Out of Equilibrium Trade, Network Trading and Transaction Costs –

an agent based model of agricultural water trade in the Murray Darling Basin

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Intent

- Develop a theoretical model of the agricultural firm's decision between their primary production activity (growing crops) and selling permits.

- Employ an agent based approach to review the model's sensitivities using a representative region from the Murray Darling basin.

Introduction

- Theoretical discussions often assume that an auction should be used to allocate permits.
- In reality, political feasibility results in at least some grandfathered allocation.

- With the assumption of efficient market trading, a grandfathered allocation is said not to matter.
- The efficient distribution will be found as long as there are no constraints to trade.

- Thus we are interested in the allocation of permits, out of equilibrium trading and general factors which inhibit trading.

One, Two, Three...

- Morgan and Wolverton (2005) reviewed the progress of 'Water Quality Trading in the United States' on behalf of the National Centre for Environmental Economics within the US Environmental Protection Agency.
- Out of the 11 offset/trading programs where trading has taken place, "four programs have had only one trade, one program has had two trades, and two programs have had three trades since inception". (Morgan & Wolverton 2005 21)

- A definite concern – especially considering the missing four.
- Either:
  - the allocation was optimal from the initial allocation and there were no changes in the region to prompt trading, or
  - significant barriers to trading have prevailed.

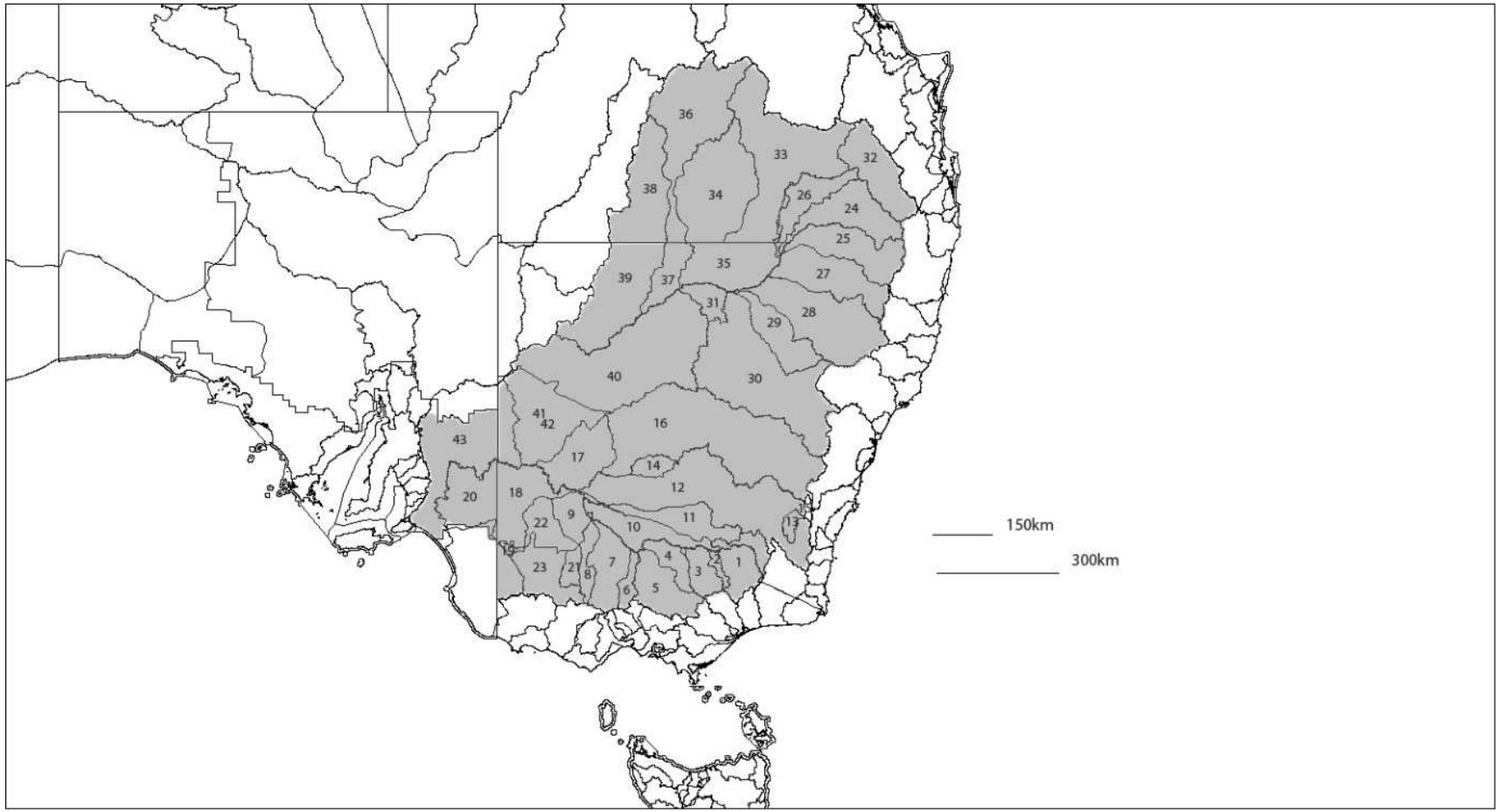
Flawed?

- Whilst non-point source water effluent is a major contributor to water pollution, it also remains largely unregulated.

- Inherent contradiction between:
  - the difficulty of monitoring nonpoint source pollution, and
  - the usefulness of trading programs when damages are associated with accumulated pollutant loads.

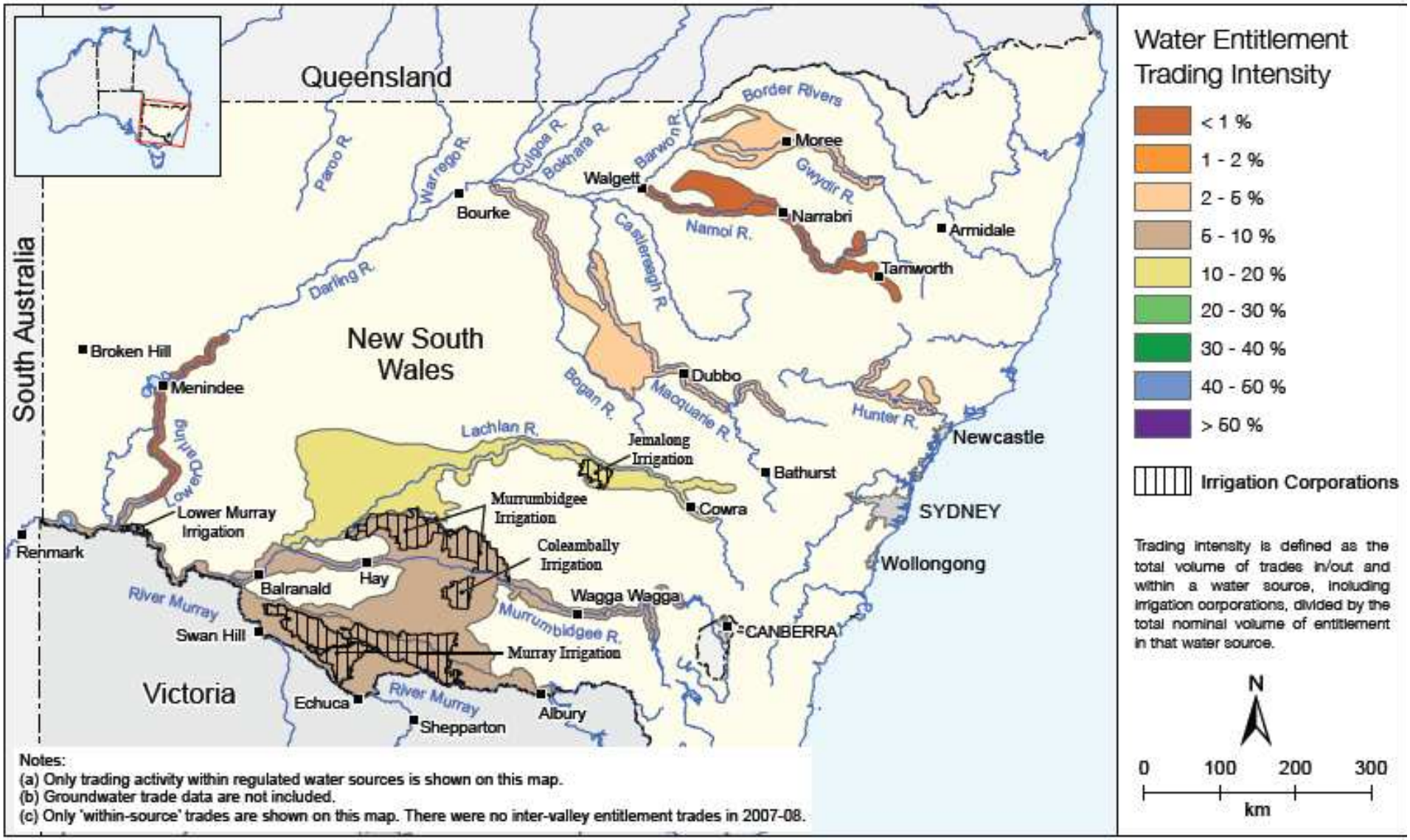
- Trading programs have primarily been of the point to point or point to nonpoint type, and it has been found that there are currently no programs in the US with a substantial nonpoint to nonpoint trading basis. (Nguyen et al 2006 12)

Murray Darling Basin – Natural Resource Management Regions and Basins



No.	Region	Abbreviation
10	Murray-Riverina	MRM
11	Murrumbidgee-Murray	MMUR
12	Murrumbidgee	MM
14	Murrumbidgee-Lachlan	ML

Figure 4.3 – Water Entitlement Trading (2007-08)



Notes:
(a) Only trading activity within regulated water sources is shown on this map.
(b) Groundwater trade data are not included.
(c) Only 'within-source' trades are shown on this map. There were no inter-valley entitlement trades in 2007-08.

Data Sources: Water system boundaries: Australian Water Resources 2005 surface water management areas. Irrigation area boundaries: Murray Irrigation Limited, Murray-Darling Basin Commission. Topographic data: Geoscience Australia (2002-08).
Map produced by the Bureau of Rural Sciences © Commonwealth of Australia.

Sourced from National Water Commission (2008)

Intersection of the Murray and Darling Rivers in South West New South Wales


May be the greatest, but they are not that intimidating.

Water Trading Model

- The firm within this model seeks profit.
- Profit is a function of the revenue from crop and permit sales (given auxiliary costs borne in producing these two products).

