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Testing Efficiency of an Arbitrage in Foreign Exchange Market (Forex): Simultaneous Ordering of Three Major Currency Pairs

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Abstract

In searching a market-neutral arbitrage strategy in forex market, we took a portfolio of three major currency pairs, EUR-USD, USD-JPY, and EUR-JPY. There are eight approaches, different cases of short and long positions; for example buying 1st and selling two others, etc.

Historical daily FX rates were gathered since January 1990 until February 2011. Monthly covariances between daily growth rate of FX rates and monthly means of profit or loss of all approaches were calculated. Some different tests were applied.

Eight approaches have been compared with each other in 28 states. Compared profit or loss of approaches in each state was calculated.

With an ANOVA test, we found a that the difference between means of approaches was significant. We found that covariances often tend to be only positive or negative. We categorized different cases of covariances on the basis of its positive or negative signs in four categories. In each category, means of eight approaches were calculated and they have been compared binarilyin 28 states. There were relations between conditions of the categories (their negative or positive signs) and results of different approaches derived. It has been recommended to use a covariance indicator in forex softwares to make better orders.

With computing the weighted average of approaches (on the basis of occurrence ratio of category) we found that BSS (buying 1st and selling the two others) and SSS (selling all the pairs) were the best approaches. They are not completely neutral, but in most of the time, they can eventuate to profit.

Keywords: Forex, currency pairs, FX rate, arbitrage, market-neutral strategy

Introduction

It is too interesting for speculators and hedgers to find riskless ways to enter into the forex market. Success of many company's international business is tied to foreign exchange rate volatility. Forex hedging is meant reducing the risk associated with a company's exposure to foreign currency balances and transactions. It is in any company's best interests to recognize these risks and formulate a hedging strategy to secure against currency fluctuations, thereby creating cost and revenue certainty for its foreign currency transactions.

There are three different designated forex hedges:

- A **cash flow hedge** may be designated for a highly probable forecasted transaction, a firm commitment (not recorded on the balance sheet), foreign currency cash flows of a recognized asset or liability, or a forecasted intercompany transaction.
- A **fair value hedge** may be designated for a firm commitment or foreign currency cash flows of a recognized asset or liability.
- A **net investment hedge** may be designated for the net investment in a foreign operation. (5)

In the simplest way, arbitrage is a risk-free type of trading where the same instrument is bought and sold simultaneously in two different markets in order to cash in on the difference between the markets. (4) Second type of arbitrage occurs when two assets trade at different prices but have the same payoff. (3). Another type of arbitrage refers to the case where the two assets' payoffs may not be identical at the future date, possibly because of limits to arbitrage resulting from transaction costs, limits on capital or capacity constraints on trading. (6)

In Forex, arbitrage is a financial operation in which currency pairs are bought and sold, either simultaneously or in minimum lapse of time, either in the same market or a different one, with the goal of obtaining a profit spread, product of the rate's price differentials.(1)Arbitrageurs track the markets to making a decent size of money.Narrow spreads also limit the rate of return. This makes difficulties for an individual with limited resources. (7)

Arbitrage models for currency/stock pairs may be designed in a variety of ways. The important key is to have knowledge of the relationships among pairs. This form of arbitrage relies on a strong correlation between two related securities. The pairstrade is market-neutral, meaning the direction of the overall market does not affect its win or loss. (1)

Riskless arbitrage is rarely encountered in practice, yet it is common in both academic studies and industry to use the riskless arbitrage strategy, even when arbitrage opportunities are risky. (6)

Definitions

Major currencies

Currencies are traded in pairs and exchanged one against the other. The majority of currencies are traded against the US dollar (USD). The four currencies

traded most frequently after the US dollar are the euro (EUR), Japanese yen (JPY), the British pound sterling (GBP), and the Swiss franc (CHF). Some sources also include the Australian dollar (AUD) and the Canadian dollar (CAD) within the group of major currencies. (4)

Spread

It is the difference between BID and ASK.

Point

Movements of exchange rates are usually in terms of points; Minimum fluctuation or smallest increment of price movements. (4)

Short position

That is the sale of a currency not owned by the seller at the time of the trade. Short position is usually made in expectation of a decline in the price. (4)

Long position

A market position where the client has bought a currency not previously owned. (4)

Preface

Most of trading systems, attempt to predict market direction, but neutral strategies reacts to priceaction and makes trading decisions.

One of the neutral strategies is when a trader takes a long position and a short position at the same time. Once two markets determined to be statistically "out of alignment", a long position is taken in the market considered to be undervalued while a short position is simultaneously taken in the market considered to be overvalued relative to the first market.

Another strategy is "Diversification". This strategy creates a complex portfolio of global currencies and adjusts its components daily. Diversification of currencies can lead to better risk-rewards for the combined portfolio. For example, in a portfolio comprised of three currency pairs, one position can be unprofitable at the moment, but the other two can show profits to more than compensating for the losses incurred with the losing one.(1)

Questions

- **Main**
  - Can simultaneous ordering of three major currency pairs make a market-neutral arbitrage strategy in forex market?
- **Secondary**
  - Are there any relationship between covariances and profit?
  - Are covariance changes regularly?
  - How constant are different eight approaches in making profit?
  - Which approach is the most profitable?
  - Is there any relationship between covariances and the most suitable approach?

Approach

If we consider all the seven major currencies, we will have 21 major currency pairs, and 1330 different baskets of three currency pairs:

$$C_2^7 = 21 \& C_3^{21} = 1330$$

We took only 3 major currencies, therefore 3 currency pairs and one basket

of three currency pairs were chosen. These currencies are USD, EUR, and JPY. The currency pairs are EURUSD, JPYUSD, and JPYEUR.

In this essay, we tried to test the efficiency of this strategy, a portfolio of three major currency pairs. We have gathered historical daily exchange rate of these currency pairs (we call it FX rate) since January 1990 to February 2011 (254 months, 7723 days).A part of the collected data is shown in 'table 1'.

First, the growth rate of FX rates was calculated. A part of the calculated data is shown in 'table 2'.

The covariance between monthly FX growth rates was calculated. A part of the calculated covariances is shown in 'table 3'.

We can have a short or a long position. Therefore there are 8 different 'approaches'. If we show the short position with "S" and the long position with "B", these approaches are: BBB, SSS, BSS, SBS, SSB, BBS, BSB, and SBB. For example ,the first approach (BBB) is buying EURUSD, JPYUSD, and JPYEUR. Or the second approach (SSS) is selling all these currency pairs.

After that, monthly profit or loss derived from all of the available approaches was calculated. A part of the result is shown in 'table 4'.

