

Applying Mathematics in Estimating Weighted Beta CAPM for Vietnam Banking Industry and Building Better Risk Management Information System (RMIS)

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Abstract

Risk management information system (RMIS) is becoming an important element in MIS system of banking sector in Vietnam in recent years and in future. We can use mathematics formulas applied in risk model to strengthen RMIS for banks. Nowadays, mathematics functions expressed high roles in economics and finance fields.

Under effects from Covid 19 and industry 4.0, Vietnam banks really need to enhance risk management and corporate governance system with RMIS channels to deliver proper risk information to clients and investors to attract more capitals via enhancing financial accounting data transparency.

This study mainly use combination of quantitative methods including mathematics applied to calculate weighted beta CAPM, a common systemic risk measurement, and qualitative methods including synthesis, inductive and explanatory methods. And it emphasizes again sustainable modern bank management, using 5 bank cases: Eximbank (EIB) and Saigon Hanoi Bank (SHB), Asia Commercial Bank (ACB), Sacombank (STB) and Saigon Hanoi bank (SHB), 5 big listed banks in our country.

Research results show us that risk model in banks can be done via some steps. First, calculating weighted beta CAPM or systemic risk via support of mathematics formula applied from market value and beta values of banks. Second, we run OLS regression for weighted beta and found out: for external impacts, exchange rate has negative correlation with weighted beta and for internal effects,

CPI and R (lending rate) have negative relationship with weighted beta, so that policy makers can adjust policies to manage risks.

Besides, this study also give out recommendations for enhancing management information system (MIS) for upgrading roles of banks in Vietnam economic development. Then, we can suggest suitable plans for sustainable management strategies.

Our research limitation is within bank sector, then we can expand for other industries and markets as well.

Key-words: Mathematics Applied, Sustainable Bank Management, Risk Management Information System, Weighted Beta CAPM, Economic Development, Vietnam.

JEL: M21, G30, G32, G38.

1. Introduction

First, we recognize the importance of applied mathematics in economics and finance over years, esp. in banking which contributed to build new theories and also increase to a new level in recent years.

Miguel et al (2012) stated that There has been so much debate on the increasing use of formal mathematical methods in Economics. Results shows concrete measures of mathematization in Economics by giving statistical evidence on the increasing trend of number of equations and econometric outputs per article. Authors argued that the training and use of mathematics has a positive correlation with the probability of winning a Nobel Prize in certain cases.

Next, We emphasize that the role of reliable internet data increasing in recent years. There is evidence in banking sector showing that internet data serving better for building information system for better bank management. Balasubramanian et al (2014) specified that the banking sector has always been in the vanguard of technology in order to add value to its products, services and efficiency. The Internet has galvanized business by increasing customer base, reducing transaction costs, and enabling sale of products globally. Khrais (2019) mentioned Business information systems are interconnected structures or procedures within a business entity that uses information and communication technology (ICT) to support decision making by generating, processing and providing useful information for the entity.

In this paper we mainly focus on using reliable internet data in comparing and evaluating 1 key factors: weighted beta CAPM under macro factors effects, for 5 big banks in Vietnam: Sacombank - STB, Asia Commercial Bank - ACB, Navibank or National Citizen bank - NVB, Eximbank -EIB and Saigon Hanoi Bank -SHB (previously, private banks).

All internet data such as stock price, exchange rate, inflation, GDP growth, risk free rate we take from reliable internet data sources, esp. from website of State Bank of Vietnam, Bureau of Statistics, Ministry of Finance, banks, etc.

Looking at exhibit 1 and 2 we can see CPI in Vietnam under control and keep stable in recent years. Whereas GDP growth is maintained at high ratio.

2. Literature Review

First, Boulding (1948) pointed that mathematics is techniques for exposition and discovery of relationships among quantities while economics deal with quantitative concepts - prices, wages, outputs, income.

Second, Trivelas and Satouridis (2013) stated that in Greece a) the externally focused Management Information System (MIS) effectiveness archetypes (OS, RM) reflecting innovation, creativity, goal setting and planning enhance task productivity b) the Internal process (IP) model of MIS effectiveness influences negatively task productivity.

