What Computable general equilibrium tells us: some environmental examples

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Beijing

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Topics

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1. Defining features of a CGE model
2. Some CGE stories
3. Agricultural subsidies in India
4. Saving a river basin in Australia
5. Concluding remarks

CGE modelling

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What makes a CGE model: defining features

- **Computable: real world data**
- **General: explicit agents with optimizing behaviour**
- **Equilibrium: price determination through the interaction of demand and supply for commodities and factors (introduces resource constraints)**

What has CGE modelling told us?

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(1) That indirect effects and magnitudes matter:

(a) Tariffs help protected industries but hurt export-oriented industries

(b) *BuyAmerica* helps U.S. steel but harms almost every other industry

(c) A guest worker program for agricultural workers in the U.S. may reduce farm income by providing a cheap substitute for farmer labour

(d) Low-skilled immigration in the U.S. may help U.S. incumbents by pushing them up the occupational ladder

(e) Cutting taxes on company income in Australia may hurt domestically-owned firms by increasing pre-tax wage rates

(f) Large scale adoption of renewable fuels in Australia would increase the cost of electricity by 50%. This is a 1.5% GDP loss phased in over 20 years

(g) Electricity & fertiliser subsidies for Indian farmers reduce farm income by cutting costs of non-farm inputs which compete with farmer labour

(h) High prices for irrigation water could stimulate employment in Australia's Southern Murray Darling Basin

Agricultural subsidies in India

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Costly from the point of view of environment and budget

But do they achieve their objectives of boosting the incomes of poor farmers and improving food security?

Enhancing a CGE model for a particular application: recognizing competition between crops for agricultural land in India

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- **Different ways of producing the same crop**
  - **differing in fertilizer &electricity intensity, and regional land use**
    - **4 ways of producing Sugarcane**
      - ***SC1 in Tamil Nadu: Fertilizer intensive***
      - ***SC2 in Maharashtra, Karnataka & Andhra Pradesh: Fertilizer intensive***
      - ***SC3 in Punjab, Haryana, Gujarat & Uttarakhand: Fertilizer light***
      - ***SC4 in Uttar Pradesh and others: Fertilizer light***
    - **4 ways of producing Cotton**
      - ***Cot1 in Punjab, Haryana: Fertilizer light***
      - ***Cot2 in Gujarat & Andhra Pradesh***
      - ***Cot3 in Rajasthan, Maharashtra & Karnataka***
      - ***Cot4 in Madhya Pradesh: Fertilizer heavy***
    - **3 ways of producing Paddy**
    - **4 ways of producing Wheat**
    - **4 ways of producing Coarse cereal**
    - **4 ways of producing Oil seeds**
- **23 different types of land defined by region**

Value of agricultural subsidies in India

Fertilizer subsidies:	0.43% of GDP
Electricity subsidies:	0.55% of GDP
Production & sales subsidies:	1.74% of GDP
All agric. subsidies:	2.73% of GDP

Percentage effects on outputs of removing agricultural subsidies in India : CGE results explained by subsidy rates

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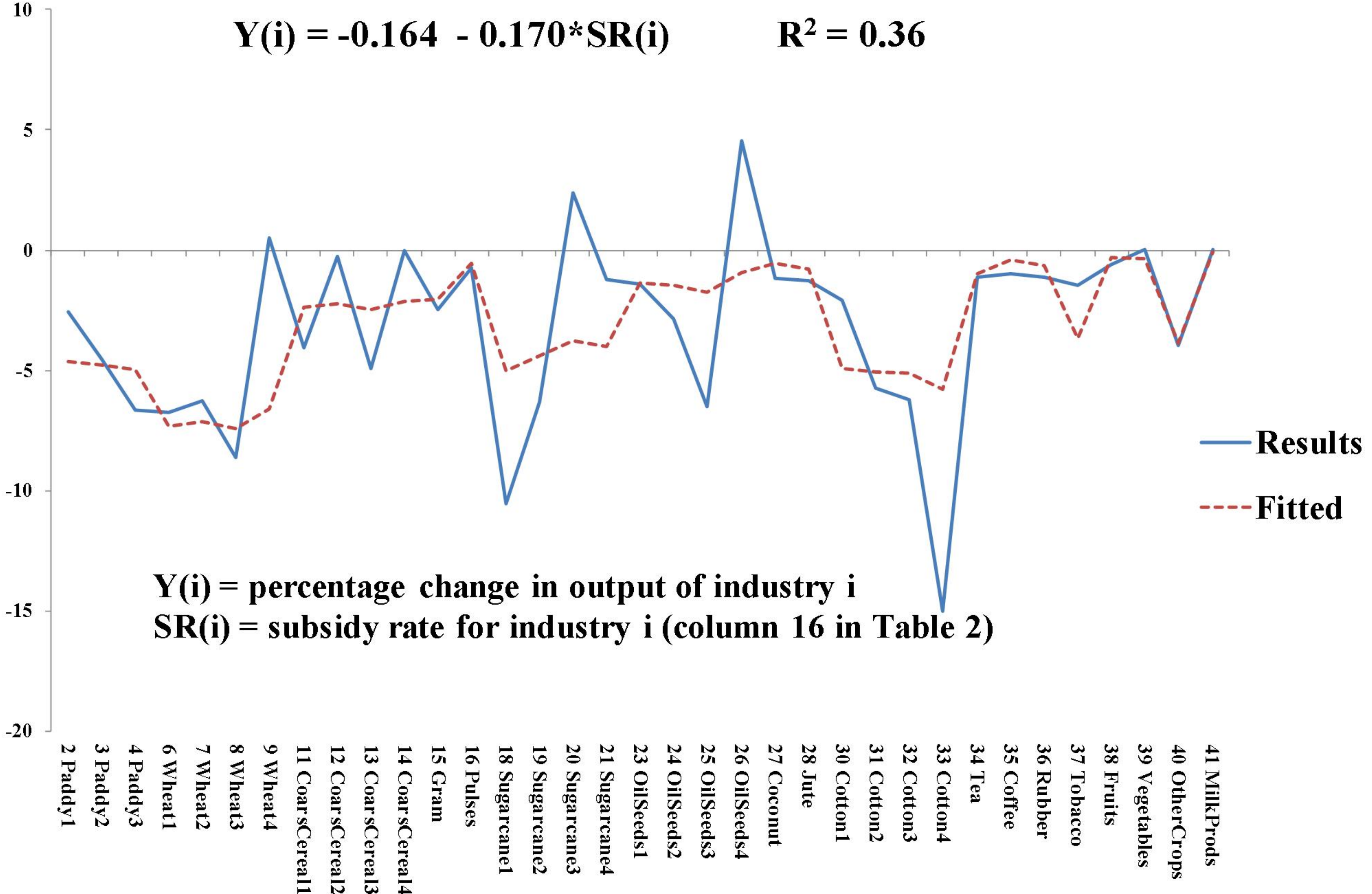

