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EXCHANGE RATE DYNAMICS IN MIXED-CURRENCY MEDICAL INSURANCE PLAN ENVIRONMENTS

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ABSTRACT

This paper examines the financial dynamics resulting from the currency exchange rate for medical insurance products that are denominated in a currency different from that in which covered medical expenses are incurred. Circumstances that can generate this type of coverage are described, and the basic assumptions of the model for analyzing the financial results are presented. A key assumption is that the morbidity of the block of business is precisely projected in the currency of the insured's country of residence, and the exchange rate between the currency of the medical expenses and that of the policies is the only component that varies. Several comments are presented about life insurance products in a mixed-currency setting, which are immunized to a much greater extent against exchange-rate swings.

Five distinct medical plan designs are defined, as well as five currency exchange rate patterns, which combine to produce a total of 25 scenarios of financial results for analysis. Four of the five plans cover medical expenses on a reasonable-and-customary-charge level basis, while the fifth is a scheduled, per-unit-of-benefit product. The first four plans are differentiated by the manner in which conversions are made between the two legal tenders for premium and for claim payments. Several key summary financial parameters for the model block of business are defined, and the variations in these quantities due to differences between actual and expected currency exchange rates are presented and interpreted. The four reasonable-and-customary-charge basis plan designs are compared to determine their relative stability in producing target financial results under different exchange rates. The conclusion is that the mixed-currency environment for medical plans introduces a significant additional risk element as well as potential administrative complications. The specific types of financial distortions that can result from the currency exchange rate influence and their relative severity vary substantially according to plan design.

I. INTRODUCTION

Any medical insurance plan that provides coverage regardless of the location of the medical services is subject to the possibility that some expenses will be incurred outside of the insureds' country of residence in a foreign currency. Usually these mixed-currency situations, in which the expenses are denominated in a medium different than that of the policy, are infrequent and are due to unexpected medical problems during business or vacation travel.

However, there are policies for which currency differences are more frequent; that is, a significant portion of the expenses covered under the policy are expected to be incurred in a currency other than that in which the policy is denominated. Several sources tend to generate policies of this type:

(1) An international company may wish to cover some or all of its employees in foreign countries under the identical health benefits program that is used for employees at the company's corporate headquarters.

(2) A company with employees in a number of countries may desire to supplement a relatively skimpy plan in each country's legal tender with a uniform medical plan in one common currency.

(3) The upper-income strata in a particular country may find it attractive to purchase an individual health policy that provides coverage in another country with a more advanced health care system. Such a policy may also cover expenses incurred in the insured's country of residence. Often a policy of this nature is denominated in the medium of exchange of the country with the technologically superior health care delivery system.

A typical example of this type of plan is a dollar-denominated individual health plan sold to the high-middle and upper economic classes in Latin America. The idea is to provide access to the advanced health care system in the U.S. and protection against catastrophic medical expenses that may be incurred in this country. In addition, the policy may reimburse medical expenses incurred in the country of residence for conditions that are not sufficiently serious to warrant a trip to the U.S. These polices appeal to the upper-income echelon who are able to afford the hard currency dollar premiums, plus additional related costs not covered by the policy, such as travel expenses to the U.S. to receive the treatment.

Insurance companies in recent years have tended to expand their geographical spheres of operation across international boundaries, thus increasing the availability of different forms of mixed-currency coverage.

The paper examines, via a simplified modeling technique in a controlled environment, the dynamics of several key policy parameters and their effect on financial results for mixed-currency medical plans. The model consists of a hypothetical block of business studied over a one-year period. Five policy designs are analyzed: four that cover medical expenses on a reasonable-and-customary-charge level basis and one that is a fully scheduled, per-unit-of-benefit product. These five plans are combined with five different assumptions for the progression of currency exchange rates throughout the year, producing a total of 25 distinct scenarios.

Although the model is constructed in the context of a dollar-denominated policy sold outside of the U.S., the same concepts apply to any mixed-currency plan, regardless of the specific countries and legal tenders. To illustrate the full impact of the dual currencies, all the covered medical expenses in the model are assumed to be in a medium of exchange different than the policy's premium and schedule of benefits. The same influences of the exchange rate described in the model are present, but to a lesser degree, for products in which a portion of the incurred expenses involve mixed currencies, with the balance of the expenses denominated in the same currency as the policy.

The starting point for the model is morbidity experience projected for a block of covered lives assuming a plan written directly in the currency of the country in which the insureds reside. The dynamics of writing several types of dollar-denominated plans that are intended to be equivalent, on an expected basis, are then analyzed. This process illustrates the potential effect of the currency exchange rate, the focus of this paper. The process does not imply that in practice the mixed-currency plan is necessarily based upon a rigorous review of expected morbidity experience in the native currency of the country, followed by the creation of an expected equivalent plan in dollars. In the real world such dollar plans might be defined and priced in a less disciplined manner by making relatively crude adjustments to a dollar plan design and rate level that would be appropriate for a U.S. location. To the extent that this actually occurs, the risk of uncertain morbidity results is quite substantial and is in addition to the influence of the currency exchange rate.

As shown in this paper, these mixed-currency products present significant additional risk elements and/or administrative complications, compared to a

straightforward single-currency environment. This answer is certainly not welcome news to actuaries who have been or will be involved with these types of medical plans as the international focus of their respective companies increases. Given the spotty record of health insurance financial results on an industry-wide basis over the last quarter-century, the standard loss ratio risk alone has been difficult to accurately project, control, and price for via the development of consistently adequate rate levels. The existence of an additional risk element in mixed-currency plans makes the attainment of desired financial results even more difficult.

To provide a contrast and a comparison for the results of the medical model, several observations are made in the next section about the operation of life insurance products in the mixed-currency environment.

II. LIFE INSURANCE PRODUCTS

Coverages denominated in a medium of exchange other than the legal tender of the insureds' country of residence are more common for life insurance than for medical plans.

Life products that are structured similarly to the medical plans analyzed in this paper—in the sense that the premiums and policy benefits are denominated in the same medium of exchange—are not subject to the same currency risks. These life products internally operate on a completely unitized basis independent of the legal tender in the insureds' country of residence. Premium rates are expressed per unit of policy benefit, and all payments generated by the life policies, such as premiums, death benefits, and surrender benefits, are in the same currency. Investments supporting the reserve liabilities of the life block of business are usually also denominated in the same medium of exchange. That the policy may be sold to persons living in a country with a different medium of exchange is essentially immaterial. It is the insured's responsibility to convert funds to the proper currency in which the policy is denominated to pay the premiums. From that point forward, the life policy functions in a manner identical to that of a product sold to persons living in the country on whose currency the policy is based.

However, there actually is an area of susceptibility for life plans in a mixed-currency environment. A large swing in the exchange rate between the two currencies can either make the life policy too expensive, at one extreme, or render the existing coverage level insufficient, at the other extreme, thereby affecting lapse rates and increasing the variability of the

financial results of the block of business. Nevertheless, this potential vulnerability appears to be relatively marginal and much less of a concern than the susceptibility of medical products to shifts in exchange rates. Furthermore, this possible problem for life plans is external, in the sense that all the internal policy values and relationships are not distorted by the currency exchange swing.

These comments do not apply to certain types of life insurance products with premiums and policy benefits denominated in different monetary units. For example, recently in both Mexico and Chile there has been interest in life coverages with local currency premiums in conjunction with benefits indexed to the U.S. dollar. There can be substantial exchange rate risk in these arrangements that would be a function of the specific structure of these products.

Finally, in the dual-currency mode that we are analyzing, it might be theorized, based upon the "unitized life plan" concept, that a fully scheduled medical product would essentially offer the same immunization against currency exchange rate swings as a life insurance product. This question is addressed in Section VIII, which contains model results for a hospital indemnity plan that provides a fixed reimbursement per day of hospital confinement on a per-unit-of-benefit basis.

III. UNDERLYING INCURRED MEDICAL EXPERIENCE IN LOCAL CURRENCY

Table 1 contains a projection of basic financial data for a block of medical policies that forms the hypothetical model in this analysis for the first four policy designs. Because the purpose of this study is to examine the impact of changes in currency exchange rates on financial results, morbidity is assumed to be accurately and precisely projected for medical services received in the insureds' country of residence. In other words, if the medical product were to be written directly in the country's currency, the Table 1 projected morbidity results would be exactly achieved for the portfolio. For convenience, that currency will be called "local currency" (LC).

In Table 1 the projected financial results assume a block of 1,000 lives covered for a calendar year under a reasonable-and-customary-expense basis medical plan, with a deductible of LC 100,000 per person per disability and 80% coinsurance. For simplicity, because variation in currency exchange rates and not morbidity is the focus, 25 claims are presumed to be incurred each month, each representing a new disability. Each claimant in January

TABLE 1

LOCAL CURRENCY MORBIDITY AND FINANCIAL DATA FOR POLICY DESIGNS A–D

(1)	(2)	(3) Lives Insured	(4) Number of Claimants	(5) Trend Factor	(6) Per Claimant Expense Incurred	(7) Per Claimant Benefit Payable	(8) Total Block Expense Incurred	(9) Total Block Benefits Payable
1	January	1,000	25	1	1,000,000	720,000	25,000,000	18,000,000
2	February	1,000	25	1.0221	1,022,104	737,684	25,552,611	18,442,089
3	March	1,000	25	1.0447	1,044,698	755,758	26,117,438	18,893,950
4	April	1,000	25	1.06779	1,067,790	774,232	26,694,749	19,355,799
5	May	1,000	25	1.09139	1,091,393	793,114	27,284,822	19,827,858
6	June	1,000	25	1.11552	1,115,518	812,414	27,887,938	20,310,350
7	July	1,000	25	1.14018	1,140,175	832,140	28,504,386	20,803,509
8	August	1,000	25	1.16538	1,165,378	852,303	29,134,459	21,307,568
9	September	1,000	25	1.19114	1,191,138	872,911	29,778,461	21,822,769
10	October	1,000	25	1.21747	1,217,468	893,974	30,436,697	22,349,358
11	November	1,000	25	1.24438	1,244,379	915,503	31,109,484	22,887,587
12	December	1,000	25	1.27189	1,271,886	937,509	31,797,142	23,437,713
Total			300		13,571,927	9,897,542	339,298,187	247,438,549

Premium per insured per month: 27493.17213
Premium for the total block: 329,918,066
Loss ratio: 0.75
Ratio of benefits paid to expenses incurred: 0.7293

generates a medical expense covered under the policy of LC 1,000,000, while the expense per claimant in subsequent months during the year is assumed to increase at an annual trend rate of 30% in the local currency. Column (5) of Table 1 displays the trend factor applicable to each month, and the resulting per claimant expense is shown in column (6).

