Portfolio Adjustment in a Reinsurance Market*

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1. Introduction

The operation of the law of large numbers suggests that an insurance portfolio comprising a very large number of similar and independent policies will have a very low variance. The process of pooling risks, in the extreme case of a very large pool, will all but remove risk. Needless to say, the ideal conditions are rarely met. Some insurance funds contain too few risks to reduce portfolio variance to an acceptable level and others may contain a small number of risks which are large in relation to the total size of the pool. A third problem which may arise concerns the independence assumption. Climatic, or economic conditions may commonly influence a large number of policies thereby leading to "runs" of claims. To cope with these possibilities insurers commonly reinsure their portfolios, or selected policies within their portfolios with aim of improving the risk return characteristics. The volume of this reinsurance trade is substantial. In 1977, the total direct property-liability premium income in the Canadian market was just over four billion (Canadian) dollars. But from this direct trade an estimated 2.2 billion dollars of indirect trade emerged, in the form of reinsurance transactions between insurers. The purpose of this paper is to examine the portfolio effects of this trade on a sample of Canadian insurance companies.

2. A Portfolio model of an insurance company

The insurance transactions involve the payment of a premium to the insurer and the generation of a contingent liability to meet specified claims. These contingent liabilities are matched by reserve funds constructed from the premium income. The reserve funds in turn are available for investment in interest bearing assets within the bounds of regulatory constraints. The reserves may be quite considerable and may be held for a long time before the insured event dictates their liquidation. For example, with life insurance the contract may remain in force for decades. Non-life lines of insurance vary in the size of the reserve funds; with liability insurance the pace of legal process often

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slows down the payment of claims until several years after the receipt of the appropriate premiums, whereas in many simple property or accident insurances the claims on average follow prepaid premiums with a six to nine month delay.

The pre-payment of premiums and the generation of reserves to meet contractual liabilities has led some writers to view the insurer as a rather special form of levered investment company (e.g. Haugen and Kronke [2], Quirin and Waters [6], Biger and Kahane [1], Roy and Witt [8]). The insurer essentially “borrows” money from the insured in return for an uncertain future repayment. The terms of this “loan”, when averaged over the whole portfolio of policies, are given by the rate of underwriting profit or loss. Thus the insurer, who manages to meet claims payments plus expenses and is still left with a profit, has effectively borrowed money at negative rate of interest; the proceeds of this loan having been available to the insurer to invest in stocks, bonds or other interest bearing securities. There is some evidence for Canadian Companies that this process has enabled insurers to outperform mutual funds with similar investment portfolios (Quirin and Waters [6] and Quirin et.al. [7]), though an earlier U.S. study revealed that above market returns on insurance portfolios were offset by sub-market returns on the investment portfolio (Haugen and Kronke [3]).

The simultaneous optimization of the investment and insurance portfolios of an insurance company has been tackled as a problem in non-linear programming in studies by Quirin et.al. [7] and by Hofflander and Markle [5]. These illustrative studies show how the optimal insurance portfolio depends on the expected returns and variances of each of the insurance and investment lines and upon their covariances. Thus whilst “unsystematic” risk within any given line of insurance may be reduced to a low and tolerable level by the operation of the “law of large numbers” any breakdown of the independence assumption will leave a residual risk within the portfolio. The residual risk may be reduced in turn by combining this portfolio with other insurance and investment portfolios with which it has a low, or better still negative, correlations. The portfolio maximization problem being to select the optimal weights for each line of insurance and security.

The portfolio optimization can be presented as follows. The profit accruing to the insurer is made up from profit on the underwriting portfolio and profit from the investment portfolio.

$$(1) \quad \pi = rA + uP \quad \text{where} \quad \begin{array}{l} \pi = \text{total profit} \\ r = \text{rate of return on investments} \\ A = \text{investable assets} \\ P = \text{premium income} \\ u = \text{rate of underwriting profit} \end{array}$$

But investable assets comprise shareholders equity E (curiously labelled policy-holders surplus) and the reserve funds R generated from the insurance operation and from which future claims are paid.

$$(2) \quad A = (E + R) \quad \text{where} \quad \begin{array}{l} E = \text{shareholders equity} \\ R = \text{reserve funds} \end{array}$$

Substituting into (1) and expressing R as a proportional function of premiums

$$\pi = r(E + \alpha P) + uP$$

or expressing as a rate of return on shareholders equity.

$$(3) \quad \pi/E = r + r\alpha P/E + u P/E$$

Disaggregating between n securities held in the investment portfolio and m lines of insurance.

$$(4) \quad \pi/E = (1 + \alpha P/E) \sum_{i=1}^n w_i r_i + (P/E) \sum_{j=1}^m z_j u_j ; \quad \sum_i w_i = \sum_j z_j = 1$$

The efficient frontier can be calculated by selecting w_i and z_j to maximize the expected return on shareholders equity subject to a given variance.

