Appendix 5.1

The Data Collection Area

TABLE 5.1: DATA COLLECTION AREA 1 – BEEF ENTERPRISE

FILENAME: RA-AREA1.WK3

	Nos	VALUE PER UNIT	TECHNICAL PARAMETERS	HISTORICAL DATA 1	2	3	4	5	FREQUENCIES 1	2	3	4	5	TARGET VALUES
RESOURCE APPRAISAL														
Livestock Land (Ha)	1111	$1,200.00												
Cropping Area (Ha)	150	$1,200.00												
Building-Improv.$	155000													
Mach-Vehicles $	85200													
Available Hay (Bales)	600	26.24												
Available Haylage (Bags)	447	34.74												
Available Oats (Ton)	50	170												
Cows inventory (Heads)	335	335		370	250	280	320	335						
Heifers inventory (Heads)	263	400		70	130	100	152	164						
Calves inventory (Heads)	14	200												
Weaners inventory (Heads)	0													
Vealers inventory (Heads)	0													
Young Rep. Heifers inventory (Heads)	0													
Steers inventory (Heads)	152	350												
Bulls inventory (Heads)	18	354												
Total No. of animals	782													
TECHNICAL PARAMETERS														
Hay production by Ha (Bales)			70											
No. Hay bales per cow per year														
No. Hay bales per heifer per year														
No. Hay bales per calf per year														
No. Hay bales per weaner per year														
No. Hay bales per vealer per year														
No. Hay bales per replac. heifer per year														
No. Hay bales per steer per year			0.5											
No. Hay bales per bull per year														
Haylage production by Ha (Bags)			60											
No. Haylage bags per cow per year														
No. Haylage bags per heifer per year														
No. Haylage bags per calf per year														
No. Haylage bags per weaner per year														
No. Haylage bags per vealer per year														
No. Haylage bags per replac. heifer per year														
No. Haylage bags per steer per year			1.5											
No. Haylage bags per bull per year														
Calving rate per breeding cow			0.95	0.75	0.8	0.9	0.95	0.98	0.2	0.2	0.2	0.2	0.2	0.90
Retaining percentage of breeding cows			0.95	0.75	0.8	0.9	0.95	0.98						
Calving rate per first calf-heifer			0.5	0.2	0.4	0.6	0.7	0.8	0.1	0.2	0.2	0.2	0.3	0.59
Retaining percentage of first calf heifers			0.5	0.2	0.4	0.6	0.7	0.8						
DSE per cow			11											
DSE per first-calf heifer			10											
DSE per calf			4											
DSE per weaner			8											
DSE per vealer			9											
DSE per young replac. heifer			9											
DSE per steer			10											
DSE per bull			12											
Total DSE (Thousands)			12.011	10.9	11.6	12.01	12.7	13.01						
Stocking rate DSE/ha			9.5	9	9.5	10.5	11	12.5	0.2	0.2	0.2	0.2	0.2	10.50
Oat production per Ha (Ton)			1											
Ton. of oat per breeding-ewe per year			0.05											
Ton.of oats per prime-lamb per year			0.1											
Cows-bull ratio			30:1											
Heifers-bull ratio			30:1											
Percentage borned calves that are weaned			0.98											
Percentage weaners transferred to vealers			0.05											
Percentage weaners transf. to young rep. heifers			0.45											
Percentage weaners transferred to steers			0.45											
MARKETING CONSTRAINTS														
Sale culled cows ratio and heads			0.1	46	36	51	27	25						
Sale culled-heifers ratio			0.8											
Sale-calves ratio			0.01											
Sale-weaners ratio			0.05											
Sale-vealers ratio			1											
Sale-young rep.heifers ratio			0.01											
Sale lean-steers ratio			0											
Sale finished-steers ratio			1	192	280	365	278	230						
Sale bulls ratio			0.1											
Maximum No. cows to be allowed			500											
Maximum No. first-calf heifer to be allowed			500											
Maximum No. calves to be allowed			500											
Maximum No. weaners to be allowed			500											

Maximum No. vealers to be allowed			500											
Maximum No. young replac. heifers to be allowed			500											
Maximum No. steers to be allowed			1000											
Maximum No. bulls to be allowed			20											
Land available for purchase (Ha)			500											
Land available for sale (Ha)			0											
FINANCIAL CONSTRAINTS														
Average sale – price per cow		360		360	400	450	480	520	0.2	0.2	0.3	0.1	0.1	431.00
Average sale – price per first calf heifer		400												
Average sale – price per calf		200												
Average sale – price per weaner		260												
Average sale – price per vealer		300												
Average sale – price per young rep. heifer		350												
Average sale – price per fat steer		495		350	400	500	520	600	0.1	0.2	0.3	0.2	0.2	479.00
Average sale – price per bull		354												
Average purchase – price per cow		400												
Average purchase – price per first calf heifer		400												
Average purchase – price per weaner to vealer		280												
Average purchase – price per weaner to rep.heifer		270												
Average purchase – price per weaner to steer		260												
Average purchase – price per vealer		300												
Average purchase – price per young replac. heifer		350												
Average purchase – price per lean steer		300												
Average purchase – price per bull		2500												
Overdraft limit			10000											
Current overdraft			0											
Overdraft interest rate			0.12											
Loan capacity ($)			200000											
Loan interest rate			0.09											
Current liabilities ($)			0											
Total variable costs last year ($)	102171													
Variable costs per DSE – cow		93.6												
Variable costs per DSE – firs calf heifer		85												
Variable costs per DSE – calf		34												
Variable costs per DSE – weaner		68												
Variable costs per DSE – vealer		76.55												
Variable costs per DSE – young replac. heifer		76.55												
Variable costs per DSE – steer		85												
Variable costs per DSE – bull		102												
Total fixed costs last year ($)			142800											
Current available cash ($)			324231											
Current bank account balance ($)			0											
Current bank account interest			0.06											
Expected off – farm income current year ($)			0											
Net worth value end of current year (livest.land)		1318.4												
Net worth value end of current year (crop.land)		1318.4												
Net worth value end of current year (buildings)		0.95												
Net worth value end of current year (mach – veh)		0.9												
Net worth value end of current year (cow)		400												
Net worth value end of current year (f – c heifer)		400												
Net worth value end of current year (calf)		200												
Net worth value end of current year (weaner)		270												
Net worth value end of current year (vealer)		300												
Net worth value end of current year (rep. heifer)		350												
Net worth value end of current year (steer)		450												
Net worth value end of current year (bull)		2000												
Agistment income per steer per year														
Agistment income per cow per year														
Profit share participation per steer per year														
Profit share participation per cow per year														

TABLE 5.2: DATA COLLECTION AREA 2 – MEAT ENTERPRISE

FILENAME: RA–AREA2.WK3

	Nos	VALUE PER UNIT	TECHNICAL PARAMETER	HISTORICAL DATA 1	2	3	4	5	FREQUENCIES 1	2	3	4	5	TARGET VALUES
RESOURCE APPRAISAL														
Livestock Land (Ha)	1111	$1,200.00												
Cropping Area (Ha)	150	$1,200.00												
Building–Improv. $	155000													
Mach–Vehicles $	85200													
Available Hay (Bales)	600	26.24												
Available Haylage (Bags)	447	34.74												
Available Oats (Ton)	50	170												
Merino ewes inventory (Heads)	511	5												
First cross ewes inventory (Heads)	288	7												
Rams inventory (Heads)	11	2000												
First cross sucker lambs inventory (Heads)														
First cross female hoggets inventory (Heads)	50	15												
First cross male prime lambs inventory (Heads)	100	20												
Second cross sucker lambs inventory (Heads)														
Second cross prime lambs inventory (Heads)	177	25												
Total No. of animals	1137													
TECHNICAL PARAMETERS														
Hay production by Ha (Bales)			70											
No. bales of hay per merino ewe per year														
No. bales of hay per crossbred ewe per year														
No. bales of hay per ram per year														
No. bales of hay per first cross lamb per year														
No. bales of hay per 1X female hogget per year														
No. bales of hay per 1X male prime lamb per year	0.1													
No. bales of hay per second cross lamb per year														
No. bales of hay per 2X prime lamb per year	0.1													
Haylage production by Ha (Bags)			60											
No. bales of haylage per merino ewe per year														
No. bales of haylage per crossbred ewe per year														
No. bales of haylage per ram per year														
No. bales of haylage per first cross lamb per year														
No. bales of haylage per 1x female hogget per year														
No. bales of haylage per 1X male prim.lamb per year														
No. bales of haylage per 2X lamb per year			1.5											
No. bales of haylage per second cross prime lamb per year														
Lambing rate per merino ewe			0.95											
Retaining percentage of breeding merino ewes			0.95											
Lambing rate of crossbred ewes			0.5											
Retaining percentage of first cross breeding ewes			0.5											
DSE per merino ewe			11											
DSE per crossbred ewe			10											
DSE per ram			4											
DSE per first cross sucker lamb			8											
DSE per first cross female hogget			9											
DSE per first cross male prime lamb			9											
DSE per second cross lamb			10											
DSE per second cross prime lamb			12											
Total DSE (Thousands)														
Stocking rate DSE/ha														
Oat production per Ha (Ton)			1											
Ton. of oat per merino ewe per year			0.06											
Ton.of oats per 1X ewe per year			0.06											
Merino ewes–ram ratio			100:1											
First crossbred ewes–ram ratio			100:1											
Percentage first cross weaned lambs (No. ewes)			0.9	0.75	0.68	0.95	0.89	0.85	120	135	100	127	130	82.00
Percentage second cross weaned lambs (No. ewes)			1.3	1.2	0.97	0.95	1.17	1.35	250	270	238	230	200	112.00
Percentage 1X sucker lambs transf. to female hoggets			0.49											
Percentage 1X female hoggets transf. to ewes			0.2											
Percentage 1X suckers transf. to prime lambs			0.49											
Percentage 2X suckers tranf. to prime lambs			0.98											
Wool production per merino ewe (kg)			5.5											
Wool production per 1X ewe (kg)			5.5											
Wool production per ram (kg)			9											
Wool production per 1X female hogget (kg)			5											
Wool production per 1X male prime lamb (kg)			3											
Wool production per 2x prime lamb (kg)			3											
MARKETING CONSTRAINTS														
Sale culled merino ewes ratio			0.3											
Sale culled 1X ewes ratio			0.3											
Sale–rams ratio			0.5											
Sale–1X suckers ratio			0.0											
Sale–1X female hoggets ratio			0.1											
Sale–1X prime lambs ratio			1											
Sale–2X sucker lambs ratio			0.5											
Sale–2X prime lambs ratio			1											

Maximum No. merino ewes to be allowed			1000											
Maximum No. 1X ewes to be allowed			1000											
Maximum No. 1X sucker lambs to be allowed														
Maximum No. 1X female hoggets to be allowed			500											
Maximum No. 1X prime lambs to be allowed														
Maximum No. 2X sucker lambs to be allowed														
Maximum No. 2X prime lambs to be allowed														
Maximum No. rams to be allowed			20											
Land available for purchase (Ha)			500											
Land available for sale (Ha)			0											
FINANCIAL CONSTRAINTS														
Average sale – price per merino ewe		5												
Average sale – price per 1X ewe		7												
Average sale – price per ram		10												
Average sale – price per 1X sucker lamb		15												
Average sale – price per 1X female hogget		20												
Average sale – price per 1X prime lamb		30		47	36	32	52	49	45	92	140	113	110	42.50
Average sale – price per 2X sucker lamb		15												
Average sale – price per 2x prime lamb		32		55	42	38	60	57	300	255	225	270	270	49.10
Average purchase – price per merino ewe		400												
Average purchase – price per 1X ewe		400												
Average purchase – price per ram		280												
Average purchase – price per 1X female hogget		270												
Average sale – price per AAA wool (kg)		3.95												
Average sale – price per AAA – hogget wool (kg)		4.83												
Average sale – price per AA wool (kg)		3.60												
Average sale – price per BBB wool (kg)		2.80												
Average sale – price per bellies wool (kg)		2.03												
Average sale – price per pieces wool (kg)		2.82												
Average sale – price per locks wool (kg)		1.41												
Average sale – price per bellies wool – hoggets (kg)		2.02												
Average sale – price per pieces wool – hoggets (kg)		2.81												
Average sale – price per fleece wool (kg)		2.04												
Overdraft limit			10000											
Current overdraft			0											
Overdraft interest rate			0.12											
Loan capacity ($)			200000											
Loan interest rate			0.09											
Current liabilities ($)			0											
Total variable costs last year ($)	102171													
Variable costs per DSE – merino ewe		15.3												
Variable costs per DSE – 1X ewe		18.7												
Variable costs per ram		21.25												
Variable costs per DSE – 1X sucker lamb		5.1												
Variable costs per DSE – 1C female hogget		14.45												
Variable costs per DSE – 1X prime lamb		14.45												
Variable costs per DSE – 2X sucker lamb		5.1												
Variable costs per DSE – 2X prime lamb		14.45												
Total fixed costs last year ($)			142800											
Current available cash ($)			324231											
Current bank account balance ($)			0											
Current bank account interest			0.06											
Expected off – farm income current year ($)			0											
Net worth value end of current year (livest.land)		1318.4												
Net worth value end of current year (crop.land)		1318.4												
Net worth value end of current year (buildings)		0.95												
Net worth value end of current year (mach – veh)		0.9												
Net worth value end of current year (merino ewe)		15												
Net worth value end of current year (1X ewe)		12												
Net worth value end of current year (1x lamb)		15												
Net worth value end of current year (1x fem. hogget)		20												
Net worth value end of current year (1x prime lamb)		30												
Net worth value end of current year (2X lamb)		15												
Net worth value end of current year (2X prime lamb)		32												
Net worth value end of current year (ram)		2000												

