Toulouse School of Economics

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Applied Econometrics for Development: Panel Estimation II

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Panel Estimation

- Estimate partial effects in the presence of unobserved heterogeneity
- Benefits of panel data:
  - Time and individual variation unobservable in cross sections or aggregate time series
- 2 examples of empirical analysis using panel data
  - Determinants of school attainment in Senegal
  - Effect of property rights on productivity in India

Early Academic Performance, Grade Repetition, and School Attainment in Senegal

Peter Glick and David E. Sahn

(World Bank Economic Review 2010)

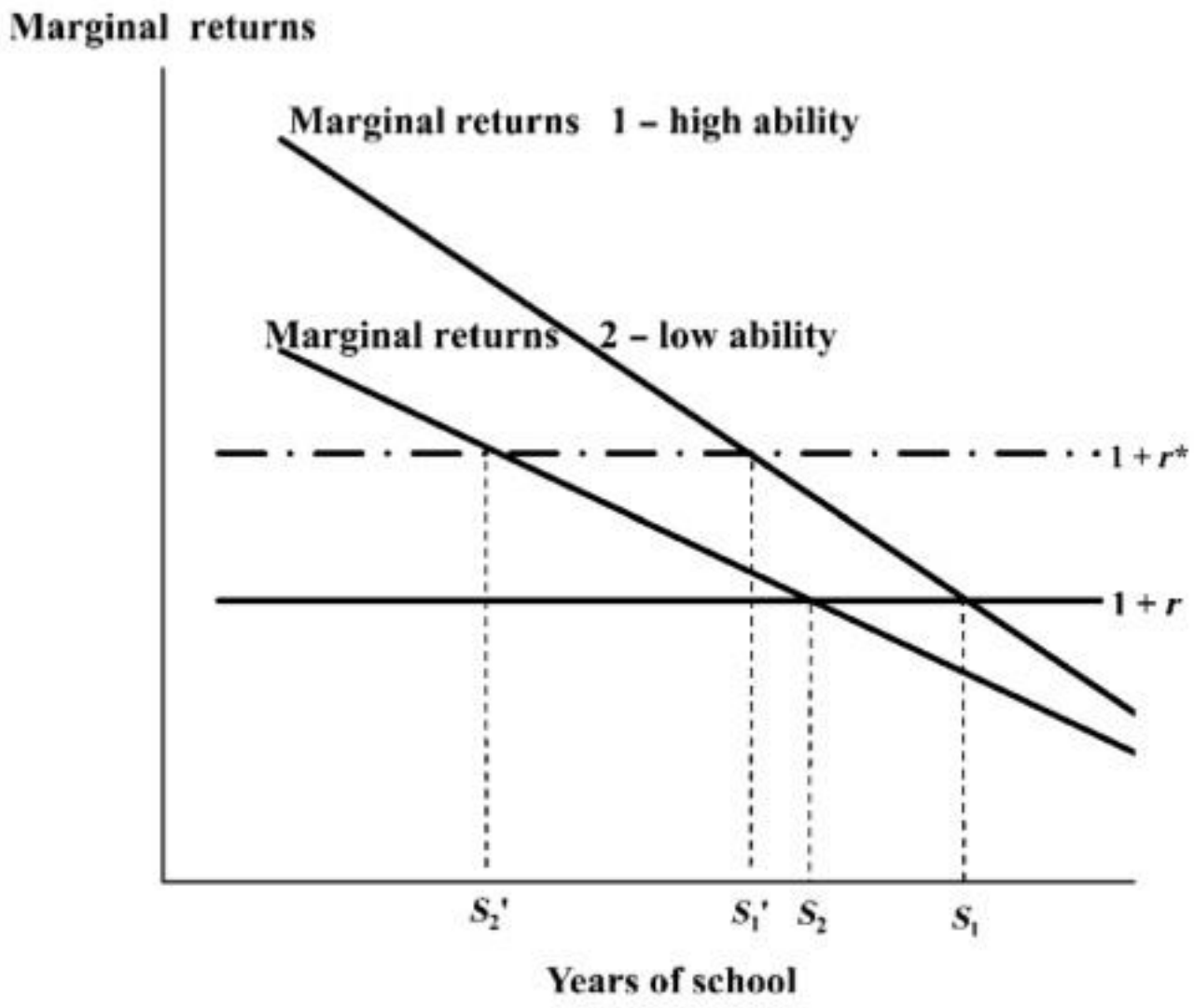
1. How to make schooling decisions in developing countries?

