THE LEVERAGE CYCLE:

A CASE STUDY OF LEHMAN BROTHER'S BANKRUPTCY

By

OH, Jaeseung

THESIS

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ABSTRACT

THE LEVERAGE CYLCE

A Case study of the Lehman Brothers' Bankruptcy

By

Jae Seung Oh

The Lehman Brothers' bankruptcy caused negative impacts on the U.S. and other advanced economies and on the major stock markets across the globe. Though there is a number of a research paper dealing with the impacts of Lehman Brothers' bankruptcy on the global economic system, only a few research papers have dealt with the causes of Lehman Brothers' bankruptcy. This paper analyzes the causes of the Lehman Brothers' collapses on the view point of leverage cycle. Through looking at the financials of Lehman Brothers, this paper extracts the adequate indexes to represent leverage cycle of Lehman Brothers in particular. This paper examines the relationship between policy interest rate and a set of indicators of leverage cycle complied from the annual and quarterly reports of the company. Interest rate has been used as a major indicator to control the economy in the governor's perspective. Leverage cycle is more direct indicator to the company, as analyzed in Lehman Brothers' case. Consequently, this paper recommends leverage cycle needs to be considered as additional indicator to control the economy along with interest rate.

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I. Introduction

On September 15, 2008 Lehman Brothers filed for bankruptcy. The collapse of Lehman Brothers, the largest investment bank that has ever declared bankruptcy, has had a major impact among economies and in most stock market across the globe (Baldwin, 2009). Though the impact of Lehman Brothers' failure on the global financial market was critical, only a few research papers tried to find out the reason of Lehman Brothers' bankruptcy.

Paremla R Hurley and Richard E Hurley tried to find out the warning signals of the impending Lehman Brothers' Bankruptcy through analysis of Lehman Brothers' cash flow and applying Z-score bankruptcy prediction model developed by Altman (1968)[1]. Christopolus examined whether Lehman Brothers' collapse could have been foreseen using the CAMELS ratio[2].

These papers used several drivers to extract the valuable conclusion to figure out the reason of Lehman Brothers' collapse. This paper aims to make re-analysis to identify causes of Lehman Brothers' collapse based on the leverage cycle.

Geankoplos presented the importance of leverage cycle in his paper[3]. He explained that loose leverage makes asset prices go up because buyers can get easy credit and spend more, and this case also applies other way around[4]. Moreover Adrian and Shin made evidences to support Geankoplo's hypotheses using analysis of major financial intermediaries' leverage[5].

This paper's objective is to find out whether leverage is related to the cause of Lehman Brothers' collapse following the orders as below.

- Analysis of trends of the Lehman Brothers' balance sheet compositions
- Representation of the indexes or indicators which explain leverage cycle based on the analysis of the Lehman Brothers.

After this, this paper tries to identify relationship between market index and leverage indexes. If market indexes cause leverage indexes, leverage indexes would deserve to be additional factors to monitor economy at the policy makers' perspective. The key findings are as below.

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[1] "Warning Signals of the Impeding Lehman Brothers' Bankruptcy Filing", Hurley and Hurley

[2] "Could Lehman Brothers' Collapse Be Anticipated? An Examination Using CAMELS Rating System", Christopolus (2011)

[3] "SOLVING THE PRESENT CRISIS AND MANAGING THE LEVERAGE CYCLE", Geanakoplos (2010)

[4] Ibid.

[5] "Liquidity and leverage", Adrian and Shin (2010)

- Market yield of 1-year U.S. treasury securities caused changes of composition of funding resources.
- Market yield of 10-year U.S treasury securities caused changes of investment on mortgages.

II. Leverage Cycle

Conventional monetary policy focuses on monitoring and adjusting interest rate to make stable financial market and prevent market from freezing. But seeing the loan market, people tends to pay interest but cannot or is not willing to pay the principals when the value of collaterals of the loan falls under the expecting paying amount. i.e. principals of the loans. Therefore, collaterals' importance should not be undervalued compared to the interest rate in monetary policy and the financial market.

Generally, the value of collaterals has negative relation with the leverage ratio. To make it easily understood, here presents the simple case[6]. One bought house amounting to 100 with the borrowing of 90 and equity of 10. The leverage at this stage is 10 (house 100 / equity 10). When the value of the house, which is collateral to the borrowing, goes up 110, the leverage is falling down to 5.5 (house 110/ equity 20, equity 20 is calculated as house 100 minus borrowing 90). This can be also interpreted as the burden of borrower becomes smaller, which also makes motivation of paying back of principals to borrower.

But this general case is not applied to financial institutions, including banks, financial intermediaries. Adrian and Shin presented that there is positive relationship between change of price of assets and leverage in the financial intermediaries' case. To make it easily understood, here presents another simple case[7]. One (company) bought security amounting to 100 with the borrowing of 90 and equity of 10. The leverage at this stage is 10 (security 100 / equity 10). When the value of the security, which is collateral to the borrowing, goes up to 100, the leverage is going up to 11 (security 110 / equity 10, equity 10 is calculated as security 100 minus borrowing 100). The difference from the general case stated above is that financial intermediaries increase the borrowing to purchase the more attractive security (the price of security went up).

Geanakoplo tried to figure out the reason of the financial crisis. He emphasized wrong management of leverage in financial institution is the one of main causes. He classified the crisis stages as below[8]:

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[6] "Liquidity and leverage", Adrian and Shin (2010)

[7] ibid

[8] "SOLVING THE PRESENT CRISIS AND MANAGING THE LEVERAGE CYCLE", Geanakoplos (2010)

▪ Bad news occurs

▪ Price goes down due the bad news.

▪ Falling prices makes credit losses to the optimistic buyers (borrowers).

▪ Lenders makes it faster to collect the loans to borrowers to prevent losses

▪ Borrowers tried to sell the collaterals, but this makes bulks of supply in the market, which makes the price goes down further.

▪ Borrowers becomes harder to sell the collaterals in the market, and easy to go bankrupt.

In these crisis stages, the very first step is bad news and falling down of the price. There were 2 bad news: falling of house price and increasing delinquency of securities backed by mortgage. And this bas news are initially caused by expansion of leverage.

When the financial institutions are willing to lend money or is expending the plan to volumes of lending, it becomes easier for borrowers to lend money. This attracts borrowers to buy a bigger houses with less money of his own. Even the passive buyers are lured to buy houses, which he did plan to buy in fact, with easy borrowing. This makes bigger demand of house in the market, even there is limit of supply, which naturally increases the price of house further. Increased gap between demand and supply makes people consider that the price of house would fall rapidly, which is completely rational reason.

In addition, this bad news also affected the payment of securities backed by mortgage. In the market, the delinquency of these securities became worse, but not impaired. Market cannot conclude that the securities would go bankrupt. But the suspicion caused by uncertainty (more delinquency, but no exact reasons) makes the bad expectation on the market.

High demand of the houses but low supply of the houses, and increased delinquency of securities are the bad news which initiated the crisis stages stated above. This bad news is originated by the expansion of leverage. That is, leverage cycle is critically important in the financial market and should be considered in the monetary policy.

III. Trend of the Lehman's Balance Sheet Compositions

To begin with the analysis of the leverage cycle, I examined the quarterly changes in the balance sheets of Lehman Brothers as described in Table 1. The data are from the regulatory filings with the U.S. Securities and Exchanges Commission (SEC) on their 10-K and 10-Q forms.

