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“Real” Risk Management
Opportunities and Limits of Consumption-Based Strategies

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Opportunities and Limits of Consumption-Based Strategies

by *Wolfgang Breuer*[†] and *Olaf Stotz*[‡]

Abstract. In general, individuals will be interested in consumption of goods with “original” prices denominated in various currencies. Traditional risk management is nominally oriented and typically neglects this differentiated consumption preferences of investors. We outline the relevance of a consumption oriented “real” risk management and sketch resulting problems connected with such an approach.

Keywords: Risk management, Cobb-Douglas utility, foreign exchange, numéraire problem, consumption preferences, hedging

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1. Onassis and the numéraire problem

Consider an international investor whom we may call “Onassis” and who – as a real “cosmopolitan” – is living, investing and consuming all over the world. At some point $t = 0$ in time Onassis invests \$ 1,000 at a riskless interest rate of 8 % until $t = 1$ for one period in the U.S. There are two possible states of nature at $t = 1$. With probability 0.9 the exchange rate e_1 between € and \$ will amount to € 1/\$ (state $s^{(1)}$), with probability 0.1 it will only be € 0.82/\$ (state $s^{(2)}$).

Moreover, there are two possible alternatives for Onassis at $t = 0$. He either may make nothing else besides investing \$ 1,000 (action $a^{(1)}$) or he may sell forward this amount against € at a forward exchange rate $e_{0,1}^{(f)} = € 0.98/\$$ (action $a^{(2)}$). Obviously, action $a^{(1)}$ leads to riskless revenues of \$ 1,080 for Onassis at time $t = 1$, while action $a^{(2)}$ results in riskless payoffs amounting to $1,080 \cdot 0.98 = € 1,058.4$. \$ 1,080 are equivalent to $1,080 \cdot 1 = € 1,080$ in $s^{(1)}$ and to $1,080 \cdot 0.82 = € 885.6$ in $s^{(2)}$, whereas € 1,058.4 can be changed into $1,058.4/1 = \$ 1,058.4$ in $s^{(1)}$ and $1,058.4/0.82 \approx \$ 1,290.73$ in $s^{(2)}$. Table 1.1 summarizes the monetary consequences at time $t = 1$ of Onassis’s engagements calculated in \$ as well as in €.

Table 1.1. Resulting payoffs for Onassis in \$ or €

\$	$s^{(1)}$	$s^{(2)}$	€	$s^{(1)}$	$s^{(2)}$
$a^{(1)}$	1,080	1,080		1,080	885.6
$a^{(2)}$	1,058.4	1,290.73		1,058.4	1,058.4

Table 1.1 displays resulting payoffs (in \$ and in €) for Onassis from his investment of \$ 1,000 at a riskless interest rate of 8 % in the case of selling the corresponding revenues of \$ 1,080 at $t = 1$ forward against € at a forward exchange rate of € 0.98/\$ (action $a^{(2)}$) or refraining from this forward transaction (action $a^{(1)}$). The €/ \$ spot rate at $t = 1$ can amount to 1 (state of nature $s^{(1)}$) or 0.98 (state of nature $s^{(2)}$).

Onassis as a true cosmopolitan now faces the problem which currency he should use as a numéraire for his decision whether to sell forward his dollar revenues or not. Apparently, investors calculating in different currencies may assess actions $a^{(1)}$ and $a^{(2)}$ in different ways. For example, in the case of risk-neutrality and applying \$ as the numéraire, Onassis would choose $a^{(2)}$, thus realizing expected \$ payoffs of $0.9 \cdot 1,058.4 + 0.1 \cdot 1,290.73 \approx 1,081.63 > 1,080$. On the contrary, a risk-neutral investor calculating in € will prefer action $a^{(1)}$, since $0.9 \cdot 1,080 + 0.1 \cdot 885.6 = 1,060.56 > 1,058.4$. This phenomenon of differing decisions depending on the chosen “basis” currency was introduced into the literature by Wolfgang Stützel in 1970 as the (today well-known) numéraire problem.¹

In particular multinational enterprises with investors in various countries face a similar numéraire problem as Onassis. Should the management of DaimlerChrysler bother about their monetary payoffs in € or in \$? We therefore want to take a closer look at the numéraire problem.

2. Consumption-oriented utility functions

In order to solve the numéraire problem one must know which kinds of goods are bought by Onassis. If Onassis restricts himself to the consumption of a fixed bundle of goods with given prices in \$ at time $t = 1$, then he should do all his computations in this currency. If instead his

¹ See also Breuer 2000, pp. 93–116.

consumption solely focuses on a fixed bundle of goods with known prices in € at time $t = 1$, then all calculations have to be done in €.

Such simple “nominal” computations are no longer sufficient if future prices of goods are uncertain or if Onassis is simultaneously interested in goods supplied at fixed prices in \$ as well as in goods with given prices in €. In such cases nominal considerations must be substituted by “real” analyses which explicitly account for the bundle of goods the decision-maker is willing to consume. In order to simplify analysis we assume Onassis to be only interested in the consumption of a given bundle of goods with prices fixed in € (call it the “€-bundle”) and a given bundle of goods with prices fixed in \$ (the “\$-bundle”). Let $\tau_T^{(\epsilon)}$ and $\tau_T^{(\$)}$ stand for the corresponding amounts of consumption of these two bundles at end T of his time horizon, then Onassis’s utility function U is of the general type $U(\tau_T^{(\epsilon)}, \tau_T^{(\$)})$. Unfortunately, optimal amounts $\tau_T^{(\epsilon)*}$ and $\tau_T^{(\$)*}$ will in general depend on the development of future prices and exchange rates and therefore are state-dependent in itself. Only in the case of a Cobb-Douglas utility function we get a (comparatively) easily treatable decision problem.² We thus narrow our further analysis somewhat more by requiring:

$$(1) U(\tau_T^{(\epsilon)}, \tau_T^{(\$)}) = (\tau_T^{(\epsilon)})^a \cdot (\tau_T^{(\$)})^b.$$

Thereby, parameters a and b are precisely describing Onassis’s consumption preferences, for it is well-known that with $\alpha := a/(a+b)$ Onassis prefers to spend the fraction α of his monetary endowment at time T for the consumption of the €-bundle and the remaining fraction $1-\alpha$ for the purchase of the \$-bundle. With a total monetary endowment $M_T^{(\text{tot}, \epsilon)}$ in € at time T and corresponding prices $p_T^{(\epsilon)}$ of the €-bundle as well as $p_T^{(\$)}$ of the \$-bundle Onassis faces the following budget constraint at point T in time:

$$(2) \tau_T^{(\epsilon)} \cdot p_T^{(\epsilon)} + \tau_T^{(\$)} \cdot p_T^{(\$)} \cdot e_T = M_T^{(\text{tot}, \epsilon)}.$$

