





MODELLING THE FINANCIAL VULNERABILITY OF FARMING SYSTEMS TO CLIMATE CHANGE

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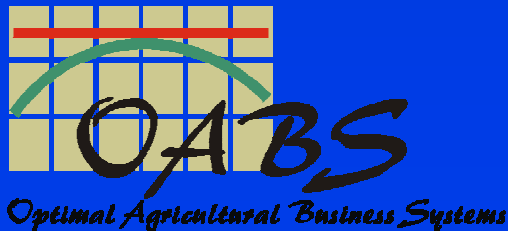


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Contract Details

KSA	KSA 4: Water Utilisation in Agriculture	
Thrust	Thrust 4: Water Resource Protection and Reclamation in Agriculture	
Programme	P2: Impact assessment and environmental management of agricultural production	
Proposer	Johnston, Dr PA	
Title	ADAPTIVE INTERVENTIONS IN AGRICULTURE TO REDUCE VULNERABILITY OF DIFFERENT FARMING SYSTEMS TO CLIMATE CHANGE IN SOUTH AFRICA	
Proposal Number	1001659	
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Content

- Introduction
- Objective
- Methodology
- Modelling Results
- Conclusions



Optimal Agricultural Business Systems

Introduction

The Fourth Assessment Report of the IPCC (2007) states that “Agricultural production and food security (including access to food) in many African countries and regions are likely to be severely compromised by climate change and climate variability”.



Optimal Agricultural Business Systems

Objective of the study

The development of a conceptual framework to investigate the financial vulnerability of different farming systems towards climate change

(To develop a dynamic model that link climatology, hydrology, crop physiology and economics at farm level)



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Methodology

- Identify study areas (*Summer, Winter, Irr, DL*)
- Identification of selected case studies
- Primary & Secondary data collection
- Excel Modelling (Base case)
- DLP Whole Farm Modelling (Base)
 - *Simulate case-study (20-year planning horizon)*
 - *DLP assume constant prices & technology*
- Construct modelling inter-phases



Methodology

- Model verification — *compare DLP results (including interphases) with Excel results*
- Impose CC on the farming systems without adaptation to test CC impact on financial vulnerability of the system
- Modeling scenarios
 - *Apsim Crop model scenarios*
 - *Expert Opinion scenarios*



Climate change modelling inter-phases

- The Apsim Crop model data - whole-farm model inter-phase
- The crop temperature & rainfall threshold whole-farm model inter-phase
- The crop yield & quality whole-farm model inter-phase
- An inter-phase to generate at random variation coefficients (*to be imposed on base scen & all crops where crop models are not*



Crop Climate Thresholds (Expert Opinions)

VREDENDAL		THRESHOLDS	
CROP	TEMP	RAINFALL	OTHER
WINE GRAPES		>3 days (10mm or more per day) after Veraison (Dec-Mar) = rot and major losses	WIND:E/SE wind plus heat (Oct-Apr)
	During flowering >38 deg before/during veraison T>42		> 4m/s during pollination
	> 20 deg at night - damaged fruit		FLOODING: after Sept any flooding of vineyards = major damage
	> 35 deg for >5 days - damaged fruit		Thunderstorms = canal flooding/damage
			HAIL: even ONCE = devastation
TABLE GRAPES	(Tmax-Tmin) >10 deg during Oct/nov affects colouration	>16 deg Bolling and 5-10mm rain (Dec/Jan) = bursting and crop damage	WIND:Fruit drop - S wind = blackspot
	> 35 deg = sunburn	Wet summer/cloudy/lower T = reduced sugar and more disease	
	1 day >38 or 35 deg plus wind - affects sugar		
	> 33 deg for > 5 days with high Tmin		
DRY GRAPES	AS ABOVE	Any Rain from December to April = bursting/rotting	
	post harvest - low T and no wind delays drying.		
TOMATOES	Flowering (week 8) >35deg for > 2 days = crop failure	Wet summer/cloudy/lower T = reduced sugar and more disease	FLOODING: major damage at any time
	(processed - Oct-Jan Fresh -July - Feb)	Blossoming - > 35 deg for > 3 days = rot	
		Harvest > 40 deg october < 25 deg ave = poor crop	

Global circulation models (GCM's)

Institute	GCM
Canadian Center for Climate Modelling and Analysis (CCCma), Canada Abbreviation: CCC	Name: CCCM3.1(T47) First published: 2005 Website: http://www.cccma.bc.ec.gc.ca/models/cgcm3.shtml
Météo-France / Centre National de Recherches Meteorologiques (CNRM), France Abbreviation: CRM	Name: CNRM-CM3 First published: 2004 Website: http://www.cnrm.meteo.fr/scenario2004/indexenglish.html
Max Planck Institute for Meteorology (MPI-M), Germany Abbreviation: ECH	Name: ECHAM5/MPI-OM First published: 2005 Website: http://www.mpimet.mpg.de/en/wissenschaft/modelle.html
NASA / Goddard Institute for Space Studies (GISS), USA Abbreviation: GISS	Name: GISS-ER First published: 2004 Website: http://www.giss.nasa.gov/tools/modelE
Institut Pierre Simon Laplace (IPSL), France Abbreviation: IPS	Name: IPSL-CM4 First published: 2005 Website: http://mc2.ipsl.jussieu.fr/simules.html

