BEWARE OF MISMATCH!

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Introduction

To pique your interest and get your mind involved in the ideas to be discussed in this paper, let's start off with a short true/false quiz:

True	False	Statement
☐	☐	1. Suppose an insurance company writes a $1,000 policy, invests the cash at a risk-free 4% yield rate, and pays $990 of losses and expenses exactly one year later. There is no way the company can lose money on the deal.
☐	☐	2. Suppose the company in the previous question can buy a one-year 4% bond or a five-year 6% bond of the same quality. It will always be better off buying the longer bond, because this will maximize its average portfolio yield.
☐	☐	3. Suppose the company in the previous question is also guaranteed that it will have enough new premiums during the five-year period that its cash flow will be positive. It can thus hold the long bond to maturity. With this guarantee, the five-year bond is always the better investment.

The obvious answer is "True" in every case, right? Therefore, even if you don't know much about mismatch, you can probably guess that the correct answer is "False". (Otherwise, why would these questions have been included here?)

If you are interested in learning more about mismatch and in understanding why these statements are false, read on.

Definition

In general, the three statements above are false because of asset/liability mismatch. Mismatch exists when the timing of the cash flows needed to settle liabilities is not equal to the timing of the cash flows generated by the assets backing these liabilities.

Of course, if a company simply doesn't have enough assets to cover all its liabilities, it is in trouble no matter how you look at it. Because of mismatch, however, even a company with enough assets (in a true economic net value sense as well as a statutory accounting sense) may still not be safe if the maturities are different.

The characteristics and significance of asset/liability mismatch, and the falsity of the three quiz statements, will be illustrated using the simple numerical examples shown in attached Exhibits A through E.

Assumptions Underlying the Examples

The assumptions used to generate these examples are shown on the sheet immediately preceding Example A. A few additional remarks about some of the assumptions may also be helpful.

In each example, a new company begins operations on 1/1/2001. Thus, all balance sheet entries are $0 just before then. Thereafter, all earnings are retained and reinvested, so that the net worth of the company at subsequent dates shows the true, cumulative profit from the business it has written.

Losses were rigged so that all policies should yield the same 5% profit. That is, for every example, Line (3) is 5% of Line (2). Thus, all business has the same inherent profit potential, irrespective of the volume of business written or the year in which it was written.

How these assumptions operate can best be seen by working through the simplest case, Example A.

Example A

First consider the 2001 column. On 1/1/2001, the company writes a premium of $1,000, which was priced to produce a profit of 5%. Because interest rates are 4%, and the premium will be invested for one year before the loss is paid, the company expects $40 of investment income. Losses are $990, generating an underwriting profit of $10, for a total Expected Net Profit of $50 on Line (3).

On Line (13) of Example A, the $1,000 premium actually is invested at 4%. In this example, the maturity of the bond is matched to the timing of the loss payment; that is, the company buys a bond which will mature on 1/1/2002, the date on which the $990 loss must be paid.

Line (12) of the 2002 column shows that the company did in fact earn the expected $50 on this policy. It now invests this for one more year, this time at 6% because interest rates have increased. The principal of $50 plus the $3 of earned investment income are 1/1/2003 cash flows. This process continues until the company has a net worth of $71 in 1/1/2006.

Example B

Example B is identical to Example A except that the bond purchased on 1/1/2001 has a maturity of five years rather than one year.

This means that all cash flows in the 2001 column are the same. However, in Example B, on 1/1/2002, only $40 of investment income is available to pay the $990 loss. Thus, $950 must be borrowed, at the 2002 new money rate of 6%.

The company continues borrowing the needed cash for one year at a time until 1/1/2006 when the bond matures. But by then, the bond is not large enough to pay off the loan which has accumulated. Instead of making $71 on the policy, the company loses $152.

This total difference of $223 is due entirely to asset/liability mismatch; all other parts of Examples A and B are identical. In Example B, just as in Example A, the pricing assumptions were perfect. The amount and timing of the loss payments were exactly as expected. The company actually did earn 4% on its investment; no asset default occurred. The only reason the result in Example B is worse than that in Example A is the fact that the asset and liability maturities were not the same.

Example B demonstrates that the first quiz statement is false. This company would actually have been better off to have put the $1,000 premium in a shoe box rather than investing it for five years; at least it would have ended up with a $10 underwriting profit.

The $223 difference between Examples A and B is huge! This impact is so great, in fact, that it provides an illustration that quiz statement 2 is false. You might like to take a few minutes and play with Example B yourself and prove that even a 6% five-year bond (which a company might be tempted to buy rather than a 1-year bond with a lower, 4% yield rate) produces a net loss of $31 by 2006.