The maximization of (1) with respect to $\tau_T^{(\epsilon)}$ and $\tau_T^{(\$)}$ subject to (2) immediately leads to the solutions

$$(3a) \tau_T^{(\epsilon)} \cdot p_T^{(\epsilon)} = \alpha \cdot M_T^{(\text{tot}, \epsilon)},$$

$$(3b) \tau_T^{(\$)} \cdot p_T^{(\$)} \cdot e_T = (1 - \alpha) \cdot M_T^{(\text{tot}, \epsilon)}.$$

Inserting (3) in (1) as well as taking into account the relationship $M_T^{(\text{tot}, \$)} = M_T^{(\text{tot}, \epsilon)} / e_T$ results in a maximum utility value U_T^* for Onassis of

$$(4) U_T^* = \left(\frac{\alpha \cdot M_T^{(\text{tot}, \epsilon)}}{p_T^{(\epsilon)}} \right)^a \cdot \left(\frac{(1 - \alpha) \cdot M_T^{(\text{tot}, \epsilon)}}{p_T^{(\$)} \cdot e_T} \right)^b \\ = \alpha^a \cdot (1 - \alpha)^b \cdot (M_T^{(\text{tot}, \epsilon)})^a \cdot (M_T^{(\text{tot}, \$)})^b \cdot \left(\frac{1}{p_T^{(\epsilon)}} \right)^a \cdot \left(\frac{1}{p_T^{(\$)}} \right)^b.$$

The constant (positive) factor $\alpha^a \cdot (1 - \alpha)^b$ can be omitted since it does not influence any kind of utility maximization. Onassis’s utility is thus determined by some kind of geometric mean of (1) his monetary endowment in € as well as in \$ and (2) the reciprocals of prices of goods in € and goods in \$. The second determinant can be interpreted as a weight which expresses the purchasing power of Onassis’s endowment with respect to his preferred consumption structure.

Obviously, (4) can be used as a starting point for consumption based or purchasing power based risk management strategies. Indeed, from a decision point $t = 0$ Onassis may strive to maximize his expected (maximum) consumption oriented utility³

² For this idea see in particular Kouri and Braga de Macedo 1978. Moreover, see Breuer 2001a, 2001b.

³ In what follows, we use a tilde “ \sim ” to denote random variables.

$$(5) E(\tilde{U}_T^*) = E\left(\tilde{M}_T^{(\text{tot},\text{€})a} \cdot \tilde{M}_T^{(\text{tot},\$)b} \cdot \left(\frac{1}{\tilde{p}_T^{(\text{€})}}\right)^a \cdot \left(\frac{1}{\tilde{p}_T^{(\$)}}\right)^b\right)$$

$$= E((\tilde{\tau}_T^{(\text{€},\text{max})})^a \cdot (\tilde{\tau}_T^{(\text{\$,max})})^b),$$

with $\tau_T^{(\text{€},\text{max})}$ and $\tau_T^{(\text{\$,max})}$ defined as maximum possible consumptions of the €- or \$-bundle, respectively. Indeed, we have now arrived at a truly “consumption” or “purchasing-power-based” oriented approach. Risk management measures are thereby able to influence the probability distribution of Onassis’s monetary endowment in € as well as in \$ at time $t = T$.

3. Onassis’s decision problem reconsidered

On the basis of the analysis of the last section we now want to return to the numerical example of section 1. Onassis’s attainable maximum utility U_1^* as seen from $t = 0$ is indeed a random variable since at least the future spot rate between € and \$ is uncertain. With $\tilde{\epsilon}_1$ being uncertain, $\tilde{M}_1^{(\text{tot},\text{€})}$ and/or $\tilde{M}_1^{(\text{tot},\$)}$ may be, too. For the sake of simplicity we assume prices $p_1^{(\text{€})}$ and $p_1^{(\$)}$ to be already known as € 1 and \$ 1, respectively, at time $t = 0$. Then, Onassis’s decision problem reduces to the maximization of

$$E\left(\tilde{M}_1^{(\text{tot},\text{€})a} \cdot \tilde{M}_1^{(\text{tot},\$)b}\right)$$

We now want to determine the optimality of actions $a^{(1)}$ and $a^{(2)}$ depending on different parameter values a and b as well as the precise optimal amount of \$ which Onassis should sell forward at time $t = 0$. For this purpose let λ characterize the hedge ratio chosen by Onassis. With s as the amount of \$ sold forward at $t = 0$ and certain revenues of \$ 1,080 at $t = 1$, we have $\lambda = s/1,080$. Obviously, $a^{(1)}$ implies $\lambda = 0$ and $a^{(2)}$ corresponds to $\lambda = 1$.

We consider all possible pairs of a and b with $a, b, a+b \in \{0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1\}$ excluding the meaningless case $a = b = a+b = 0$. We restrict ourselves to situations with $a+b \leq 1$ because otherwise – as can be seen from the first line of formula (4) – Onassis’s marginal utility with respect to his monetary endowment $\tilde{M}_1^{(\text{tot},\text{€})}$ in € would be monotone increasing in $\tilde{M}_1^{(\text{tot},\text{€})}$ and thus not satisfy the reasonable requirement of decreasing or at most constant marginal utility.

For all resulting 65 scenarios strategies $\lambda = 0$ (“no hedge”) and $\lambda = 1$ (“full hedge”) are evaluated. Independently of the given sum $a+b$, in all cases there is a critical value for the utility parameter a beyond which the investor prefers the no-hedge alternative. The reason for this specific result is that the investor is (significantly) reducing his expected earnings in € when applying the full-hedge-strategy instead of choosing $\lambda = 0$. An increase in a for constant sum $a+b$ gives more weight to the “€-perspective” of the hedging problem and thus makes it here more interesting to choose $\lambda = 0$. In Table 3.1 for any sum $a+b$ under consideration we give the fraction of analyzed scenarios for which Onassis prefers the no-hedge alternative.

Table 3.1. Fraction of scenarios with the optimality of $\lambda = 0$ depending on $a+b$

a+b	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
fraction	1	0.68	0.75	0.60	0.67	0.57	0.63	0.56	0.6	0.55

For each sum $a+b$ the relative portion of scenarios under consideration leading to the superiority of a hedge ratio $\lambda = 0$ compared to $\lambda = 1$ is reported.

Rather interestingly, at least for situations from $a+b = 0.2$ to $a+b = 1$ threshold values only vary between 55 % and 75 % and correspond to medium levels of a and b for given sum $a+b$ (e.g. situations like $a = b = 0.4$ for $a+b = 0.8$). As a first reasonable consequence, one might

conclude to prefer the €-perspective (here equivalent to the no-hedge alternative) above the \$-perspective (here corresponding to the full-hedge alternative) if the weight of the €-bundle exceeds the weight of the \$-bundle while the amount of the investor's risk aversion (as determined by the sum $a+b$) is only of secondary importance.

Nevertheless, it remains to be analyzed how optimal hedging strategies λ^* are affected by different values for a , b , and $a+b$. For all 65 scenarios under consideration optimal hedging strategies have been calculated. In any case the lower a , the higher λ^* for given sum $a+b$. Moreover, the resulting range of optimal values of the investor's optimal hedge ratio λ^* for different pairs (a,b) is monotone increasing in the sum $a+b$. Finally, the no-hedge alternative remains interesting at least for investors with medium-level preferences as in the case of $a = 0.4$ and $b = 0.4$ or $a = 0.4$ and $b = 0.5$. Table 3.2 presents resulting intervals of optimal hedge ratios depending on the sum $a+b$. Thereby, the lower bound of the interval is always achieved for $b = 0$, while the upper bound coincides with the case of $a = 0$.

