Covariance Matrix Estimation via Macroeconomic Factor Modeling

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Abstract

This report compares the performance of two asset allocation strategies namely; Risk Parity and Mean Variance during periods of volatility in South Africa. Using South African financial data, the risk adjusted and information ratio of a unleverd Risk Parity Index porfolio and Tangency Index porfolio are compared. The research paper found that the Mean Variance Optimisation approach is an superior asset allocation strategy during periods of high volatility in South Africa.

Keywords: Asset Allocation, Risk Parity, Mean Variance Optimisation, Volatility

1. Introduction

References are to be made as follows: Fama & French (1997: 33) and Grinold & Kahn (2000) Such authors could also be referenced in brackets (Grinold & Kahn, 2000) and together Grinold & Kahn (2000). Source the reference code from scholar.google.com by clicking on "cite'' below article name. Then select BibTeX at the bottom of the Cite window, and proceed to copy and paste this code into your ref.bib file, located in the directory's Tex folder. Open this file in Rstudio for ease of management, else open it in your preferred Tex environment. Add and manage your article details here for simplicity - once saved, it will self-adjust in your paper.

As per Flannery & Protopapadakis (2002).. factor models are good shit!

> I suggest renaming the top line after @article, as done in the template ref.bib file, to something more intuitive for you to remember. Do not change the rest of the code. Also, be mindful of the fact that bib references from google scholar may at times be incorrect. Reference Latex forums for correct bibtex notation.

To reference a section, you have to set a label using "\label'' in R, and then reference it in-text as e.g. referencing a later section, Section **??**.

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2. Literature Review

3. Exploratory Analysis

As can be seen in Section 2

3.1. Data and Descriptive Statistics

Table 3.1: Macroeconomic Factors

Name	Description	Source
Bcom_Index	Bloomberg Commodities Index	N. Katzke
Inflation	Inflation (Consumer Prices)	IMF International Financial Statistics
MM.Rate	SA Money Market Rate	IMF International Financial Statistics
Real.GDP	SA Real Gross Domestic Product	IMF International Financial Statistics
Real.INV	SA Real Gross Fixed Capital Formation	IMF International Financial Statistics
US_10Yr	US 10 Year Bond Yields	N. Katzke
USDZAR	USD/ZAR Spot Price	N. Katzke
VIX	CBOE Volatility Index	N. Katzke

Table 3.2: Summary Statistics: Macroeconomic Factors

	US_10Yr	Bcom_Index	VIX	USDZAR	MM.Rate	Real.GDP	Real.INV	Inflation
median	2.490	125.747	16.520	9.881	6.530	1.07e+12	1.86e+11	1.236
mean	2.745	123.179	19.383	10.563	6.513	1.04e+12	1.79e+11	1.295
SE.mean	0.138	4.753	1.076	0.415	0.230	1.08e+10	2.36e+09	0.082
CI.mean.0.95	0.276	9.490	2.148	0.829	0.459	2.15e+10	4.71e+09	0.164
var	1.282	1513.671	77.528	11.563	3.534	7.78e+21	3.73e+20	0.453
std.dev	1.132	38.906	8.805	3.400	1.880	8.82e+10	1.93e+10	0.673
coef.var	0.412	0.316	0.454	0.322	0.289	0.0848	0.108	0.519

Table 3.3: T40 Constituents

Ticker	Constituent	Super Industry
ABG	ABSA GROUP LTD	Financials
AGL	ANGLO AMER PLC	Resources
AMS	ANGLO AMERICAN P	Resources
ANG	ANGLOGOLD ASHANT	Resources
APN	ASPEN PHARMACARE	Industrials
BHP	BHP GROUP PLC	Resources
BID	BID CORP LTD	Industrials
BVT	BIDVEST GROUP	Industrials
BTI	BRIT AMER TOBACC	Industrials
CPI	CAPITEC BANK HOL	Financials
CLS	CLICKS GROUP LTD	Industrials
DSY	DISCOVERY LTD	Financials
EXX	EXXARO RESOURCES	Resources
FSR	FIRSTRAND LTD	Financials
GLN	GLENCORE PLC	Resources
GFI	GOLD FIELDS LTD	Resources
GRT	GROWTHPOINT PROP	Financials
IMP	IMPALA PLATINUM	Resources
INL	INVESTEC LTD	Financials
INP	INVESTEC PLC	Financials
MNP	MONDI PLC	Industrials
MRP	MR PRICE GROUP	Industrials
MTN	MTN GROUP LTD	Industrials
MCG	MULTICHOICE GROU	Industrials
NPN	NASPERS LTD-N	Industrials
NED	NEDBANK GROUP	Financials
NRP	NEPI ROCKCASTLE	Financials
NPH	NORTHAM PLATINUM	Resources
OMU	OLD MUTUAL LTD	Financials
PRX	PROSUS NV	Industrials
RNI	Reinet Investments SCA	Financials
CFR	RICHEMONT-DR	Industrials
SLM	SANLAM LTD	Financials
SOL	SASOL LTD	Resources
SHP	SHOPRITE HLDGS	Industrials
SSW	SIBANYE STILLWAT	Resources
SPP	SPAR GRP LTD/THE	Industrials
SBK	STANDARD BANK GR	Financials
VOD	VODACOM GROUP	Industrials
WHL	WOOLWORTHS HLDGS	Industrials