TABLE 5.3: DATA COLLECTION AREA 3 – WOOL ENTERPRISE

FILENAME: RA–AREA3.WK3

	Nos	VALUE PER UNIT	TECHNICAL PARAMETER	HISTORICAL DATA 1	2	3	4	5	FREQUENCIES 1	2	3	4	5	TARGET VALUES
RESOURCE APPRAISAL														
Livestock Land (Ha)	1111.00	$1,200.00												
Cropping Area (Ha)	150.00	$1,200.00												
Building–Improv. $	155000.00													
Mach–Vehicles $	85200.00													
Available Hay (Bales)	600.00	26.24												
Available Haylage (Bags)	447.00	34.74												
Available Oats (Ton)	50.00	170.00												
Merino ewes inventory (Heads)	511	5												
Merino rams inventory (Heads)	3	110												
Merino sucker lambs inventory (Heads)	0													
Merino female weaners inventory (Heads)	200	15												
Merino weaner wethers inventory (Heads)	200	20												
Merino female hoggets inventory (Heads)	100	25												
Merino wethers inventory (Heads)	298	25												
Total No. of animals	1312.00													
TECHNICAL PARAMETERS														
Hay production by Ha (Bales)			70.00											
No. bales of hay per ewe			0.02											
No. bales of hay per ram			0.02											
No. bales of hay per sucker lamb														
No. bales of hay per female weaner			0.01											
No. bales of hay per weaner wether			0.01											
No. bales of hay per female hogget			0.01											
No. bales of hay per wether			0.02											
Haylage production by Ha (Bags)			60.00											
No. bags of haylage per ewe														
No. bags of haylage per ram														
No. bags of haylage per sucker lamb														
No. bags of haylage per female weaner														
No. bags of haylage per weaner wether														
No. bags of haylage per female hogget														
No. bags of haylage per wether														
Lambing rate per merino ewe			0.9											
Retaining percentage of breeding merino ewes			0.9											
DSE per merino ewe			1.8											
DSE per ram			2.5											
DSE per sucker lamb			0.4											
DSE per merino female weaners			0.6											
DSE per merino weaner wethers			0.6											
DSE per merino female hoggets			1											
DSE per merino wethers			1											
Total DSE (Thousands)														
Stocking rate DSE/ha														
Oat production per Ha (Ton)			1.00											
Ton. of oat per merino ewe per year			0.05											
Merino ewes–ram ratio			100:1											
Percentage weaned lambs (No. ewes)			0.9	0.75	0.68	0.95	0.89	0.85	383	340	475	445	425	0.84
Percentage merino sucker lambs transf. to female weaners			0.45											
Percentage merino suckers transf. to wether weaners			0.45											
Percentage merino female weaners transf. to female hoggets			0.10											
Percentage merino wether weaners to wethers			0.10											
Percentage merino female hoggets transf. to ewes			0.05											
Wool production per merino ewe (kg)			5.5											
Wool production per merino ram (kg)			9											
Wool production per merino female weaner (kg)			3											
Wool production per merino weaner wether (kg)			3											
Wool producion per merino female hogget (kg)			4											
Wool producion per merino wether (kg)			6.2											
MARKETING CONSTRAINTS														
Sale culled merino ewes ratio			0.3											
Sale–merino rams ratio			0.2											
Sale–merino suckers ratio			0.0											
Sale–merino female weaners ratio			0.1											
Sale–merino weaner wethers ratio			0.20											
Sale–merino female hoggets ratio			0.2											
Sale–merino wethers ratio			0.25											

Maximum No. merino ewes to be allowed			1000											
Maximum No. merino rams to be allowed			10.00											
Maximum No. merino female weaners to be allowed			500.00											
Maximum No. merino weaner wethers to be allowed			500											
Maximum No. merino female hoggets to be allowed			500											
Land available for purchase (Ha)			500.00											
Land available for sale (Ha)			0.00											
FINANCIAL CONSTRAINTS														
Average sale – price per merino ewe		5												
Average sale – price per merino ram		10												
Average sale – price per female weaner		20												
Average sale – price per weaner wether		30												
Average sale – price per female hogget		15												
Average sale – price per wether		32												
Average sale – price per AAA wool (kg)		3.95		4.74	4.54	6.00	3.79	3.95	0.05	0.10	0.40	0.29	0.16	4.74
Average sale – price per AAA – hogget wool (kg)		4.83		5.79	5.55	7.34	4.63	4.83	0.05	0.10	0.40	0.29	0.16	5.90
Average sale – price per AA wool (kg)		3.60												
Average sale – price per BBB wool (kg)		2.80												
Average sale – price per bellies wool (kg)		2.03												
Average sale – price per pieces wool (kg)		2.82												
Average sale – price per locks wool (kg)		1.41												
Average sale – price per bellies wool – hoggets (kg)		2.02												
Average sale – price per pieces wool – hoggets (kg)		2.81												
Average sale – price per fleece wool (kg)		2.04												
Overdraft limit			10000.00											
Current overdraft			0.00											
Overdraft interest rate			0.12											
Loan capacity ($)			200000.00											
Loan interest rate			0.09											
Current liabilities ($)			0.00											
Total variable costs last year ($)	102171.00													
Variable costs per DSE – merino ewe		15.3												
Variable costs per merino ram		21.25												
Variable costs per DSE – merino sucker lamb		3.4												
Variable costs per DSE – merino female weaner		5.10												
Variable costs per DSE – merino weaner wether		5.10												
Variable costs per DSE – merino female hogget		8.5												
Variable costs per DSE – merino wether		8.50												
Total fixed costs last year ($)			142800.00											
Current available cash ($)			324231.00											
Current bank account balance ($)			0.00											
Current bank account interest			0.06											
Expected off – farm income current year ($)			0.00											
Net worth value end of current year (livest.land)		1318.40												
Net worth value end of current year (crop.land)		1318.40												
Net worth value end of current year (buildings)		0.95												
Net worth value end of current year (mach – veh)		0.90												
Net worth value end of current year (merino ewe)		15												
Net worth value end of current year (merino ram)		2000												
Net worth value end of current year (female weaner)		20												
Net worth value end of current year (weaner wether)		30												
Net worth value end of current year (female hogget)		15												
Net worth value end of current year (wether)		32												

Appendix 5.2

Probabilistic Density Functions of the Random Variables

Appendix 5.2 Probabilistic Density Functions of the Random Variables

Table 5.1 **Density Function for Calving Rate of Breeding Cows.**

n	X_i	$p(X_i)$
370	0.75	0.24
250	0.80	0.17
280	0.90	0.18
320	0.95	0.21
335	0.98	0.22

Source: Farm Data. n = No. of breeding cows

A set of 5 years of observations with different levels of data by year shows an expected value for the calving rate μ = 89 per cent; a standard deviation σ = 7 per cent and a coefficient of variation, CV = 8 per cent, values generated following Keller et al. (1990, p. 233). The basic statistical analysis indicates significance at a level of confidence of 90 per cent for the parameter.

Table 5.2 **Density Function for Calving Rate of First-calf Heifers.**

n	X_i	$p(X_i)$
70	.20	.114
130	.40	.211
100	.60	.162
152	.72	.246
164	.80	.266

Source: Farm Data. n = No. of first-calf heifers

A set of 5 years of observations shows an expected calving rate μ = 59 per cent; a standard deviation σ = 9 per cent and a coefficient of variation CV = 15 per cent. The basic statistical analysis indicates that the parameter is significant at a level of confidence

of 90 per cent.

Table 5.3 **Density Function for Stocking Rate**

n	X_i	$P(X_i)$
10.9	9.0	.18
11.6	9.5	.19
12.0	10	.20
12.7	11	.21
13.0	12.5	.22

Source: Farm Data. n = DSE (thousand)

A set of 5 years of observations shows an expected stocking rate μ = 10.5 DSE per ha; a standard deviation σ = 2.78 DSE and a coefficient of variation CV = 26 per cent. The basic statistical analysis indicates that the parameter is not significant at a level of confidence of 90 per cent.

Table 5.4 **Density Function for Sale-price of Steers**

n	X_i	$p(X_i)$
192	350	0.14
280	400	0.208
278	520	0.207
365	500	0.271
230	600	0.171

Source: Farm Data. n = No. of steers sold

A set of 5 years of observations shows an expected nominal sale price μ = $479 per fat steer; a standard deviation σ = $144 and a coefficient of variation CV = 30 per cent. The basic statistical analysis indicates that the parameter is non-significant at a level of confidence of 90 per cent.

Table 5.5 **Density Function for Sale-price of Culled Cows**

n	X_i	$p(X_i)$
25	520	0.135
27	480	0.146
36	400	0.194
46	360	0.248
51	450	0.276

Source: Farm Data. n = Cows sold per year X_i = Average price

A set of 5 years of observations shows an expected sale price μ = \$431 per cow; a standard deviation σ = \$54 and a coefficient of variation CV = 12 per cent. The basic statistical analysis indicates that the parameter is significant at a level of confidence of 90 per cent.

Table 5.6 **Density Function for Lambing Rate of 1X-breeding Ewes**

n	X_i	$p(X_i)$
135	0.68	0.220
120	0.75	0.196
130	0.85	0.212
127	0.89	0.210
100	0.95	0.163

Source: Farm Data. n = 1X-breeding ewe numbers

A set of 5 observations shows an expected lambing rate μ = 82 per cent; a standard deviation σ= 9 per cent and a coefficient of variation CV = 11 per cent. The basic statistical analysis indicates that the parameter is non-significant at a level of confidence of 90 per cent.

Table 5.7 **Density Function for Lambing Rate of 2X-breeding Ewes**

n	X_i	$P(X_i)$
238	0.95	0.20
270	0.97	0.23
230	1.17	0.194
250	1.20	0.21
200	1.35	0.168

Source: Farm Data.

A set of 5 years of observations shows an expected lambing rate μ = 112 per cent; a standard deviation σ = 14 per cent and a coefficient of variation CV = 12 per cent. The basic statistical analysis indicates that the parameter is significant at a level of confidence of 90 per cent.

Table 5.8 **Density Function for 1X-prime Lamb Prices**

n	X_i	$p(X_i)$
140	32	0.28
92	36	0.18
45	47	0.09
110	49	0.22
113	52	0.23

Source: Farm Data.

A set of 5 years of observations shows an expected sale price μ = \$42.5 per prime lamb; a standard deviation σ = \$8.38 and a coefficient of variation CV = 20 per cent. The basic statistical analysis indicates that the parameter is significant at a level of confidence of 90 per cent.

Table 5.9 **Density Function for 2X-prime Lamb Prices**

n	X_i	$p(X_i)$
225	38	0.17
255	42	0.19
300	55	0.23
270	57	0.20
279	57	0.20

Source: Farm Data

A set of 5 years of observations shows an expected sale price μ = \$49 per prime lamb; a standard deviation σ = \$8.66 and a coefficient of variation CV = 18 per cent. The basic statistical analysis indicates that the parameter is significant at a level of confidence of 90 per cent.

Table 5.10 **Density Function for Lambing Rate of Merino Ewes**

n	X_i	$p(X_i)$
340	0.68	0.16
383	0.75	0.17
425	0.85	0.20
445	0.89	0.25
475	0.95	0.22

Source: Proview (1993)

A set of 5 years of observations shows an expected lambing rate μ = 84 per cent; a standard deviation σ = \$21 and a coefficient of variation CV = 25 per cent. The basic statistical analysis indicates that the parameter is non-significant at a level of confidence of 90 per cent.

Table 5.11 **Density Function for Sale-price of Type A Wool**

X_i	$p(X_i)$
3.79	0.29
3.95	0.16
4.54	0.10
4.74	0.05
6.00	0.40

Source: Proview (1993)

Table 5.12 **Density Function for Sale-price of Type B Wool**

X_i	$p(X_i)$
4.63	0.29
4.83	0.16
5.55	0.10
5.79	0.05
7.34	0.40

Source: Proview (1993)

A set of observations for the period 1989-1992 (Proview 1993) shows an expected sale price μ = \$4.74 per kg of type A wool and a μ = \$5.90 for type B wool; standard deviations σ = \$1.00 and σ = \$1.22 respectively, and coefficients of variation CV = 21 and CV = 21 respectively. The parameters are significant at the highest level of confidence since the data is the time series prices for the above mentioned period.

Table 5.13 **Density Function for Land Prices**

X_i (Deflated $)	$p(X_i)$
689	0.272
810	0.182
930	0.182
1050	0.091
1170	0.272

Source: Centre for Agricultural Risk Management (1993)

A set of observations on land prices of the Orange region for the period 1982-1992 (CARM 1993) were the base to build a density function with the following parameters: μ = 868.73 and σ = 201. The parameters are significant at the 99 per cent level of confidence.

Table 5.14 **Density Function for Sustainability Effect of Ecosystem Resources on Stocking Rate**

SR	Probability
0.000	0.0000
0.033	0.0476
0.065	0.0952
0.099	0.1428
0.1317	0.1904
0.1482	0.2381
0.1647	0.2857

This table was built up as per guidelines contained in Appendix 5.3

Appendix 5.3

Sustainability Management Within the Stochastic Modelling Framework

Appendix 5.3 Sustainability Management Within the Stochastic Modelling Framework

The exercise of generating a hard solution to incorporate the effect of ecosystem resources depletion on farm performance was built up through an empirical exercise with the farmer of this study. Ecosystems effect were added into the quantitative model to present an added degree of holistic relevance for the farm situation under examinantion.

Supported on Gill (1995) a sustainability index set (SI) was arranged, where an index 0.00 indicates the extreme situation of ecosystem resource depletion and an index of 1.00 indicates a no negative effect of ecosystem resources on farm performance. Values in between indicates a modification factor of the same magnitude upon the related critical variable(s) of the farm system.

A discrete variable of the whole-farm system was selected to apply the sustainability effect on the farm model. Stocking rate (SR) was considered suitable to be used to interrelate with a density function that would stochastically affect the performance of that variable, modified by a sustainability index effect in the domain of a distribution, linearly segmented.