Table 3.2. Intervals of optimal hedge ratios λ^*

a+b	0.1	0.2	0.3	0.4	0.5
interval	[0.32, 0.43]	[0.24, 0.49]	[0.14, 0.56]	[0.01, 0.66]	[-0.17, 0.8]
a+b	0.6	0.7	0.8	0.9	
interval	[-0.43, 1.02]	[-0.83, 1.39]	[-1.55, 2.21]	[-3.08, 5.17]	

For each sum $a+b$ the interval of optimal hedge ratios λ^* as a consequence of differing values for a and b is reported

Indeed, λ^* reacts quite sensitively with respect to changes of a and b for given sum $a+b$. In particular, this holds true for great values of $a+b$ while small values of $a+b$, denoting situations with relatively high risk aversion, are characterized by less importance of the precise specification of a and b . In any case, if a decision-maker does not want to restrict himself to the analysis of simple hedging strategies as the no-hedge case and the full-hedge case, it seems necessary to take a closer look at the relevant investor's consumption preferences.

4. Consumption oriented utility and international invitations for tenders

4.1 The general setting

Apparently, our numerical example of section 3. is quite too simple to allow more than preliminary insights into the importance of "real preferences". On the other hand, it should not be too surprising at all that it is quite difficult to derive general analytical results with respect to optimal hedging strategies in the case of consumption preferences for several goods denoted in more than just one currency. We therefore want to follow an alternative path of analysis by examining another numerical problem which is this time characterized by a somewhat more realistic setting. In fact, we want to look at a German entrepreneur who participates in an international invitation for tenders. Thereby, we use the same setting as in Breuer and Gürtler 2001a⁴ with the most relevant modification regarding the entrepreneurial utility function. To be precise, we consider a German entrepreneur who is participating in an international tender, for example, a major construction project where bids have to be denominated in \$. At time $t = 0$, the entrepreneur enters an offer B in foreign currency for which he is prepared to supply a certain (investment) good at a future point in time $t = 2$. At time $t = 1$, the entrepreneur finds out whether he is awarded the contract and consequently given the order. At $t = 2$, on receipt of the order the good is delivered and the amount B in foreign currency is handed

⁴ See also Breuer and Gürtler 2001b.

over in return. The production costs calculated in domestic currency will also be incurred at $t = 2$ and be denoted C .

In such a situation at $t = 0$, the entrepreneur is confronted by two different risks. First, it is not clear whether he will be awarded the contract. Second the spot rate \tilde{e}_2 governing the possible exchange of the amount in foreign currency B he may receive at $t = 2$ is uncertain. With $\tilde{\gamma}$ as a Bernoulli-distributed random variable having at time t the value 1 on receipt of the order and otherwise the value 0, overall entrepreneurial payoffs in domestic currency at $t = 2$ will amount to $M_2^{(\text{tot},\text{€})} = \tilde{\gamma} \cdot (B \cdot \tilde{e}_2 - C)$. Accordingly, uncertain payoffs in \$ can be expressed as $M_2^{(\text{tot},\$)} = \tilde{\gamma} \cdot (B - C / \tilde{e}_2)$. With given prices for the €- and the \$-bundle, we knew from the preceding sections that the maximum entrepreneurial utility level as seen from $t = 0$ can be written as

$$(6) \tilde{U}^* = (\tilde{M}_2^{(\text{tot},\text{€})})^a \cdot (\tilde{M}_2^{(\text{tot},\$)})^b.$$

This formula in general even holds true if we allow for forward transactions by the entrepreneur at time $t = 0$. To be precise, $s_\tau^{(1)}$ represents the amount of foreign exchange sold forward at time $t = \tau$ with maturity at $t = 2$ at a current forward rate $e_{\tau,2}^{(f)}$. Moreover, $s_\tau^{(2)}$ describes the number of usual currency put options for \$ 1 each, purchased at $t = \tau$ for an option premium in € of $v_\tau^{(P)}$ with a strike price of $e_{\tau,2}^{(f)}$ and maturity at $t = 2$, so that we have

$\tilde{v}_2^{(P)} = \max(\tilde{e}_{\tau,2}^{(f)} - \tilde{e}_2, 0)$. Allowing for such risk management transactions the resulting entrepreneurial total payoff in € or \$, respectively, at time $t = 2$ as seen from $t = 0$ can be written as (with index ‘‘R’’ for ‘‘Risk Management’’):

$$(7) \tilde{M}_2^{(\text{tot},\text{R},\text{€})} = \tilde{\gamma} \cdot (B \cdot \tilde{e}_2 - C) + s_0^{(1)} \cdot (e_{0,2}^{(f)} - \tilde{e}_2) + \tilde{s}_1^{(1)} \cdot (\tilde{e}_{1,2}^{(f)} - \tilde{e}_2) + s_0^{(2)} \cdot (v_0^{(P,\text{€})} \cdot (1 + r_{0,1}^{(\text{€})}) \cdot (1 + r_{1,2}^{(\text{€})}) - \tilde{v}_2^{(P,\text{€})}) + \tilde{s}_1^{(2)} \cdot (\tilde{v}_1^{(P,\text{€})} \cdot (1 + r_{1,2}^{(\text{€})}) - \tilde{v}_2^{(P,\text{€})}),$$

It should be noted

$$\tilde{M}_2^{(\text{tot},\text{R},\$)} = \tilde{\gamma} \cdot (B - C / \tilde{e}_2) + s_0^{(1)} \cdot (e_{0,2}^{(f)} / \tilde{e}_2 - 1) + \tilde{s}_1^{(1)} \cdot (\tilde{e}_{1,2}^{(f)} / \tilde{e}_2 - 1) + s_0^{(2)} \cdot ((v_0^{(P,\text{€})} / \tilde{e}_2) \cdot (1 + r_{0,1}^{(\text{€})}) \cdot (1 + r_{1,2}^{(\text{€})}) - \tilde{v}_2^{(P,\text{€})}) + \tilde{s}_1^{(2)} \cdot ((\tilde{v}_1^{(P,\text{€})} / \tilde{e}_2) \cdot (1 + r_{1,2}^{(\text{€})}) - \tilde{v}_2^{(P,\text{€})}).$$

with respect to (7) that risk management transactions at time $t = 1$ can be conditioned upon the then prevailing state of nature and thus must be regarded as random variables as seen from $t = 0$. Moreover, $r_{\tau,T}^{(\text{€})}$ stands for the (forward) interest rate for lending/borrowing in € from $t = \tau$ to $t = T$.