3.2. Factor and Industry Plots

US 10 Year Yield

Figure 3.1: US Long-Term Bond Yields
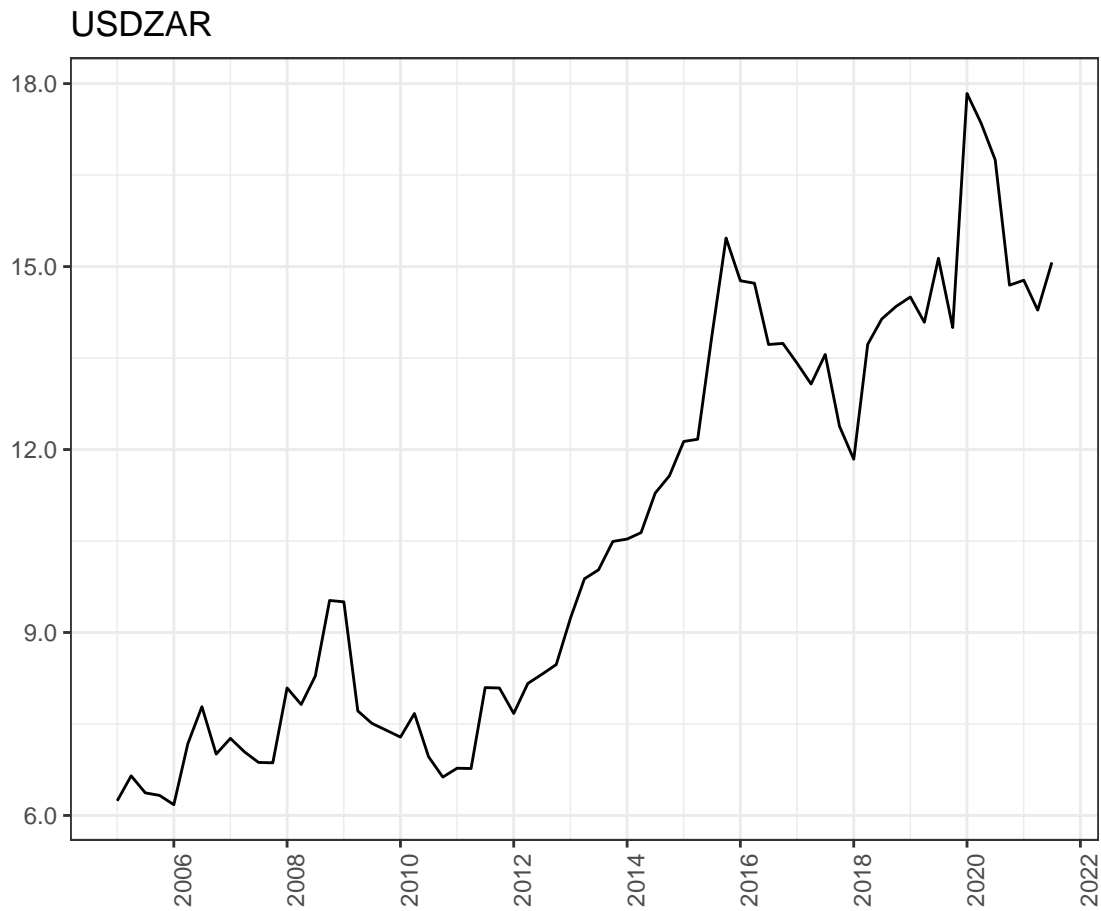
Figure 3.2: USDZAR Spot Price
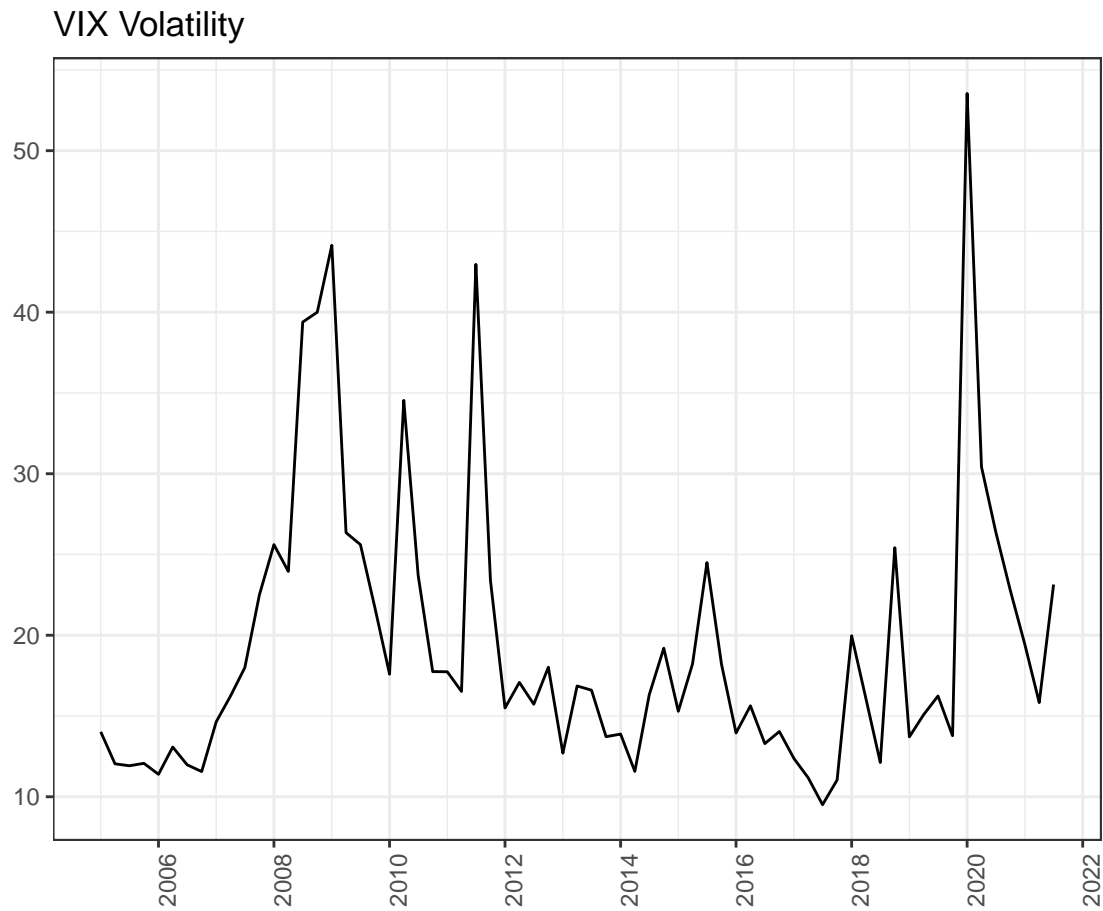
VIX Volatility

