$

The preceding results are summarized in proposition 1.

Proposition 1: In a completely segmented capital market a domestic investor

- buys a fraction of the market portfolio,
- trades the domestic global minimum variance portfolio for borrowing and lending,
- and engages in side betting for optimal allocation of non-marketable assets risk.

## 2 Currency Choice for Credit Contracts

In this section the currency choice for credit contracts will be discussed in relation to the exchange rate regime. The preceding section has shown that differences in individual time preferences are balanced by trading the DGMVP. Borrowing and lending imply a redistribution of consumption over time between investors. On an aggregate level, the expected return from a credit contract is earned by the lender and paid by the borrower. Hence expected returns of both add up to zero. Therefore, welfare is the higher, the lower the risk is which the borrower and the lender incur. This risk is lowest if borrowing is done through the DGMVP.

In the following, the structure of the DGMVP will be analysed. If a risk free asset exists, then the DGMVP contains only this asset<sup>2)</sup>. With uncertain inflation, a risk free asset exists if an indexed bond, denominated in domestic currency, exists, regardless of the exchange rate regime. Hence the indexed bond would be used to balance differences in time preferences.

This bond cannot be used, however, to allocate non-marketable asset risk across investors since only risky assets can serve this purpose. As an interesting example, assume that all investors earn a deterministic nominal cash flow at date 1 from their non-marketable assets. Then  $\sigma_{ki}$  is the covariance between the real return of asset  $i$  and the inverse of the price index, multiplied by investor  $k$ 's nominal cash flow from non-marketable assets. Define  $c_i \equiv \sum_k \sigma_{ki}$  and  $c_k$  to be investor  $k$ 's nominal cash flow as a fraction of aggregate no-

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<sup>2</sup> The model as formulated above does not include a risk free asset if the covariance matrix  $V$  is non-singular. It is easy to show, however, that the DGMVP would disappear in equation (8) if a risk free asset existed. Hence risky assets would not be used to balance differences in individual time preferences.

minimal cash flow. Hence  $\sigma_{ki} = c_k \sigma_i \quad \forall i \in I_1$  so that  $\underline{\sigma}_k = c_k \underline{\sigma}$  for every investor  $k$ . Hence investor  $k$ 's portfolio for allocating non-marketable asset risk is  $V^{-1} \underline{\sigma} (\alpha_k - c_k)$ . All investors use the same portfolio  $V^{-1} \underline{\sigma}$ .

This portfolio is composed only of domestic non-indexed bonds. In order to see this, consider the portfolio  $\underline{y}^* = V^{-1} \underline{\sigma}$  or  $V \underline{y}^* = \underline{\sigma}$ .  $\underline{\sigma}$  is proportional to the vector of covariances between real returns of marketable assets and the real return of a domestic non-indexed bond. Since this bond is a marketable asset, there exists a column of  $V$  which is proportional to  $\underline{\sigma}$ . Hence a portfolio  $\underline{y}^*$ , composed only of domestic, non-indexed bonds, satisfies the equation  $V \underline{y}^* = \underline{\sigma}$ . The preceding results are summarized in proposition 2.

Proposition 2: In a completely segmented capital market domestic investors

- a) balance differences in time preferences by trading only domestic, indexed bonds,
- b) allocate non-marketable asset risk by trading only domestic, non-indexed bonds, if all non-marketable assets generate a deterministic nominal cash flow.

Proposition 2 is based on the assumption that enforceable domestic, indexed bonds exist. Now consider a country which does not permit trading domestic, indexed bonds, but it permits credit contracts, denominated in foreign currency without indexation. Such a contract does not necessarily involve any transfer of foreign exchange, all transactions can be done in domestic currency. Then the foreign currency is used only for determining the borrower's obligation at date 1.

Without loss of generality, the nominal and the real exchange rate at date 0 are assumed to be 1. Let  $R_F$  denote the deterministic, nominal gross return on funds in foreign

currency. Then the corresponding real gross return in domestic currency,  $r_F$ , is given by

$$r_F = R_F \cdot S / I_D = (R_F / I_F) \cdot S \quad (11)$$

$S$  [ $s$ ] denotes the nominal [real] exchange rate at date 1 (units of domestic currency per unit of foreign currency).  $I_D$  and  $I_F$  denote the gross inflation rates of domestic and foreign currency, respectively. The real exchange rate at date 1,  $s$ , is given by

$$s = S I_F / I_D. \quad (12)$$

If the borrower and the lender agree on the gross nominal interest rate  $R_F$  in foreign currency, then the borrower has to pay at date 1 the gross real rate of return  $r_F$  in domestic currency. This claim will be called a foreign, non-indexed bond.