Suppose the optimal portfolio frontier is identified : Would it then be plausible to expect all insurers to hold a portfolio on this frontier ? Not necessarily ! First, it may be noted that the optimal frontier may not be the same for all companies. Different pricing policies or levels of marketing, production or administrative efficiency imply that the optimum portfolio may not be constant over all companies. Furthermore there may be economies of specialization in one or a limited number of lines of insurance. Marketing economies may be reaped from promoting a single line; perhaps in terms of a specialised agency system. Technical or scale economies may be gained from specialisation in a single line, for example, boiler/machinery insurers need to maintain a force of engineers, liability insurers may develop particular skills in legal processes etc. The economies of specialization may operate against the advantages of maintaining a balanced portfolio. However, these economies operate largely on the portfolio which is directly underwritten by the insurer. Reinsurance contracts between insurers are predominately financial arrangements with little marketing input, relatively low administrative costs and the supply of few, if any, ancillary services requiring special technical expertise.

It might therefore be expected that whilst the insurer may be willing to hold a portfolio of direct policies which is suboptimal in order to reap economies of specialization he would seek to rectify the portfolio imbalance by maintaining a net outflow of reinsurance contracts on his line of specialization and a net inflow of contracts on other lines. In this way reinsurance would act as a secondary adjustment mechanism which would bring the insurer closer to the optimal portfolio.

This function for reinsurance fits well with descriptions of the uses of reinsurance given in insurance literature. A fairly typical statement is given by Johnson [4] who suggests that "historically, reinsurance performed only four basic functions :"

- (i) Financing i.e. the release of funds tied up in premium reserves.
- (ii) Stabilization of the portfolio by smoothing out claims/premium flows over time.
- (iii) Capacity i.e. to permit the direct insurer "to accept risks larger than its resources ordinarily would permit" and
- (iv) to protect against catastrophic losses arising from major disasters or accumulation of loss.

The second and fourth of these functions state directly that reinsurance is intended to improve the risk characteristics of the portfolio. Further, since the capacity of an insurer may be defined as the ability to absorb additional policies into

the portfolio whilst still maintaining acceptable risk/return characteristics for the portfolio as a whole then the third function is also concerned with portfolio stabilization. Only the first of the four functions is not concerned with stabilization though it is conceded that "If financing is the only reason for reinsurance it usually is an expensive one" (Johnson [4], p. 57). In the more general literature on capital market behavior, stability has its cost which can be measured in terms of the foregone expected return. It is therefore appropriate to measure the effects of reinsurance not only in terms of stability but also in terms of portfolio performance in risk/return space. This has been done in sections 4 and 5 below.

3. The sample data

Insurers operating in the Canadian property/liability insurance market may be divided into two categories (a) foreign companies which maintain head offices outside Canada and (b) companies registered in Canada. For foreign companies it might be thought that any portfolio balancing would be based on the international portfolio subject to the constraints imposed on transactions in the differing national markets and also to the restrictions imposed on the movement of funds. Consequently an examination of the Canadian transactions of foreign companies may not detect any meaningful portfolio adjustment. The sample used was therefore confined to companies registered in Canada. This sample still includes companies which are subsidiaries of expatriate companies though it is not clear *a priori* whether these are autonomous decision units or subject to central portfolio control by the parent. It was decided to retain these in the sample and to compare their reinsurance activity with those of the truly domestic companies.