Figure 3.3: CBOE VIX Volatility Index

Commodity Price

Figure 3.4: Bloomberg Commodity Price Index

SA Money Market Rate
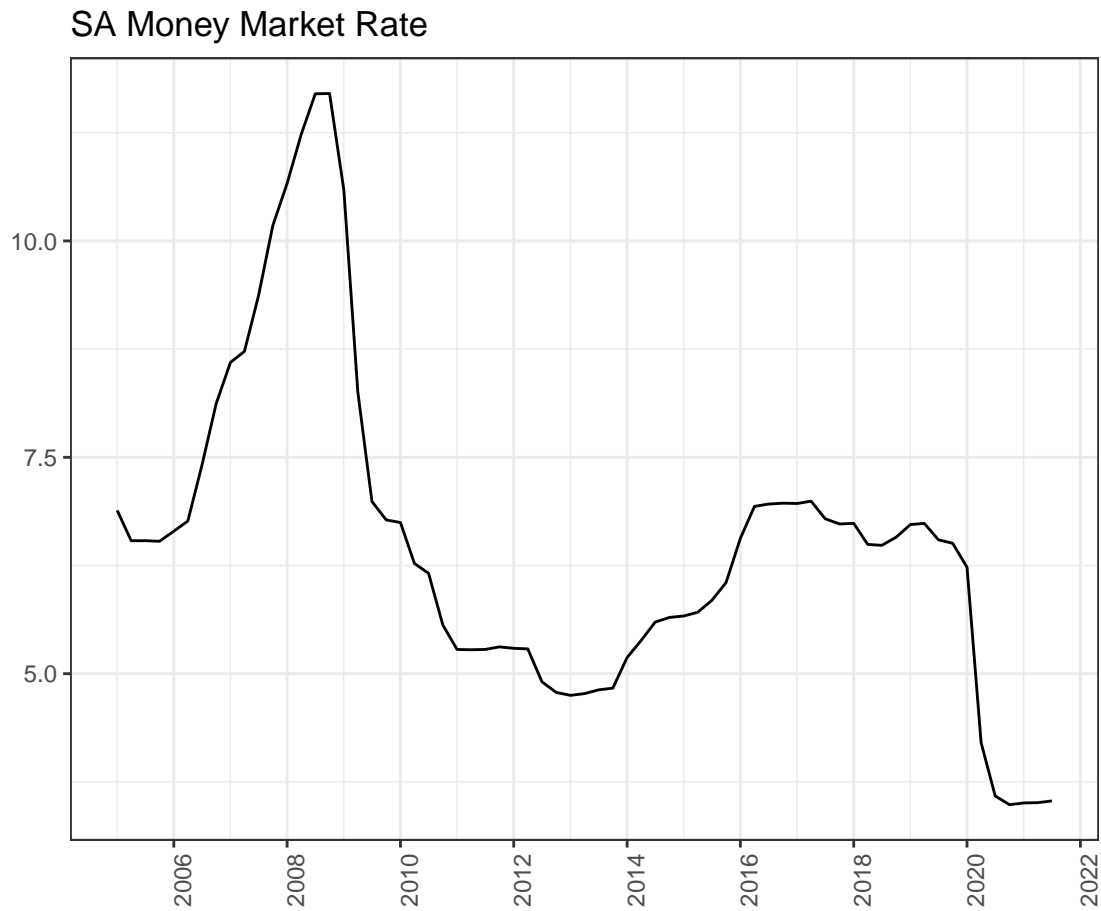
Figure 3.5: South Africa Money Market Rate
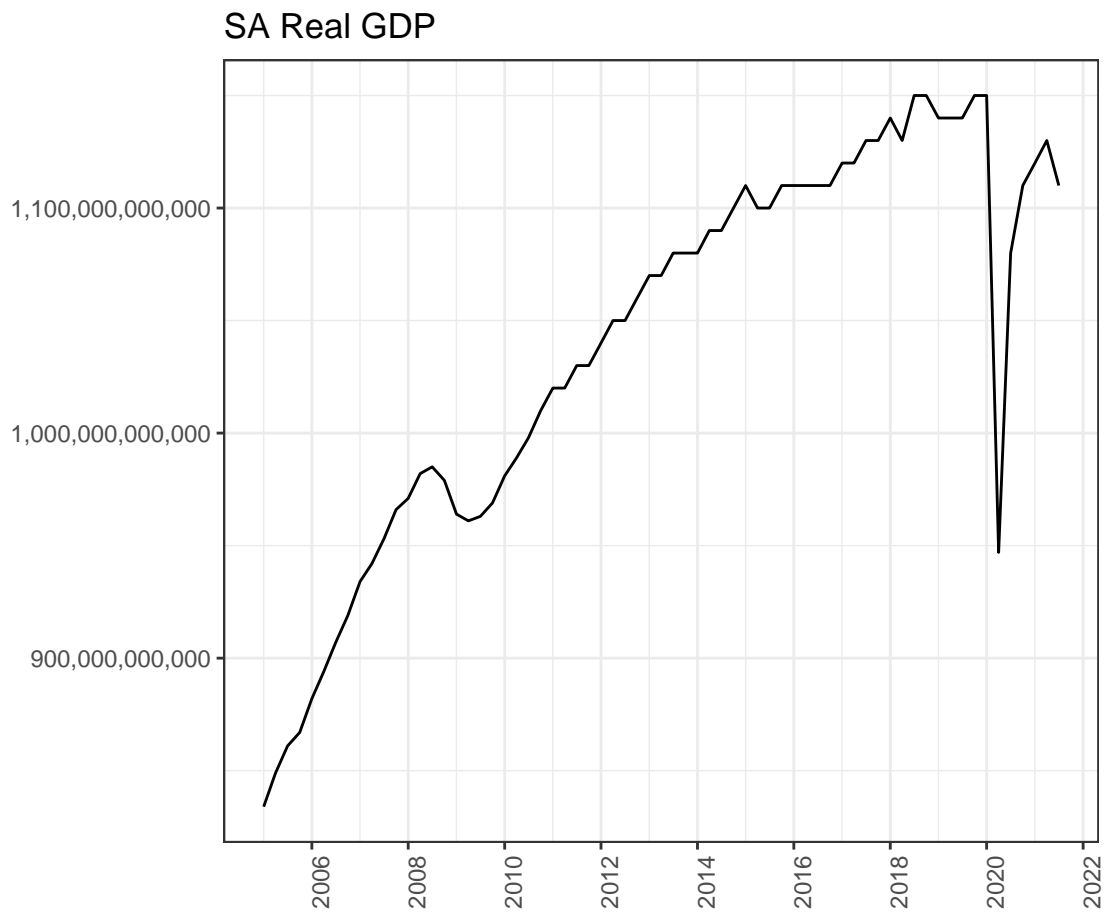
SA Real GDP