Third, Winhua and Miling (2014) found Bank income much affected by macro effects.

Fourth, Krirsna (2015) mentioned that Between stock price and macro factors there are causal relation.

Fifth, Kulathunga (2015) stated that In Sri Lanka, stock market curtailed bu increasing deposit rates

Sixth, Ahmad and Ramzan (2016) found out that Investors might consider macro effects in portfolio of stock investment.

Seventh, Gunaratha (2016) said that whereas firm size negatively impacts on the financial risk, financial leverage and financial risk has positive relationship.

Last but not least, Hami (2017) specified that financial depth has been affected negatively by inflation in Iran during the observation period.

Moreover, Gupta (2019) specified that Information system (IS) is important in almost all the functional areas of any bank i.e. HR, Marketing, Finance, etc. It also helps in risk management and cash management along with maintaining long run customer relationship.

Then, We summarize previous studies as follows:

Table 1 – Summary of Previous Studies

Authors	Year	Contents, results
Karim, A.J	2011	Management Information Systems (MIS) is the key factor to facilitate and attain efficient decision making in an organization.
Avegrou, C.	2008	Roles of Information system (IS) in emerging markets enhanced via the transformation of social relations and macro-level institutions.
Gunaratha	2016	whereas firm size negatively impacts on the financial risk, financial leverage and financial risk has positive relationship.
Hami	2017	financial depth has been affected negatively by inflation in Iran during the observation period.
Giebe et al	2019	“Big Data & Analytics”. is considered as effective tool for customer-oriented services and products, in the banking sector, is currently defined as
Feitosa et al	2019	Changes in client relation, communication, labor skills and relations much supported by Disruptive technologies.
Kantos and Batolomeo	2020	when the probabilities of rare extreme events are considered, strategies that focus on “alpha” (risk adjusted return) as defined in Jensen (J Finance 23(2):389–416, 1967) are structurally superior to “smart beta” strategies that seek to outperform a market index benchmark.

3. Methodology

Method and Data

This study mainly use combination of quantitative methods and qualitative methods including synthesis, inductive and explanatory methods. And it emphasizes again important roles of internet data in sustainable modern bank management.

For quantitative analysis, the study is supported with OLS regression.

Data is collected from reliable internet sources and websites of Bureau Statistics, State Bank and Ministry of Finance and Vietnam banks.

Below figures describe correlation between beta of banks and macro effects.

Figure 1 – NVB Beta and Macro Factors Relation

Correlation Matrix										
	BETANVB	CPI	EX RATE	G	IM	R	RF	SP500	TRADEBA...	VNINDEX
BETANVB	1.000000	0.198754	-0.495650	0.095546	0.356647	0.058524	0.226459	-0.168160	0.044034	-0.191149
CPI	0.198754	1.000000	-0.382440	0.090566	0.500206	0.428665	0.580486	-0.844053	0.156409	-0.861426
EX RATE	-0.495650	-0.382440	1.000000	0.519076	0.038528	0.006143	-0.772931	0.476195	-0.491811	0.295409
G	0.095546	0.090566	0.519076	1.000000	0.440105	0.223263	-0.421402	0.136776	-0.107369	-0.016434
IM	0.356647	0.500206	0.038528	0.440105	1.000000	0.663798	0.117679	-0.613771	0.161388	-0.664368
R	0.058524	0.428665	0.006143	0.223263	0.663798	1.000000	-0.045403	-0.664122	0.553061	-0.746263
RF	0.226459	0.580486	-0.772931	-0.421402	0.117679	-0.045403	1.000000	-0.652624	0.264192	-0.444136
SP500	-0.168160	-0.844053	0.476195	0.136776	-0.613771	-0.664122	-0.652624	1.000000	-0.485719	0.950618
TRADEBA...	0.044034	0.156409	-0.491811	-0.107369	0.161388	0.553061	0.264192	-0.485719	1.000000	-0.375438
VNINDEX	-0.191149	-0.861426	0.295409	-0.016434	-0.664368	-0.746263	-0.444136	0.950618	-0.375438	1.000000