The per-claimant benefit payable in column (7) of Table 1 reflects the application of the benefit formula to the column (6) expense, that is, the deductible of LC 100,000 and the 80% coinsurance.

Columns (8) and (9) contain the expenses incurred and the benefits payable for the entire block and are equal to columns (6) and (7), respectively, multiplied by the total of 25 claimants each month.

Several key summary financial results for this assumed portfolio are shown at the bottom of the table. In particular, the loss ratio and the ratio of benefits paid to covered medical expenses incurred are of primary importance:

$$\text{Loss Ratio} = \frac{247{,}438{,}549}{329{,}918{,}066} = 0.7500$$

$$\text{Benefits Paid/(Expenses Incurred)} = \frac{247{,}438{,}549}{339{,}298{,}187} = 0.7293$$

The premise is that given the specified plan design written directly in local currency, the experience can be accurately projected as in Table 1 such that the aggregate benefits payable will equal 72.93% of the total expenses incurred and the target incurred loss ratio of 75% will be achieved. What is the effect on these key parameters if we interject into the environment a medical plan denominated in another currency that on an expected basis is intended to be equivalent to the specified local currency plan?

IV. DOLLAR POLICY PLAN DESIGNS

For this block of 1,000 covered lives, the medical plan is not to be defined in the local currency, but rather in dollars, at an expected currency exchange rate for the forthcoming calendar year of \$1.00=LC 200. Therefore, the expected equivalent dollar medical plan that will be written to cover these individuals during the calendar year will feature a \$500 per person per disability deductible and 80% coinsurance.

In the administration of this dollar plan throughout the year, there are several possibilities for collecting dollar premiums and paying dollar claims, four of which are described as policy designs A to D below. For the premium

quantity in these descriptions, the community rate in local currency that is appropriate for the underlying morbidity is shown in Table 1 as LC 27,493.17 per person per month.

Policy Design A

- *Premiums.* Converted at the expected exchange rate throughout the policy year, so that the monthly rate per person is LC 27,493.17/200=$137.47.
- *Claims.* Local currency covered medical expenses are converted to dollars by the expected exchange rate factor of 1/200 for all claims incurred during the year.

Policy Design B

- *Premiums.* The dollar premium payable each month is determined by dividing LC 27,493.17 by the market currency exchange rate for that month.
- *Claims.* Local currency covered medical expenses are converted to dollars for application of the policy's benefit formula via multiplication by the market currency exchange rate for the month in which the claims are incurred.

Policy Design C

- *Premiums.* Converted at the expected exchange rate throughout the policy year, so that the monthly rate per person is LC 27,493.17/200=$137.47 (same as policy design A).
- *Claims.* Converted at the market currency exchange rate each month throughout the policy year (same as policy design B).

Policy Design D

- *Premiums.* Converted at the market currency exchange rate each month throughout the policy year (same as policy design B).
- *Claims.* Converted by the expected exchange rate factor of 1/200 throughout the year (same as policy design A).

Each dollar policy design contains inherent advantages and disadvantages that may influence its selection from among the four alternatives. Several general considerations that may be involved in evaluating, on a surface level, the relative attractiveness of each policy design are described below.

Policy design A is appealing from several perspectives. Because both the premiums and claims are converted by the same expected exchange rate factor of 1/200 during the year, the conversion of these two quantities is "matched," regardless of market exchange rates during the one-year term period. Administration is simplified with the application of the same 1/200 factor throughout, and the insureds should better understand how their policies function. They pay the same dollar premium each month, and any claims incurred during the year are converted by a constant factor.

Policy design B appears even more attractive than A from a financial perspective. Not only are the premium and claim conversions matched at the same exchange rates during the policy year, but the conversion is at the market rate for each month, so the dollar quantities stay completely synchronized with the changing value of the dollar relative to the local currency. This plan is not so kind to the insured or to the administrative process, however, because the premium payable in dollars fluctuates each month, as does the rate of conversion to effect claim payments in dollars. In addition, there may be significant legal and regulatory obstacles to receiving approval from the proper authorities to sell this style of plan design in some countries.

Policy design C can be considered an appropriate compromise to the relative advantages and disadvantages of B. The complexities of the plan to the insured can be substantially reduced by specifying a constant dollar monthly premium payable, rather than the possibility of varying and unknown installments each month. On the claims side, the use of the market exchange rate can be considered a means of keeping the claims payment current with the changing relativity of the two currencies.

For policy design D, it is a little more difficult to identify a compelling rationale for its use. Perhaps it could be argued that the insureds would be willing to let their premiums float according to the market currency exchange rate during the year, but would want to "know what they are buying" by having the claim conversion fixed at issue for the year.

V. CURRENCY EXCHANGE RATES

Five distinct currency exchange rate outcomes are studied in this model, as shown in columns (1) through (5) of Table 2.

Each of the five sets of exchange rate progressions begins with an actual rate of $1.00=LC 178 in January, under the supposition that when the column (1) expected scale of exchange rates was postulated, the timing was sufficiently close to the first month of the policy year so that the actual result

in each outcome equals the expected value for January. Thereafter, the monthly actual market exchange rates in the other four outcomes diverge from the expected values.

TABLE 2

CURRENCY EXCHANGE RATE OUTCOMES

		Actual Market Exchange Rates				
		(1) Expected (E)	(2) Moderately High (MH)	(3) Substantially High (SH)	(4) Moderately Low (ML)	(5) Substantially Low (SL)
1	January	178	178	178	178	178
2	February	182	186	190	179	176
3	March	186	194	202	180	174
4	April	190	202	214	181	172
5	May	194	210	226	182	170
6	June	198	218	238	183	168
7	July	202	226	250	184	166
8	August	206	234	262	185	164
9	September	210	242	274	186	162
10	October	214	250	286	187	160
11	November	218	258	298	188	158
12	December	222	266	310	189	156
Average exchange rate		200	222	244	183.5	167

The moderately high (MH) and substantially high (SH) outcomes involve monthly devaluations of +8 and +12, respectively, compared to the expected monthly devaluation in the exchange rate of +4. The moderately low (ML) progression incorporates a monthly increase of +1, while the substantially low (SL) series includes a reversal of direction in the exchange rate, with a monthly change of −2.

The linear functions selected for the exchange rate scenarios are not meant to suggest that these normally follow this type of pattern, with the possible exception of countries whose currency is managed by the governmental authorities to produce a steady, programmed devaluation over time. Rather, the linear progression simplifies the model and is an appropriate assumption because the primary purpose of this paper is to study the effects on certain financial parameters of a block of medical policies, given that a divergence between the levels of actual and expected exchange rates occurs during an experience year. The focus is not on the dynamics of currency exchange rates themselves; the theoretical and statistical considerations of projecting

actual currency exchange rate relationships are not intended to be addressed by this analysis.

Note that the average currency exchange rate applicable to the calendar year is 200 for the expected set of values, which is the constant factor for the policy year in those policy designs that involve conversions of the premiums or the claims at the expected exchange rate.

Throughout this paper the assumption is made that a free market exists for the legal and convenient exchange of currencies at these exchange rates.

VI. PORTFOLIO FINANCIAL RESULTS

Combining the four policy designs (described in Section IV) with the five currency exchange rate outcomes (in Section V) produces a total of 20 scenarios of financial results for the dollar medical plans during the calendar year. Table 3 displays detailed month-by-month premium and claim figures for the first of these 20 outcomes in the model. The plan analyzed in this scenario is policy design A, and the actual currency exchange rate progression for the year is the expected set of values.

To reduce the bulk of this paper, detailed results in the Table 3 format are not shown for scenarios 2–20. However, key summary statistics from the entire set of 20 tables in the Table 3 format have been extracted and are displayed in Table 4.

Column (4) of Table 3 contains the actual dollar premiums paid by the block of 1,000 lives during the year, which in each scenario is a function of the policy design and the exchange rate outcome. Note that in Table 3, due to the number of significant digits carried internally by the computer, this monthly premium of $137,465.85 differs very slightly from the premium quantity based upon the dollar rate specified in Section IV, which is: (1,000)(137.47)=$137,470.00. There may be other minor rounding differences, which have no bearing on the analysis in this paper. Column (5), the local currency total expense incurred, is taken directly from column (8) of Table 1.

The imputed dollar total expense incurred in column (6) is obtained from multiplying column (5) by the appropriate currency exchange rate, according to the policy design and exchange rate outcome under consideration in each scenario.

Dollar total benefits payable in column (7) are derived from column (6) by application of the dollar benefit formula, which consists of a $500 deductible per person per disability, with 80% coinsurance.