Since there are 8 approaches, we can compare profit or loss in 28 'states'. For example, the first state is whether the profit of 'BBB' is greater than the profit of 'SSS'. And the second state represents whether the profit of 'BBB' is greater than 'BSS'. All the states are shown in 'table 5' and a part of the result of binarily comparison is shown in 'table 6'. 'Y' means the positive comparison result and 'N' means the negative comparison result.

Conclusions

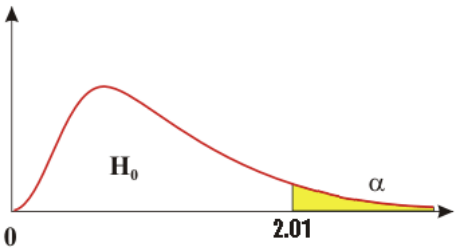
1. Profit or loss of all approaches is summarized in 'table 7'. The 1st row shows all the profits or losses. The 2nd line show monthly average of profit during 254 months. The 3rd row shows the number of months with a positive profit. The 4th row shows the number of months with a negative loss. And the last line indicates the percent of months with a positive profit.

   Diagrams 1 to 8 show the trend of profit changes during 254 months of all approaches.
2. There are different covariances between currency pairs. As shown in diagram 9, covariance between EURUSD & JPYUSD is often negative. 87.80% of covariances are negative and only 12.20% of them are positive. It means when FX rate of EURUSD rises, most of the time, FX rate of JPYUSD falls and vice versa. Both of two other currency pairs tend to have positive covariances. These states are shown in diagrams10 and 11. In diagram ten, 91.34% and in diagram eleven, 92.13% of covariances are positive. It means that most of the time, they have convergent rates and they change in the same side.
3. With applying an 'Analysis of Variance'test, the p value for the test is not under the area between0 and

Fdf1, df2. In this case, as shown in 'table 8', Fstat= 29.85 with 7 and 2024 degrees of freedom.

Using the Ftable we note F0.05, 7, 2024= 2.01.Thereforewe can conclude that there is a meaningful difference between the averages of approaches:

n	8
k	254
$\Sigma(T^2)$	660,001,529
$\Sigma\Sigma x^2_{ij}$	878,206,003
SST	878,205,042
SS(Tr)	82,175,387
SSE	796,029,655



4. There is not any condition that all three variances are negative in the same time. But as will be discussed, in some months, all of them are positive with together.
5. We can categorize the result, with regard to covariances, as shown in diagram 12.

These categories are:

a. Category A: covariances are negative, positive, and, positive. (- , + , +)

In 181 months (71%), first covariance was negative and two others were positive. Under this circumstance, result of all 28 states is shown in diagram 13. For example the first column in the right represents that in this situation, in 53.59% of months, BBB had a better profit than SSS. All the ratios are between 43.85% and 56.35%.

In this category, BSS was the most profitable approach with an average profit about $56 per month, and SBB was the worst (-$56 loss per month). Average profit of each approach is shown in diagram 14.

b. Category B: covariances are negative, positive, and, positive. (+ , + , +)

In 31months (12%), all three covariances were positive. Under this circumstance, result of all 28 states is shown in diagram 15. In this situation it seems to have a meaningful difference between results. Only in 25.81% of months, BBB is better than SBB, but in 74.19% of months, SSS is better than BSS.

In this category, SSS was the most profitable approach with an average profit about $317 per month, and BBB was the worst (-$317 loss per month). Average profit of each approach is shown in diagram 16.

c. Category C: covariances are negative, positive, and, negative. (- , + , -)

In 20 months (8%), the first and the third covariances were negative and the second was positive. Under this circumstance, result of all 28 states is shown in diagram 17.

In this category, BSS was the most profitable approach with an average profit

about $137 per month, and SBB was the worst (-$136 loss per month). Average profit of each approach is shown in diagram 18.

d. Category D: covariances are negative, negative, and, positive. (- , - , +)

In 22 months (9%), the first and the second covariances were negative and the third waspositive. Under this circumstance, result of all 28 states is shown in diagram 19.

In this category, BSBwas the most profitable approach with an average profit about $171 per month, and SBSwas the worst (-$171 loss per month). Average profit of each approach is shown in diagram 20.

6. Diagram 21 represents how frequently these categorized covariances happened in different months of the year. For example situations of category A, very often happened in March (85.7%) and rarely in October (42.8%).Or situations of category C, happened in October more than other months (24%).It has never been seen in January, February and April.
7. There was a relation between categorized covariances and the best approaches in categories A & B. As shown in 'table 9', in category A, when covariances are -, +, + then the best is BSS and the worst is SBB (please pay attention to their sequence). In category B, when covariances are +, +, + then the best is SSS and the worst is BBB. In category C, BSB and SBS are not the best and the worst, but the profit and loss in these approaches are considerable.
8. With computing a weighted average, as shown in the above table, we can see that totally, regardless of different categories, the best approaches are BSS& SSS.
9. There was not any approach that can be always profitable. It means that there is not a market-neutral strategy with this portfolio ordering. Also there is not such a thing in any categories. We could not define an 'always profitable' portfolio of three major currency pairs. But, the achieved results interestingly can help us to use 'probabilities theory'. Specially with calculating the covariances, we know in which category we are, and then we can use an approach which is often profitable.
10. An indicator that shows the amount of covariances in forex softwares (such as "Meta-Trader") could help us be better orders (as described in items 8 & 9). It can be in different time spans on the basis of our decision making span(hourly, daily, weekly, and monthly).

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Table 1(FX rates derived from combination of three major currencies.)

Date	EURUSD	JPYUSD	JPYEUR
02/28/2011	1.3834	0.012214	0.008829
02/27/2011	1.3762	0.012231	0.008887
02/26/2011	1.3762	0.012231	0.008887
02/25/2011	1.3762	0.012231	0.008887
02/24/2011	1.3773	0.012222	0.008874
02/23/2011	1.3731	0.012078	0.008796
02/22/2011	1.3667	0.012028	0.0088
02/21/2011	1.3668	0.012023	0.008797
02/20/2011	1.3627	0.011993	0.008801
02/19/2011	1.3627	0.011993	0.008801
02/18/2011	1.3627	0.011993	0.008801
02/17/2011	1.356	0.011959	0.008819
.	.	.	.
.	.	.	.
.	.	.	.
01/09/1990	1.209715	0.006894	0.005699
01/08/1990	1.210252	0.00692	0.005718
01/07/1990	1.196233	0.00693	0.005793
01/06/1990	1.196233	0.00693	0.005793
01/05/1990	1.196233	0.00693	0.005793
01/04/1990	1.190769	0.006911	0.005804
01/03/1990	1.186533	0.006863	0.005784
01/02/1990	1.201528	0.006932	0.00577