The farmer provided information that the average stocking rate of the farm was 8.5 DSE/ha. With an allocated DSE of 1.8 to a breeding ewe the land ratio use per ewe is 0.2117 ha/ewe (i.e. 1.8DSE/ewe/8.5DSE/ha). This value is modified by the index set in order to obtain the values of the variable to become deemed stochastic, as follows:

SI = 0.00 corresponds to a SR = 0.000 ha/ewe
SI = 0.20 corresponds to a SR = 0.042 ha/ewe
SI = 0.40 corresponds to a SR = 0.085 ha/ewe
SI = 0.60 corresponds to a SR = 0.127 ha/ewe
SI = 0.80 corresponds to a SR = 0.169 ha/ewe
SI = 1.00 corresponds to a SR = 0.2117 ha/ewe

Probabilities for the variable deemed stochastic because of sustainability issues (i.e. SR) may be worked out in a two-fold manner. Firstly, if on-farm historical data of SR is available, frequency distribution tables and relative frequency distributions (RFD) may be generated. Otherwise, subjective farmer's weighted values have to be used. The latter method was adopted, where the farmer allocated the number 1 to the less likely scenario (i.e. SI = 0.000 with SR = 0.000) and increasing number onwards following his/her empirical perception about the sustainability effect phenomenon being the highest number the most likely scenario to happen. A RFD criterion was used to work out probabilities of the variable stochastically affected by sustainability indexes of ecosystem resources depletion, as per the following table:

SI	SR	Weighted Value	Probability
0.00	0.000	0	0.0000
0.20	0.042	1	0.0476
0.40	0.085	2	0.0952
0.60	0.127	3	0.1428
0.80	0.169	4	0.1904
0.90	0.190	5	0.2381
1.00	0.212	6	0.2857
		n = 21	

Finally a target value of reference SI = 0.90 (i.e SR = 0.20 ha/ewe) was set by the farmer as the reference point to modify his/her management attitude to sustainability effect upon SR. This is the minimal value at which substantial modifications to ecosystem resources management should be undertaken.

With this information on hand, SR is considered a random variable and a subjective density function of probabilistic values replace the discrete value of the deterministic model. The arrangement of this part of the stochastic model may be observed in Appendix 5.4, Table 5.3.

Appendix 5.4

A Demonstrative Deterministic and Stochastic Farm Model

Appendix 5.4 A Demonstrative Deterministic and Stochastic Farm Model

Using MP an optimal solution is aimed in the combination of resources and activities for the following farm:

(a)	Area:	10 ha
(b)	Available cash:	$100
(c)	Overdraft option:	$2000 (i=0.12)
(d)	Loan option:	$5000 (i=0.09)
(e)	Activity:	Prime-lamb production
(f)	Variable costs per ewe:	$3.50
(g)	Breeding-ewe price:	$15
(h)	Prime-lamb price:	$20
(i)	Culled-ewe price:	$10
(j)	Lambing rate:	100%
(k)	Ewe DSE:	1.8

Consider that lambing rate and sustainability effect on stocking rate are the critical factors for this exercise, with a farmer exhibiting a constant relative risk aversion (r=0.000001). Therefore using the HSM approach an optimal solution may be found under the following assumptions:

(a) Rather than using a deterministic value for the lambing rate parameter a historical set of data from the last five years of farm performance is used. Consider that the minimal value of lambing rate that the farmer is prepared to accept, before to modify his/her technical risk aversion attitude is 100 per cent.

Year 1: 120% Year 2: 95% Year 3: 110%
Year 4: 80% Year 5: 95%

(b) A sustainability effect to farm performance through effect in stocking density is organised through a density function of sustainability indexes (SI) with allocated weighted subjective probabilities. An index of 1.00 indicates that the sustainability factor has not effect in stocking rate. Index values below 1.00 modify stocking density for that factor. An index of 0.90 is considered critical to the system operation.

SI 0.00 : 0.0001	SI 0.20 : 0.0049	SI 0.60 : 0.005
SI 0.80 : 0.04	SI 1.00 : 0.95	

The deterministic programming matrix is hereafter attached as Table 1 and its related input and output files (i.e. TESTDM1).

The stochastic programming matrix with one random variable (i.e. LR) is hereafter attached as Table 2 with its related input and output files (i.e. TESTHSM1).

The stochastic programming matrix with one random variable (i.e. SI) is hereafter attached as Table 3 with its related input and output files (i.e. TESTHSM2).

The stochastic programming matrix with the two random variables (i.e. LR and SI) is hereafter attached as Table 4 with its related input and output files (i.e. TESTHSM2).

TESTDM1 LP maximising 12/06 /93 21:55

Deterministic Demonstrative Model

			PAST	FEW	BEW	PLAMB	BYEW	BYPL	SEW	SPL	ODF	PYODF	LOAN	PYLOAN	BYLAND	PVC	TBKB	TSAB	TWB
Obj	Z	=E=																1.00	1.00
CCAP	0.00	=G=	−1.00	0.21															
LAND	10.00	=G=	1.00												−1.00				
EWINV	0.00	=G=			1.00		−1.00												
BFEWT	0.00	=E=		1.00	−1.00														
PLINV	0.00	=G=			−1.00	1.00		−1.00											
EWSP	1.00	=G=			−0.20				1.00										
PLSP	0.00	=G=				−1.00				1.00									
EWMKS	0.00	=L=					1.00												
PLMKS	0.00	=L=						1.00											
LANDMK	10.00	=G=													1.00				
ODFOPT	2000.00	=G=									1.00								
ODFTIE	0.00	=E=									−1.12	1.00							
LOANOR	5000.00	=G=											1.00						
LOANTIE	0.00	=E=											−1.09	1.00					
COSTAC	0.00	=E=			3.50		15.00	20.00							500.00	−1.00			
BKACC	100.00	=G=							−10.00	−20.00	−1.00	1.00	−1.00	1.00		1.00	1.00		
SAVACC	0.00	=E=															−1.06	1.00	
FARMW	0.00	=E=	−500.00		−15.00														1.00

Table 1: Programming Matrix of the Demonstrative Model: Deterministic Scenario

TESTDM1: DEMONSTRATIVE TEST MODEL: DETERMINISTIC SCENARIO

C:\LOTUS123\NEWTHESI\TESTDM1.WK3
C:\LOTUS123\NEWTHESI\TESTDM1.GMS
C:\WP51\NEWTHESI\TESTDM1.DOC

INPUT FILE:

DECISION VARIABLES

PAST	Pasture production (DSE)
FEW	Stocking rate per ha to the ewe
BEW	Breeding ewes activity (heads)
PLAMB	Prime lambs activity (heads)
BYEW	Buying ewes activity (heads)
BYPL	Buying prime lambs activity (heads)
SEW	Sell ewes activity (heads)
SPL	Sell prime lambs activity (heads)
ODF	Overdraft option (A$)
PYODF	Pay overdraft i = 0.12
LOAN	Loan option (A$)
PYLOAN	Pay loan i = 0.09
BYLAND	Buy land (ha)
PVC	Pay variable costs (A$)
TBKB	Transfer bank account balance (index)
TSAB	Transfer saving account balance to objective function
TWB	Transfer farm wealth account balance to objective function

EQUATION VARIABLES

Obj	Maximise Farm Equity (A$)
CCAP	Carrying Capacity in ha per ewe
LAND	Available land (ha)
EWINV	Ewes inventory (heads)
BFEWT	Breeding-feeding ewes tie (index)
PLINV	Prime lambs inventory (heads)
EWSP	Ewes sale pool (heads)
PLSP	Prime lambs sale pool (heads)
EWMKS	Ewes marker supply (heads)
PLMKS	Prime lambs market supply (heads)
LANDMKS	Land market supply (ha)
ODFOPT	Overdraft option (A$)
ODFTIE	Overdraft option and overdraft payment tie (index)
LOANOPT	Loan option (A$)
LOANTIE	Loan option and loan payment tie (index)
COSTACC	Cost account (A$)
BKACC	Bank account (A$)
SAVACC	Saving Account (Current Operation Farm Profit)

FARMW Farm Wealth Account (Current Operation Assets Value);

MATHEMATICAL PROGRAMMING EQUATIONS

```
Obj..       Z=E= +1*TSAB +1*TWB;
CCAP..      0=G= -1*PAST +0.212*FEW;
LAND..      10=G= +1*PAST -1*BYLAND;
EWINV..     0=G= +1*BEW -1*BYEW;
BFEWT..     0=E= +1*FEW -1*BEW;
PLINV..     0=G= -1*BEW +1*PLAMB -1*BYPL;
EWSP..      1=G= -0.200*BEW +1*SEW;
PLSP..      0=G= -1*PLAMB +1*SPL;
EWMKS..     0=L= +1*BYEW;
PLMKS..     0=L= +1*BYPL;
LANDMKS..   10=G= +1*BYLAND;
ODFOPT..    2000=G= +1*ODF;
ODFTIE..    0=E= -1.120*ODF +1*PYODF;
LOANOPT..   5000=G= +1*LOAN;
LOANTIE..   0=E= -1.090*LOAN +1*PYLOAN;
COSTACC..   0=E= +3.500*BEW +15*BYEW +20*BYPL +500*BYLAND
            -1*PVC;
BKACC..     100=G= -10*SEW -20*SPL -1*ODF +1*PYODF -1*LOAN
            +1*PYLOAN +1*PVC +1*TBKB;
SAVACC..    0=E= -1.060*TBKB +1*TSAB;
FARMW..     0=E= -500*PAST -15*BEW +1*TWB;

MODEL TESTDM1 /ALL/;

SOLVE TESTDM1 USING LP maximising Z;
```

OUTPUT FILE

GAMS 2.25 PC AT/XT 06/16/96 17:49:04 PAGE 12

TESTDM1

Solution Report SOLVE TESTDM1 USING LP FROM LINE 71

S O L V E S U M M A R Y

MODEL TESTDM1	OBJECTIVE Z
TYPE LP DIRECTION	MAXIMIZE
SOLVER BDMLP	FROM LINE 71
**** SOLVER STATUS	1 NORMAL COMPLETION
**** MODEL STATUS	1 OPTIMAL
**** OBJECTIVE VALUE	6032.2927

EXIT -- OPTIMAL SOLUTION FOUND.

	LOWER	LEVEL	UPPER	MARGINAL
---- VAR Z	-INF	6032.293	+INF	.
---- VAR PAST	.	10.569	+INF	.
---- VAR FEW	.	49.854	+INF	.
---- VAR BEW	.	49.854	+INF	.
---- VAR PLAMB	.	49.854	+INF	.
---- VAR BYEW	.	49.854	+INF	.
---- VAR BYPL	.	.	+INF	EPS
---- VAR SEW	.	10.971	+INF	.
---- VAR SPL	.	49.854	+INF	.
---- VAR ODF	.	.	+INF	.
---- VAR PYODF	.	.	+INF	-0.126
---- VAR LOAN	.	.	+INF	.
---- VAR PYLOAN	.	.	+INF	-0.097
---- VAR BYLAND	.	0.569	+INF	.
---- VAR PVC	.	1206.780	+INF	.
---- VAR TBKB	.	.	+INF	.
---- VAR TSAB	.	.	+INF	-0.114
---- VAR TWB	.	6032.293	+INF	.

**** REPORT SUMMARY :	0	NONOPT
	0	INFEASIBLE
	0	UNBOUNDED

STEP SUMMARY:

0.170 STARTUP
0.000 COMPILATION
0.220 EXECUTION
0.000 CLOSEDOWN
0.390 TOTAL SECONDS

**** FILE SUMMARY

INPUT C:\LOTUS123\NEWTHESI\TESTDM1.GMS
OUTPUT C:\LOTUS123\NEWTHESI\TESTDM1.LST

TESTHSM1 LP maximising 16/06 /96 20:12

Demonstrative Holistic Stochastic Model
One Stochastic Variable (1R)

			PAST	FEW	BEW	PLAMB	BYEW	BYPL	SEV	SPL	ODF	PYODF	LOAN	PYLOAN	BYLAND	PVC	TBKB	TLR01	TLR02	TLR03	TLR04	TLR05	TTARG	RISKLR	TSAB	WB
Obj	Z	=E=																							1.00	1.00
CCAP	0.00	=G=	-1.00	0.21																						
LAND	10.00	=G=	1.00													-1.00										
EWINV	0.00	=G=			1.00		-1.00																			
BFEWT	0.00	=E=		1.00	-1.00																					
PLINV	0.00	=G=				1.00		-1.00																-1.00		
EWSP	1.00	=G=			-0.20				1.00																	
PLSP	0.00	=G=				-1.00				1.00																
EWMKS	0.00	=L=					1.00																			
PLMKS	0.00	=L=						1.00																		
LANDMK	10.00	=G=														1.00										
ODFOPT	2000.00	=G=									1.00															
ODFTIE	0.00	=F=									-1.12	1.00														
LOANOP	5000.00	=G=											1.00													
LOANTIE	0.00	=E=											-1.09	1.00												
COSTAC	0.00	=E=			3.50		15.00	20.00								500.00	-1.00									
BKACC	100.00	=G=							-10.00	-20.00	-1.00	1.00	-1.00	1.00		1.00		1.00								
SAVACC	0.00	=E=															-1.06								1.00	
FARMW	0.00	=E=	-500.00		-15.00																					1.00
LR01	0.00	=G=			-1.20													1.00								
LR02	0.00	=G=			-1.05														1.00							
LR03	0.00	=G=			-1.10															1.00						
LR04	0.00	=G=			-0.90																1.00					
LR05	0.00	=G=			-1.30																	1.00				
RFDLR	0.00	=G=																-0.20	-0.20	-0.20	-0.20	-0.20	1.00			
TARGET	1.00	=G=																					-1.00	1.00		

Table 2: Programming Matrix of the Demonstrative odel: Holistic Stochastic Scenario with 1 R ndom Variable (LR)

TESTHSM1: DEMONSTRATIVE TEST: STOCHASTIC MODEL WITH LAMBING RATE AS THE RANDOM INPUT-OUTPUT VARIABLE AND AN EXPONENTIAL OBJECTIVE FUNCTION

INPUT VARIABLES

DECISION VARIABLES

7	PAST	Pasture production (DSE)
8	FEW	DSE ewe ratio to the ha.
9	BEW	Breeding ewes activity (heads)
10	PLAMB	Prime lambs activity (heads)
11	BYEW	Buying ewes activity (heads)
12	BYPL	Buying prime lambs activity (heads)
13	SEW	Sell ewes activity (heads)
14	SPL	Sell prime lambs activity (heads)
15	ODF	Overdraft option (A$)
16	PYODF	Pay overdraft i = 0.12
17	LOAN	Loan option (A$)
18	PYLOAN	Pay loan i = 0.09
19	BYLAND	Buy land (ha)
20	PVC	Pay variable costs (A$)
21	TBKB	Transfer bank account balance (index)
22	TLR01	Transfer lambing rate of year 1 (probabilistic index)
23	TLR02	Transfer lambing rate of year 2 (probabilistic index)
24	TLR03	Transfer lambing rate of year 3 (probabilistic index)
25	TLR04	Transfer lambing rate of year 4 (probabilistic index)
26	TLR05	Transfer lambing rate of year 5 (probabilistic index)
27	TTARG	Transfer of distribution lambing rate values to target row (index)
28	RISKLR	Risk lambing rate transferring to major stochastic constraint (index)
29	TSAB	Transfer saving account balance to objective function
30	TWB	Transfer farm wealth account balance to objective function