- The decision of how the firm shall prioritise its resources and efforts are predominantly based on:
  - the price of the crop they produce, and
  - the permits held.

- A natural extension is the possibility of a long term predilection toward switching crops or adopting newly developed efficient irrigation technology.

Water Trading Model

- A major quantification of our agricultural firm, as compared to a 'typical' firm, is that this firm produces goods on a 'produce to order' basis.

- We will assume that their entire crop is eventually bought at the agreed terms based on the exogenous crop price.

- The decision of allocating resources between selling crops and selling permits is made before the trading/production period.

Water Trading Model

- The assumption that all crops will be bought based on the regional price doesn't hold for water permits.

- The crop price is assumed to be set at a market clearing price either due to:
  - efficient interception of supply and demand
  - in this case, a near monopolistic/duopolistic buyer, or
  - government trading desk obligations to do so.

- Uncertainty and inefficiency is assumed to exist within the permit market as it is not within the traditional production process for the firms involved.
- Hence it may be difficult or costly to efficiently conduct transactions.

Water Trading Model

- Auctioning implies some intermediary intervention.

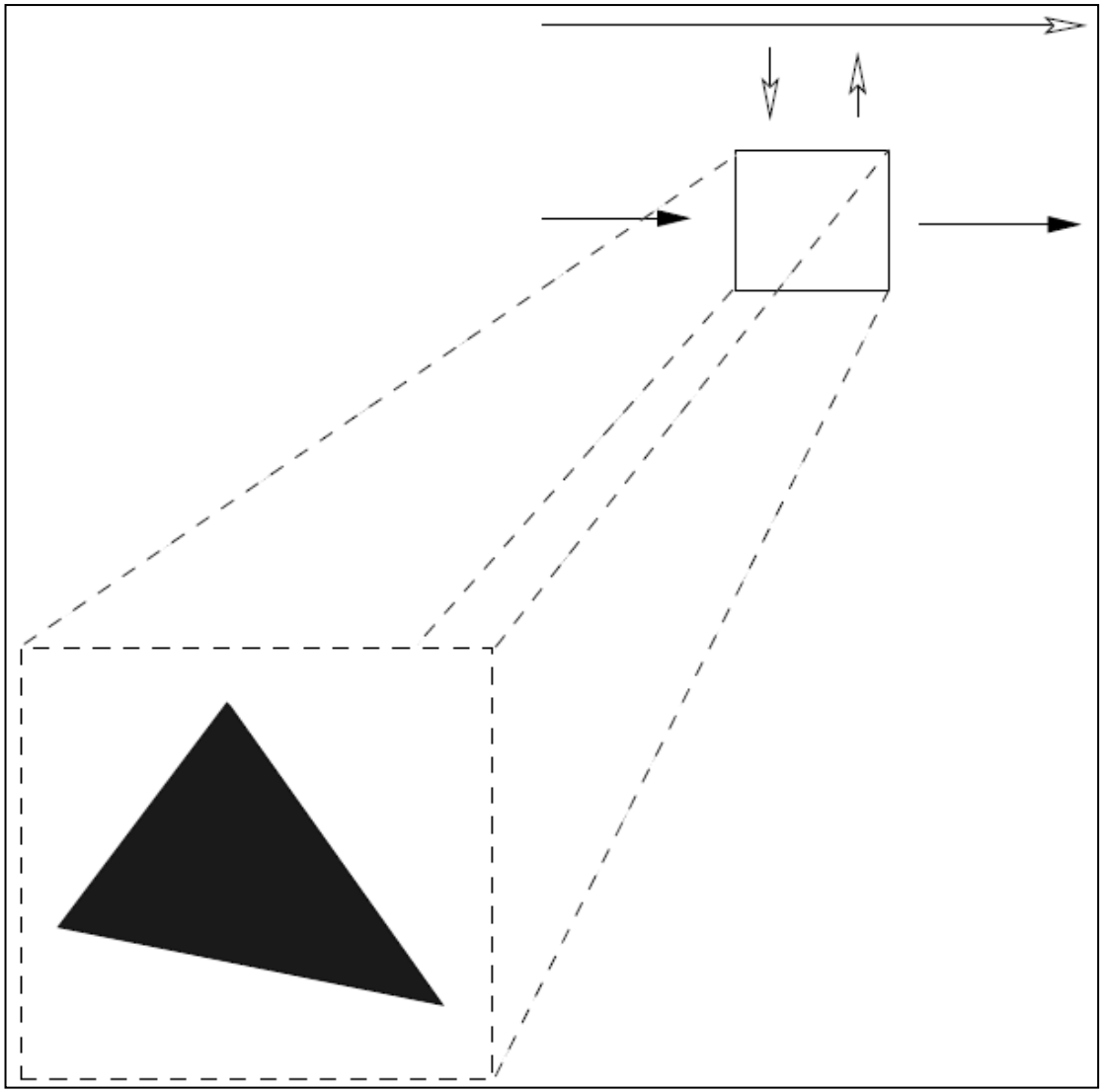
- Trading after the initial stages typically occurs via a procurement process.
- This is driven by the individual firms desire to gain permits to match the intended seeding and thus the projected crop output.

- A simplifying assumption will be that any trades of water are permanent.

Individual Farm Baseline Scenario – based on NSW Dept Primary Industries Gross Margin Budgets (which differ between region and crop)

Indicator	Region	Rice	Maize	Soybeans	Units
10	Murray-Riverina	712.099	731.8221	714.7234	ML
11	Murrumbidgee-Murray	336.2891	326.2648	377.3323	ML
12	Murrumbidgee	245.2108	237.9014	275.1381	ML
14	Murrumbidgee-Lachlan	630.5421	611.7465	707.4981	ML
10	Murray-Riverina	50.86421	81.31356	71.47234	t
11	Murrumbidgee-Murray	24.02065	36.25164	37.73323	t
12	Murrumbidgee	17.51506	26.43349	27.51381	t
14	Murrumbidgee-Lachlan	45.03872	67.97183	70.74981	t
10	Murray-Riverina	5.651579	27.10452	6.80689	h
11	Murrumbidgee-Murray	2.402065	9.062911	3.593641	h
12	Murrumbidgee	1.751506	6.608372	2.620363	h
14	Murrumbidgee-Lachlan	4.503872	16.99296	6.738077	h

