Bt Cotton Adoption and Wellbeing of Cotton Farmers in Pakistan

By

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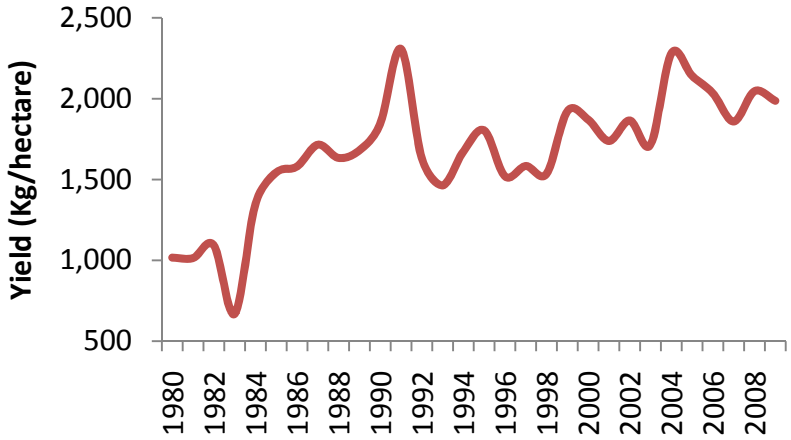
Plan of Presentation

- Background
- Research gaps and objectives
- Analytical framework and data
- Results
- Conclusions
- Limitations and policy implications

Background – Pakistan and Cotton

- 4th largest producer
- 3rd largest consumer
- Cotton and textiles contribute
  - 8% to GDP
  - 17% to employment
  - 54% to export earnings (yarn and finished textile products)
- Cotton farmers' problem
  - high fluctuations in yield due primarily to pest infestation
    - resulting in high cost of production (25-30% on plant protection)



Background

- Bt cotton addresses crop loss by controlling the pest infestation (Pray *et al.,* 2001; Ismael *et al.,* 2002; Qaim and de Janvry, 2003; Traxler *et al.*, 2003; Qaim, 2003; Gandhi and Namboodiri, 2006)
  - Cost advantages (lower pesticide expenditure)
  - Yield advantages
  - Higher profit than conventional varieties

- Bt technology is IPR protected,
  - commercial adoption is conditional on a per acre fee (technology fee) paid to the owners of the gene $\Rightarrow$ high seed price

- Among four large cotton producing countries, Pakistan is the only one that has not formally adopted Bt cotton under IPR "commercial adoption"

- However, the cultivation of Bt cotton, although unapproved and unregulated, increased rapidly after 2005 (PARC, 2008)

Research Gaps and Objectives

- Impact of Bt cotton in Pakistan - (Hayee, 2004; Sheikh *et al.,* 2008; Arshad *et al.,* 2009, Ali and Abdulai, 2010) - why yield/hectare is declining?
  - Lack of in-depth research on the impact of Bt cotton under different agro-climatic conditions in Pakistan

- Previous analyses are based on the difference of means tests
  - When sample is drawn from non-experimental design, the difference of means method may give biased results

- Objectives:
  - To estimate the impact of adoption of Bt cotton (causal effect) on the wellbeing of cotton farmers under different agro-climatic conditions
  - Cotton yield, profit, household per capita income and poverty headcount are used as wellbeing indicators

Analytical Framework : Measuring Causal Effect

- The causal effect of a treatment (e.g., technology adoption) is the difference between outcomes with treatment (Y_1) and without it (Y_0): treatment effect= Y_1-Y_0

- Impact evaluation can suffer from two problems
  - Selection problem: individuals select themselves into treatment if they perceive $U(Y_1) > U(Y_0)$
  - Evaluation problem: for the same individual, either Y_1 is observed or Y_0

- Problem of missing counterfactual:
  - How much did the treated individuals benefit from the treatment compared to the situation if they would not have been treated?

- Average Treatment Effect: ATE $= [E(Y_1)|I=1] - [E(Y_0)|I=0]$
- Average Treatment effect on the Treated: ATT=$[E(Y_1-Y_0)|I=1]$

Analytical Framework: Estimation Methods

Methods	Advantages/disadvantages
Difference of means	Difficult to isolate the true effect if treatment is not random
OLS	Does not control self-selection bias if treatment is not random
IV/2SLS	Controls selection bias, problem in finding out right instrument
Heckman's two-steps	Controls selection bias, does not examine the counterfactual situation
Difference in difference	Requires panel data
Propensity score matching	Addresses the issue of selection bias and examines counterfactual

Analytical Framework
(Propensity Score Matching)

- When treatment is not randomly assigned
  - $E[Y_{0i}|I=0] \neq E[Y_{0i}|I=1]$

- PSM creates a good counterfactual
  - Treated and non-treated units have identical characteristics except the decision of being treated (unconfoundedness)
  - Treated and non-treated units should be overlapped
  - Estimate propensity score (logit or probit model)
  - Matching (treated with non-treated) using matching algorithm (nearest neighbour, radius, kernel, and stratification matching)
  - Creates $\Rightarrow E[Y_{0i}|I=0] = E[Y_{0i}|I=1] \Rightarrow$ situation similar to random assignment
  - Estimate average treatment effect on the treated (ATT)