- Households in developing countries are credit constrained and investments in human capital might be costly
- Parents might need signals of child's ability to make decisions on how long to continue school
- Is there a connection between early achievement and subsequent school attainment?
- Hard problem to study: appropriate data for the dynamic analyses of school attainment is hardly available
  - This paper uses a panel dataset from Senegal including test scores in 2nd grade
  - Follow up survey seven years later
  - Data includes school and household characteristics to control for confounding factors

2. Model of Household Schooling Investments

- Two children differing in ability $A^1 > A^2$ (given exogenously to the parents)
- Pure investment model where parents maximize consumption in a two period model subject to an intertemporal budget constraint
  - Children consume schooling levels S^1 and S^2 in period 1.
  - Schooling and ability are inputs of the returns function $W^i(A^i, S^i)$, from which parents benefit in period 2
  - FOC: Parents invest in schooling until the marginal return equates the market rate of interest
  - The model implies that children with different abilities will get different levels of schooling
  - Credit constrained households are forced to invest less in schooling years for their children

2. Model of Household Schooling Investments



3. Data and Empirical Approach

- Two datasets from Senegal
- PASEC study: includes French and Math tests for every kid from second grade to the end of primary school (1995)
- EBMS survey: a follow-up survey on PASEC's subjects (2003)
  - 50% of the original 120 PASEC school clusters (28 urban + 32 rural)
  - Approx. 20 children per cluster in PASEC
  - In the follow-up ~15 of them were found in rural clusters and ~17 were found in urban clusters
  - Attrition problems

3. Empirical Approach: Specification

$$S_i = a_0 + a_1 A_{95i} + a_2 X_i + a_3 Q_i + a_4 A_{95i} X_i + a_5 A_{95i} Q_i + e_i$$

- S_i is a grade attainment (measured in 2003)
- A_{95i} is the child's test in second grade (measured in 1995)
- X_i is a vector of individual and household variables
- Q_i is a vector of school inputs

- Three ways to measure ability (A_{95i})
  - With the actual tests in 1995 (end of the year)
    - Is very noisy as a measure of ability because it includes the "inputs" from second grade
  - With the pretests from 1995 (beginning of the year)
    - Is less noisy, but still reflects home inputs and learning during the first grade
  - The residual method: unexplained part in a production function regression

$$TS_i = b_0 + b_1 X_i + b_2 Q_{95i} + \nu_i$$

  - $\widehat{\nu_i}$ is an ability measure purged of the effects of X_i and Q_{95i}

3. Empirical Approach: Specification

- Still, there are problems with the residual method
  - Endogeneity problem: unmeasured inputs that also explain the test score and may be correlated with school attainment
  - Measurement error: the test score is a noisy measure of knowledge
- The problem of measurement error
  - We want to estimate $S_i = \beta_0 + \beta_1 ability_i + u_i$
  - But we can estimate $S_i = \beta_0 + \beta_1 A_{95i} + e_i$
  - We have noise measuring ability $A_{95i} = ability_i + w_i$
    - Assume $E(w_i) = 0$, $Cov(ability, w_i) = 0$, $Var(w_i) = \sigma_w^2$
  - By replacing we have $S_i = \beta_0 + \beta_1 (A_{95i} - w_i) + u_i$
  - As w_i is unobserved we have $e_i = u_i - \beta_1 w_i$
  - So we have an endogeneity issue:

$$Cov(A_{95i}, e_i) = Cov[(ability_i + w_i)(u_i - \beta_1 w_i)] = -\beta_1 \sigma_w^2$$

3. Empirical Approach: Measurement Error

- Measurement error leads to an “attenuation bias” problem
  - It can be shown that $\widehat{\beta_1} = \beta_1 \left(\frac{\sigma_x^2}{\sigma_x^2+\sigma_w^2}\right)$
- The proposed solution is the “multiple indicators approach”
  - If there are two alternative measures of ability, use one to predict the other and then plug the predicted measure into the main equation (assuming the errors are uncorrelated)
  - For the intuition of this method consider the regressions

$$A_{95i} = a_0 + a_1 TS1_i + \mu_{1i} \qquad A_{95i} = b_0 + b_1 TS2 + \mu_{2i}$$

    - If $Cov(\mu_{1i}, \mu_{2i}) = 0$ then the only source of correlation between $TS1_i$ and $TS2_i$ is through A_{95i}