Figure 2 – EIB Beta and Macro Factors Relation

Correlation Matrix										
	BETA EIB	CPI	EX_RATE	G	IM	R	RF	SP500	TRADEBA...	VNINDEX
BETA EIB	1.000000	0.406334	-0.589294	-0.080846	0.264906	-0.223848	0.788821	-0.415616	0.227360	-0.200664
CPI	0.406334	1.000000	-0.382440	0.090566	0.500206	0.428665	0.580486	-0.844053	0.156409	-0.861426
EX_RATE	-0.589294	-0.382440	1.000000	0.519076	0.038528	0.006143	-0.772931	0.476195	-0.491811	0.295409
G	-0.080846	0.090566	0.519076	1.000000	0.440105	0.223263	-0.421402	0.136776	-0.107369	-0.016434
IM	0.264906	0.500206	0.038528	0.440105	1.000000	0.663798	0.117679	-0.613771	0.161388	-0.664368
R	-0.223848	0.428665	0.006143	0.223263	0.663798	1.000000	-0.045403	-0.664122	0.553061	-0.746263
RF	0.788821	0.580486	-0.772931	-0.421402	0.117679	-0.045403	1.000000	-0.652624	0.264192	-0.444136
SP500	-0.415616	-0.844053	0.476195	0.136776	-0.613771	-0.664122	-0.652624	1.000000	-0.485719	0.950618
TRADEBA...	0.227360	0.156409	-0.491811	-0.107369	0.161388	0.553061	0.264192	-0.485719	1.000000	-0.375438
VNINDEX	-0.200664	-0.861426	0.295409	-0.016434	-0.664368	-0.746263	-0.444136	0.950618	-0.375438	1.000000

Figure 3 – STB Beta and Macro Factors Relation

Correlation Matrix										
	BETA STB	CPI	EX_RATE	G	IM	R	RF	SP500	TRADEBA...	VNINDEX
BETA STB	1.000000	-0.497514	-0.255442	-0.054426	0.106597	0.052337	-0.182597	0.207067	0.486338	0.294760
CPI	-0.497514	1.000000	-0.382440	0.090566	0.500206	0.428665	0.580486	-0.844053	0.156409	-0.861426
EX_RATE	-0.255442	-0.382440	1.000000	0.519076	0.038528	0.006143	-0.772931	0.476195	-0.491811	0.295409
G	-0.054426	0.090566	0.519076	1.000000	0.440105	0.223263	-0.421402	0.136776	-0.107369	-0.016434
IM	0.106597	0.500206	0.038528	0.440105	1.000000	0.663798	0.117679	-0.613771	0.161388	-0.664368
R	0.052337	0.428665	0.006143	0.223263	0.663798	1.000000	-0.045403	-0.664122	0.553061	-0.746263
RF	-0.182597	0.580486	-0.772931	-0.421402	0.117679	-0.045403	1.000000	-0.652624	0.264192	-0.444136
SP500	0.207067	-0.844053	0.476195	0.136776	-0.613771	-0.664122	-0.652624	1.000000	-0.485719	0.950618
TRADEBA...	0.486338	0.156409	-0.491811	-0.107369	0.161388	0.553061	0.264192	-0.485719	1.000000	-0.375438
VNINDEX	0.294760	-0.861426	0.295409	-0.016434	-0.664368	-0.746263	-0.444136	0.950618	-0.375438	1.000000