Data

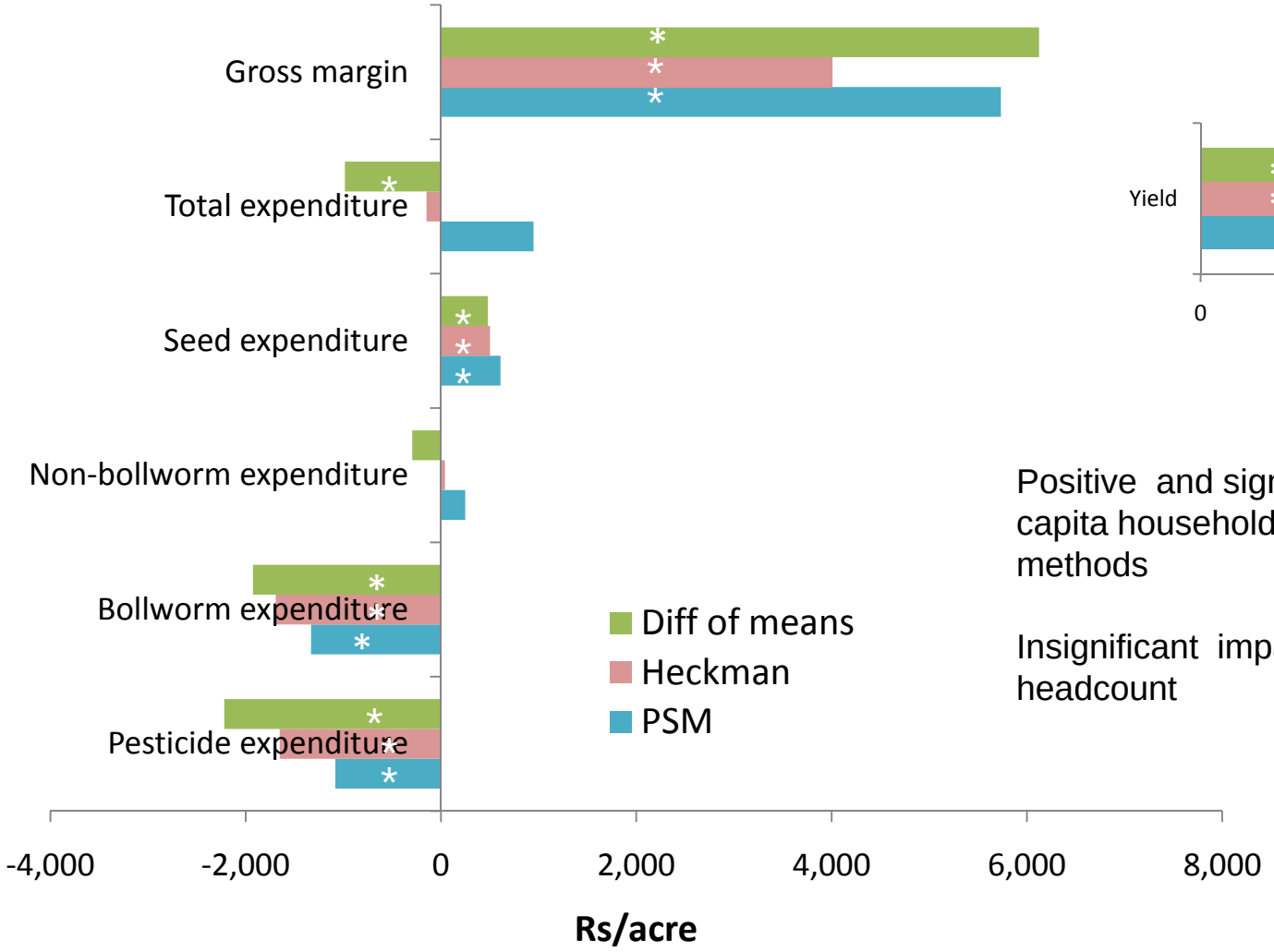
- Cotton farmer survey in 2009
- Two districts (Bahawalpur and Mirpur Khas)
- These districts similar in terms of development ranking and incidence of poverty but have different agro-climatic conditions:
  - Bahawalpur (hot and dry - non-bollworm pests)
  - Mirpur Khas (hot and humid - bollworm pests)
- 16 villages and 208 cotton farmers