32 EQUATION VARIABLES

33	Obj	Maximise Cash Flow (A$)
34	CCAP	Carrying Capacity (DSE)
35	LAND	Available land (ha)
36	EWINV	Ewes inventory (heads)
37	BFEWT	Breeding-feeding ewes tie (index)
38	PLINV	Prime lambs inventory (heads)
39	EWSP	Ewes sale pool (heads)
40	PLSP	Prime lambs sale pool (heads)
41	EWMKS	Ewes marker supply (heads)
42	PLMKS	Prime lambs market supply (heads)

43	LANDMKS	Land market supply (ha)
44	ODFOPT	Overdraft option (A$)
45	ODFTIE	Overdraft option and overdraft payment tie (index)
46	LOANOPT	Loan option (A$)
47	LOANTIE	Loan option and loan payment tie (index)
48	COSTACC	Cost account (A$)
49	BKACC	Bank account (A$)
50	SAVACC	Saving account (A$)
51	FARMW	Farm Wealth account (A$)
52	LR01	Lambing rate year 1 (density function value)
53	LR02	Lambing rate year 2 (density function value)
54	LR03	Lambing rate year 3 (density function value)
55	LR04	Lambing rate year 4 (density function value)
56	LR05	Lambing rate year 5 (density function value)
57	RFDLR	Relative frequency distribution of lambing rates (probability)
58	TARGETLR	Target lambing rate (index)

MATHEMATICAL PROGRAMMING EQUATIONS

```
61 Obj..      Z=E= +1*TSAB +1*TWB^(1-r);
62 CCAP..     0=G= -1*PAST +0.212*FEW;
63 LAND..     10=G= +1*PAST -1*BYLAND;
64 EWINV..    0=G= +1*BEW -1*BYEW;
65 BFEWT..    0=E= +1*FEW -1*BEW;
66 PLINV..    0=G= +1*PLAMB -1*BYPL -1*RISKLR;
67 EWSP..     1=G= -0.200*BEW +1*SEW;
68 PLSP..     0=G= -1*PLAMB +1*SPL;
69 EWMKS..    0=L= +1*BYEW;
70 PLMKS..    0=L= +1*BYPL;
71 LANDMKS..  10=G= +1*BYLAND;
72 ODFOPT..   2000=G= +1*ODF;
73 ODFTIE..   0=E= -1.120*ODF +1*PYODF;
74 LOANOPT..  5000=G= +1*LOAN;
75 LOANTIE..  0=E= -1.090*LOAN +1*PYLOAN;
76 COSTACC..  0=E= +3.500*BEW +15*BYEW +20*BYPL +500*BYLAND
                -1*PVC;
78 BKACC..    100=G= -10*SEW -20*SPL -1*ODF +1*PYODF -1*LOAN
                +1*PYLOAN +1*PVC +1*TBKB;
80 SAVACC..   0=E= -1.060*TBKB +1*TSAB;
81 FARMW..    0=E= -500*PAST -15*BEW +1*TWB;
82 LR01..     0=G= -1.200*BEW +1*TLR01;
83 LR02..     0=G= -1.050*BEW +1*TLR02;
84 LR03..     0=G= -1.100*BEW +1*TLR03;
85 LR04..     0=G= -0.900*BEW +1*TLR04;
86 LR05..     0=G= -1.300*BEW +1*TLR05;
87 RFDLR..    0=G= -0.200*TLR01 -0.200*TLR02 -0.200*TLR03 -0.200*TLR04
                -0.200*TLR05+1*TTARG;
89 TARGETLR.. 1=G= -1*TTARG +1*RISKLR;
```

```
 90
 91  MODEL TESTHSM1 /ALL/;
 92
 93  SOLVE TESTHSM1 USING LP maximising Z;

GAMS 2.25  PC AT/XT                    06/16/96 22:24:58  PAGE     15
TESTHSM1
Solution Report     SOLVE TESTHSM1 USING LP FROM LINE 93


               S O L V E     S U M M A R Y

     MODEL TESTHSM1    OBJECTIVE  Z
     TYPE LP           DIRECTION  MAXIMIZE
     SOLVER BDMLP      FROM LINE  93

**** SOLVER STATUS     1 NORMAL COMPLETION
**** MODEL STATUS      1 OPTIMAL
**** OBJECTIVE VALUE 6188.7338

                    LOWER      LEVEL      UPPER      MARGINAL

---- VAR Z          -INF       6188.734   +INF       .
---- VAR PAST        .         10.843     +INF       .
---- VAR FEW         .         51.147     +INF       .
---- VAR BEW         .         51.147     +INF       .
---- VAR PLAMB       .         57.773     +INF       .
---- VAR BYEW        .         51.147     +INF       .
---- VAR BYPL        .          .         +INF       EPS
---- VAR SEW         .         11.229     +INF       .
---- VAR SPL         .         57.773     +INF       .
---- VAR ODF         .          .         +INF       .
---- VAR PYODF       .          .         +INF       -0.129
---- VAR LOAN        .          .         +INF       .
---- VAR PYLOAN      .          .         +INF       -0.100
---- VAR BYLAND      .         0.843      +INF       .
---- VAR PVC         .         1367.747   +INF       .
---- VAR TBKB        .          .         +INF       .
---- VAR TLR01       .         61.376     +INF       .
---- VAR TLR02       .         53.704     +INF       .
---- VAR TLR03       .         56.261     +INF       .
---- VAR TLR04       .         46.032     +INF       .
---- VAR TLR05       .         66.491     +INF       .
---- VAR TTARG       .         56.773     +INF       .
---- VAR RISKLR      .         57.773     +INF       .
---- VAR TSAB        .          .         +INF       -0.138
---- VAR TWB         .         6188.734   +INF       .
```

**** REPORT SUMMARY :

0	NONOPT
0	INFEASIBLE
0	UNBOUNDED

EXECUTION TIME = 0.280 SECONDS VERID TP5-00-037

STEP SUMMARY:

0.160 STARTUP
0.000 COMPILATION
0.280 EXECUTION
0.000 CLOSEDOWN
0.440 TOTAL SECONDS

**** FILE SUMMARY

INPUT C:\LOTUS123\NEWTHESI\TESTHSM1.GMS
OUTPUT C:\LOTUS123\NEWTHESI\TESTHSM1.LST
SYNTHESIS C:\WP51\NEWTHESI\TESTHSM1.DOC

TESTHSM2 LP maximising 17/06 /96 09:08

Demonstrative Holistic Stochastic Model

Second Stochastic Variable (SI)

	PAST	FEW	BEW	PLAMB	BYEW	BYPL	SEW	SPL	ODF	PYODF	LOAN	PYLOAN	BYLAND	PVC	TBKB	TSI01	TSI02	TSI03	TSI04	TSI05	TTGSI	RISKSI	TSAB	TWB
Obj Z =E=																							1.00	1.00
CCAP 0.00 =G=		0.21																				−1.00		
LAND 10.00 =G=	1.00												−1.00											
EWINV 0.00 =G=			1.00		−1.00																			
BFEWT 0.00 =E=		1.00	−1.00																					
PLINV 0.00 =G=			−1.00	1.00		−1.00																		
EWSP 1.00 =G=			−0.20				1.00																	
PLSP 0.00 =G=				−1.00				1.00																
EWMKS 0.00 =L=					1.00																			
PLMKS 0.00 =L=						1.00																		
LANDMK 10.00 =G=													1.00											
ODFOPT 2000.00 =G=									1.00															
ODFTIE 0.00 =E=									−1.12	1.00														
LOANOP 5000.00 =G=											1.00													
LOANTIE 0.00 =E=											−1.09	1.00												
COSTAC 0.00 =E=			3.50		15.00	20.00							500.00	−1.00										
BKACC 100.00 =G=							−10.00	−20.00	−1.00	1.00	−1.00	1.00		1.00	1.00									
SAVACC 0.00 =E=															−1.06								1.00	
FARMW 0.00 =E=	−500.00		−15.00																					1.00
SI5 0.00 =G=	−0.50															1.00								
SI7 0.00 =G=	−0.70																1.00							
SI8 0.00 =G=	−0.80																	1.00						
SI9 0.00 =G=	−0.90																		1.00					
SI1 0.00 =G=	−1.00																			1.00				
RFDSI 0.00 =G=																−0.07	−0.13	−0.20	−0.27	−0.33	1.00			
TGSI 0.90 =G=																					−1.00	1.00		

Table 3: Programmming Matrix of the Demonstrative Model: Holistic Stochastic Scenario with 1 Random Variable (SI)

TESTHSM2: DEMONSTRATIVE TEST: STOCHASTIC MODEL WITH SUSTAINABILITY:STOCKING DENSITY RATIO AS THE INPUT-OUTPUT RANDOM VARIABLE AND AN EXPONENTIAL OBJECTIVE FUNCTION

DECISION VARIABLES

7	PAST	Pasture production (DSE)
8	FEW	DSE ewe ratio to the ha.
9	BEW	Breeding ewes activity (heads)
10	PLAMB	Prime lambs activity (heads)
11	BYEW	Buying ewes activity (heads)
12	BYPL	Buying prime lambs activity (heads)
13	SEW	Sell ewes activity (heads)
14	SPL	Sell prime lambs activity (heads)
15	ODF	Overdraft option (A$)
16	PYODF	Pay overdraft i = 0.12
17	LOAN	Loan option (A$)
18	PYLOAN	Pay loan i = 0.09
19	BYLAND	Buy land (ha)
20	PVC	Pay variable costs (A$)
21	TBKB	Transfer bank account balance (index)
22	TSI01	Transfer Sustainability Index 1
23	TSI02	Transfer Sustainability Index 2
24	TSI03	Transfer Sustainability Index 3
25	TSI04	Transfer Sustainability Index 4
26	TSI05	Transfer Sustainability Index 5
27	TTGSI	Transfer to Target Sustainability Index
28	RISKSI	Transfer random value to the main random equation
29	TSAB	Transfer saving account balance to objective function
30	TWB	Transfer farm wealth account balance to objective function (index)

EQUATION VARIABLES

33	Obj	Maximise Cash Flow (A$)
34	CCAP	Carrying Capacity (DSE)
35	LAND	Available land (ha)
36	EWINV	Ewes inventory (heads)
37	BFEWT	Breeding-feeding ewes tie (index)
38	PLINV	Prime lambs inventory (heads)
39	EWSP	Ewes sale pool (heads)
40	PLSP	Prime lambs sale pool (heads)
41	EWMKS	Ewes marker supply (heads)
42	PLMKS	Prime lambs market supply (heads)
43	LANDMKS	Land market supply (ha)
44	ODFOPT	Overdraft option (A$)
45	ODFTIE	Overdraft option and overdraft payment tie (index)

```
46      LOANOPT     Loan option (A$)
47      LOANTIE     Loan option and loan payment tie (index)
48      COSTACC     Cost account (A$)
49      BKACC       Bank account (A$)
50      SAVACC      Saving account (A$)
51      FARMW       Farm wealth account (A$)
52      SI5         Sustainability index 1
53      SI7         Sustainability index 2
54      SI8         Sustainability index 3
55      SI9         Sustainability index 4
56      SI1         Sustainability index 5
57      RFDSI       Density function for SI
58      TGSI        Target for SI;
```

MATHEMATICAL PROGRAMMING EQUATIONS

```
60
61 Obj..      Z=E= +1*TSAB +1*TWB^(1-r);
62 CCAP..     0=G= +0.212*FEW -1*RISKSI;
63 LAND..     10=G= +1*PAST -1*BYLAND;
64 EWINV..    0=G= +1*BEW -1*BYEW;
65 BFEWT..    0=E= +1*FEW -1*BEW;
66 PLINV..    0=G= -1*BEW +1*PLAMB -1*BYPL;
67 EWSP..     1=G= -0.200*BEW +1*SEW;
68 PLSP..     0=G= -1*PLAMB +1*SPL;
69 EWMKS..    0=L= +1*BYEW;
70 PLMKS..    0=L= +1*BYPL;
71 LANDMKS..  10=G= +1*BYLAND;
72 ODFOPT..   2000=G= +1*ODF;
73 ODFTIE..   0=E= -1.120*ODF +1*PYODF;
74 LOANOPT..  5000=G= +1*LOAN;
75 LOANTIE..  0=E= -1.090*LOAN +1*PYLOAN;
76 COSTACC..  0=E= +3.500*BEW +15*BYEW +20*BYPL +500*BYLAND
                -1*PVC;
78 BKACC..    100=G= -10*SEW -20*SPL -1*ODF +1*PYODF
                -1*LOAN+1*PYLOAN +1*PVC +1*TBKB;
80 SAVACC..   0=E= -1.060*TBKB +1*TSAB;
81 FARMW..    0=E= -500*PAST -15*BEW +1*TWB;
82 SI5..      0=G= -0.500*PAST +1*TSI01;
83 SI7..      0=G= -0.700*PAST +1*TSI02;
84 SI8..      0=G= -0.800*PAST +1*TSI03;
85 SI9..      0=G= -0.900*PAST +1*TSI04;
86 SI1..      0=G= -1*PAST +1*TSI05;
87 RFDSI..    0=G= -0.070*TSI01 -0.130*TSI02 -0.200*TSI03 -0.270*TSI04
                -0.330*TSI05+1*TTGSI;
89 TGSI..     0.900=G= -1*TTGSI +1*RISKSI;

91 MODEL TESTHSM2 /ALL/;
92
```

```
 93  SOLVE TESTHSM2 USING LP maximising Z;

TESTHSM2

Solution Report     SOLVE TESTHSM2 USING LP FROM LINE 93

               S O L V E      S U M M A R Y

     MODEL TESTHSM2           OBJECTIVE  Z
     TYPE LP DIRECTION MAXIMIZE
     SOLVER BDMLP             FROM LINE  93

**** SOLVER STATUS     1 NORMAL COMPLETION
**** MODEL STATUS      1 OPTIMAL
**** OBJECTIVE VALUE   5979.2836

 EXIT -- OPTIMAL SOLUTION FOUND.

                  LOWER      LEVEL      UPPER      MARGINAL

---- VAR Z        -INF       5979.284   +INF       .
---- VAR PAST     .          10.549     +INF       .
---- VAR FEW      .          46.988     +INF       .
---- VAR BEW      .          46.988     +INF       .
---- VAR PLAMB    .          46.988     +INF       .
---- VAR BYEW     .          46.988     +INF       .
---- VAR BYPL     .          .          +INF       EPS
---- VAR SEW      .          10.398     +INF       .
---- VAR SPL      .          46.988     +INF       .
---- VAR ODF      .          .          +INF       .
---- VAR PYODF    .          .          +INF       -0.124
---- VAR LOAN     .          .          +INF       .
---- VAR PYLOAN   .          .          +INF       -0.095
---- VAR BYLAND   .          0.549      +INF       .
---- VAR PVC      .          1143.743   +INF       .
---- VAR TBKB     .          .          +INF       .
---- VAR TSI01    .          5.274      +INF       .
---- VAR TSI02    .          7.384      +INF       .
---- VAR TSI03    .          8.439      +INF       .
---- VAR TSI04    .          9.494      +INF       .
---- VAR TSI05    .          10.549     +INF       .
---- VAR TTGSI    .          9.062      +INF       .
---- VAR RISKSI   .          9.962      +INF       .
---- VAR TSAB     .          .          +INF       -0.089
---- VAR TWB      .          5979.284   +INF       .

**** REPORT SUMMARY :
                     0 NONOPT
```