Figure 4 – SHB Beta and Macro Factors Relation

Correlation Matrix										
	BETA SHB	CPI	EX_RATE	G	IM	R	RF	SP500	TRADEBA...	VNINDEX
BETA SHB	1.000000	0.281708	-0.463483	-0.038732	0.595530	0.745907	0.245152	-0.631007	0.805984	-0.555125
CPI	0.281708	1.000000	-0.382440	0.090566	0.500206	0.428665	0.580486	-0.844053	0.156409	-0.861426
EX_RATE	-0.463483	-0.382440	1.000000	0.519076	0.038528	0.006143	-0.772931	0.476195	-0.491811	0.295409
G	-0.038732	0.090566	0.519076	1.000000	0.440105	0.223263	-0.421402	0.136776	-0.107369	-0.016434
IM	0.595530	0.500206	0.038528	0.440105	1.000000	0.663798	0.117679	-0.613771	0.161388	-0.664368
R	0.745907	0.428665	0.006143	0.223263	0.663798	1.000000	-0.045403	-0.664122	0.553061	-0.746263
RF	0.245152	0.580486	-0.772931	-0.421402	0.117679	-0.045403	1.000000	-0.652624	0.264192	-0.444136
SP500	-0.631007	-0.844053	0.476195	0.136776	-0.613771	-0.664122	-0.652624	1.000000	-0.485719	0.950618
TRADEBA...	0.805984	0.156409	-0.491811	-0.107369	0.161388	0.553061	0.264192	-0.485719	1.000000	-0.375438
VNINDEX	-0.555125	-0.861426	0.295409	-0.016434	-0.664368	-0.746263	-0.444136	0.950618	-0.375438	1.000000

Figure 5 – ACB Stock Price and Macro Factors Relation

Correlation Matrix										
	BETA ACB	CPI	EX_RATE	G	IM	R	RF	SP500	TRADEBA...	VNINDEX
BETA ACB	1.000000	-0.259573	-0.025960	0.151048	0.455759	0.411131	-0.170895	-0.126552	0.631612	-0.088073
CPI	-0.259573	1.000000	-0.382440	0.090566	0.500206	0.428665	0.580486	-0.844053	0.156409	-0.861426
EX_RATE	-0.025960	-0.382440	1.000000	0.519076	0.038528	0.006143	-0.772931	0.476195	-0.491811	0.295409
G	0.151048	0.090566	0.519076	1.000000	0.440105	0.223263	-0.421402	0.136776	-0.107369	-0.016434
IM	0.455759	0.500206	0.038528	0.440105	1.000000	0.663798	0.117679	-0.613771	0.161388	-0.664368
R	0.411131	0.428665	0.006143	0.223263	0.663798	1.000000	-0.045403	-0.664122	0.553061	-0.746263
RF	-0.170895	0.580486	-0.772931	-0.421402	0.117679	-0.045403	1.000000	-0.652624	0.264192	-0.444136
SP500	-0.126552	-0.844053	0.476195	0.136776	-0.613771	-0.664122	-0.652624	1.000000	-0.485719	0.950618
TRADEBA...	0.631612	0.156409	-0.491811	-0.107369	0.161388	0.553061	0.264192	-0.485719	1.000000	-0.375438
VNINDEX	-0.088073	-0.861426	0.295409	-0.016434	-0.664368	-0.746263	-0.444136	0.950618	-0.375438	1.000000

4. Main Results

4.1 Overall Results

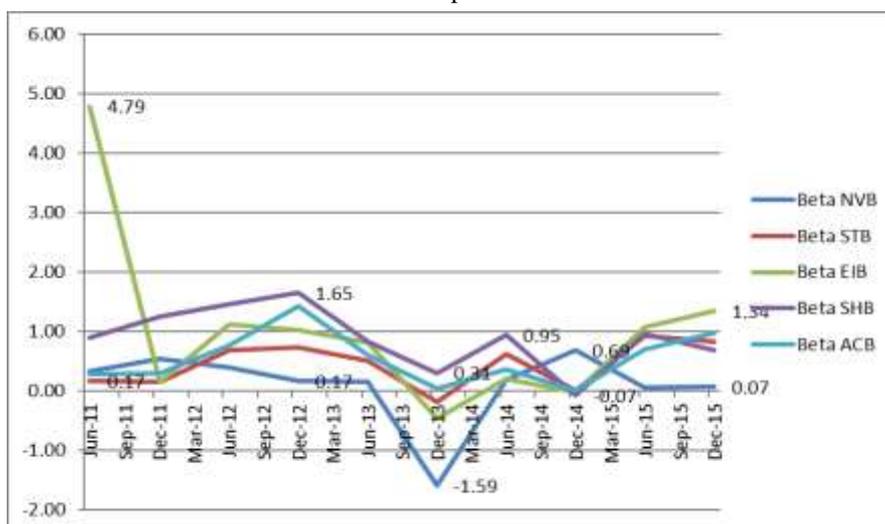
Looking at descriptive statistics in above figures, we see that: exchange rate and VNIndex has negative correlation with NVB, SHB, ACB and EIB beta values (for STB only exchange rate has

negative relationship). Whereas IM (industrial manufacturing) and Rf have positive correlation with beta of 5 banks.