4.2 Capital Market Data

In order to determine numerically ‘‘reasonable’’ engagements in forwards and options depending on the outcome $\tilde{\gamma}$ of the tender it is necessary to specify several variables in some more detail. First of all, we assume $\tilde{\gamma}$ to be stochastically independent of all future prices on the foreign exchange markets. Because all bids are denominated in \$, there is no reason why the tender outcome should be dependent on the situation on the foreign currency market. Moreover, the period of time between offer submission and award ($t = 0$ to $t = 1$) will be three months, but the period of time between award and delivery as well as payment ($t = 1$ to $t = 2$) will be 21 months, that is, seven quarters.

For the sake of simplification, a flat interest yield curve is assumed to exist in (perfect) domestic and international capital markets. The corresponding 3-month interest rates in Germany and the United States for risk-free lending and borrowing are fixed at 0.4963 % as the € interest rate $r_{0,1}^{(\text{€})}$ and 0.2491 % as the \$ interest rate $r_{0,1}^{(\$)}$ on the basis of the respective fund rates of the European Central Bank and the Federal Reserve Bank of the United States (as of

June 2003). The exchange rate e_0 between € and \$ at $t = 0$ is based on data of June 2003 as well and is quantified as € 0.8696/\$. Moreover, we assume that capital and foreign exchange market valuation is risk-neutral. Because of this, there are no possibilities to increase expected payoffs in € by way of engagements in forwards or options, i.e. these instruments cannot be used to speculate in € but only for pure hedging purpose. This assumption enables us to draw some parallels to the results in Breuer and Gürtler 2001a.⁵

A logarithmic normal distribution is adopted for the future spot exchange rates. This probability distribution is not only useful in a number of ways, it also forms the basis for the evaluation of currency put options by way of the Garman and Kohlhagen 1983 formula. The application of this formula is permissible because of the assumed exclusion of speculation alone, even if a continuous trade in securities is not possible. This is because the impossibility of realizing expected returns from transactions in foreign exchange markets directly implies a risk-neutral market evaluation. The random variable $\tilde{v}_1^{(P,€)}$ can thus be traced back to the spot rate \tilde{e}_1 prevailing at $t = 1$.

On the basis of the assumed perfect capital and foreign exchange markets, the theory of covered interest rate parity is applicable at each point in time. For this reason and also because of the flat interest rate structure, the forward rate $\tilde{e}_{1,2}^{(f)}$ can thus also be expressed as a function of \tilde{e}_1 as well as of the interest rates $r_{1,2}^{(€)}$ and $r_{1,2}^{(S)}$ from $t = 1$ to $t = 2$ in Germany and the United States, respectively:

$$(8) \quad \tilde{e}_{1,2}^{(f)} = \tilde{e}_1 \cdot \frac{1 + r_{1,2}^{(€)}}{1 + r_{1,2}^{(S)}} = \tilde{e}_1 \cdot \left(\frac{1 + r_{0,1}^{(€)}}{1 + r_{0,1}^{(S)}} \right)^7 \approx 1.01739 \cdot \tilde{e}_1.$$

As a result of the assumed impossibility of speculation by way of currency forwards, not only the covered but also the uncovered interest rate parity is valid in each point in time. The spot rate expected for $t = 1$ can, therefore, be determined as follows:

$$(9) \quad E(\tilde{e}_1) = e_0 \cdot \frac{1 + r_{0,1}^{(€)}}{1 + r_{0,1}^{(S)}} = 0.8696 \cdot \frac{1.004963}{1.002491} \approx €0.87174/\$.$$

To describe the probability distribution of \tilde{e}_1 , the volatility of future exchange rates finally needs to be specified. This volatility denotes the standard deviation σ of the one-periodic logarithmic exchange rate with normal distribution. We follow Breuer and Gürtler 2001a by assuming for a 3-month-period a volatility of approximately 4.53 % which was obtained by the analysis of historical data as well as by the calculation of implied volatilities for currency options. In the same way, the conditional probability distribution of \tilde{e}_2 can be specified by $E(\tilde{e}_2 | e_{1,2}^{(f)}) = e_{1,2}^{(f)}$ (with a conditional volatility of about $\sqrt{7} \cdot 0.0453 \approx 11.99\%$.) because of our assumption that there are no opportunities to speculate with respect to expected payoffs in €.

4.3 Entrepreneurial data

Moreover and again similarly to Breuer and Gürtler 2001a the value € 125,000,000 production costs C at $t = 2$ is arbitrarily chosen. To determine suitable and fairly plausible values for bid B , the insecure sales return of the German entrepreneur in the case of his being awarded the contract is chosen as a starting point:

$$(10) \quad \frac{B \cdot \tilde{e}_2 - C}{B \cdot \tilde{e}_2} = 1 - \frac{C}{B \cdot \tilde{e}_2}.$$

Its expectation value is

⁵ It should be noted that because of the Siegel paradox there will be opportunities to speculate in \$ even if speculation in € is not possible. See Siegel 1972, 1975.

$$(11) \overline{SR} := 1 - \frac{C}{B} \cdot E\left(\frac{1}{\tilde{e}_2}\right).$$

Three different values will be introduced for \overline{SR} : 5, 15, and 25 %. The corresponding individual offers are \$ 149,590,000, \$ 167,190,000, and € 189,480,000. As argued in Breuer and Gürtler 2001a it can be assumed that sales returns for individual orders will hardly move outside this scale. On the contrary, 25 % would more likely represent an extremely high value for the expected sales return under discussion.

Second, it is necessary to define probabilities p to be considered for winning the contract as seen from $t = 0$. We allow for different scenarios by assuming p to be either very small ($p = 0.2$), achieve a medium level ($p = 0.5$) or be very great ($p = 0.8$).

Finally, the entrepreneur's consumption preferences as well as his monetary endowment need to be specified. To do so, let us temporarily consider an individual whose utility u can be solely described as a function of his terminal monetary endowment in € at time T . As is known from decision theory, constant relative risk aversion

$\kappa := -(M_T^{(tot,€)}) \cdot (u''(M_T^{(tot,€)}) / u'(M_T^{(tot,€)})) > 1$ for such an individual is implied by

$$(12) u(M_T^{(tot,€)}) = -(M_T^{(tot,€)})^{1-\kappa}.$$

With this in mind, in the simple numerical example of section 3. the cases $b = 0$ for given sum $a+b$ apparently correspond with an individual exhibiting constant relative risk aversion of 0 (risk-neutral behavior) to 0.9. Constant relative risk aversion means that an individual wants to invest a constant fraction of his monetary wealth in risky assets even if his initial monetary endowment is changed in an arbitrary way.⁶ Indeed, the assumption of constant relative risk aversion fits quite well empirical findings, though they rather imply constant relative risk aversion in the range of 1 to 2. For our "tender problem" we therefore assume $a+b = -0.5$ and thus $\kappa = 1.5$.⁷ In addition, because of the assumption $a+b < 0$ (6) has to be multiplied with -1 in order to get a strictly concave utility function (see also (12)).