OBSERVATION: Mismatch risk can have a significant impact in addition to all of the risks inherent in pricing uncertainties, potential reserve shortages, asset defaults, etc.

Example C

This example is the same as Example A except that a new policy is written in each of five years. Not writing a sixth policy in 2006 enables us to run off the first five policies and reduce the company to a cash position of $305 as of 1/1/2006 for comparison with other examples.

Note on Line (3) that the five policies are all priced to produce the same 5% Expected Net Profit. Incurred losses increase over time, but higher investment income can be earned on the premium.

Example D

All the assumptions in Examples C and D are identical except that the original $1,000 4% bond purchased on 1/1/2001 matures in five years in Example D as opposed to one year in Example C. All other differences in the results are caused by this one change.

Observe in this case that the company did not have to borrow as in Example B. Instead, the new premiums coming in were used to pay the old claims. This ongoing book of business makes the mismatch risk less apparent than in Example B.

Nevertheless, the cost of the mismatch has not changed, as can be seen from a comparison of the net worth as of 1/1/2006:

1/1/2006 Net Worth

Example A:	(Single 2001 Policy, Matched)	+$71
Example B:	(Single 2001 Policy, Mismatched)	-152
	Net Mismatch Cost	$223
Example C:	(Five Policies, 2001 Matched)	+$305
Example D:	(Five Policies, 2001 Mismatched)	-82
	Net Mismatch Cost	$223

The net cost of mismatch in both pairs of examples is identical. The actual fact of whether or not the company actually borrowed cash rather than using new premiums to pay old losses does not make any difference.

OBSERVATION: Mismatch risk is not eliminated, nor even reduced, for a company which continues producing enough business to avoid borrowing or forced asset sales.

These examples demonstrate the falsity of quiz statement 3. Using new premiums to pay old losses simply obscures any mismatch situation which may exist, thereby making mismatch even more dangerous. A company can get into deep trouble for reasons it perceives as loss of premium volume, poor cash flow, or inability to price competitively due to a low portfolio yield rate. These are just the symptoms; mismatch is the real cause.

Example E

This example is the same as Example D with three exceptions. First, this company invests all cash (as opposed to 2001 cash) for five years.

Second, a total of six policies are written, and a total of eleven years of data are shown in order to allow time for all bonds and loans to become liquid so that a net worth position can more easily be determined.

Third, premiums grow at 10% per year during the ten years. This helps to cover up the mismatch in the short run, but of course cannot avoid the ultimate cost.

Observe that even though premiums continue to grow and all new business is priced on a basis which should make it profitable (Line (3) is still 5% of Line (2) as in the other examples), the company gets into a negative cash flow position in 2007. By 2011, instead of accumulating a large profit (as it would have if it had been matched), it ends up with a net loss of $7.

OBSERVATION: Even with a growing volume of business which "should be" profitable, a company investing its assets without giving appropriate consideration to the maturities of the corresponding liabilities may bear a substantial risk.

Relevance of These Examples

These examples are greatly simplified, and the scenario of interest rates rising continuously over a long period of time may be extreme.

On the other hand, it is a fact that interest rates were generally increasing from 1965 to 1981, and the average rate of increase from 1977 to 1981 did approximate 2% per year. In addition, companies commonly purchase assets with maturities of 15, 20, or 30 years rather than 5 years, which greatly increases mismatch risk for most property/casualty companies.

The examples, therefore, show not only the direction in which mismatch can operate but also give a rough feel for the magnitude of the impacts which are possible.

Does Mismatch Ever Help?

Mismatch risk is a true "risk" in a mathematical sense; "risk" implies variability and uncertainty, but the impact of the variation can be favorable as well as unfavorable.

In Examples A through E, for instance, if interest rates were decreasing rather than increasing, the company would benefit from being mismatched. Conversely, a company with 5-year liabilities and 1-year assets would be hurt by interest rate decreases and helped by increases.

Thus, on the average, mismatch impacts may balance out over time, provided the average can be taken over an extremely long period. In practice, however, companies must survive every year of a long period; the fact that some benefits were "just around the corner" is of little consolation to a company that never gets to the end of the current block.

For this reason, it may be appropriate for a company to forgo the possible benefits of being mismatched. That is, it may conclude that it already has enough risk due to its insurance underwriting business without voluntarily taking on additional risk through its investment operation by implicitly speculating in future interest rates.

Summary

Asset/liability mismatch can add a significant amount of risk to the earnings, and even to the solvency, of any property/casualty insurance company which has assets and liabilities with significantly different maturities.

Mismatch is insidious. Its cost is present even if a company does not literally have to sell assets or borrow cash; using current premiums from a growing volume of business to pay old claims does not eliminate mismatch. It is prudent for a company to make itself aware of its level of mismatch and to manage this risk as carefully and as consciously as it does any other risk associated with the insurance business.