3. Empirical Approach: Multiple Indicators

- Which pair of test scores they can use?
  - Predict Math pretest score with the French pretest score?
  - Predict Math posttest score with the French posttest score?
  - Predict Math/French pretest score with the Math/French posttest score?
- They use the average posttest score in Math and French to predict average pretest score
  - This IV strategy deals with measurement error but not with the potential endogeneity bias in estimating a_1
  - Unmeasured school or home inputs are still correlated with all tests

3. Empirical Approach: Panel Data

- Think about the nature of the data. Which model use?
  - An ordered probit: the discrete ordered choices are the schooling levels
  - It treats grade attainment as the outcome of a series of ordered discrete choices
- Two alternative specifications (each has different assumptions about school-level unobserved heterogeneity):
  - Random effects: it is assumed that school unobserved characteristics are not correlated to A_{95i} or X_i
  - Fixed effects: this assumption is not necessary
    - Fixed effects introduced with a dummy variable per school
    - It comes at the cost of dropping the variables that do not vary across schools
    - But teachers and classroom supplies are retained because they vary across students within the school

4. Early Performance and Grade Attainment

TABLE 2. Ordered Probit Models of Grade Attainment

Variable	School-level random effects (1)	(2)	School-level fixed effects (3)	(4)
Intercept	3.785 (3.26)***	4.012 (3.16)***	3.432 (4.43)***	3.502 (4.36)***
Second-grade pretest score[a]	0.602 (5.15)***	0.448 (2.27)**	0.689 (8.59)***	0.587 (7.01)***
Girl	−0.173 (0.92)	−0.081 (0.42)	−0.278 (1.89)*	−0.199 (1.43)
Asset index	0.360 (2.24)**	0.371 (2.15)**	0.407 (5.24)***	0.414 (5.35)***
Mother's schooling	−0.009 (0.28)	−0.012 (0.36)	−0.006 (0.36)	−0.009 (0.49)
Missing mother's schooling	−0.142 (0.36)	−0.112 (0.29)	−0.128 (0.69)	−0.071 (0.37)
Father's schooling	0.035 (1.38)	0.035 (1.26)	0.034 (2.34)**	0.033 (2.40)**
Missing father's schooling	−0.357 (1.49)	−0.357 (1.44)	−0.343 (1.86)*	−0.338 (1.76)*
Pretest score × asset index		0.120 (0.98)		0.131 (1.96)**
Pretest score × girl		0.481 (1.98)**		0.364 (2.51)**
Pretest score × father schooling		0.004 (0.10)		0.002 (0.07)
Director's experience	0.000 (0.01)	−0.004 (0.18)		
Director has baccalauréat or higher	−0.145 (0.45)	−0.206 (0.67)		
Teachers, average experience	−0.016 (0.66)	0.018 (0.68)	−0.050 (2.09)**	−0.052 (2.22)**
Teachers, share with baccalauréat or higher	0.217 (0.65)	0.182 (0.54)	0.671 (1.45)	0.624 (1.38)
Teachers, share female	−0.640 (1.44)	−0.652 (1.40)	−1.485 (4.57)***	−1.383 (4.56)***
Girl × share teachers female	0.321 (0.90)	0.179 (0.44)	0.536 (2.32)**	0.397 (1.72)*
Classroom supplies first principal component	0.041 (0.36)	0.040 (0.35)	−0.015 (0.19)	−0.022 (0.29)
School facilities first principal component	0.002 (0.01)	0.002 (0.01)	−0.097 (0.72)	0.000 (0.00)
Rural	−0.256 (0.48)	−0.314 (0.53)		
Rho	0.068 (1.41)	0.070 (1.36)		
Number of observations	834	834	834	834

4. Early Performance: Interquartile Comparison

- Estimates are then used to predict the attainment of children in different quartiles of the pretest score distribution
- Even if wealth and paternal gaps are eliminated the predicted gap in probability is large

TABLE 3. Predicted Probabilities of Completing Sixth Grade for First and Fourth Quartiles of Second-Grade Pretest Scores

		First pretest score quartile		
Model and probability	Fourth pretest score quartile (1)	(2)	Eliminate wealth gaps[a] (3)	Eliminate wealth and paternal education gaps (4)
School random effects model				
Probability (grade ≥ 6)	0.787	0.326	0.393	0.414
Difference in probabilities for fourth and first quartile		0.461	0.395	0.374
School fixed effects model				
Probability (grade ≥ 6)	0.799	0.386	0.464	0.486
Difference in probabilities for fourth and first quartile		0.413	0.334	0.313