From equations (11) and (12) follows immediately that the real return in domestic currency is deterministic if

- the foreign inflation rate is deterministic and purchasing power parity prevails,
- or the foreign inflation rate is stochastic, but the nominal exchange rate is adjusted only for domestic inflation, not for foreign inflation.

Then a domestic, indexed bond and the foreign, non-indexed bond are perfect substitutes. Hence differences in time preference will be balanced by the latter if the former is not allowed. This may be interpreted as currency flight.

If the government does not permit any of these bonds for lending among domestic citizens, then it creates a strong incentive for the lender to invest his money in foreign capital markets. This may be interpreted as capital flight. As a result, the domestic supply of funds will be reduced.



The domestic government can reduce the attractiveness of foreign bonds by switching to another exchange rate regime. If the government credibly pegs the nominal exchange rate to be deterministic, then the foreign, non-indexed and the domestic, non-indexed bond are perfect substitutes. Then there is no reason to use foreign, non-indexed bonds. In this situation there is no simple structure of the DGMVP.

Pegging the nominal exchange rate despite of the uncertainty of domestic inflation may be undesirable, however, because such an exchange rate regime destabilizes the country's international trade.

Proposition 3: In a completely segmented capital market with domestic, indexed bonds being prohibited, investors balance differences in time preference by trading foreign, non-indexed bonds if

- a) the foreign inflation rate is deterministic and purchasing power parity prevails, or
- b) if the nominal exchange rate is adjusted only for domestic inflation.

If the nominal exchange rate is deterministic, then foreign, non-indexed bonds and domestic, non-indexed bonds are perfect substitutes. Thus the former are irrelevant.

From propositions 2 and 3 follows that domestic, indexed bonds are suited best for balancing differences in time preference.

Remark 1: With many commodities, domestic, indexed bonds are actually not risk free because of the missing index problem. It takes some time to collect price information and derive the price index. Thus an indexed credit contract has to be settled on the basis of outdated information and therefore some inflation risk always remains.

Remark 2: If the missing index problem is considered to be substantial, then investors may prefer foreign bonds which actually have to be settled by paying foreign exchange. Then, however, there exists always the risk that the borrower is not able to get the necessary amount of foreign exchange. The domestic banks including the central bank, for example, may not have any foreign exchange.

This problem also exists with "dollarization" which some Latin American countries used to prevent capital flight (Dodsworth, El-Erian and Hammann [1987]). These countries allowed their citizens to deposit US-dollars on dollar accounts with domestic banks. In principle, the depositors could withdraw these dollars at any time. Mexico, for example, started dollarization in the seventies. At the end of 1981, the value of the Mexdollars reached one quarter of the Mexican money supply. In September 1982, when Mexico defaulted on its foreign debt, no dollars were available to pay the depositors. Thus the Mexdollars had to be converted into Pesos (Luke [1986]). Peru's experience is similar.

These experiences show that dollarization is not a perfect substitute for indexation in domestic currency. The problem arises from the fact that in the case of a lack of foreign exchange the government chooses the date and the exchange rate at which dollars are converted compulsorily into domestic currency. This government choice generates a special exchange risk.

Remark 3: Whenever the government of a country announces some exchange rate policy, there exists a credibility problem. This problem arises especially with policies which endanger the country's international trade balance.

Pegging the nominal exchange rate, for example, may be detrimental to the country's international trade. Despite of this such a policy has been followed by some countries for

limited periods of time. From December 1979 to February 1981 Argentina adopted a Tablita policy such that the nominal exchange rate followed a preannounced pattern of movements. Chile applied the same policy from February 1978 to June 1979 and then froze the exchange rate. Israel followed a policy of devaluation of 5 percent per month from September 1982 to October 1983. Such a policy implies deterministic nominal exchange rates. Of course, none of the countries mentioned above followed such a policy for a long time. Thus nominal exchange rate risk never really ceased to exist.

### III Currency Choice in International Lending

#### 1 Derivation of Optimal Portfolios and Equilibrium

So far, currency choice has been analysed for domestic investors. In this section currency choice in international lending will be investigated. Suppose there exist a domestic and a foreign country. The domestic and the foreign capital market are competitive, moreover they are perfectly integrated. There are no transaction costs in the international capital market; the set of marketable assets is the same in both countries. This setting provides the opportunity for international lending. Again the question is which currency will be used for lending.