CGE results explained by subsidy rates & relative rates

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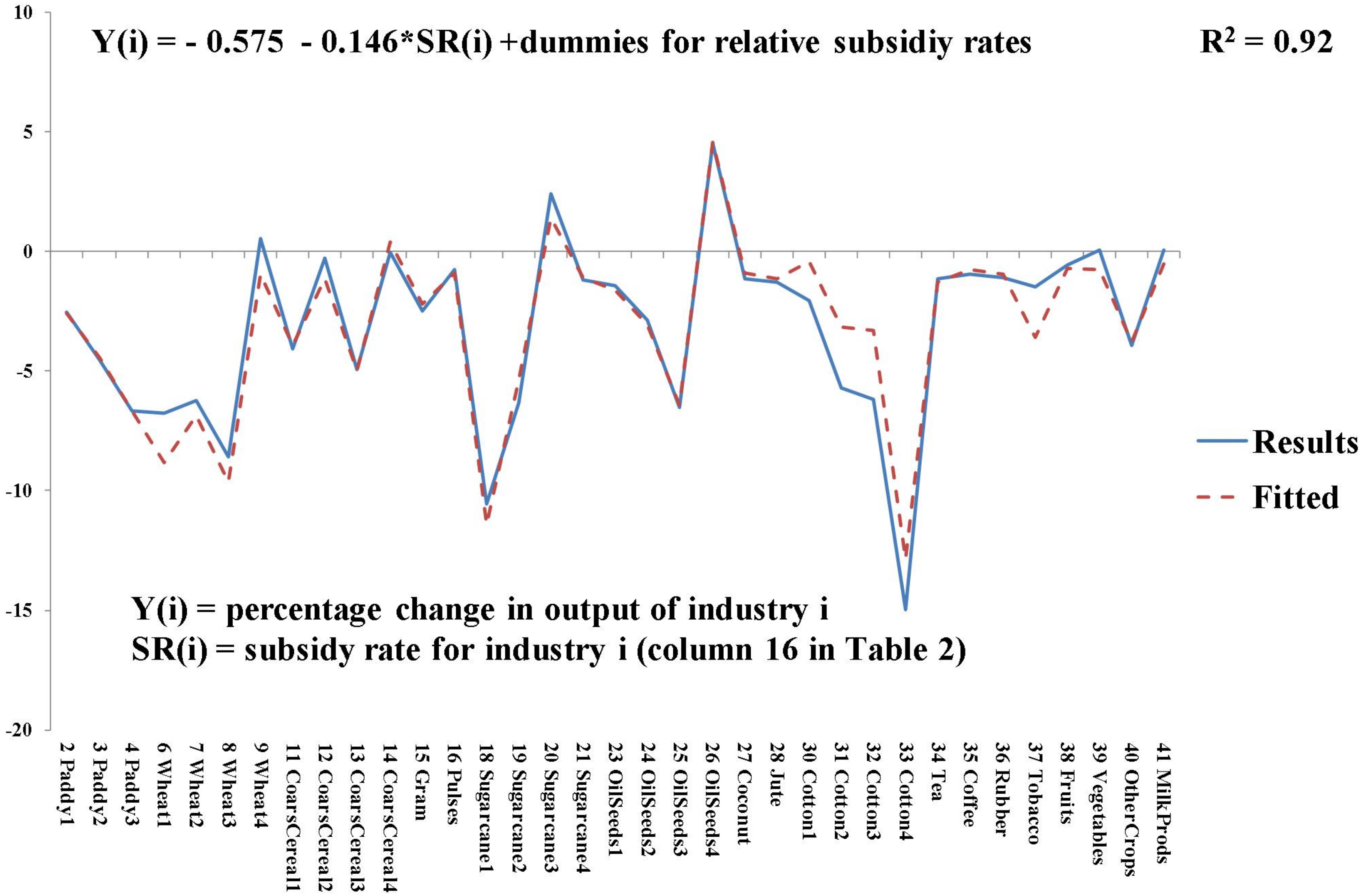

