IRADe - Stanford Collaboration

Energy and Agriculture

Kirit S. Parikh

Chairman, Integrated Research and Action for Development (IRADe)

and

Prof. Emeritus, Indira Gandhi Institute of Development Research (IGIDR)

Indian Agriculture

- Major Transformation occurring
  - Policy Reforms – Subsidy/Pricing
  - WTO
  - Bio-technology
  - Diversification
  - Processing Industries
- Attain the transformation under constraints of Political Economy
  - Minimize Pain
  - Maximize Gain
- Impact will vary across regions/classes
- A detailed understanding is needed of the impacts and how they are distributed

Some Questions to be Answered

- What should be the strategy of liberalization?
  - Phasing
  - Balance across commodities
- Level of subsidies?
  - Needed
  - Optimal levels
- What would be the welfare impact?
  - On different groups
  - Different regions
- How to protect the vulnerable sections?
  - In what ways
  - Self targeting and self liquidating options

Needed - Analytical Tools

- Empirical regionally disaggregated General Equilibrium (GE) Model
- We need to understand
  - Supply Behavior
  - Demand Behavior
  - And their interactions across regions
- Our project with Stanford is a promising first step

Energy Policy Reforms and Agriculture

- Electricity and energy price reforms
  - Cost of Water
  - Cost of Fertilizer

Reforms are INESCAPABLE

Will have profound impact on agriculture

- production of crops
- prices of crops
- incomes of farmers
- consumption of agricultural & non-agricultural goods
- welfare of consumers

General Equilibrium

- **NO FREE LUNCH**
- Physical flows balance for goods and services
  - Wheat, rice, electricity, etc.
- Financial flows balance for **all** agents
- Each agent behaves in a rational manner – optimizes whatever she wants within her resource constraints
- These conditions are like laws of conservation and self evident.
- Enough to find an equilibrium solution.

Why General Equilibrium?

- **Who should do what?**
- **Can we analyze a set of policies simultaneously?**

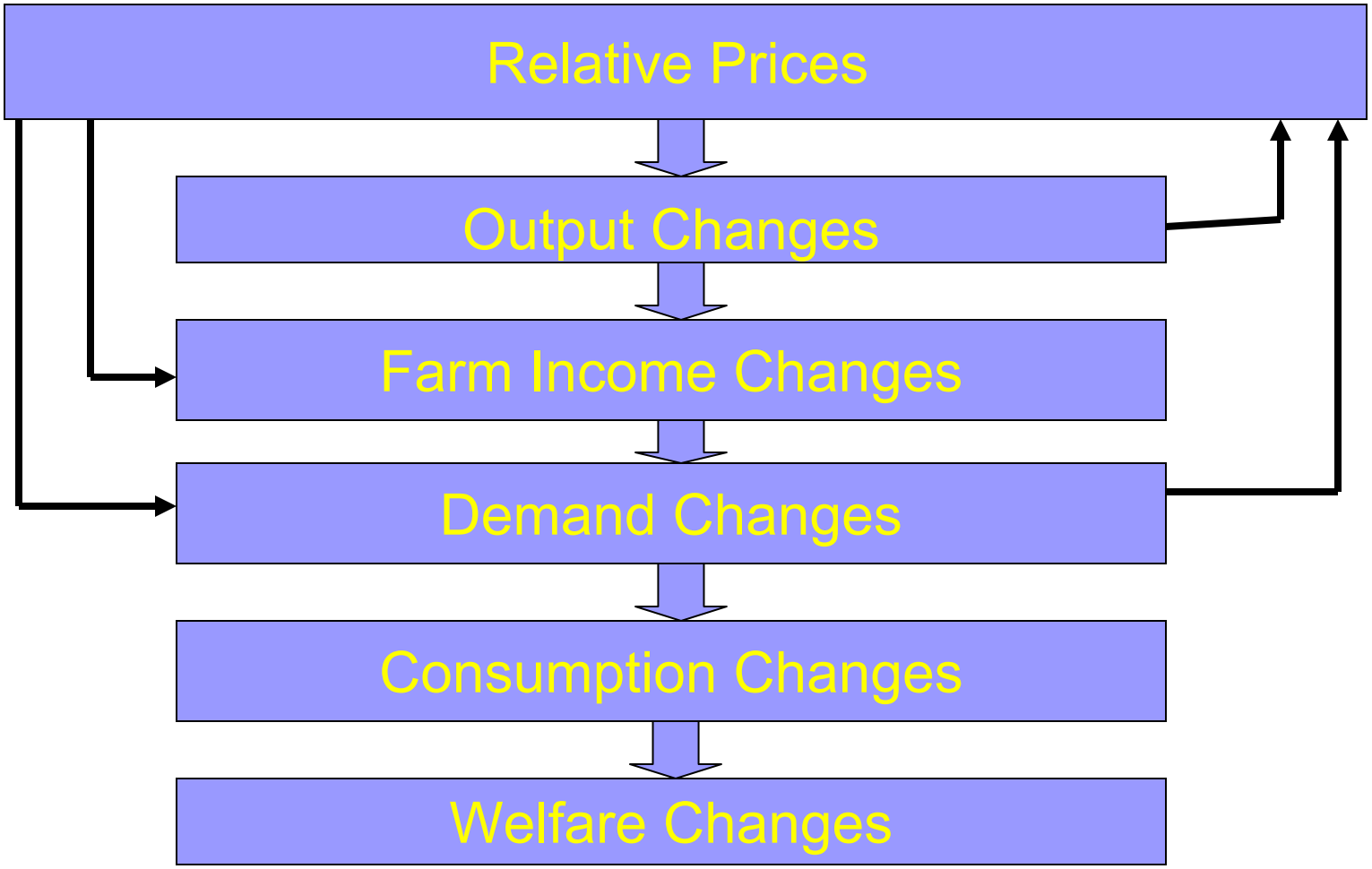
  e.g. price change anti-poverty programme such as PDS, Food for Work, Trade policy, Tax policy, Investment policy, etc.