A sample of twenty eight Canadian property-liability companies which were operating in the period 1975-77 was chosen as the initial sample. The companies were chosen on the basis of the size of their net property-liability portfolios : the largest 28 companies being chosen. This sample accounts for 70 % of the net premium income of Canadian companies and excludes only fairly small companies. In spite of the exclusion of small companies there is still a considerable size variation in the sample such that reinsurance strategies can be compared between large and small insurers. The sample comprises property and liability insurance underwriters. Although some of the insurers had life insurance portfolios the analysis was confined to the property-liability lines. Theoretically, there is no reason to exclude life insurance from the lines considered in devising the optimal portfolio. However, there are legal and organizational constraints which effectively separate long term business from the general lines being considered here.

The sample data include premiums and claims on the direct (i.e. before reinsurance) and net (i.e. after reinsurance) portfolio of each insurer disaggregated by line of business. Eight classes of business were used, property, accident and sickness, aircraft, automobile, boiler and machinery, guarantee, liability and marine. Data on returns are not directly observable by line of business nor are returns on the aggregate direct portfolio available. In order to estimate market returns by line, expense ratios (expenses to premiums) were

gleaned from several sources¹ and it was assumed that returns from reinsurance transactions for any given line of business were the same as the returns for net business in that line. Unless otherwise stated, data were extracted from the Annual Reports of the Superintendent of Insurance for Canada Volume I and II from 1964-1977.

4. The stabilizing effects of reinsurance

The simplest measure of the effectiveness of reinsurance in stabilizing insurance portfolios is to examine the historical variation in the direct and reinsured portfolios. The initial sample of companies was pruned to isolate only those companies which had been in operation in the Canadian market continuously since 1964. Companies which were mainly reinsurance companies were also excluded since their direct portfolios were small and relatively unimportant. This left twenty one companies. The aggregate claims and premiums² for each of these companies were recorded before and after reinsurance and the standard deviations of the claims premium ratios for the direct and reinsured portfolios were compared. It is hypothesized that the reinsured portfolio would exhibit greater stability which, with constancy of the expense ratio, implies greater stability of rates of return. Table 1 measures stability in rates of return by the standard deviations of the claims premium ratios for the sample companies. Data are shown for each of the three major lines (property, automobile and liability) and for the total property-liability portfolio; separate figures are shown on the direct (before reinsurance) and net (after reinsurance) portfolios³.

In eight of the twenty-one sample companies there is no appreciable difference in the stability of the overall property liability portfolio before and after reinsurance. For ten companies however the net portfolio displays a lower standard deviation and for three companies the net portfolio had a higher standard deviation. To test whether these changes in the standard deviations were significant a one tailed F test was used. The validity of these tests rests on the assumption that the distributions of returns before and after reinsurance are both normal. The results show that in six of the twenty one sample companies the net portfolio had a standard deviation which was significantly lower than

¹ Some of these were extracted from Quirin et.al. [7] Chapter 7). In other cases, particularly where the categories differ from those used by Quirin et.al., the overall expense ratios on net business of the three largest specialist insurers in that class were averaged to provide an estimate of the market expense ratio for that class. Attempts to break down the overall expense ratios into classes by cross section multiple regression did not produce meaningful results.

² The claims figures related to claims incurred in the insurance year. These include estimates of the values of claims which are incurred but not settled. Premiums compared are those received during the year (written premiums) rather than those earned during the year. Although the latter would be preferable, comparisons on this basis were not possible. Although the differences between written and earned premiums could be substantial during a period of rapid growth they do not cause a major problem in the current sample.

³ Although the sample was drawn from companies classified as Canadian in 1975/7, some (4) had operated in the Canadian market as foreign companies for the early part of the period before registering in Canada. In these cases there had been major disturbances in the claims ratios during the year of registration as existing contracts were "run off" with the foreign parent. Therefore data for the year of registration were not included for purposes of comparing the direct and reinsured portfolios.

Table 1 – Stability of direct and net portfolios
Standard deviations of claims/premium ratios