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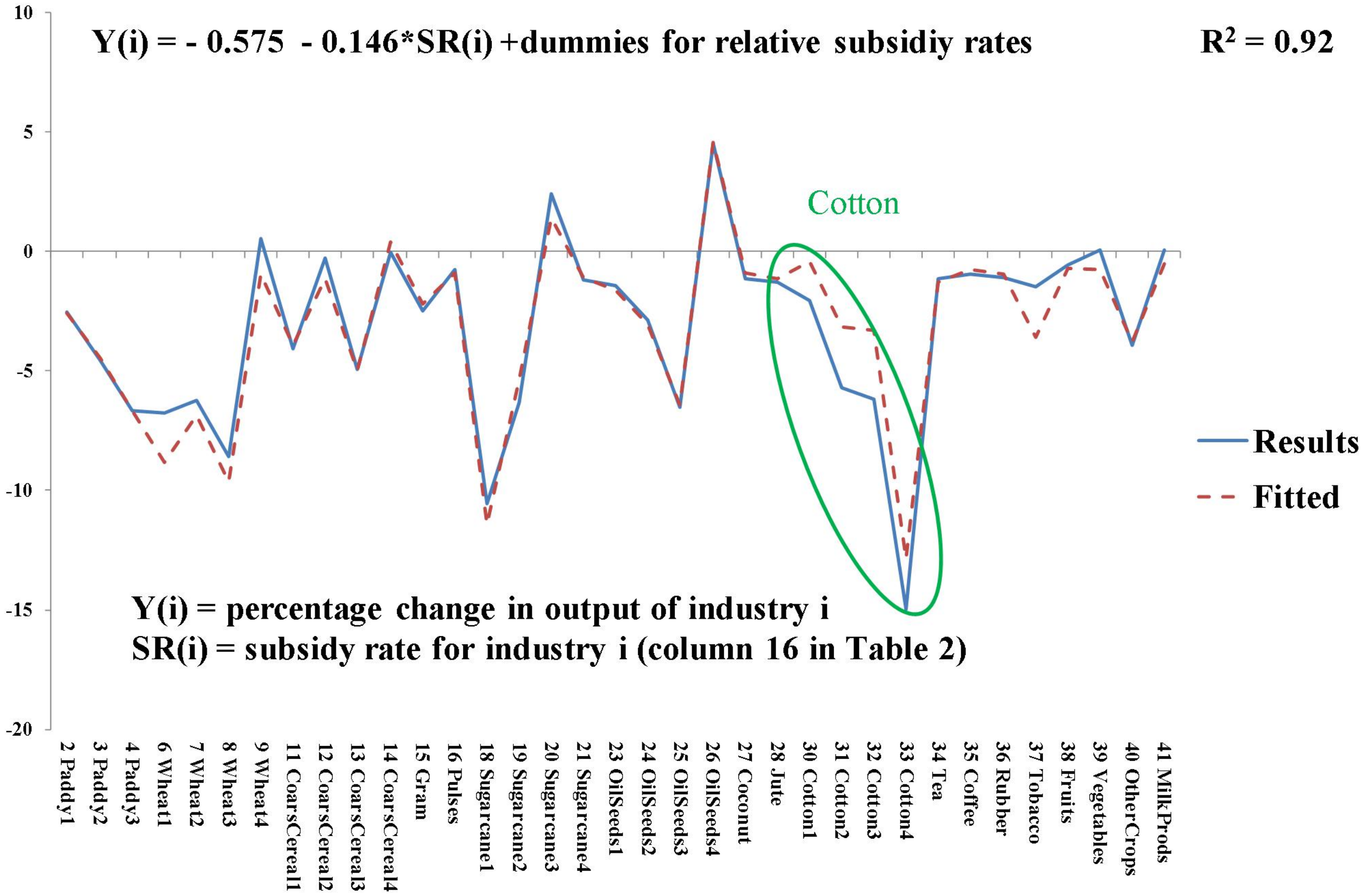

CGE results explained by subsidy rates & relative rates & exposure to price-sensitive exports