5. How grade repetition affects attainment?

- Grade repetition is very common in Francophone Africa (20%)
  - In Anglophone Africa is 10% and in OECD countries is 2%
  - 76% of the students in the PASEC sample repeated at least one year
- Cost of repetition is clearly large (both for the education system and families)
- The main issue is that repetition is not exogenous to school attainment
  - Use of panel data to control for academic achievement at the decision time for repetition
- The authors study the effect of 2nd grade repetition on the probability that the child completes 4th grade
- There is a serious problem of attrition. Consequences?

5. How grade repetition affects attainment

- Absence from the sample is not random: children absent for the 1997 follow-up scored significantly lower than those present
- Selection into sample is related positively to the propensity for continuing in school
- The probability of repetition is negatively and strongly affected by posttest score
  - A 1 s.d. reduction in test score increases probability of repetition by 11%
  - Wealth also decreased the probability of repetition (even in the f.e. model)
- The fixed effects model cannot be estimated
  - Identification of repetition effects conditional on academic performance relies on variation across classes in teacher/school repetition practices
  - Differences among students within a school eliminates this variation

5. How grade repetition affects attainment

TABLE 4. Determinants of Dropout before Fifth Grade and 1997 Test Score

	Dropout[a]		Test score[b]	
Variable	Coefficient	*t*-statistic	Coefficient	*t*-statistic
Intercept	−1.973	−5.961***	0.000	−0.001
Second-grade posttest score[c]	−0.237	−1.837*	0.804	14.618***
Repeated second grade	0.492	2.306**	−0.204	−1.601
Girl	0.008	0.043	0.010	0.116
Asset index	−0.240	−2.475**	0.066	1.221
Mother's schooling	−0.032	−1.036	0.011	1.001
Missing mother's schooling	0.040	0.161	0.018	0.132
Father 's schooling	−0.001	−0.051	0.014	1.691*
Missing father's schooling	0.609	3.233***	0.059	0.510
Rural	0.153	0.889	−0.045	−0.297
Director's experience	−0.001	−0.180	0.004	0.632
Director has baccalauréat or higher	−0.067	−0.466	0.190	1.322
Teachers, average experience	0.021	2.033**	−0.016	−1.833*
Teacher has baccalauréat or higher	0.338	1.837*	0.097	0.553*
Teachers, share female	0.387	1.556	0.156	0.768
Girl × share teachers female	−0.382	−0.826	−0.011	−0.067
Classroom supplies principal component	−0.023	−0.590	0.025	0.571
School facilities principal component	−0.031	−0.644	0.071	1.424
Number of observations[d]	664		556	

6. Conclusion

- Early academic performance is an important predictor of school attainment
  - The positive effects of early achievement are greater for girls and wealthier households
- Grade repetition is one of the policies currently directed to lagging children
  - Seems to exacerbate negative impacts of poor school performance on attainment
- What is the mechanism behind the repetition story?

Empowerment and Efficiency: Tenancy Reform in West Bengal

Abhijit Banerjee, Paul J. Gertler and Maitreesh Ghatak

(Journal of Political Economy 2002)

1. Agricultural Property Rights and Productivity

- The relationship between property rights and efficiency is hard to evaluate
  - Large-scale changes in property rights tend to be accompanied by major social unrest
  - Analyzing impact on efficiency is difficult because of data limitations
  - Structure of property rights is itself endogenous
- Operation Barga offers an opportunity to make this kind of evaluation
  - Major change in property rights in West Bengal
  - Tenants would be entitled to permanent tenure if they paid the landlord at least 25% of output as rent
  - Improvement of tenants' contracts and more secure tenure
  - Transfer of property rights was limited (it gave the tenant the right to claim a higher share of the crop and permanent tenure)

1. Agricultural Property Rights and Productivity

- Theoretically, two different effects play a role in the impact on productivity
  - Bargaining power: the legal contract becomes the tenant's outside option so it increases his bargaining power and forces the landlord to offer a higher share
  - Security of tenure: two opposing effects
    - Disallows eviction restricting the use of this type of incentives
    - Greater security of tenure encourages the tenant to invest more