Agent In Focus



Psuedo Code of Agent Based Model

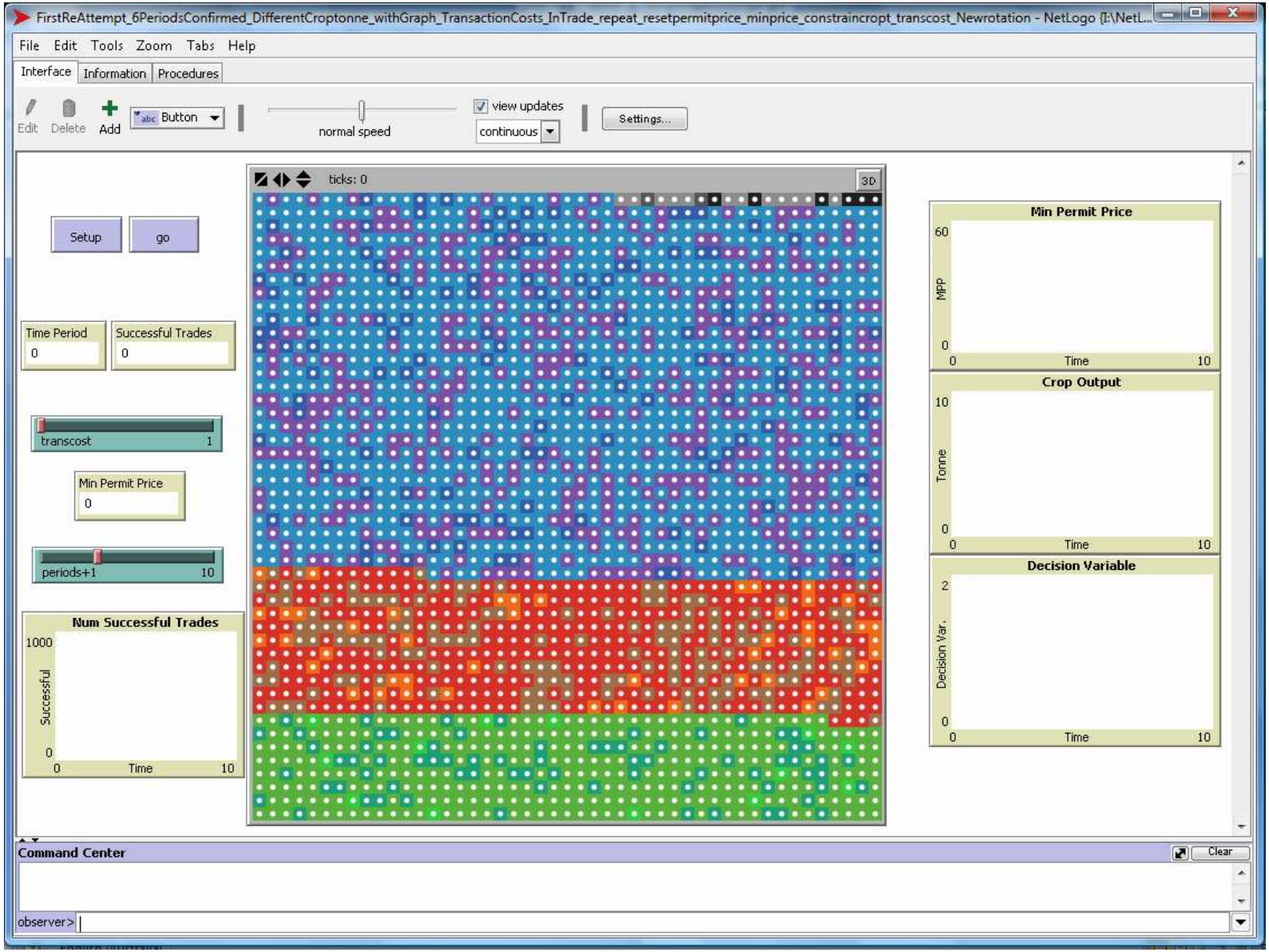
To Set up

- Clear all
- Set up the variables
- Set up plots on program interface

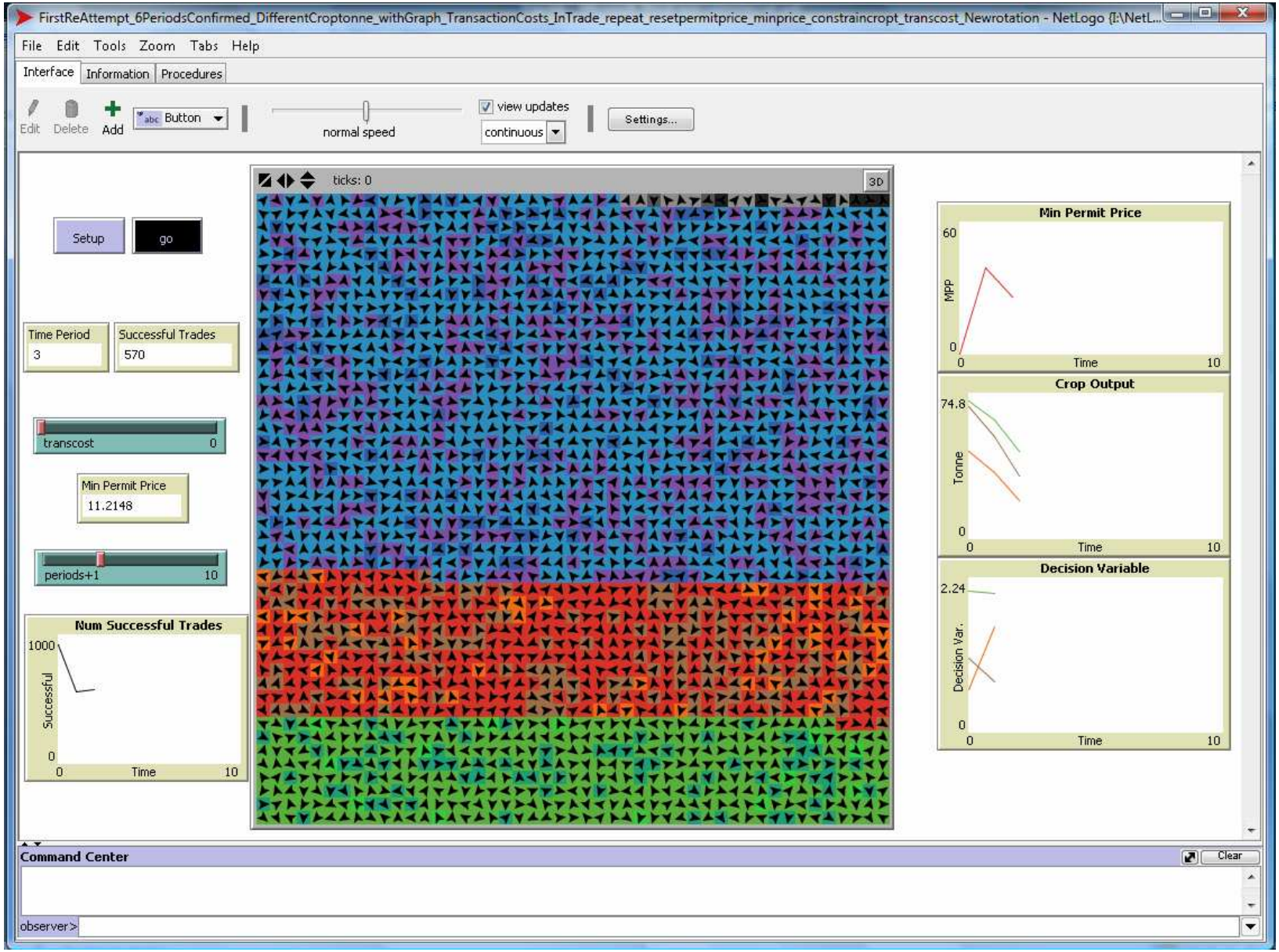
To Go

- Each agent makes a production/sale decision
- Set up and move each agent as part of trading process
- Allow any feasible trades to occur and update data accordingly
- Move agent back to their patch and update the plots on the interface
- Set up next trading period
- Run subsequent trading periods by repeating the above 'To Go' commands

NetLogo Program – Time Period Zero – Patches



NetLogo Program – Time Period Three – Agents



$$profit_{it} = croprev_{it} + permrev_{it} - cost_{it} \quad (4.1)$$

Profit Maximisation

$$croprev_{it} = \alpha_{ct}\left(w_{it}^{\beta_1} * landsize_{it}^{\beta_2}\right) * p_{ct} \quad (4.2)$$

$$permrev_{it} = p_{pt}(l_{it}) \quad (4.3)$$

$$cost_{it} = TrC_{it} + ac_{it} \quad (4.4)$$

Decision Variable

$$\frac{a_{it}}{b_{it}} \equiv d_{it} = \frac{E(croprev_{it})}{E(permrev_{it})} \quad (4.5)$$

$$E(permrev_{it}) = minpermp_{t-1} * l_{it} \quad (4.6)$$

$$E(croprev_{it}) = p_{ct-1} * qc_{it} \quad (4.7)$$

$$ls_{it} = \frac{E(permrev_{it})}{E(permrev_{it})+E(croprev_{it})} * l_{it} \quad (4.8)$$

Licences Sold

$$lu_{it} = \frac{E(croprev_{it})}{E(permrev_{it})+E(croprev_{it})} * l_{it} \quad (4.9)$$

Licences Used

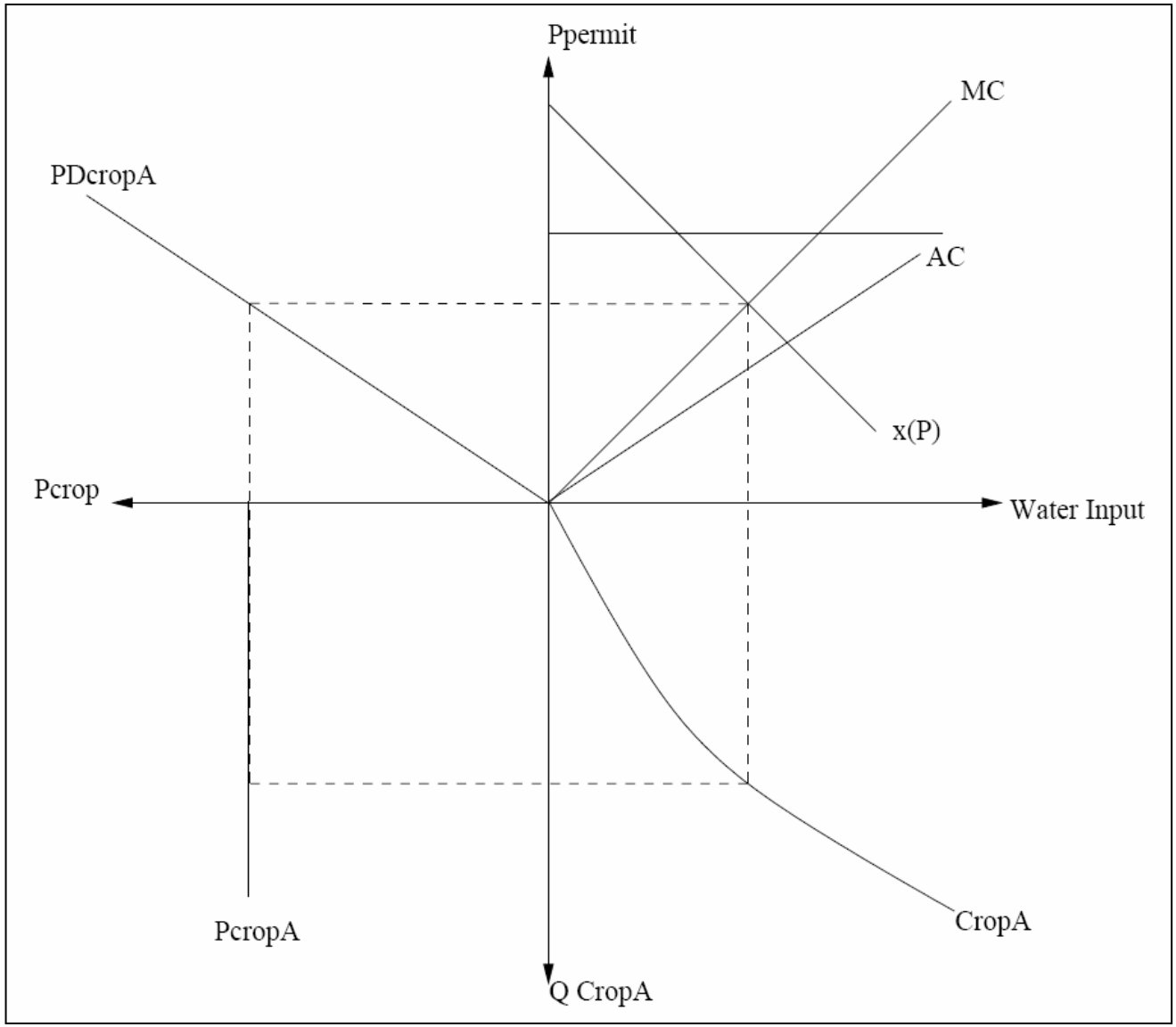
$$prp_{it} = \frac{E(croprev_{it})}{l_{it}} \quad (4.10)$$

Permit Price when the Decision equation set equal to one.