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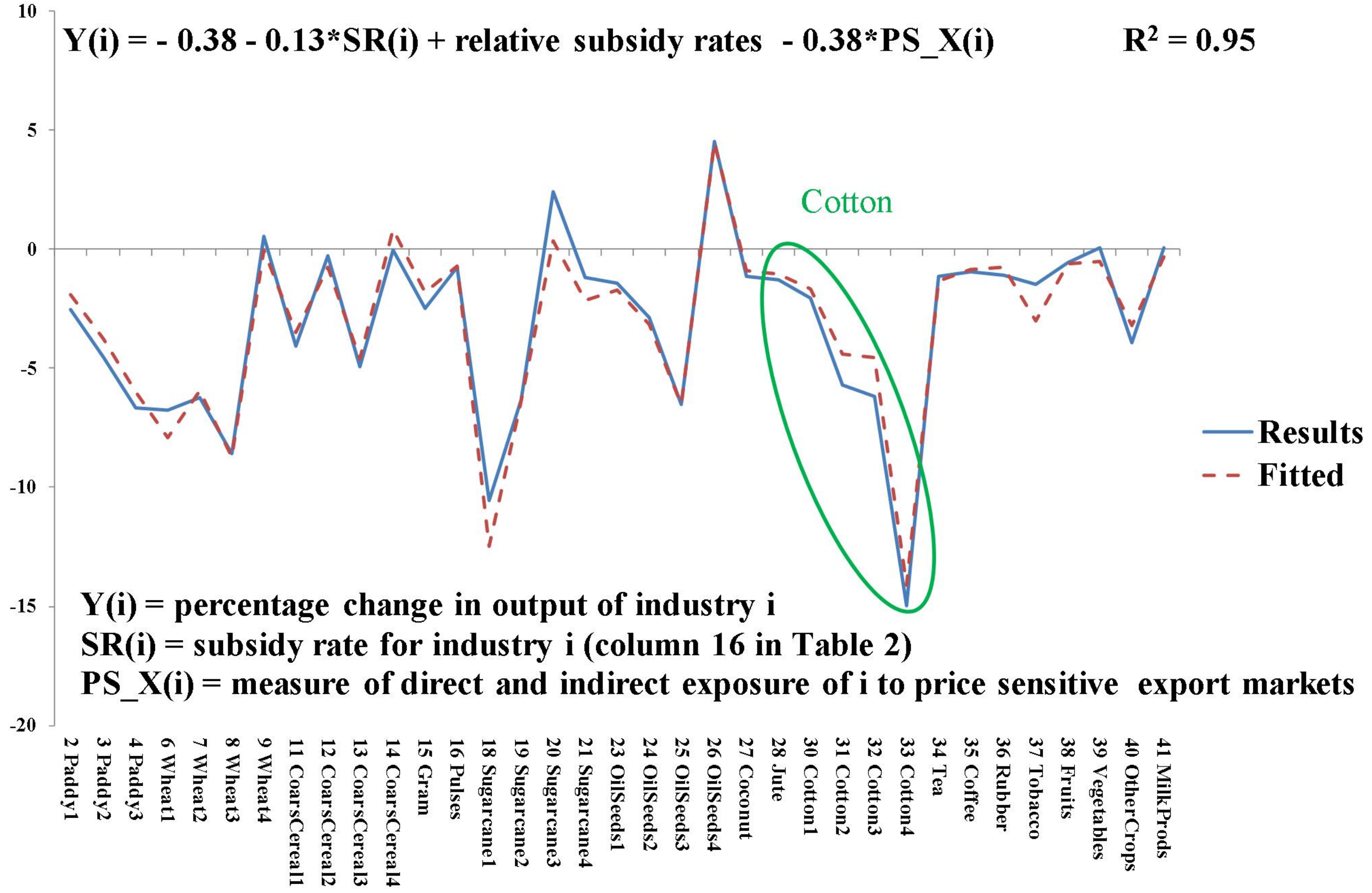

Effects on GDP of removing agricultural subsidies on: Fertilizer, Electricity, Production & sales (%)

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	Fertilizer	Electricity	Production & Sales	All agricultural subsidies
Real GDP	0.060	0.089	0.048	0.204

Removing the subsidy on Fertilizer inputs to Agriculture: calculating the GDP or welfare triangle