Source: fxtop.com

Table 2 (Growth rate of FX rates)

Date	EURUSD	growth rate	JPYUSD	growth rate	JPYEUR	growth rate
02/28/2011	1.3834	0.5205%	0.012214	0.1336%	0.008829	0.6534%
02/27/2011	1.3762	0.0000%	0.012231	0.0000%	0.008887	0.0000%
02/26/2011	1.3762	0.0000%	0.012231	0.0000%	0.008887	0.0000%
02/25/2011	1.3762	-0.0799%	0.012231	-0.0711%	0.008887	-0.1511%
02/24/2011	1.3773	0.3049%	0.012222	-1.1960%	0.008874	-0.8874%
02/23/2011	1.3731	0.4661%	0.012078	-0.4153%	0.008796	0.0528%
02/22/2011	1.3667	-0.0073%	0.012028	-0.0367%	0.0088	-0.0440%
02/21/2011	1.3668	0.3000%	0.012023	-0.2479%	0.008797	0.0528%
02/20/2011	1.3627	0.0000%	0.011993	0.0000%	0.008801	0.0000%
02/19/2011	1.3627	0.0000%	0.011993	0.0000%	0.008801	0.0000%
02/18/2011	1.3627	0.4917%	0.011993	-0.2907%	0.008801	0.2024%
02/17/2011	1.356	0.3687%	0.011959	-0.1311%	0.008819	0.2381%
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.	.	.	.	.	.	.
01/09/1990	1.209715	-0.0444%	0.006894	0.3789%	0.005699	0.3347%
01/08/1990	1.210252	1.1584%	0.00692	0.1381%	0.005718	1.2949%
01/07/1990	1.196233	0.0000%	0.00693	0.0000%	0.005793	0.0000%
01/06/1990	1.196233	0.0000%	0.00693	0.0000%	0.005793	0.0000%
01/05/1990	1.196233	0.4568%	0.00693	-0.2776%	0.005793	0.1805%
01/04/1990	1.190769	0.3557%	0.006911	-0.6906%	0.005804	-0.3325%
01/03/1990	1.186533	-1.2638%	0.006863	0.9955%	0.005784	-0.2557%
01/02/1990	1.201528	-	0.006932	-	0.00577	-

Table 3 (Covariances between FX rate changes)

Month	EURUSD&JPYUSD	JPYUSD&JPYEUR	JPYEUR&EURUSD
2011, Feb.	-0.00000712	0.00000829	0.00000729
2011, Jan.	-0.00000710	0.00001207	0.00002885
2010, Dec.	-0.00002084	0.00001135	0.00000830
2010, Nov.	-0.00001350	0.00001300	0.00003403
2010, Oct.	-0.00001358	-0.00000121	0.00001923
2010, Sep.	0.00000120	0.00003380	0.00002831
2010, Aug.	-0.00000332	0.00002037	0.00002417
2010, Jul.	-0.00003122	0.00000947	0.00003645
2010, Jun.	0.00001394	0.00003590	0.00005129
2010, May	0.00001771	0.00005889	0.00008999
2010, Apr.	0.00000515	0.00002433	0.00002327
2010, Mar.	-0.00000637	0.00002121	0.00001736
2010, Feb.	0.00000466	0.00002952	0.00003032
.	.	.	.
.	.	.	.
.	.	.	.
1990, Jun.	-0.00000191	0.00000974	0.00000712
1990, May	-0.00000128	0.00005055	0.00001665
1990, Apr.	-0.00000562	0.00001986	0.00000703
1990, Mar.	-0.00000987	0.00001370	0.00000853
1990, Feb.	-0.00000746	0.00000669	0.00001492
1990, Jan.	-0.00001144	0.00000513	0.00002445

Table 4 (Resultsof different approaches)

Month	BBB	SSS	BSS	SBS	SSB	BBS	BSB	SBB
2011, Feb.	$194.83	-$194.83	$89.17	-$269.06	-$14.94	$14.94	$269.06	-$89.17
2011, Jan.	$893.44	-$893.44	-$233.44	-$692.71	$32.71	-$32.71	$692.71	$233.44
2010, Dec.	$6.17	-$6.17	$721.83	-$633.17	-$94.83	$94.83	$633.17	-$721.83
2010, Nov.	-$822.14	$822.14	-$895.86	$1,573.81	$144.19	-$144.19	-$1,573.81	$895.86
2010, Oct.	-$330.85	$330.85	$748.85	-$298.25	-$119.75	$119.75	$298.25	-$748.85
2010, Sep.	$1,600.15	-$1,600.15	$335.85	-$1,883.44	-$52.56	$52.56	$1,883.44	-$335.85
2010, Aug.	-$1,241.70	$1,241.70	$545.70	$765.01	-$69.01	$69.01	-$765.01	-$545.70
2010, Jul.	$930.16	-$930.16	$583.84	-$1,448.27	-$65.73	$65.73	$1,448.27	-$583.84
2010, Jun.	-$785.31	$785.31	$713.31	$144.99	-$72.99	$72.99	-$144.99	-$713.31
2010, May	-$2,758.05	$2,758.05	$742.05	$2,104.40	-$88.40	$88.40	-$2,104.40	-$742.05
2010, Apr.	-$73.75	$73.75	-$254.25	$293.71	$34.29	-$34.29	-$293.71	$254.25
2010, Mar.	$919.43	-$919.43	-$1,101.43	$17.81	$164.19	-$164.19	-$17.81	$1,101.43
2010, Feb.	-$1,120.35	$1,120.35	$328.35	$841.79	-$49.79	$49.79	-$841.79	-$328.35
2010, Jan.	-$1,454.81	$1,454.81	$574.81	$981.56	-$101.56	$101.56	-$981.56	-$574.81
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
1990, Jun.	$338.56	-$338.56	$13.82	-$348.66	-$3.72	$3.72	$348.66	-$13.82
1990, May	-$1,150.89	$1,150.89	$1,012.33	$248.52	-$109.96	$109.96	-$248.52	-$1,012.33
1990, Apr.	$464.01	-$464.01	-$222.39	-$263.23	$21.61	-$21.61	$263.23	$222.39
1990, Mar.	$1,276.66	-$1,276.66	-$1,272.34	-$121.87	$117.55	-$117.55	$121.87	$1,272.34
1990, Feb.	$590.97	-$590.97	-$640.07	-$14.88	$63.98	-$63.98	$14.88	$640.07
1990, Jan.	$212.65	-$212.65	-$13.25	-$203.51	$4.11	-$4.11	$203.51	$13.25