ASSUMPTIONS COMMON TO ALL EXAMPLES

1. All balance sheet items are $0 as of 12/31/2000, just before the first premium is written.

2. All cash flows occur on January 1.

3. Premiums (written and earned) are $1,000 for 2001, the first year in which a policy is written.

4. Expenses are $0.

5. Losses are paid exactly 1 year after policy issue, and are such that each policy will yield a profit of 5% of premium, assuming investment income is earned at the new money rate in effect at the time the policy is issued.

6. Bonds purchased 1/1/2001 yield 4% interest. Yield rates increase 2% per year thereafter. Coupon interest on bonds is paid annually.

7. Loans are made for a period of one year, and interest is paid annually. Loan rates are the same as bond new money rates available at the same time.

8. FIT is ignored.

9. All earnings are retained and reinvested; no dividends are paid, no capital contributions are added to the company, etc.

ASSUMPTIONS WHICH VARY BY EXAMPLE

Example	Number of Policies	Premium Growth	Asset Life
A	1	0%	1 year
B	1	0	5 years
C	5	0	1 year
D	5	0	5 years *
E	6	10	5 years

* Initial 5-year bond; subsequent reinvestment for 1 year

EXAMPLE A
SINGLE POLICY--MATCHED

ASSUMPTIONS:	2001	2002	2003	2004	2005	2006
1) New Money Rate	4%	6%	8%	10%	12%	14%
2) Premium	1000	0	0	0	0	0
3) Expected Net Profit	50	0	0	0	0	0
4) Expected Inv. Income	40	0	0	0	0	0
5) Loss Incurred	990	0	0	0	0	0
CASH FLOWS (JAN 1):						
6) Premium	1000	0	0	0	0	0
7) Asset Maturity	0	1000	50	53	57	63
8) Investment Income	0	40	3	4	6	8
9) Losses Paid	0	-990	0	0	0	0
10) Loan Principal Due	0	0	0	0	0	0
11) Interest Paid	0	0	0	0	0	0
12) Cash Avail. for Inv.	1000	50	53	57	63	71
BONDS PURCHASED (JAN 1):						
13) Amount	1000	50	53	57	63	
14) Yield Rate	4%	6%	8%	10%	12%	
15) Annual Inv. Income	40	3	4	6	8	
16) Maturity Date	1/02	1/03	1/04	1/05	1/06	
MONEY BORROWED (JAN 1):						
17) Amount	0	0	0	0	0	
18) Interest Rate						
19) Annual Interest						
20) Loan Due						
21) NET WORTH ON 1/1/06						71

EXAMPLE B
SINGLE POLICY--MISMATCHED

ASSUMPTIONS:	2001	2002	2003	2004	2005	2006
1) New Money Rate	4%	6%	8%	10%	12%	14%
2) Premium	1000	0	0	0	0	0
3) Expected Net Profit	50	0	0	0	0	0
4) Expected Inv. Income	40	0	0	0	0	0
5) Loss Incurred	990	0	0	0	0	0
CASH FLOWS (JAN 1):						
6) Premium	1000	0	0	0	0	0
7) Asset Maturity	0	0	0	0	0	1000
8) Investment Income	0	40	40	40	40	40
9) Losses Paid	0	-990	0	0	0	0
10) Loan Principal Due	0	0	-950	-967	-1004	-1064
11) Interest Paid	0	0	-57	-77	-100	-128
12) Cash Avail. for Inv.	1000	-950	-967	-1004	-1064	-152
BONDS PURCHASED (JAN 1):						
13) Amount	1000	0	0	0	0	
14) Yield Rate	4%					
15) Annual Inv. Income	40					
16) Maturity Date	1/06					
MONEY BORROWED (JAN 1):						
17) Amount	0	950	967	1004	1064	
18) Interest Rate		6%	8%	10%	12%	
19) Annual Interest		57	77	100	128	
20) Loan Due		1/03	1/04	1/05	1/06	
21) NET WORTH ON 1/1/06						-152