Transaction Cost – function of cost level and distance between traders

Trade if $pbp_{it} - (tc_{it} * td_{it}) > prp_{pt}$ (4.11)

Graphical Representation – Decision between Growing Crops and Selling Permits



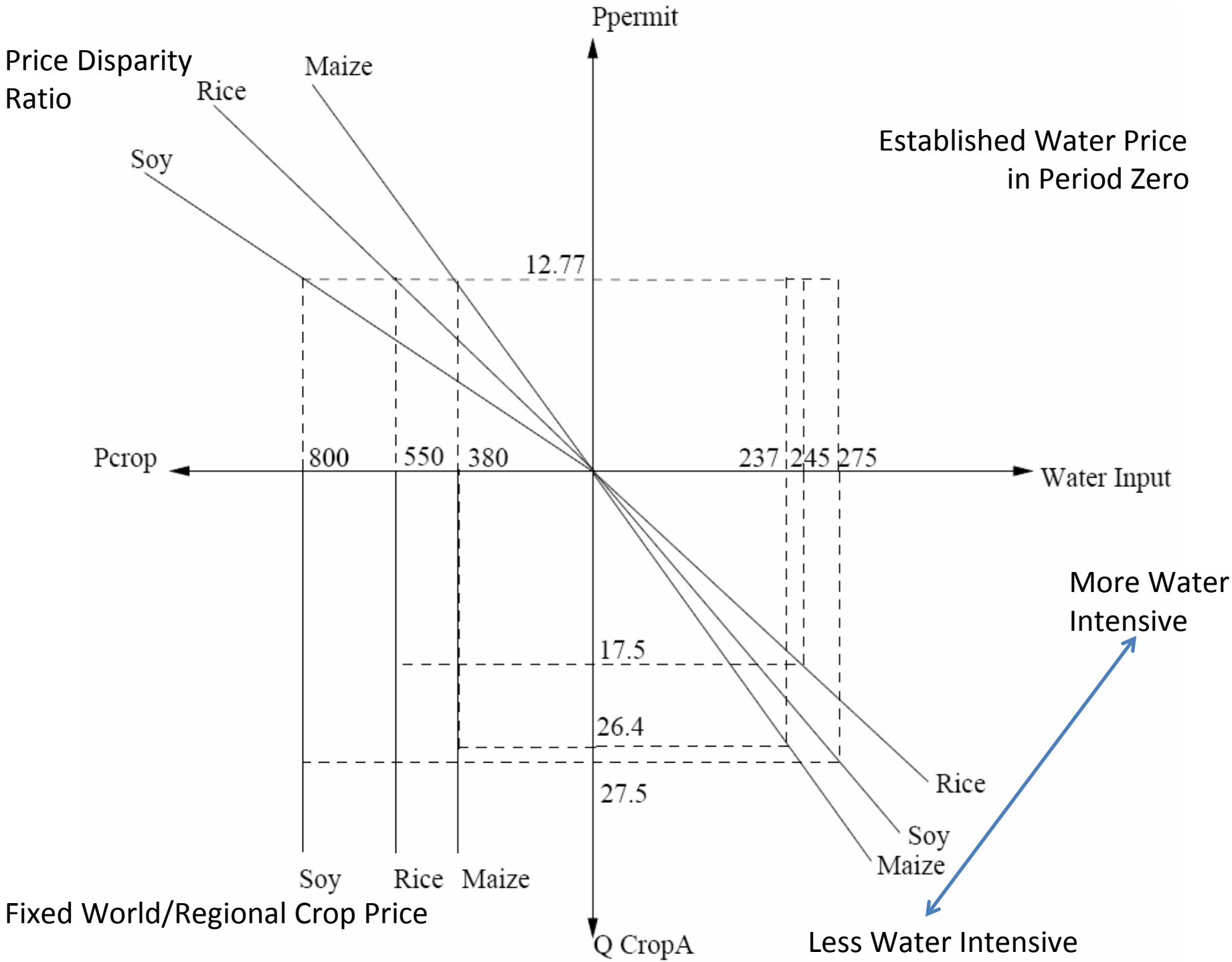

Price Disparity Ratio
Maize
Rice
Soy
Ppermit
Established Water Price in Period Zero
12.77
Pcrop
800
550
380
237
245
275
Water Input
More Water Intensive
17.5
26.4
27.5
Rice
Soy
Maize
Soy
Rice
Maize
Fixed World/Regional Crop Price
Q CropA
Less Water Intensive