Table 1 Samples

Year	Samples
1992 – 1993	Year-end Financials (as of 31, December)
1994	Q1 (as of 31, March)
	Q2 (as of 30, June)
	Q3 (as of 31, August)
	Q4 (as of 30, November)*
1995 – 2008	1995Q1 – 2008Q2

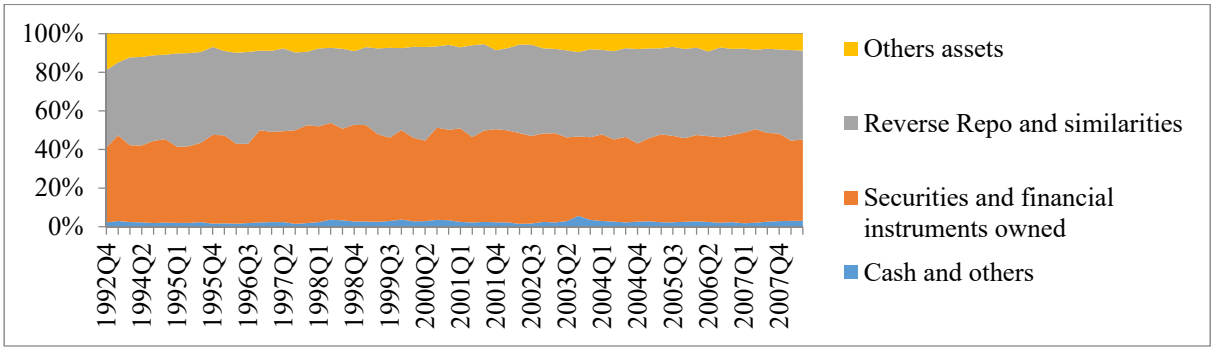
* Note that Lehman Brothers changed their year-end to as of 30 November at 1994.

The balance sheet of Lehman Brothers can be stylized as follows

Assets	Liabilities
Cash and others	Short term borrowings
Securities and financial instruments owned	Securities and financial instruments sold but not yet purchased
Reverse Repo and similarities	Repos and similarities
Other assets	Long term debts
	Other liabilities
	Shareholders' equity

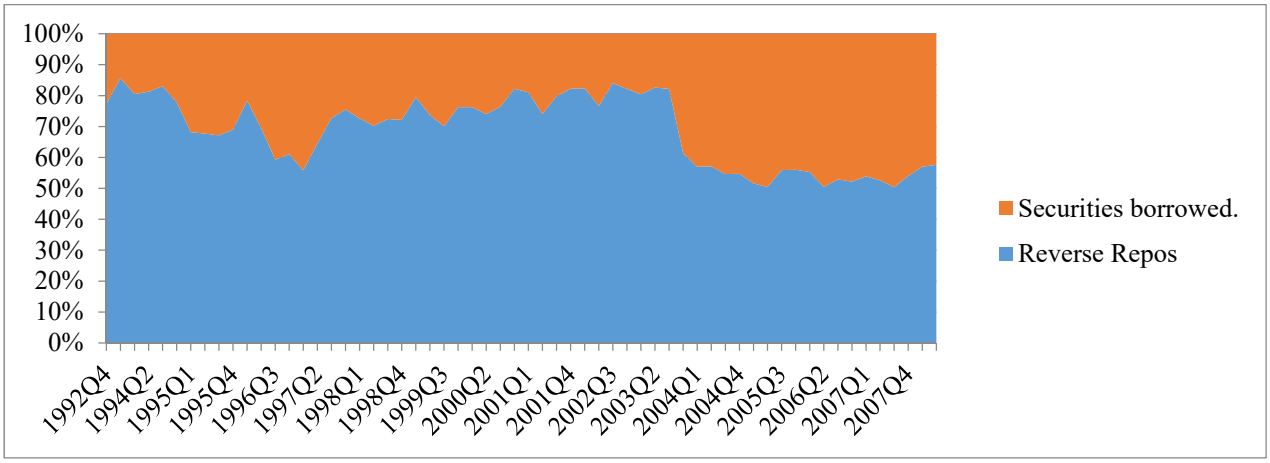
On the asset side, securities and financial instruments owned are valued at market prices, or reverse repos and similarities for which the discrepancy between face value and market value are very small due to the very short term borrowing. The majorities of assets are securities and financial instrument owned and reverse repos and similarities as described in Fig. 1.

Fig. 1 Total assets



Reverse repos and similarities are approximately 45% and securities and financial instruments owned are approximately 45% of total assets during the tested periods. Reverse repos and similarities consist of reverse repos as described at Fig. 2.

Fig. 2 Reverse repos and similarities



The last period before Lehman Brothers' bankruptcy, securities borrowed increased dramatically. The key difference between reverse repos and securities borrowed is that reverse repos is for general collateral whereas securities borrowed is typically driven by the need to borrow securities. Looking at the change of the composition of securities and financial instruments, the securities' portion had been decreased, whereas the portion of mortgage and mortgage-backed increased as described at Fig.3. This implies that Lehman Brothers wanted to use securities for the collateral but did not want to use mortgage-backed assets for collaterals, of which profits exceeded the overall profit from securities.

That is, Lehman Brothers increased the securities for the loans which are deemed to resell, but decreased other financial instruments for the loans which are deeded to resell. The last period of Lehman Brothers' bankruptcy showed the increase of return rate of subprime mortgage as described at Fig.4, which motivated Lehman Brothers to hold these financial instruments, rather than use of collateral to make loans.

On the liabilities side, repos and similarities and securities and financial instruments are majorities as described at Fig.5. These liabilities are short term, of which market value is almost same as book value.

Repos and similarities is approximately 50%, though this number had been decreased, of total liabilities during the tested period. Repos and similarities consist of repos, securities loaned and other secured borrowing as described at Fig 6. Compared to reverse repos and similarities on asset side, repos and similarities represent repos in majority.

Fig. 3 Securities and other financial instruments owned.