EXAMPLE C
ANNUAL POLICIES--MATCHED

ASSUMPTIONS:	2001	2002	2003	2004	2005	2006
1) New Money Rate	4%	6%	8%	10%	12%	14%
2) Premium	1000	1000	1000	1000	1000	0
3) Expected Net Profit	50	50	50	50	50	0
4) Expected Inv. Income	40	60	80	100	120	0
5) Loss Incurred	990	1010	1030	1050	1070	0
CASH FLOWS (JAN 1):						
6) Premium	1000	1000	1000	1000	1000	0
7) Asset Maturity	0	1000	1050	1103	1161	1227
8) Investment Income	0	40	63	88	116	148
9) Losses Paid	0	-990	-1010	-1030	-1050	-1070
10) Loan Principal Due	0	0	0	0	0	0
11) Interest Paid	0	0	0	0	0	0
12) Cash Avail. for Inv.	1000	1050	1103	1161	1227	305
BONDS PURCHASED (JAN 1):						
13) Amount	1000	1050	1103	1161	1227	
14) Yield Rate	4%	6%	8%	10%	12%	
15) Annual Inv. Income	40	63	88	116	148	
16) Maturity Date	1/02	1/03	1/04	1/05	1/06	
MONEY BORROWED (JAN 1):						
17) Amount	0	0	0	0	0	
18) Interest Rate						
19) Annual Interest						
20) Loan Due						
21) NET WORTH ON 1/1/06						305

EXAMPLE D
ANNUAL POLICIES--MISMATCHED

ASSUMPTIONS:	2001	2002	2003	2004	2005	2006
1) New Money Rate	4%	6%	8%	10%	12%	14%
2) Premium	1000	1000	1000	1000	1000	0
3) Expected Net Profit	50	50	50	50	50	0
4) Expected Inv. Income	40	60	80	100	120	0
5) Loss Incurred	990	1010	1030	1050	1070	0
CASH FLOWS (JAN 1):						
6) Premium	1000	1000	1000	1000	1000	0
7) Asset Maturity	0	0	50	83	100	1100
8) Investment Income	0	40	43	47	50	52
9) Losses Paid	0	-990	-1010	-1030	-1050	-1070
10) Loan Principal Due	0	0	0	0	0	0
11) Interest Paid	0	0	0	0	0	0
12) Cash Avail. for Inv.	1000	50	83	100	100	82
BONDS PURCHASED (JAN 1):						
13) Amount	1000	50	83	100	100	
14) Yield Rate	4%	6%	8%	10%	12%	
15) Annual Inv. Income	40	3	7	10	12	
16) Maturity Date	1/06	1/03	1/04	1/05	1/06	
MONEY BORROWED (JAN 1):						
17) Amount	0	0	0	0	0	
18) Interest Rate						
19) Annual Interest						
20) Loan Due						
21) NET WORTH ON 1/1/06						82

EXAMPLE E
ANNUAL POLICIES--MISMATCHED--10% PREMIUM GROWTH

ASSUMPTIONS:	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1) New Money Rate	4%	6%	8%	10%	12%	14%	16%	18%	20%	22%	24%
2) Premium	1000	1100	1210	1331	1464	1610	0	0	0	0	0
3) Exp. Net Profit	50	55	61	67	73	81	0	0	0	0	0
4) Exp. Inv. Inc.	40	66	97	133	176	225	0	0	0	0	0
5) Loss Incurred	990	1111	1246	1397	1567	1754	0	0	0	0	0
CASH FLOWS (JAN 1):											
6) Premium	1000	1100	1210	1331	1464	1610	0	0	0	0	0
7) Asset Maturity	0	0	0	0	0	1000	150	148	146	143	1136
8) Inv. Income	0	40	49	61	76	93	212	203	191	176	159
9) Losses Paid	0	-990	-1111	-1246	-1397	-1567	-1754	0	0	0	0
10) Loan Princ. Due	0	0	0	0	0	0	0	-1392	-1264	-1155	-1067
11) Interest Paid	0	0	0	0	0	0	0	-223	-228	-231	-235
12) Cash for Inv.	1000	150	148	146	143	1136	-1392	-1264	-1155	-1067	-7
BONDS PURCHASED (JAN 1):											
13) Amount	1000	150	148	146	143	1136	0	0	0	0	
14) Yield Rate	4%	6%	8%	10%	12%	14%					
15) Annual Inv. Inc	40	9	12	15	17	159					
16) Maturity Date	1/06	1/07	1/08	1/09	1/10	1/11					
MONEY BORROWED (JAN 1):											
17) Amount	0	0	0	0	0	0	1392	1264	1155	1067	
18) Interest Rate							16%	18%	20%	22%	
19) Annual Interest							223	228	231	235	
20) Loan Due							1/08	1/09	1/10	1/11	
21) NET WORTH ON 1/1/13											-7

REPRINT OF AN OLD PLAY

In the interest of resurrecting classic documents, this issue of the Actuarial Forum reprints the script from a play presented in 1974 entitled "How To Succeed As An Actuary." We hope that you enjoy this lighthearted look at the world of the "big time" corporate actuary. With the 1989 anniversary meeting coming up, perhaps someone would have the talent and interest to adapt another play to an actuarial setting. How about it, all you creative actuaries?