4.2. Mathematics Applied in Estimating Weighted Beta CAPM for Banking Sector

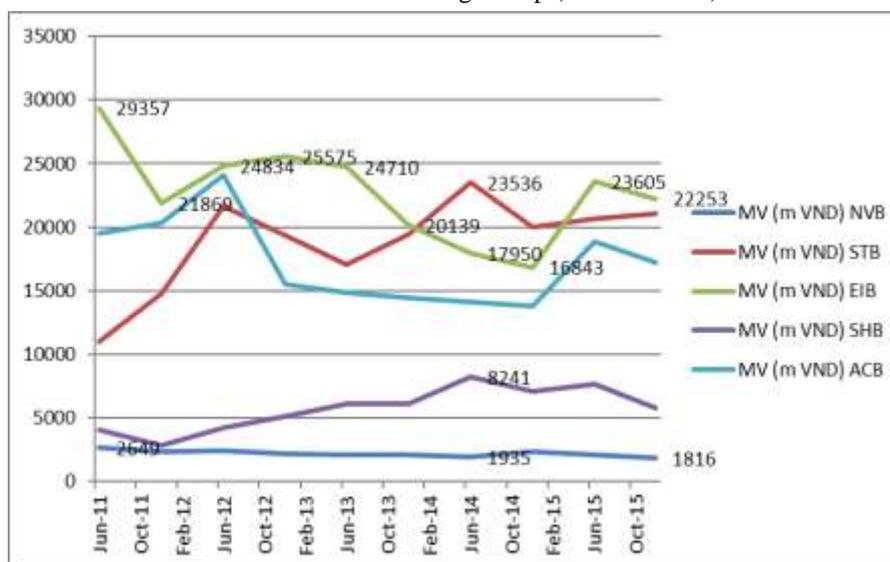
We get the data Beta CAPM which is calculated from stock price (weekly data on Vietnam stock exchange) for listed banking group as below chart.

Chart 1 – Beta CAPM of Group of 5 Listed Banks 2011-2015



Next, we see market value (MV) of banking group in below chart:

Chart 2 – MV of Banking Group (Unit: m VND)



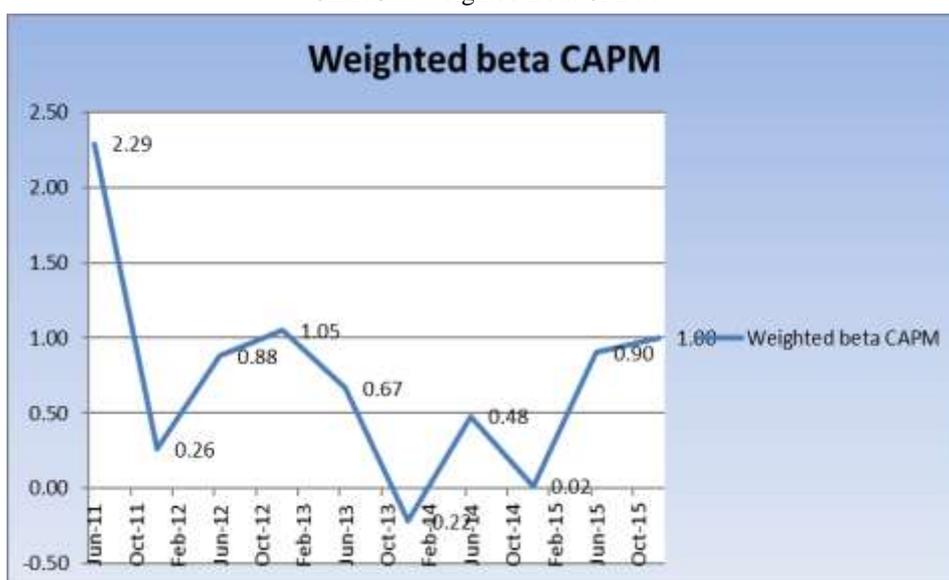
Then, we apply the mathematical formula to calculate Weighted beta CAPM for banking sector as follows:

Here we see the results in below table:

Table 2 – Results of Calculating Weighted Beta CAPM

Pre-L inflation	Beta NVB	MV (m VND)	Beta STB	MV (m VND)	Beta EIB	MV (m VND)	Beta SHB	MV (m VND)	Beta ACB	MV (m VND)	Weighted beta CAPM
Thg6-11	0.33	2649	0.17	11015	4.79	29357	0.90	4041	0.28	19504	2.29
Thg12-11	0.53	2322	0.16	14762	0.15	21869	1.25	2838	0.29	20348	0.26
Thg6-12	0.39	2381	0.69	21622	1.12	24834	1.46	4234	0.76	24099	0.88
Thg12-12	0.17	2143	0.73	19382	1.03	25575	1.65	5138	1.42	15472	1.05
Thg6-13	0.16	2084	0.52	17044	0.82	24710	0.83	6112	0.61	14868	0.67
Thg12-13	-1.59	2113	-0.18	19423	-0.45	20139	0.31	6114	0.05	14468	-0.22
Thg6-14	0.19	1935	0.62	23536	0.20	17950	0.95	8241	0.37	14102	0.48
Thg12-14	0.69	2322	0.01	19994	-0.02	16843	-0.07	7089	0.01	13803	0.02
Thg6-15	0.05	2054	0.94	20679	1.08	23605	0.97	7680	0.71	18822	0.90
Thg12-15	0.07	1816	0.84	21103	1.34	22253	0.69	5783	0.97	17208	1.00