0 INFEASIBLE
0 UNBOUNDED

STEP SUMMARY:

0.160 STARTUP
0.000 COMPILATION
0.280 EXECUTION
0.000 CLOSEDOWN
0.440 TOTAL SECONDS

***FILE SUMMARY

INPUT	C:\LOTUS123\NEWTHESI\TESTHSM2.GMS
OUTPUT	C:\LOTUS123\NEWTHESI\TESTHSM2.LST
SYNTHESIS	C:\WP51\NEWTHESI\TESTHSM2.DOC

TESTHSM3 LP maximising 16/06 /96 22:55

Demonstrative Holistic Stochastic Model

Two Stochastic Variables (LR & SI)

			PAST	FEW	BEW	PLAMB	BYEW	BYPL	SEW	SPL	ODF	PYODF	LOAN	PYLOAN	BYLAND	PVC	TBKB	TLR01	TLR02	TLR03	TLR04	TLR05	TTARG	RISKLR	TLR01	TLR02	TLR03	TLR04	TLR05	TTARG	RISKLR	TSAB	TWB
Obj	Z	=E=																														1.00	1.00
CCAP	0.00	=G=		0.21																				−1.00									
LAND	10.00	=G=	1.00												−1.00																		
EWINV	0.00	=G=			1.00		−1.00																										
BFEWT	0.00	=E=		1.00	−1.00																												
PLINV	0.00	=G=				1.00		−1.00																								−1.00	
EWSP	1.00	=G=			−0.20				1.00																								
PLSP	0.00	=G=				−1.00				1.00																							
EWMKS	0.00	=L=					1.00																										
PLMKS	0.00	=L=						1.00																									
LANDMK	10.00	=G=													1.00																		
ODFOPT	2000.00	=G=									1.00																						
ODFTIE	0.00	=L=									−1.12	1.00																					
LOANOP	5000.00	=G=											1.00																				
LOANTIE	0.00	=E=											−1.09	1.00																			
COSTAC	0.00	=E=			3.50		15.00	20.00							500.00	−1.00																	
BKACC	100.00	=G=							−10.00	−20.00	−1.00	1.00	−1.00	1.00		1.00	1.00																
SAVACC	0.00	=E=															−1.06															1.00	
FARMW	0.00	=E=	−500.00		−15.00																												1.00
SI5	0.00	=G=	−0.50															1.00															
SI7	0.00	=G=	−0.70																1.00														
SI8	0.00	=G=	−0.80																	1.00													
SI9	0.00	=G=	−0.90																		1.00												
SI1	0.00	=G=	−1.00																			1.00											
RFDSI	0.00	=G=																−0.07	−0.13	−0.20	−0.27	−0.33	1.00										
TGSI	0.90	=G=																					−1.00	1.00									
LR01	0.00	=G=			−1.20																				1.00								
LR02	0.00	=G=			−1.05																					1.00							
LR03	0.00	=G=			−1.10																						1.00						
LR04	0.00	=G=			−0.90																							1.00					
LR05	0.00	=G=			−1.30																								1.00				
RFDLR	0.00	=G=																							−0.20	−0.20	−0.20	−0.20	−0.20	1.00			
TARGET	1.00	=G=																												−1.00	1.00		

Table 4: Programming Matrix of the Demonstrative Model: Holistic Stochastic Scenario with 2 Random Variables (LR and SI)

TESTHSM3: DEMONSTRATIVE TEST: STOCHASTIC MODEL WITH TWO INPUT-OUTPUT RANDOM VARIABLES (LAMBING RATE AND SUSTAINABILITY INDEX) PLUS AN EXPONENTIAL OBJECTIVE FUNCTION

DECISION VARIABLES

7	PAST	Pasture production (DSE)
8	FEW	DSE ewe ratio to the ha.
9	BEW	Breeding ewes activity (heads)
10	PLAMB	Prime lambs activity (heads)
11	BYEW	Buying ewes activity (heads)
12	BYPL	Buying prime lambs activity (heads)
13	SEW	Sell ewes activity (heads)
14	SPL	Sell prime lambs activity (heads)
15	ODF	Overdraft option (A$)
16	PYODF	Pay overdraft i = 0.12
17	LOAN	Loan option (A$)
18	PYLOAN	Pay loan i = 0.09
19	BYLAND	Buy land (ha)
20	PVC	Pay variable costs (A$)
21	TBKB	Transfer bank account balance (index)
22	TLR01	Transfer LR 1
23	TLR02	Transfer LR 2
24	TLR03	Transfer LR 3
25	TLR04	Transfer LR 4
26	TLR05	Transfer LR 5
27	TTGLR	Transfer to target value of LR
28	RISKLR	Transfer random value to the main equation
29	TLSI1	Transfer SI 1
30	TLSI2	Transfer SI 2
31	TLSI3	Transfer SI 3
32	TLSI4	Transfer SI 4
33	TLSI5	Transfer SI 5
34	TTGSI	Transfer SI to target row
35	RISKSI	Risk sustainability index transferring to major stochastic constraint
36	TSAB	Transfer saving account balance to objective function
37	TWB	Transfer farm wealth account balance to objective function (index);
38		

39 **EQUATION VARIABLES**

40	Obj	Maximise Cash Flow (A$)
41	CCAP	Carrying Capacity (DSE)
42	LAND	Available land (ha)
43	EWINV	Ewes inventory (heads)
44	BFEWT	Breeding-feeding ewes tie (index)
45	PLINV	Prime lambs inventory (heads)
46	EWSP	Ewes sale pool (heads)

```
47      PLSP      Prime lambs sale pool (heads)
48      EWMKS     Ewes marker supply (heads)
49      PLMKS     Prime lambs market supply (heads)
50      LANDMKS Land market supply (ha)
51      ODFOPT    Overdraft option (A$)
52      ODFTIE    Overdraft option and overdraft payment tie (index)
53      LOANOPT Loan option (A$)
54      LOANTIE Loan option and loan payment tie (index)
55      COSTACC Cost account (A$)
56      BKACC     Bank account (A$)
57      SAVACC    Saving account (A$)
58      FARMW     Farm wealth account (A$)
59      SI5       Sustainability index 1
60      SI7       Sustainability index 2
61      SI8       Sustainability index 3
62      SI9       Sustainability index 4
63      SI1       Sustainability index 5
64      RFDSI     Density function of sustainability effect
65      TGSI      Target value of sustainability index
66      LR01      Lambing rate year 1 (density function value)
67      LR02      Lambing rate year 2 (density function value)
68      LR03      Lambing rate year 3 (density function value)
69      LR04      Lambing rate year 4 (density function value)
70      LR05      Lambing rate year 5 (density function value)
71      RFDLR     Relative frequency distribution of lambing rates (probability)
72      TARGETLR        Target lambing rate;
```

74 **MATHEMATICAL PROGRAMMING EQUATIONS**

```
75 Obj..        Z=E= +1*TSAB +1*TWB^(1-r);
76 CCAP..       0=G= +0.212*FEW -1*RISKLR;
77 LAND..       10=G= +1*PAST -1*BYLAND;
78 EWINV..      0=G= +1*BEW -1*BYEW;
79 BFEWT..      0=E= +1*FEW -1*BEW;
80 PLINV..      0=G= +1*PLAMB -1*BYPL -1*RISKLR;
81 EWSP..       1=G= -0.200*BEW +1*SEW;
82 PLSP..       0=G= -1*PLAMB +1*SPL;
83 EWMKS..      0=L= +1*BYEW;
84 PLMKS..      0=L= +1*BYPL;
85 LANDMKS..    10=G= +1*BYLAND;
86 ODFOPT..     2000=G= +1*ODF;
87 ODFTIE..     0=E= -1.120*ODF +1*PYODF;
88 LOANOPT..    5000=G= +1*LOAN;
89 LOANTIE..    0=E= -1.090*LOAN +1*PYLOAN;
90 COSTACC..    0=E= +3.500*BEW +15*BYEW +20*BYPL +500*BYLAND
                -1*PVC;
92 BKACC..      100=G= -10*SEW -20*SPL -1*ODF +1*PYODF -1*LOAN
93              +1*PYLOAN +1*PVC +1*TBKB;
```

```
 94  SAVACC..     0=E= -1.060*TBKB +1*TSAB;
 95  FARMW..      0=E= -500*PAST -15*BEW +1*TWB;
 96  SI5..        0=G= -0.500*PAST +1*TLR01;
 97  SI7..        0=G= -0.700*PAST +1*TLR02;
 98  SI8..        0=G= -0.800*PAST +1*TLR03;
 99  SI9..        0=G= -0.900*PAST +1*TLR04;
100  SI1..        0=G= -1*PAST +1*TLR05;
101  RFDSI..      0=G= -0.070*TLR01 -0.130*TLR02 -0.200*TLR03 -0.270*TLR04
                  -0.330*TLR05+1*TTARG;
103  TGSI..       0.900=G= -1*TTARG +1*RISKLR;
104  LR01..       0=G= -1.200*BEW +1*TLR01;
105  LR02..       0=G= -1.050*BEW +1*TLR02;
106  LR03..       0=G= -1.100*BEW +1*TLR03;
107  LR04..       0=G= -0.900*BEW +1*TLR04;
108  LR05..       0=G= -1.300*BEW +1*TLR05;
109  RFDLR..      0=G= -0.200*TLR01 -0.200*TLR02 -0.200*TLR03 -0.200*TLR04
                  -0.200*TLR05+1*TTARG;
111  TARGETLR..   1=G= -1*TTARG +1*RISKLR;
112
113  MODEL TESTHSM3 /ALL/;
114
115  SOLVE TESTHSM3 USING LP maximising Z;

Model Statistics    SOLVE TESTHSM3 USING LP FROM LINE 115

MODEL STATISTICS

BLOCKS OF EQUATIONS     33     SINGLE EQUATIONS       33
BLOCKS OF VARIABLES     25     SINGLE VARIABLES       25
NON ZERO ELEMENTS       81

TESTHSM3
Solution Report     SOLVE TESTHSM3 USING LP FROM LINE 115


               S O L V E     S U M M A R Y

     MODEL   TESTHSM3          OBJECTIVE  Z
     TYPE    LP                DIRECTION  MAXIMIZE
     SOLVER  BDMLP             FROM LINE  115

**** SOLVER STATUS     1 NORMAL COMPLETION
**** MODEL STATUS      1 OPTIMAL
**** OBJECTIVE VALUE            5276.1400

                    LOWER       LEVEL       UPPER       MARGINAL

---- VAR Z          -INF         5276.140    +INF          .
```

---- VAR PAST	.	10.000	+INF	.
---- VAR FEW	.	10.000	+INF	.
---- VAR BEW	.	10.000	+INF	.
---- VAR PLAMB	.	8.700	+INF	.
---- VAR BYEW	.	10.000	+INF	.
---- VAR BYPL	.	.	+INF	EPS
---- VAR SEW	.	3.000	+INF	.
---- VAR SPL	.	8.700	+INF	.
---- VAR ODFU	.	.	+INF	.
---- VAR PYODF	.	.	+INF	-0.114
---- VAR LOAN	.	.	+INF	.
---- VAR PYLOAN	.	.	+INF	-0.088
---- VAR BYLAND	.	.	+INF	-15.954
---- VAR PVC	.	185.000	+INF	.
---- VAR TBKB	.	119.000	+INF	.
---- VAR TLR01	.	5.000	+INF	.
---- VAR TLR02	.	7.000	+INF	.
---- VAR TLR03	.	8.000	+INF	.
---- VAR TLR04	.	9.000	+INF	.
---- VAR TLR05	.	10.000	+INF	.
---- VAR TTARG	.	7.800	+INF	.
---- VAR RISKLR	.	8.700	+INF	.
---- VAR TSAB	.	126.140	+INF	.
---- VAR TWB	.	5150.000	+INF	.

**** REPORT SUMMARY :

0 NONOPT
0 INFEASIBLE
0 UNBOUNDED

STEP SUMMARY:

0.160 STARTUP
0.000 COMPILATION
0.280 EXECUTION
0.000 CLOSEDOWN
0.440 TOTAL SECONDS

**** FILE SUMMARY

INPUT C:\LOTUS123\NEWTHESI\TESTHSM3.GMS
OUTPUT C:\LOTUS123\NEWTHESI\TESTHSM3.LST
SYNTHESIS C:\WP51\NEWTHESI\TESTHSM3.DOC

Appendix 6.1
The Farm Planning Scenarios

Appendix 6.1 The Farm Planning Scenarios

6.1.1 The farm planning scenarios

The farm planning scenarios of the on-farm exercise were organised as deterministic and stochastic options. The names and codes of each of the farm plans are described hereafter. A printed copy of the two major scenarios is attached to this appendix and the whole set of files is located in the computer disk annexed to this document.