Figure 3.6: South Africa Real GDP

SA Real Investment
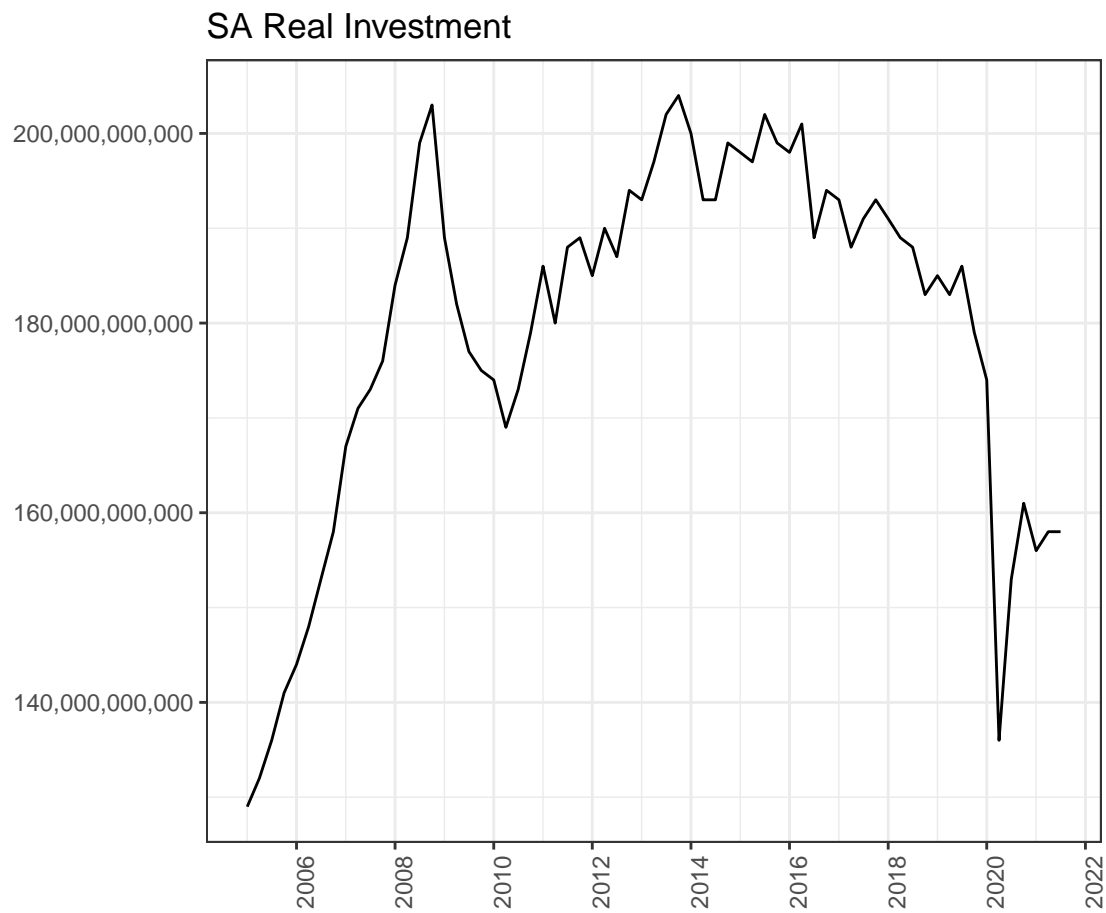

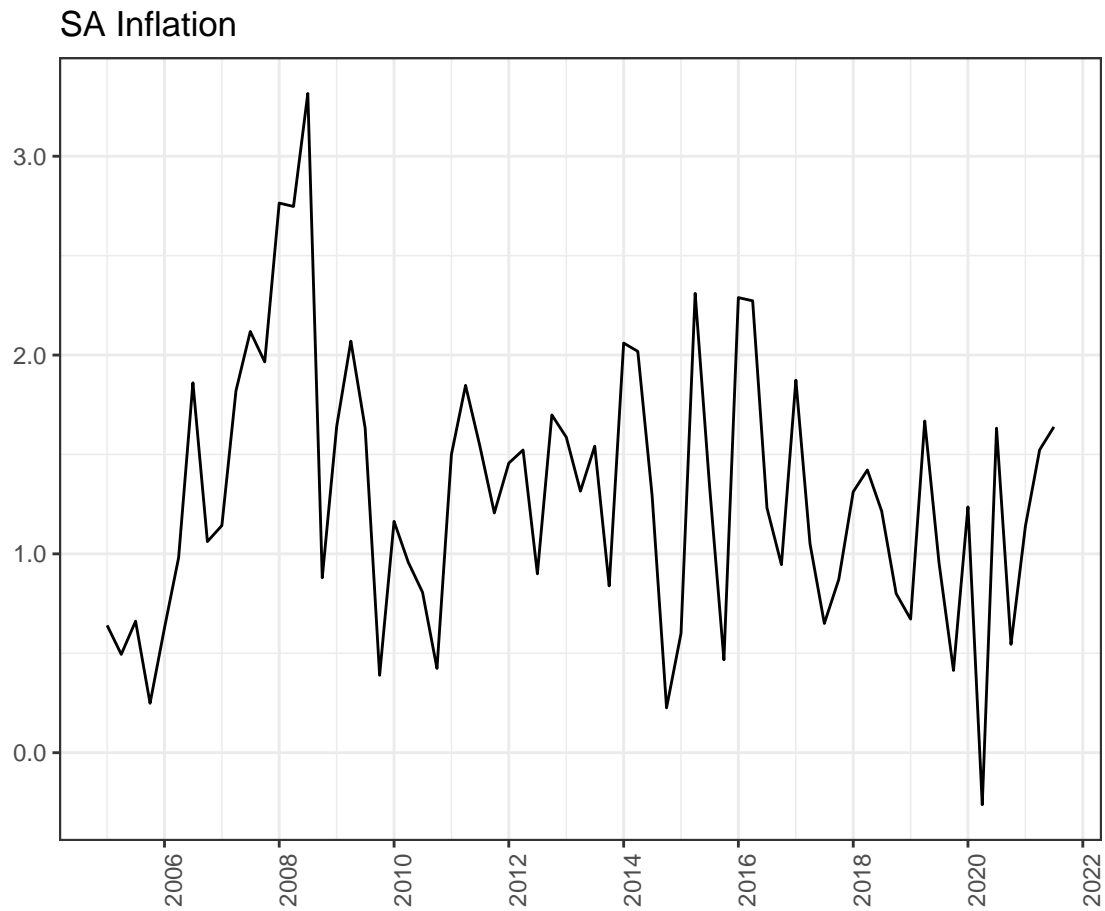Figure 3.7: South Africa Real Gross Fixed Capital Formation