Chart 3 – Weighted Beta CAPM

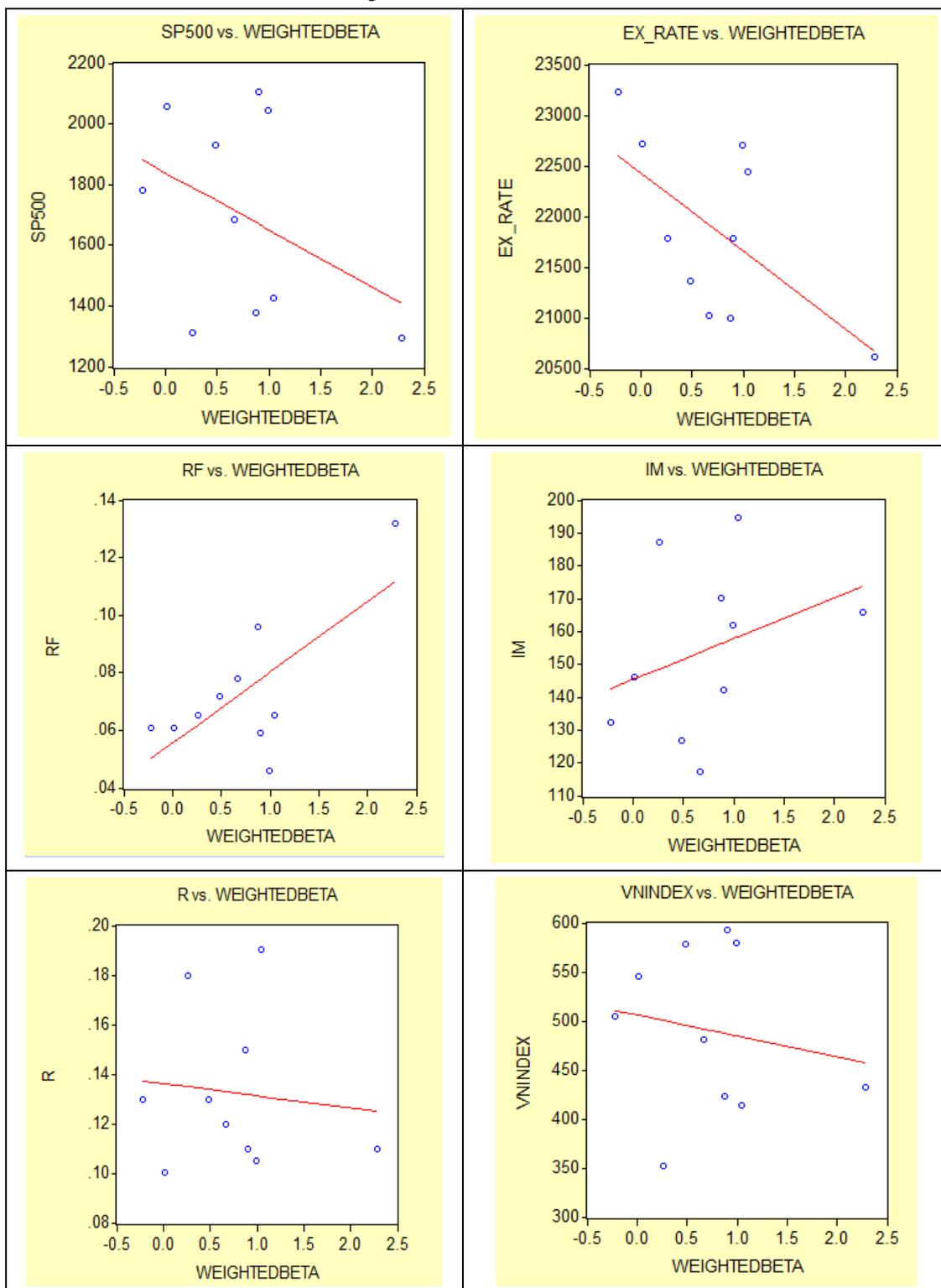


Next step is we use OLS regression to measure macro (internal and external) effects on Weighted beta CAPM, a common systemic risk measurement for banking industry.

4.3 OLS Regression Results

First, we recognize from below charts that weighted beta and external factors such as Sp500 and exchange rate has negative correlation. Whereas between weighted beta and IM or Rf there is positive correlation.

Chart 4 - Scatter Chart between Weighted Beta CAPM vs. External and Internal Macro Variables



Second, we see from below figure that: exchange rate and SP500 has negative relationship with weighted beta of 5 banks.

Figure 6 - Weighted Beta and External Macro Factors

Correlation Matrix				
	WEIGHTE...	EX_RATE	SP500	TRADEBA...
WEIGHTE...	1.000000	-0.613905	-0.399251	0.402092
EX_RATE	-0.613905	1.000000	0.476195	-0.491811
SP500	-0.399251	0.476195	1.000000	-0.485719
TRADEBA...	0.402092	-0.491811	-0.485719	1.000000

Third, we see from below figure that: lending rate and GDP growth and Vnindex has negative relationship with weighted beta of 5 banks.

Figure 7 - Weighted Beta and Internal Macro Factors

Correlation Matrix							
	WEIGHTE...	CPI	G	IM	R	RF	VNINDEX
WEIGHTE...	1.000000	0.288991	-0.059373	0.332320	-0.106016	0.699389	-0.177278
CPI	0.288991	1.000000	0.090566	0.500206	0.428665	0.580486	-0.861426
G	-0.059373	0.090566	1.000000	0.440105	0.223263	-0.421402	-0.016434
IM	0.332320	0.500206	0.440105	1.000000	0.663798	0.117679	-0.664368
R	-0.106016	0.428665	0.223263	0.663798	1.000000	-0.045403	-0.746263
RF	0.699389	0.580486	-0.421402	0.117679	-0.045403	1.000000	-0.444136
VNINDEX	-0.177278	-0.861426	-0.016434	-0.664368	-0.746263	-0.444136	1.000000

Next, Run OLS regression with Eviews gives below results:

Figure 8- Regression Results for Comparison of Internal Effects on 5 Banks Beta during Pre-L Inflation Time

Dependent Variable: WEIGHTEDBETA
 Method: Least Squares
 Date: 03/09/21 Time: 15:45
 Sample: 1 10
 Included observations: 10