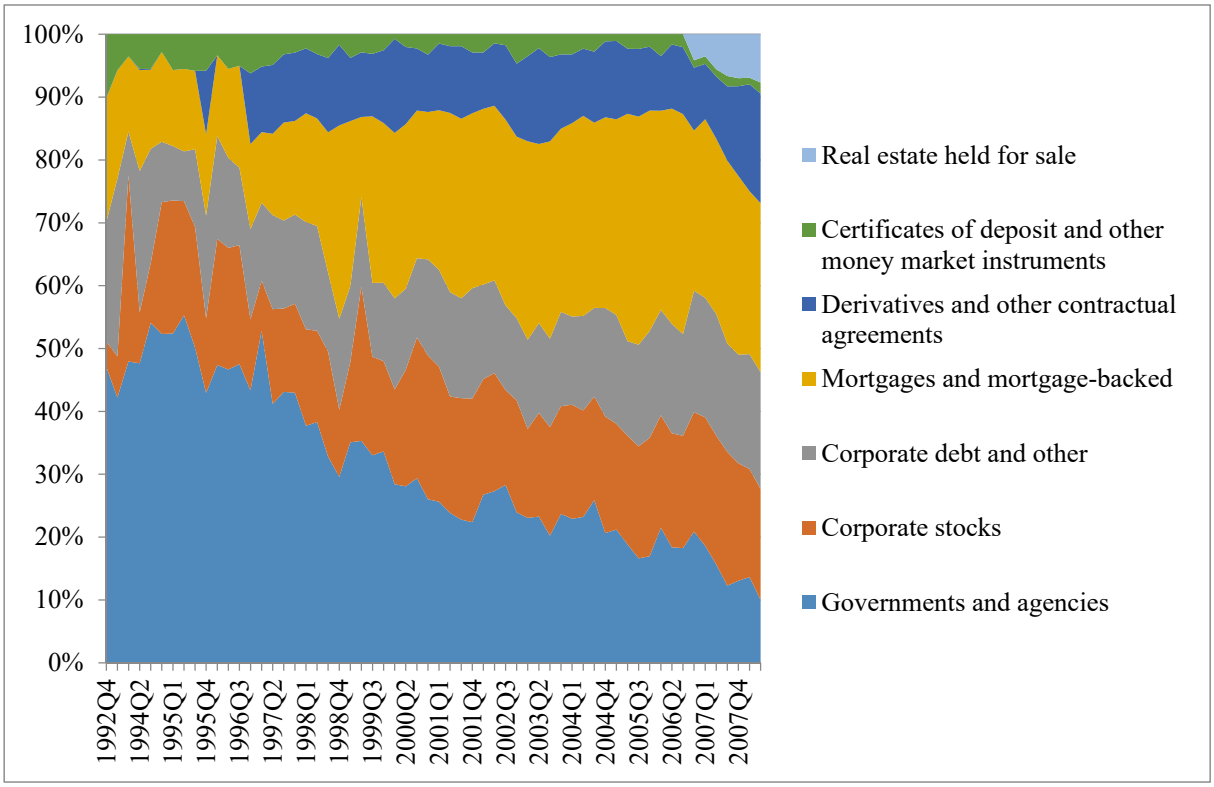
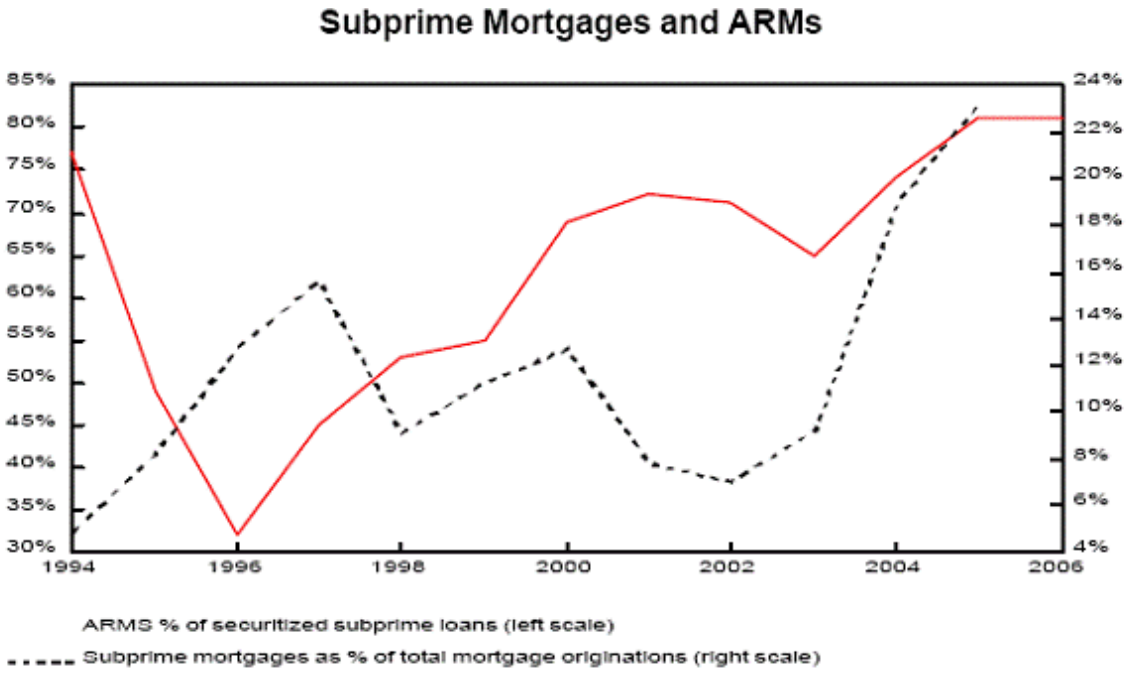


Fig. 4 Change of rate of subprime mortgage



Resource: The Coming collapse in housing by John Mauldin, Millennium Wave Advisors

Fig. 5 Total liabilities

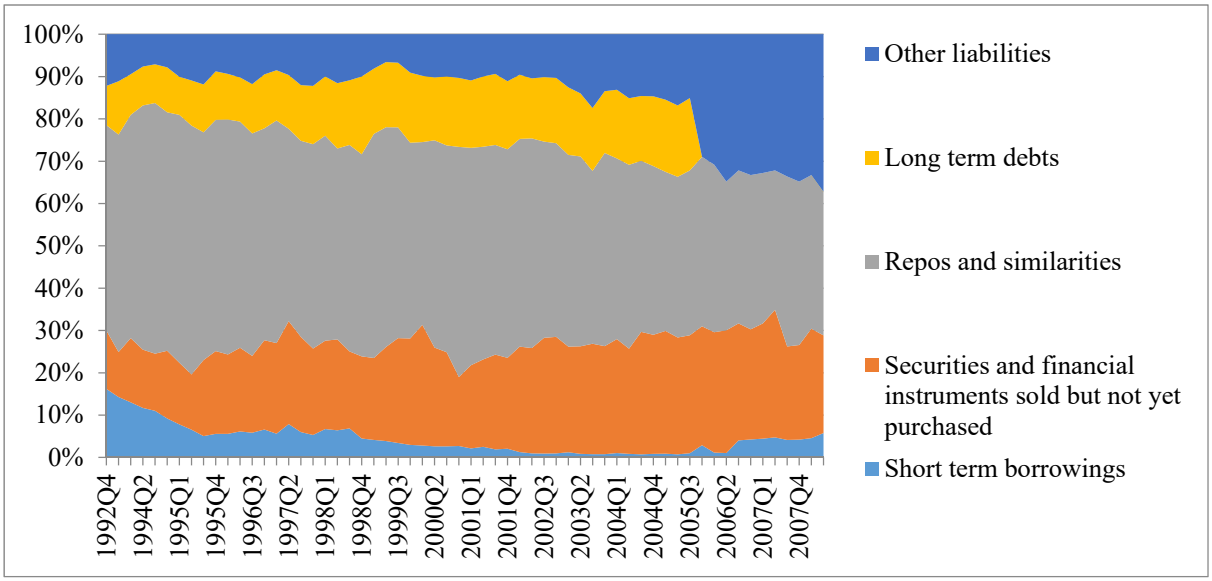
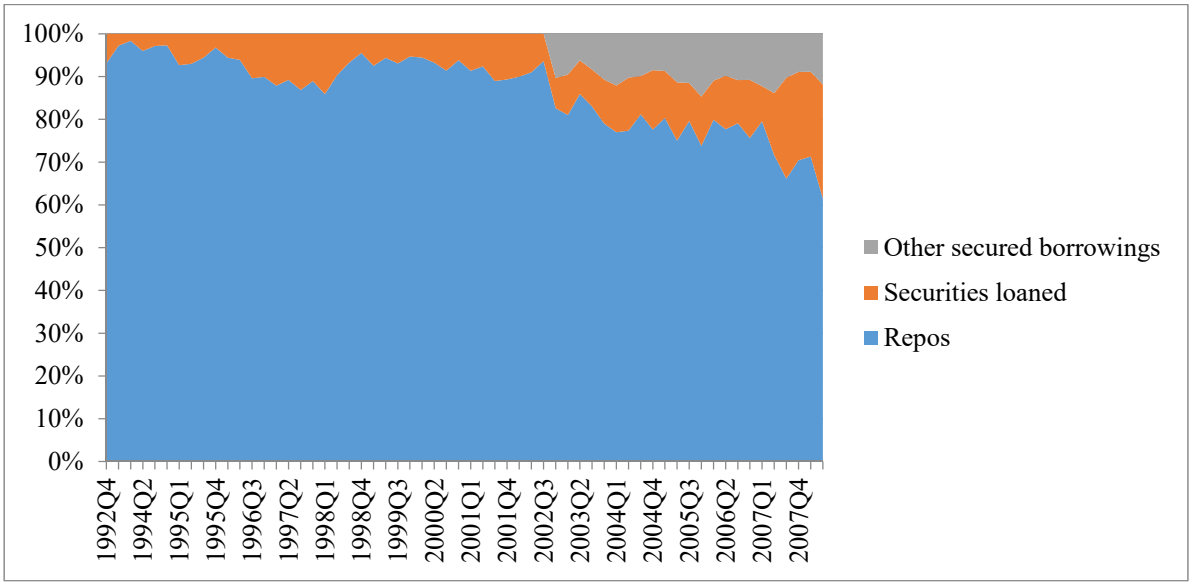
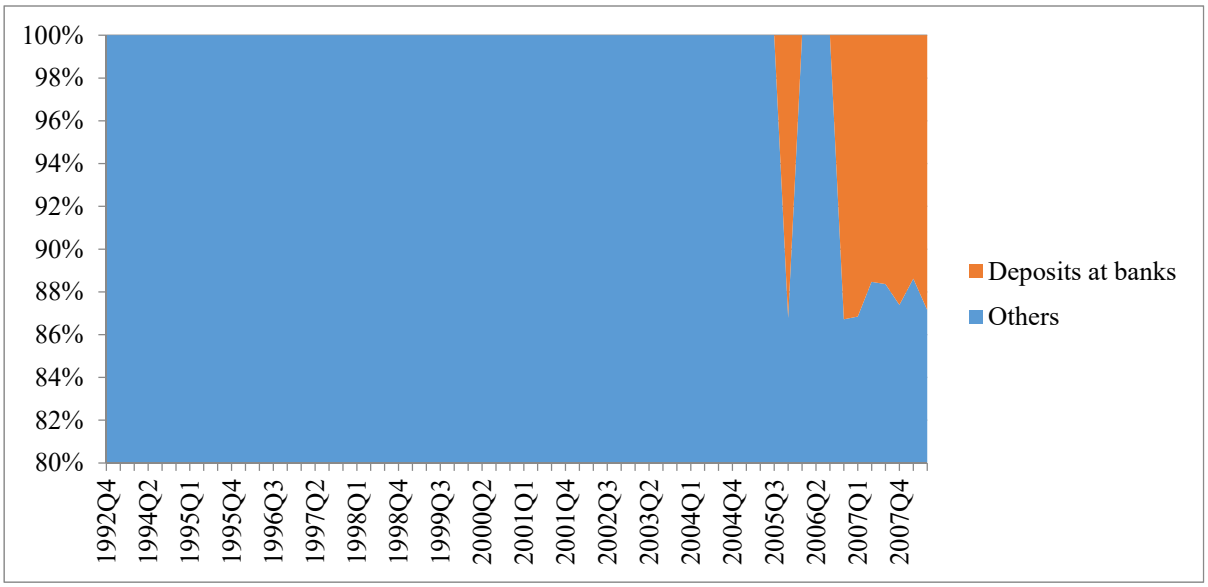