Figure 4.4 – Rice – Permit Price and Decision Variable

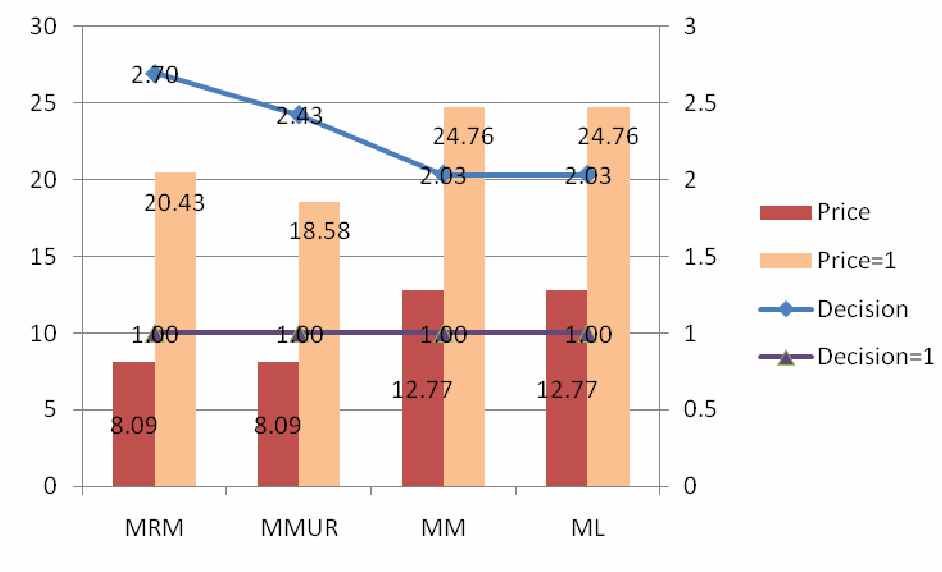


Figure 4.5 – Soy – Permit Price and Decision Variable

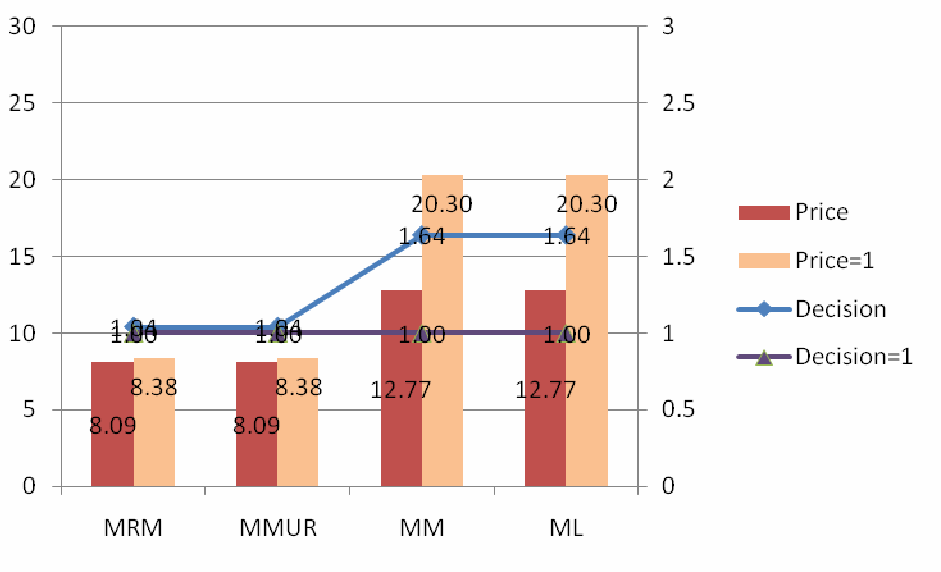
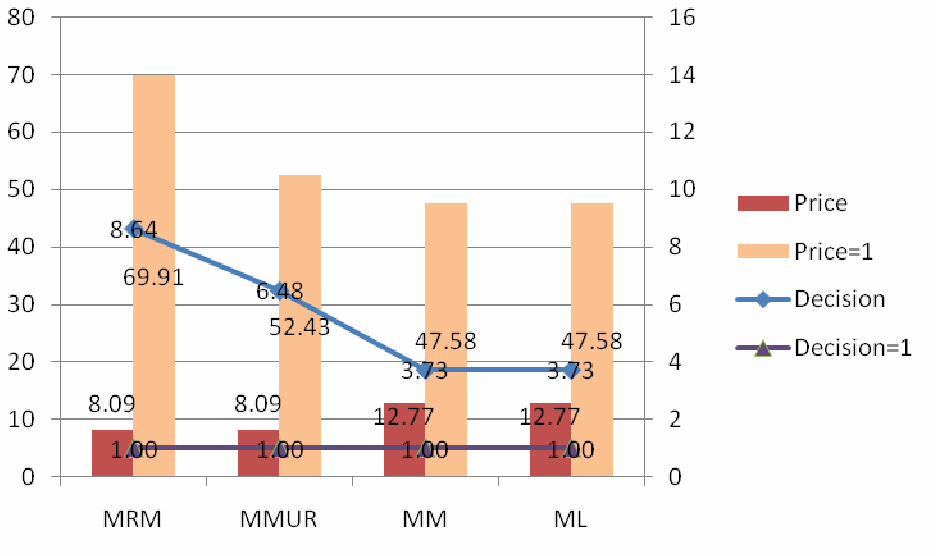
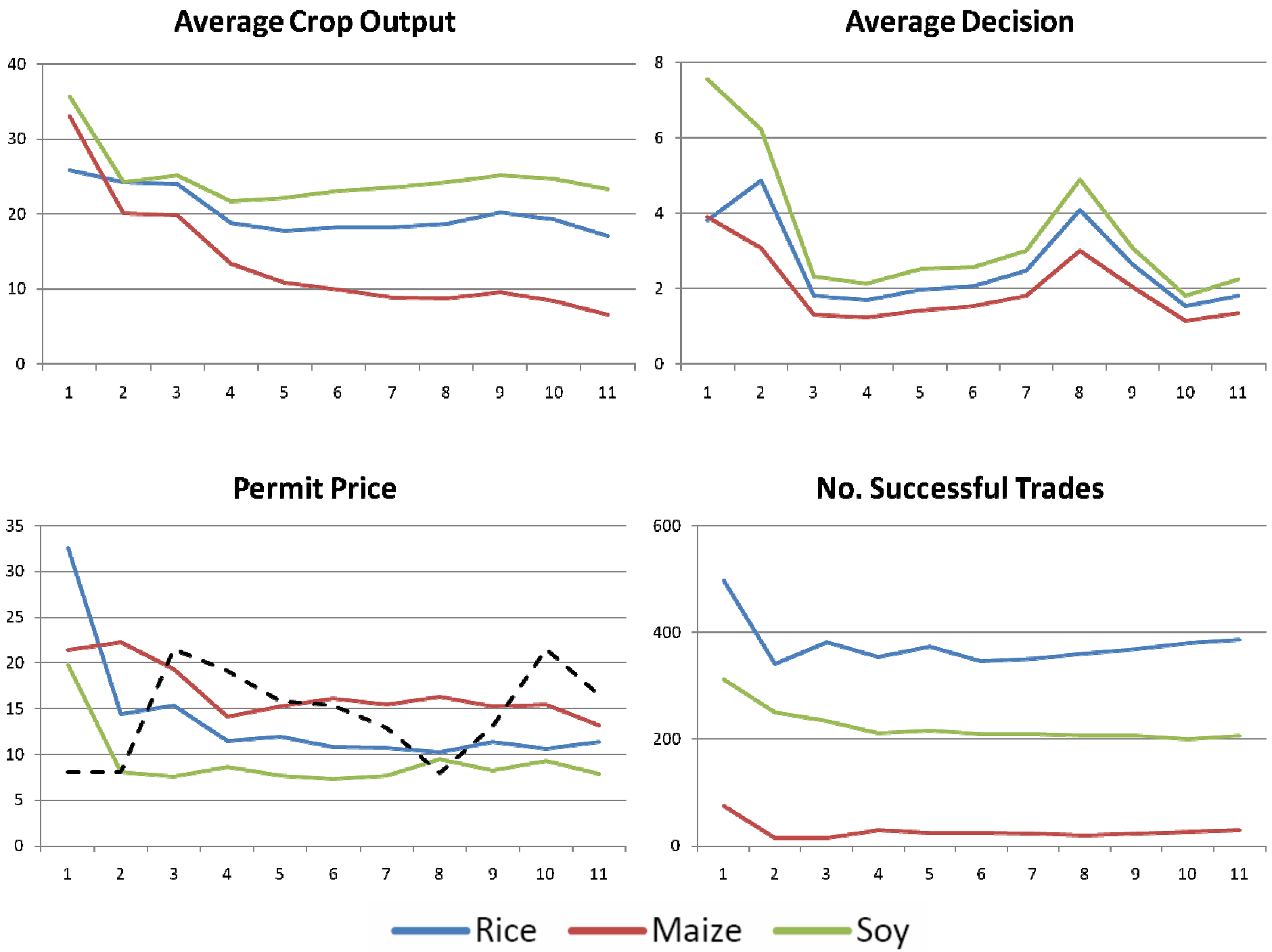
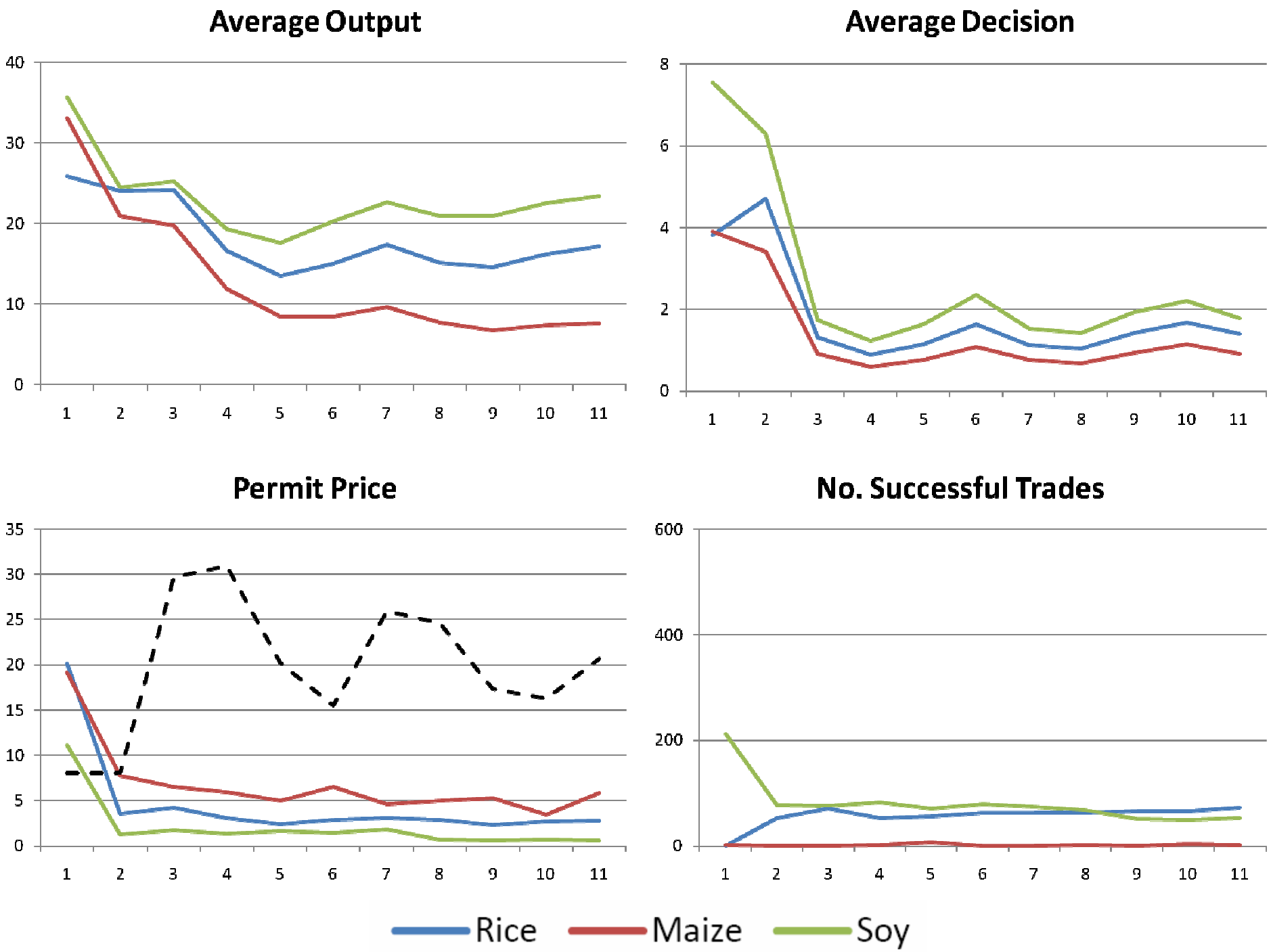


Figure 4.6 – Maize – Permit Price and Decision Variable




Average Crop Output
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11
Average Decision
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11
Permit Price
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11
No. Successful Trades
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11
Rice
Maize
Soy


Average Output
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11
Average Decision
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11
Permit Price
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11
No. Successful Trades
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11
Rice
Maize
Soy

Base Data for Elasticity Calculation

	Units	X – MRM	X – MMUR	X – ML	X – MM
SMRM	DV	1	0	0	0
SMMur	DV	0	1	0	0
SML	DV	0	0	1	0
SMM	DV	0	0	0	1
MMRM	DV	1	0	0	0
MMMurr	DV	0	1	0	0
MML	DV	0	0	1	0
MMM	DV	0	0	0	1
RMRM	DV	1	0	0	0
RMMurr	DV	0	1	0	0
RML	DV	0	0	1	0
RMM	DV	0	0	0	1
t_soy	Yrs	1	1	1	1
t_rice	Yrs	1	1	1	1
t_maize	Yrs	1	1	1	1
Output_soy	t	71.47	37.73	70.75	27.51
Output_rice	t	50.86	24.02	45.04	17.52
Output_maize	t	81.31	36.26	67.97	26.43
Decision_soy	α	9.89	9.90	6.27	6.27
Decision_rice	α	4.86	4.86	3.08	3.07
Decision_maize	α	5.22	5.22	3.31	3.31
Min_Pprice	Aus $	19.35	19.35	19.35	19.35
Reserve_Pprice	Aus $	5.0414	6.2823	5.4034	6.2409
Diversity	Aus $	1.4696	1.6484	1.4969	1.4302
Diversitypos	Aus $	7.8344	10.1466	10.6540	10.2462
Diversityneg	Aus $	-15.5579	-15.7246	-18.1262	-15.5074

Table 4.6 –Probability of a Successful Trade – Random Search – No Trans Costs

	Probit	Elasticity – MRM	Elasticity – MMUR	Elasticity – ML	Elasticity – MM
SMRM	-2.1169***	-1.3133***			
	(0.12)	(0.29)			
SMMur	-2.0610***		-1.9707***		
	(0.10)		(0.21)		
SML	-1.9413***			-5.0819***	
	(0.18)			(1.10)	
SMM	-1.9615***				-5.3682***
	(0.09)				(0.37)
MMRM	-3.3198***	-2.0596***			
	(0.22)	(0.45)			
MMMurr	-3.2096***		-3.0690***		
	(0.17)		(0.33)		
MML	-3.7138***			-9.7221***	
	(0.47)			(2.74)	
MMM	-3.1663***				-8.6654***
	(0.15)				(0.60)
RMRM	-2.6939***	-1.6712***			
	(0.08)	(0.36)			
RMMurr	-2.5347***		-2.4237***		
	(0.08)		(0.24)		
RML	-2.6751***			-7.0031***	
	(0.14)			(1.34)	
RMM	-2.4511***				-6.7080***
	(0.07)				(0.39)
t_soy	0.0105***	0.0065*	0.0101*	0.0276*	0.0288*
	(0.01)	(0.00)	(0.01)	(0.02)	(0.02)
t_rice	0.0144***	0.0089***	0.0137***	0.0376***	0.0393***
	(0.00)	(0.00)	(0.00)	(0.02)	(0.01)
t_maize	0.0251***	0.0156*	0.0240*	0.0657*	0.0687*
	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)
Output_soy	0.0047**	0.2074**	0.1688**	0.8665**	0.3523**
	(0.00)	(0.09)	(0.07)	(0.38)	(0.15)
Output_rice	0.0098***	0.3103***	0.2259***	1.1594***	0.4714***
	(0.00)	(0.07)	(0.03)	(0.23)	(0.05)
Output_maize	0.0098**	0.4943***	0.3396**	1.7435**	0.7088**
	(0.00)	(0.17)	(0.15)	(0.74)	(0.31)
Decision_soy	0.1981***	1.2148***	1.8748***	3.2504***	3.3980***
	(0.01)	(0.26)	(0.19)	(0.61)	(0.26)
Decision_rice	0.3005***	0.9053***	1.3964***	2.4219***	2.5278***
	(0.01)	(0.20)	(0.14)	(0.44)	(0.16)
Decision_maize	0.4841***	1.5671***	2.4180***	4.1887***	4.3789***
	(0.04)	(0.35)	(0.22)	(0.83)	(0.38)
Min_Pprice	0.0556***	0.5014***	0.7728***	2.1156***	2.2117***
	(0.00)	(0.11)	(0.08)	(0.40)	(0.17)
Reserve_Pprice	-0.0016	-0.0049	-0.0094	-0.0222***	-0.0268***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
i	2209				
t	11				
χ^2_{Zz}	6576.18***				
Y		0.6158	0.4054	0.0115	0.0081