2. Operation Barga

- The nationwide Land Reforms Act in 1955 had two main clauses:
  - Sharecroppers will have permanent and inheritable incumbency rights to land that is registered in their name provided some conditions
  - Share that the landlord can demand from a registered tenant cannot be greater than 25%
  - This reform failed in the implementation
    - Little institutional support for program registration
    - Threats from landowners to tenants to prevent registration
- A left political party elected in 1977 in West Bengal passed the Land Reforms Act that closed the loopholes in 1955 and launched Operation Barga
  - Campaign to register tenants and ensure their rights
- The authors argue that Operation Barga was an exogenous shock

3. Model of Landlord-Tenant Relationship

- One landlord and a large population of tenants with a reservation payoff of m
- Output can take two values depending on effort:

$$Y = \begin{cases} 1 & \text{with probability} \quad e \\ 0 & \text{with probability} \quad 1 - e \end{cases}$$

- The tenant chooses effort that costs him $c(e)$
- The contract in any period needs to specify 4 things:

$$\left.\begin{array}{l} h = \text{payment to the tenant} \\ \varphi = \text{probability of eviction} \end{array}\right\} when\ Y = 1$$

$$\left.\begin{array}{l} l = \text{payment to the tenant} \\ \vartheta = \text{probability of eviction} \end{array}\right\} when\ Y = 0$$

3. Model of Landlord-Tenant Relationship

- Optimal tenancy contract without eviction
  - One period contracting problem
  - The landlord faces a tradeoff between provide incentives to work and extract the surplus from the tenant
  - Ideally a fixed contract if tenant is wealthy enough
  - The bargaining power effect: an increase in the outside option of the tenant forces the landlord to pay more (extra bonus for success), which gives stronger incentives to work hard
- Optimal tenancy contracts with eviction
  - The eviction threat is a mechanism to increase tenant's effort when he is poor
  - Unless the increase in the outside option is large enough, efforts will fall
  - Operation Barga may have a negative effect on efficiency through this channel

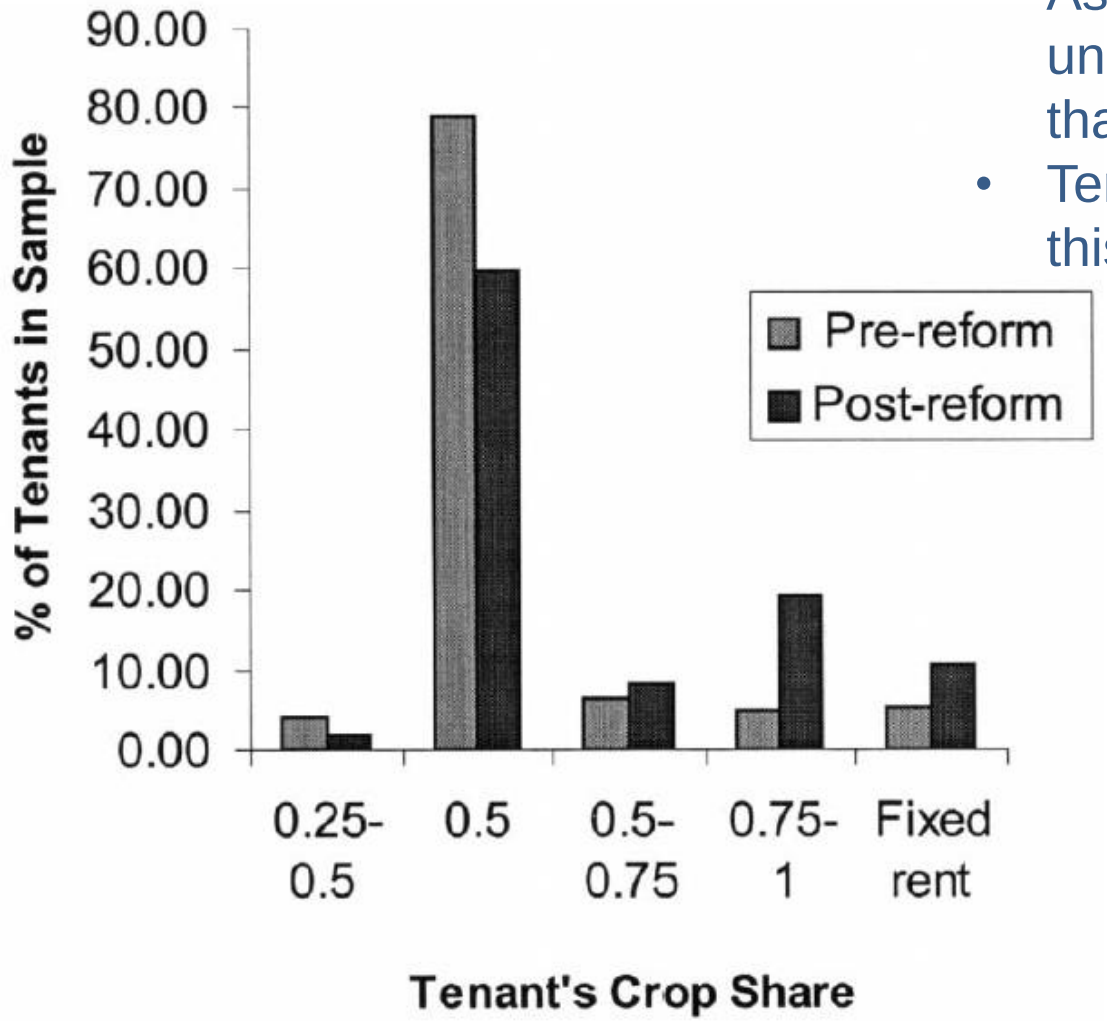
3. Operation Barga and Investment Incentives