TABLE 3

FINANCIAL RESULTS FOR POLICY DESIGN A
CURRENCY EXCHANGE RATE OUTCOME: EXPECTED
PREMIUMS CONVERTED AT: EXPECTED
CLAIMS CONVERTED AT: EXPECTED

(1)	(2)	(3) Market Currency Exchange Rate	(4) Total Block Dollar Premium Payable	(5) Local Currency Total Expense Incurred	(6) Imputed Dollar Total Expense Incurred	(7) Dollar Total Benefits Payable	(8) Benefits Converted at Market to Local Currency	(9) Premium Converted at Market to Local Currency
1	January	178	137,465.85	25,000,000	125,000	90,000	16,020,000	24,468,921
2	February	182	137,465.85	25,552,611	127,763	92,210	16,782,301	25,018,785
3	March	186	137,465.85	26,117,438	130,587	94,470	17,571,374	25,568,648
4	April	190	137,465.85	26,694,749	133,474	96,779	18,388,009	26,118,512
5	May	194	137,465.85	27,284,822	136,424	99,139	19,233,022	26,668,375
6	June	198	137,465.85	27,887,938	139,440	101,552	20,107,247	27,218,238
7	July	202	137,465.85	28,504,386	142,522	104,018	21,011,544	27,768,102
8	August	206	137,465.85	29,134,459	145,672	106,538	21,946,795	28,317,965
9	September	210	137,465.85	29,778,461	148,892	109,114	22,913,907	28,867,829
10	October	214	137,465.85	30,436,697	152,183	111,747	23,913,813	29,417,692
11	November	218	137,465.85	31,109,484	155,547	114,438	24,947,470	29,967,555
12	December	222	137,465.85	31,797,142	158,986	117,189	26,015,862	30,517,419
Total			1,649,590	339,298,187	1,696,491	1,237,193	248,851,342	329,918,040

Dollar loss ratio: 0.7500
Local currency benefits paid/expenses incurred: 0.7334
Dollar benefits paid/expenses incurred: 0.7293
Local currency benefits paid/premium: 0.7543

Columns (8) and (9) represent columns (7) and (4), respectively, multiplied month by month by the market currency exchange rates displayed in column (3). These are the dollar benefits and dollar premiums generated by this block of business in the model converted back to local currency according to the monthly market exchange rate.

Since the plan is actually denominated in dollars, what is the value of including in Table 3 the premium and claim quantities converted back to local currency? This question is addressed shortly, as part of the description in subsequent paragraphs of the remaining table entries, which consist of summary financial ratios for the policy year displayed in the bottom left portion of the table. These ratios, which represent key policy parameters consisting of comparisons for the entire year of claims to premiums and of benefits paid to expenses incurred, are shown in the last four columns of Table 4 for all 20 outcomes, along with the expected target values for these quantities. Table 4 also specifies the currency exchange rate outcome and the policy design that correspond to each scenario.

TABLE 4

RESULTS OF DEVIATIONS IN ACTUAL TO EXPECTED CURRENCY EXCHANGE RATES FOR THE POLICY DESIGN AND EXCHANGE RATE SCENARIOS

Scenario Number	Currency Exchange Rate Outcome	Policy Design	Target Loss Ratio	Target Benefits Paid/ Expenses Incurred	Actual Ratios Experienced			
					Dollar Loss Ratio	Local Currency Benefits Paid/ Expenses Incurred	Dollar Benefits Paid/ Expenses Incurred	Local Currency Benefits Paid/ Premium
1	E	A	0.75	0.7293	0.7500	0.7334	0.7293	0.7543
2	E	B	0.75	0.7293	0.7461	0.7293	0.7292	0.7500
3	E	C	0.75	0.7293	0.7496	0.7293	0.7292	0.7500
4	E	D	0.75	0.7293	0.7464	0.7334	0.7293	0.7543
5	MH	A	0.75	0.7293	0.7500	0.8178	0.7293	0.7577
6	MH	B	0.75	0.7293	0.7355	0.7215	0.7220	0.7420
7	MH	C	0.75	0.7293	0.6731	0.7215	0.7220	0.6685
8	MH	D	0.75	0.7293	0.8195	0.8178	0.7293	0.8411
9	ML	A	0.75	0.7293	0.7500	0.6701	0.7293	0.7512
10	ML	B	0.75	0.7293	0.7549	0.7351	0.7350	0.7560
11	ML	C	0.75	0.7293	0.8230	0.7351	0.7350	0.8240
12	ML	D	0.75	0.7293	0.6879	0.6701	0.7293	0.6892
13	SH	A	0.75	0.7293	0.7500	0.9022	0.7293	0.7605
14	SH	B	0.75	0.7293	0.7259	0.7137	0.7151	0.7340
15	SH	C	0.75	0.7293	0.6131	0.7137	0.7151	0.6016
16	SH	D	0.75	0.7293	0.8880	0.9022	0.7293	0.9278
17	SL	A	0.75	0.7293	0.7500	0.6069	0.7293	0.7474
18	SL	B	0.75	0.7293	0.7647	0.7409	0.7412	0.7620
19	SL	C	0.75	0.7293	0.9174	0.7409	0.7412	0.9126
20	SL	D	0.75	0.7293	0.6252	0.6069	0.7293	0.6241

The most important summary quantity is the dollar loss ratio. Defined as the dollar claims payable divided by the dollar premiums received, it is a direct barometer of the financial success, or lack thereof, of the insurance company responsible for this hypothetical block of business.

Recall that our target loss ratio is 75% and that the underlying morbidity level for the plan design in local currency (Table 1) produces exactly this desired result. The only aspects of the portfolio scenarios shown in Table 4 that differ compared to Table 1 are:

(1) The utilization of a dollar plan design that is intended to have an equivalent deductible on an expected currency exchange rate basis
(2) A specific methodology for converting currencies at either market or expected rates (policy designs A–D)
(3) Actual variation in the market exchange rate throughout the year compared to the expected progression.

Table 5, column (4), displays the differences between actual and target results for the dollar loss ratio, revealing that 11 of the 20 scenarios have actual values that vary from the 75% target by more than $\pm 1.0\%$. Eight of these deviate by more than $\pm 5.0\%$, with a minimum dollar loss ratio of 61.31% and a maximum level of 91.74%. This deviation in the actual versus the expected financial results is due entirely to the effect of the exchange rates in the mixed-currency medical plan environment, as the underlying morbidity in local currency remains unchanged.

The ratio, in local currency, of benefits paid to expenses incurred in Table 3 is column (8) divided by column (5). This ratio is significant, and the derivation of this quantity is one reason that the conversions of the dollar premiums and claims back into local currency are given in the last two columns of the table.

To appreciate the significance of this statistic, the practical mechanics of the disposition of the policy benefits must be considered. The insured will receive a dollar benefit under the medical plan according to the application of the exchange rate to the covered expenses incurred in local currency and the benefit formula of the $500 deductible, 80% coinsurance. To pay the suppliers of medical services, whose bills are in local currency, the claimant must convert the dollar plan benefits back to local currency. This is accomplished at the prevailing, available market currency exchange rate. Effectively, therefore, the percentage of the total local currency expenses reimbursed by the insurance program is determined by comparing the dollar reimbursement converted back into local currency to the original expenses incurred in that same medium of exchange.

TABLE 5

DIFFERENCE BETWEEN TABLE 4 ACTUAL AND TARGET FINANCIAL RATIOS

Scenario Number	Currency Exchange Rate Outcome	Policy Design	Dollar Loss Ratio	Local Currency Benefits Paid / Expenses Incurred	Local Currency Benefits Paid / Premium
1	E	A	0.0000	0.0041	0.0043
2	E	B	−0.0039	0.0000	0.0000
3	E	C	−0.0004	0.0000	0.0000
4	E	D	−0.0036	0.0041	0.0043
5	MH	A	0.0000	0.0885	0.0077
6	MH	B	−0.0145	−0.0078	−0.0080
7	MH	C	−0.0769	−0.0078	−0.0815
8	MH	D	0.0695	0.0885	0.0911
9	ML	A	0.0000	−0.0592	0.0012
10	ML	B	0.0049	0.0058	0.0060
11	ML	C	0.0730	0.0058	0.0740
12	ML	D	−0.0621	−0.0592	−0.0608
13	SH	A	0.0000	0.1729	0.0105
14	SH	B	−0.0241	−0.0156	−0.0160
15	SH	C	−0.1369	−0.0156	−0.1484
16	SH	D	0.1380	0.1729	0.1778
17	SL	A	0.0000	−0.1224	−0.0026
18	SL	B	0.0147	0.0116	0.0120
19	SL	C	0.1674	0.0116	0.1626
20	SL	D	−0.1248	−0.1224	−0.1259

The local currency plan in Table 1 generated an expected value for the benefits paid to expenses incurred ratio of 72.93%. The corresponding column in Table 5 reveals, however, that 12 of the 20 scenarios have reimbursement ratios that vary from the target by more than ±1.0%. Eight of these 12 differ by more than ±5.0%, with a minimum ratio of 60.69% and a maximum level of 90.22%.

There is a direct link between the percentage of expenses reimbursed by a medical plan and the morbidity level. The model contains the assumption that, given the local currency plan with the deductible of LC 100,000 and 80% coinsurance, the morbidity results in Table 1 will be generated. This plan operates to reimburse an aggregate percentage of 72.93% of the total expenses incurred. To the extent that the application of the currency exchange rates in the dollar plan that is intended to be equivalent function to change that expense reimbursement ratio, the underlying morbidity level will be affected. For those scenarios in the model whose ratios of local currency benefits paid to expenses incurred are substantially greater than

72.93%, the dollar loss ratio shown is actually understated, because the model assumption of unchanged morbidity would no longer be valid and the total of incurred expenses would be higher. Conversely, for those scenarios with reimbursement ratios substantially less than the target of 72.93%, the dollar loss ratio shown is overstated.

Note that scenario 16 appears to be a particularly dangerous situation, because it combines an 88.8% dollar loss ratio with a reimbursement level of 90.22% of local currency expenses incurred. At the other extreme, scenario 20 produces a dollar loss ratio of 62.52% along with a local currency expense reimbursement ratio of 60.69%.

The third summary financial statistic to be discussed is the local currency ratio of benefits paid to premiums. In Table 3, this is the quotient of column (8) and column (9). This statistic measures the value, from a total block of business perspective, that the insureds receive for their premium. As previously described, the insureds will likely convert at a market exchange rate the dollar reimbursement received from the plan to a local currency quantity to fund the amounts due to the providers of the medical services. On the premium side, although dollar amounts are payable to the insurance company, the dollars used to pay these premiums are often obtained via a conversion of the insureds' local currency funds at the available market rate of exchange. This comparison, at market exchange rates, of the benefits converted to local currency to the local currency annual equivalent of the premiums indicates the return that the insureds receive in the form of benefit payments for their funds utilized to pay the premiums.

In the Table 1 results for the equivalent plan written directly in the local legal tender, the loss ratio achieved is 75%. In the Table 4 display of summary statistics by scenario, 11 of the 20 scenarios produce a result that differs from the 75% target by more than $\pm 1\%$. Eight of these deviations are by more than $\pm 5\%$, with a minimum ratio of 60.16% and a maximum value of 92.78%.