COMPANY	(1)		(2)		(3)		(4)	
	PROPERTY		AUTOMOBILE		LIABILITY		TOTAL P-L-PORTFOLIO	
	(a)Direct	(b)Net	(a)Direct	(b)Net	(a)Direct	(b)Net	(a)Direct	(b)Net
1	.08	.10	.11	.12	.49	.50	.07	.09
2	.11	.11	.09	.08	.29	* .17	.08	.08
3	.10	.11	.08	.07	.20	.17	.08	.08
4	.12	.12	.09	.08	.11	.15	.09	.09
5	.08	* .05	.06	.06	.19	* .12	.07	* .04
6	.11	.12	.09	.10	.11	.15	.09	.09
7	.13	.13	.08	.09	.30	.24	.08	.08
8	.19	* .43	.21	.16	.48	* 1.22	.20	* .12
9	.15	.15	.10	.10	.31	.21	.09	.09
10	.19	* .06	.08	* .05	.80	.74	.14	* .06
11	.12	.10	.08	.08	.10	.10	.07	.07
12	.08	.08	.08	.10	.16	.15	.07	.08
13	.17	* .07	.09	* .05	1.25	* .12	.14	* .05
14	.14	.10	.05	.07	.25	* .15	.09	.07
15	.13	.12	.09	.06	.40	.32	.08	* .05
16	.14	.09	.05	.06	.20	.16	.06	.05
17	.17	.12	.08	.06	.14	.11	.08	.07
18	.10	.11	.06	.06	.22	.16	.07	.07
19	.13	.09	.11	.12	.20	.16	.13	.10
20	.18	.18	.13	.13	.66	.66	.19	.16
21	.12	.09	.14	* .06	.21	.25	.11	* .06

Note : Companies 1 to 12 are domestically owned
 Companies 13 to 21 are foreign owned subsidiaries
 * Significant @ 5 % level

that for the direct portfolio at the 5 % confidence level. In no case was the standard deviation of the net distribution significantly higher than that of the direct distribution. The other side of the coin reveals that of the twenty one companies, fifteen (76 %) failed to achieve any significant change in stability by use of reinsurance facilities.

In attempting to explain the differences in the stabilizing effects of reinsurance three possibilities were sought. First, was the stabilising effect, if any, related to the volume of reinsurance transactions ? Secondly, were there any significant differences between Canadian and foreign owned companies ? And, third, were the stabilising effects related to the size of the company ? Various attempts were made to explain the results but no significant relationships were found. For example, one such result was a linear regression of the reduction in the standard deviation for each company (RED) on the total volume of reinsurance transactions (VOL), a dummy to separate domestic and foreign ownership (DUMMY) and direct premium income (PREM) which was used as a measure of size. The result was :

$$\text{RED} = -1.4 + 0.7\text{VOL} - 0.6\text{DUMMY} - 0.2\text{PREM} \quad R^2 = 0.012$$

(-1.1)
(0.2)
(-0.4)
(0.01)
(t values)

The absence of a statistically significant relationship between RED and VOL might indicate redundancy in the reinsurance transactions. For example, the total volume of reinsurance business as a percentage of direct premium income for the eight companies which had unchanged standard deviations for their property-liability portfolios averages 73 %.

A further observation which might be made is that, in spite of the casual observation from Table 1, that seven out of nine foreign subsidiaries had lower standard deviations on their net portfolios, against three of the twelve Canadian companies, no significant relationship could be found between the size of the reduction and ownership. There is no evidence here that Canadian companies are any more or any less effective in arranging their reinsurances than foreign owned companies. Nor is there any evidence that smaller companies, who have more to potentially gain from reinsurance in terms of large number diversification, have been any more successful than the larger companies.

Table 1 also shows the effects of reinsurance on the main lines within the P-L portfolio. Property, automobile and liability account for about 96 % of the P-L business of the sample companies. In the property and automobile lines the stabilizing effect of reinsurance is somewhat weaker. In ten companies, the net property insurance portfolios were more stable than the direct portfolio but in five companies the effects of reinsurance appear to be destabilizing. But the large majority of these changes were not significant at the 5 % level. In only three of the companies was there a significant increase in stability and in one company there was a significant destabilizing effect. In automobile insurance, reinsurance has led to a reduced standard deviation in nine companies but only three of these reductions were statistically significant. Reinsurance facilities are usually considered to be more important for liability insurance since the distribution of losses produces much more violent fluctuations in claims ratios than in other major lines. But although fourteen companies exhibit lower standard deviations on their net liability

portfolios only four of these companies managed to achieve a statistically significant improvement in stability and one company shows a significant destabilizing effect. There is some evidence that some of the sample insurers appear to be consistently more effective in stabilizing their insurance portfolios than others. The correlation coefficient between the values of the reductions in the standard deviations for property and liability business (i.e. the two lines in which reinsurance has had the most success in increasing stability) is 0.766. However, the correlation between other combinations, property-automobile and automobile-liability, are not statistically significant at the 5 % level.