GCM's – Calculation of thresholds events

		Predicted rainfall for Mooreesburg					Threshold Occurance					
		MAY : rain in mm					MAY <50 (1=YES and 0=NO)					MEDIAN
		CCC	CRM	ECH	GISS	IPS	CCC	CRMECH	GISS	IPS		
Present	1971	47.5	50.8	73.9	107.1	106.8	1	0	0	0	0	0
	1972	65	86.3	118.6	36	38	0	0	0	0	1	0
	1973	57.7	50	80.4	72.8	14	0	0	0	0	1	0
	1974	81	78	157.5	23.6	65.4	0	0	0	1	0	0
	1975	85.1	49.8	59	22.7	70.3	0	0	1	1	0	0
	1976	67.7	28.8	90.6	59.9	87.3	0	1	0	0	0	0
	1977	34.4	20.4	22	3.5	94.7	1	1	1	1	0	1
	1978	54.5	3.5	73.4	4.4	40.3	0	1	0	1	1	1
	1979	89.4	40.3	82.9	21.9	55.5	0	0	0	1	0	0
	1980	51.8	29	110.3	1	39.4	1	1	0	1	1	1
	1981	65.6	25.3	54.8	16.8	101	0	1	1	1	0	1
	1982	97.1	48.7	69.4	3.1	49.4	0	0	1	1	1	1
	1983	36.4	2.7	83.8	44.4	48.4	1	1	0	0	1	1
	1984	75.5	66.4	63.4	0	60.3	0	0	1	1	0	0
	1985	31.7	46.5	78.7	53.2	76.8	1	0	0	0	0	0
	1986	87.9	58.5	9.9	51.3	67.3	0	0	1	0	0	0
	1987	63.6	25.5	54.7	10.8	93.3	0	1	1	1	0	1
1988	28.4	57.3	61.7	65.2	25.2	1	0	1	0	1	1	
1989	88.6	15.4	153.8	29.2	38.8	0	1	0	0	1	0	
1990	67.3	14.5	185.8	27.1	60.5	0	1	0	0	0	0	

Crop Climate Thresholds Yield Penalty Factor

Crop Climate threshold	Yield penalty factor
Mid May_Aug Max T > 20 deg	-0.10
Sum of T_max over 25 Sept	-0.10
Rainfal May - less than 50mm	-0.10
Rainfal May - Sep < 200mm	-0.30
Rainfal May - Sep > 400mm	0.20
Rainfal May - Sep > 10 mm/week	0.33
Rainfal Sep week 1&2 > 10 mm	0.10
Rainfal Sep week 3&4 > 10 mm	0.10
May_Jun no rain	-0.10
Jun_Jul < 70mm	-0.10
Jul_Aug < 70mm	-0.10
Sep < 15	-0.10

Yield scaling due to thresholds exceeded

	Mid May_Aug Max T > 20 deg	Sum of T_max over 25 Sept	Rainfal May - less than 50mm	Rainfal May - Sep < 200mm	Rainfal May - Sep > 400mm	Rainfal May - Sep > 10 mm/week	Rainfal Sep week 1&2 > 10 mm	Rainfal Sep week 3&4 > 10 mm	May_Jun no rain	Jun_Jul < 70mm	Jul_Aug < 70mm	Sep < 15	Sep < 5	Temp Yield Scaling factor	Rainfal Yield Scaling factor	Temp & Rain Yield Scaling factor	Rainfal model scaling code
1971			-0.1				0.1							0	0	0	10
1972								0.1						0	0.1	0.1	13
1973							0.1	0.1						0	0.2	0.2	15
1974												-0.1		0	-0.1	-0.1	8
1975							0.1				-0.1			0	0	0	10
1976							0.1							0	0.1	0.1	13
1977			-0.1				0.1	0.1						0	0.1	0.1	13
1978												-0.1		0	-0.1	-0.1	8
1979							0.1				-0.1			0	0	0	10
1980			-0.1				0.1	0.1						0	0.1	0.1	13
1981							0.1					-0.1		0	0	0	10
1982					0.2		0.1							0	0.3	0.3	17
1983			-0.1				0.1							0	0	0	10
1984							0.1	0.1			-0.1			0	0.1	0.1	13
1985			-0.1				0.1	0.1						0	0.1	0.1	13
1986				-0.3							-0.1	-0.1		0	-0.5	-0.5	1
1987							0.1	0.1						0	0.2	0.2	15
1988			-0.1				0.1							0	0	0	10
1989							0.1	0.1						0	0.2	0.2	15
1990							0.1			-0.1				0	0	0	10
Total	0	0	-0.6	-0.3	0.2	0	1.6	0.8	0	-0.1	-0.4	-0.4	0	0	0.8	0.04	11.35

Scaling of yield grading

Table 1.6: Allocating a code to scale the quality – Morreesburg example

	y2012	y2013	y2014	y2015	y2016	y2017	y2018	y2019	y2020	y2021	y2022	y2023	y2024	y2025	y2026
WheatE	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5
WheatM	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5
WheatL	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5
Barley	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oats	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Triticale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Canola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Medics	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STDum1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STDum2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STDum3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	Y2027	Y2028	Y2029	Y2030	Y2031										
WheatE	5	5	5	5	5										
WheatM	5	5	5	5	5										
WheatL	5	5	5	5	5										
Barley	0	0	0	0	0										
Oats	0	0	0	0	0										
Triticale	0	0	0	0	0										
Canola	0	0	0	0	0										
Medics	0	0	0	0	0										
STDum1	0	0	0	0	0										
STDum2	0	0	0	0	0										
STDum3	0	0	0	0	0										