Although the simplified model does not incorporate a lapse rate assumption, it could be theorized that the effect of changing relationships between local currency benefits paid and premiums would influence the persistency of the block of insured lives and be a further destabilizing influence on the portfolio's financial results. As this ratio decreases throughout the year in certain scenarios due to the currency exchange rate dynamics, the policy would appear less attractive in general and insureds would begin to drop out of the program at an accelerated rate. Conversely, as this ratio increases in other scenarios, fewer people than expected would lapse their coverage.

The fourth summary statistic shown in Table 3 is the dollar comparison of benefits paid to expenses incurred, computed as column (7) divided by column (6). This is the least interesting of the set of four summary ratios. It varies much less than the other indices, ranging in Table 4 from a low of 71.51% to a high of 74.12%. Furthermore, it does not appear to have a meaningful interpretation with respect to its effect, if any, on the results of the portfolio. While the numerator is significant in that it represents the actual dollar claims paid, the denominator is only a converted currency figure that is utilized to apply the benefit formula of the $500 deductible, 80% coinsurance. This quantity does not appear worthy of further comment or analysis and has been omitted from the Table 5 display of differences between actual and target values.

It is also revealing to examine the combined effect of the key financial ratios for each scenario. This is efficiently accomplished via a review of the Table 5 differences between actual and target results.

For the first four scenarios, in which the actual market currency exchange rates are accurately projected in advance of the policy year, all the Table 5 differences are less than 0.50%. This indicates that in an environment in which the currency exchange rates are correctly predicted, all four policy designs produce results that are perfectly consistent with those expected according to the underlying morbidity.

Of the remaining 16 scenarios that involve deviations between the actual and expected market currency exchange rates, all but one feature ratio differences in Table 5 that are all in the same direction. In other words, for scenarios 5–20, except for cells with a zero difference, the values are either all positive or all negative. The one exception is scenario 9, in which the positive difference is so small that it is essentially zero.

This indicates that the deviations in the first two financial ratios (that is, the dollar loss ratio and the local currency ratio of benefits paid to expenses incurred) are always compounded, such that there are never any offsets and both of the deviations combine to force the financial results in the same direction. For example, any scenario with a dollar loss ratio higher than expected will also experience a local currency ratio of benefits paid to expenses incurred that equals or exceeds the target. Positive deviations in this latter ratio will result in increased utilization of medical services, which will, in turn, further force the dollar loss ratio in an upward direction. In addition, this type of scenario will produce a local currency ratio of benefits to premium that exceeds the target level. In a more realistic and sophisticated model, this would tend to increase the persistency of the portfolio and,

therefore, generate a greater total volume of losses, because the aggregate financial results would not be diluted to the extent that would be expected due to lapsation.

Conversely, any scenario with a Table 4 dollar loss ratio less than expected should, in reality, experience an actual dollar loss ratio that is even further depressed than the Table 4 value. This is due to reduced utilization caused by the influence of the local currency ratio of benefits to expenses being lower than the target. Furthermore, because of the downward distortion in the comparison of local currency benefits to premiums, the increased lapsation that would result should serve to dilute the exceptionally high profits that would otherwise accrue as a result of the low dollar loss ratio.

VII. POLICY DESIGN ANALYSIS

The model has indicated that a medical plan in a mixed-currency environment is subject to several destabilizing influences and that a significant currency exchange rate risk can be superimposed upon the usual loss ratio, or morbidity, risk of this type of product. However, is any of the four policy designs superior to the others for maintenance of the original intended financial parameters under shifting currency exchange rate circumstances?

This question is addressed in Tables 6, 7, and 8, which revisit in a modified format the 20 scenario values for the three key summary financial ratios—the dollar loss ratio, the ratio of benefits paid to expenses incurred, and ratio of benefits paid to premium, respectively—for the model portfolio. A standard deviation statistic is developed for the ratios shown in each table for each policy design, computed via the typical formula:

$$\text{Std. Dev.} = \left(\frac{\sum_{n=1}^{n=5} (r_n - \text{target})^2}{5} \right)^{1/2}$$

The symbol r above signifies the financial ratio for which the standard deviation is being calculated.

In Table 6, the dollar loss ratios that reflect the actual currency exchange rate pattern matching the expected series all appear consistent with the target loss ratio. This indicates that all four policy designs function well in this environment. However, the dollar loss ratio stability produced by policy designs A and B is clearly superior to that for C and D for the other four currency exchange rate outcomes. For policy design A, there is no change

in the dollar loss ratio resulting from exchange rate swings, while the effect on policy design B is minimal. Policy designs C and D display financial results that are quite sensitive to currency exchange fluctuations, having standard deviations equal to 7.4 times and 6.4 times, respectively, the standard deviation of policy design B.

Note also that policy designs C and D react in opposite directions to fluctuations in the currency exchange rates. For upward deviations in the exchange rates, policy design D produces poorer financial results, while policy design C generates more favorable dollar loss ratios. For downward deviations in the exchange rates, the loss ratio movement is reversed for the two types of plans. These dynamics are not surprising given the opposite methods that these two policy designs employ for converting premiums and claims.

TABLE 6

DOLLAR LOSS RATIOS FOR THE POLICY DESIGN AND EXCHANGE RATE SCENARIOS

Currency Exchange Rate Outcome	Target Loss Ratio	Policy Design*	Dollar Loss Ratio
1. Expected	0.75	A	0.7500
		B	0.7461
		C	0.7496
		D	0.7464
2. Moderately High (MH)	0.75	A	0.7500
		B	0.7355
		C	0.6731
		D	0.8195
3. Substantially High (SH)	0.75	A	0.7500
		B	0.7259
		C	0.6131
		D	0.8880
4. Moderately Low (ML)	0.75	A	0.7500
		B	0.7549
		C	0.8230
		D	0.6879
5. Substantially Low (SL)	0.75	A	0.7500
		B	0.7647
		C	0.9174
		D	0.6252
6. Standard Deviation		A	0.0000
		B	0.0145
		C	0.1077
		D	0.0931

*A = Premiums, expected; claims, expected
B = Premiums, market; claims, market
C = Premiums, expected; claims, market
D = Premiums, market; claims, expected

Table 7 contains interesting results for the effectiveness of the plan designs in maintaining the ideal 72.93% relationship between the benefits paid, converted back to local currency, and the original expenses incurred. In this category, policy designs B and C, both of which use market exchange rates to convert the covered medical expenses incurred to dollars for the application of the benefit formula, do a good job of maintaining the target reimbursement ratio in spite of exchange rate fluctuations. Policy designs A and D, however, which use the expected exchange rate for the application of the benefit formula, do a relatively poor job of maintaining a stable relationship. The standard deviation of policy designs A and D is 10.9 times as great as that of policy designs B and C.

TABLE 7

LOCAL CURRENCY RATIO OF BENEFITS PAID TO EXPENSES INCURRED FOR THE POLICY DESIGN AND EXCHANGE RATE SCENARIOS

Currency Exchange Rate Outcome	Target Benefit/Expense Ratio	Policy Design*	Ratio of Benefits Paid to Expenses Incurred
1. Expected	0.7293	A	0.7334
		B	0.7293
		C	0.7293
		D	0.7334
2. Moderately High (MH)	0.7293	A	0.8178
		B	0.7215
		C	0.7215
		D	0.8178
3. Substantially High (SH)	0.7293	A	0.9022
		B	0.7137
		C	0.7137
		D	0.9022
4. Moderately Low (ML)	0.7293	A	0.6701
		B	0.7351
		C	0.7351
		D	0.6701
5. Substantially Low (SL)	0.7293	A	0.6069
		B	0.7409
		C	0.7409
		D	0.6069
6. Standard Deviation		A	0.1061
		B	0.0097
		C	0.0097
		D	0.1061

*A = Premiums, expected; claims, expected
B = Premiums, market; claims, market
C = Premiums, expected; claims, market
D = Premiums, market; claims, expected

In Table 8, which displays the ratios of local currency benefits paid to premium, the relative effectiveness of each plan follows the same order as for the dollar loss ratio in Table 6, although essentially in this last table policy designs C and D are just about equally poor. Policy designs A and B both are relatively stable with respect to the 75% target loss ratio.

TABLE 8

LOCAL CURRENCY RATIO OF BENEFITS PAID TO PREMIUM FOR THE POLICY DESIGN AND EXCHANGE RATE SCENARIOS

Currency Exchange Rate Outcome	Target Loss Ratio	Policy Design*	Ratio of Benefits Paid to Premium
1. Expected	0.75	A	0.7543
		B	0.7500
		C	0.7500
		D	0.7543
2. Moderately High (MH)	0.75	A	0.7577
		B	0.7420
		C	0.6685
		D	0.8411
3. Substantially High (SH)	0.75	A	0.7605
		B	0.7340
		C	0.6016
		D	0.9278
4. Moderately Low (ML)	0.75	A	0.7512
		B	0.7560
		C	0.8240
		D	0.6892
5. Substantially Low (SL)	0.75	A	0.7474
		B	0.7620
		C	0.9126
		D	0.6241
6. Standard Deviation		A	0.0063
		B	0.0100
		C	0.1101
		D	0.1091

*A = Premiums, expected; claims, expected
B = Premiums, market; claims, market
C = Premiums, expected; claims, market
D = Premiums, market; claims, expected

So how should these plan designs be ranked for their overall desirability in maintaining stability in the financial parameters in the face of fluctuating exchange rates, or in other terms, in minimizing the currency exchange risk?

If each plan design is graded 1 through 4 from best to worst in each category, recognizing the ties in Table 7, we have the following tabulation:

POLICY DESIGN RANKING

	A	B	C	D
Dollar Loss Ratio	1	2	4	3
LC Benefits Paid/Expenses Incurred	2	1	1	2
LC Benefits Paid/Premium	1	2	4	3

Interestingly, no one policy design is consistently the best or worst across the three financial ratio tests. Policy designs C and D appear to be clearly inferior to A and B. Policy design A is the best in the two loss ratio categories and experiences no fluctuation in the critical dollar loss ratio statistic. However, its performance in maintaining a stable local currency benefits paid to expenses incurred ratio is poor, leaving it subject to changes in underlying utilization patterns if the exchange rates shift. Policy design B performs relatively well in all categories, as none of the three financial parameters become significantly distorted as a result of the exchange rate influence. However, as mentioned in Section IV, a market-exchange-rate-based policy design that is subject to monthly changes in the factor for converting premiums and claims is the most difficult to administer. It also presents uncertainties and inconveniences to the insureds, as well as potential legal and regulatory problems in some countries.