Unfortunately, the domain of power utility functions is generally restricted to positive values. Therefore we must define lower bounds $\underline{M}^{(€)}$ and $\underline{M}^{(\$)}$ below which the part $(\tilde{M}_2^{(tot,R,€)})^a$ or $(\tilde{M}_2^{(tot,R,\$)})^b$ of the power utility function is replaced by another, for example a negative exponential utility function exhibiting constant absolute risk aversion regarding future payoffs in € or \$, respectively. Constant absolute risk aversion means that an individual wants to invest a constant absolute amount in risky assets even if his initial monetary endowment is changed in an arbitrary way.⁸ At least for moderate variations of individuals' endowments, constant absolute risk aversion may be rather a good approximation of true human preferences as well. Moreover, the corresponding negative exponential utility function possesses the advantage of being defined over all real numbers.

Since we have in general $\tilde{M}_2^{(tot,R,\$)} = \tilde{M}_2^{(tot,R,€)} / \tilde{e}_2$ and thus $\tilde{U}^* = (\tilde{M}_2^{(tot,R,€)})^{a+b} / \tilde{e}_2^b$, with $\tilde{e}_2 \geq 0$, in fact it suffices to introduce a lower bound $\underline{M}^{(€)}$. The transition from the first part of the compound utility function to the second one should be designed in such a way as to assure continuous differentiability for all values $\tilde{M}_2^{(tot,R,€)} \in \Re$. Analogously to Breuer and Gürtler 2001a this leads to

⁶ See for example Cochrane 2001.

⁷ Our findings of sections 1. and 3. are underpinned by the examination of situations $a+b = -0.5$ and $a+b = -1$. When varying a and b from -0.5 to 0 or from -1 to 0 , respectively, for given sum $a+b$, we get optimal hedge ratios λ^* reaching from 0.26 to 0.59 or from 0.19 to 0.69 thereby monotone increasing in b and spreading more for higher (constant) absolute value of $a+b$. The critical values analogous to those of Table 1.1 amount to 66.67 % for $a+b = -0.5$ and to 54.55 % for $a+b = -1$ verifying our results of sections 1. and 3. as well.

⁸ See once again Cochrane 2001.

$$(13) U(\tilde{M}_2^{(tot,R,\epsilon)}, \tilde{\epsilon}_2) = \begin{cases} -(\tilde{M}_2^{(tot,R,\epsilon)})^{a+b} / \tilde{\epsilon}_2^b & \tilde{M}_2^{(tot,\epsilon)} \geq \underline{M}^{(\epsilon)}, \\ \frac{(\underline{M}^{(\epsilon)})^{a+b}}{(1-(a+b)) \cdot \tilde{\epsilon}_2^b} \cdot \left[1 - (a+b) \cdot \exp(1-(a+b)) \cdot \exp\left((a+b-1) \cdot \frac{\tilde{M}_2^{(tot,R,\epsilon)}}{\underline{M}^{(\epsilon)}} \right) \right] & \text{otherwise.} \end{cases}$$

Finally, we need some kind of “fine-tuning” of entrepreneurial risk aversion. For this purpose we apply the concept of certainty equivalents. In general, the extent of an individual’s risk aversion can be described as the amount by which the certainty equivalent of an uncertain cash flow lies below the respective expectation value. Unfortunately, even in a situation without any engagement in forwards or options the entrepreneurial utility according to (6) depends on two random variables, $\tilde{\gamma}$ and $\tilde{\epsilon}_2$. Certainty equivalents can only be determined in the case of just one source of risk. We thus have to work with “conditional” certainty equivalents or abstract from one uncertainty source. We have chosen the second possible solution by temporarily assuming that the future spot rate at time $t = 2$ equals the forward exchange rate $e_{0,2}^{(f)}$ with certainty. Under this condition the entrepreneur just behaves like any other individual who is only nominally oriented, i.e. who looks at his future payoffs in € (or \$).

With this in mind, we allow for additional riskless earnings $c_2^{(\epsilon)}$ in € at time $t = 2$. We specify this additional cash flow $c_2^{(\epsilon)}$ in such a way as to assure that in a situation without any engagement in forwards or options, relative risk discounts RRD of 10, 30, 50, 70 and 90 % are levied upon the expectation value of the total € payoff from the tender participation to derive the matching certainty equivalent. For our given data this leads to values for $c_2^{(\epsilon)}$ as presented in Table 4.1.

Table 4.1. Additional certain cash flows $c_2^{(\epsilon)}$ for fine-tuning entrepreneurial risk aversion

relative risk discount	0.1	0.3	0.5	0.7	0.9
$c_2^{(\epsilon)}$	28,998,915	10,467,367	5,056,938	2,306,408	615,311

For each relative risk discount the variable $c_2^{(\epsilon)}$ characterizes that additional certain payoff in € which implies the relative risk discount under consideration in a situation without any exchange rate risk but risk of losing the contract.

Moreover, we use the results for $c_2^{(\epsilon)}$ as critical values $\underline{M}^{(\epsilon)}$ according to the definition of U in (13).

4.4 Risk management situations

The entrepreneur’s task now would be to determine optimal engagements in foreign exchange forward sales and purchases of currency put options at time $t = 0$ as well as time $t = 1$. Unfortunately, this complex problem is still too difficult to be handled in this paper on a large scale. We therefore restrict ourselves to the analysis of some special cases.

4.4.1 Active risk management only at $t = 1$

4.4.1.1 Assumptions

First of all, we assume that the entrepreneur refrains from any engagement on foreign exchange markets at time $t = 0$ and is just wondering how to choose the optimal \$ amount $s_1^{(1)*}$ sold forward at time $t = 1$ as a function of the current spot rate e_1 and the outcome γ of the tender. We consider all values $a, b \in \{-0.5, -0.4, -0.3, -0.2, -0.1, 0\}$ with $a+b = -0.5$ and assume the current spot exchange rate at time $t = 1$ to be equal to its expectation value as seen from $t = 0$ according to equation (9). Moreover, we focus on a situation with $\gamma = 1$, i.e. the German entrepreneur has been awarded the contract. Summarizing, we solve the following decision problem:

$$(14) E[U(\tilde{M}_2^{(tot,R,\epsilon)}, \tilde{\epsilon}_2)] \\ = E[U((B - s_1^{(1)}) \cdot \tilde{\epsilon}_2 + s_1^{(1)} \cdot e_{1,2}^{(f)} - C + c_2^{(\epsilon)}, \tilde{\epsilon}_2)] \\ \rightarrow \max_{s_1^{(1)}} .!$$

Obviously, this setting parallels that of the Onassis problem described in sections 1. and 3. As a consequence of our assumptions we can be sure that the entrepreneur will decide to realize the full-hedge alternative for $b = 0$. For expected return sales of 5 %, 15 %, and 25 %, as determined by (11) we compute optimal hedge ratios $\lambda^* := s_1^{(1)*} / B$.