- So far, the model ignores the role of investment
  - If investments are contractible there is no problem
  - The problem appears with non-contractible investments under the threat of eviction
- Operation Barga makes eviction threats non credible, which makes landlord and tenant better off

4. Survey Evidence

- 80% of surveyed tenants reported threats of eviction prior to Operation Barga
- Tenants responded positively to the reform: registration went up from 15% to 65%
- But, this doesn’t imply that the reform affected contractual terms
- Surveyed a random sample of 480 sharecroppers from 48 villages in West Bengal

4. Survey Evidence



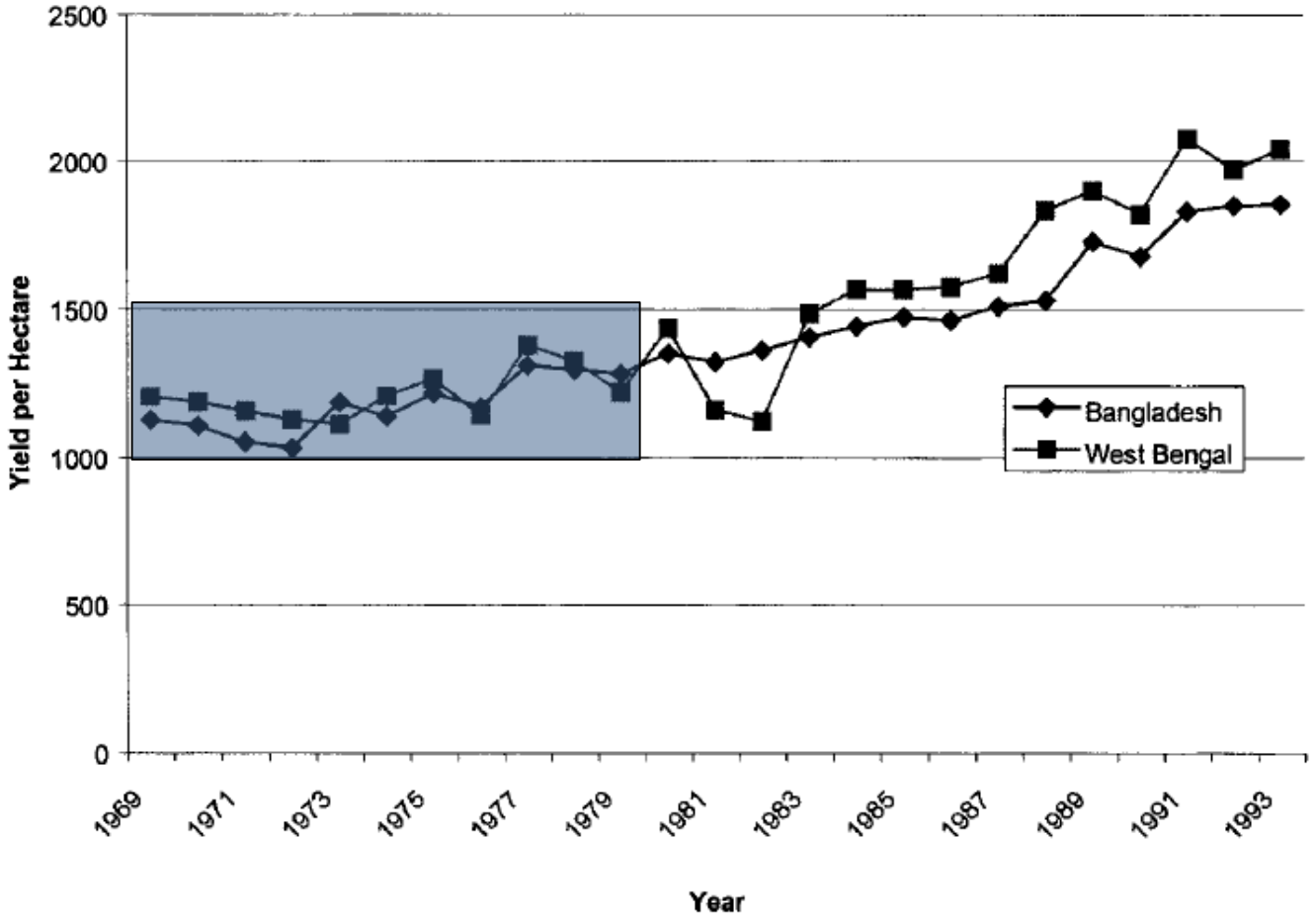
- Crop shares increased after the reform
- As this is an ex post survey the effect is underestimated (it only includes those that are still tenants in 1995)
- Tenants that become landlords during this time do not appear in the survey