The deterministic scenarios are:

	Farm Plan Name	Computer filename
(a)	Single beef farm plan	BEEFDM
(b)	Single meat sheep farm plan	MEATDM
(c)	Single wool sheep farm plan	WOOLDM
(d)	Holistic farm plan	HDM

The stochastic scenarios are:

(a)	Single beef farm plan	BEEFSM
(b)	Single meat farm plan	MEATSM
(c)	Single wool farm plan	WOOLSM
(d)	Holistic farm plan	HSM

The deterministic and stochastic farm plans for the parameterisation exercise are:

(a)	Deterministic whole-farm plan (Critical variables values 50% below standard farm plan)	HDM1
(b)	Deterministic whole-farm plan (Critical variables 50% standard farm plan)	HDM2

(c) Stochastic whole-farm plan HSM1

(Critical target values 50% below standard farm plan)

(d) Stochastic whole-farm plan HSM2

(Critical target values 50% above standard farm plan)

6.1.2 Variable codes

The codes of the decision variables and the equations are described as follows:

(a) Decision variables

PAST	Pasture production land (ha)
FODDER	Fodder production land (ha)
BIA	Buildings value ($)
MACH	Machinery and vehicles value ($)
FCOW	Stocking rate cow to the ha DSE ratio
FHF	Stocking rate heifer to the ha DSE ratio
FCV	Stocking rate calf to the ha DSE ratio
FWN	Stocking rate weaner to the ha DSE ratio
FST	Stocking rate steer to the ha DSE ratio
FBULL	Stocking rate bull to the DSE ratio
BCOW	Breeding cows activity (heads)
BHF	Breeding heifers activity (heads)
CALV	Calf activity (heads)
WNR	Weaners activity (heads)
STEER	Trading steers activity (heads)
BULL	Bulls activity (heads)
BYCOW	Buying cows activity (heads)
BYCALV	Buying calves activity (heads)
BYHF	Buying heifers activity (heads)
BYWN	Buying weaners (heads)
BST	Buying steers activity (heads)
BBUL	Buying bulls activity (heads)
SCOW	Sell cows activity (heads)
SWNR	Sell calves activity (heads)
SHF	Sell heifers activity (heads)
SST	Sell trading steers activity (heads)
SBUL	Sell bulls activity (heads)
FMEW	Stocking rate ewe to the ha DSE ratio
FMRAM	Stocking rate ram to the ha DSE ratio
FPLAMB	Stocking rate prime lamb to the ha DSE ratio
MEW	Breeding meat ewes activity (heads)
MRAM	Meat rams activity (heads)

PLAMB	Prime lambs activity (heads)
BYMEW	Buying meat ewes activity (heads)
BYMR	Buying meat rams activity (heads)
BYPL	Buying prime lambs activity (heads)
SMEW	Sell meat ewes activity (heads)
SMR	Sell meat rams activity (heads)
SPL	Sell prime lambs activity (heads)
FWEW	Stocking rate wool ewe to the ha DSE ratio
FWRAM	Stocking rate wool ram to the ha DSE ratio
FWHG	Stocking rate female hogget to the ha DSE ratio
FWTH	Stocking rate wether to the ha DSE ratio
WEW	Breeding wool ewes activity (heads)
WRAM	Wool rams activity (heads)
WFHG	Wool female hoggets activity (heads)
WTH	Wethers activity (heads)
BYWEW	Buying wool ewes activity (heads)
BYWR	Buying wool rams activity (heads)
BYFHG	Buying female hoggets activity (heads)
BYWT	Buying wethers activity (heads)
SWEW	Sell culled wool ewes activity (heads)
SWR	Sell culled rams activity (heads)
SFHG	Sell female hoggets activity (heads)
SWT	Sell wethers activity (heads)
SWTA	Sell wool type A activity (A$)
SWTB	Sell wool type B activity (A$)
SWTC	Sell wool type C activity (A$)
ODF	Overdraft option (A$)
PYODF	Pay overdraft i = 0.12
LOAN	Term loan option (A$)
PYLOAN	Pay loan i = 0.09
BYLAND	Buy land (ha)
PFC	Pay fixed costs ($)
PVC	Pay variable costs (A$)
TBKB	Bank account balance (transferred to saving account)
TSAB	Saving account balance (tranferred to objective function)
TWB	Farm wealth balance (transferred to objective function)
TCP1	Transfer Cow Price 1
TCP2	Transfer Cow Price 2
TCP3	Transfer Cow Price 3
TCP4	Transfer Cow Price 4
TCP5	Transfer Cow Price 5
TPCP	Probabilistic Transfer
RISKCP	Risk transfer to main variable place
TSP1	Transfer steer price 1
TSP2	Transfer steer price 2
TSP3	Transfer steer price 3
TSP4	Transfer steer price 4

TSP5	Transfer steer price 5
TPSP	Probabilistic transfer
RISKSP	Risk transfer to main variable place
TLR01	Transfer lambing rate of year 1 (probabilistic index)
TLR02	Transfer lambing rate of year 2 (probabilistic index)
TLR03	Transfer lambing rate of year 3 (probabilistic index)
TLR04	Transfer lambing rate of year 4 (probabilistic index)
TLR05	Transfer lambing rate of year 5 (probabilistic index)
TTGLR	Transfer of distribution lambing rate values to target row (index)
RISKLR	Risk lambing rate transferring to major stochastic constraint (index)
TPLP1	Tranfer prime lamb price 1
TPLP2	Tranfer prime lamb price 2
TPLP3	Tranfer prime lamb price 3
TPLP4	Tranfer prime lamb price 4
TPLP5	Tranfer prime lamb price 5
TPPLP	Probabilistic transfer
RISKPLP	Risk transfer to main variable place
TWLR01	Transfer wool lambing rate of year 1 (probabilistic index)
TWLR02	Transfer lambing rate of year 2 (probabilistic index)
TWLR03	Transfer lambing rate of year 3 (probabilistic index)
TWLR04	Transfer lambing rate of year 4 (probabilistic index)
TWLR05	Transfer lambing rate of year 5 (probabilistic index)
TWTGLR	Transfer of distribution lambing rate values to target row (index)
RISKWLR	Risk lambing rate transferring to major stochastic constraint
TWAP1	Probability transfer for wool price 1
TWAP2	Probability transfer for wool price 2
TWAP3	Probability transfer for wool price 3
TWAP4	Probability transfer for wool price 4
TWAP5	Probability transfer for wool price 5
TPWAP	Transfer of the density function for wool price
RISKWA	Risk effect for wool A price
TSI01	Probabilistic transfer of SI 1
TSI02	Probabilistic transfer of SI 2
TSI03	Probabilistic transfer of SI 3
TSI04	Probabilistic transfer of SI 4
TSI05	Probabilistic transfer of SI 5
TTGSI	Transfer of the density function SI
RISKSI	Risk effect of SI on stocking density
TLP1	Probabilistic transfer of land price 1
TLP2	Probabilistic transfer of land price 2
TLP3	Probabilistic transfer of land price 3
TLP4	Probabilistic transfer of land price 4
TLP5	Probabilistic transfer of land price 5

TPLP	Transfer of the density function land prices
RISKLP	Risk effect of land prices

(b) Equations

Obj. Funct.	Maximise Farm Assets (A$)
CCAP	Carrying Capacity 8.5 DSE value to the ha
LIVLAND	Available livestock land (ha)
CROPLAND	Available cropping land
BUILDG	Buildings initial inventory
MACHINV	Machinery initial inventory
COWINV	Cows inventory (heads)
BFCWT	Breeding-feeding cows tie
CVINV	Calves inventory (heads)
BFCFT	Breeding-feeding calves tie
HFINV	Replacement heifers inventory (heads)
BFHFT	Breeding-feeding heifers tie
WNINV	Weaners inventory (heads)
BFWNT	Breeding-feeding weaners tie
STINV	Trading steers inventory (heads)
BFSTT	Breeding-feeding steers tie
BLINV	Bulls inventory (heads)
BFBLT	Breeding-feeding bulls tie
CWSP	Cows sale pool (heads)
CFWNT	Calf-weaner tie
HFSP	Heifers sale pool (heads)
WNSP	Weaners sale pool (heads)
STSP	Steers sale pool (heads)
BLSP	Bulls sale pool (heads)
CWMKS	Cows marker supply (heads)
HFMKS	Heifers market supply (heads)
WNMKS	Weaners market supply (heads)
STMKS	Steers market supply (heads)
BLMKS	Bulls market supply (heads)
MEINV	Ewes inventory (heads)
BFMET	Breeding-feeding ewes tie (index)
MRINV	Meat rams inventory (heads)
BFMRT	Breeding-feeding rams tie
PLINV	Prime lambs inventory (heads)
BFPLT	Breeding-feeding prime lambs tie
MEWSP	Meat ewes sale pool (heads)
MRSP	Meat rams sale pool (heads)
PLSP	Prime lambs sale pool (heads)
MEMKS	Meat Ewes market supply (heads)
MRMKS	Meat rams market supply (heads)
PLMKS	Prime lambs market supply (heads)
WEINV	Wool ewes inventory (heads)
BFWET	Breeding-feeding ewes tie (index)

WLINV	Wool lambs inventory (heads)
WRINV	Wool rams inventory (heads)
BFWRT	Breeding-feeding rams tie
HGINV	Hoggets inventory (heads)
BFHGT	Breeding-feeding hoggets tie
WTINV	Wethers inventory (heads)
BFWTT	Breeding-feeding wethers tie
WEWRT	Ewe:ram tie
WEHWT	Breeding ewe tie to hogget and wether
WESP	Meat ewes sale pool (heads)
WRSP	Meat rams sale pool (heads)
WHGSP	Prime lambs sale pool (heads)
WTSP	Wethers sale pool (heads)
WEMKS	Ewes marker supply (heads)
WRMKS	Rams market supply (heads)
HGMKS	Hoggets market supply (heads)
WTMKS	Wethers market supply (heads)
WTASP	Wool type A sale pool
WTBSP	Wool type B sale pool
WTCSP	Wool type C sale pool
LANDMKS	Land market supply (ha)
ODFOPT	Overdraft option (A$)
ODFTIE	Overdraft option and overdraft payment tie (index)
LOANOPT	Loan option (A$)
LOANTIE	Loan option and loan payment tie (index)
COSTACC	Variable costs account (A$)
FCACC	Fixed costs account
BKACC	Bank account (A$)
SAVACC	Saving bank account (A$)
FARMW	Farm Assets Account (A$)
CWP1	Cow price 1
CWP2	Cow price 2
CWP3	Cow price 3
CWP4	Cow price 4
CWP5	Cow price 5
RFDCP	Probability transfer
TARGCP	Target cow price
STP1	Steer price 1
TP2	Steer price 2
STP3	Steer price 3
STP4	Steer price 4
STP5	Steer price 5
RFDSP	Probability transfer
TARGSP	Target steer price
LR01	Lambing rate year 1 (density function value)
LR02	Lambing rate year 2 (density function value)
LR03	Lambing rate year 3 (density function value)
LR04	Lambing rate year 4 (density function value)

LR05	Lambing rate year 5 (density function value)
RFDLR	Relative frequency distribution of lambing rates (probability)
TARGETLR	Target lambing rate (index)
PLP1	Prime lamb price 1
PLP2	Prime lamb price 2
PLP3	Prime lamb price 3
PLP4	Prime lamb price 4
PLP5	Prime lamg price 5
RFDPLP	Probability transfer
TGPLP	Target prime lamb price
WLR01	Wool lambing rate year 1 (density function value)
WLR02	Lambing rate year 2 (density function value)
WLR03	Lambing rate year 3 (density function value)
WLR04	Lambing rate year 4 (density function value)
WLR05	Lambing rate year 5 (density function value)
RFDWLR	Relative frequency distribution of lambing rates (probability)
TGWLR	Target lambing rate (index)
WTAP1	Wool A price 1
WTAP2	Wool A price 2
WTAP3	Wool A price 3
WTAP4	Wool A price 4
WTAP5	Wool A price 5
RFDWAP	Probability transfer
TGWAP	Target price wool type A
SI5	Sustainability index 0.50
SI7	Sustainability index 0.70
SI8	Sustainability index 0.80
SI9	Sustainability index 0.90
SI1	Sustainability index 1.00
RFDSI	Probability transferring
TGSI	Target sustainability index
LP1	Land price 1
LP2	Land price 2
LP3	Land price 3
LP4	Land price 4
LP5	Land price 5
RFDLP	Probability transferring
TGLP	Target land price