VIII. SCHEDULED MEDICAL PLAN

In Section II, general considerations and comments were made about life insurance products with premiums and policy benefits denominated in a currency other than the medium of exchange of the insureds' country of residence. It was asserted that the life products, as a result of their completely unitized structure, internally function independently of the particular currency of the country in which the policy is sold. The question was: does a medical plan structured on a completely scheduled, per-unit basis afford the same immunity against currency exchange rate fluctuations as a life insurance product?

To address this question, a fifth policy design, E, was established. In contrast to policy designs A–D, policy design E is a fully scheduled plan that provides a benefit of $800.00 per day of confinement as an inpatient in a hospital.

A similar methodology was utilized to examine the results for this scheduled plan. Table 9 is analogous to Table 1 in that it contains a display of the underlying morbidity experience. Once again the model tracks the results

of 1,000 insured lives for a policy year equal to the calendar year. In this simple environment, 27 inpatient hospital days are generated each month by the block of insured lives. In local currency, the average hospital charge per day starts in January at LC 180,000 and then increases at an annual trend rate of 25%.

Column (7) in Table 9 displays the total local currency hospital charges generated by the claimants each month and is equal to the product of the number of hospital days in column (4) and the trended hospital charge per day in column (6).

The monthly community rate per 1.00 of benefit per day of hospital confinement, with a 75% target loss ratio and regardless of the currency in which the hospital plan is denominated, is computed as:

$$\frac{(27 \times 12)}{(1000)(12)(0.75)} = 0.036$$

Since our hospital indemnity product provides a benefit of $800 per day, the premiums are as follows:

Per person per month	($800)(0.036)	= $28.80
Total block per month	(1000)($28.80)	= $28,800
Total block, annual	(12)($28,800)	= $345,600

Total claims paid for the year will be: ($800)(27)(12)=$259,200. The calculation below confirms that the desired loss ratio is in fact achieved:

$$\frac{\$259,200}{\$345,600} = 0.75$$

Note that in the administration of this policy design for both premiums and claims, no currency conversions are required. The unit rate, as mentioned previously, is independent of currency. This rate is multiplied by the desired daily benefit amount in any currency to produce the proper premium payable.

For claim payments, the amount due for any confinement is determined as the contractual daily benefit in the currency of the policy multiplied by the number of days of the hospital stay.

Since policy design E involves no explicit currency conversions, it would appear to be protected against currency exchange rate changes in the same manner that a life product is immunized. To test this hypothesis, policy

TABLE 9

MORBIDITY AND FINANCIAL DATA FOR SCHEDULED PLAN (POLICY DESIGN E)

(1)	(2)	(3) Number of Insured Lives	(4) Number of Hospital Inpatient Days	(5) Trend Factor	(6) Local Currency Hospital Charges per Day	(7) Total Local Currency Hospital Charges	(8) Dollar Benefits Payable at $800 per Day	(9) Dollar Premiums for $800 per Day Benefit
1	January	1000	27	1.00000	180,000	4,860,000	21,600	28,800
2	February	1000	27	1.01877	183,378	4,951,219	21,600	28,800
3	March	1000	27	1.03789	186,820	5,044,149	21,600	28,800
4	April	1000	27	1.05737	190,327	5,138,824	21,600	28,800
5	May	1000	27	1.07722	193,899	5,235,276	21,600	28,800
6	June	1000	27	1.09744	197,538	5,333,539	21,600	28,800
7	July	1000	27	1.11803	201,246	5,433,645	21,600	28,800
8	August	1000	27	1.13902	205,023	5,535,631	21,600	28,800
9	September	1000	27	1.16040	208,871	5,639,530	21,600	28,800
10	October	1000	27	1.18218	212,792	5,745,380	21,600	28,800
11	November	1000	27	1.20437	216,786	5,853,217	21,600	28,800
12	December	1000	27	1.22697	220,855	5,963,077	21,600	28,800
Total			324			64,733,488	259,200	345,600

Monthly rate per 1.00 unit of daily benefit: 0.036
Dollar benefit per day: $800
Total dollar monthly premium: $28,800
Loss ratio for dollar hospital product: 0.75

design E was analyzed in the context of five scenarios defined by the five currency exchange rate outcomes specified in Section V. Table 10 displays detailed month-by-month financial information for the first scenario, in which the actual market exchange rates experienced conform to the expected pattern.

Columns (3), (4), and (5) in Table 10 are taken directly from Table 9. The assumed series of market currency exchange rates appears in column (6). Columns (7) and (8) contain the actual dollar benefits and premiums, respectively, generated by this portfolio during the year converted to local currency at the market currency exchange rates. Therefore, column (7) is equal to the product of columns (4) and (6), while column (8) is determined by multiplying columns (5) and (6).

Summary financial ratios similar to those developed in the review of policy designs A–D are shown in the bottom left corner of Table 10 and are summarized in the last two columns of Table 11 for the five currency exchange rate outcomes.

In contrast to the prior analysis, there are only two summary statistics, which are the local currency ratios of the benefits paid to the expenses incurred and the benefits paid to the premium. The first of these quantities is computed in Table 10 as the ratio of columns (7) and (3), while the second is derived via the quotient of column (7) and column (8). The two dollar ratios that were included in the study of policy designs A through D do not exist for policy design E, since the dollar results shown in Table 9 do not vary according to the currency exchange rate outcome.

The relationship of the local currency benefits paid to premium is not influenced by the varying currency exchange rate outcomes, as Table 11, column (5) demonstrates that the target 75% relativity of claims to premium is always maintained in local currency.

Unfortunately, the results displayed in Table 11, column (6) are not as encouraging. The local currency ratio of benefits paid to expenses incurred is quite sensitive to the influence of the currency exchange rate. When the actual market currency exchange rates conform to the expected pattern, the local currency benefit is about 80% of the charges, which represents a reasonable and typical benefit level. However, this reimbursement ratio fluctuates upward to 97.7% for the "substantially high" exchange rate outcome and plummets to 66.87% in the "substantially low" exchange rate environment.

Under typical circumstances, when the medical policy's dollar benefit is received by the claimant, it must be converted into local currency to

TABLE 10

FINANCIAL RESULTS FOR POLICY DESIGN E
CURRENCY EXCHANGE RATE OUTCOME: EXPECTED

(1)	(2)	(3) Total Local Currency Hospital Charges	(4) Dollar Benefits Payable at $800 per Day	(5) Dollar Premiums for $800 per Day Benefit	(6) Market Exchange Rate	(7) Benefits Converted to Local Currency at Market Rate	(8) Premiums Converted to Local Currency at Market Rate
1	January	4,860,000	21,600	28,800	178	3,844,800	5,126,400
2	February	4,951,219	21,600	28,800	182	3,931,200	5,241,600
3	March	5,044,149	21,600	28,800	186	4,017,600	5,356,800
4	April	5,138,824	21,600	28,800	190	4,104,000	5,472,000
5	May	5,235,276	21,600	28,800	194	4,190,400	5,587,200
6	June	5,333,539	21,600	28,800	198	4,276,800	5,702,400
7	July	5,433,645	21,600	28,800	202	4,363,200	5,817,600
8	August	5,535,631	21,600	28,800	206	4,449,600	5,932,800
9	September	5,639,530	21,600	28,800	210	4,536,000	6,048,000
10	October	5,745,380	21,600	28,800	214	4,622,400	6,163,200
11	November	5,853,217	21,600	28,800	218	4,708,800	6,278,400
12	December	5,963,077	21,600	28,800	222	4,795,200	6,393,600
Total		64,733,488	259,200	345,600		51,840,000	69,120,000

Converted Local Currency Comparisons:
Benefits paid/expenses incurred: 0.8008
Benefits paid/premiums: 0.7500

TABLE 11

SUMMARY OF FINANCIAL RATIOS FOR POLICY DESIGN E FOR CURRENCY EXCHANGE RATE OUTCOMES

(1) Currency Exchange Rate Outcome	(2) Outcome Number	(3) Target Loss Ratio	(4) Target Benefits Paid/ Expenses Incurred	(5) Actual Benefits Paid/ Premium	(6) Actual Benefits Paid/ Expenses Incurred
Expected (E)	1	0.75	0.8008	0.75	0.8008
Moderately High (MH)	2	0.75	0.8008	0.75	0.8889
Substantially High (SH)	3	0.75	0.8008	0.75	0.977
Moderately Low (ML)	4	0.75	0.8008	0.75	0.7348
Substantially Low (SL)	5	0.75	0.8008	0.75	0.6687

reimburse the providers of medical care. In this specific example, it is the hospital bills denominated in the local medium of exchange that must be paid.

Due only to changes in the currency exchange rate outcome, this model produces hospital expense reimbursement levels ranging from about 67% to 98%. Such a range would be expected to influence the underlying morbidity, such that the projection of 27 inpatient days per 1,000 per month, which may have been a perfectly accurate assumption at 80% reimbursement in the expected exchange rate situation, would not be an accurate morbidity projection at reimbursement percentages substantially deviating from this level. A 98% hospital expense reimbursement would produce a greater number of inpatient days per month, making the 0.036 unit rate insufficient, while a 67% reimbursement ratio would generate fewer than 27 inpatient days per month, resulting in an excessive unit rate.

Thus it appears that even the fully scheduled hospital plan's internal financial components are not immune to changes in currency exchange rates. Apart from the standard morbidity risk, there is a definite exchange rate risk that adds additional uncertainty to the financial results.

Note that this scheduled plan reacts in a similar manner as policy design A, in that both are sensitive and vulnerable to the effect on utilization of the expense reimbursement ratio in local currency, but are quite stable with respect to the other currency-generated sources of financial instability.