5. Empirical Analysis

- They want to measure the impact of the reform on agricultural productivity
- As a measure of productivity, they use agricultural rice yields
- Two approaches:
  - Difference in Differences estimator using Bangladesh as a control
  - Program intensity using the sharecropper registration rate in each district as a measure of intensity

5.A Empirical Evidence: Diff-in-Diff Approach

- Why the comparison with Bangladesh?
  - Bangladesh and West Bengal were part of the same state prior to Independence



4. Empirical Evidence: Dif-in-Dif Approach

$$\ln y_{dt} = \alpha_d + \psi_t + \beta \times treatment_d \times post_t + \sum \phi_{jdt} + \epsilon_{dt}$$

- y_{dt} is rice yield per hectare in district d in time t
- α_d are the district fixed effects
- ψ_t are the time fixed effects
- β is the difference in difference estimate of the effect of Operation Barga

- A potential problem with this comparison: competing policies
  - Differences in adoption of High Yield Variety (HYV) grains of rice
  - Differences in the provision of public irrigation systems
  - Both grew faster in Bangladesh.

5.A Empirical Evidence: Diff-in-Diff Approach

TABLE 2

DIFFERENCE-IN-DIFFERENCE MODELS OF LOG OF RICE YIELD PER HECTARE (1969–93)

	DIFFERENCE (1969–78) (1)	LEVEL 1969–93 (2)	LEVEL Excluding 1981–82 (3)
West Bengal (=1)	.004 (.17)	…	…
West Bengal × (1979–83)[a]	…	-.09*** (3.75)	−.01 (.38)
West Bengal × (1984–88)	…	.05** (1.99)	.05** (2.00)
West Bengal × (1988–93)	…	.05* (1.77)	.05* (1.78)
District fixed effects *F*-statistic	…	44.55	42.61
Year fixed effects *F*-statistic	4.26***	29.75***	31.81***
R^2	.12	.80	.81
Sample size	256	717	659

NOTE.—*t*-statistics are in parentheses.

[a] These variables are obtained by interacting a dummy variable that takes the value one if a district is in West Bengal and zero if it is in Bangladesh with another dummy variable that takes the value one if the observation is in the indicated time period (1979–83 in this case) and zero otherwise.