SA Inflation
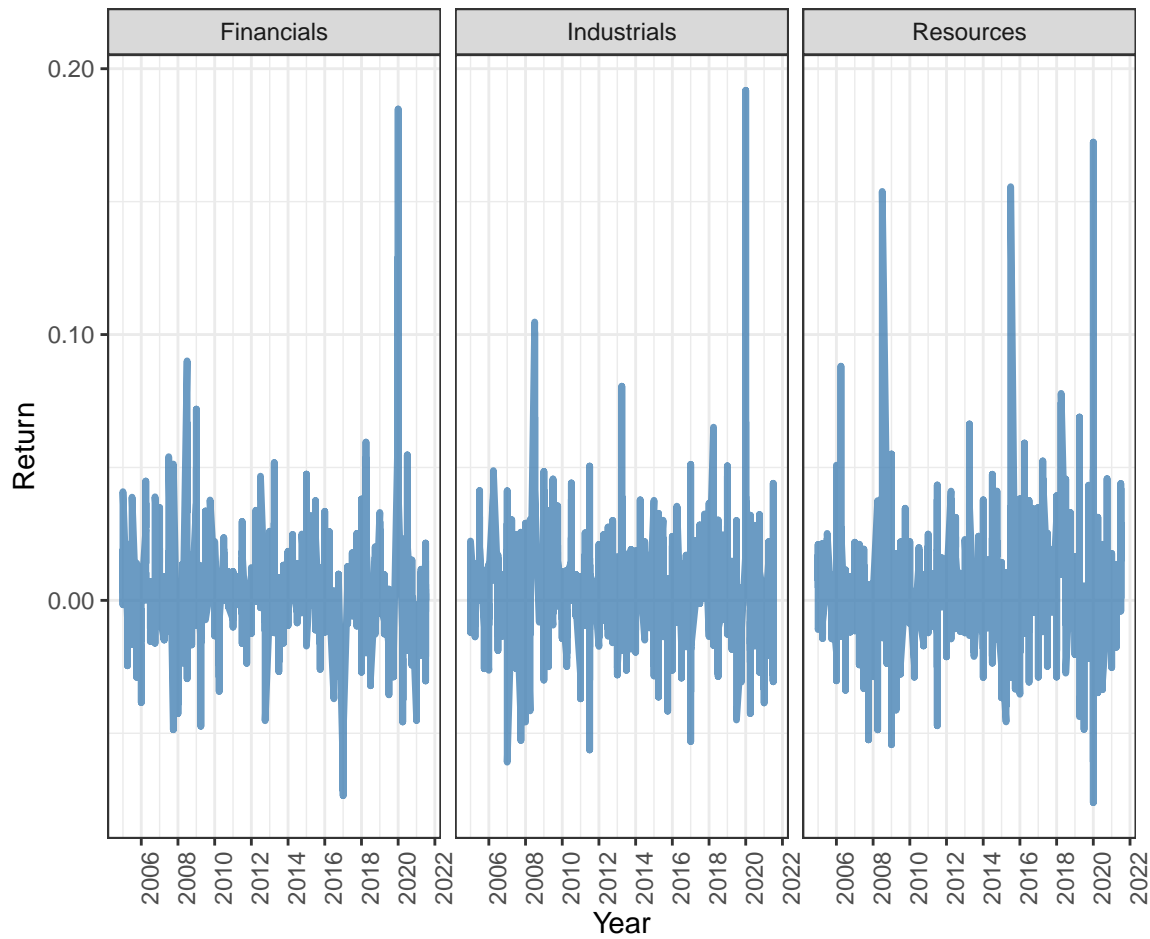

Figure 3.8: South Africa Consumer Price Inflation

Figure 3.9: Asset Returns by Industry

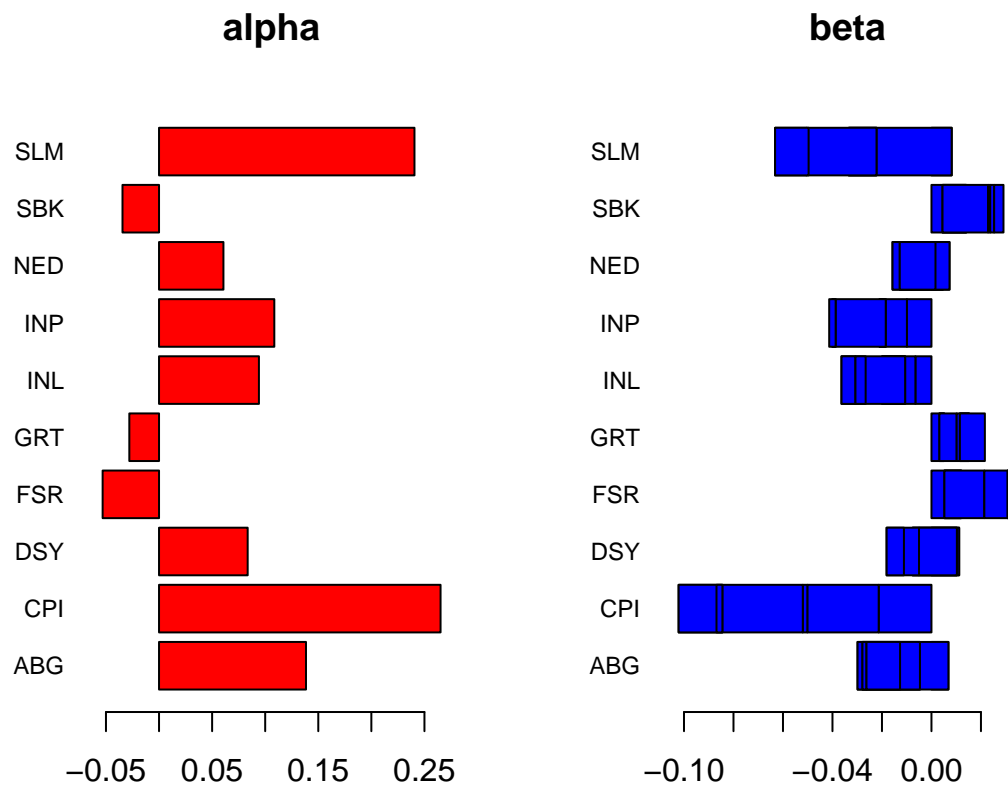## 4. Empirical Analysis

4.1. Methodology

4.2. Model Estimation (by Industry)

Figure 4.1: Factor Analysis: Financials
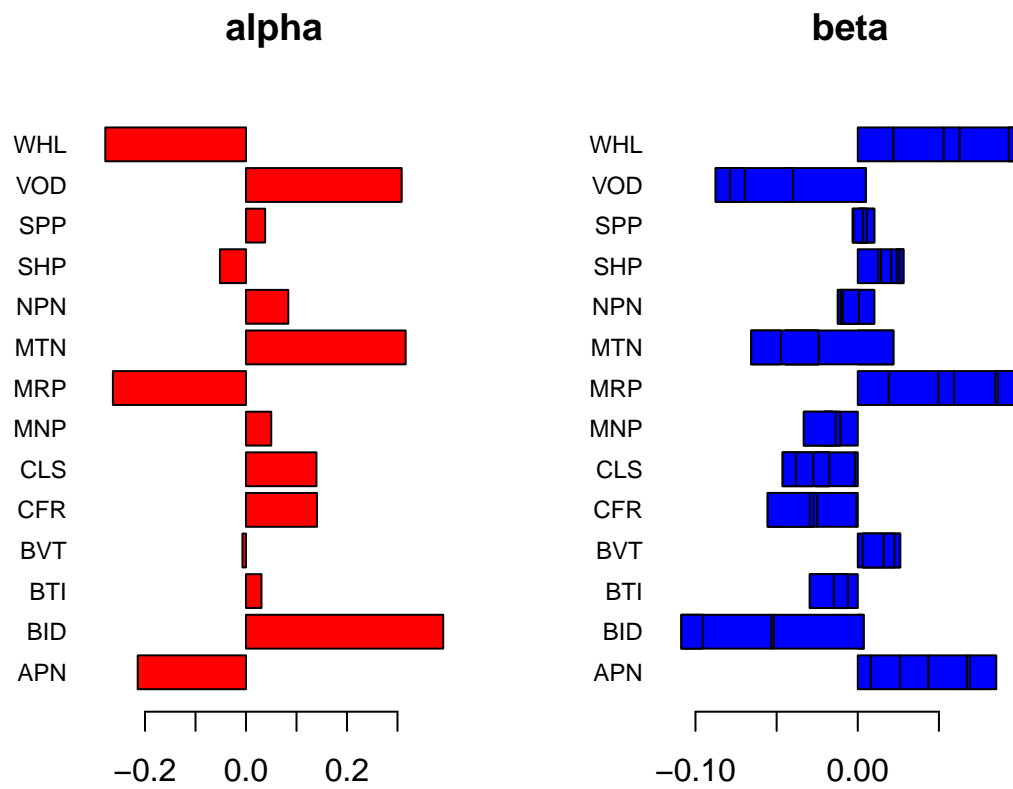
Figure 4.2: Factor Analysis: Industrial
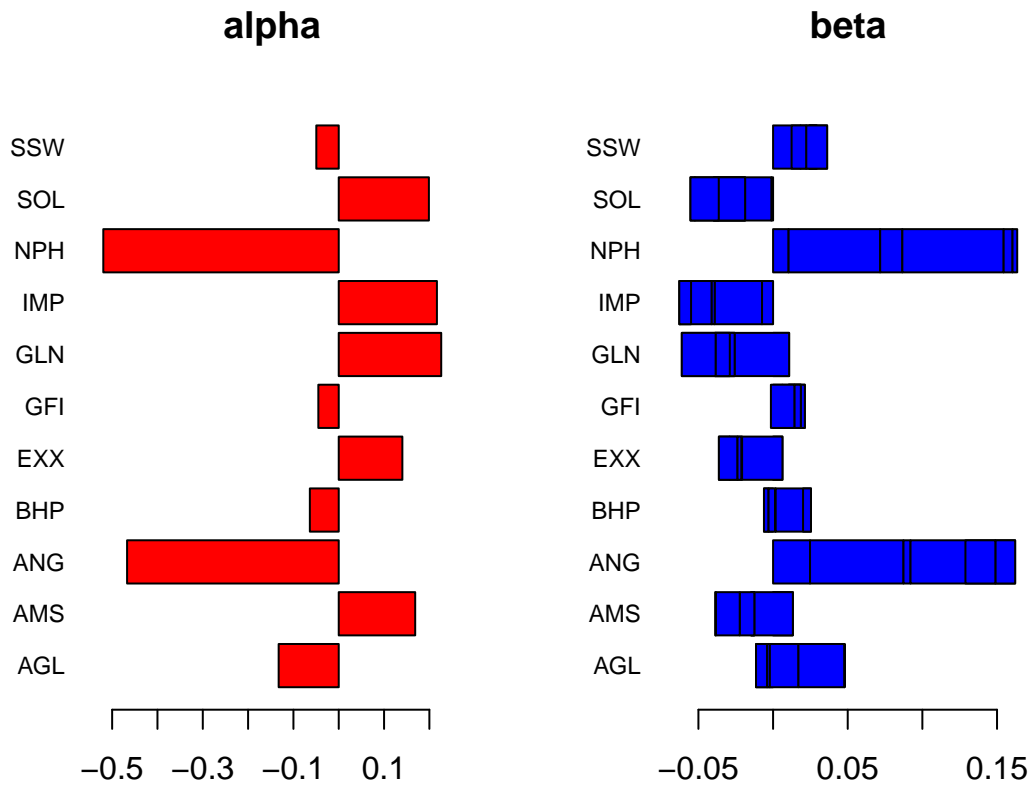
Figure 4.3: Factor Analysis: Resources

4.3. Discussion of Results

5. Conclusion

6. References

10 Fama, E.F. & French, K.R. 1997. Industry costs of equity. *Journal of financial economics.* 43(2):153–193.

Flannery, M. & Protopapadakis, A.A. 2002. Macroeconomic factors do influence aggregate stock returns. *Review of Financial Studies.* 15(3):751–782.

Grinold, R.C. & Kahn, R.N. 2000. Active portfolio management.

7. Appendices

To reference the plot above, add a "\label'' after the caption in the chunk heading, as done above. Then reference the plot as such: As can be seen, Figures **??** and **??** are excellent, with Figure **??** being particularly aesthetically pleasing due to its device setting of Tikz. The nice thing now is that it correctly numbers all your figures (and sections or tables) and will update if it moves. The links are also dynamic.

[1]

Equations should be written as such:

$$\beta = \sum_{i=1}^{\infty} \frac{\alpha^2}{\sigma_{t-1}^2} \tag{7.1}$$
$$\int_{x=1}^{\infty} x_i = 1$$

If you would like to see the equations as you type in Rmarkdown, use \$ symbols instead (see this for yourself by adjusted the equation):

$$\beta = \sum_{i=1}^{\infty} \frac{\alpha^2}{\sigma_{t-1}^2} \int_{x=1}^{\infty} x_i = 1$$

Note again the reference to equation 7.1. Writing nice math requires practice. Note I used a forward slashes to make a space in the equations.