Fig. 6 Repos and similarities



Interestingly, from 2005 to 2008 there had been no long term debt but other liabilities increased dramatically. Lehman Brothers started using deposits in banks rather than using the long term debt as described at Fig. 7. Long-term debt is the financial instruments traded in the market. Therefore, the stop of using of long term debt at 2005 implies that Lehman Brothers' credibility in the market decreased or the management of Lehman Brothers considered not for long term strategy but short term strategy for the Company. Deposit at banks might needs more funding expenses, i.e. interest cost, but is easier to use than the debt in the market.

Fig. 7 Other liabilities



Looking at the assets and liabilities, it is found that short term liabilities had been used for resources to invest in assets. And the invested assets are also mostly for short term. For this reason, leverage change has effects on Lehman Brothers significantly for its life before bankruptcy.

IV. Index of leverage cycle

We have seen the financials of Lehman Brothers. And we found that Lehman Brothers uses short term resources and invested in short term assets. Then, which index would explain Lehman Brothers' leverage cycle?

1. Total assets per total equity

Conventionally, total assets per total equity had been used as leverage index. Total assets per total equity of Lehman Brothers for the tested periods are as follows.

Table 2 Total assets per total equity

	Obs	Mean	Std. Dev	Min	Max
Panel A: US$ million					
Total Assets (A)	60	274,906	166,305	80,474	786,035
Equity (B)	60	9,868	6,471	2,033	26,276
Index (A/B)	60	30.15	5.65	22	55
Panel B: Quarterly Change					
Total Assets	59	3.82%	8..61%	-19.46%	39.51%
Index	59	-0.12%	10.3%	-35.16%	40.82%

To explain the leverage cycle, the index should be any explainable relationship with the growth or change of the Company, as mentioned by Geanakplos in his report, SOLVING THE PRESENT CRISIS AND MANAGSING THE LEVERAGE CYCLE. The first look of the relationship is represented at Fig 8.

Fig. 8 Total Assets and leverage

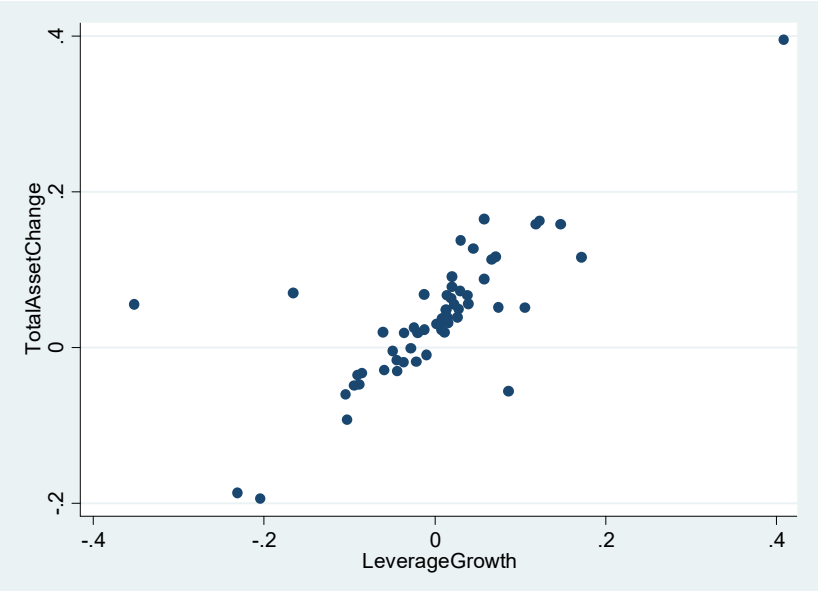


Table 3 shows the results of a regression for the change in leverage.

Table 3 leverage regression (index1)

: Dependent variable (total assets' change) / independent variable (leverage's change)

		Total assets (quarterly change)
Leverage's Change	Coef.	.6375
	p-value	0.00
Constant	Coef.	.0390
	p-value	0.00
Number of observation		59
R2		58.36%

As seen above, there is statically significant relationship between this index and total assets' change. The coefficient is positive, which means that Lehman Brothers used more leverage to increase their assets.

In addition, it could be asked which relationship there is, between lagged leverage.

Table 4 Leverage regression with lagged leverage (index1)

: Dependent variable (leverage' change) / independent variable (lagged leverage's change)

		Leverage
Lagged leverage	Coef.	-.3179
	p-value	0.02
Constant	Coef.	-.0019
	p-value	0.88
Number of observation		58
R2		9.35%

As seen above, there is statically significant relationship between lagged leverage. The coefficient is negative, which means that Lehman Brothers decreased leverage's change when the lagged leverage's change is higher than expected. That is, Lehman Brothers managed leverage to maintain their target leverage.

2. Total assets excluding matched assets per total equity

As per Lehman Brothers' financial reporting, they represent this index is more meaningful for the reason as below.

Matched book represents a short-term interest rate arbitrage collateralized primarily by U.S. government and agency securities. Several nationally recognized rating agencies consider "securities purchased under agreements to resell" ("reverse repos") a proxy for

matched book assets. These rating agencies consider reverse repos to have a low risk profile, and when evaluating the Company's capital strength and financial ratios, exclude reverse repos in the calculation of total assets divided by total equity. Although there are other assets with similar risk characteristics on the Company's balance sheet, the exclusion of reverse repos from total assets in this calculation reflects the fact that these assets are matched against liabilities of a similar nature, and therefore require minimal amounts of capital support. Accordingly, the Company believes the ratio of total assets excluding matched book to total stockholders' equity to be a more meaningful measure of the Company's leverage.