Table 4.6 –Probability of a Successful Trade – Random Search – No Trans Costs

	Probit	Elasticity – MRM	Elasticity – MMUR	Elasticity – ML	Elasticity – MM
SMRM	-2.1169***	-1.3133***			
	(0.12)	(0.29)			
SMMur	-2.0610***		-1.9707***		
	(0.10)		(0.21)		
SML	-1.9413***			-5.0819***	
	(0.18)			(1.10)	
SMM	-1.9615***				-5.3682***
	(0.09)				(0.37)
MMRM	-3.3108***	-2.0596***			
t_soy	0.0105***	0.0065*	0.0101*	0.0276*	0.0288*
	(0.01)	(0.00)	(0.01)	(0.02)	(0.02)
t_rice	0.0144***	0.0089***	0.0137***	0.0376***	0.0393***
	(0.00)	(0.00)	(0.00)	(0.02)	(0.01)
t_maize	0.0251***	0.0156*	0.0240*	0.0657*	0.0687*
	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)
Output_soy	0.0047**	0.2074**	0.1688**	0.8665**	0.3523**
	(0.00)	(0.09)	(0.07)	(0.38)	(0.15)
Output_rice	0.0098***	0.3103***	0.2259***	1.1594***	0.4714***
	(0.00)	(0.07)	(0.03)	(0.23)	(0.05)
Output_maize	0.0098**	0.4943***	0.3396**	1.7435**	0.7088**
	(0.00)	(0.17)	(0.15)	(0.74)	(0.31)
Decision_soy	0.1981***	1.2148***	1.8748***	3.2504***	3.3980***
	(0.01)	(0.26)	(0.19)	(0.61)	(0.26)
Decision_rice	0.3005***	0.9053***	1.3964***	2.4219***	2.5278***
	(0.01)	(0.20)	(0.14)	(0.44)	(0.16)
Decision_maize	0.4841***	1.5671***	2.4180***	4.1887***	4.3789***
	(0.04)	(0.35)	(0.22)	(0.83)	(0.38)
Min_Pprice	0.0556***	0.5014***	0.7728***	2.1156***	2.2117***
	(0.00)	(0.11)	(0.08)	(0.40)	(0.17)
Reserve_Pprice	-0.0016	-0.0049	-0.0094	-0.0222***	-0.0268***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
i	2209				
t	11				
χ^2_{22}	6576.18***				
Y		0.6158	0.4054	0.0115	0.0081

Table 4.6 – Probability of a Successful Trade – Random Search – No Trans Costs

	Probit	Elasticity – MRM	Elasticity – MMUR	Elasticity – ML	Elasticity – MM
SMRM	-2.1169*** (0.12)	-1.3133*** (0.29)			
SMMur	-2.0610*** (0.10)		-1.9707*** (0.21)		
SML	-1.9413*** (0.18)			-5.0819*** (1.10)	
SMM	-1.9615*** (0.09)				-5.3682*** (0.37)
MMRM	-3.3108***	-2.0596***			
t_soy	0.0105*** (0.01)	0.0065* (0.00)	0.0101* (0.01)	0.0276* (0.02)	0.0288* (0.02)
t_rice	0.0144*** (0.00)	0.0089*** (0.00)	0.0137*** (0.00)	0.0376*** (0.02)	0.0393*** (0.01)
t_maize	0.0251*** (0.01)	0.0156* (0.01)	0.0240* (0.01)	0.0657* (0.04)	0.0687* (0.04)
Output_soy	0.0047** (0.00)	0.2074** (0.09)	0.1688** (0.07)	0.8665** (0.38)	0.3523** (0.15)
Output_rice	0.0098*** (0.00)	0.3103*** (0.07)	0.2259*** (0.03)	1.1594*** (0.23)	0.4714*** (0.05)
Output_maize	0.0098** (0.00)	0.4943*** (0.17)	0.3396** (0.15)	1.7435** (0.74)	0.7088** (0.31)
Decision_soy	0.1981*** (0.01)	1.2148*** (0.26)	1.8748*** (0.19)	3.2504*** (0.61)	3.3980*** (0.26)
Decision_rice	0.3005*** (0.01)	0.9053*** (0.20)	1.3964*** (0.14)	2.4219*** (0.44)	2.5278*** (0.16)
Decision_maize	0.4841*** (0.04)	1.5671*** (0.35)	2.4180*** (0.22)	4.1887*** (0.83)	4.3789*** (0.38)
Min_Pprice	0.0556*** [illegible]	0.5014*** (0.11)	0.7728*** [illegible]	2.1156*** [illegible]	2.2117*** (0.17)
Reserve_Pprice	[illegible] (0.00)	[illegible] (0.00)	[illegible] (0.00)	[illegible] (0.01)	-0.0268*** (0.01)
i	2209				
t	11				
χ^2_{22}	6576.18***				
Y		0.6158	0.4054	0.0115	0.0081

Increase in minimum permit price increases the probability of successful trade

Increase in reserve price is insignificant and negative

Table 4.6 – Probability of a Successful Trade – Random Search – No Trans Costs

	Probit	Elasticity – MRM	Elasticity – MMUR	Elasticity – ML	Elasticity – MM
SMRM	-2.1169***	-1.3133***			
	(0.12)	(0.29)			
SMMur	-2.0610***		-1.9707***		
	(0.10)		(0.21)		
SML	-1.9413***			-5.0819***	
	(0.18)			(1.10)	
SMM	-1.9615***				-5.3682***
	(0.09)				(0.37)
MMRM	-3.3108***	-2.0596***			
t_soy	0.0105***	0.0065*	0.0101*	0.0276*	0.0288*
	(0.01)	(0.00)	(0.01)	(0.02)	(0.02)
t_rice	0.0144***	0.0089***	0.0137***	0.0376***	0.0393***
	(0.00)	(0.00)	(0.00)	(0.02)	(0.01)
t_maize	0.0251***	0.0156*	0.0240*	0.0657*	0.0687*
	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)
Output_soy	0.0047**	0.2074**	0.1688**	0.8665**	0.3523**
	(0.00)	(0.09)	(0.07)	(0.38)	(0.15)
Output_rice	0.0098***	0.3103***	0.2259***	1.1594***	0.4714***
	(0.00)	(0.07)	(0.03)	(0.23)	(0.05)
Output_maize	0.0098**	0.4943***	0.3396**	1.7435**	0.7088**
	(0.00)	(0.17)	(0.15)	(0.74)	(0.31)
Decision_soy	0.1981***	1.0140***	1.8748***	3.2504***	3.3980***
	(0.01)	(0.25)	(0.19)	(0.61)	(0.26)
Decision_rice	0.2[illegible]	0.[illegible]	1.[illegible]	2.[illegible]	2.5278***
	(0.01)	(0.20)	(0.[illegible]	(0.[illegible]	(0.16)
Decision_maize	0.4841***	2.5671***	2.4180***	4.1887***	4.3789***
	(0.02)	(0.[illegible]	(0.[illegible]	(0.[illegible]	(0.38)
Min_Pprice	0.0556***	0.5014***	0.7728***	2.1156***	2.2117***
	(0.00)	(0.11)	(0.08)	(0.40)	(0.17)
Reserve_Pprice	-0.0016	-0.0049	-0.0094	-0.0222***	-0.0268***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
i	2209				
t	11				
χ^2_{22}	6576.18***				
Y		0.6158	0.4054	0.0115	0.0081

An increase in the decision variable (from the regional and crop average) leads to an increase in the overall probability of successful trade.
This implies less competition in the permit market due to the consequence that more licences are being used to grow that specific crop.

Table 4.7 –Probability of a Successful Trade – Random Search – Trans Costs

	Probit	Elasticity – MRM	Elasticity – MMUR	Elasticity – ML	Elasticity – MM		Probit	Elasticity – MRM	Elasticity – MMUR	Elasticity – ML	Elasticity – MM
SMRM	-2.1834***	-10.5904***				Min_Pprice	0.0219***	2.6500***	2.8956***	3.6048***	3.7100***
	(0.08)	(0.50)					(0.00)	(0.16)	(0.14)	(0.27)	(0.19)
SMMur	-1.6609***		-8.8028***			Reserve_Pprice	-0.0019***	-0.0469***	-0.0638***	-0.0683***	-0.0812***
	(0.06)		(0.33)				(0.00)	(0.01)	(0.01)	(0.02)	(0.02)
SML	-2.1840***			-14.4095***		Transcost=$1psq	-1.0094***	-4.8958***	-5.3495***	-6.6597***	-6.8540***
	(0.12)			(1.24)			(0.02)	(0.18)	(0.13)	(0.38)	(0.14)
SMM	-1.4749***				-10.0154***	Transcost=$2psq	-0.7484***	-3.6300***	-3.9664***	-4.9379***	-5.0819***
	(0.05)				(0.39)		(0.01)	(0.13)	(0.09)	(0.28)	(0.10)
MMRM	-2.6571***	-12.8878***				Transcost=$3psq	-0.6016***	-2.9180***	-3.1885***	-3.9693***	-4.0851***
	(0.20)	(1.05)					(0.01)	(0.11)	(0.07)	(0.23)	(0.08)
MMMurr	-2.5618***		-13.5774***			Transcost=$4psq	-0.4944***	-2.3981***	-2.6203***	-3.2621***	-3.3573***
	(0.14)		(0.79)				(0.01)	(0.09)	(0.06)	(0.19)	(0.07)
MML	-2.6758***			-17.6547***		Transcost=$5psq	-0.4498***	-2.1817***	-2.3839***	-2.9677***	-3.0543***
	(0.35)			(3.07)			(0.01)	(0.08)	(0.06)	(0.17)	(0.07)
MMM	-2.4850***				-16.8739***	Transcost=$6psq	-0.3893***	-1.8880***	-2.0630***	-2.5682***	-2.6432***
	(0.12)				(0.88)		(0.01)	(0.07)	(0.05)	(0.15)	(0.06)
RMRM	-2.5446***	-12.3424***				Transcost=$7psq	-0.3436***	-1.6665***	-1.8210***	-2.2669***	-2.3331***
	(0.05)	(0.48)					(0.01)	(0.06)	(0.05)	(0.13)	(0.05)
RMMurr	-2.1763***		-11.5343***			Transcost=$8psq	-0.3242***	-1.5727***	-1.7184***	-2.1393***	-2.2017***
	(0.05)		(0.33)				(0.01)	(0.06)	(0.05)	(0.13)	(0.05)
RML	-2.6017***			-17.1655***		Transcost=$9psq	-0.2969***	-1.4402***	-1.5737***	-1.9591***	-2.0163***
	(0.11)			(1.31)			(0.01)	(0.06)	(0.05)	(0.12)	(0.05)
RMM	-2.0575***				-13.9713***	Transcost=$10psq	-0.2819***	-1.3673***	-1.4940***	-1.8599***	-1.9141***
	(0.04)				(0.37)		(0.01)	(0.06)	(0.04)	(0.11)	(0.05)
t_soy	0.0195***	0.0944***	0.1031***	0.1284***	0.1321***	i	2209				
	(0.00)	(0.02)	(0.02)	(0.03)	(0.03)						
t_rice	0.0469***	0.2274***	0.2485***	0.3094***	0.3184***	t	11				
	(0.00)	(0.02)	(0.02)	(0.03)	(0.02)						
t_maize	0.0417***	0.2023***	0.2210***	0.2751***	0.2832***	χ^2_{32}	65190.42***				
	(0.01)	(0.06)	(0.06)	(0.08)	(0.08)						
Output_soy	0.0208***	7.2052***	4.1565***	9.7020***	3.8831***	y		1.645e-06	1.551e-07	5.610e-11	1.505e-11
	(0.00)	(0.49)	(0.27)	(0.77)	(0.24)						
Output_rice	0.0165***	4.0816***	2.1062***	4.9162***	1.9676***						
	(0.00)	(0.26)	(0.12)	(0.38)	(0.11)						
Output_maize	0.0068*	2.6959**	1.3133*	3.0655**	1.2269*						
	(0.00)	(1.36)	(0.69)	(1.56)	(0.64)						
Decision_soy	0.1317***	6.3164***	6.9106***	5.4481***	5.6070***						
	(0.01)	(0.39)	(0.37)	(0.43)	(0.32)						
Decision_rice	0.2166***	5.1028***	5.5798***	4.4006***	4.5218***						
	(0.01)	(0.25)	(0.22)	(0.30)	(0.19)						
Decision_maize	0.3433***	8.6870***	9.5021***	7.4849***	7.7032***						
	(0.03)	(0.80))	(0.75)	(0.80)	(0.66)						