Table 5 (All the 28 states that we can have with 8 approaches)

BBB>SSS	BBB>BSS	BBB>SBS	BBB>SSB	BBB>BBS	BBB>BSB	BBB>SBB
	SSS>BSS	SSS>SBS	SSS>SSB	SSS>BBS	SSS>BSB	SSS>SBB
		BSS>SBS	BSS>SSB	BSS>BBS	BSS>BSB	BSS>SBB
			SBS>SSB	SBS>BBS	SBS>BSB	SBS>SBB
				SSB>BBS	SSB>BSB	SSB>SBB
					BBS>BSB	BBS>SBB
						BSB>SBB

Table 6 (Binarily comparison of results between 28 states)

state	1	2	3	4	5	…	27	28
Month	BBB> SSS	BBB> BSS	BBB> SBS	BBB> SSB	BBB> BBS	…	BBS> SBB	BSB> SBB
2011-02	Y	Y	Y	Y	Y	…	Y	Y
2011-01	Y	Y	Y	Y	Y	…	N	Y
2010-12	Y	N	Y	Y	N	…	Y	Y
2010-11	N	Y	N	N	N	…	N	N
2010-10	N	N	N	N	N	…	Y	Y
2010-09	Y	Y	Y	Y	Y	…	Y	Y
.	.	.	.	.	.		.	.
.	.	.	.	.	.		.	.
1990-02	Y	Y	Y	Y	Y	…	N	N
1990-01	Y	Y	Y	Y	Y	…	N	Y

Table 7 (Profit or loss of all approaches)

	BBB	SSS	BSS	SBS	SSB	BBS	BSB	SBB
Sum	-12.157$	12.157$	15.795$	-1.918$	-1.720$	1.720$	1.918$	-15.795$
Average	-47.86$	47.86$	62.18$	-7.55$	-6.77$	6.77$	7.55$	-62.18$
+ #	136	118	133	116	119	135	138	121
- #	118	136	121	138	135	119	116	133
+ %	53.54%	46.46%	52.36%	45.67%	46.85%	53.15%	54.33%	47.64%

Diagram 1 (Profit or loss of 1st approach – BBB)

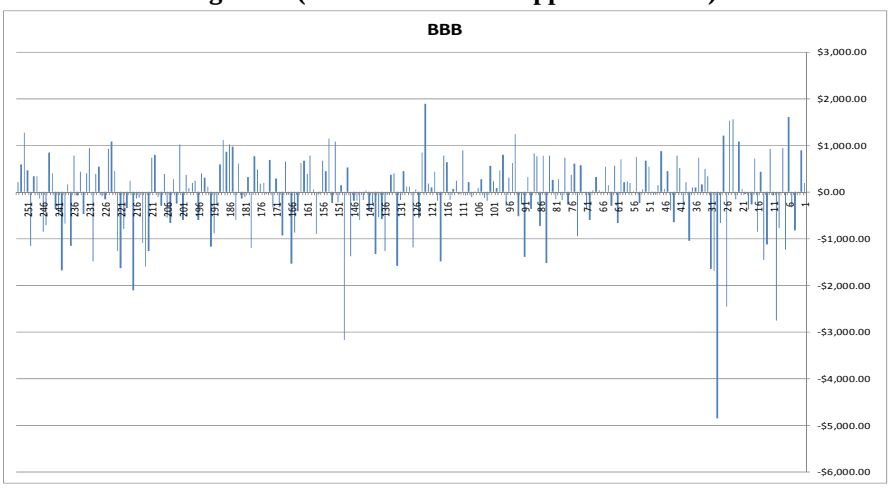

Diagram 2 (Profit or loss of 2nd approach – SSS)

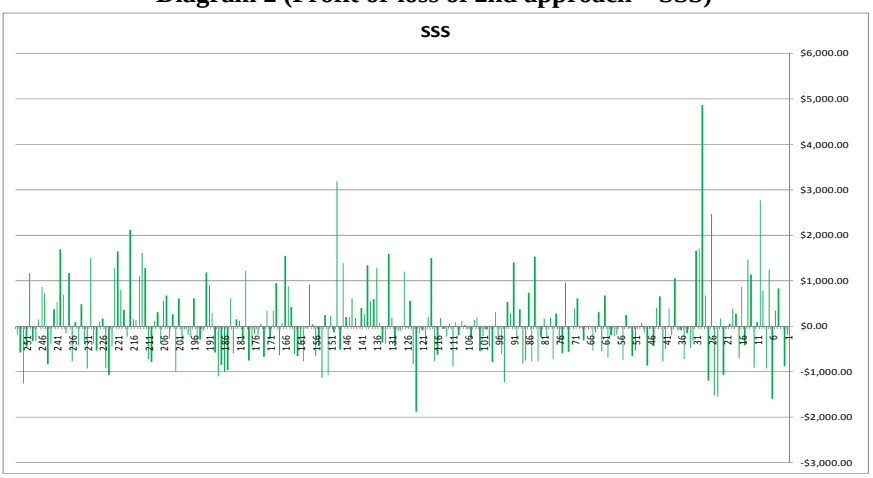

Diagram 3 (Profit or loss of 3rd approach – BSS)

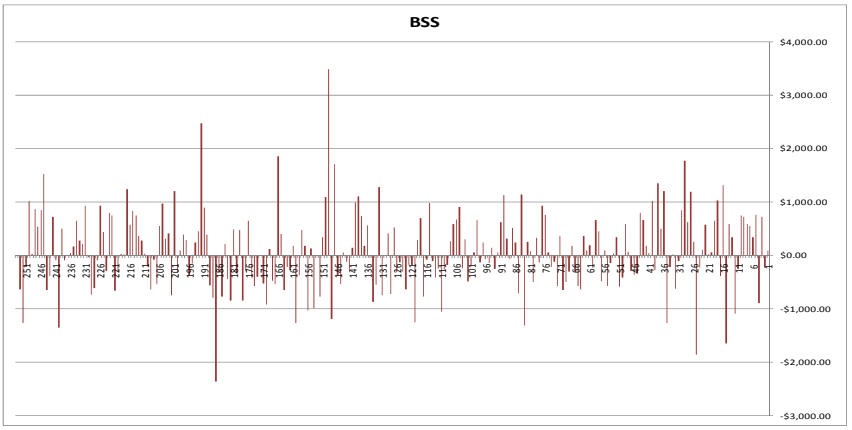

Diagram 4 (Profit or loss of 4th approach – SBS)