4.4.1.2 Results

As already mentioned, though expected payoffs in € at $t = 2$ cannot be manipulated at $t = 1$ because of $E(\tilde{\epsilon}_2 | e_{1,2}^{(f)}) = e_{1,2}^{(f)} \approx \text{€}0.8869/\text{\$}$, there are possibilities to speculate with respect to the entrepreneurial expected payoffs in \$ since $E(1/\tilde{\epsilon}_2 | e_{1,2}^{(f)}) \approx \text{\$}1.13686/\text{€} > 1/e_{1,2}^{(f)} \approx \text{\$}1.12756/\text{€}$. To do so, it is necessary to buy forward €, i.e. to sell forward \$.

Obviously, a hedge ratio $\lambda = 1$ implies certain € payoffs at time $t = 2$ for the entrepreneur. Certain \$ payoffs require to buy forward € 125,000,000 production costs, that is to sell forward approximately $125,000,000/0.8869 = \text{\$}140,940,354$. Depending on bid B and thus expected sales returns \overline{SR} this leads to hedge ratios λ of about 0.94, 0.84, or 0.74 for $\overline{SR} = 0.05, 0.15, \text{ or } 0.25$, respectively, while speculating in \$ requires higher hedge ratios. Indeed, incentives to speculate with respect to his \$ payoffs as well as the pure hedging incentive regarding his € payoffs generally induce the entrepreneur to choose optimal hedge ratios between these lower bounds just computed and unity, as Table 4.2 reveals. Thereby, these intervals are increasing in expected sales returns and the higher b and the lower a , the greater will be in general the optimal value of hedge ratio λ (though we certainly have $\lambda^* = 1$ for $b = 0$). Moreover, the influence of RRD seems to be of only minor importance for the optimal entrepreneurial risk management strategy, while the distribution of the sum $a+b$ between exponents a and b plays even a more central role than \overline{SR} underlining the relevance of consumption-based risk management.

Table 4.2. Optimal hedge ratios λ^* for different scenarios in the tender example (optimization at time $t = 1$)

SR = 5 %					
RRD	0.1	0.3	0.5	0.7	0.9
λ^*	[0.94, 1.00]	[0.96, 1.00]	[0.96, 1.00]	[0.96, 1.00]	[0.96, 1.00]
SR = 15 %					
RRD	0.1	0.3	0.5	0.7	0.9
λ^*	[0.83, 1.00]	[0.87, 1.00]	[0.89, 1.00]	[0.89, 1.00]	[0.90, 1.00]
SR = 25 %					
RRD	0.1	0.3	0.5	0.7	0.9
λ^*	[0.72, 1.00]	[0.79, 1.00]	[0.81, 1.00]	[0.82, 1.00]	[0.83, 1.00]

For given sum $a+b = -0.5$ the interval of optimal hedge ratios λ^* in the tender example as a consequence of differing values for $a, b \in \{0, -0.1, -0.2, -0.3, -0.4, -0.5\}$ is reported as a function of expected sales returns $SR \in \{0.05, 0.15, 0.25\}$ and relative risk discounts $RRD \in \{0.1, 0.3, 0.5, 0.7, 0.9\}$.

In general the results of Table 4.2 correspond fairly well with the ones of sections 1. and 3. for Onassis's decision problem and are apt to extend them.

4.4.2 Active risk management only at $t = 0$

4.4.2.1 Assumptions

The entrepreneur's decision problem as seen from point in time $t = 0$ certainly seems to be even more interesting than the previous one. This problem can optimally be solved only for given future entrepreneurial behavior at $t = 1$. At least to our best knowledge, up to now such a problem has only been analyzed for nominally oriented entrepreneurs.⁹ We speak of the "€-nominal case" in situations with a German entrepreneur who is only looking at his total earnings in € until time $t = 2$ and we call a situation the "\$-nominal case" when the entrepreneur is only interested in his revenues denominated in \$.

In particular, for the €-nominal case there are two simple heuristics described in the literature of foreign exchange risk management as reasonable engagements in forward transactions and currency options. First of all, some authors recommend the entrepreneur to purchase currency options for an amount in \$ of B instead of using forward transactions because of the uncertainty regarding the outcome of the tender.¹⁰ There is no special recommendation for the entrepreneur's best behavior at time $t = 1$ after learning the realization of γ . In fact, a perfect hedge is possible at time $t = 1$ by selling all previously bought currency options and engaging in currency forward sales to a \$ amount of $\gamma \cdot B$. Because of our assumption of the impossibility of speculation when calculating in €, such a perfect hedge is best for any nominally oriented German entrepreneur with concave utility function. We thus call the strategy which consists of the purchase of currency options for an amount in \$ of B at time $t = 0$ and realizing a perfect hedge at time $t = 1$ as a "nominal options hedge".

Another strand of literature points out that minimization of the variance of the entrepreneur's payoffs in € at time $t = 2$ is achieved by selling forward expected \$ earnings $p \cdot B$ at $t = 0$ and expanding this forward position to B at $t = 1$ for $\gamma = 1$ or buying forward the \$ amount of $p \cdot B$ in the case of $\gamma = 0$. We call this strategy the "nominal forward hedge".¹¹ As a third possibility the entrepreneur could refrain from any active risk management operations at all at time $t = 0$ and only realize a perfect hedge at time $t = 1$ ("nominal no-hedge alternative"). These three

⁹ Besides Breuer and Gürtler 2001a, 2001b, see for example Steil 1994, Breuer 1997, Pfennig 1998, and Schlottman 1999.

¹⁰ See e.g. Giddy 1994.

¹¹ See e.g. Breuer and Gürtler 2001a. Because of our assumptions this strategy actually is optimal in the €-nominal case with quadratic entrepreneurial utility.

basis strategies may be used as possible heuristics for the rather complex (“nominal”) decision problem under consideration. As was shown in Breuer and Gurtler 2001a, it is possible to apply these three basis strategies depending on expected sales returns \overline{SR} , success probability p , relative risk discount RRD and exchange rate volatility in such a way that in many cases satisfying approximations of the “true” expected utility optimum can be achieved. Things may look quite different for consumption preferences as described by a utility function as in equation (6). From now on, a situation with entrepreneurial preferences according to (6) (multiplied with -1 if $a+b < 0$) is called the “real case”.

Without any further engagement on the foreign exchange markets and for given decisions $s_0^{(1)}$ and $s_0^{(2)}$ at time $t = 0$ as seen from $t = 1$ there are revenues in \$ at time $t = 2$ amounting to $\gamma \cdot B - s_0^{(1)}$ and cash flows in € summing up to a total of $c_2^{(\epsilon)} - C + s_0^{(1)} \cdot e_{0,2}^{(f)} + s_0^{(2)} \cdot (\tilde{v}_2^{(P,\epsilon)} - v_0^{(P,\epsilon)} \cdot (1 + r_{0,1}^{(\epsilon)}) \cdot (1 + r_{1,2}^{(\epsilon)}))$. We call the first expression the “original \$ cash flow” and the second one the “original € cash flow”.