	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
1	21.00	6.00	160.00	110.00	3.90	2.62	16.46	0.00	1.00	4.00	4.00
2	21.00	6.00	160.00	110.00	3.90	2.88	17.02	0.00	1.00	4.00	4.00
3	22.80	4.00	108.00	93.00	3.85	2.32	18.61	1.00	1.00	4.00	1.00
4	21.40	6.00	258.00	110.00	3.08	3.21	19.44	1.00	0.00	3.00	1.00
5	18.70	8.00	360.00	175.00	3.15	3.44	17.02	0.00	0.00	3.00	2.00

Table 7.1: Short Table Example

To reference calculations **in text**, *do this:* From table 7.1 we see the average value of mpg is 20.98.

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[1]This is an example of a footnote by the way. Something that should also not be overused.

Including tables that span across pages, use the following (note that I add below the table: "continue on the next page''). This is a neat way of splitting your table across a page.

Use the following default settings to build your own possibly long tables. Note that the following will fit on one page if it can, but cleanly spreads over multiple pages:

Table 7.2: Long Table Example

mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
21.00	6.00	160.00	110.00	3.90	2.62	16.46	0.00	1.00	4.00	4.00
21.00	6.00	160.00	110.00	3.90	2.88	17.02	0.00	1.00	4.00	4.00
22.80	4.00	108.00	93.00	3.85	2.32	18.61	1.00	1.00	4.00	1.00
21.40	6.00	258.00	110.00	3.08	3.21	19.44	1.00	0.00	3.00	1.00
18.70	8.00	360.00	175.00	3.15	3.44	17.02	0.00	0.00	3.00	2.00
18.10	6.00	225.00	105.00	2.76	3.46	20.22	1.00	0.00	3.00	1.00
14.30	8.00	360.00	245.00	3.21	3.57	15.84	0.00	0.00	3.00	4.00
24.40	4.00	146.70	62.00	3.69	3.19	20.00	1.00	0.00	4.00	2.00
22.80	4.00	140.80	95.00	3.92	3.15	22.90	1.00	0.00	4.00	2.00
19.20	6.00	167.60	123.00	3.92	3.44	18.30	1.00	0.00	4.00	4.00
17.80	6.00	167.60	123.00	3.92	3.44	18.90	1.00	0.00	4.00	4.00
16.40	8.00	275.80	180.00	3.07	4.07	17.40	0.00	0.00	3.00	3.00
17.30	8.00	275.80	180.00	3.07	3.73	17.60	0.00	0.00	3.00	3.00
15.20	8.00	275.80	180.00	3.07	3.78	18.00	0.00	0.00	3.00	3.00
10.40	8.00	472.00	205.00	2.93	5.25	17.98	0.00	0.00	3.00	4.00
10.40	8.00	460.00	215.00	3.00	5.42	17.82	0.00	0.00	3.00	4.00
14.70	8.00	440.00	230.00	3.23	5.34	17.42	0.00	0.00	3.00	4.00
32.40	4.00	78.70	66.00	4.08	2.20	19.47	1.00	1.00	4.00	1.00
30.40	4.00	75.70	52.00	4.93	1.61	18.52	1.00	1.00	4.00	2.00
33.90	4.00	71.10	65.00	4.22	1.83	19.90	1.00	1.00	4.00	1.00
21.50	4.00	120.10	97.00	3.70	2.46	20.01	1.00	0.00	3.00	1.00
15.50	8.00	318.00	150.00	2.76	3.52	16.87	0.00	0.00	3.00	2.00
15.20	8.00	304.00	150.00	3.15	3.44	17.30	0.00	0.00	3.00	2.00
13.30	8.00	350.00	245.00	3.73	3.84	15.41	0.00	0.00	3.00	4.00
19.20	8.00	400.00	175.00	3.08	3.85	17.05	0.00	0.00	3.00	2.00
27.30	4.00	79.00	66.00	4.08	1.94	18.90	1.00	1.00	4.00	1.00
26.00	4.00	120.30	91.00	4.43	2.14	16.70	0.00	1.00	5.00	2.00
30.40	4.00	95.10	113.00	3.77	1.51	16.90	1.00	1.00	5.00	2.00
15.80	8.00	351.00	264.00	4.22	3.17	14.50	0.00	1.00	5.00	4.00
19.70	6.00	145.00	175.00	3.62	2.77	15.50	0.00	1.00	5.00	6.00
15.00	8.00	301.00	335.00	3.54	3.57	14.60	0.00	1.00	5.00	8.00

Table 7.2: Long Table Example

mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
21.40	4.00	121.00	109.00	4.11	2.78	18.60	1.00	1.00	4.00	2.00

Note that I do not include this in the ordinary template, as some latex users have complained it breaks when they build their Rmds (especially those using tidytex - I don't have this problem as I have the full Miktex installed on mine). Up to you, but I strongly recommend installing the package manually and using huxtable. To make this work, uncomment the *Adding additional latex packages* part in yaml at the top of the Rmd file. Then comment out the huxtable example in the template below this line. Reknit, and enjoy.

Table 7.3: Regression Output

	Reg1	Reg2	Reg3
(Intercept)	-2256.361 ***	5763.668 ***	4045.333 ***
	(13.055)	(740.556)	(286.205)
carat	7756.426 ***		7765.141 ***
	(14.067)		(14.009)
depth		-29.650 *	-102.165 ***
		(11.990)	(4.635)
N	53940	53940	53940
R2	0.849	0.000	0.851

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.