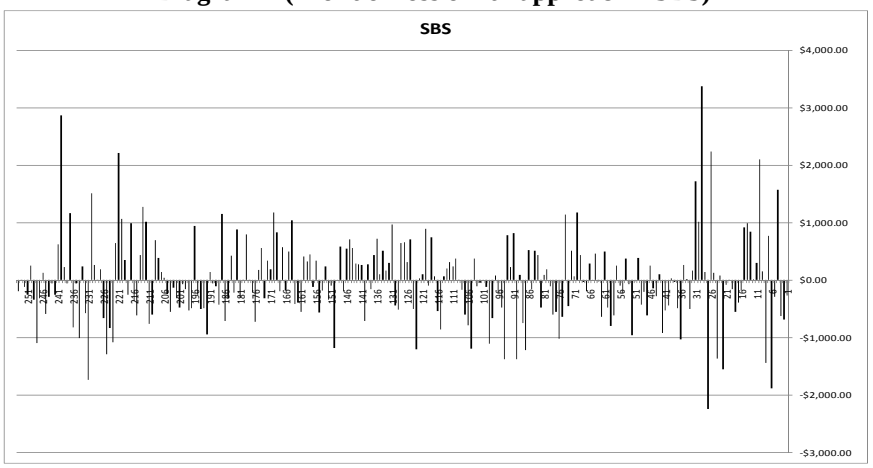

Diagram 5 (Profit or loss of 5th approach – SSB)

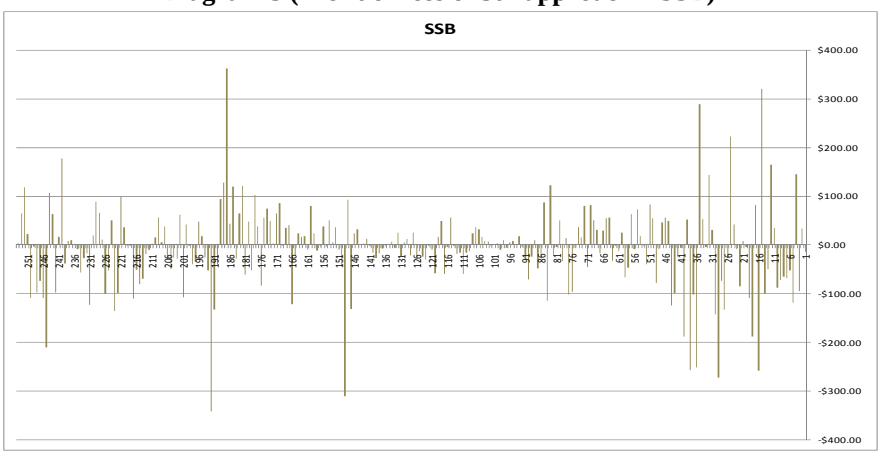

Diagram 6 (Profit or loss of 6th approach – BBS)

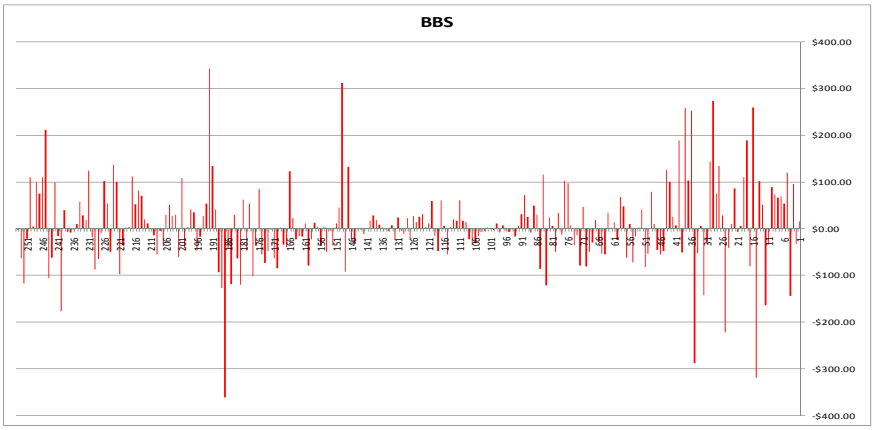

Diagram 7 (Profit or loss of 7th approach – BSB)

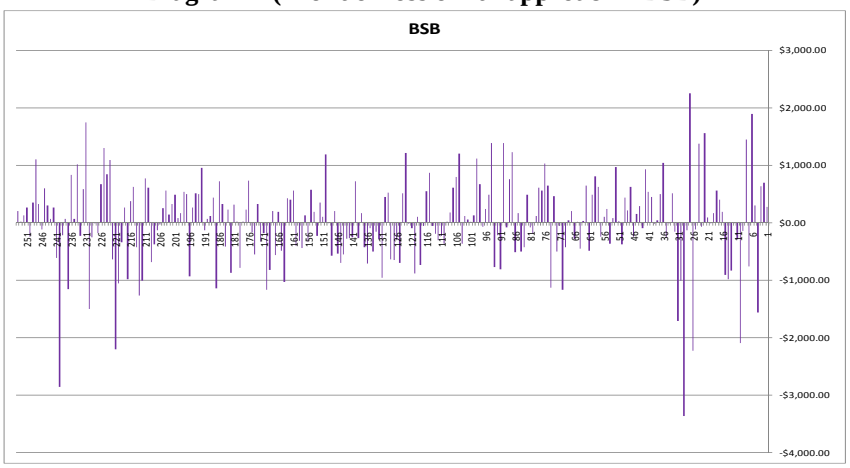

Diagram 8 (Profit or loss of 8th approach – SBB)

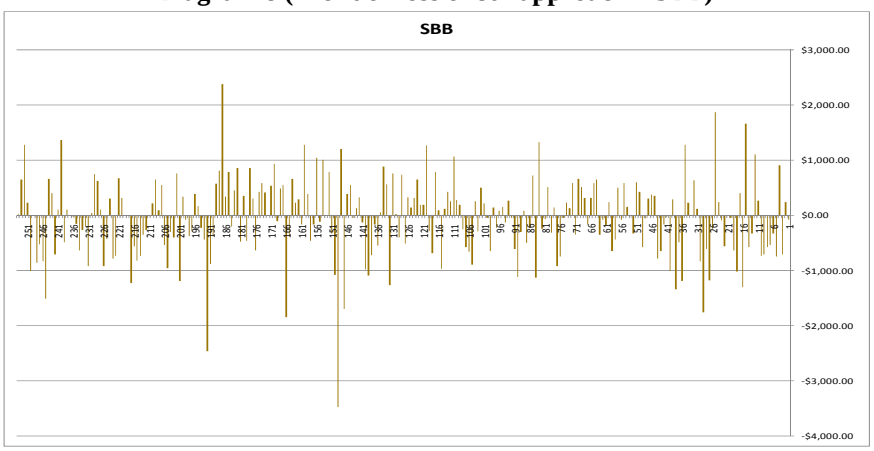

Diagram 9 (Covariances between EURUSD & JPYUSD)