IX. EFFECT OF INTRODUCING ADDITIONAL VARIABLES AND CHANGES IN POLICY DESIGNS

Sections VI and VII present the financial results of the model portfolio and an analysis of the characteristics of policy designs A–D, given the specific model and plan definitions described in earlier sections.

This section contains an analysis of the effects on the key financial ratios of injecting specific changes into the definition of the policy designs and into certain aspects of the operation of the model.

A. Variation in Deductible Level

The underlying local-currency model claim costs in Table 1 were developed by utilizing a medical plan with a per-cause deductible of LC 100,000. The equivalent dollar plan deductible was $500 at the expected exchange rate of LC 200=$1.00 for the policy year.

Two additional sets of tables corresponding to Table 1 and Table 2 (for all 20 scenarios) were generated for deductibles that were equal to one-half and double the original plan specifications, that is, deductibles equal to LC 50,000 ($250) and LC 200,000 ($1,000). The differences between actual and target ratios are summarized in the following tables for the three deductible levels:

Table 12: Dollar Loss Ratios

Table 13: Local-Currency Benefits Paid/Expenses Incurred

Table 14: Local-Currency Benefits Paid/Premium

In each of these tables, the column of differences between actual and target ratios for the $500 deductible plan is taken directly from Table 5.

There are no surprises in these results: similar influences of the currency exchange rate are present for all three deductibles. The magnitude of the deviations changed somewhat in several of the scenarios for the alternative deductibles, and there are interesting patterns by currency exchange rate outcome and policy design combination in each table.

In Table 12, the analysis of dollar loss ratios, regardless of the deductible level, the target 0.75 value is always achieved for scenarios 1, 5, 9, 13, and 17. This is not surprising because policy design A converts both covered expenses and premiums to dollars throughout the policy year at the expected exchange rate and therefore maintains the same dollar loss ratio of 0.75 inherent in the local currency results.

For policy design D there also is no effect on the dollar loss ratios due to varying the plan deductible. For B and C, however, the deviation between the actual and expected ratios is influenced by the deductible level, because it generally increases with the size of the deductible.

TABLE 12

DIFFERENCE BETWEEN ACTUAL AND TARGET DOLLAR LOSS RATIOS FOR PLANS WITH VARIOUS DEDUCTIBLES

Scenario Number	Currency Exchange Rate Outcome	Policy Design	Dollar Loss Ratio		
			$250 Deductible Plan	$500 Deductible Plan	$1,000 Deductible Plan
1	E	A	0.0000	0.0000	0.0000
2	E	B	−0.0039	−0.0039	−0.0040
3	E	C	−0.0003	−0.0004	−0.0004
4	E	D	−0.0036	−0.0036	−0.0036
5	MH	A	0.0000	0.0000	0.0000
6	MH	B	−0.0106	−0.0145	−0.0235
7	MH	C	−0.0733	−0.0769	−0.0851
8	MH	D	0.0695	0.0695	0.0695
9	ML	A	0.0000	0.0000	0.0000
10	ML	B	0.0018	0.0049	0.0121
11	ML	C	0.0696	0.0730	0.0809
12	ML	D	−0.0621	−0.0621	−0.0621
13	SH	A	0.0000	0.0000	0.0000
14	SH	B	−0.0166	−0.0241	−0.0415
15	SH	C	−0.1306	−0.1369	−0.1516
16	SH	D	0.1380	0.1380	0.1380
17	SL	A	0.0000	0.0000	0.0000
18	SL	B	0.0082	0.0147	0.0297
19	SL	C	0.1596	0.1674	0.1853
20	SL	D	−0.1248	−0.1248	−0.1248

Table 13 differs from 12 and 14 in that the target for the quotient of the converted local-currency benefits paid and expenses incurred varies by deductible level:

Deductible	Target Ratio of Local Currency Benefits Paid to Expenses Incurred
$ 250	0.7646
$ 500	0.7293
$1,000	0.6585

Identical patterns by scenario number are exhibited for each of the three deductibles. The ratios for policy designs A and D are always equal for each currency exchange rate outcome, because both plans convert covered expenses in the claim adjudication process at the expected exchange rate. Similarly, the policy design B and C ratios are identical because both plans convert covered expenses at the market exchange rate.

TABLE 13

DIFFERENCE BETWEEN ACTUAL AND TARGET RATIOS OF LOCAL-CURRENCY BENEFITS PAID TO EXPENSES INCURRED FOR PLANS WITH VARIOUS DEDUCTIBLES

Scenario Number	Currency Exchange Rate Outcome	Policy Design	Ratio of Local Currency Benefits Paid to Expenses Incurred		
			$250 Deductible Plan	$500 Deductible Plan	$1,000 Deductible Plan
1	E	A	0.0042	0.0041	0.0040
2	E	B	0.0000	0.0000	0.0000
3	E	C	0.0000	0.0000	0.0000
4	E	D	0.0042	0.0041	0.0040
5	MH	A	0.0925	0.0885	0.0808
6	MH	B	−0.0039	−0.0078	−0.0155
7	MH	C	−0.0039	−0.0078	−0.0155
8	MH	D	0.0925	0.0885	0.0808
9	ML	A	−0.0620	−0.0592	−0.0533
10	ML	B	0.0030	0.0058	0.0117
11	ML	C	0.0030	0.0058	0.0117
12	ML	D	−0.0620	−0.0592	−0.0533
13	SH	A	0.1807	0.1729	0.1574
14	SH	B	−0.0077	−0.0156	−0.0311
15	SH	C	−0.0077	−0.0156	−0.0311
16	SH	D	0.1807	0.1729	0.1574
17	SL	A	−0.1282	−0.1224	−0.1107
18	SL	B	0.0059	0.0116	0.0234
19	SL	C	0.0059	0.0116	0.0234
20	SL	D	−0.1282	−0.1224	−0.1107

There is some sensitivity by deductible level in the difference between actual and target values for the ratio of benefits paid to expenses incurred. Interestingly, as the deductible increases, the deviation for policy designs A and D decreases. Conversely, for policy designs B and C the ratio differences either remain at zero or increase as the deductible grows in magnitude.

Like Table 12, the Table 14 target ratio, 0.75, is identical for all deductible levels for the comparison of the local-currency benefits paid to the premiums. For all four plan designs, the deviation in the actual compared to the target value either is unaffected or increases as the deductible becomes larger. The effect is minimal on policy designs A and D, because the change in the differences by deductible level is very slight. There is a more substantial impact on policy designs B and C, except for scenarios 2 and 3 in which the actual result achieved is the target ratio for all deductible levels.

TABLE 14

DIFFERENCE BETWEEN ACTUAL AND TARGET RATIOS OF LOCAL-CURRENCY BENEFITS PAID TO PREMIUM FOR PLANS WITH VARIOUS DEDUCTIBLES

Scenario Number	Currency Exchange Rate Outcome	Policy Design	Ratio of Local-Currency Benefits Paid to Premium		
			$250 Deductible Plan	$500 Deductible Plan	$1,000 Deductible Plan
1	E	A	0.0041	0.0043	0.0047
2	E	B	0.0000	0.0000	0.0000
3	E	C	0.0000	0.0000	0.0000
4	E	D	0.0041	0.0043	0.0047
5	MH	A	0.0074	0.0077	0.0085
6	MH	B	−0.0038	−0.0080	−0.0177
7	MH	C	−0.0778	−0.0815	−0.0903
8	MH	D	0.0907	0.0911	0.0920
9	ML	A	0.0011	0.0012	0.0013
10	ML	B	0.0029	0.0060	0.0133
11	ML	C	0.0706	0.0740	0.0819
12	ML	D	−0.0607	−0.0608	−0.0609
13	SH	A	0.0100	0.0105	0.0117
14	SH	B	−0.0076	−0.0160	−0.0354
15	SH	C	−0.1415	−0.1484	−0.1643
16	SH	D	0.1773	0.1778	0.1792
17	SL	A	−0.0024	−0.0026	−0.0028
18	SL	B	0.0057	0.0120	0.0266
19	SL	C	0.1551	0.1626	0.1800
20	SL	D	−0.1258	−0.1259	−0.1261

In summary, while the deductible level does exert some influence in the actual key financial ratios generated by the portfolio, the same underlying distorting effects of the exchange rates are present for plans with various deductibles. Depending upon the particular currency exchange rate outcome, policy design, and financial quantity, a difference in plan deductible level may cause the portfolio's financial performance to be affected moderately, but the financial ratios generated will be generally consistent by deductible level.

B. Per-Cause Versus Per-Calendar-Year Deductible Policies

The medical plan utilized in the model incorporates a deductible defined on a per-cause basis. What is the effect, if any, of changing the policy specifications to a per-calendar-year deductible?

Maintaining the deductible amount at the same quantity but changing the basis from per cause to per calendar year would have the same effect on the model as retaining the per-cause basis and lowering the deductible amount. Both types of changes would increase incurred claims and therefore also the required premiums for a given universe of covered medical expenses. In theory, the claim cost generated by any per-cause deductible should correspond to that produced by a specific per-calendar-year deductible of greater magnitude.

Therefore, the results shown in the prior discussion of varying per-cause deductible amounts would also be pertinent to the effect on the model of changing the policy specifications from a per-cause to a per-calendar-year deductible.

C. Lag between Claim Incurral and Paid Dates

It is interesting to consider the effect of claim payment lags, and variations in the lag patterns, in the analyses. Claim runout has not yet been addressed, because the model results to this point ideally assume that claims are paid in the same month as incurred.

1. Dollar Loss Ratios

According to the policy design definitions in Section IV, for both the expected and market exchange rate bases for converting covered expenses to dollars for claim adjudication, the conversion is a function of the incurral date of the medical expense. Therefore, with this definition, the dollar loss ratios displayed in Table 6 would be unaffected by claim lags. Regardless of the time between the incurral and payment dates, the dollar benefit payable would be unchanged.

2. Local-Currency Ratios of Benefits Paid to Expenses Incurred and of Benefits Paid to Premiums

As previously explained in the analyses of the two local-currency ratios of benefits paid to expenses incurred and of benefits paid to premium, these quantities are significant as a result of the insured's conversion of the dollar policy's benefit payment into the local currency to pay the suppliers of medical services. This conversion would be at market exchange rates and, when claim payment lags are incorporated into the process, would logically occur during the month of claim payment.