6.1.3 Mathematical Programming System (MPS) files

(a) Holistic Deterministic Farm Plan

The input and output MPS files for HDM farm plan are described hereafter.

```
151 Obj..        Z      =E=   +1*TSAB +1*TWB;
```

```
152 CCAP.          0       =G=   -1.0*PAST +1.294*FCOW +1.177*FHF +0.471*FCV
                                 +0.941*FWN +1.177*FST +1.412*FBULL
                                 +0.212*FMEW +0.294*FMRAM +0.200*FPLAMB
                                 +0.212*FWEW +0.294*FWRAM +0.200*FWHG
                                 +0.118*FWTH ;
155 LIVLAND..     1111    =G=   +1*PAST -1*BYLAND;
156 CROPLAND..    150     =G=   +1*FODDER;
157 BUILDG..      155000=G=     +1*BIA;
158 MACHINV..     85200   =G=   +1*MACH;
159 COWINV..      0       =G=   +1*BCOW -1*BYCOW;
160 BFCWT..       0       =E=   +1*FCOW -1*BCOW;
161 CVINV..       0       =G=   -0.950*BCOW +1*CALV -1*BYCALV;
162 BFCFT..       0       =E=   +1*FCV -1*CALV;
163 HFINV..       0       =G=   +1*BHF -1*BYHF;
164 BFHFT..       0       =E=   +1*FHF -1*BHF;
165 WNINV..       0       =G=   +1*WNR -1*BYWN;
166 BFWNT..       0       =E=   +1*FWN -1*WNR;
167 STINV..       0       =G=   +1*STEER -1*BST;
168 BFSTT..       0       =E=   +1*FST -1*STEER;
169 BLINV..       0       =G=   +1*BULL -1*BBUL;
170 BFBLT..       0       =E=   +1*FBULL -1*BULL;
171 CWSP..        1       =G=   -0.200*BCOW +1*SCOW;
172 CFWNT..       0       =E=   -1*CALV +1*WNR;
173 HFSP..        1       =G=   -0.500*BHF +1*SHF;
174 WNSP..        1       =G=   -1*WNR +1*SWNR;
175 STSP..        1       =G=   -1*STEER +1*SST;
176 BLSP..        1       =G=   -0.200*BULL +1*SBUL;
177 CWMKS..       0       =L=   +1*BYCOW;
178 HFMKS..       0       =L=   +1*BYHF;
179 WNMKS..       0       =L=   +1*BYWN;
180 STMKS..       0       =L=   +1*BST;
181 BLMKS..       0       =L=   +1*BBUL;
182 MEINV..       0       =G=   +1*MEW -1*BYMEW;
183 BFMET..       0       =E=   +1*FMEW -1*MEW;
184 MRINV..       0       =G=   +1*MRAM -1*BYMR;
185 BFMRT..       0       =E=   +1*FMRAM -1*MRAM;
186 PLINV..       0       =G=   -1*MEW +1*PLAMB -1*BYPL;
187 BFPLT..       0       =E=   +1*FPLAMB -1*PLAMB;
188 WEWRT..       0       =E=   -1.00*WEW +0.02*WRAM;
189 WEHWT..       0       =E=   -1.00*WEW +0.50*WFHG +0.50*WTH ;
190 MEWSP..       1       =G=   -0.200*MEW +1*SMEW;
191 MRSP..        1       =G=   +0.250*MRAM +1*SMR;
192 PLSP..        0       =G=   -1*PLAMB +1*SPL;
193 MEMKS..       0       =L=   +1*BYMEW;
194 MRMKS..       0       =L=   +1*BYMR;
195 PLMKS..       0       =L=   +1*BYPL;
196 WEINV..       1       =G=   +1*WEW -1*BYWEW;
197 BFWET..       0       =E=   +1*FWEW -1*WEW;
```

```
198 WLINV..      1        =G=   -0.900*WEW +0.450*WFHG +0.450*WTH;
199 WRINV..      1        =G=   +1*WRAM -1*BYWR;
200 BFWRT..      0        =E=   +1*FWRAM -1*WRAM;
201 HGINV..      1        =G=   +1*WFHG -1*BYFHG;
202 BFHGT..      0        =E=   +1*FWHG -1*WFHG;
203 WTINV..      1        =G=   +1*WTH -1*BYWT;
204 BFWTT..      0        =E=   +1*FWTH -1*WTH;
205 WESP..       1        =G=   -0.200*WEW +1*SWEW;
206 WRSP..       1        =G=   -0.250*WRAM +1*SWR;
207 WHGSP..      1        =G=   -1*WFHG +1*SFHG;
208 WTSP..       1        =G=   -0.500*WTH +1*SWT;
209 WTASP..      1        =G=   -3.500*MEW -3.500*WEW -5.500*WRAM
                                -2.500*WFHG -3.700*WTH +1*SWTA;
211 WTBSP..      1        =G=   -1*MEW -1*MRAM -1*WEW -0.500*WRAM
                                -0.500*WFHG -0.500*WTH +1*SWTB ;
213 WTCSP..      1        =G=   -1*MEW -8*MRAM -1*WEW -3.500*WRAM
                                -1*WFHG -2*WTH +1*SWTC;
215 WEMKS..      0        =L=   +1*BYWEW;
216 WRMKS..      0        =L=   +1*BYWR;
217 HGMKS..      0        =L=   +1*BYFHG;
218 WTMKS..      0        =L=   +1*BYWT;
219 LANDMKS..    500      =G=   +1*BYLAND;
220 ODFOPT..     5000     =G=         +1*ODF;
221 ODFTIE..     0        =E=   -1.120*ODF +1*PYODF;
222 LOANOPT..    100000=G=      +1*LOAN;
223 LOANTIE..    0        =E=   -1.090*LOAN +1*PYLOAN;
224 FCACC..      -71400=E=      -1*PFC;
225 BKACC..      324231=G=      +65*BCOW +59*BHF +24*CALV +48*WNR
                                +59*STEER +71*BULL +400*BYCOW
                                +50*BYCALV +400*BYHF +150*BYWN +300*BST
                                +2500*BBUL +10.640*MEW +14.770*MRAM
                                +10.050*PLAMB +15*BYMEW +250*BYMR
                                +20*BYPL +10.640*WEW +14.770*WRAM
                                +5.900*WFHG +5.900*WTH +15*BYWEW
                                +1000*BYWR +20*BYFHG +30*BYWT -360*SCOW
                                -300*SWNR -360*SHF -500*SST -354*SBUL
                                -10*SMEW -10*SMR -20*SPL -3.950*SWTA
                                -3.600*SWTB -2.200*SWTC -5*SWEW -10*SWR
                                -20*SFHG -30*SWT -1*ODF +1*PYODF -1*LOAN
                                +1*PFC +1200*BYLAND +1*TBKB;
234 SAVACC..     0        =E=   -1.060*TBKB +1*TSAB;
235 FARMA..      0        =E=   -1318.400*PAST -1318.400*FODDER -0.950*BIA
                                -0.900*MACH -400*BCOW -400*BHF -50*CALV
                                -300*WNR -500*STEER -2500*BULL -15*MEW
                                -200*MRAM -15*WEW -1000*WRAM +1*PYLOAN
                                +1*TWB;
240 MODEL HDM /ALL/;
242 SOLVE HDM USING LP maximising Z;
```

OPTIMAL SOLUTION

	LOWER	LEVEL	UPPER	MARGINAL
---- VAR Z	INF	3.0376E+6	+INF	.
---- VAR PAST	.	1562.653	+INF	.
---- VAR FODDER	.	150.000	+INF	.
---- VAR BIA	.	1.5500E+5	+INF	.
---- VAR MACH	.	85200.000	+INF	.
---- VAR FCOW	.	.	+INF	-311.913
---- VAR FHF	.	.	+INF	-132.276
---- VAR FCV	.	.	+INF	.
---- VAR FWN	.	.	+INF	-235.552
---- VAR FST	.	1327.400	+INF	.
---- VAR FBULL	.	.	+INF	.
---- VAR BCOW	.	.	+INF	.
---- VAR BHF	.	.	+INF	.
---- VAR CALV	.	.	+INF	.
---- VAR WNR	.	.	+INF	.
---- VAR STEER	.	1327.400	+INF	.
---- VAR BULL	.	.	+INF	.
---- VAR BYCOW	.	.	+INF	-645.511
---- VAR BYCALV	.	.	+INF	.
---- VAR BYHF	.	.	+INF	-645.511
---- VAR BYWN	.	.	+INF	-242.067
---- VAR BST	.	1327.400	+INF	.
---- VAR BBUL	.	.	+INF	-2407.571
---- VAR SCOW	.	1.000	+INF	.
---- VAR SWNR	.	1.000	+INF	.
---- VAR SHF	.	1.000	+INF	.
---- VAR SST	.	1328.400	+INF	.
---- VAR SBUL	.	1.000	+INF	.
---- VAR FMEW	.	.	+INF	.
---- VAR FMRAM	.	.	+INF	.
---- VAR FPLAMB	.	.	+INF	.
---- VAR MEW	.	.	+INF	-98.317
---- VAR MRAM	.	.	+INF	.
---- VAR PLAMB	.	.	+INF	-107.570
---- VAR BYMEW	.	.	+INF	-24.207
---- VAR BYMR	.	.	+INF	-378.833
---- VAR BYPL	.	.	+INF	-32.276
---- VAR SMEW	.	1.000	+INF	.
---- VAR SMR	.	1.000	+INF	.
---- VAR SPL	.	.	+INF	.
---- VAR FWEW	.	0.020	+INF	.
---- VAR FWRAM	.	1.000	+INF	.
---- VAR FWHG	.	.	+INF	-53.818
---- VAR FWTH	.	0.040	+INF	.
---- VAR WEW	.	0.020	+INF	.

---- VAR WRAM	.	1.000	+INF	.
---- VAR WFHG	.	.	+INF	.
---- VAR WTH	.	0.040	+INF	.
---- VAR BYWEW	.	.	+INF	-24.207
---- VAR BYWR	.	.	+INF	-767.905
---- VAR BYFHG	.	.	+INF	-32.276
---- VAR BYWT	.	.	+INF	-48.413
---- VAR SWEW	.	1.004	+INF	.
---- VAR SWR	.	1.250	+INF	.
---- VAR SFHG	.	1.000	+INF	.
---- VAR SWT	.	1.020	+INF	.
---- VAR SWTA	.	6.718	+INF	.
---- VAR SWTB	.	1.540	+INF	.
---- VAR SWTC	.	4.600	+INF	.
---- VAR ODF	.	.	+INF	-0.194
---- VAR PYODF	.	.	+INF	.
---- VAR LOAN	.	1.0000E+5	+INF	.
---- VAR PYLOAN	.	1.0900E+5	+INF	.
---- VAR BYLAND	.	451.653	+INF	.
---- VAR PFC	.	71400.000	+INF	.
---- VAR TBKB	.	.	+INF	.
---- VAR TSAB	.	.	+INF	-0.522
---- VAR TWB	.	3.0376E+6	+INF	.

(b) The holistic stochastic farm plan (HSM)