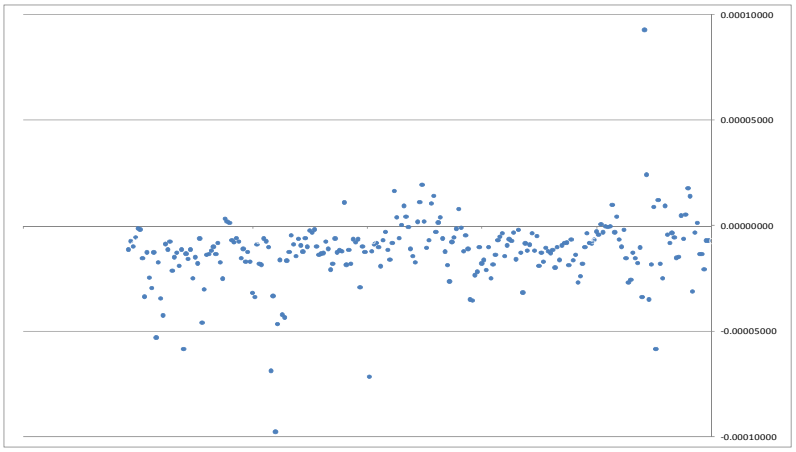

Diagram 10 (Covariances between JPYUSD & EURJPY)

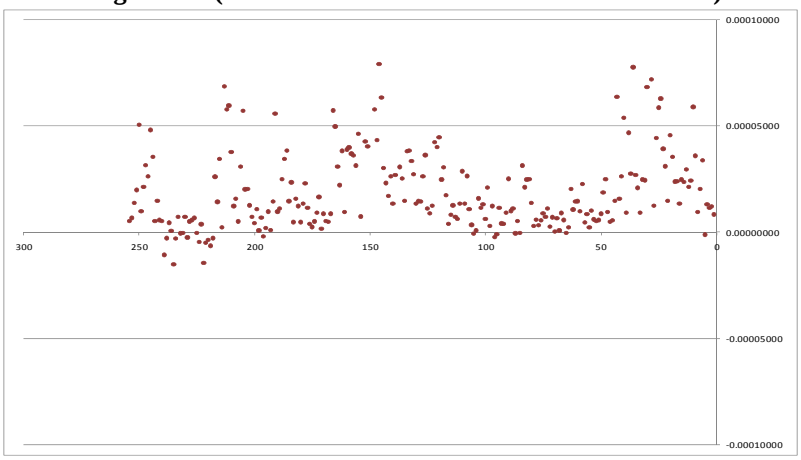

Diagram 11 (Covariances between EURUSD & EURJPY)

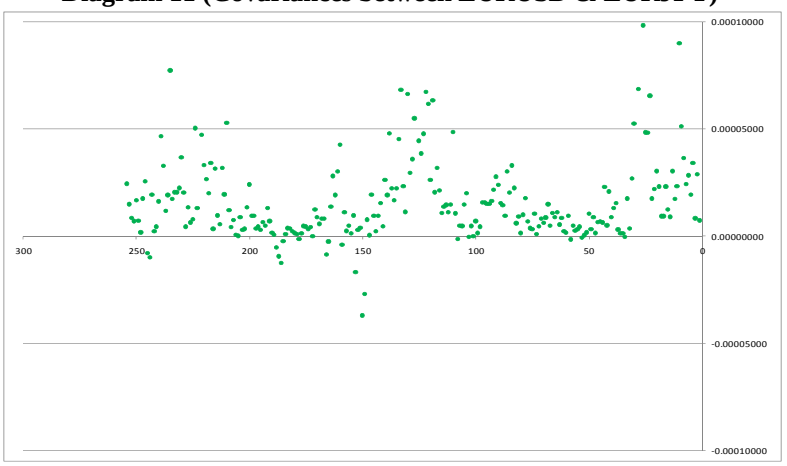

Table 8 (calculating Fstat)

Source	Sum of sq	df	Mean sq	F
between	82,175,387	7	11739341.04	29.8486
Within	796,029,655	2024	393295.284	
Total	878,205,042	2.31		

Diagram 12 (Volume of different categories, with regard tocovariances)

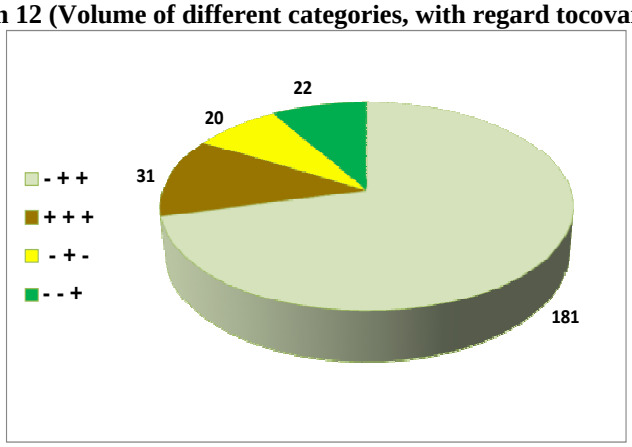

Diagram 13 (Result of 28 states, when covarianceswere -, +, +)

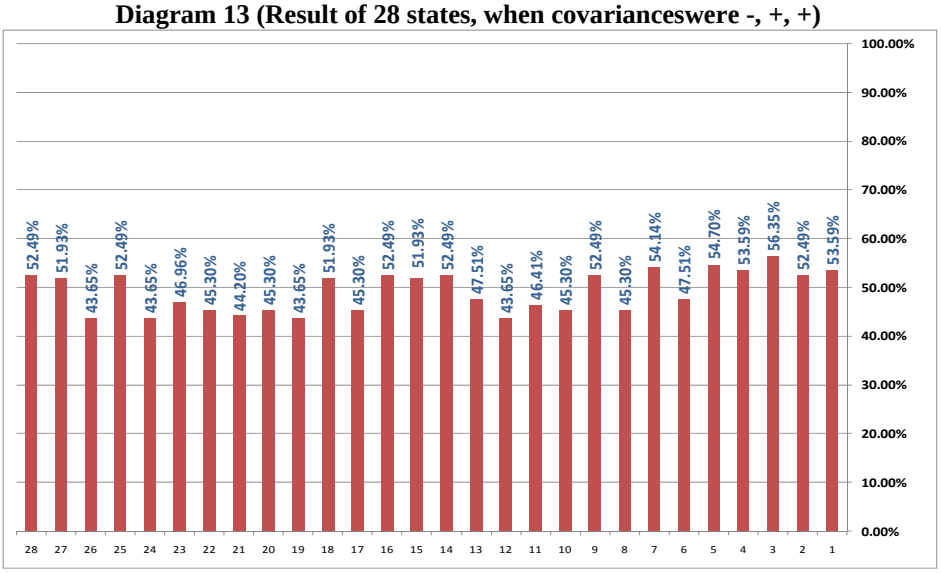

Diagram 14 (Average profit of approaches – category A)