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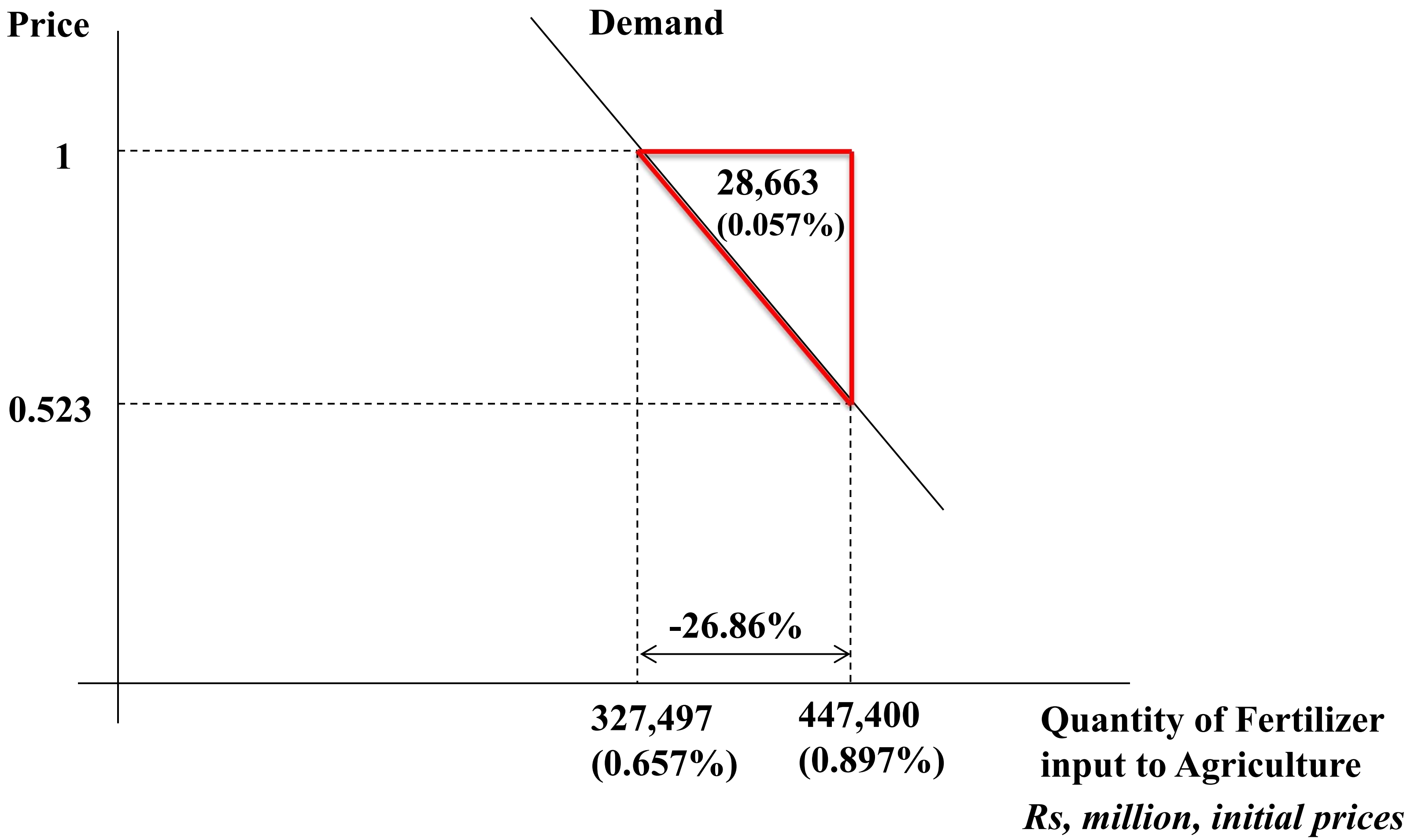
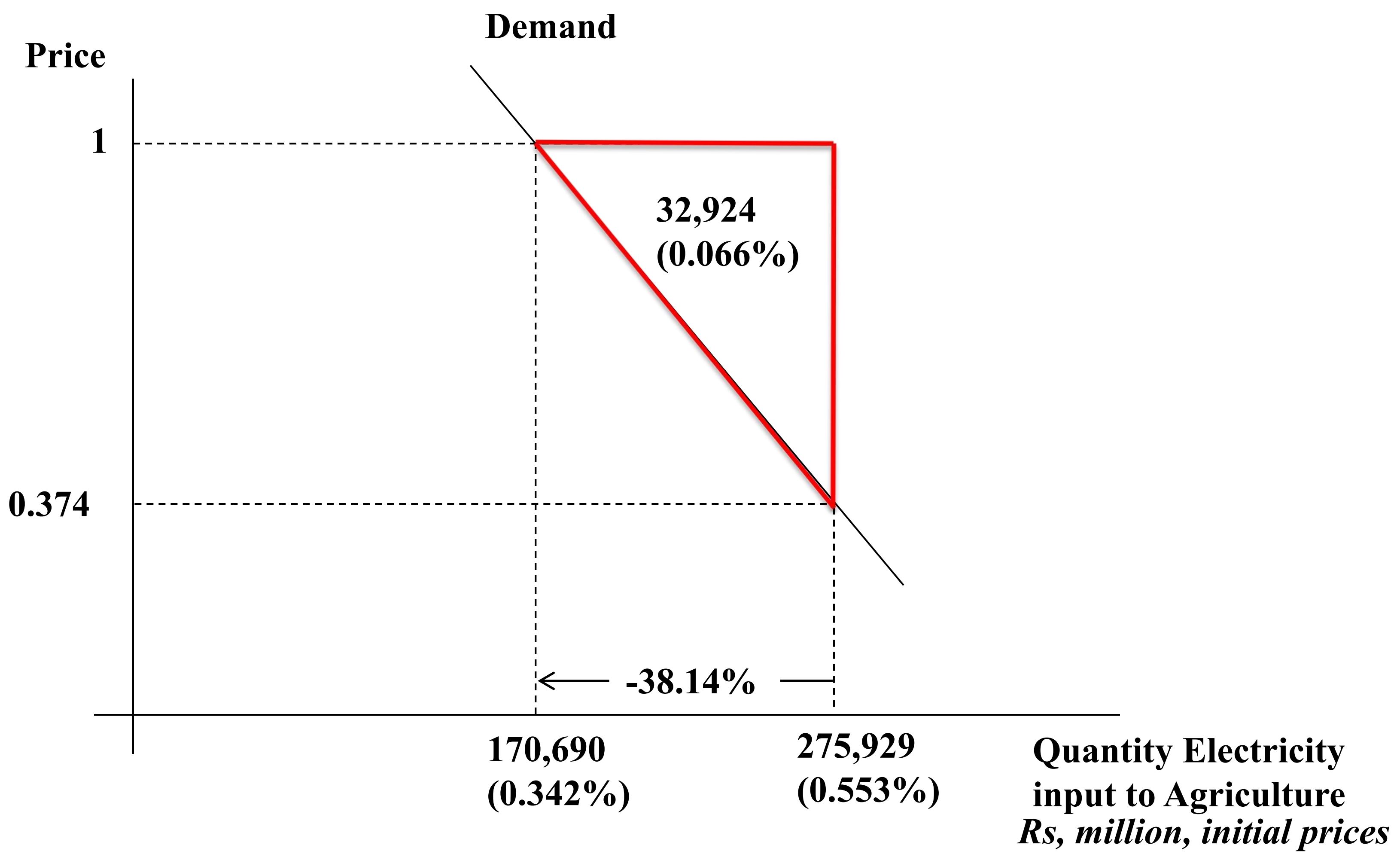


Removing the subsidy on Electricity inputs to Agriculture: calculating the GDP or welfare triangle

CoPS



Removing subsidy on production and sales of agricultural commodities: calculating the GDP or welfare triangle