5.A Empirical Evidence: Diff-in-Diff Approach

TABLE 3
DIFFERENCE-IN-DIFFERENCE MODELS OF LOG OF RICE YIELD (1977–91)

	Whole Sample			Excluding Drought Years 1981–82		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
West Bengal × (1979–83)	−.08*** (−2.43)	−.07** (−2.05)	−.05 (−1.58)	.001 (.01)	.002 (.06)	.015 (.47)
West Bengal × (1984–87)	.04 (1.17)	.05 (1.47)	.07** (2.04)	.04 (1.24)	.04 (1.26)	.06** (1.93)
West Bengal × (1988–91)	.08** (2.20)	.12*** (3.28)	.18*** (5.11)	.07** (2.33)	.11*** (2.97)	.17*** (4.95)
Log(rainfall)	…	.01 (.40)	.007 (.32)	…	.019 (.70)	.01 (.46)
Log(public irrigation)	…	.122*** (7.22)	.07*** (4.27)	…	.103 (5.77)	.04*** (2.69)
HYV share of grain cultivation area	…	…	1.04*** (8.18)	…	…	1.05*** (8.21)
District fixed effects *F*-statistic	40.02***	20.14***	14.76***	41.43***	18.8***	14.64***
Year fixed effects *F*-statistic	20.18***	12.14***	7.73***	21.67***	12.41***	6.04***
R^2	.82	.85	.87	.83	.85	.88
Sample size	424	424	424	367	367	367

5.B Empirical Evidence: Program Intensity

- The authors exploit the variation in registration rates across districts over time
  - Ideally use the proportion of tenants with opportunity to register (lagged one period)
  - In practice they use the proportion of tenants who actually registered
- The estimated model is

$$\ln y_{dt} = \alpha_d + \varphi_t + \gamma b_{dt-1} + \sum_k \beta_k \ln X_{kdt} + \epsilon_{dt}$$

  - b_{dt-1} is the proportion of registered tenants in district d at time $t-1$
    - γ measures the effect of the reform on agricultural productivity
  - X_{kdt} is a publicly available input

5.B Empirical Evidence: Program Intensity

- Identification issue: registration rate may be correlated with productivity
  - The sequence in which villages were offered registration might be demand driven and not purely random
    - If the sequence depend on the initial productivity (before Operation Barga) the district fixed effects capture the differences.
    - If the sequence depend on current productivity the fixed effects are biased.
  - The registration opportunities might be correlated with the progression of other programs omitted in this analysis
    - The omitted policies are a program of loans to tenants and a program of land redistribution, but in practice none of them were actually implemented
  - Another potential problem is that people in more productive districts might be systematically different from those in other districts
    - This is captured in the district fixed effects

5.B Empirical Evidence: Program Intensity

TABLE 5
EFFECT OF REGISTRATION ON THE LOG OF RICE YIELD IN WEST BENGAL, 1979–93
(N=210)

	Model 1 (1)	Model 2 (2)	Model 3 (3)	Model 4 (4)	Model 5 (5)	Model 6 (6)
Sharecropper registration (one year lagged)	.43*** (3.46)	.42*** (3.44)	.43*** (3.55)	.35*** (2.69)	.36*** (2.64)	.36*** (2.63)
Log(rainfall)	…	−.07* (−1.67)	−.08* (−1.82)	−.07 (−1.59)	−.08* (−1.74)	−.08* (−1.77)
Log(public irrigation)	…	.02 (1.01)	.01 (.70)	.01 (.60)	.02 (.83)	.02 (.79)
Log(roads)	…	.28*** (2.75)	.25** (2.46)	.21** (1.99)	.19 (1.55)	.22 (1.54)
HYV share of rice area	…	…	.57*** (2.85)	.45** (2.10)	.47** (2.16)	.47** (2.16)
F-statistic:						
South × year[a]	…	…	…	4.73***	4.36***	4.38***
Left Front × year[b]	…	…	…	…	2.64**	2.65**
Sharecropping × year[c]	…	…	…	…	2.64**	.12
District fixed effects	72.23***	15.10***	8.99***	9.01***	8.47***	7.68***
Year fixed effects	28.31***	27.67***	21.60***	17.63***	17.83***	12.17***
R^2	.91	.92	.92	.92	.92	.92

5.B Empirical Evidence: Program Intensity

- The effect of Operation Barga on productivity is about 25-28%
- The effect on sharecropper yield is 62%
- Comparison with other studies
  - Shaban (1987) finds for a sample of eight indian villages that changing status from sharecropper to owner increase the productivity by 16%
  - Laffont and Matousi (1995) use data from Tunisia to show that switching from sharecropper to fixed-rent tenancy/ownership the output raised 33%

5. Conclusion

- Tenancy laws that lead to improved crop shares and higher security of tenure can have a positive effect on productivity
- Operation Barga explains about 28 percent of subsequent growth in agricultural productivity

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Applied Econometrics for Development: Panel Estimation II

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