In summary, reinsurance appears to have some effect in reducing risk in property-liability insurance lines though statistically significant results were only observed for a small minority of the sample companies. There is some noticeable variation in the effects of reinsurance between different lines. For automobile, the sample is not far short of being equally divided between those companies for whom reinsurance was stabilising and those for whom it was destabilising. The stabilising effects are stronger in the more volatile liability insurance.

5. The effects of portfolio adjustment

The analysis so far has been restricted in two ways. First, only the effects on the insurance portfolio have been considered and, second, attention has been given only to the primary hypothesis that reinsurance reduces portfolio risk rather than the secondary hypothesis that reinsurance may be used to improve performance in risk/return space. It was not possible to measure historical performance of individual companies since data on direct returns by company were not available. However, it is possible to measure the effects of portfolio adjustments through reinsurance on expected performance if a reasonable hypothesis about expectations can be formulated. Thus, it is assumed that individual companies substitute aggregate market data on returns/variances/covariances into their decision function. Further, since returns on each line of direct business are not observable, they are assumed to be equal to the net returns for that line : (i.e. the effects of competitive process equalize returns on direct and reinsurance transactions within each line of business), though returns differ between different lines. These assumptions enable us to estimate the effects of changes in the composition of the insurance portfolio brought about by reinsurance on expected portfolio performance.

Table 2 shows the Sharpe performance measures for the sample companies based on expected performance before and after reinsurance⁴. Results are shown for portfolio adjustments in 1975, 1976 and 1977; in each case the market data for the preceding part of the sample period was used to estimate the mean returns, variances etc. The

⁴The Sharpe measure is defined as :
$$\frac{\bar{r}_p - r_f}{S_p}$$

where : $\bar{r}_p$ = the expected portfolio return
 r_f = the return on one year Federal Government Bonds for the year
 S_p = the portfolio standard deviation.

Table 2 – Sharpe performance measures

Company	1975		1976		1977	
	Direct	Net	Direct	Net	Direct	Net
1	.117	.115	.117	.115	.076	.079
2	.125	.128	.142	.150	.145	.154
3	.120	.128	.127	.132	.128	.133
4	.122	.116	.154	.146	.156	.150
5	.097	.095	.086	.087	.095	.091
6	.128	.123	.126	.127	.134	.131
7	.145	.143	.121	.104	.127	.116
8	.098	.106	.099	.100	.124	.125
9	.129	.129	.114	.118	.139	.148
10	.120	.121	.130	.131	.124	.125
11	.103	.104	.103	.106	.120	.120
12	.093	.095	.117	.119	.124	.127
13	.124	.124	.131	.131	.139	.139
14	.084	.084	.120	.125	.116	.120
15	.142	.153	.129	.139	.129	.136
16	.121	.123	.132	.135	.131	.133
17	.114	.114	.108	.110	.122	.124
18	.085	.113	.112	.131	.136	.145
19	.133	.134	.153	.155	.175	.179
20	.148	.147	.141	.141	.132	.132
21	.235	.206	.242	.231	.217	.208
22	.117	.110	.118	.110	.119	.113
23	.106	.101	.139	.130	.141	.130
24	.120	.123	.131	.134	.132	.133
25	.124	.129	.083	.087	.159	.151
26	.112	.114	.111	.112	.114	.114
27	.125	.145	.110	.112	.123	.134
28	.125	.125	.135	.135	.126	.126
Mean	.122	.123	.126	.127	.132	.133

Companies with :

improved performance

14

19

15

similar performance

5

3

5

worse performance

9

6

8

results do suggest an overall improvement in performance with considerable more companies recording higher, rather than lower, performance on their net portfolios. However, the effects are relatively weak for, in each year, there was still a sizeable minority of companies recording lower performance on their portfolio. In addition, those which did record improvements as a result of reinsurance typically only sustained a small improvement. This is revealed by the mean performance measures for the direct and the net portfolios of the sample companies which record only a marginal improvement through reinsurance.