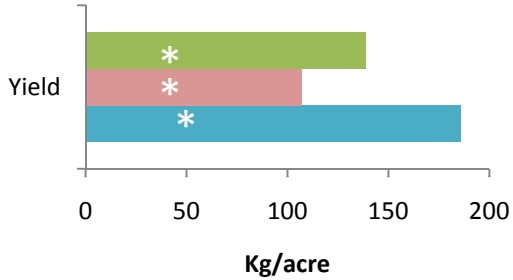
Basic Facts: Selected Households

- Farm size
  - 81.6% operate less than 12.5 acres of land.
  - most of them are concentrated in the category less than 5 acres
- Type of tenure
  - 77.9% farmers in Bahawalpur are owner
  - most of the sharecroppers are in Mirpur Khas (73.1%)
- Bt cotton adoption rate is high
  - 87% in Mirpur Khas
  - 74% in Bahawalpur
- The level of awareness about Bt technology and its use is extremely low in both districts
  - farmers do not know the name of seed variety or the seed company
  - farmers do not have any knowledge about the importance of seed quality and the refuge area

Results:

Three Estimation Techniques (Full Sample)



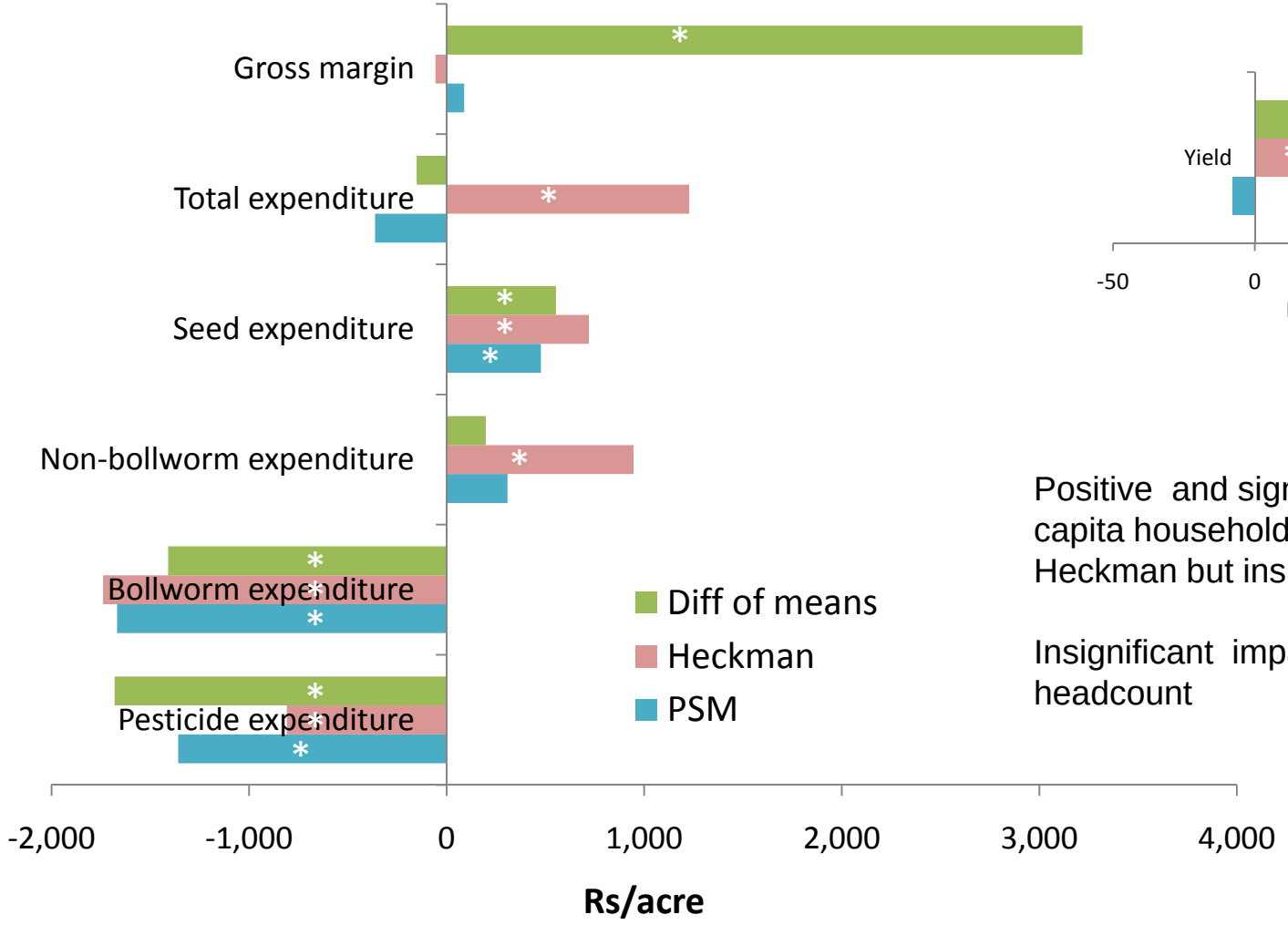


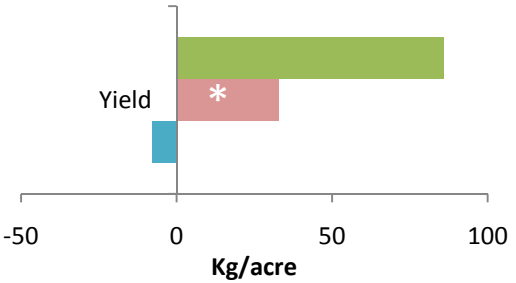
Positive and significant impact on per capita household income in all methods