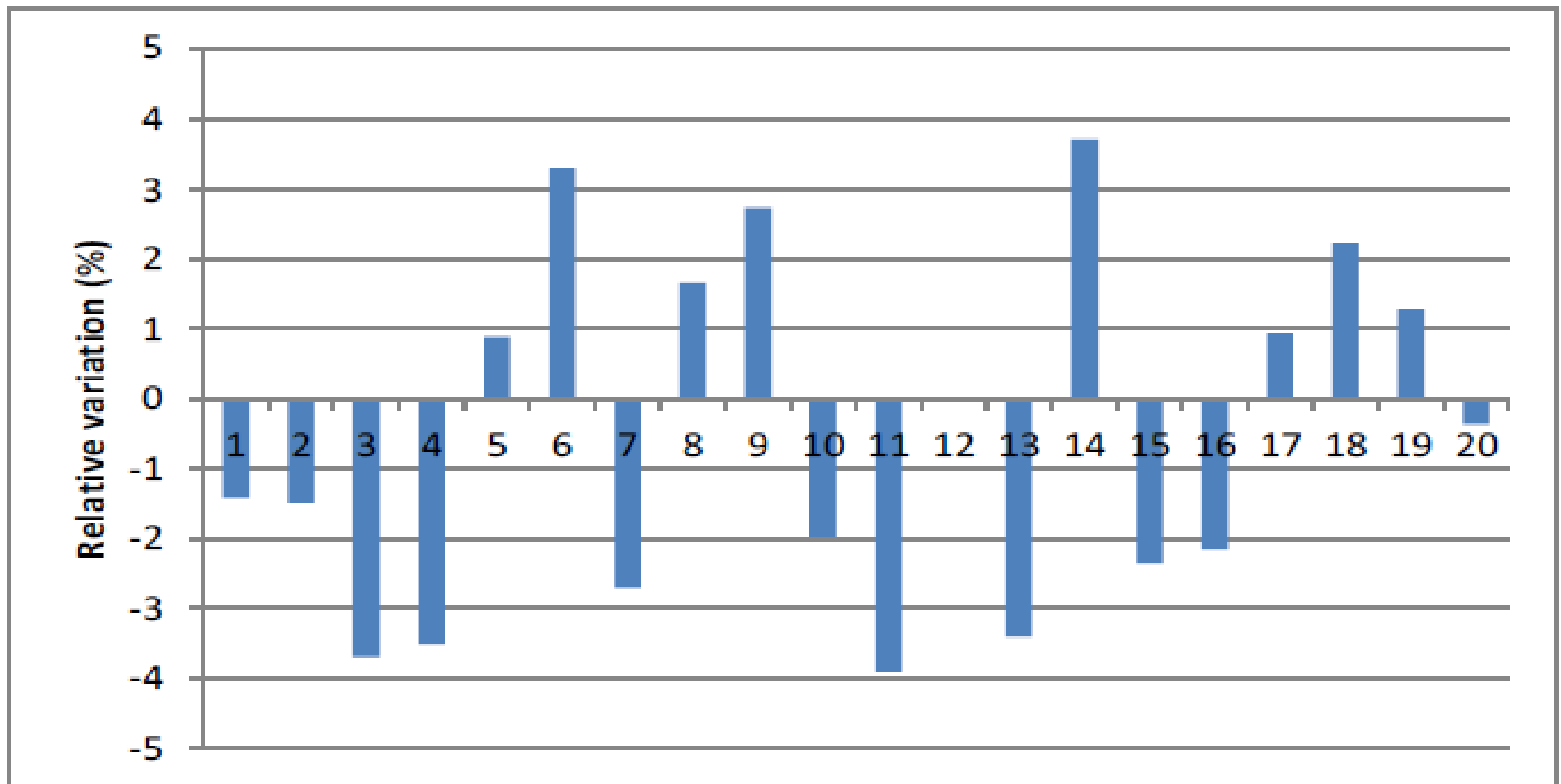
For example if a code of 5 is allocated the GAMS model will establish from Table 1.7 below that there is zero change. A code 4 will result in the model changing the Grade 1 yield with -10% and increasing Grade 1 and 2 with respectively +5%.

Table 1.7: Scaling of yield grading due to quality impact condition

Grade	1	2	3	4	5	6	7	8	9
Grain1	-0.4	-0.3	-0.2	-0.1	0	0.01	0.02	0.03	0.04
Grain2	0.3	0.2	0.15	0.05	0	-0.01	-0.02	-0.03	-0.04
Grain3	0.1	0.1	0.05	0.05	0	0	0	0	0

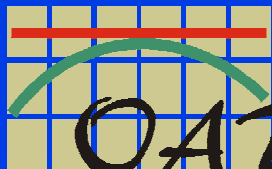
Random Variation Coefficients

Parameter AnualY ;
AnualY(Ph) = Uniform(-5,5) ;



Modelling results: Scenarios

- Base run
- Present GCM's Expert Opinions (PEO)
- Intermediate GCM's Expert Opinion (IEO)
- Intermediate GCM's Apsim Crop models (IACM)



Modelling results: Moorreesburg

1 000ha farm (445ha wheat, 445ha medics
& 1300 sheep (ewes))