Resource: Lehman Brothers' 10-Q filings

This index follows Lehman Brothers' approach, which matched assets are reverse repos

Table 5 Total assets excluding matched assets per total equity

	Obs	Mean	Std. Dev	Min	Max
Panel A: US$ million					
Total Assets excluding matched assets (A)	60	196,608	130,438	54,428	575,869
Equity (B)	60	9,868	6,471	2,033	26,276
Index (A/B)	60	20.96	3.70	15.50	34.99
Panel B: Quarterly Change					
Total Assets excluding matched assets (A)	59	3.82%	8..61%	-19.46%	39.51%
Index	59	-0.09%	9.51%	-35.79%	31.94%

Table 6 shows the results of a regression for the change in leverage

Table 6 leverage regression

: Dependent variable (total assets' change) / independent variable (leverage's change)

		Total assets (quarterly change)
Leverage's Change	Coef.	.6205
	p-value	0.00
Constant	Coef.	0.038
	p-value	0.00
Number of observation		59
R2		47.06%

This index's regression shows very similar result to the index represented as total assets per total equity described 1) above. The difference is that the coefficient of this index is slightly smaller than the index described 1).

But as we have seen at the financials, reverse repos are not immaterial assets in quantitative respect. Unless the change of reverse repos is not related to the change of total assets, it is hardly to say that reverse repos could be removed in considering leverage.

Table 7 regression between total assets and reverse repos

: Dependent variable (total assets' change) / independent variable (Reverse repos' change)

		Total assets (quarterly change)
Reverse repos' Change	Coef.	.4926
	p-value	0.00
Constant	Coef.	.0179
	p-value	0.01
Number of observation		59
R2		66.48%

As seen above, total assets' change is strongly correlated to reverse repos' change. Therefore, this is hardly to say the reverse repos are necessarily to be removed in calculating leverage.

3. Repos per total funding resources

We have seen that repos are significant resources funding at financials' analysis 1 above. This implies that repos play significantly for Lehman Brothers to decide the change of assets.

Funding resource are short term borrowing, repos, securities loaned, other secured borrowing and long term debts. Securities and financial instruments sold but not yet purchased is hardly to be regarded as funding resources, because this is not for investment.

Table 8 Repos per total funding resources

	Obs	Mean	Std. Dev	Min	Max
Panel A: US$ million					
Repos(A)	60	95,200	33,257	37,437	197,128
Total funding resources (B)	60	148,239	55,783	61,321	311,038
Index (A/B)	60	.651	.060	.512	.776
Panel B: Quarterly Change					
Total Assets	59	3.82%	8..61%	-19.46%	39.51%
Index	59	-0.06%	6.29%	-17.06%	25.56%

Table 9 shows the results of a regression for the change in leverage.

Table 9 regression between total assets and index (index2)

: Dependent variable (total assets' change) / independent variable (leverage's change)

		Total assets (quarterly change)
Leverage' Change	Coef.	.4369
	p-value	0.01
Constant	Coef.	.0384
	p-value	0.00
Number of observation		59
R2		10.22%

As seen above, there is statically significant relationship between this index and total assets' change. The coefficient is positive, which means that Lehman Brothers used more repos in total funding resources to increase their assets.

In addition, it could be asked which relationship there is, between lagged leverage.

Table 10 Leverage regression with lagged leverage (index2)

: Dependent variable (leverage' change) / independent variable (lagged leverage's change)

		Leverage
Lagged leverage	Coef.	0206
	p-value	0.14
Constant	Coef.	-.0018
	p-value	0.818
Number of observation		58
R2		3.77%

As seen above, there is no statically significant relationship between lagged leverage. Therefore, it is interpreted that Lehman Brothers did not consider management of repos in their operation. Instead, Lehman Brothers considered repos as one of the instruments to manage the total assets per total equity.

4. Mortgage per repos

We have seen that last period before bankruptcy, Lehman Brothers increased mortgage in their assets and decreased use of mortgage as the collateral of loans at the financials' analysis 1 above. Repos are the major and significant funding resources, which is also used to invest in the mortgage. Considering the increase and significance of mortgage in Lehman Brothers' financial before bankruptcy, this index can be considered as index of leverage.

Table 11 Mortgage per repos

	Obs	Mean	Std. Dev	Min	Max
Panel A: US$ million					
Mortgage (A)	60	32,683	24,397	5,328	89,106
Repos (B)	60	95,200	33,257	37,437	197,128
Index (A/B)	60	.302	.152	.090	.588
Panel B: Quarterly Change					
Total Assets	59	3.82%	8..61%	-19.46%	39.51%
Index	59	0.44%	23.0%	-56.15%	110.0%

Table 12 shows the results of a regression for the change in leverage.

Table 12 regression between total assets and index (index3)

: Dependent variable (total assets' change) / independent variable (leverage's change)

		Total assets (quarterly change)
Leverage' Change	Coef.	-.1703
	p-value	0.00
Constant	Coef.	.0457
	p-value	0.00
Number of observation		59
R2		20.81%

As seen above, there is statically significant relationship between this index and total assets' change. The coefficient is negative, which means more Lehman Brothers used repo in investing mortgage, less Lehman Brothers increased their total assets.

Conclusion)

Indexes of leverage cycle are summarized as below:

Table 13 summary of IV

Index	Coef.	P-value	Reasonable?
Total assets per total equity	.6375	0.00	Reasonable
Total assets excluding matched assets per total equity	.6205	0.00	Unreasonable
Repos per total funding resources	.4369	0.01	Reasonable
Mortgage per repos	-.1703	0.00	Reasonable

'Total assets per total equity' is positive relationship with the total assets' change. Lehman Brothers increased this index to increase their assets

'Total assets excluding matched assets per total equity' is positive relationship with the total assets' change. But considering the strong relationship between reverse repos' change and total assets' change, it is not reasonable to exclude matched assets, i.e. reverse repos.

'Repos per total funding resources' is positive relationship with the total assets' change. Lehman Brothers increases this index to increase their assets

'Mortgage per repos" is negative relationship with the total assets' change. Lehman Brothers decreased this index to increase their assets.

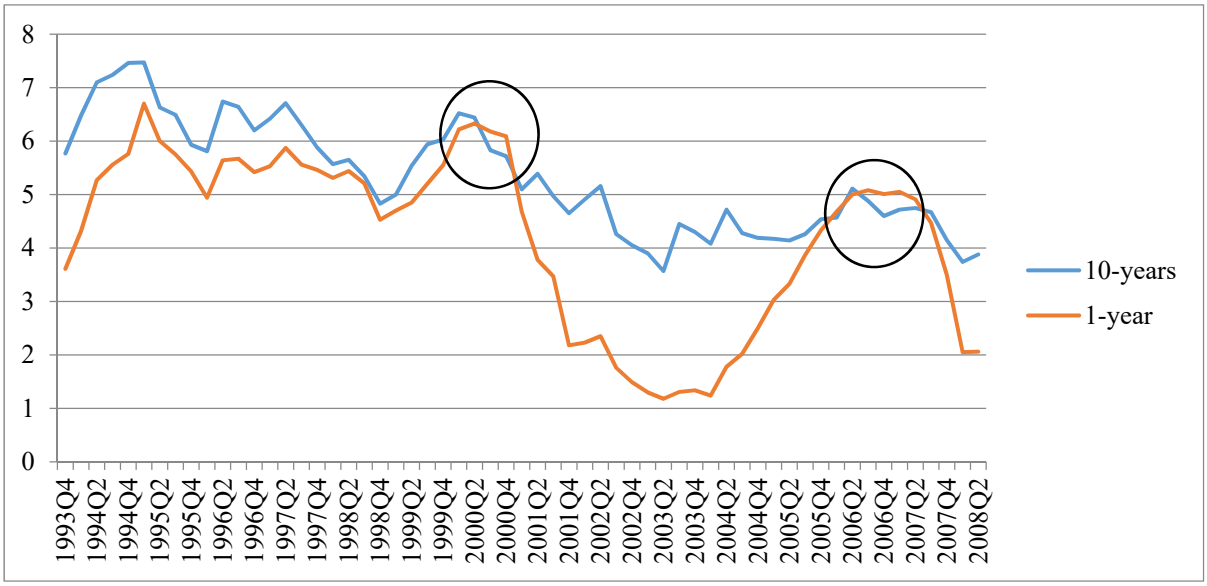
V. Leverage and market

We have seen that there could be 3 indexes representing leverage cycle. Now the question arises that whether market caused these indexes. If market is found to cause these indexes, we could anticipate the leverage indexes, and consequently monitor leverage more systematically.