Insignificant impact on poverty headcount

Results:

Three Estimation Techniques (Bahawalpur)



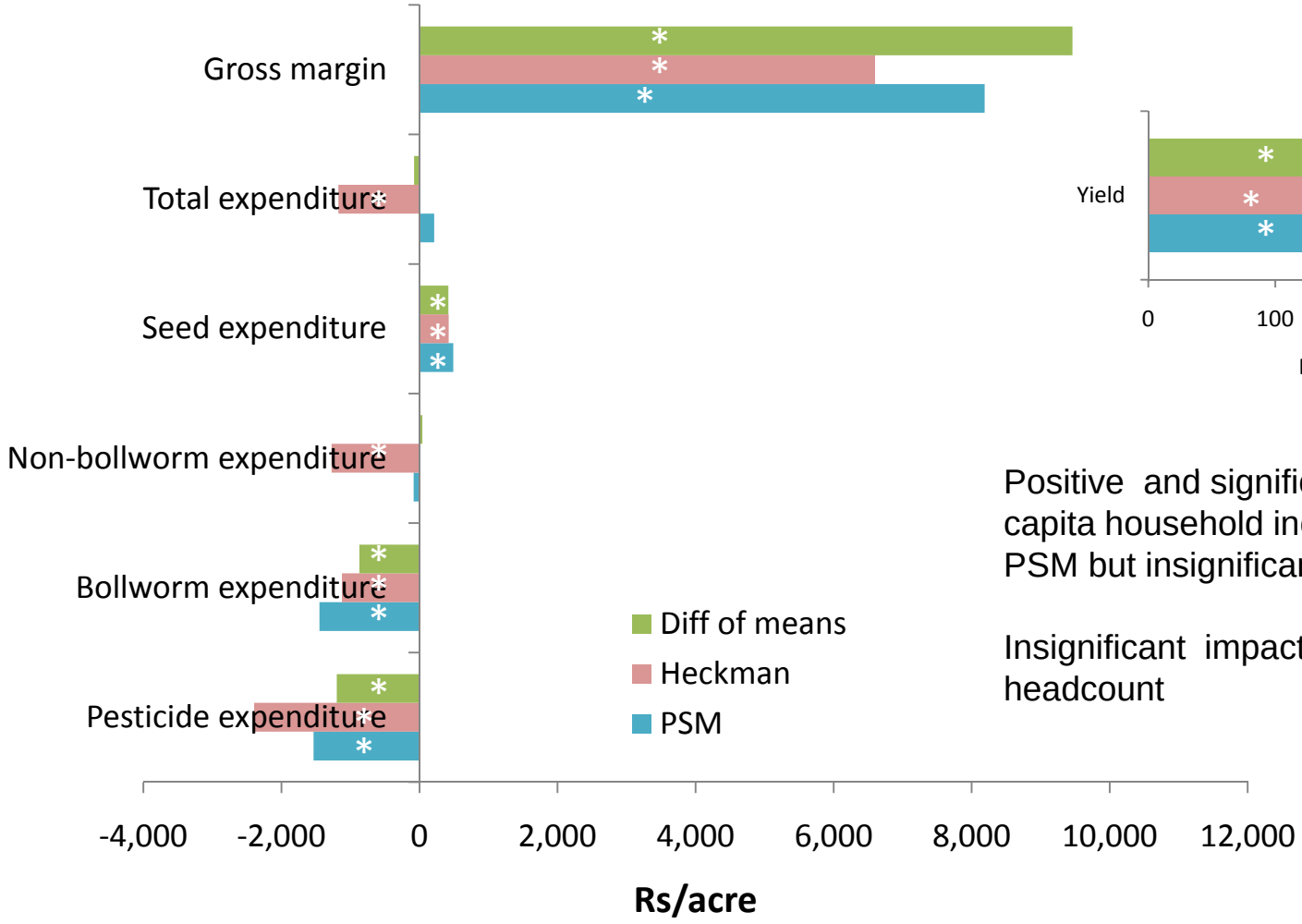


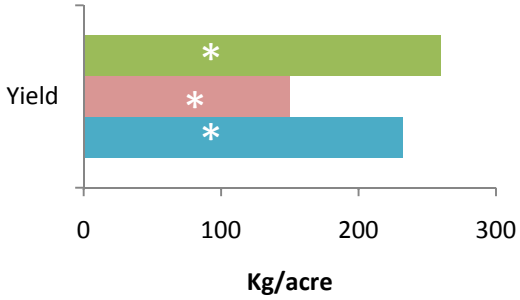
Positive and significant impact on per capita household income in DM and Heckman but insignificant in PSM