In this situation, the Table 7 and 8 local-currency ratios would be affected by the payment lag. The exchange rate applied to produce local-currency benefit payments would, on average, be that for a date several months after the incurral month instead of for the incurral month as shown in the tables. Given that the uncertainty in future exchange rates increases as the time lengthens from the present, the application of market exchange rates determined by claim payment dates to generate these local-currency ratios would serve to increase the fluctuations and distortions in policy values that may result.

Longer claim payment lag patterns would tend to intensify the effect described in the prior paragraph, while faster runout would diminish this influence. In the limiting case for shorter lags, in which the payment date approaches the incurral date, the model values displayed in Tables 7 and 8 would be applicable.

To gain further insight into how the specific policy design determines the effect of the exchange rates on the financial parameters, the claim runout influence can be examined in the context of changing the policy design B and C methods for converting local-currency expenses to dollars in the claim adjudication process. These modified products would apply a market exchange rate based upon the paid month, rather than the incurral month, to produce dollar expenses for application of the benefit formula.

In this situation the Table 6 dollar loss ratios would be affected by the application of market exchange rates that would tend to be for later times than those defined by incurral months. If the local currency were devaluating against the dollar, the dollar loss ratios would decrease in comparison to the original values, while an appreciation in the local currency would result in higher dollar loss ratios.

Of course, the longer the claim lags and the greater the rate of change of the relative currency values, the more pronounced the effect on the financial results.

Interestingly, for the modified policy designs B and C, the local currency statistics in Tables 7 and 8 will not be significantly affected because the exchange rate effectively cancels out in the double currency conversion process. This results from the fact that, regardless of whether the local-currency incurred medical expenses are expressed in dollars via multiplications by market rates defined by incurral or paid months, following the application of the plan benefit formula the identical exchange rate is used to convert the dollar benefit back into the local currency. In fact, if it were not for the leveraging effect of the $500 deductible, the dollar benefit paid converted

back to local currency would be independent of the exchange rate utilized in the claim calculation process.

D. Experience Rated Versus Manually Rated Products

What is the impact of deviations in actual compared to expected currency exchange rates for insurance products that have been experience-rated (for example, group cases), versus those with a manual or tabular rating foundation?

The potential for exchange rate deviations to distort financial results and internal expected product relationships exists equally for medical plans with both techniques of rate development. A key concept in this analysis is that the morbidity results for the group of covered lives have been accurately projected for the experience year in local currency. The dollar premiums charged are equal to the theoretically correct local premiums converted at either the expected rate for the entire year or the actual market exchange rate each month depending upon the policy design. Whether these exact local premiums were derived via an experience evaluation or a tabular rating basis is immaterial with respect to the currency exchange rate influence demonstrated in this paper.

E. HMO and Other Managed Care Products

From a practical perspective, the mixed-currency scenarios addressed in this paper are applicable to indemnity-style medical products and not to managed care programs featuring negotiated arrangements with providers. The currency influences arise from a medical plan that reimburses insureds on an expense incurred basis for covered charges generated in a different monetary unit. For a medical product to be subject to this situation, it almost by definition would have to be a wide open indemnity-style plan designed to reimburse expenses regardless of incurral location and without an emphasis on the provision of medical care in a limited geographical location close to the insured's residence.

Conversely, HMO and other managed care products with networks of participating providers are structured for medical care services in a limited area with convenient access for the covered population. In order for the same types of currency mismatches reviewed in this paper to occur in a managed care, fee-for-service arrangement outside of the U.S., the following financial arrangements would have to exist:

(a) Contracted providers would have fees negotiated in their native currency
(b) The actual plan reimbursement would be payable in dollars, with the amount determined by converting the fee at either the market or a fixed exchange rate
(c) Dollar premiums would be payable by the enrolled group for the coverage.

Obviously, such a managed care program would not exist in practice. The local care orientation of these network-focused products would always involve a single-currency environment.

X. CONCLUSION

This paper has attempted to analyze via a simplified, hypothetical model the dynamics of medical insurance coverage that is denominated in a currency other than that in which the medical expenses are incurred.

Three key summary financial ratios for the model portfolio were studied to determine their level of stability for five distinct potential policy designs in an environment in which the basic morbidity was accurately projected, but the currency exchange rates varied from the expected progression during the policy year. Four of the five policy designs displayed a lack of stability in one or more of these financial parameters and therefore demonstrated a vulnerability to fluctuations in currency exchange rates. Because this instability in these financial parameters either directly affects the financial performance of the portfolio or would be expected to significantly alter the underlying morbidity, these policy designs inherently contain an additional risk element of currency exchange rate fluctuation in addition to the typical medical insurance morbidity risk.

Policy design B, which involves monthly currency conversions at market exchange rates for both premium payments and claim computations, was the only plan structure for which all three financial ratios remained relatively stable for the various exchange rate scenarios. While none of the three ratios for policy design B was unaffected by the shifting currency relativities, the variation in the financial parameters was not nearly as substantial as for the most sensitive policy designs for each ratio, and none of the financial values was significantly distorted.

However, as previously pointed out, policy design B is the most difficult to administer, and it is less convenient and more difficult for the insured to understand due to currency conversion factors that are subject to change on

a monthly basis. Also, this policy design with dynamic values pegged to a foreign currency may face legal and regulatory barriers in some countries.

Following are several comments about the model used to study these scenarios:

(1) The analysis was presented in the context of a dollar-denominated plan operating in a country outside of the U.S. Actually, the same dynamics and considerations would apply in any mixed-currency situation, regardless of the specific countries and legal tenders involved.

(2) Substantial variations in the key financial parameters were shown to exist for four of the five policy designs due solely to the exchange rate influence. When this effect is combined with the potential differences that may occur in reality between the actual morbidity experienced and the expected morbidity level projected prior to the policy year, the financial results are subject to much greater fluctuation and uncertainty. Variations in morbidity may occur independently of, or be induced by, the exchange rate outcomes.

Additional analysis could be performed to study the compound effects of deviations of the actual compared to the expected experience with respect to both the exchange rates and the underlying morbidity.

(3) The model could be additionally refined by varying the trend rate assumed in the local currency charges according to the exchange rate patterns. It would be reasonable to expect that a country's internal rate of trend (that is, inflation) can be affected by differing relationships of its currency to that of other countries. In effect, recognition of this dynamic in the model would be one form of introducing changes into the underlying assumed morbidity.

(4) Other potential enhancements include lapse rates that vary according to changes in the financial ratios, and varying morbidity levels of the lapsing policyholders compared to those that persist in the portfolio.

(5) A fundamental assumption in the approach to the mixed-currency medical policy environment discussed in this paper is that the starting point for pricing one of these policies is a projection of the expected morbidity in the underlying local currency.

However, to the extent that these policies are priced in practice directly in a foreign currency, without good information regarding the actual local currency expected morbidity, the level of risk and uncertainty of the eventual financial performance of the portfolio is greatly magnified.

(6) To focus on the destabilizing influence of dual currencies, all the covered medical expenses in the model were assumed to be incurred in a

different medium of exchange than the policy. In practice, medical products designed for the international market are typically structured to pay benefits for covered expenses incurred both in dollars and in local currencies, depending upon the location at which the medical services are received. The same currency influences will occur for these products, but to a lesser degree than demonstrated in the model as the dollar portion of the covered expenses is matched with the currency in which the policy is denominated.

Given that a market exists for comprehensive medical insurance to cover expenses with significant portions incurred in more than one currency, what options and strategies might be available to an insurer to reduce the vulnerability of the financial results to swings in the relative values of the monetary units? Several possibilities along with potential advantages and disadvantages are briefly presented below.

Use of the shortest possible period over which policy values are fixed as a result of projected currency exchange rates reduces the risk of actual experience differing from expected due to the exchange rate influence. The longer the period for which currency exchange rates (as well as other pricing assumptions, of course) must be projected to determine expected values, the higher the probability of deviations within the projection interval and the greater the magnitude of the deviations.

Note that according to the financial ratios for policy designs A, C, and D in Tables 6, 7, and 8 and for policy design E in Table 11, the results differ only slightly from the targets when the progression of actual currency exchange rates is consistent with the expected values for the projection period.

Policy design B, which maintains all its internal financial relativities for all exchange rate outcomes, is a special case in which the plan is structured so that there is, in effect, no projection period with a fixed, expected exchange rate. Its premium and claim quantities self-adjust each month according to the actual market exchange rate patterns.

Administrative complexities and possibly regulatory restrictions may provide a lower bound for the interval over which a projected currency exchange rate must be utilized, forcing the insurer to accept the exchange rate risk for this period.

In situations in which there is a significant level of uncertainty about fluctuations in both directions of currency exchange rates, the pricing development could include a conservative assumption for the exchange rate progression during the projection interval, plus perhaps an extra explicit

margin in the rates. Certainly this would provide additional protection against deterioration in the financial performance of the portfolio resulting from unfavorable swings in the currency relativities.

To make such a conservatively priced product more salable and to avoid excessive lapsation, it could be offered on a participating basis such that dividends or refunds are distributed to policyholders if favorable financial results are realized. To the extent, however, that other companies may be willing to offer a lower-priced similar product on a nonparticipating basis, it could be difficult to market.

A natural issue in the context of international, multi-currency insurance coverages is the medium of exchange in which to invest the assets backing the portfolio's liabilities, and whether switching assets from one legal tender to another should form part of the company's investment strategy.

For the types of policies reviewed in this paper, the insurer is not required to convert the funds it handles from one currency to another, because all premiums are received in dollars and all claims are paid in dollars. The currency exchange risk borne by the insurer in these examples results from the medical expenses reimbursed by these policies being denominated in a non-dollar legal tender. In this environment, it would appear that the most straightforward approach would be to invest the assets supporting the reserves and surplus for this line of business in dollar instruments.

However, if periods can be accurately predicted during which a local currency will strengthen against the dollar and the expected internal rate of return on local currency assets plus the currency appreciation would produce significantly higher total returns than dollar-denominated assets, then it would be advantageous to convert dollar investments into local currency instruments. Such investment actions could entail significant risk and might prudently be limited to temporary periods under special circumstances. The dollar denomination of the policies studied in this paper would seem to require that, over the long term, the portfolio's liabilities and surplus be backed by dollar assets.