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CPI	-1.626970	10.78571	-0.150845	0.8897
G	11.94309	47.95658	0.249040	0.8194
IM	0.016204	0.013982	1.158890	0.3304
R	-1.332800	15.19226	-0.087729	0.9356
RF	27.84554	13.77253	2.021817	0.1364
VNINDEX	0.004105	0.010800	0.380128	0.7292
C	-6.219205	7.423427	-0.837781	0.4636
R-squared	0.754578	Mean dependent var	0.733000	
Adjusted R-squared	0.263733	S.D. dependent var	0.695526	
S.E. of regression	0.596803	Akaike info criterion	2.001569	
Sum squared resid	1.068522	Schwarz criterion	2.213378	
Log likelihood	-3.007844	F-statistic	1.537304	
Durbin-Watson stat	1.849757	Prob(F-statistic)	0.388999	

Figure 9- Regression Results for Comparison of External Effects on 5 Banks Beta during Pre-L Inflation Time

Dependent Variable: WEIGHTEDBETA
 Method: Least Squares
 Date: 03/09/21 Time: 15:40
 Sample: 1 10
 Included observations: 10

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EX_RATE	-0.000409	0.000304	-1.346329	0.2268
SP500	-0.000227	0.000810	-0.280068	0.7888
TRADEBALANCE	0.000144	0.000575	0.251021	0.8102
C	10.10007	6.300168	1.603143	0.1600
R-squared	0.397984	Mean dependent var		0.733000
Adjusted R-squared	0.096977	S.D. dependent var		0.695526
S.E. of regression	0.660941	Akaike info criterion		2.298871
Sum squared resid	2.621062	Schwarz criterion		2.419905
Log likelihood	-7.494357	F-statistic		1.322173
Durbin-Watson stat	1.596357	Prob(F-statistic)		0.351589

We can infer from the above table that lending rate and CPI has negative correlation with weighted beta CAPM of 5 banks, then we can infer that lending rate and inflation not need to decrease too much.

5. Discussion

During Post – L Inflation: 2011-2015

Above chart 1 and 2 show us that: beta or market risk of Eximbank get highest level in 2015 while beta of ACB get lowest level.

In groups of banks we find out: GDP growth and Risk free rate (Rf) have higher impacts on beta CAPM, and positively effects, for internal factors. While for external factors, trade balance has positive correlation with weighted beta, SP500 and exchange rate has negative relationship with market risk.

Mathematics Applied

We use math formula with market value of 5 banks to calculate weighted beta CAPM, then we can apply this formula in various economic stages. For instance, before and after crisis, before and after low inflation stages, before and after China-USA commerce war, etc.

6. Conclusion

Because GDP growth and Risk free rate have higher effects on market risks (weighted beta) of banks, Ministry of Finance, State bank of Vietnam and relevant agencies need to control GDP growth as well as rates of Treasury bonds toward benefits for managing risk.

Espinisa et al (2012) specified that more mathematics has a negative impact on the probability of winning a Nobel Prize or becoming a famous scholar; however, mathematics has a positive effect on the probability of winning a Nobel when the scholar is already famous. Also, an analysis of the evolution of mathematics and empirical research in Economics through time is presented. Results show that Arrow and Debreu's (1954) article had a clear impact of the consolidation of an upward trend in the use of mathematics in Economics. Also, a structural break in the trend of the empirical works in Economics occurred when personal computers became available for most U.S universities.

Mukhamadeev et al (2019) stated that the role of information systems for entrepreneurship education in developing countries on the example of the Azerbaijan education system and Internet banking. The information systems role in entrepreneurship education was determined with the help of online questionnaire. As a result of the study, it was found out that about 29% of higher entrepreneurship education institutions use IT technologies and e-learning principles in the learning process.

Management Information System (MIS) Implications

A risk model need to be built, with support of mathematics applied, for instance, our above weighted beta CAPM model, then this risk model can be incorporated into RMIS system of banks and they will deliver proper risk information to investors and stakeholders.

Our study contributes to policy making to manage risks in bank system.

Limitation of Research

We can expand our research model for other industries and other markets.

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