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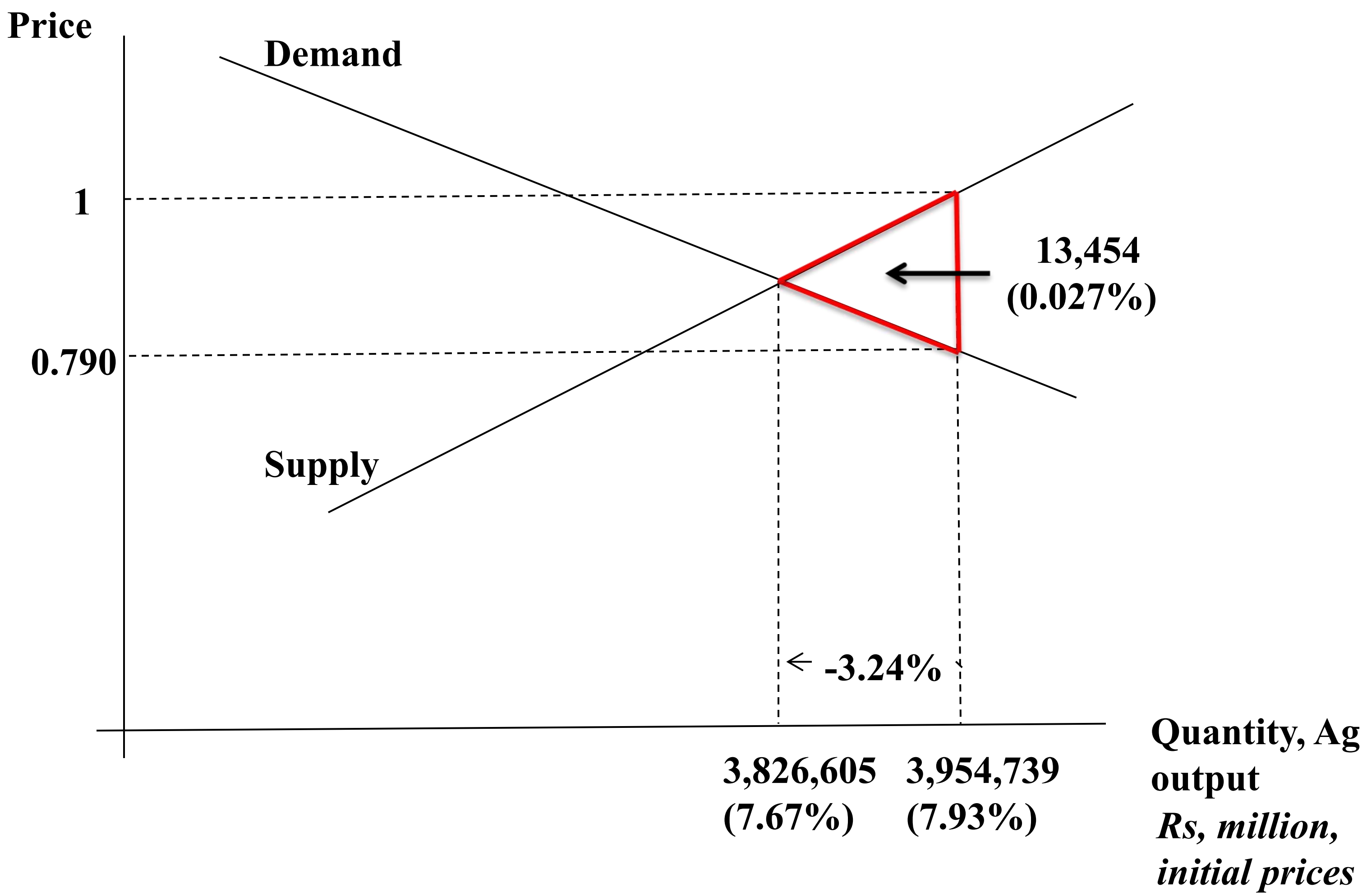

Percentage effects on real farm income of removing agricultural subsides

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Components of real farm income	Fertilizer	Electricity	Production and sales	All agricultural subsidies
Capital	-0.042	-0.018	-3.495	-3.572
Labour	0.027	0.080	-3.545	-3.453
Land	2.277	1.900	-6.780	-2.610
Total real farm income	1.041	0.893	-5.011	-3.089

Percentage effects on real prices and consumption of food products from removing agricultural subsidies

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Fertilizer		Electricity		Production and sales		All agricultural subsidies	
Price	***Quantity***	***Price***	***Quantity***	***Price***	***Quantity***	***Price***	***Quantity***
1.25	-0.17	0.98	-0.11	4.90	-0.47	7.15	-0.74

Answers to questions about Indian agricultural subsidies

Yes. They do improve food security by increasing output and reducing prices to consumers

Yes. The Production and Sales subsidies do increase farm income. But the Fertiliser and Electricity subsidies reduce farm income. They should be removed.

Saving the Southern Murray Darling basin

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Prolonged drought and heavy agricultural use of water from the Murray and Darling rivers threatened major environmental damage

The Australian government implemented a Buyback scheme to increase rivers flows

Would this scheme cause major *economic* damage in the Basin?

> ***"Buying up … water entitlements to revitalize the ailing Murray-Darling river system will lead to a national tragedy in which rural towns are slowly strangled to death"***
>
> **Warren Truss, leader of the National Party, 11 June, 2009**