Since we know that in the real case the entrepreneur will spend only the fraction $\alpha = a/(a+b)$ for the €-bundle and the rest for the consumption of the \$-bundle, the entrepreneur can achieve certain consumption positions at time $t = 2$ as seen from $t = 1$, if he performs the following transactions:

- (a) Selling all currency options previously bought at time $t = 0$ at a price $v_1^{(P,\epsilon)}$ so that the original € cash flow turns out to be a certain value $c_2^{(\epsilon)} - C + s_0^{(1)} \cdot e_{0,2}^{(f)} + s_0^{(2)} \cdot (v_1^{(P,\epsilon)} \cdot (1 + r_{1,2}^{(\epsilon)}) - v_0^{(P,\epsilon)} \cdot (1 + r_{0,1}^{(\epsilon)}) \cdot (1 + r_{1,2}^{(\epsilon)}))$,
- (b) selling forward the \$ amount $(1 - \alpha) \cdot (\gamma \cdot B - s_0^{(1)})$ against € at a forward exchange rate of $e_{1,2}^{(f)}$, and
- (c) selling forward the fraction $1 - \alpha$ of the original € cash flow after being transformed according to (a) against \$ at a forward exchange rate of $1/e_{1,2}^{(f)}$.

Summarizing, as a consequence of transactions (a) to (c) the entrepreneur possesses a certain € income $M_2^{(R,\epsilon)}$ and a certain \$ income $M_2^{(R,S)}$ at time $t = 2$ with

$$(15) \quad M_2^{(R,\epsilon)} = \alpha \cdot (\gamma \cdot B - s_0^{(1)}) \cdot e_{1,2}^{(f)} + \alpha \cdot (c_2^{(\epsilon)} - C + s_0^{(1)} \cdot e_{0,2}^{(f)} + s_0^{(2)} \cdot (v_1^{(P,\epsilon)} \cdot (1 + r_{1,2}^{(\epsilon)}) - v_0^{(P,\epsilon)} \cdot (1 + r_{0,1}^{(\epsilon)}) \cdot (1 + r_{1,2}^{(\epsilon)}))),$$

$$M_2^{(R,S)} = (1 - \alpha) \cdot (\gamma \cdot B - s_0^{(1)}) + (1 - \alpha) \cdot (c_2^{(\epsilon)} - C + s_0^{(1)} \cdot e_{1,2}^{(f)} + s_0^{(2)} \cdot (v_1^{(P,\epsilon)} \cdot (1 + r_{1,2}^{(\epsilon)}) - v_0^{(P,\epsilon)} \cdot (1 + r_{0,1}^{(\epsilon)}) \cdot (1 + r_{1,2}^{(\epsilon)}))) / e_{1,2}^{(f)},$$

so that we have $M_2^{(R,\epsilon)} = \alpha \cdot (M_2^{(R,\epsilon)} + M_2^{(R,S)} \cdot e_{1,2}^{(f)})$ and correspondingly $M_2^{(R,S)}$

$= (1 - \alpha) \cdot (M_2^{(R,\epsilon)} / e_{1,2}^{(f)} + M_2^{(R,S)})$ which describes the optimal division of total monetary payoffs in € and \$, if consumption has to be specified at time $t = 1$. As opposed to the € nominal perfect hedge described above, we call such a behavior at time $t = 1$ a “real” perfect hedge because consumption at time $t = 2$ is already fixed at $t = 1$. Moreover, this “real” perfect hedge is an immediate extension of the nominal perfect hedges, because for $\alpha = 1$ it becomes an € nominal perfect hedge and for $\alpha = 0$ we arrive at a \$ nominal perfect hedge.

With this in mind, we are allowed to calculate entrepreneurial overall € revenues and \$ revenues, respectively, at time 2 as

$$(16) \quad M_2^{(\text{tot},R,\epsilon)} = M_2^{(R,\epsilon)} + M_2^{(R,S)} \cdot e_{1,2}^{(f)},$$

$$M_2^{(\text{tot},R,S)} = M_2^{(R,\epsilon)} / e_{1,2}^{(f)} + M_2^{(R,S)}.$$

Because of (16) the entrepreneurial utility can be written as a function of solely $M_2^{(\text{tot},R,\epsilon)}$ and $\tilde{e}_{1,2}^{(f)}$ so that for this special setting under consideration the utility function U according to (13)

applies with the future spot rate \tilde{e}_2 replaced by the future forward rate $\tilde{e}_{1,2}^{(f)}$. Certainly, $M_2^{(\text{tot},R,\epsilon)}$ is a function of risk management operations $s_0^{(1)}$ and $s_0^{(2)}$ at time $t = 2$. Entrepreneurial utility as seen from $t = 0$ thus becomes

$$(17) \quad \tilde{U} = U(\tilde{M}_2^{(\text{tot},R,\epsilon)}(s_0^{(1)}, s_0^{(2)}), \tilde{e}_{1,2}^{(f)}).$$

With this background we are now able to introduce three more possible heuristics if we replace the € nominal perfect hedge as part of our first three basis strategies by a real perfect hedge. We call these additional risk management strategies the “real” options hedge, the “real” forward hedge and the “real no-hedge alternative”.

Summing up, we define six basis strategies. Because of computational restrictions (nominal basis strategies simultaneously involve uncertain future spot and forward rates, while the consequences of real basis strategies do not depend on the future spot rate at time $t = 2$) we only analyze the ability of the “real” ones to reach high expected utility levels for the entrepreneur. As a reference we additionally compute numerically the optimal entrepreneurial risk management strategies at time $t = 0$ when a “real” perfect hedge is performed at time $t = 1$ and determine which percentage of this certainty equivalent can be realized by our three real basis strategies. We call these percentages “index values”. Certainly, our reference just defined does not describe the overall optimal behavior because the real perfect hedge is not optimal at all. As a consequence of the so-called Siegel paradox¹² there are always possibilities to speculate with respect either to entrepreneurial expected € payoffs or \$ payoffs. Only in the case of infinite risk aversion a German entrepreneur would prefer the real perfect hedge at time $t = 1$.¹³ Unfortunately, a lack of computing capacity and existing time constraints prevents us from endogenizing simultaneously the entrepreneurial behavior at time $t = 0$ and time $t = 1$. However, our results seem to be of interest even for the reference just described. In particular, the relative ranking of the three real basis strategies is not affected by the selection of a rather “constrained” optimal reference, only demonstrated index values for these three strategies may be even smaller when computed on the basis of the “true” optimal sequential risk management strategy.

4.4.2.2 Results

At first glance, somewhat surprisingly, in particular in the light of the outcomes of section 4.4.1 a variation of a and b for given sum $a+b = -0.5$ hardly affects resulting index values for our three real basis strategies. Certainly, this is a consequence of our real perfect hedge at time $t = 1$ by which values of a and b are explicitly considered. We therefore can now restrict ourselves to the analysis of a setting like, say, $a = -0.2$ and $b = -0.3$. Results for this case are presented in Table 4.3. Figures in this table show the highest attainable index values by one of the three real basis strategies. The shading of each cell of the table indicates which basis strategy turns out to be best for the corresponding special setting. For example, in the case of a relative risk discount $\text{RRD} = 70\%$, probability $p = 0.2$ and an expected sales return $\overline{\text{SR}} = 5\%$ the “real” forward hedge leads to a certainty equivalent which amounts to approximately 72.54 % of the certainty equivalent when optimizing hedging behavior at time $t = 0$ but still is greater than corresponding index values for the real no-hedge alternative and the real options hedge.