1. Market yield on U.S. treasury securities at 1-year and 10-years.

Market yield on U.S. treasury securities has been used to benchmark the interest rate of other securities. Moreover, this is used to control the macro-economy by most of central banks.

Fig. 9 Flux (market yield on U.S. treasury securities)



Resource: FRB data

Generally, market yield of 1-year securities is less than 10-years securities. But as seen at Fig.9, there was reverse status of market yield at 2000 and 2006.

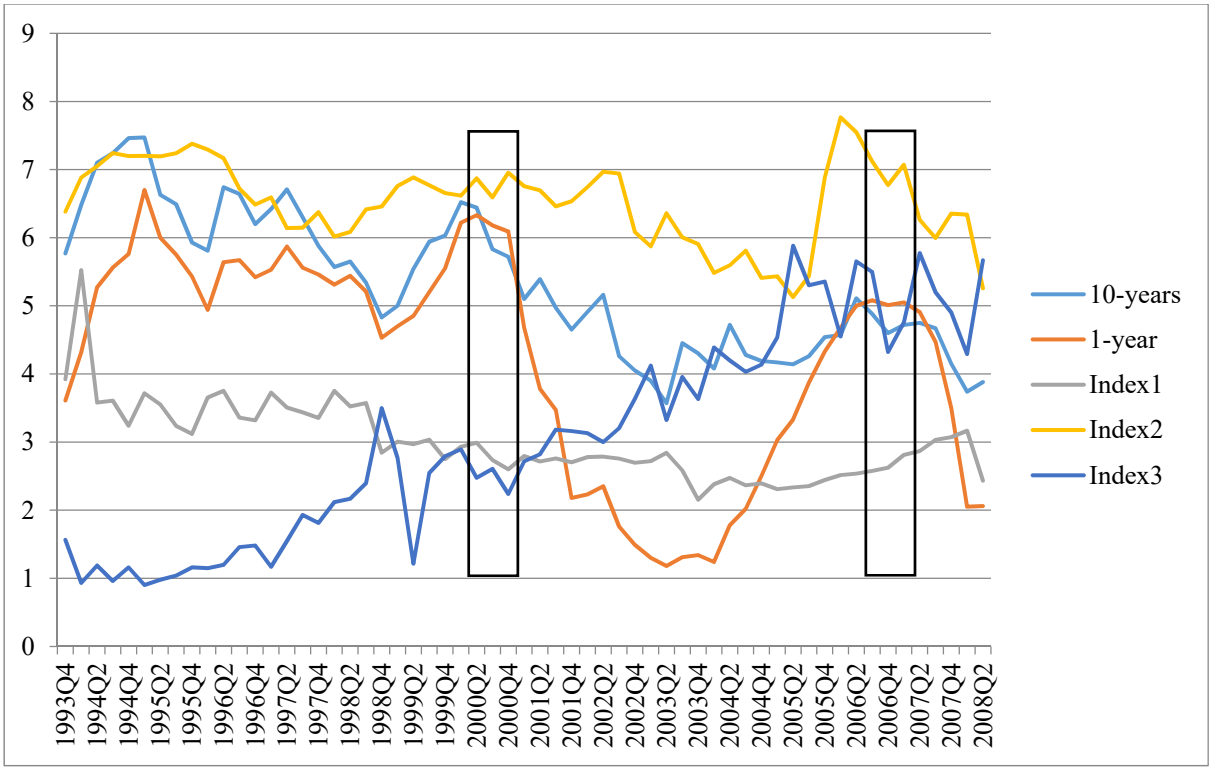
2. Indexes and market yield on U.S. treasury securities.

The flux of leverage indexes with the flux of market yield on U.S. treasury is shown at Fig. 10. To compare the trend easily, the numbers of leverage indexes are modified as table 14.

Table 14 modification of number of leverage indexes

	Leverage index	Modification
Index 1	Total assets per total equity	Divide by 10.
Index 2	Repos per total funding resources	Multiply by 10.
Index 3	Mortgage per repos	Multiply by 10.

Fig. 10 Flux (indexes and market yield on U.S. treasury securities)



At the spot period when the market yield of 1-year exceeded that of 10-years U.S. treasury securities, index 1 (total assets per total equity) does not show significant changes. But index 2 (repos per total funding resources) shows increase and index 3 (mortgage per repos) shows decrease.

Reverse of market yield between maturities means that market does not expect for long term, or in other words, believes in instability. Instead market wants to have short term profits, which brings increase of needs of short term borrowings. Subsequently, the cost for funding from short term borrowings increases. Upon the same reason, market does not want to invest mortgage, of which maturity is generally long term.

This market's sense is applicable in Lehman Brothers as well. At the spot period when the market yield of 1-year exceeded that of 10-years U.S. treasury securities, Lehman Brothers 1) increased repos, which is very short term borrowings and 2) decreased use of repos in investing mortgage, of which maturity is generally long term.

3. Did market yield on U.S. treasury securities cause leverage in Lehman Brothers?

As seen 1) above, there is signal that there is somehow relationship between market and leverage in Lehman Brothers. Upon this first look, I made assumption as below.

Hypothesis 1:

The market yield of **1-year** U.S. Treasury security causes a change of leverage cycle.

1 year U.S. treasury security is for short-term, which has effects on interest rate of short term borrowings. Especially, this market index is deemed to have significant effects on index 2, repos per total funding resources, because repos are for very short term period.

To do so, the empirical equation is set as below:

Leverage Index (t)	C1 Market yield of 1-year U.S. Treasury Security(t-i) + C2 Leverage Index (t-i) + error term
Legend	*C1,2 : coefficient* *t: spot time* *i: lagged time* *C2 leverage index is used for fixed effect.*

[Test 1] The market yield of 1-year U.S. Treasury security on **Index 1**

To find whether there is meaningful relationship between market yield of 1 year U.S. treasury security and leverage index1, granger causality test is used, and the result is as below.

Table 15 Granger causality test w/ leverage index 1 (Hypothesis 1)

		Leverage index 1 (dependent variable)
1-year U.S.	Prob>F	0.1037
(lagged = 1 quarter)	df_r	55
1-year U.S.	Prob>F	0.0055
(lagged = 2 quarter)	df_r	52
1-year U.S.	Prob>F	0.0712
(lagged = 3 quarter)	df_r	49

As seen above, when lagged time is 2quarters, there is statically significant relationship between the market yield of 1-year U.S. treasury securities and leverage index 1.

When lagged time is 2 quarter, the coefficient is as below.

Table 16 regression: leverage index 1 and 1-year U.S. treasury security (Hypothesis 1)

		Leverage index 1 (dependent variable)
1-year U.S.	Coef.	.089236
(lagged = 1 quarter)	p-value	0.891
1-year U.S.	Coef.	.7174023
(lagged = 2 quarter)	p-value	0.274
Number of observation		57

As seen at table 15, the market yield of 1-year U.S. Treasury security caused leverage index 1 with 2-quarter lagged time. But as seen table 16, it is hardly identified the coefficient between these 2 variables.

[Test 2] The market yield of 1-year U.S. Treasury security on **Index 2**

To find whether there is meaningful relationship between market yield of 1 year U.S. treasury security and leverage index2, granger causality test is used, and the result is as below.

Table 17 Granger causality test w/ leverage index 2 (Hypothesis 1)

		Leverage index 2 (dependent variable)
1-year U.S.	Prob>F	0.0374
(lagged = 1 quarter)	df_r	55
1-year U.S.	Prob>F	0.0322
(lagged = 2 quarter)	df_r	52
1-year U.S.	Prob>F	0.1044
(lagged = 3 quarter)	df_r	49

As seen above, when lagged time is 1 quarter and 2 quarters, there is statically significant relationship between the market yield of 1-year U.S. treasury securities and leverage index 1.

When lagged time is 1 quarter, the coefficient is as below.