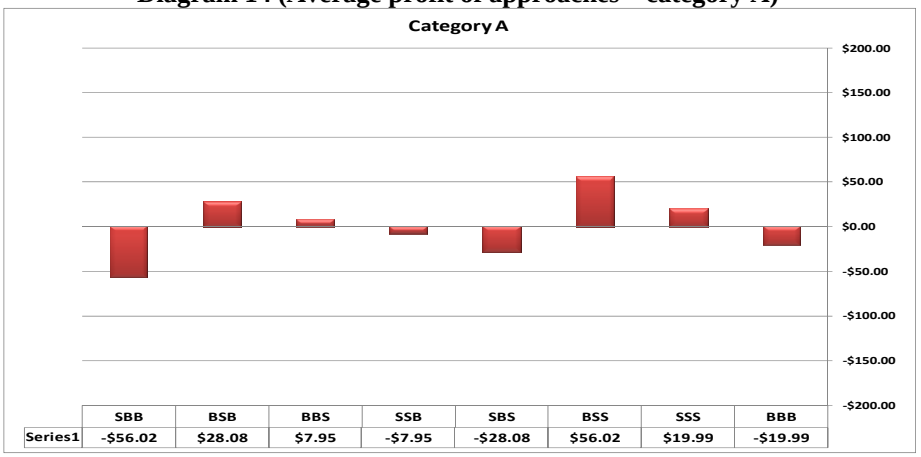

Diagram 15 (Result of 28 states, when covarianceswere+, +, +)

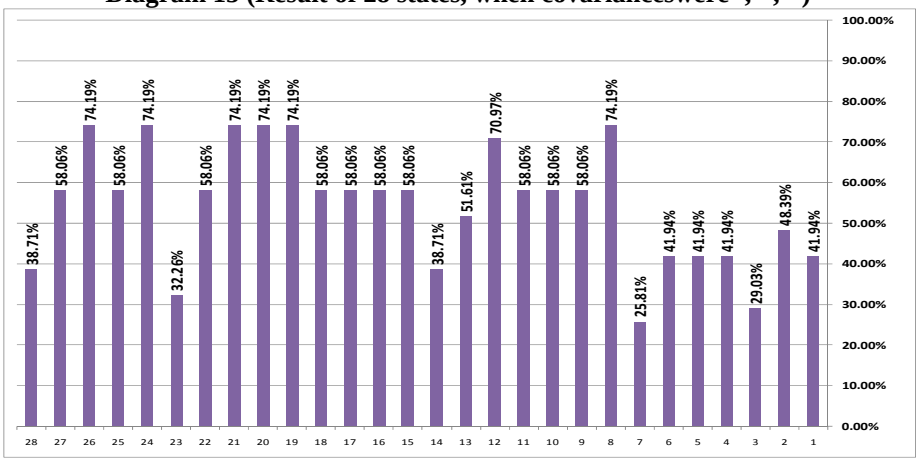

Diagram 16 (Average profit of approaches – category B)

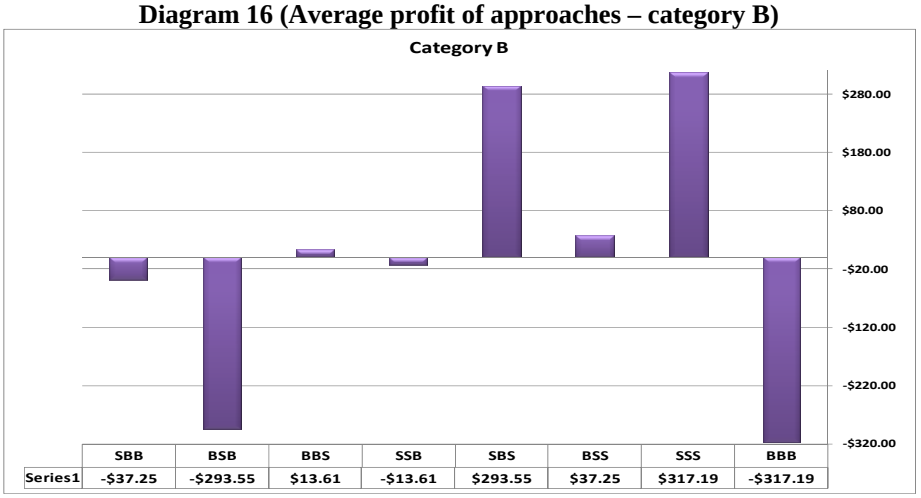

Diagram 17 (Result of 28 states, when covarianceswere -, +, -)

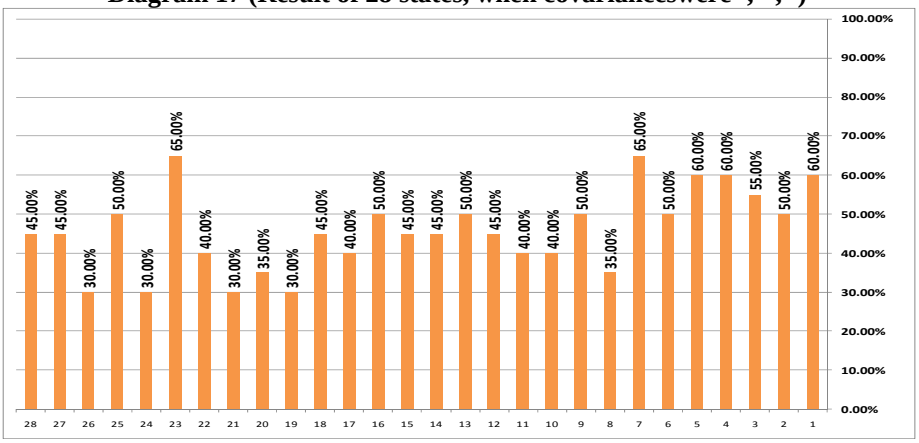

Diagram 18 (Average profit of approaches – category C)