Insignificant impact on poverty headcount

Results:

Three Estimation Techniques (Mirpur Khas)



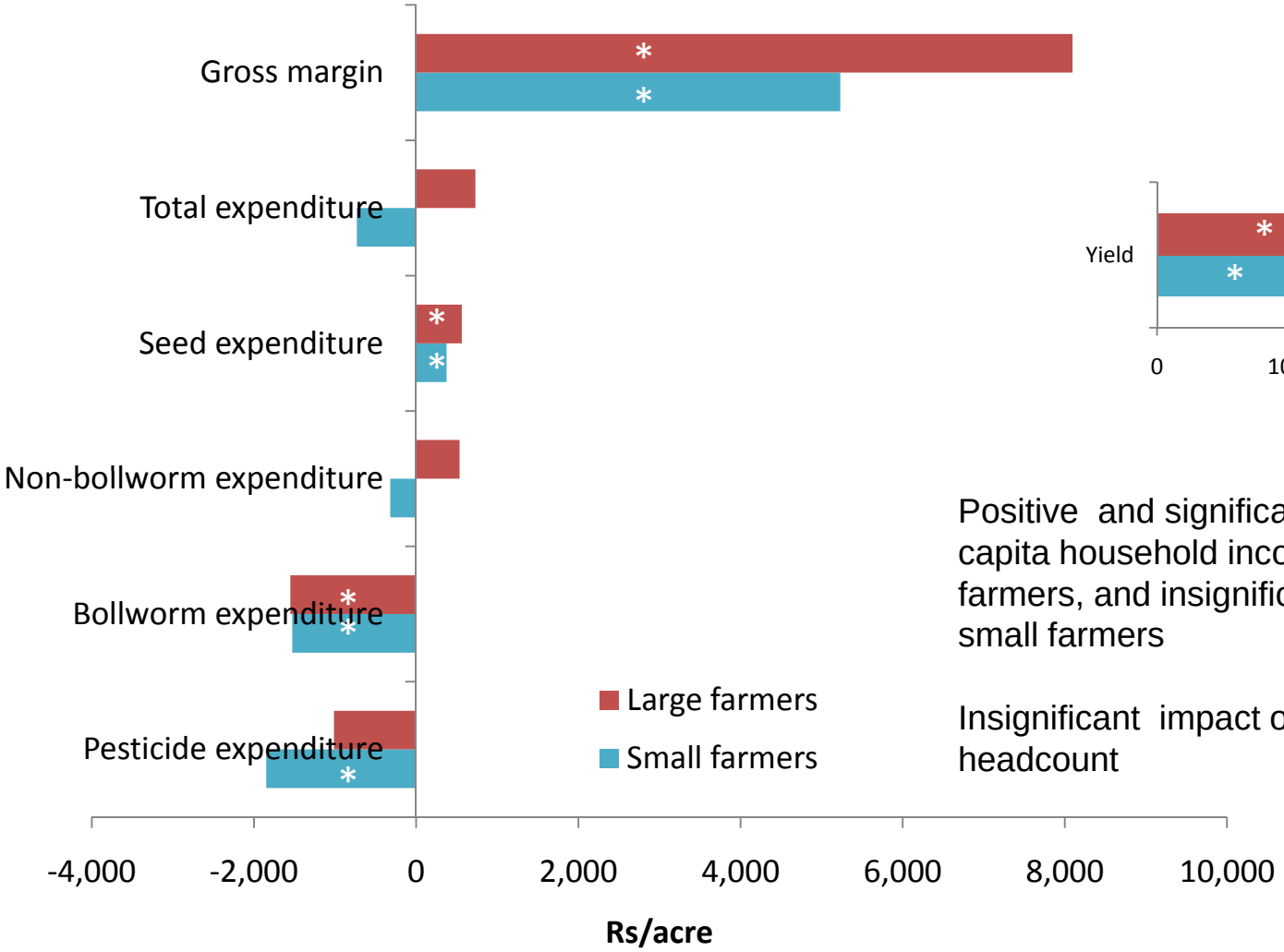


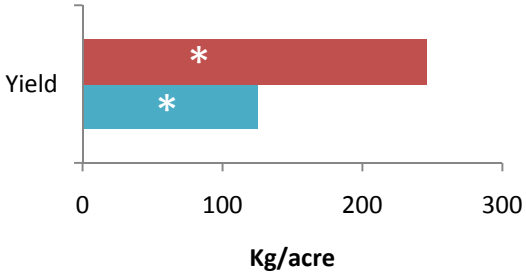
Positive and significant impact on per capita household income in DM and PSM but insignificant in Heckman