Table 18 regression: leverage index 1 and 1-year U.S. treasury security (lagged time = 1 quarter) (Hypothesis 1)

		Leverage index 2 (dependent variable)
1-year U.S.	Coef.	.0076001
(lagged = 1 quarter)	p-value	0.037
Number of observation		58

When lagged time is 2 quarter, the coefficient is as below.

Table 19 regression: leverage index 1 and 1-year U.S. treasury security (lagged time = 2 quarter) (Hypothesis 1)

		Leverage index 2 (dependent variable)
1-year U.S.	Coef.	.0153101
(lagged = 1 quarter)	p-value	0.099
1-year U.S.	Coef.	-.007199
(lagged = 2 quarter)	p-value	0.449
Number of observation		57

As seen at table 17, the market yield of 1-year U.S. Treasury security caused leverage index 2 with 1- quarter lagged time and 2- quarter lagged time. But as seen at table 19, it is hardly identified the coefficient between these 2 variables when lagged time is 2 quarter. But as seen at table 18, it could be said that the market yield of 1-year U.S. Treasury security caused leverage index 2 at the same time with coefficient of 0.0076.

[Test 3] The market yield of 1-year U.S. Treasury security on **Index 3**

To find whether there is meaningful relationship between market yield of 1 year U.S. treasury security and leverage index3, granger causality test is used, and the result is as below.

Table 20 Granger causality test w/ leverage index 3 (Hypothesis 1)

		Leverage index 3 (dependent variable)
1-year U.S.	Prob>F	0.2176
(lagged = 1 quarter)	df_r	55
1-year U.S.	Prob>F	0.4052
(lagged = 2 quarter)	df_r	52
1-year U.S.	Prob>F	0.5543
(lagged = 3 quarter)	df_r	49

As seen above, there is no statically significant relationship between the market yield of 1-year U.S. treasury securities and leverage index 3.

Findings for Hypothesis 1:

There is statically significant granger causality of the market yield of 1 year U.S. Treasury security on

- Leverage index 1 with 2 quarter lagged time
- Leverage index 2 with 1 quarter and 2 quarter lagged time

But it is hardly identified which coefficient between leverage index 1 and market yield of 1 year U.S. Treasury security.

Leverage index 2 with 1 quarter time lagged, that is at the same time, shows statically significant positive coefficient with market yield of 1 year U.S. Treasury security as set as empirical assumption.

Hypothesis 2:

The market yield of **10-year** U.S. Treasury security causes a change of leverage cycle.

10 year U.S. treasury security is for long-term, which has effects on interest rate of long term debt. Especially, this market index is deemed to have significant effects on index 3, Mortgage per repos, because mortgage is generally for long term investment.

To do so, the empirical equation is set as below:

Leverage Index (t)	C1 Market yield of 10-year U.S. Treasury Security(t-i) + C2 Leverage Index (t-i) + error term
Legend	*C1,2 : coefficient* *t: spot time* *i: lagged time* *C2 leverage index is used for fixed effect.*

[Test 1] The market yield of 10-year U.S. Treasury security on **Index 1**

To find whether there is meaningful relationship between market yield of 10 year U.S. treasury security and leverage index1, granger causality test is used, and the result is as below.

Table 21 Granger causality test w/ leverage index 1 (Hypothesis 2)

		Leverage index 1 (dependent variable)
10-year U.S.	Prob>F	0.0390
(lagged = 1 quarter)	df_r	55
10-year U.S.	Prob>F	0.0022
(lagged = 2 quarter)	df_r	52
10-year U.S.	Prob>F	0.0337
(lagged = 3 quarter)	df_r	49
10-year U.S.	Prob>F	0.3196
(lagged = 3 quarter)	df_r	46

As seen above, when lagged time is 1 quarter, 2 quarters and 3 quarters, there is statically significant relationship between the market yield of 10-year U.S. treasury securities and leverage index 1.

When lagged time is 1 quarter, the coefficient is as below.

Table 22 regression: leverage index 1 and 10-year U.S. treasury security (lagged time = 1 quarter) (Hypothesis 2)

		Leverage index 1 (dependent variable)
10-year U.S.	Coef.	1.339327
(lagged = 1 year)	p-value	0.039
Number of observation		58

When lagged time is 2 quarter, the coefficient is as below.

Table 23 regression: leverage index 1 and 10-year U.S. treasury security (lagged time = 2 quarter) (Hypothesis 2)

		Leverage index 1 (dependent variable)
10-year U.S.	Coef.	-.2277107
(lagged = 1 quarter)	p-value	0.792
10-year U.S.	Coef.	1.838059
(lagged = 2 quarter)	p-value	0.031
Number of observation		57

When lagged time is 3 quarter, the coefficient is as below.

Table 24 regression: leverage index 1 and 10-year U.S. treasury security (lagged time = 3 quarter) (Hypothesis 2)

		Leverage index 1 (dependent variable)
10-year U.S.	Coef.	.1667177
(lagged = 1 quarter)	p-value	0.842
10-year U.S.	Coef.	-.080408
(lagged = 2 quarter)	p-value	0.945
10-year U.S.	Coef.	1.423387
(lagged = 2 quarter)	p-value	0.096
Number of observation		56

As seen at table 21, the market yield of 10-year U.S. Treasury security caused leverage index 1 with 1- quarter lagged time,2- quarter lagged time and 3- quarter lagged time. But as seen at table 24, it is hardly identified the coefficient between these 2 variables when lagged time is 3 quarter. But as seen at table 22, it could be said that the market yield of 10-year U.S. Treasury security caused leverage index 1 at the same time with coefficient of 1.3393 and as seen at table 23, it could be said that the market yield of 10-year U.S. Treasury security caused leverage index 2 with time lagged of 2 quarter with coefficient of 1.838059.

[Test 2] The market yield of 10-year U.S. Treasury security on **Index 2**

To find whether there is meaningful relationship between market yield of 10 year U.S. treasury security and leverage index2, granger causality test is used, and the result is as below.

Table 25 Granger causality test w/ leverage index 2 (Hypothesis 2)

		Leverage index 1 (dependent variable)
10-year U.S.	Prob>F	0.0895
(lagged = 1 quarter)	df_r	55
10-year U.S.	Prob>F	0.1061
(lagged = 2 quarter)	df_r	52

As seen above, there is no statically significant relationship between the market yield of 10-year U.S. treasury securities and leverage index 2.

[Test 3] The market yield of 10-year U.S. Treasury security on **Index 3**

To find whether there is meaningful relationship between market yield of 10 year U.S. treasury security and leverage index3, granger causality test is used, and the result is as below.

Table 26 Granger causality test w/ leverage index 2 (Hypothesis 2)

		Leverage index 1 (dependent variable)
10-year U.S.	Prob>F	0.0170
(lagged = 1 quarter)	df_r	55
10-year U.S.	Prob>F	0.0793
(lagged = 2 quarter)	df_r	52

As seen above, when lagged time is 1 quarter, there is statically significant relationship between the market yield of 10-year U.S. treasury securities and leverage index 3.

When lagged time is 1 quarter, the coefficient is as below.

Table 27 regression: leverage index 3 and 10-year U.S. treasury security (lagged time = 1 quarter) (Hypothesis 2)

		Leverage index 1 (dependent variable)
10-year U.S.	Coef.	-.0303047
(lagged = 1 year)	p-value	0.017
Number of observation		58

As seen at table 26, the market yield of 10-year U.S. Treasury security caused leverage index 3 with 1- quarter lagged time. And as seen at table 27, it could be said that the market yield of 10-year U.S. Treasury security caused leverage index 3 at the same time with coefficient of -.0303047.

Findings for Hypothesis 2:

There is statically significant granger causality of the market yield of 10 year U.S. Treasury security on

- Leverage index 1 with 1 quarter, 2 quarter and 3 quarter lagged time
- Leverage index 3 with 1 quarter lagged time

Leverage index 1 with 1 quarter and 2quarter time lagged shows statically significant positive coefficient with market yield of 10 year U.S. Treasury security.

Leverage index 3 with 1 quarter time lagged shows statically significant negative coefficient with market yield of 10 year U.S. Treasury security as set as empirical assumption.