The input and output MPS files for HSM farm plan are described hereafter>

```
269  Obj..          Z       =E=   +1*TSAB +1*TFAB^(1-0.0001);
270  CCAP..         0       =G=   -1.00*RISKSI +1.294*FCOW +1.177*FHF
                                  +0.471*FCV +0.941*FWN +1.177*FST
                                  +1.412*FBULL +0.212*FMEW +0.294*FMRAM
                                  +0.200*FPLAMB +0.212*FWEW +0.294*FWRAM
                                  +0.200*FWHG +0.118*FWTH ;
273  LIVLAND        1111    =G=   +1*PAST -1*BYLAND;
274  CROPLAND..     150     =G=   +1*FODDER;
275  BUILDG..       155000  =G=   +1*BIA;
276  MACHINV..      85200   =G=   +1*MACH;
277  COWINV..       0       =G=   +1*BCOW -1*BYCOW;
278  BFCWT..        0       =E=   +1*FCOW -1*BCOW;
279  CVINV..        0       =G=   -0.950*BCOW +1*CALV -1*BYCALV;
280  BFCFT..        0       =E=   +1*FCV -1*CALV;
281  HFINV..        0       =G=   +1*BHF -1*BYHF;
282  BFHFT..        0       =E=   +1*FHF -1*BHF;
283  WNINV..        0       =G=   +1*WNR -1*BYWN;
284  BFWNT..        0       =E=   +1*FWN -1*WNR;
285  STINV..                0     =G=   +1*STEER -1*BST;
286  BFSTT..                0     =E=   +1*FST -1*STEER;
```

```
287 BLINV..      0      =G=    +1*BULL -1*BBUL;
288 BFBLT..      0      =E=    +1*FBULL -1*BULL;
289 CWSP..       1      =G=    -0.200*BCOW +1*SCOW;
290 CFWNT..      0      =E=    -1*CALV +1*WNR;
291 HFSP..       1      =G=    -0.500*BHF +1*SHF;
292 WNSP..       1      =G=    -1*WNR +1*SWNR;
293 STSP..       1      =G=    -1*STEER +1*SST;
294 BLSP..       1      =G=    -0.200*BULL +1*SBUL;
295 CWMKS..      0      =L=    +1*BYCOW;
296 HFMKS..      0      =L=    +1*BYHF;
297 WNMKS..      0      =L=   +1*BYWN;
298 STMKS..      0      =L=   +1*BST;
299 BLMKS..      0      =L=   +1*BBUL;
300 MEINV..      0      =G=   +1*MEW -1*BYMEW;
301 BFMET..      0      =E=   +1*FMEW -1*MEW;
302 MRINV..      0      =G=   +1*MRAM -1*BYMR;
303 BFMRT..      0      =E=   +1*FMRAM -1*MRAM;
304 PLINV..             0      =G=    -1*RISKLR +1*PLAMB -1*BYPL;
305 BFPLT..             0      =E=    +1*FPLAMB -1*PLAMB;
306 WEWRT..      0      =E=   -1.00*WEW +0.02*WRAM;
307 WEHWT..      0      =E=   -1.00*WEW +0.50*WFHG +0.50*WTH ;
308 MEWSP..      1      =G=   -0.200*MEW +1*SMEW;
309 MRSP..       1      =G=   +0.250*MRAM +1*SMR;
310 PLSP..       0      =G=   -1*PLAMB +1*SPL;
311 MEMKS..      0      =L=   +1*BYMEW;
312 MRMKS..      0      =L=   +1*BYMR; 313  PLMKS..    0=L= +1*BYPL;
314 WEINV..      1      =G=   +1*WEW -1*BYWEW;
315 BFWET..      0      =E=   +1*FWEW -1*WEW;
316 WLINV..      1      =G=   -1.0*RISKWLR +0.450*WFHG +0.450*WTH;
317 WRINV..      1      =G=   +1*WRAM -1*BYWR;
318 BFWRT..      0      =E=   +1*FWRAM -1*WRAM;
319 HGINV..      1      =G=   +1*WFHG -1*BYFHG;
320 BFHGT..      0      =E=   +1*FWHG -1*WFHG;
321 WTINV..      1      =G=   +1*WTH -1*BYWT;
322 BFWTT..      0      =E=   +1*FWTH -1*WTH;
323 WESP..       1      =G=   -0.200*WEW +1*SWEW;
324 WRSP..       1      =G=   -0.250*WRAM +1*SWR;
325 WHGSP..      1      =G=   -1*WFHG +1*SFHG;
326 WTSP..       1      =G=   -0.500*WTH +1*SWT;
327 WTASP..      1      =G=   -3.500*MEW -3.500*WEW -5.500*WRAM
                            -2.500*WFHG -3.700*WTH +1*SWTA;
329 WTBSP..      1      =G=   -1*MEW -1*MRAM -1*WEW -0.500*WRAM
                            -0.500*WFHG -0.500*WTH +1*SWTB ;
331 WTCSP..      1      =G=   -1*MEW -8*MRAM -1*WEW -3.500*WRAM
                            -1*WFHG -2*WTH +1*SWTC;
333 WEMKS..      0      =L=   +1*BYWEW;
334 WRMKS..      0      =L=   +1*BYWR;
335 HGMKS..      0      =L=   +1*BYFHG;
```

```
336 WTMKS..      0        =L=  +1*BYWT;
337 LANDMKS..    500      =G=  +1*BYLAND;
338 ODFOPT..     5000     =G=  +1*ODF;
339 ODFTIE..     0        =E=  -1.120*ODF +1*PYODF;
340 LOANOPT..    100000=G=  +1*LOAN;
341 LOANTIE..    0        =E=  -1.090*LOAN +1*PYLOAN;
342 FCACC..      -71400=E=  -1*PFC;
343 BKACC..      324231=G=  +65*BCOW +59*BHF +24*CALV +48*WNR
                           +59*STEER +71*BULL +400*BYCOW
                           +50*BYCALV +400*BYHF +150*BYWN +300*BST
                           +2500*BBUL +10.640*MEW +14.770*MRAM
                           +10.050*PLAMB +15*BYMEW +250*BYMR
                           +20*BYPL +10.640*WEW +14.770*WRAM
                           +5.900*WFHG +5.900*WTH +15*BYWEW
                           +1000*BYWR +20*BYFHG +30*BYWT
                           -1.0*RISKCP -300*SWNR -360*SHF -1.0*RISKSP
                           -354*SBUL -10*SMEW -10*SMR -1.00*RISKPLP
                           -1.0*RISKWA -3.600*SWTB -2.200*SWTC
                           -5*SWEW -10*SWR -20*SFHG -30*SWT -1*ODF
                           +1*PYODF -1*LOAN +1*PFC +1200*BYLAND
                           +1*TBKB;
353 SAVACC..     0        =E=  -1.060*TBKB +1*TSAB;
354 FARMA..      0        =E=  -1.00*RISKLP -1318.400*FODDER -0.950*BIA
                           -0.900*MACH -400*BCOW -400*BHF -50*CALV
                           -300*WNR -500*STEER -2500*BULL -15*MEW
                           -200*MRAM -15*WEW - 1000*WRAM +1*PYLOAN
                           +1*TFAB;
358 CWP1..       0        =G=  -520*SCOW +1.0*TCP1;
359 CWP2..       0        =G=  -480*SCOW +1.0*TCP2;
360 CWP3..       0        =G=  -400*SCOW +1.0*TCP3;
361 CWP4..       0        =G=  360*SCOW +1.0*TCP4;
362 CWP5..       0        =G=  -450*SCOW +1.0*TCP5;
363 RFDCP..      0        =G=  -0.136*TCP1 -0.146*TCP2 -0.194*TCP3 -0.248*TCP4
                           -0.276*TCP5 +1.0*TPCP;
365 TARGCP.      450      =G=  -1.0*TPCP +1.0*RISKCP;
366 STP1..       0        =G=  -350*SST +1*TSP1;
367 STP2..       0        =G=  -400*SST +1*TSP2;
368 STP3..       0        =G=  -520*SST +1*TSP3;
369 STP4..       0        =G=  -500*SST +1*TSP4;
370 STP5..       0        =G=  -600*SST +1*TSP5;
371 RFDSP.       0        =G=  -0.14*TSP1 -0.211*TSP2 -0.207*TSP3 -0.271*TSP4
                           -0.171*TSP5 +1*TPSP;
373 TARGSP.      400      =G=  -1*TPSP +1*RISKSP;
375 LR01..       0        =G=  0.68*MEW +1*TLR01;
376 LR02..       0        =G=  -0.75*MEW +1*TLR02;
377 LR03..       0        =G=  -0.85*MEW +1*TLR03;
378 LR04..       0        =G=  -0.89*MEW +1*TLR04;
379 LR05..       0        =G=  -0.95*MEW +1*TLR05;
```

```
380 RFDLR..      0      =G=   -0.16*TLR01 -0.170*TLR02 -0.200*TLR03
                              -0.250*TLR04 -0.220*TLR05 +1*TTGLR;
382 TARGETLR..   1      =G=   -1*TTGLR +1*RISKLR;
383 PLP1..        0      =G=   -32.0*SPL +1*TPLP1;
384 PLP2..        0      =G=   -36.0*SPL +1*TPLP2;
385 PLP3..        0      =G=   -47.0*SPL +1*TPLP3;
386 PLP4..        0      =G=   -49.0*SPL +1*TPLP4;
387 PLP5..        0      =G=   -52.0*SPL +1*TPLP5;
388 RFDPLP..     0      =G=   -0.28*TPLP1 -0.180*TPLP2 -0.090*TPLP3
                              -0.220*TPLP4 -0.230*TPLP5 +1*TPPLP;
390 TGPLP..      1      =G=   -1*TPPLP +1*RISKPLP;
391 WLR01..      0      =G=   -0.68*WEW +1*TWLR01;
392 WLR02..      0      =G=   -0.75*WEW +1*TWLR02;
393 WLR03..      0      =G=   -0.85*WEW +1*TWLR03;
394 WLR04..      0      =G=   -0.89*WEW +1*TWLR04;
395 WLR05..      0      =G=   -0.95*WEW +1*TWLR05;
396 RFDWLR..     0      =G=   -0.16*TWLR01 -0.170*TWLR02 -0.200*TWLR03 -
                              0.250*TWLR04 -0.220*TWLR05 +1*TWTGLR;
398 TGWLR..      0.85   =G=   -1*TWTGLR +1*RISKWLR;
399 WTAP1..      0      =G=   -3.79*SWTA +1.0*TWAP1;
400 WTAP2..      0      =G=   -3.95*SWTA +1.0*TWAP2;
401 WTAP3..      0      =G=   -4.54*SWTA +1.0*TWAP3;
402 WTAP4..      0      =G=   -4.74*SWTA +1.0*TWAP4;
403 WTAP5..      0      =G=   -6.00*SWTA +1.0*TWAP5;
404 RFDWAP..     0      =G=   -0.29*TWAP1 -0.16*TWAP2 -0.10*TWAP3
                              -0.05*TWAP4 -0.40*TWAP5 +1.0*TPWAP;
406 TGWAP..      0.85   =G=   -1.0*TPWAP +RISKWA;
407 SI5..        0      =G=   -0.500*PAST +1*TSI01;
408 SI7..        0      =G=   -0.700*PAST +1*TSI02;
409 SI8.         0      =G=   -0.800*PAST +1*TSI03;
410 SI9..        0      =G=   -0.900*PAST +1*TSI04;
411 SI1..        0      =G=   -1*PAST +1*TSI05;
412 RFDSI..      0      =G=   -0.070*TSI01 -0.130*TSI02 -0.200*TSI03
                              -0.270*TSI04 -0.330*TSI05 +1*TTGSI;
414 TGSI..       0.900  =G=   -1*TTGSI +1*RISKSI;
415 LP1..        0      =G=   -689*PAST +1.0*TLP1;
416 LP2..        0      =G=   -810*PAST +1.0*TLP2;
417 LP3..        0      =G=   -930*PAST +1.0*TLP3;
418 LP4..        0      =G=   -1050*PAST +1.0*TLP4;
419 LP5..        0      =G=   -1170*PAST +1.0*TLP5;
420 RFDLP.       0      =G=   -0.272*TLP1 -0.182*TLP2 -0.182*TLP3 -0.091*TLP4
                              -0.272*TLP5+1.0*TPLP;
422 TGLP..       800    =G=   -1.00*TPLP +1.0*RISKLP;
423
424 MODEL HSM /ALL/;
426 SOLVE HSM USING LP maximising Z;
```

OPTIMAL SOLUTION

	LOWER	LEVEL	UPPER	MARGINAL
---- VAR Z	-INF	2.2626E+6	+INF	.
---- VAR PAST	.	1518.440	+INF	.
---- VAR FODDER	.	150.000	+INF	.
---- VAR BIA	.	1.5500E+5	+INF	.
---- VAR MACH	.	85200.000	+INF	.
---- VAR FCOW	.	.	+INF	-222.596
---- VAR FHF	.	.	+INF	.
---- VAR FCV	.	.	+INF	.
---- VAR FWN	.	.	+INF	.
---- VAR FST	.	1108.697	+INF	.
---- VAR FBULL	.	.	+INF	.
---- VAR BCOW	.	.	+INF	.
---- VAR BHF	.	.	+INF	-99.008
---- VAR CALV	.	.	+INF	.
---- VAR WNR	.	.	+INF	-210.766
---- VAR STEER	.	1108.697	+INF	.
---- VAR BULL	.	.	+INF	.
---- VAR BYCOW	.	.	+INF	-461.302
---- VAR BYCALV	.	.	+INF	.
---- VAR BYHF	.	.	+INF	-461.302
---- VAR BYWN	.	.	+INF	-172.988
---- VAR BST	.	1108.697	+INF	.
---- VAR BBUL	.	.	+INF	-1149.416
---- VAR SCOW	.	1.000	+INF	.
---- VAR SWNR	.	1.000	+INF	.
---- VAR SHF	.	1.000	+INF	.
---- VAR SST	.	1109.697	+INF	.
---- VAR SBULL	.	1.000	+INF	.
---- VAR FMEW	.	.	+INF	.
---- VAR FMRAM	.	.	+INF	.
---- VAR FPLAMB	.	.	+INF	.
---- VAR MEW	.	.	+INF	.
---- VAR MRAM	.	.	+INF	.
---- VAR PLAMB	.	.	+INF	.
---- VAR BYMEW	.	.	+INF	.
---- VAR BYMR	.	.	+INF	-243.284
---- VAR BYPL	.	.	+INF	-23.065
---- VAR SMEW	.	1.000	+INF	.
---- VAR SMR	.	1.000	+INF	.
---- VAR SPL	.	.	+INF	-71.186
---- VAR FWEW	.	0.020	+INF	.
---- VAR FWRAM	.	1.000	+INF	.
---- VAR FWHG	.	.	+INF	-47.931
---- VAR FWTH	.	0.040	+INF	.
---- VAR WEW	.	0.020	+INF	.

---- VAR WRAM	.	1.000	+INF	.
---- VAR WFHG	.	.	+INF	.
---- VAR WTH	.	0.040	+INF	.
---- VAR BYWEW	.	.	+INF	-17.299
---- VAR BYWR	.	.	+INF	-288.098
---- VAR BYFHG	.	.	+INF	-23.065
---- VAR BYWT	.	.	+INF	-34.598
---- VAR SWEW	.	1.004	+INF	.
---- VAR SWR	.	1.250	+INF	.
---- VAR SFHG	.	1.000	+INF	.
---- VAR SWT	.	1.020	+INF	.
---- VAR SWTA	.	6.718	+INF	.
---- VAR SWTB	.	1.540	+INF	.
---- VAR SWTC	.	4.600	+INF	.
---- VAR ODF	.	.	+INF	-0.138
---- VAR PYODF	.	.	+INF	.
---- VAR LOAN	.	1.0000E+5	+INF	.
---- VAR PYLOAN	.	1.0900E+5	+INF	.
---- VAR BYLAND	.	407.440	+INF	.
---- VAR PFC	.	71400.000	+INF	.
---- VAR TBKB	.	.	+INF	.
---- VAR TSAB	.	.	+INF	-0.088
---- VAR TFAB	.	2.2626E+6	+INF	.
---- VAR TCP1	.	520.000	+INF	.
---- VAR TCP2	.	480.000	+INF	.
---- VAR TCP3	.	400.000	+INF	.
---- VAR TCP4	.	360.000	+INF	.
---- VAR TCP5	.	450.000	+INF	.
---- VAR TPCP	.	431.380	+INF	.
---- VAR RISKCP	.	881.380	+INF	.
---- VAR TSP1	.	3.8839E+5	+INF	.
---- VAR TSP2	.	4.4338E+5	+INF	.
---- VAR TSP3	.	5.7704E+5	+INF	.
---- VAR TSP4	.	5.5485E+5	+INF	.
---- VAR TSP5	.	6.6582E+5	+INF	.
---- VAR TPSP	.	5.3170E+5	+INF	.
---- VAR RISKSP	.	5.3210E+5	+INF	.
---- VAR TLR01	.	.	+INF	.
---- VAR TLR02	.	.	+INF	.
---- VAR TLR03	.	.	+INF	.
---- VAR TLR04	.	.	+INF	.
---- VAR TLR05	.	.	+INF	.
---- VAR TTGLR	.	.	+INF	-120.704
---- VAR RISKLR	.	1.000	+INF	.
---- VAR TPLP1	.	.	+INF	.
---- VAR TPLP2	.	.	+INF	.
---- VAR TPLP3	.	.	+INF	.
---- VAR TPLP4	.	.	+INF	.

---- VAR TPLP5	.	.	+INF	.
---- VAR TPPLP	.	.	+INF	.
---- VAR RISKPLP	.	1.000	+INF	.
---- VAR TWLR01	.	0.014	+INF	.
---- VAR TWLR02	.	0.015	+INF	.
---- VAR TWLR03	.	0.017	+INF	.
---- VAR TWLR04	.	0.018	+INF	.
---- VAR TWLR05	.	0.019	+INF	.
---- VAR TWTGLR	.	.	+INF	EPS
---- VAR RISKWLR	.	.	+INF	EPS
---- VAR TWAP1	.	25.461	+INF	.
---- VAR TWAP2	.	26.536	+INF	.
---- VAR TWAP3	.	30.500	+INF	.
---- VAR TWAP4	.	31.843	+INF	.
---- VAR TWAP5	.	40.308	+INF	.
---- VAR TPWAP	.	32.395	+INF	.
---- VAR RISKWA	.	33.245	+INF	.
---- VAR TSI01	.	759.220	+INF	.
---- VAR TSI02	.	1062.908	+INF	.
---- VAR TSI03	.	1214.752	+INF	.
---- VAR TSI04	.	1366.596	+INF	.
---- VAR TSI05	.	1518.440	+INF	.
---- VAR TTGSI	.	1304.340	+INF	.
---- VAR RISKSI	.	1305.240	+INF	.
---- VAR TLP1	.	1.0462E+6	+INF	.
---- VAR TLP2	.	1.2299E+6	+INF	.
---- VAR TLP3	.	1.4121E+6	+INF	.
---- VAR TLP4	.	1.5944E+6	+INF	.
---- VAR TLP5	.	1.7766E+6	+INF	.
---- VAR TPLP	.	1.3937E+6	+INF	.
---- VAR RISKLP	.	1.3945E+E	+INF	.

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