Essentially two aspects render the analysis more difficult now.

(1) Domestic investors are concerned with domestic inflation, foreign investors with foreign inflation.

(2) When a foreign investor lends domestic currency to a domestic investor, he converts foreign into domestic currency at date 0 and reconverts at date 1. Hence he benefits or suffers from exchange rate changes while the domestic investor does not. Some third party, a central bank for example, earns the corresponding gains or losses from exchange rate changes.

Both aspects create asymmetries between domestic and foreign investors. The optimization problem of the domestic investors is formally the same as before. The foreign investor is interested in real returns, denominated in foreign currency. Real returns in foreign currency equal real returns in domestic currency, divided by the real exchange rate of date 1 (assuming that the date 0 real exchange rate equals 1). Real exchange rates in foreign currency are marked by a star so that  $\tilde{r}_1^* = \tilde{r}_1/\tilde{s}$ ,  $\forall i$ . Similarly  $V^*$  denotes the covariance matrix of real returns of marketable assets in foreign currency,  $\underline{g}_1^*$  denotes the vector of covariances between real returns of marketable assets and foreign investor 1's real cash flows from non-marketable assets, in foreign currency.  $l$  is the index of foreign investors.

The foreign investor's portfolio problem is formally the same as the domestic investor's, with domestic returns being replaced by foreign returns. From  $\tilde{r}_1^* = \tilde{r}_1/\tilde{s}$  follows

$$E(\tilde{r}_1^*) \equiv r_1^* = E(\tilde{s}^{-1}) [r_1 + \sigma_{1s}] \quad \forall i \quad (13)$$

with  $\sigma_{1s} \equiv \text{cov}[\tilde{r}_1, \tilde{s}^{-1}/E(\tilde{s}^{-1})]$ . Define  $\underline{g}_s \equiv (\sigma_{1s})$ . Then equation (6) yields for the foreign investor 1

$$-U_1^0 \sigma \underline{g} + U_1^0 \sigma E(\tilde{s}^{-1}) [\underline{r} + \underline{g}_s] - \underline{g}_1^* = V^* \underline{y}_1 \quad (14)$$

Hence the real exchange rate affects the foreign investor's portfolio choice as compared to a domestic investor by its expected change and its variability. If a marketable asset exists which is risk free in both currencies, then its domestic return equals

$$U_1^0 \sigma / [U_1^0 \sigma E(\tilde{s}^{-1})] = U_1^0 \mu / E(\tilde{s}^{-1}) = U_k^0 \mu.$$

Hence the marginal rates of substitution between date 0 consumption and expected date 1 consumption are not the same in-

ternationally. The difference between domestic and foreign investors is created by the expected exchange rate change. Such a change acts like a tax or a subsidy to the foreign investor as compared to the domestic investor.

Another asymmetry between domestic and foreign investors is created by the covariances between domestic returns of marketable assets and the inverse exchange rate. As is well known, this asymmetry exists independently of risk attitudes.

Equilibrium is derived in a manner similar to section II.1. Let D and F denote aggregate values over domestic and foreign investors, respectively. Then aggregation of equation (6) over domestic investors yields

$$-U_D^{0\sigma} \underline{e} + U_D^{\mu\sigma} \underline{r} - \underline{\sigma}_D = V \underline{y}_D, \quad (15)$$

aggregation of equation (14) over foreign investors yields

$$-U_F^{0\sigma} \underline{e} + U_F^{\mu\sigma} [\underline{r} + \underline{\sigma}_S] - \underline{\sigma}_F^* = V^* \underline{y}_F, \quad (16)$$

with  $U_{1*}^{0\sigma} \equiv U_1^{\mu\sigma} E(\tilde{S}^{-1})$ . By definition,  $\underline{y}_D + \underline{y}_F = \hat{\underline{y}}$ .