- Behavioral responses are important
  - How would farmers adapt and respond to changing prices?
  - How would consumers change consumption pattern?
- Accounts for feedback

Why GE? Feedbacks are important

- **Feedbacks are important**
- Price of water and fertilizer changes
  - Output changes
    - Farm incomes change
      - Demand changes
        - Consumption changes
        - Welfare changes

Why GE? Feedbacks are important



Consistency In Many Ways

1. Quantities produced, demanded and traded balance at the national level
2. Expenditures, savings and incomes balance for each consumer
3. Prices for producers, consumers and govt. taxes are consistent
4. Income earned is consistent with income generated by production and trade
5. Consumer demand and production levels are consistent with the prices
6. Government expenditure and inflow balance
7. Exports, imports and foreign exchange flows balance

Ensures NO FREE LUNCH – No Unaccounted Sinks or Sources

Issues Addressed in this Project

- Special advantage of a GE approach is Policy Analysis
- Issues addressed
  - What is the impact on welfare of different groups of people due to energy price reforms?
  - Should power for agriculture be subsidized? If so, at what level?
  - What are the most relevant scenarios of price changes and other associated policy measures?
  - How should different subsidies be phased out?

Some Possible Scenarios

- Subsidy continues – reference
- Irrigation charges increased by 10%, 50%, 100%
  - With no special programme
  - With Food for Work with money saved
  - Additional agricultural investment with money saved
- Ground water depletion/weather shock
  - Increase cost of tube well irrigation
  - Increased electricity consumption without any change in output

Research Challenges

- Modeling Farmers' Response
  - Data for Electricity consumption by agriculture needs careful handling
  - Explore alternative sources and approaches
- Data Sources
  - District-wise information – time series
    - Area, production, prices, irrigated area, HYV area, labour, bullock, tractors, fertilizers- some crop-wise other district levels
  - Irrigation by sources
    - District level, tank, canal, tube wells, other wells & other sources
  - Commission on Agricultural Cost and Prices (CACP) estimates of cost of irrigation by crops & states for various years

Alternative Approaches

- Change in total value of crops produced due to energy price change
- Simultaneous estimation of yields of different crops
- A programming approach based on CACP data