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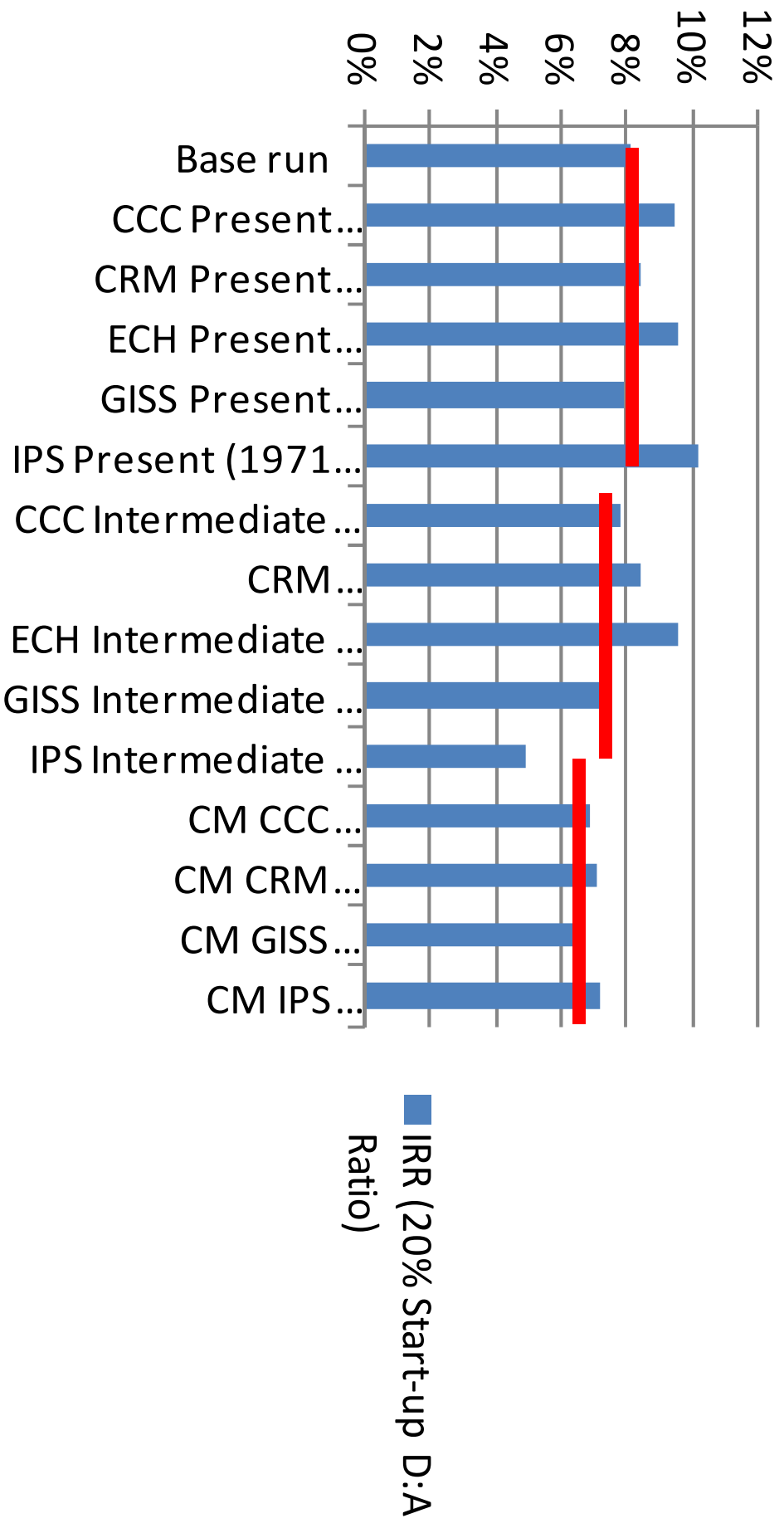
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Modelling results: Moorreesburg

	IRR	NPV	Cash flow ratio	Highest D:A Ratio	Highest debt
Base	8%	9,147,498	138%	26%	(5,111,068)
CCC Present	9%	12,386,451	144%	34%	(6,502,397)
CRM Present	8%	8,873,696	135%	31%	(6,043,281)
ECH Present	10%	11,307,050	139%	31%	(6,043,281)
GISS Present	8%	8,662,294	136%	28%	(5,431,125)
IPS Present	10%	12,850,332	143%	26%	(4,972,009)
CCC Intermediate	8%	9,238,654	139%	34%	(6,502,397)
CRM Intermediate	8%	8,873,696	135%	31%	(6,043,281)
ECH Intermediate	10%	12,395,320	143%	34%	(6,502,397)
GISS Intermediate	7%	8,300,849	136%	38%	(7,420,626)
IPS Intermediate	5%	1,921,510	122%	27%	(5,149,618)
CM CCC Intermediate	7%	7,432,550	135%	37%	(7,102,584)
CM CRM Intermediate	7%	8,086,021	137%	37%	(7,102,584)
CM GISS Intermediate	7%	6,517,282	133%	37%	(7,168,049)
CM IPS Intermediate	7%	8,143,335	137%	37%	(7,102,584)