The most direct and probably the best technique for eliminating the types of currency exchange risk described herein is simply to avoid mixing currencies by structuring the policy or policies, so that coverage is explicitly and separately denominated in the major currencies in which expenses are expected to be incurred.

In a situation involving two principal mediums of exchange, dollars and a specific local currency, there would be a separate schedule of insurance and distinct premiums payable in both dollars and the local currency.

Although this might involve some administrative complications, there would never be a currency mismatch, because regardless of the locations in which the expenses were incurred, the schedule of insurance in the correct currency would generate a benefit with the proper relativity to the medical expenses. Furthermore, the rate level development in each currency would involve only the usual morbidity projection risk and not the additional uncertainty inherent in projecting the exchange rate throughout the guarantee period during which rates and other policy parameters are fixed.

DISCUSSION OF PRECEDING PAPER

FRANK E. FINKENBERG:

I would like to extend Kevin Law's consideration of mixed-currency medical plans into two areas: hedging and rate-making.

Currency Hedging

The currency risk analyzed in Mr. Law's paper is of limited duration. It is the risk that the exchange rate between the currency in which medical expenses are incurred (local currency, or LC in Mr. Law's analysis) and the currency in which the plan is denominated (U.S. dollars in Mr. Law's paper) will be different at the time claims are incurred from the exchange rate in effect at the time premiums are set. In countries with reasonably developed financial markets, this risk can be greatly reduced. It is not necessary that a futures market exist for the local currency, as long as relatively safe short-term debt instruments (bills or notes of a government, central bank, or other high-grade issuer) are available. The method is outlined below.

Under Mr. Law's assumption that the medical expenses in LC are accurately predicted, the insurer knows the benefits that would be payable month by month if the plan were denominated in LC. Under plan designs B and C, however, benefits in dollars are obtained by converting medical expenses from LC to dollars at the exchange rate at the time claims are incurred, and then applying a dollar deductible and coinsurance. To avoid currency gains or losses in this type of plan, the insurer could purchase notes denominated in LC, matched in amount and maturity to the expected monthly benefit outflow at today's exchange rate. At each note's maturity, its proceeds would be converted back to dollars at the then-current exchange rate. If LC appreciates against the dollar during the term of the note, more dollars will be obtained at maturity than the initial investment plus the expected interest; this offsets the additional dollar benefits payable that month resulting from the exchange rate shift. If LC depreciates, the loss on the hedging investment is offset by the exchange rate gain on the claims.

In a plan without a deductible or with a deductible in LC, the hedge described above would be perfect; the direct currency risk is eliminated. (As Mr. Law notes, an indirect currency risk exists under some designs: the adverse effect on morbidity of a high replacement ratio measured in LC. The above hedge does not remove this.) A hedged plan with a dollar deductible will still experience some currency gains or losses due to the

deductible's nonlinear effect on claims, although the fluctuations will be much smaller than an unhedged plan. In a rich medical plan with a reasonable calendar-year deductible, the remaining currency gains or losses are probably *de minimis.*

In practice a hedge is not needed for every month or every currency; restricting hedging to the currencies most important to the plan and grouping expected claims by quarter will likely yield quite an acceptable reduction of risk. The insurer should model various currency and hedging scenarios to determine the residual risk, and structure the hedge accordingly.

The above method involves committing capital to investments in LC. The insurer is compensated for this, of course, by interest received. In some currencies, as short-term interest rates tend to be higher than those in dollars, the hedge actually makes money for the insurer while reducing currency risk.

If there is a futures market in LC, advance commitment of assets is not needed; the insurer merely contracts to purchase the desired amounts of LC for delivery in the appropriate months. The futures contract is sold before the delivery date, so the insurer never actually holds LC. If there is an efficient market, the gain or loss on the transaction will be the same as if a direct investment had been made. The price paid for the futures contract must reflect any interest differential between the currencies; otherwise, one party would be better off using the direct investment method described above, and arbitrage would bring the futures price back into line.

The above discussion of hedging shows that direct or derivative investments in the currency in which claims are incurred reduces risk. I therefore disagree with Mr. Law's conclusion that plan assets should be invested in dollars. Not just plan assets, but an amount equivalent to the remaining claims of the policy term, should in effect be invested in LC, either directly or through futures contracts.

Mr. Law makes an exception to dollar investments where the local currency "can be accurately predicted" to strengthen. This is pure currency speculation, which is extraordinarily risky. The last 15 years have seen extreme volatility in currency markets, with sharp moves having little to do with underlying economic strength or purchasing power parity. The beauty of hedging is that it frees the insurer from any need to forecast currency values during the policy term.

Experience-Rated Premiums for Mixed-Currency Plans

Mr. Law stresses the "fundamental assumption" of his model that morbidity in local currency is accurately projected; he properly adds a strong caveat that, absent good data, risk is greatly magnified. The problem is that, in a plan with medical expenses incurred in a number of currencies, it is not practical to maintain and use local currency morbidity experience in the annual experience rating process. To do so would require, in effect, readjudicating all claims during the whole experience period each year, based on the latest exchange rates. If, on the other hand, premiums are based on experience kept in the plan's currency of account, out-of-date exchange rates will introduce distortions. Claims incurred when local currencies were stronger than now will artificially inflate the premium, and vice versa.

As consulting actuary for a worldwide group medical plan, I have addressed this problem by building a weighted index of historical exchange rates between the 15 currencies with the largest claim volume (comprising more than 82% of claims) and the plan currency (the dollar). This plan is large enough and stable enough that the simplifying assumption of a uniform distribution of claims in each currency over the year can be used. The weights, which can change each year, are the ratios of the dollar volume of claims in each currency in the index to the total dollar claims for the 15 currencies. The index is called the claim purchasing power index (CPPI), because it shows the relative strength of the dollar against the currencies in which medical expenses are incurred. If today's CPPI is 105 and that at time t was 100, it means the dollar "buys" 5% more in claims today than at time t.

For experience rating purposes, historical claims paid in dollars are adjusted to the latest available exchange rates by applying the ratio of the CPPI at the time claims were paid to the current CPPI. In the example of the last paragraph, the dollar claims of time t are multiplied by $100 \div 105$. The result closely approximates the effect of maintaining experience in each claim currency and readjudicating claims at current exchange rates.

The importance of this adjustment can be seen in the historical range of the CPPI for the plan. Just from 1990 through 1994, annual average CPPI values ranged from 82.8 to 101.3 (January $1995 = 100$). The use of unadjusted experience from this period, during which the dollar was on balance much weaker than at its end point, would greatly overstate the premium required to meet the plan's expected claims based on today's exchange rates. Conversely, using unadjusted experience from a period in which the dollar

was stronger than at its end point would understate the needed premium. The CPPI minimizes these errors without the need to maintain experience in many currencies and without overly complicating the rate-setting process.

(AUTHOR'S REVIEW OF DISCUSSION)

KEVIN M. LAW:

I thank Frank Finkenberg for his contribution to the subject of mixed-currency medical plans.

The currency-hedging technique described by Mr. Finkenberg would eliminate the direct dollar loss ratio risk for policy designs B and C, as he points out. This is particularly important for policy design C, since the structure of plan B effectively provides protection against all the types of distortions in the portfolio's financial parameters that are addressed in the paper.

The hedging strategy does not correct the indirect currency exchange rate risks resulting from the local currency comparisons of benefits paid to medical expenses incurred or of benefits paid to premium. These ratios would continue to experience deviations in actual results compared to expected values, potentially affecting the underlying morbidity level and the persistency of the portfolio.

The direct investment-hedging method (that is, without using futures contracts) would function best if the medical policies' premiums were paid annually in advance, rather than monthly. This would allow the premiums for the coverage to directly fund the claims payments, instead of initially using the company's surplus and later repaying it as the premium installments are paid during the year.

The hedging technique in effect substantially reduces the degree of currency mismatches in policy design C. This is consistent with my recommendation in the next to last paragraph of the paper for the "most direct and probably the best technique for eliminating the types of currency exchange risk described herein," which is to structure the policy directly in the major monetary unit(s) in which the medical expenses are expected to be incurred.

Mr. Finkenberg disagrees with my conclusion that plan assets are more appropriately invested in dollar instruments. I believe that this issue is more of a difference in context, than a divergence of opinion on the proper medium of exchange for the investments.

In the context of an insurer attempting to better match currencies via the hedging technique, I concur with Mr. Finkenberg's assertion that the assets required to fund the policies' remaining liabilities for the policy term be invested in LC-denominated assets. My analysis in the paper was in the context of an insurer that was not directly attempting to match currencies to reduce an exchange rate risk, but rather considering switching assets from one legal tender to another as part of an investment strategy. In the absence of a currency-matching plan, the prudent approach, in general, would be to maintain the portfolio assets in dollars, which is the currency in which the policy is denominated.

However, I am not certain that swapping currencies should be completely ruled out, although I do agree with Mr. Finkenberg that this can be extremely risky. Any endeavors of this nature should be limited and considered with extreme caution.

Mr. Finkenberg mentions at the beginning of the discussion that the currency risk analyzed in the paper is that the exchange rate between the currencies at the time claims are incurred will be different from that when the premiums are established. I would state this in a slightly different manner; the risk involves the actual market currency exchange rate deviating from the expected pattern as of the beginning of the period. Note that all the policy designs studied in the paper produce undistorted financial parameters for the expected progression of currency exchange rates during the interval, although the exchange rates at the end of the year differ by 25% from those at the beginning.

Finally, Mr. Finkenberg describes a workable, practical CPPI index method for adjusting prior claim experience from multiple currencies to a constant set of exchange rates: "historical claims paid in dollars are adjusted to the latest available exchange rates by applying the ratio of the CPPI at the time claims are paid to the current CPPI." I suggest that for prospective experience rating purposes, an additional step be incorporated to restate the claims according to a projected CPPI that corresponds to the expected exchange rates for the future period for which the new rate level will apply.

Once again, I thank Mr. Finkenberg for his comments and observations.