Table 4.7 –Probability of a Successful Trade – Random Search – Trans Costs

	Probit	Elasticity MRM
SMRM	-2.1834***	-10.5904*
	(0.08)	(0.50)
SMMur	-1.6609***	
	(0.06)	
SML	-2.1840***	
	(0.12)	
SMM	-1.4749***	
	(0.05)	
MMRM	-2.6571***	-12.8878*
	(0.20)	(1.05)
MMMurr	-2.5618***	
	(0.14)	
MML	-2.6758***	
	(0.35)	
MMM	-2.4850***	
	(0.12)	
RMRM	-2.5446***	-12.3424*
	(0.05)	(0.48)
RMMurr	-2.1763***	
	(0.05)	
RML	-2.6017***	
	(0.11)	
RMM	-2.0575***	
	(0.04)	
t_soy	0.0195***	0.0944**
	(0.00)	(0.02)
t_rice	0.0469***	0.2274**
	(0.00)	(0.02)
t_maize	0.0417***	0.2023**
	(0.01)	(0.06)
Output_soy	0.0208***	7.2052**
	(0.00)	(0.49)
Output_rice	0.0165***	4.0816**
	(0.00)	(0.26)
Output_maize	0.0068*	2.6959*
	(0.00)	(1.36)
Decision_soy	0.1317***	6.3164**
	(0.01)	(0.39)
Decision_rice	0.2166***	5.1028**
	(0.01)	(0.25)
Decision_maize	0.3433***	8.6870**
	(0.03)	(0.80)

	Probit	Elasticity – MRM	Elasticity – MMUR	Elasticity – ML	Elasticity – MM
Min_Pprice	0.0219***	2.6500***	2.8956***	3.6048***	3.7100***
	(0.00)	(0.01)	(0.01)	(0.02)	(0.02)
Reserve_Pprice	-0.0019***	-0.0168***	-0.0634***	-0.0683***	-0.0753***
	(0.00)	(0.01)	(0.01)	(0.02)	(0.02)
Transcost=$1psq	-1.0094***	-4.8958***	-5.3495***	-6.6597***	-6.8540***
	(0.02)	(0.18)	(0.13)	(0.38)	(0.14)
Transcost=$2psq	-0.7484***	-3.6300***	-3.9664***	-4.9379***	-5.0819***
	(0.01)	(0.13)	(0.09)	(0.28)	(0.10)
Transcost=$3psq	-0.6016***	-2.9180***	-3.1885***	-3.9693***	-4.0851***
	(0.01)	(0.11)	(0.07)	(0.23)	(0.08)
Transcost=$4psq	-0.4944***	-2.3981***	-2.6203***	-3.2621***	-3.3573***
	(0.01)	(0.09)	(0.06)	(0.19)	(0.07)
Transcost=$5psq	-0.4498***	-2.1817***	-2.3839***	-2.9677***	-3.0543***
	(0.01)	(0.08)	(0.06)	(0.17)	(0.07)
Transcost=$6psq	-0.3893***	-1.8880***	-2.0630***	-2.5682***	-2.6432***
	(0.01)	(0.07)	(0.05)	(0.15)	(0.06)
Transcost=$7psq	-0.3436***	-1.6665***	-1.8210***	-2.2669***	-2.3331***
	(0.01)	(0.06)	(0.05)	(0.13)	(0.05)
Transcost=$8psq	-0.3242***	-1.5727***	-1.7184***	-2.1393***	-2.2017***
	(0.01)	(0.06)	(0.05)	(0.13)	(0.05)
Transcost=$9psq	-0.2969***	-1.4402***	-1.5737***	-1.9591***	-2.0163***
	(0.01)	(0.06)	(0.05)	(0.12)	(0.05)
Transcost=$10psq	-0.2819***	-1.3673***	-1.4940***	-1.8599***	-1.9141***
	(0.01)	(0.06)	(0.04)	(0.11)	(0.05)
i	2209				
t	11				
χ^2_{32}	65190.42***				
y		1.645e-06	1.551e-07	5.610e-11	1.505e-11

Increase in minimum permit price increases probability of suc. trade
Increase in reserve price is significant and negative – impact of trans

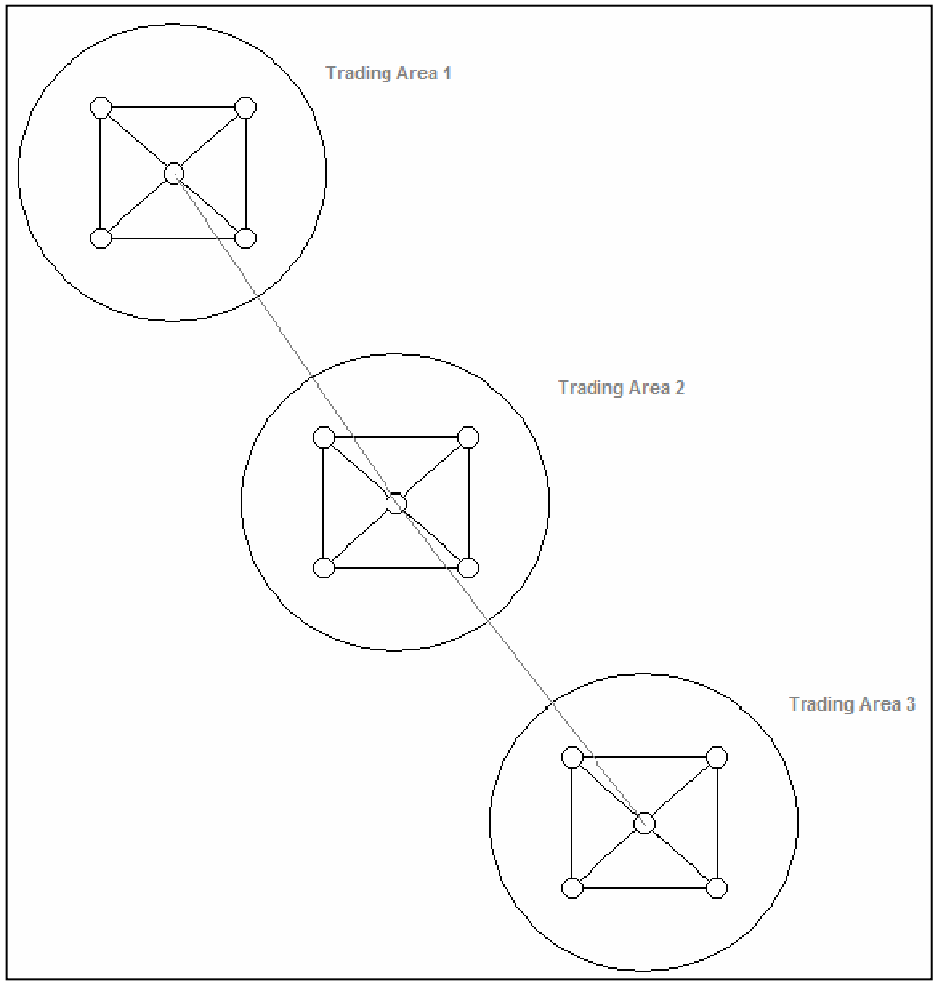
Table 4.7 –Probability of a Successful Trade – Random Search – Trans Costs

	Probit	Elasticity MRM
SMRM	-2.1834***	-10.5904*
	(0.08)	(0.50)
SMMur	-1.6609***	
	(0.06)	
SML	-2.1840***	
	(0.12)	
SMM	-1.4749***	
	(0.05)	
MMRM	-2.6571***	-12.8878*
	(0.20)	(1.05)
MMMurr	-2.5618***	
	(0.14)	
MML	-2.6758***	
	(0.35)	
MMM	-2.4850***	
	(0.12)	
RMRM	-2.5446***	-12.3424*
	(0.05)	(0.48)
RMMurr	-2.1763***	
	(0.05)	
RML	-2.6017***	
	(0.11)	
RMM	-2.0575***	
	(0.04)	
t_soy	0.0195***	0.0944**
	(0.00)	(0.02)
t_rice	0.0469***	0.2274**
	(0.00)	(0.02)
t_maize	0.0417***	0.2023**
	(0.01)	(0.06)
Output_soy	0.0208***	7.2052**
	(0.00)	(0.49)
Output_rice	0.0165***	4.0816**
	(0.00)	(0.26)
Output_maize	0.0068*	2.6959*
	(0.00)	(1.36)
Decision_soy	0.1317***	6.3164**
	(0.01)	(0.39)
Decision_rice	0.2166***	5.1028**
	(0.01)	(0.25)
Decision_maize	0.3433***	8.6870**
	(0.03)	(0.80))