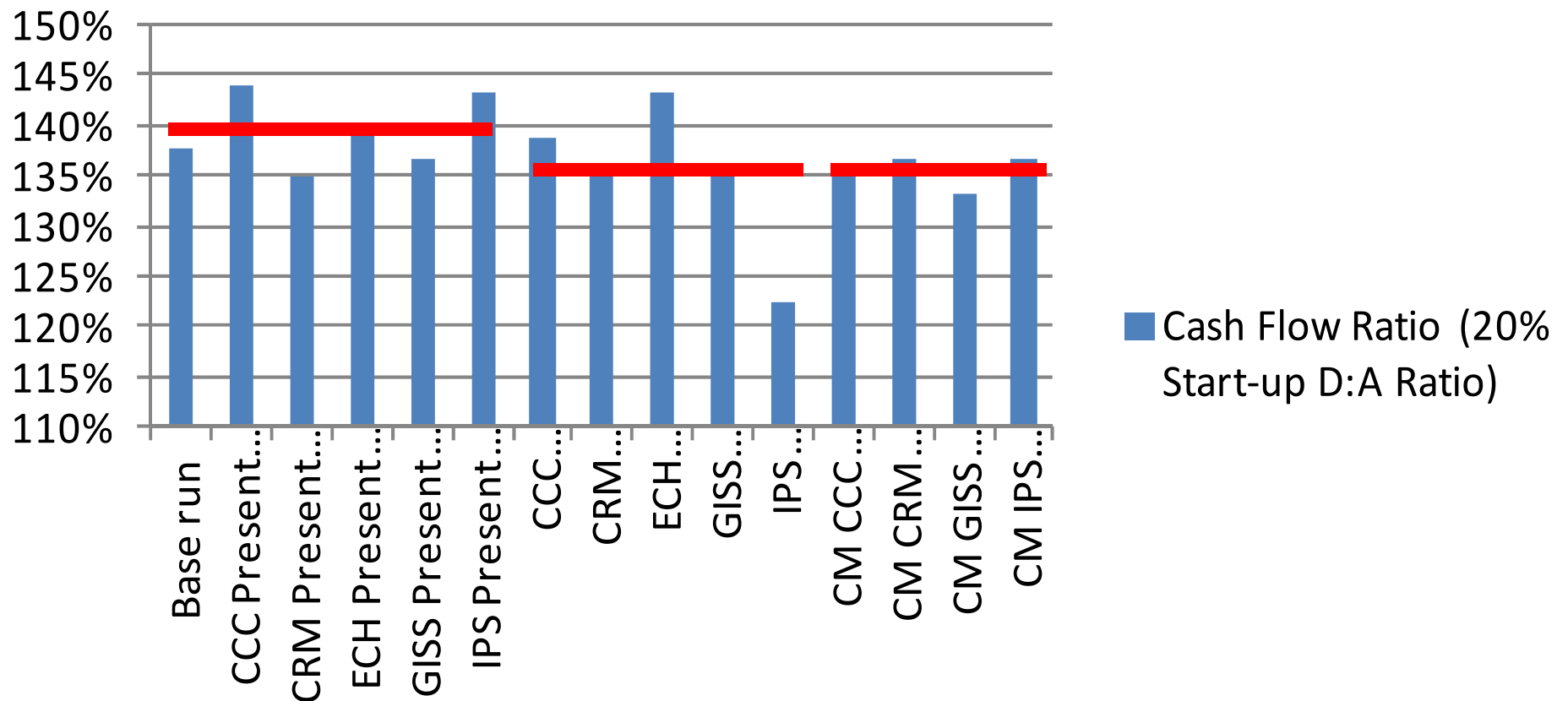
Modelling results: Moorreesburg

IRR (20% Start-up D:A Ratio)

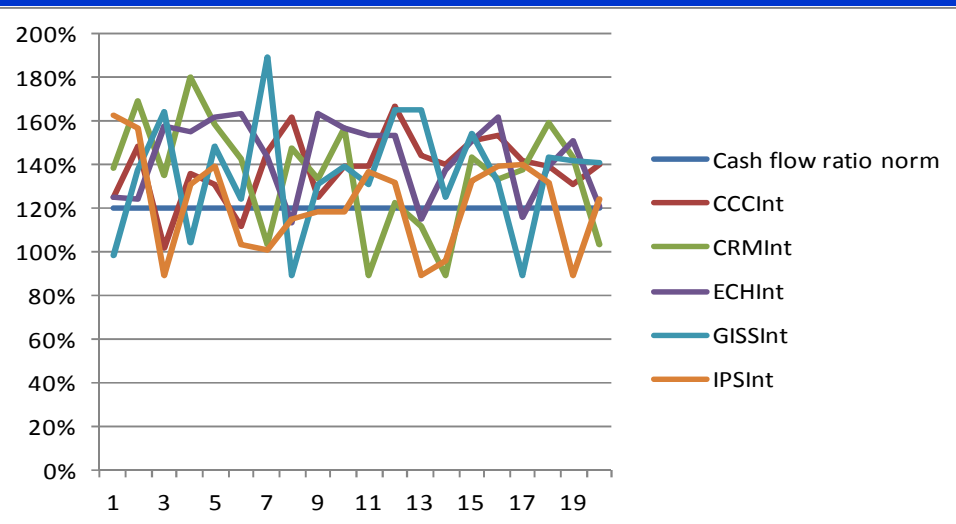
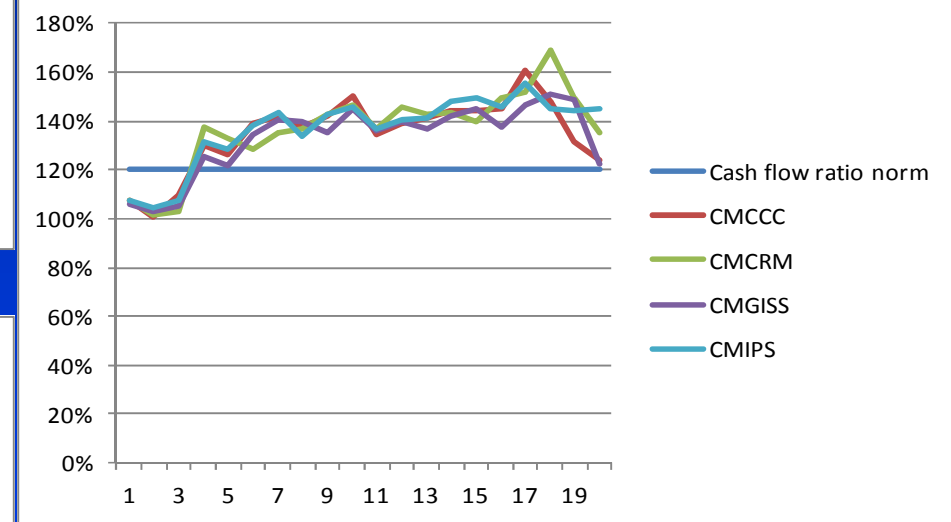
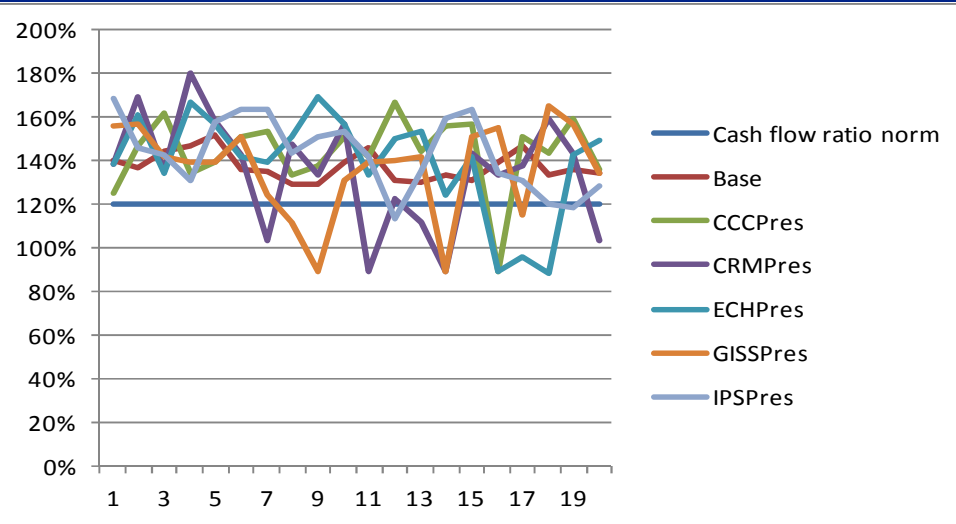