There exist two routes for proceeding. If expected asset returns are the focus of interest, then multiply equations (15) and (16) by  $V^{-1}$  and  $V^{*-1}$ , add them and solve for  $\underline{r}$ . If, however, currency choice in international lending is of primary interest, then substitute  $\underline{r}$  from equation (15) in equation (16) and solve for  $\underline{y}_F$ , making use of  $\underline{y}_D + \underline{y}_F = \hat{\underline{y}}$ . This yields after some manipulation

$$\begin{aligned} \underline{y}_F = & \alpha_F \hat{V}^{-1} V \hat{\underline{y}} + \Gamma_F \hat{V}^{-1} \underline{e} + \hat{V}^{-1} [\alpha_F \underline{\sigma}_D - \alpha_D \underline{\sigma}_F^*] \\ & + \alpha_F U_D^{\mu\sigma} \hat{V}^{-1} \underline{\sigma}_S. \end{aligned} \quad (17)$$

Equation (17) and  $\underline{y}_D = \hat{\underline{y}} - \underline{y}_F$  imply

$$\underline{y}_D = \alpha_D \hat{V}^{-1} V^* \hat{y} - \Gamma_F \hat{V}^{-1} \underline{e} - \hat{V}^{-1} [\alpha_F \underline{\sigma}_D - \alpha_D \underline{\sigma}_F^*] - \alpha_F U_D^{\mu\sigma} \hat{V}^{-1} \underline{\sigma}_S. \quad (18)$$

with

$\alpha_F \equiv U_{F^*}^{\mu\sigma} / [U_D^{\mu\sigma} + U_{F^*}^{\mu\sigma}]$  being a measure of the foreign investors' risk tolerance relative to aggregate risk tolerance,  $\alpha_F + \alpha_D = 1$ ;

$\Gamma_F \equiv \alpha_F U^{0\sigma} - U_F^{0\sigma}$  being a measure of foreign investors' time preference minus average time preference;  $\Gamma_F + \Gamma_D = 0$ ;

$$\hat{V} \equiv \alpha_D V^* + \alpha_F V. \quad (19)$$

A comparison of equation (8) with equations (17) and (18) reveals the effects of real exchange rate changes on international portfolio choice. If the real exchange rate is deterministic, then  $V = V^* = \hat{V}$  and  $\underline{\sigma}_S = \underline{0}$  so that equations (17) and (18) coincide with equation (8).

If the real exchange rate is stochastic, then domestic and foreign investors buy differently structured parts of the world market portfolio. This is well known. Differences in time preferences across countries are balanced by trading the international global minimum variance portfolio (IGMVP). This is derived from the international covariance matrix  $\hat{V}$  which, by equation (19), is a convex combination of the domestic and the foreign covariance matrix of marketable asset returns. The weights are the foreign and the domestic investors' relative risk tolerances.

Similarly, the risk of initial endowments is allocated across countries by a portfolio which depends on the international covariance matrix. Finally, the domestic and the foreign investors trade a portfolio which does not exist if only domestic investors exist. This portfolio with structure  $\hat{V}^{-1}\underline{\sigma}_s$  serves to balance differences between expected domestic and expected foreign returns of marketable assets which derive from the covariances between the domestic asset returns and the inverse exchange rate. Assets with positive covariance have a higher expected return in foreign than in domestic currency. Hence, ceteris paribus, foreign investors buy more of these assets than domestic investors.

## 2 Currency Choice for Credit Contracts

### 2.1 The Domestic Country is Small

Now the currency choice for credit contracts between domestic and foreign investors will be analysed. First assume that the domestic country is small relative to the foreign country. Then  $\alpha_D \rightarrow 0$  and  $\alpha_F \rightarrow 1$  so that  $\hat{V} \rightarrow V$ . Then equation (18) yields

$$\begin{aligned} \underline{y}_D \rightarrow \alpha_D V^{-1} V^* \hat{\underline{Y}} - \Gamma_F V^{-1} \underline{e} - V^{-1} [\alpha_F \underline{\sigma}_D - \alpha_D \underline{\sigma}_F^*] \\ - \alpha_F U_D^{\mu\sigma} V^{-1} \underline{\sigma}_s. \end{aligned} \quad (20)$$

Hence, in the limit, domestic investors choose the domestic global minimum variance portfolio for balancing international differences in time preferences and choose portfolios based on the domestic covariance matrix of marketable asset returns, for the allocation of non-marketable asset risk and for balancing effects of the expected return differences, due to  $\underline{\sigma}_s$ . Interestingly, however, the domestic investors do not buy a fraction of the world market portfolio as  $V^{-1}V^*\hat{\underline{Y}} \neq \hat{\underline{Y}}$ .

The essential observation is that the international covariance matrix  $V$  converges to the domestic matrix  $V$  if the domestic economy is small. The international covariance matrix determines the portfolios for balancing time differences, for allocating non-marketable asset risks and effects of the exchange rate on expected return differences. The risks of these portfolios in domestic currency are different from those in foreign currency. Insofar as these risks are specific domestic currency risks, they can be shifted costlessly to foreign investors. Since many foreign investors as compared to domestic investors exist, the effect of domestic risk shifts on a foreigner's risk is very small. Foreigners regard this risk as unsystematic. Hence risk shifting between domestic and foreign investors is governed by domestic investors' risk perception.