Insignificant impact on poverty headcount

Results:

Large Vs Small Farmers using PSM (Full sample)





Positive and significant impact on per capita household income for large farmers, and insignificant impact on small farmers

Insignificant impact on poverty headcount

Conclusions

- Impact of Bt cotton varies across agro-climatic conditions
  - More effective in the areas with hot and humid weather where bollworm pressure is high
- Impact on wellbeing indicators is overestimated if the issue of self-selection bias is not addressed
- In the area of high bollworm pressure, even after addressing the issue of self-selection bias, Bt cotton results in:
  - higher yield, higher Profit, and higher per capita income (consistent with Ali and Abdulai, 2010)
  - Increase in income is not enough to reduce poverty (inconsistent with Ali and Abdulai, 2010)
- Bt cotton appeared effective for both large and small farmers – per acre gains for large farmers are higher

Limitations and Suggestions

- Small sample survey – did not allow disaggregation
  - Due to the high diversity of the cotton-growing areas, large sample size with more location-specific information should be selected

- Lack of data on the quantities of pesticide and on detailed disaggregated information on labour use (family and hired – both casual and permanent)
  - Such data could be analysed using appropriate methods

Policy Implications

- Commercialize Bt cotton in regularized seed market
- Conduct regular surveys to monitor pest pressure and performance of Bt cotton
- Address the needs of small farmers through institutional support (information flow, provision of credit and availability of inputs)