	Probit	Elasticity – MRM	Elasticity – MMUR	Elasticity – ML	Elasticity – MM
Min_Pprice	0.0219***	2.6500***	2.8956***	3.6048***	3.7100***
	(0.00)	(0.16)	(0.14)	(0.27)	(0.19)
Reserve_Pprice	-0.0019***	-0.0469***	-0.0638***	-0.0683***	-0.0812***
	(0.00)	(0.01)	(0.01)	(0.02)	(0.02)
Transcost=$1psq	-1.0094***	-4.8958***	-5.3495***	-6.6597***	-6.8540***
	(0.02)	(0.18)	(0.13)	(0.38)	(0.14)
Transcost=$2psq	-0.7484***	-3.6300***	-3.9664***	-4.9379***	-5.0819***
	(0.01)	(0.13)	(0.09)	(0.28)	(0.10)
Transcost=$3psq	-0.6016***	-2.9180***	-3.1885***	-3.9693***	-4.0851***
	(0.01)	(0.11)	(0.07)	(0.23)	(0.08)
Transcost=$4psq	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	(0.01)	(0.09)	(0.06)	(0.19)	(0.07)
Transcost=$5psq	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	(0.01)	(0.08)	(0.06)	(0.17)	(0.07)
Transcost=$6psq	-0.3893***	-1.8880***	-2.0630***	-2.5682***	-2.6422***
	[illegible]	[illegible]	[illegible]	[illegible]	(0.06)
Transcost=$7psq	-0.3436***	-1.6665***	-1.8210***	-2.2669***	-2.3331***
	[illegible]	[illegible]	[illegible]	[illegible]	(0.05)
Transcost=$8psq	-0.3242***	-1.5727***	-1.7184***	-2.1393***	-2.2017***
	(0.01)	(0.06)	(0.05)	(0.13)	(0.05)
Transcost=$9psq	-0.2969***	-1.4402***	-1.5737***	-1.9591***	-2.0163***
	(0.01)	(0.06)	(0.05)	(0.12)	(0.05)
Transcost=$10psq	-0.2819***	-1.3673***	-1.4940***	-1.8599***	-1.9141***
	(0.01)	(0.06)	(0.04)	(0.11)	(0.05)
i	2209				
t	11				
χ^2_{32}	65190.42***				
y		1.645e-06	1.551e-07	5.610e-11	1.505e-11

The first unit of transaction cost has the largest marginal effect, which per unit, decreases over the overall amount of transaction costs applied to the model.

Network Trading Model

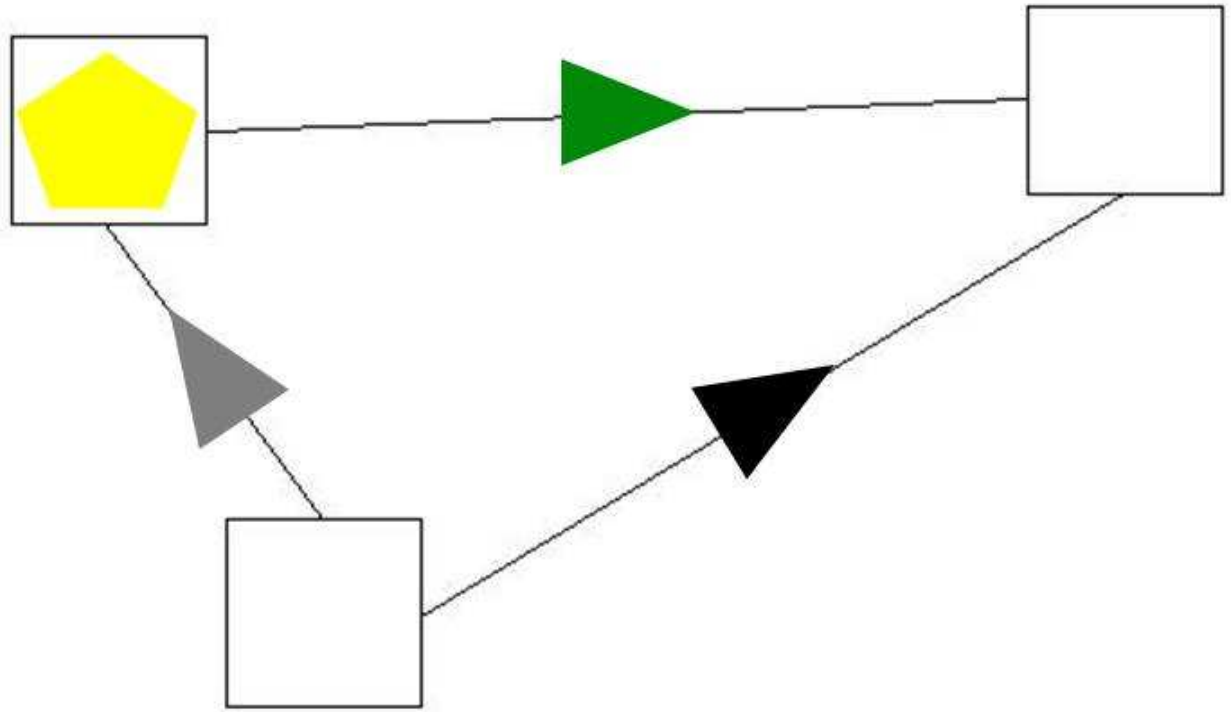


-Aims to improve trading conditions via an intermediary to help reduce transaction costs.

-Allows pollutants and additional environmental concerns to be addressed via govt involvement via the monitoring of a tax system based on regional trends.
(Idea of monitoring at the level at which issues can be observed)

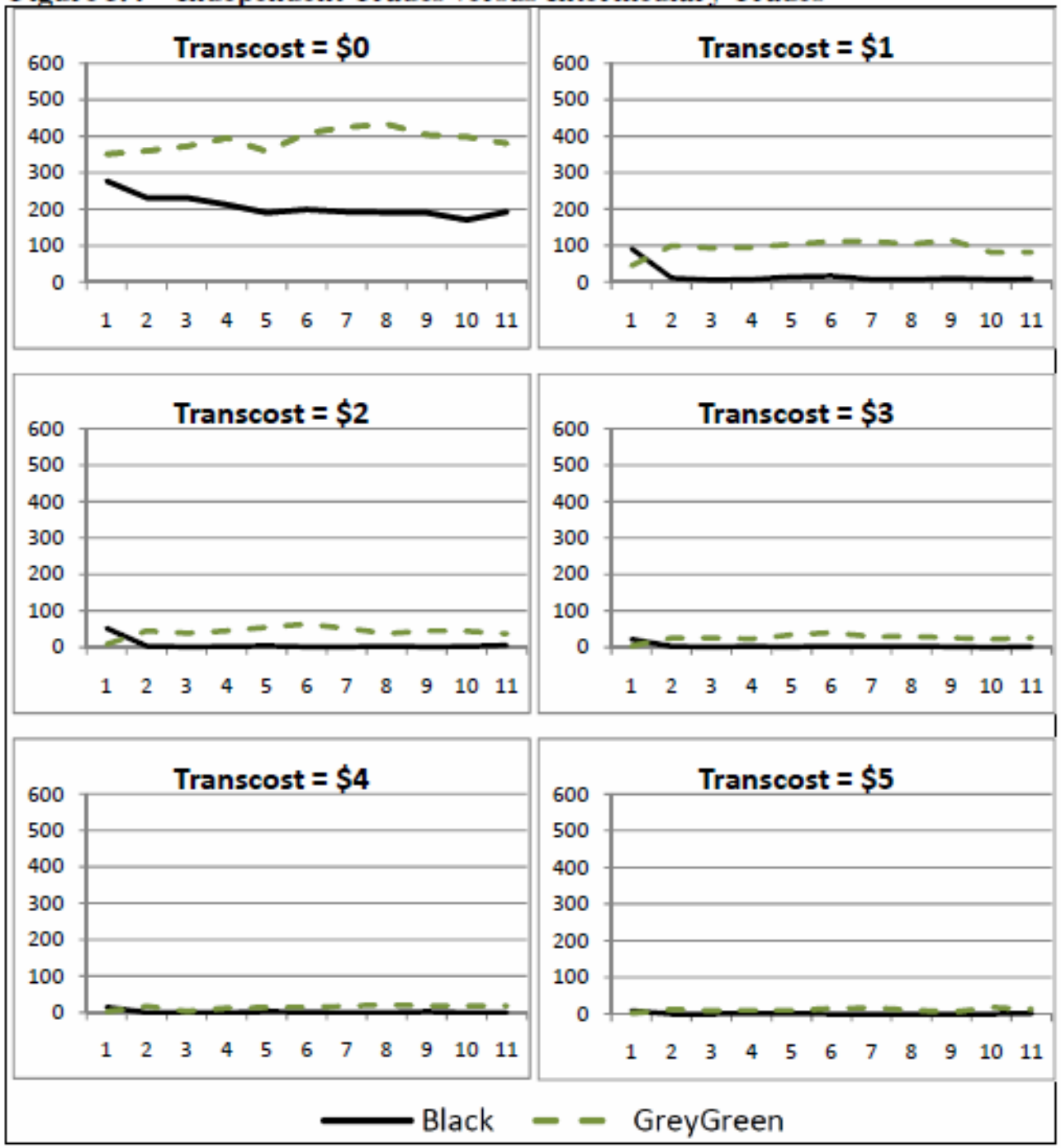
- Also aims to impose peer monitoring within the trading regions due to tax.

Intermediary/Representative Agent



1. **Independent trade with full transaction costs and taxes applied,**
2. **Trade through representative agent – firstly between agents in the same region,**
3. **Representative agent facilitates trade between regions, hence transaction costs are reduced and a fee applies (rather than a tax).**

Figure 5.4 – Independent Trades versus Intermediary Trades



Planned Extensions/Further Work

- Further Work:
  - Review of network trading in the transcost=1 case,
  - Transaction cost levels below $1 per patch,
  - Scenarios unearthing the costs and benefits of imposing the tax implied by the network trading framework,
  - Refinement of regressions and the number of replications
- Extension:
  - Impacts of pessimism and frustration,
  - Differing levels of intelligence,
  - Within trading (based on connected firms),
  - Construction of a computerised representative agent