Modelling results: Moorreesburg

Cash Flow Ratio (20% Start-up D:A Ratio)

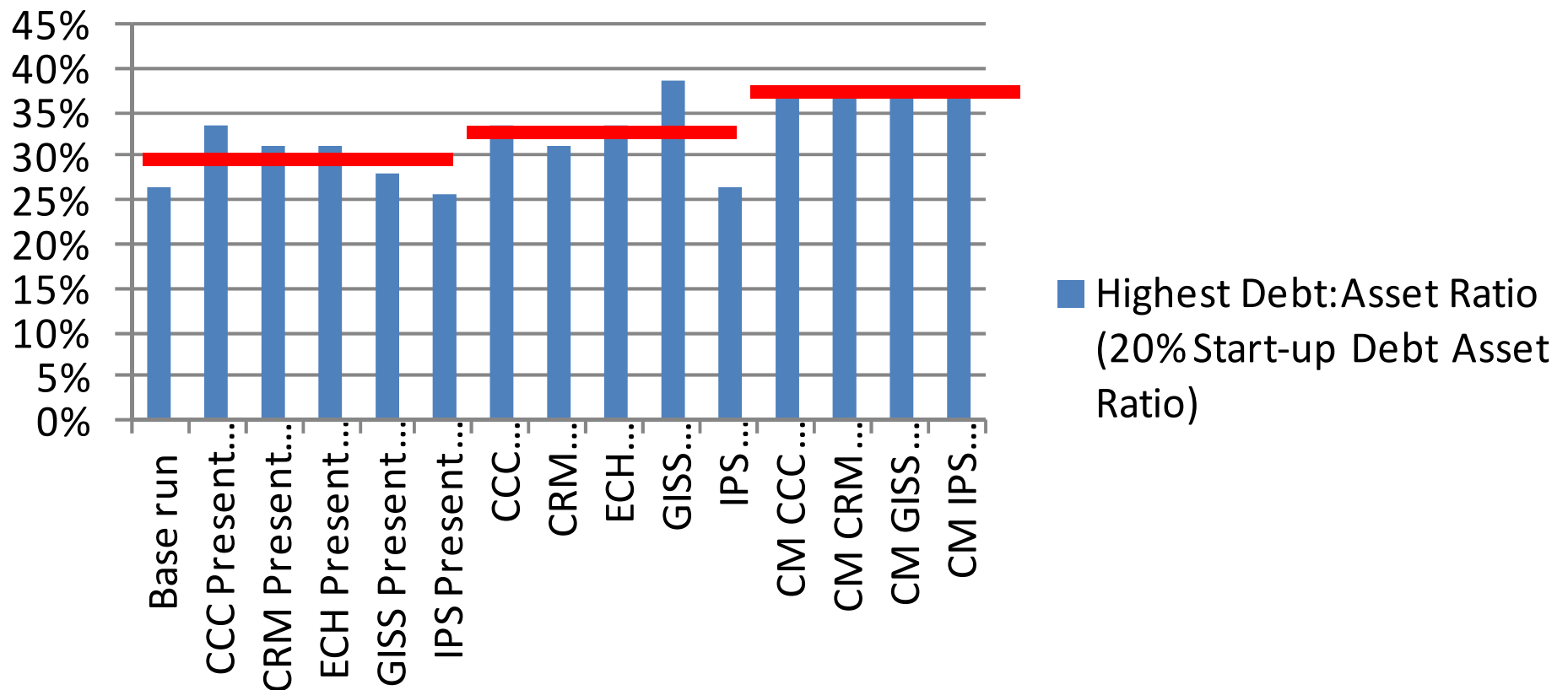


Modelling results: Moorreesburg

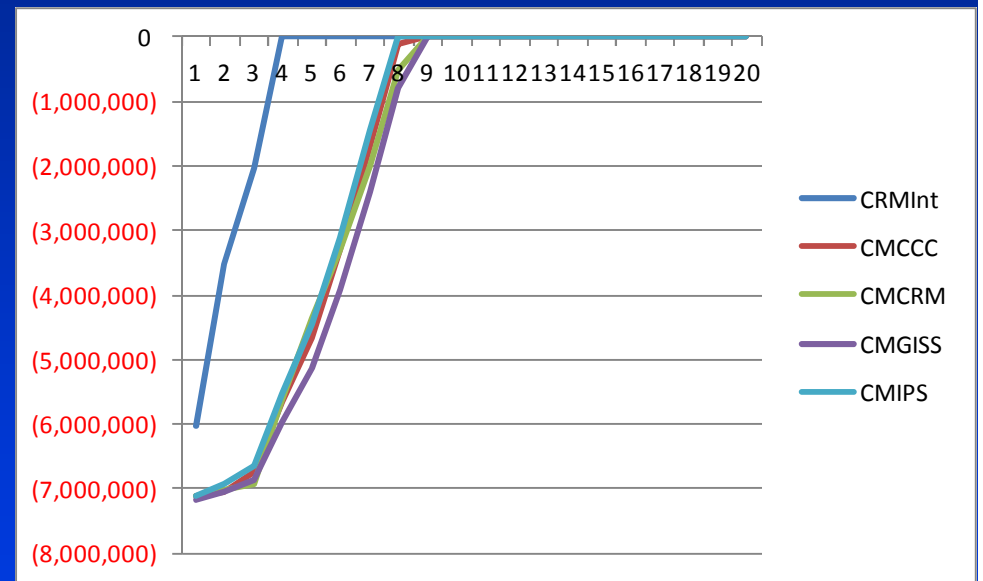