Model for Total Value of Output

- ICRISAT data: 28 years, 271 districts, 13 major states
- Bullock, Tractor and Labor have been extrapolated
- **Dependent variable** – Total value of output (15 crops - cereals, pulses and oilseeds)
- **Independent variables** – Labor, Fertilizer, Bullock, Tractor, Irrigation by sources (canals, tanks, tube well, other well, other sources) [all have been normalized by NCA before taking log]; LGP (dist. dummy), two climatic variables: June and July/August rainfall normalized by PET

Model Results: All India

Variables	Coef.	Std. Err.	t – values	p-values
Labor	-0.06292	0.038347	-1.64	0.1010
Fertilizer	0.278159	0.0129	21.56	0.0000
Bullock	0.183677	0.026196	7.01	0.0000
Tractor	-0.05731	0.011309	-5.07	0.0000
Canal Irr.	0.660981	0.035228	18.76	0.0000
Tank Irr.	1.848024	0.162531	11.37	0.0000
Tube well Irr.	2.030031	0.091394	22.21	0.0000
Other well Irr.	1.276292	0.142017	8.99	0.0000
Other Sources Irr.	1.336205	0.35741	3.74	0.0000
LGP	0.377596	0.061572	6.13	0.0000
JuneRain/PET	-0.11657	0.208932	-0.56	0.5770
July-AugRain/PET	-0.14441	0.088088	-1.64	0.1010
_cons	1.096085	0.39456	2.78	0.0050
R^2 = 0.433, Adj. R^2 = 0.432, No. of Obs. = 4962				

Simultaneous estimation of crop yields

- System of Equations (Translog Specification)

$$y_c = \alpha_c + \sum_{i=1}^{n} \beta_{ic} x_{ic} + \frac{1}{2} \sum_{i=1}^{n} \beta_{iic} x_{ic}^2 + \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ijc} x_{ic} x_{jc}$$

  - **Dependent variables** are the yields of Wheat, Rice, Maize, Bajra and Jowar in log terms
  - Independent Variables are Area under crop *c,* HYV plantation area under crop *c,* Irrigation, Labor, Bullocks, Tractors and Fertilizers (the common independent variables have been normalized by GCA before taking logs)
  - District Dummy and Time Dummy
  - 271 districts (13 major states), 1957-1988 (Sanghi, Kavi Kumar and McKinley)

Simultaneous estimation of crop yields (Cont'd…)

- Marginal Effects (MEs)

$$\frac{\partial y_c}{\partial x_{ic}} = \beta_{ic} + \beta_{iic} x_{ic} + \sum_{j=1}^{n} \gamma_{ijc} x_{jc}$$

  - Also known as partial elasticities
  - Mean level has been used for inputs

Partial Elasticities of Yields

Variable	Wheat	Rice	Maize	Jowar	Bajra
Area	-0.02	-0.002	1E-05	-0.001	0.002
HYV	0.079	0.929	-0.021	0.129	0.834
Irr. prop	3.005	0.077	0.784	-0.524	-0.283
Labor	-1.237	0.202	-0.67	1.122	0.182
Fertilizer	1.619	0.243	0.017	0.001	-0.079
Bullock	-0.269	-0.361	-0.575	-0.223	0.097
Tractors	0.001	0.007	0.088	0.225	-0.07

Partial Elasticities of Yields (Cont'd….)

- Irrigation has negative impact on Bajra and Jowar
- Almost all the signs are consistent with our expectations

Stochastic Frontier Approach

- A frontier is estimated: all firms operating on frontiers are technically efficient
- Helps to model inefficiency explicitly, measured by the position of a particular firm away from the frontier
- Can accommodate multiple inputs and outputs

Programming Approach

- Maximize net profit, given the prices and costs of inputs and outputs
- Calibration to reproduce the past behavior, with the parameters of diminishing returns to area of a particular crop

Supply Responses to Policy Analysis

- Supply responses tell how farmers would react to different policy changes
- We will integrate these in a GE model
- Will develop policy scenarios
- Draw policy conclusions
- Discuss with stakeholders
- Refine
- Finalize
- Disseminate