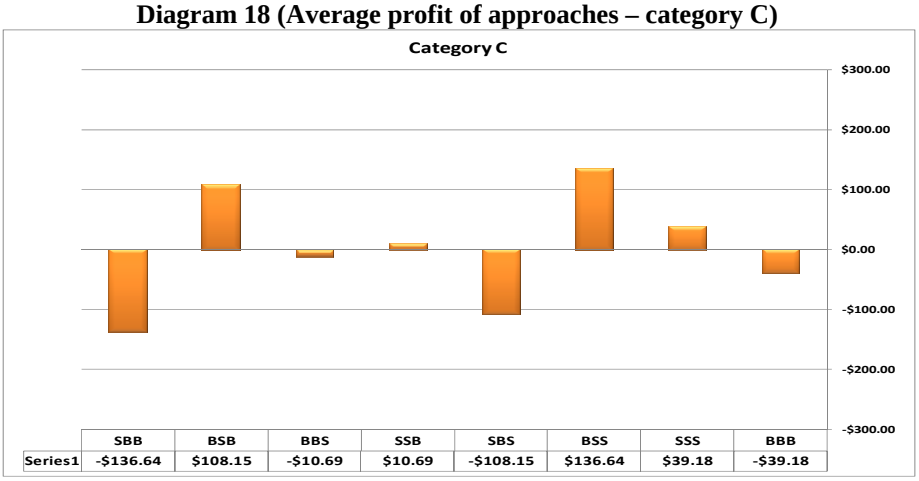

Diagram 19 (Result of 28 states, when covarianceswere -, -, +)

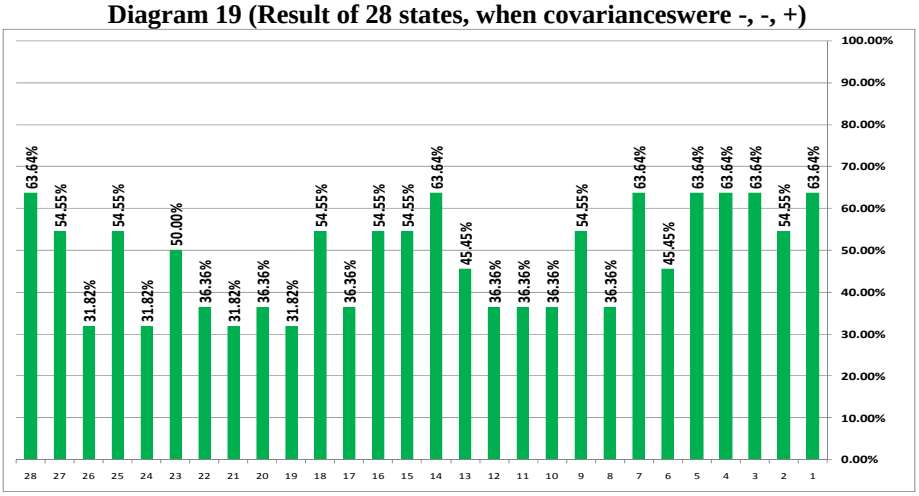

Diagram 20 (Average profit of approaches – category D)

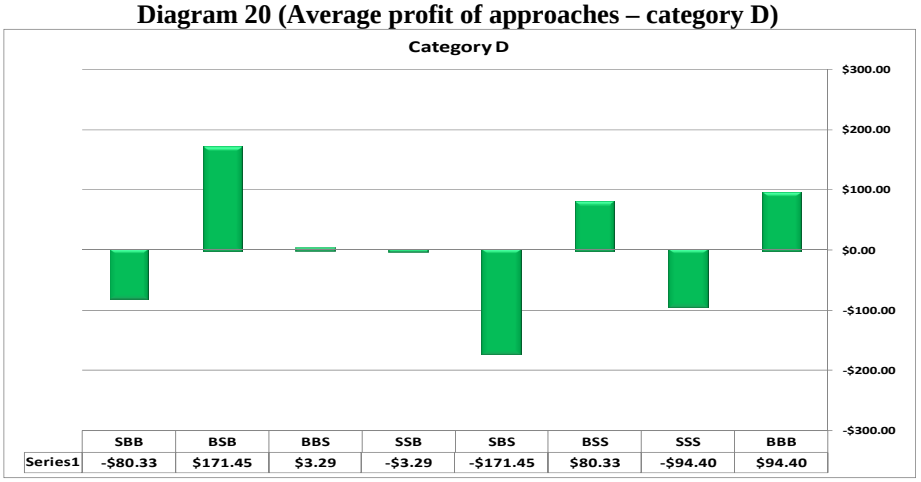

Diagram 21 (frequently categorized covariances happened in different months of the year)

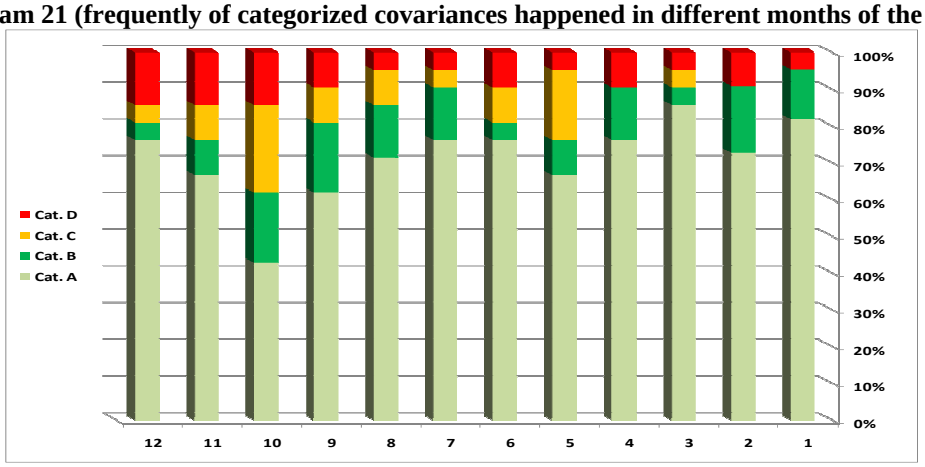

Table 9 (monthly average of profits of approaches)

		BBB	SSS	BSS	SBS	SSB	BBS	BSB	SBB
A	- + +	-19.99	19.99	56.02	-28.08	-7.95	7.95	28.08	-56.02
B	+ + +	-317.19	317.19	37.25	293.55	-13.61	13.61	-293.55	-37.25
C	- + -	-39.18	39.18	136.64	-108.15	10.69	-10.69	108.15	-136.64
D	- - +	94.40	-94.40	80.33	-171.45	-3.29	3.29	171.45	-80.33
Wght Ave.		**-47.86**	**47.86**	**62.18**	**-7.55**	**-6.77**	**6.77**	**7.55**	**-62.18**