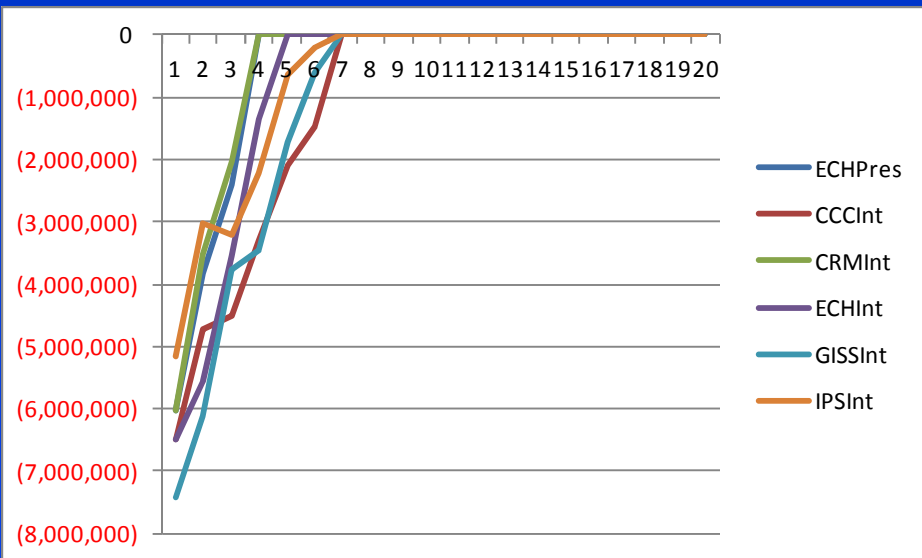
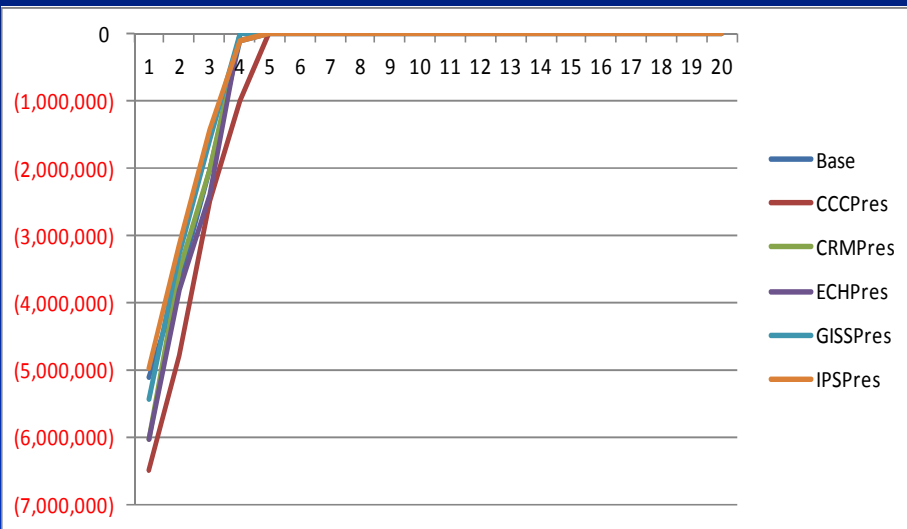


Modelling results: Moorreesburg

Highest Debt:Asset Ratio (20% Start-up Debt Asset Ratio)