Bottom-up regional modelling: the water buyback scheme

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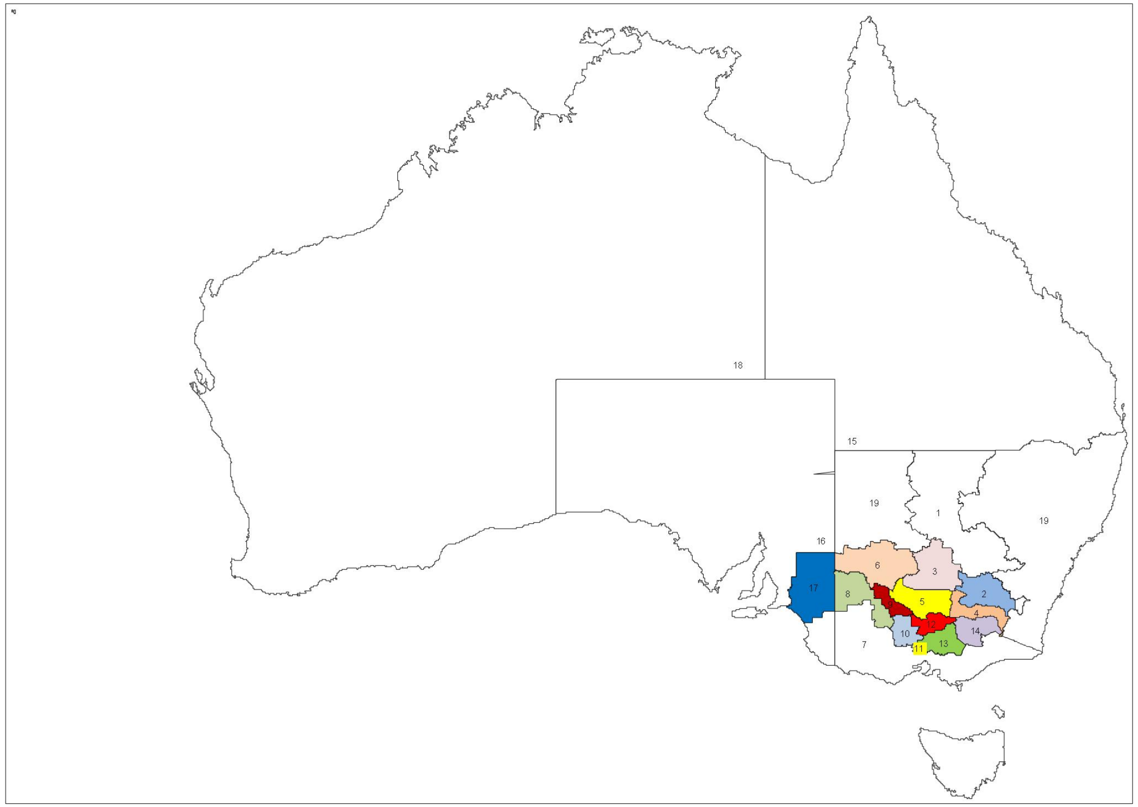
The Australian government proposed to buy water rights from farmers in the Southern Murray-Darling Basin (SMDB)

Requires bottom-up modelling because policy affects costs in SMDB relative to the rest of Australia



Water buyback analyzed via TERM-H2O

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TERM -- The Enormous Regional Model
Developers -- Mark Horridge & Glyn Wittwer at CoPS
Features -- Enormous regional database (200 industries x 150 regions)
and aggregation programs

TERM-H2O
Dynamic
19 regions: 13 in the SMDB, 6 in the rest of Australia
35 industries: 17 farm industries
10 farm commodities : e.g. Rice, Fruit, Dairy cattle, etc
2 industries for 7 of the farm commodities, e.g. Fruit irrig & Fruit dry
Water accounts: water per unit of land in each irrigated industry

Water buyback scheme

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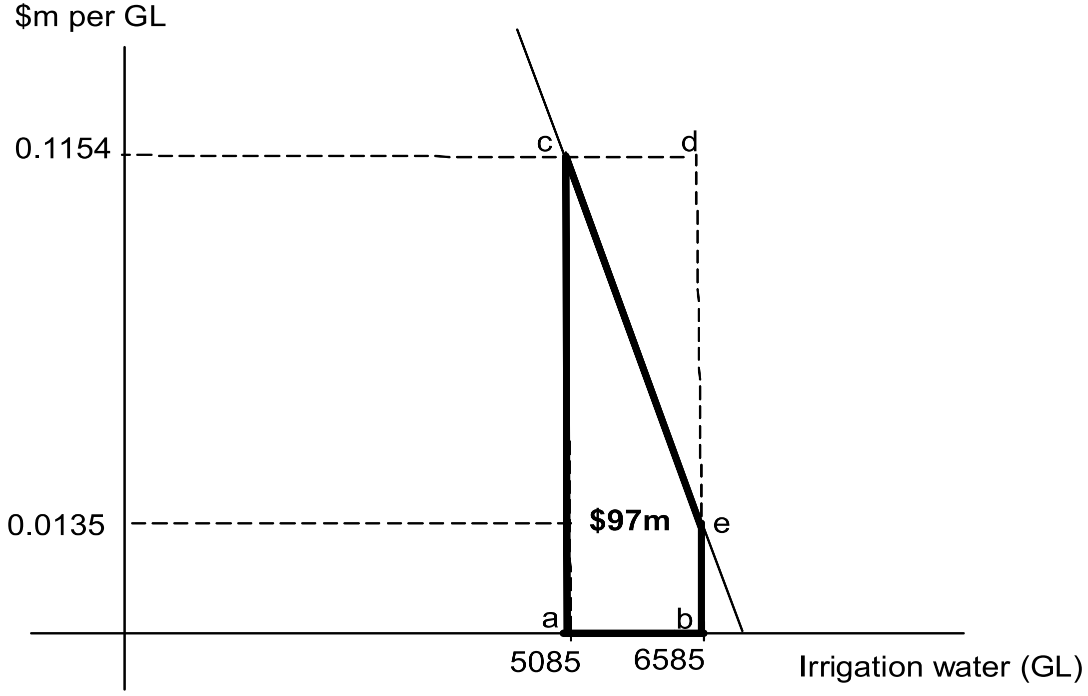
The buyback scheme to be phased in from 2009 to 2016
Long-run cut in water supply to irrigated farms in SMDB of 22.8 %.