This argument does not apply to the purchase of securities, issued by firms. As risk and return of these securities differ for domestic and foreign investors, their portfolios of these securities are structured differently.

International differences in time preferences are balanced by trading the DGMVP. This portfolio contains only domestic, indexed bonds if they exist (proposition 2). If these claims are not permitted, then, under the conditions of proposition 3, foreign, non-indexed bonds would be used for balancing differences in time preferences.

International allocation of non-marketable asset risk is accomplished through trading only the marketable asset  $j$  if the covariance vector  $[\alpha_F \underline{g}_D - \alpha_D \underline{g}_F^*]$  is proportional to the covariance vector of a marketable asset  $j$ ,  $(\text{cov}(\tilde{r}_j, \tilde{r}_i); i \in I)$ . With a stochastic real exchange rate, it is unlikely that such an asset exists.

Similarly, the portfolio  $V^{-1} \underline{g}_s$  for balancing effects of differences in expected domestic and foreign asset returns does



not appear to have a simple structure. A bond  $j$  with a deterministic real return in foreign currency yields the return  $r_j = \tilde{s}$  in domestic currency. As  $\sigma_{1s} = \text{cov}[\tilde{r}_1, \tilde{s}^{-1}/E(\tilde{s}^{-1})] \forall i$ ,  $\sigma_s \neq \text{cov}(\tilde{r}_i, \tilde{r}_j)$ . Thus bond  $j$  alone is not optimal for balancing effects of differences in expected domestic and foreign asset returns. It is hard to imagine any single asset which yields a return in domestic currency, being proportional to  $\tilde{s}^{-1}$ .

The main results of this section are summarized in proposition 4.

Proposition 4: Assume that the domestic country is small. Then in a completely integrated international capital market portfolios for shifting risks between domestic and foreign investors depend on the domestic covariance matrix, but not on the foreign covariance matrix.

- a) Differences in international time preferences are balanced by trading the domestic global minimum variance portfolio,
- b) in general no portfolio with a simple structure allocates optimally non-marketable asset risk internationally,
- c) no portfolio with a simple structure balances the effects of international differences in expected asset returns, due to covariances between their returns and the inverse real exchange rate.

Remark 4: Proposition 4a) is in conflict with empirical evidence. Creditors living in hard currency countries do not appear to hold indexed bonds, denominated in weak currencies, not even at a small scale. Various explanations are available. First, creditors are afraid of exchange rate manipulations which devalue their claims. This fear is especially strong if the debtor country itself is highly indebted to creditors living in other countries. Second, many weak currency countries severely restrict international transfers of domestic money. Article VIII, 2b of the International Mone-

tary Fund rules out litigation in IMF-countries to enforce claims which violate capital transfer restrictions. Third, even if weak currency bonds could be traded in hard currency countries, liquidity of the secondary markets could be insufficient for maintaining an orderly market.

## 2.2 The Domestic Country is Not Small

### a) Purchasing Power Parity

Now assume that the domestic country is not small relative to the foreign country. First suppose that the domestic country maintains purchasing power parity. Then real asset returns are the same in both currencies, hence  $V = V^* = \hat{V}$ . The distinction between domestic and foreign investors disappears. Differences in time preference are balanced by trading domestic, indexed or foreign, indexed bonds which are perfect substitutes. If the former do not exist, then domestic investors engage in currency flight.

If non-marketable assets generate deterministic nominal returns in domestic and/or in foreign currency, then the non-marketable asset risk is allocated internationally by trading domestic, non-indexed and foreign, non-indexed bonds only. This follows from the fact that with purchasing power parity  $[\alpha_F \sigma_D - \alpha_D \sigma_F^*]$  is a linear combination of  $\text{cov}(\tilde{x}, \tilde{I}_D^{-1})$  and  $\text{cov}(\tilde{x}, \tilde{I}_F^{-1})$ . These covariance vectors are the two column vectors of  $V$  for domestic, non-indexed and foreign, non-indexed bonds. Hence trading these bonds only satisfies the equation  $Vy = [\alpha_F \sigma_D - \alpha_D \sigma_F^*]$ .