As a check on the Sharpe performance measure a second performance measure was also used to detect portfolio improvement through reinsurance. Since, the attainable frontier in risk return space may be non linear for any given premium equity ratio the Sharpe measure may accordingly introduce bias (against high risk portfolios if the frontier is concave downwards). The efficient frontier was therefore calculated by an analytical method and the constant variance distances (i.e. vertical distances) from the frontier for the direct and net portfolios were then calculated and compared. A portfolio improvement was defined as a shift towards the efficient frontier. The frontier thus identified is almost certainly over ambitious since (a) the technique does not capture the constraints facing insurance investment programmes and (b) identification of the frontier required the assumption of constant returns by line of business. (If a number of companies were to approach the frontier then they would all need to make major portfolio shifts towards one or two minor insurance lines; particularly guarantee insurance which has been highly profitable. This major shift in supply would then have price effects.) In spite of these problems the technique is probably useful for identifying directional changes in performance and Table 3 records the reduction in constant variance distance from the efficient frontier. For 1975, eighteen companies recorded an improvement in performance against seven which recorded a deterioration. In 1976 the figures are : nineteen improvements and eight deteriorations and 1977 seventeen improvements and eight deteriorations. In view of the problems of accurate identification of the frontier the sizes of these changes are probably unreliable. Though to check consistency with the Sharpe performance measures rank correlation coefficients were taken on performance improvement for each company as picked up by the respective measures. The results were :

1975	$r = 0.507$
1976	$r = 0.751$
1977	$r = 0.778$

6. Conclusion

The main conclusions of this paper appear to be as follows. The explicit purpose of reinsurance is to stabilize insurance portfolios. Our sample data suggests that for the majority of companies the effects of reinsurance did appear to be marginally stabilizing though (a) in very few cases were the results significant and (b) there was a sizeable minority of companies for whom reinsurance might well have been destabilizing.

The second result concerned the effects of changes in the composition of insurance portfolios by reinsurance on anticipated performance in risk/return space. Again the

Table 3 – Alternative performance measures
Change in constant variance distance
from efficient frontier

	1975	1976	1977
1	−0.45	−0.41	—
2	1.61	1.45	0.72
3	−2.85	1.47	0.82
4	0.98	−2.35	−1.46
5	—	—	—
6	−0.84	0.16	−0.29
7	0.84	−2.67	−1.54
8	1.27	0.18	0.04
9	−0.34	1.23	1.81
10	0.12	0.41	0.23
11	0.74	0.99	0.16
12	0.85	0.56	0.60
13	0.04	0.06	0.06
14	—	0.81	0.43
15	5.20	2.59	1.56
16	0.92	1.14	0.43
17	0.32	0.63	0.53
18	−1.34	−1.90	−1.64
19	0.71	1.22	6.43
20	−0.09	0.02	0
21	−4.46	−1.54	−0.26
22	—	−0.90	−0.59
23	0.39	−0.8	−0.73
24	0.91	1.12	0.27
25	4.00	0.45	−0.82
26	0.49	0.31	0.13
27	5.86	−0.8	1.11
28	1.02	0.08	0.11

results are far from conclusive. Using two separate performance measures, the majority of companies did record improvements in risk/return performance as a result of reinsurance though the improvement did appear to be of a minor nature and again there was a sizeable minority of the sample for which reinsurance appears to have produced adverse effects.

The analysis did require certain strong assumptions. Possibly the more important being those concerning the expense ratios for different lines of business and that the returns on net and direct underwriting in the same insurance line were identical. The somewhat inconclusive results might reflect the inappropriateness of these assumptions. It may also be that the objectives of reinsurance differ from those specified. For example, reinsurance may be used within a multinational company to transfer income between different tax locations. Insufficient information on the placing of reinsurance treaties precluded tests of this thesis. Alternatively, the use of variance may not fully capture the effects of risk as understood by insurance managers. Actuarial literature has been more concerned with the probability of 'ruin' which occurs when liabilities exceed available reserves. This may not be a serious restriction since an increase in variance would be associated with an increase in the probability of ruin in many of the types of distributions assumed in the actuarial literature. Failing these explanations, it would appear that the enormous volume of dollars changing hands in reinsurance transactions brings only small and uncertain benefits to those involved. Whether there are potential gains which are not being realised due to inefficiencies in the negotiation of reinsurance treaties or whether insurers are already sufficiently diversified that further major portfolio improvement becomes impossible, is unclear.

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