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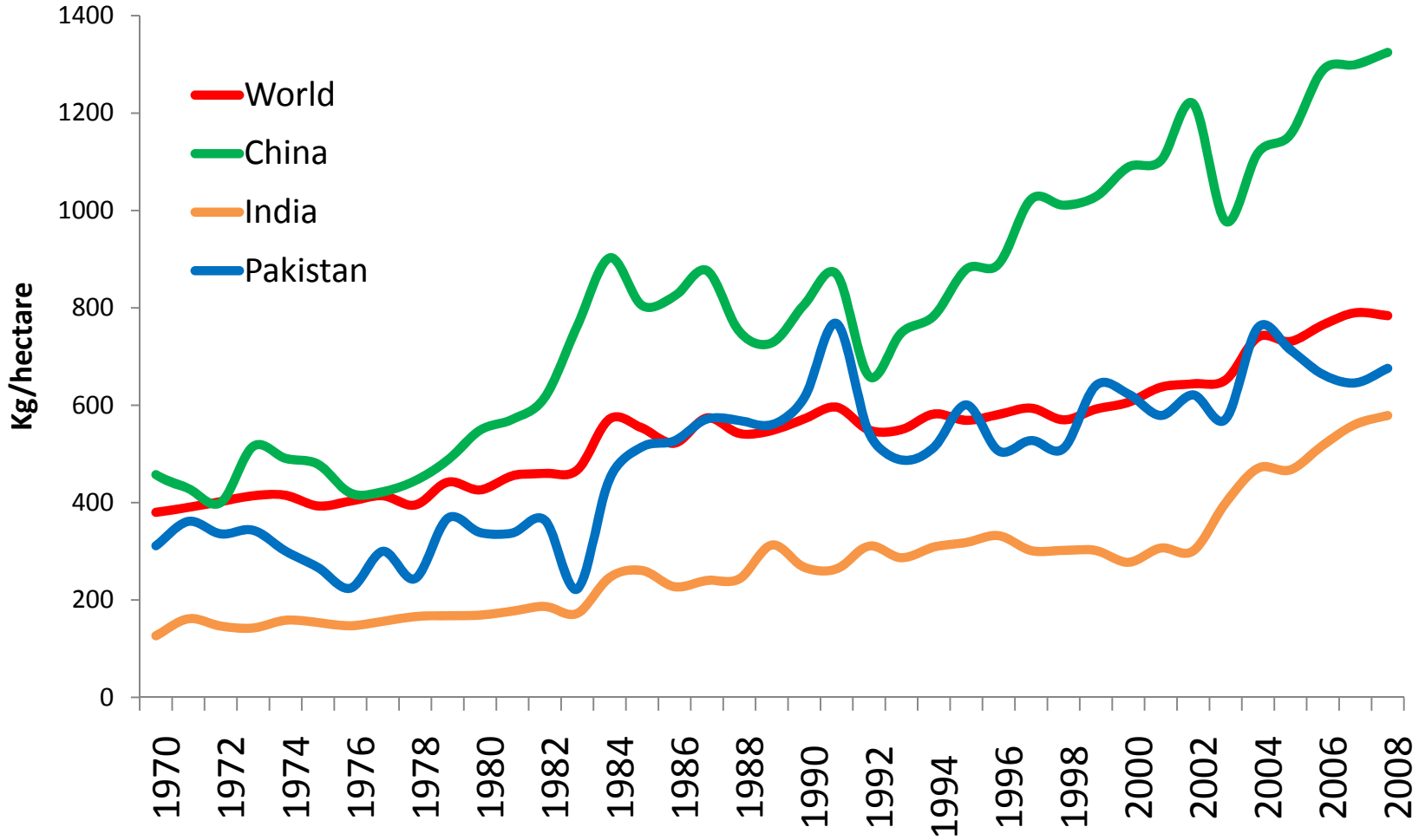
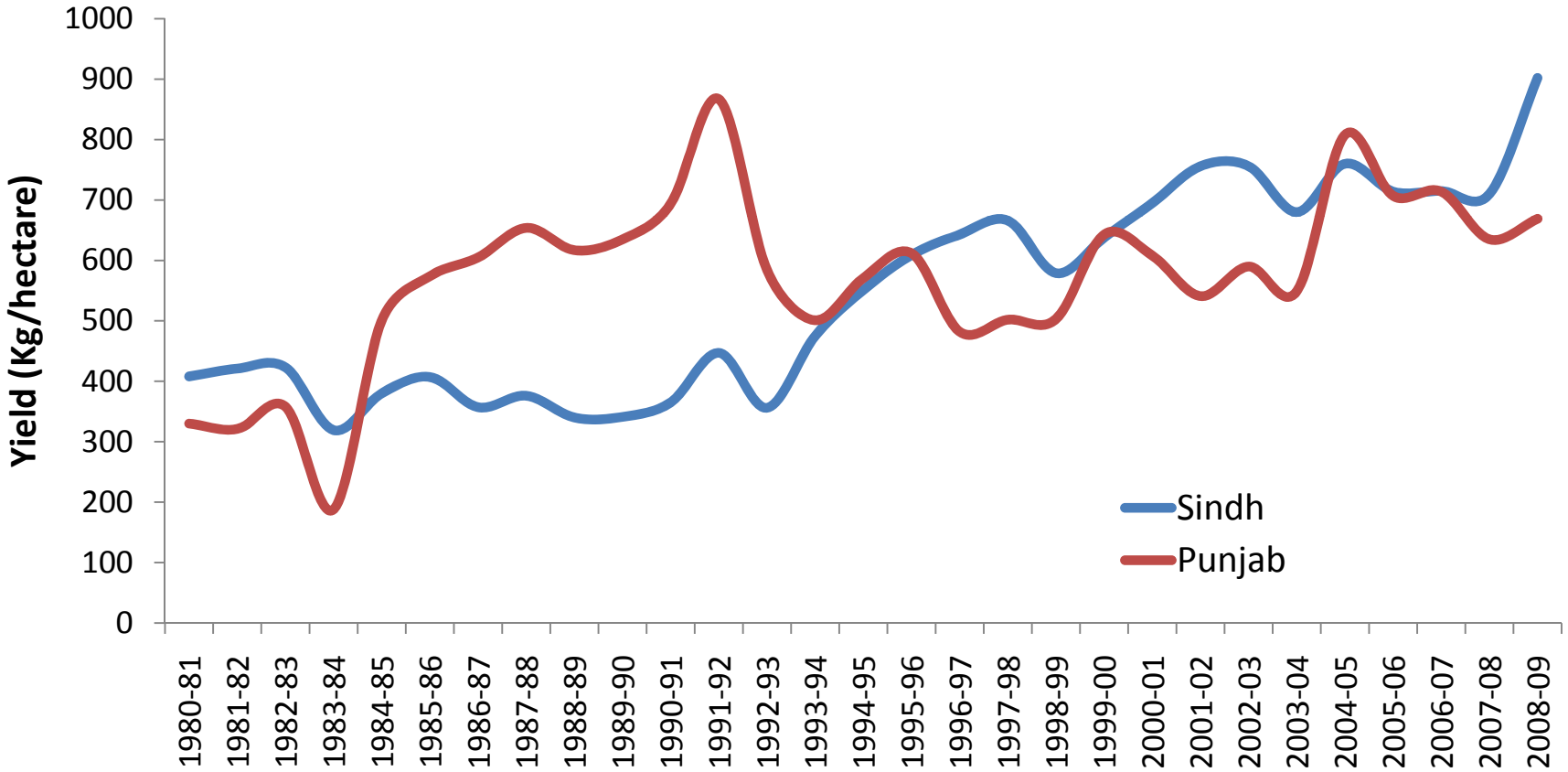
IMPROVING LIFE