¹² See already footnote 5.

¹³ There are two other minor objections. First, since the entrepreneur’s utility function is modified according to (13) results from sections 1. to 3. cannot be applied without (moderate) warning. Second, a real perfect hedge requires that the entrepreneur is indeed able to buy goods forward at time $t = 1$ for maturity $t = 2$. Since we assume certain future prices of the €- and the \$-bundle this problem seems to be of only little importance, too.

Table 4.3. Maximum index values and best “real” heuristics for different scenarios in the tender example (optimization at time $t = 0$)

	real no hedge	real forward	real option		
$\overline{SR} = 5\%$	0.9765	0.9570	0.8175	0.7254	0.7774
$\overline{SR} = 15\%$	0.9483	0.9502	0.9659	0.9812	0.9728
$\overline{SR} = 25\%$	0.9467	0.9461	0.9477	0.9665	1.0000
$p = 0.2$	RRD=0.1	0.3	0.5	0.7	0.9
$\overline{SR} = 5\%$	0.9739	0.9308	0.8025	0.7903	0.8071
$\overline{SR} = 15\%$	0.9574	0.9560	0.9537	0.9718	0.9600
$\overline{SR} = 25\%$	0.9540	0.9529	0.9471	0.9538	1.0000
$p = 0.5$	RRD=0.1	0.3	0.5	0.7	0.9
$\overline{SR} = 5\%$	0.9862	0.6521	0.4856	0.3215	0.1985
$\overline{SR} = 15\%$	0.9703	0.9621	0.9712	0.9565	0.8669
$\overline{SR} = 25\%$	0.9664	0.9602	0.9521	0.9552	1.0000
$p = 0.8$	RRD=0.1	0.3	0.5	0.7	0.9

For given parameters $a = -0.2$ and $b = -0.3$ maximum attainable index values (percentages of “optimal” certainty equivalents by the three real basis strategies indicated above are presented for different parameter constellations. The shading of a cell reveals the best real basis strategy for the corresponding setting.

Our “real” analysis shows some parallels to the purely “nominal” analysis by Breuer and Gürtler 2001a. Firstly, index values of our best basis strategies are (on the whole) decreasing for ceteris paribus higher relative risk discounts. Secondly, the real no-hedge alternative generally performs quite well and becomes more interesting for higher expected sales returns. Thirdly, maximum index values are generally increasing for higher expected sales returns. Opposed to Breuer and Gürtler 2001, the real forward hedge and the real options hedge can outperform the real no-hedge alternative only for high relative risk discounts.

Since index values would be even smaller when applying a better reference, there are some reservations about the application of our basis strategies in particular in the case of low expected sales returns and high relative risk discounts, while for medium-level and higher expected sales returns the (real) no-hedge alternative seems to perform at least sufficiently.

These findings match quite well the results of Breuer and Gürtler 2001a.

There is no doubt that this analysis is somewhat preliminary. Further research seems necessary to address the problems of simultaneous optimization at time $t = 0$ and time $t = 1$ as well as the determination of the adequacy of the nominal three basis strategies in presence of “real” preferences for consumption of goods with original prices in different currencies.

5 Conclusion

Typically, risk management strategies are nominally oriented in the sense that the entrepreneurs or investors under consideration are only interested in earnings denominated in just one currency. This assumption implies consumption only of goods with exogenously fixed prices in just that currency. Apparently, in many cases individuals will be interested in the consumption of goods from various countries and thus prices given in several different currencies. This thought gives rise to the analysis of “real” risk management instead of “nominal” risk management. We show the consequences of such consumption preferences for optimal risk management strategies by analyzing, among other things, numerically the decision problem of a

German entrepreneur participating in an international invitation for tenders. Indeed, the structure of an individual's consumption behavior may significantly affect his optimal risk management operations in particular in the case of low risk aversion.

While there seems to be a need for "real" risk management as defined in this article, it should not be overlooked that there is another important decision problem which was mentioned at the beginning of this article but in fact slightly deviates from the ones examined above. It is that of a multinational corporation with national investors from different countries all consuming only domestic goods with given domestic prices. Such a problem differs to some extent from the ones described above as long as it is not possible to represent all investors of a firm by just one representative agent with differentiated consumption preferences. It should be interesting to compare a situation with many heterogeneous investors from different countries all nominally oriented in their domestic currency with a set of homogeneous investors with identical consumption preferences simultaneously aiming at goods from different countries.

References

- Breuer W (1997) Hedging von Wechselkursrisiken bei internationalen Ausschreibungen. *Zeitschrift für Betriebswirtschaft* 71: 1065–1089
- Breuer W (2000) *Unternehmerisches Währungsmanagement: Theoretische Grundlagen und praktische Anwendungen*, 2nd edn. Gabler, Wiesbaden
- Breuer W (2001a) Konsumorientiertes Währungsmanagement. *WiSt - Wirtschaftswissenschaftliches Studium* 30: 122–126
- Breuer W (2001b) Konsumorientiertes Währungsmanagement bei der International AG. *WiSt - Wirtschaftswissenschaftliches Studium* 30: 178–180
- Breuer W, Gürtler M (2001a) Hedging von Wechselkursrisiken bei internationalen Ausschreibungen. Eine numerische Analyse. *Zeitschrift für Betriebswirtschaft* 71: 1065–1089
- Breuer W, Gürtler M (2001b) Hedging in Incomplete Markets: An Approximation Procedure for Practical Application. *Journal of Futures Markets* 21: 599–631
- Cochrane JH (2001) *Asset Pricing*, Princeton
- Garman MB, Kohlhagen SW (1983) Foreign Currency Option Values. *Journal of International Money and Finance* 2: 231–237
- Giddy I (1994) *Global Financial Markets*, Heath and Company, Lexington
- Kouri PJK, Braga de Macedo J (1978) Exchange Rates and International Adjustment Process. *Brookings Papers on Economic Activity* 1: 111–150
- Pfennig M (1998) *Optimale Steuerung des Währungsrisikos mit derivativen Instrumenten*, Gabler, Wiesbaden
- Schlottman R (1999) Berücksichtigung von Wechselkursrisiken in der internationalen Preispolitik am Beispiel des Großanlagenbaus, Josef Eul, Lohmar
- Siegel JE (1972) Risk, Interest Rates and the Forward Exchange. *Quarterly Journal of Economics* 86: 303–309
- Siegel JE (1975) Reply: Risk, Interest Rates and the Forward Exchange. *Quarterly Journal of Economics* 89: 173–175
- Steil B (1993) Currency Options and Optimal Hedging of Contingent Foreign Exchange Exposure. *Economica* 60: 413–431
- Stützel W (1970) Die Relativität der Risikobeurteilung von Vermögensbeständen. In: Hax H (ed) *Entscheidungen bei unsicheren Erwartungen*, Westdeutscher Verlag, Opladen, pp. 9–26