### b) Deterministic Nominal Exchange Rates

The situation changes completely when the nominal exchange rate is fixed at a deterministic level. Then domestic, non-indexed and foreign, non-indexed bonds are perfect substitu-

tes. They are risky for domestic investors, but riskless for foreign investors if the foreign inflation rate is deterministic. Hence they are perfect hedging instruments for domestic investors who receive a deterministic nominal return from their non-marketable assets.

A domestic, indexed bond is riskless for domestic investors, but risky for foreign investors since its real return in foreign currency is perfectly correlated with the domestic inflation rate, divided by the foreign inflation rate. The analogue statement is true of a foreign, indexed bond.

The preceding discussion shows that no portfolio of indexed and non-indexed bonds exists which is risk free for domestic and foreign investors. Hence the international global minimum variance portfolio has no simple structure. Proposition 5 summarizes the main results.

Proposition 5: Suppose that the domestic and the foreign capital market are completely integrated and that the domestic country is not small.

a) With purchasing power parity,

-- international differences in time preferences are balanced by indexed bonds,

-- non-indexed bonds are traded to allocate non-marketable asset risk if these assets generate deterministic nominal returns in domestic and/or foreign currency.

b) With a deterministic nominal exchange rate,

-- the international global minimum variance portfolio which is used for balancing international differences in time preferences has no simple structure,

-- non-indexed bonds are traded to hedge perfectly non-marketable asset risk if these assets generate a deterministic nominal return in domestic currency and if the foreign inflation rate is deterministic.

If neither the nominal nor the real exchange rate is kept at a deterministic level, then it is difficult to derive meaningful results about the structure of the international global minimum variance portfolio and that of the portfolio for allocating non-marketable asset risk.

#### IV Conclusions

This paper discusses the currency choice for credit contracts in a  $(\mu, \sigma)$ -world. In such a world an investor's portfolio can be decomposed into separate components each of which relates to some specific difference among investors. Thus differences in time preferences are balanced by trading a national or international global minimum variance portfolio. Another portfolio is used to allocate non-marketable asset risk across investors.

It has been shown that in a completely segmented capital market domestic investors trade domestic, indexed bonds to balance differences in time preferences. If these bonds do not exist, then the use of foreign bonds depends on the exchange rate regime. With PPP, foreign, indexed bonds are perfect substitutes for domestic, indexed bonds. With nominal exchange rates, adjusted only for domestic inflation, foreign, non-indexed bonds are perfect substitutes. Thus, if a country with substantial inflation risk does not permit the use of domestic, indexed bonds, it induces its citizens to currency flight. If, in addition, its citizens are not allowed to denominate credit contracts in foreign currency, then lenders may prefer to invest their money in other places. Capital flight will occur and shorten the supply of funds in the domestic country.

Domestic, non-indexed bonds are traded for the allocation of non-marketable asset risk if these assets generate a deterministic nominal return in domestic currency.

Alternatively, if the domestic and the foreign capital market are completely integrated, then real returns in both currencies matter. If the domestic country is small, then risks which are specific domestic currency risks, can be shifted costlessly to foreign investors. Hence international differences in time preferences are balanced by the domestic global minimum variance portfolio, i.e. in exactly the same manner as in the completely segmented market.

If the domestic economy is not small and PPP prevails, then indexed bonds of either currency can be used to balance differences in international time preference. If PPP does not prevail, then this purpose cannot be fulfilled by a portfolio of bonds.

Domestic investors hedge non-marketable asset risk which is pure domestic and foreign inflation risk, by trading non-indexed bonds in a PPP world. If the nominal exchange rate and the foreign inflation rate are deterministic, then domestic investors sell domestic, non-indexed bonds to hedge non-marketable asset risk which is pure domestic inflation risk.

The analysis has shown that the currency choice for credit contracts depends heavily on a country's exchange rate policy. A PPP-policy pushes domestic investors into hard currency contracts if domestic, indexed bonds do not exist. If a country wants to avoid this "currency flight", then it has to destabilize its real exchange rate or admit domestic, indexed contracts. In general, weak currency, non-indexed credit contracts are not attractive for balancing differences in time preference since they would raise the lender's and the borrower's risk unnecessarily. Then the lender would require a corresponding risk premium which the borrower would not be ready to pay. This may explain why heavily indebted, weak currency-countries do not borrow internationally by issuing non-indexed bonds in their own currency, apart from moral

hazard considerations. The latter may explain why foreign creditors even do not accept indexed bonds, denominated in the currency of the borrowing country.

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