$97m = 1.1% of baseline value of SMDB farm value added

$97m = 0.0052% of Australian GDP

Demand for irrigation water in SMDB in 2018



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Long-run % effects of water buyback on farm outputs in Southern Murray-Darling basin

Industry / Region	R2	R3	R4	R5	R6	R8	R9	R10	R11	R12	R13	R14	R17	SMDB totals
1 Cereal Dry	5	14	4	34	5	6	7	4	4	7	5	5	6	6
2 Cereal Irig	-40	-27	-42	-3	-36	-37	-37	-41	-42	-37	-40	-40	-43	-21
3 Rice	-40	-26		3		-30	-30			-30	-34	-33		-21
4 DairyCat Dry	15	22	15	32	14	14	15	13	13	17	14	14	16	17
5 DairyCat Irig	-16	-7	-17	11	-13	-11	-11	-13	-14	-10	-13	-13	-13	-10
8 Cotton Dry		20			14									20
9 Cotton Irig		-12			-13									-13
10 Grapes	-6	2	-7	16	-3	-5	-5	-8	-8	-9	-10	-7	-6	-4
11 Vegetables	2	18	0	58	7	4	5	1	1	5	2	2	1	5
12 Fruit Dry	6	15	5	28	6	6	8	5	5	9	6	7	6	8
13 Fruit Irig	-3	5	-4	21	0	-2	-1	-3	-3	-1	-3	-3	-3	-1
18 Regional totals	-1.6	-2.4	-1.5	-2.1	-0.6	-1.1	-1.4	-1.6	-1.3	-1.9	-1.7	-1.8	-1.1	-1.3
19 Irrig share in farm income	0.25	0.69	0.23	0.97	0.74	0.48	0.58	0.32	0.42	0.64	0.38	0.48	0.66	0.54

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Irrigation industries contract, dry-land industries expand
But what about vegetables?

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		√		√		√	√			√				

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	X	√	X	√	X	√	√	X	X	√	X	X	X	

Regional results are not explained by dependence on irrigation

Mysteries and answers

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Why does Buyback (and consequent increase in the price of irrigation water) stimulate production of vegetables?

Answer:

When water prices are high, growing Vegetables is a better use of irrigable land and water than growing other crops such as Rice

High water prices reduce the value of irrigable land. Consequently crops that use relatively little water per unit of irrigable land gain a competitive advantage

Why does Buyback have a relatively minor effect on farm output in an irrigation-intensive region such as R6 (0.6% contraction , 74% dependence)?

Answer:

Because Grapes and Fruit irrig are major irrigation industries in R6 and these are not as badly effected by Buyback as Rice and other irrigation crops which are barely represented in R6

Little opportunity to move irrigable land to dry-land use in R6

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Long-run % effects of water buyback on regional farm outputs and consumption in SMDB

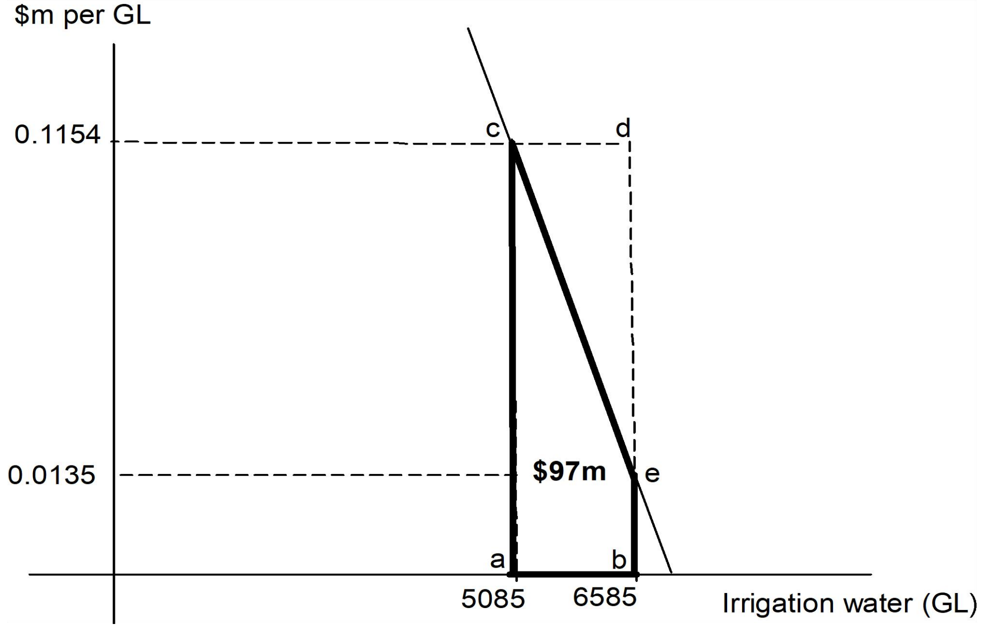
Region	R2	R3	R4	R5	R6	R8	R9	R10	R11	R12	R13	R14	R17	SMDB totals
Regional farm outputs	-1.6	-2.4	-1.5	-2.1	-0.6	-1.1	-1.4	-1.6	-1.3	-1.9	-1.7	-1.8	-1.1	-1.3
Regional consumption	0.09	2.11	-0.07	2.80	0.36	0.61	0.58	-0.02	-0.06	0.48	0.08	0.00	0.39	0.34

Regions gain $173m from water payments, area acdb

and lose $97m of productive input, area aceb

Net gain to SMDB = $76m

Demand for irrigation water in SMDB in 2018



Concluding remarks

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CGE has become a powerful technique for analysing issues in trade, public finance, major projects, micro reform and many other areas.

It has been particularly effective in environmental analysis, often highlighting unexpected indirect effects as well as giving realistic back-of-the-envelope estimates of the costs of meeting environmental challenges