Conclusion)

The market yield of 1-year and 10-year U.S. Treasury security statically significantly caused leverage index1, total assets per total equity, which is generalized leverage cycle.

But looking at specialized or more detail leverage index, the market yield of 1-year U.S. Treasury security as statically significantly caused leverage index 2, Repos per total funding resources, but not index 3. The market yield of 10-year U.S. Treasury security statically significantly caused leverage index 3, Mortgage per repo, but not index 2.

It can be explained that short-term market index caused change of short term funding resources and long-term market index caused long term investment, i.e. mortgage.

Interestingly, short-term market index caused positively change of short term funding resources, but long-term market index caused negatively change of long term investment in Lehman Brothers.

VI. Warning signals of the impending Lehman Brothers' bankruptcy

There were tries to identify warning signals of the impending Lehman Brothers' bankruptcy. Paremla R Hurley and Richard E Hurley tried to find out the warning signals of the impending Lehman Brothers' Bankruptcy through analysis of Lehman Brothers' cash flow and applying Z-score bankruptcy prediction model developed by Dr. Edward Altman (1968)[9] as shown at table 27. Christopolus examined whether Lehman Brothers' collapse could have been foreseen using the CAMELS ratio[10] as shown at table 28.

Table 28 Paremla R Hurley and Richard E Hurley (Z-score)

Fiscal Year	Z-Score
2007	0.604
2006	0.626
2005	0.556
2004	0.244
2003	0.241

Table 29 Christopolus (CAMELS Ratio)

Fiscal Year	CAMLES ratio
2007	43
2006	66
2005	63.5
2004	50.5
2003	47

Comparing these 2 results, the direction of warning signals is similar as below:

To show comparison easily, z-score is multiplied with 1,000 and CAMLES ratio is multiplied with 10.

Fiscal Year	Z-score X 1,000	CAMLES ratio X 10
2007 (5)	604	430
2006 (4)	626	660
2005 (3)	556	635
2004 (2)	244	505
2003 (1)	241	470

[9] "Warning Signals of the Impeding Lehman Brothers' Bankruptcy Filing", Hurley and Hurley

[10] "Could Lehman Brothers' Collapse Be Anticipated? An Examination Using CAMELS Rating System", Christopolus (2010)

Fig.11. Comparison (Z-score and CAMELS ratio)

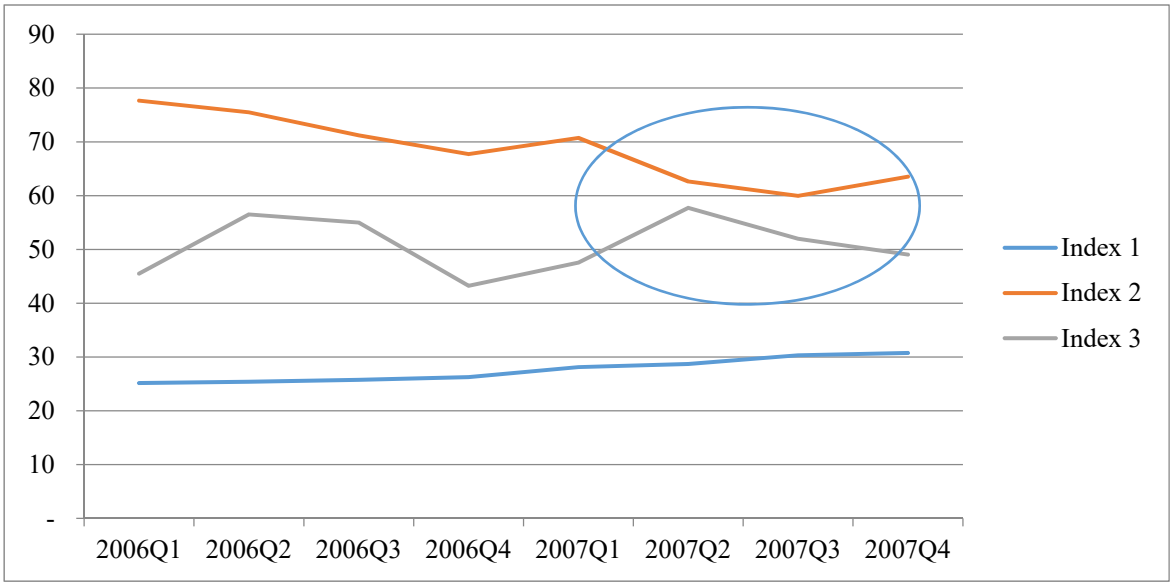
But there is difference at the period between 2006 and 2007. Z-score shows more flat change than CAMLES rate. The period between 2006 and 2007 is latest period before Lehman Brothers' bankruptcy, which is deemed to be most critical signal.

Using Leverage Indexes which defined above, the directions of change in this period are shown as below.

Table 29 Leverage Indexes during 2006 Q1 t0 2007 Q4

Quarter	Index 1	Index 2 (multiplied by 100)	Index 3 (multiplied by 100)
2006 Q1	25	77.66	45.49
2006 Q2	25	75.47	56.52
2006 Q3	26	71.20	54.97
2006 Q4	26	67.72	43.22
2007 Q1	28	70.71	47.56
2007 Q2	29	62.63	57.72
2007 Q3	30	59.95	51.98
2007 Q4	31	63.52	49.03

Fig. 12 Leverage Indexes during 2006 Q1 t0 2007 Q4



As seen Fig 12 above, leverage index 2 and 3 shows dynamic change at this period.

Though both of Z-score and CAMELS ratio shows empirical signals for Lehman Brothers' bankruptcy, leverage ratio or combined ratio would be more direct signals for Lehman Brothers' bankruptcy.

VI. Conclusion and Policy Implications

This paper analyzed causes of Lehman Brothers' bankruptcy based on Leverage cycle. Through looking at trend of Lehman's balance sheet through 1992 to 2007, 3 indexes are extracted to be adequate indexes to represent leverage cycle: (Index 1) Total assets per total equity, (Index 2) Repos per total funding resources, (Index 3) Mortgage per repos.

Index 1 has been generally recognized as leverage index. But index 2 and index 3 was found be to specialized leverage indexes. These are supported also by the relationship with market index, market yield on U.S. treasury securities 1 year and 10 years. Yield of 1-year U.S. treasury security is analyzed to have caused index 2 and yield of 10-year U.S. treasury securities is analyzed to have caused index 3.

Moreover, this paper represented that leverage indexes are closely linked to Lehman Brothers' bankruptcy, especially at the latest period before Lehman Brothers' collapse. Index 2 and index 3 show dramatic changes at the latest period, 2007. Lehman Brothers increased use of repos for their funding resources before bankruptcy and decreased investing mortgage with repos for investing resources. But the most outstanding change was that of index 2, repos per total funding resources. Company who is exposed to risk of collapse cannot use long-term funding resources, because there is low guarantee of sustainability of the company. Therefore, company cannot but use short term funding resources. These repos are usually used to increase assets, which the company wants to show to the investors so that the investors can be confident with the company's sustainability.

In this context, leverage index could be factors with which policy makers monitor economy.

Taylor[11] represented the rule to set policy interest rate in his paper. He emphasized interest rate has so important to the economy that policy makers should follow their own rules to set the interest rate. Moreover, Bernanke developed Taylor rule to monitor policy interest rate at his paper[12].

These papers all emphasized policy interest rate. Through policy interest rate is important the effect of policy interest rate on the market takes time. As seen above, interest rate, i.e. market yield, caused leverage cycles. Leverage cycle is more direct to the companies, and this is not remote to the policy interest rate.

As seen Lehman Brothers' case above, direct monitoring on leverage cycle would have regulated more detail on Lehman Brothers, which might have prevented Lehman Brothers' bankruptcy.

If leverage cycle, especially 'repos per total funding resources' is considered making policy for economy, policy could be more detail and effective to the companies.

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[11] "Discretion versus policy rules in practice", Taylor (1993)

[12] "Monetary Policy and the Hosing Bubble", Bernanke (2010)

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