Thank You

Yield (Kg/hectare) in Selected Countries



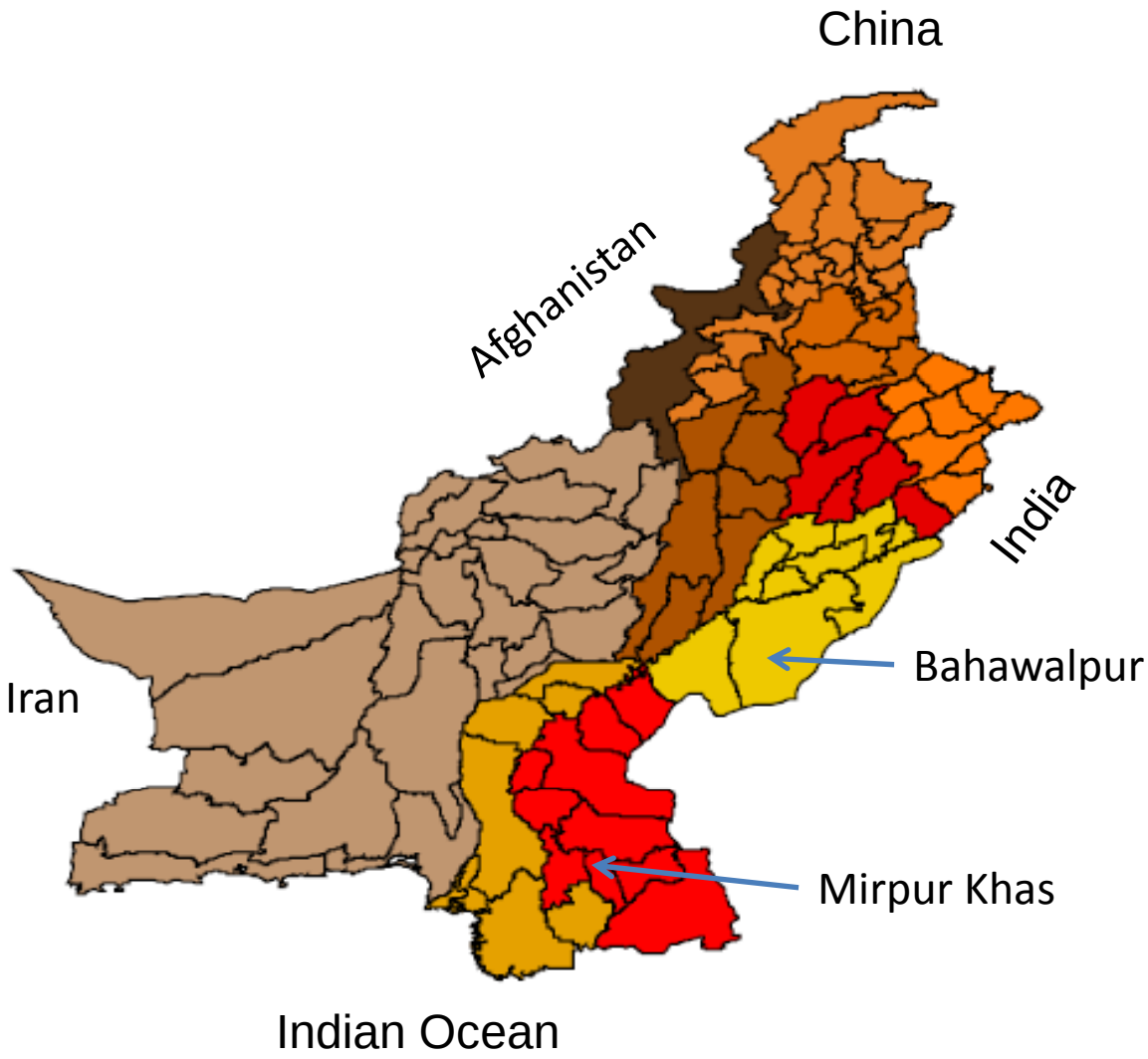
Yield (Kg/hectare) in Punjab and Sindh



Comparison of Pakistan's Unapproved Bt Varieties with China and India's Approved Bt Varieties

	# of sprays	Percentage difference in Bt and non-Bt varieties				Gross margin (US$/ha)	
		Pesticide cost	Seed cost	Total cost	Yield	Bt	Non Bt
China (2001)	--	-58.1	333.3	-27.5	10.9	277	-225
India (2006)							
Gujrat	--	--	136.8	13.7	35.4	715	407
Maharashtra	-1.9	-21.3	192.4	36.5	46.3	504	319
Andhra Pradesh	-3.8	-25.8	173.1	5.6	44.6	420	121
Tamil Nadu	-2.0	-54.5	237.0	13.7	28.5	340	129
Pakistan (2009)							
Bahawalpur	-0.9	-21.1	64.9	-4.2	5.9	452	384
Mirpur Khas	-1.9	-26.8	76.3	4.5	39.3	408	230

Agro-climatic Zones of Pakistan



Basic Facts: Selected Districts

	CW-Punjab	CW -Sindh
Incidence of poverty (%) (2005-06)	29.3	32.4
% of rural population	17.42	10.34
% of rural poor	17.76	11.11
	Bahawalpur	**Mirpur Khas**
Development Rank (2001)	64/100	65/100
Weather	Hot and dry	Hot and humid
Soil quality	Sandy	Clay

Pest infestation in Punjab (2007 and 2008)