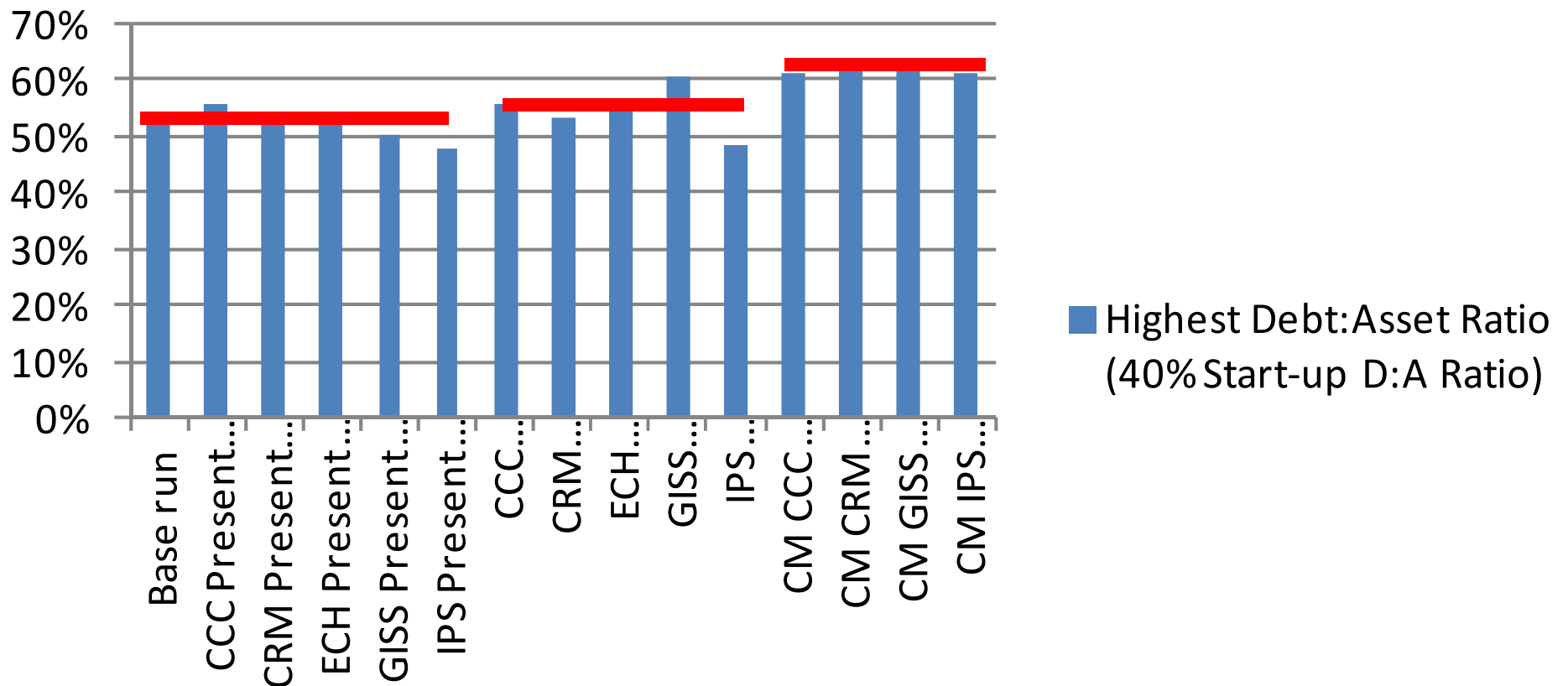


Modelling results: Moorreesburg



Modelling results: Moorreesburg

Highest Debt:Asset Ratio (40% Start-up D:A Ratio)



Modelling results: Moorreesburg

For the wheat growing area of Moorreesburg, the results show that from a financial point of view *a slight decrease* in profitability can be expected, although farming operations will still be profitable. Farmers with *high debt levels ratios will be more financially vulnerable* than those with low debt levels.

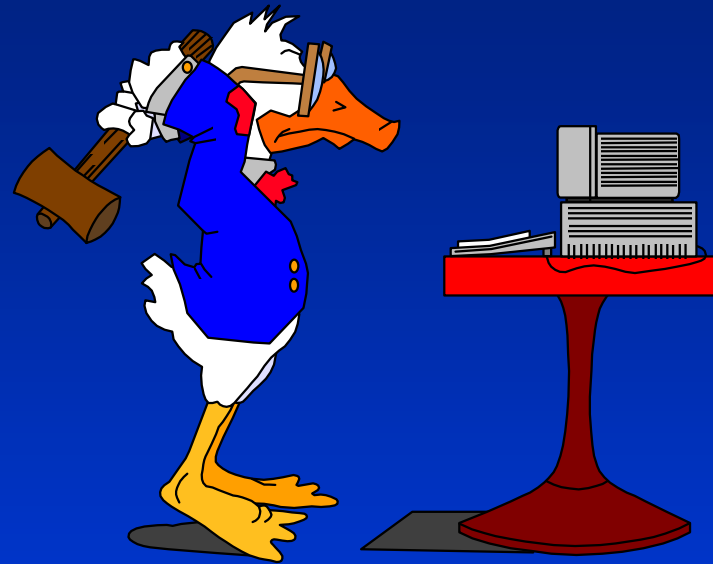


Summary & Conclusions

- The Model proof to be reliant in determining the financial vulnerability of farming systems to climate change.
- The results of the expert opinion models correlate with the Apsim crop model results (*except grapes – prototype/no quality measurement*)
- In the absence of reliable crop models – expert opinion panels can be used to determine crop critical thresholds
- The quality of the expert panel inputs will determine the accuracy of the results.



THE END



Thank you !



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