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The role of risk mitigation in production efficiency: A case study of Bolivian potatoes producers

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Outline

- Background
- Theoretical and empirical framework
- Data
- Results
- Comparisons
- Conclusions

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Background

- Potato production in the Bolivian Andes:
  - Main cash and sample crop
- Low yield:
  - Steep sloped hills: soil erosion
  - Limited financial resources: no access to certified seeds, fertilizer, pesticides, etc.
  - Out-migration: labor shortage
  - Vulnerable to idiosyncratic microclimatic shocks: drought, frost, hail, etc.
- Environmental risk mitigation techniques:
  - Lower production variance
  - Lower yield ?
- **Objective**: Understanding the linkages between environmental risk, risk management strategies, and technical efficiency

Theoretical framework

- Farmers incorporate risk mitigation strategies into their agricultural practices:
  1. Flexibility in farming practices (Fafchamps,1993):
     - Farmers make continuous labor allocation decisions in response to environmental shocks
  2. Adoption of management strategies that reduce the production portfolio variance (Carter, 1997):
     - Activity diversification
     - Environmental diversification
- Stochastic production frontier:
  - To incorporate the stochastic nature of the production environment
- Inefficiency model :
  - To incorporate the outcomes of risk mitigation strategies

Theoretical framework

1. <u>Two-time periods with flexible farming strategies</u>:
   - Period 1:
     - Land preparation and planting decisions
   - Period 2:
     - Management period
     - Households incorporate the outcomes of microclimatic idiosyncratic shocks that have occurred between t=1 and t=2 into their input allocation decisions

- Growth processes and labor constraint for both periods:

$$y_{ij1} = f(x_{ij1}, L_{ij1})$$

$$y_{ij2} = f(x_{ij2}(\theta_{ij}), L_{ij2}(\theta_{ij}))$$

$$L_{ijt} = \sum_{j=1}^{n} \sum_{t=1}^{2} L_{ijt}$$

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Theoretical framework

- Production functions:
  - Combining the two-time periods : $y_{ij} = f(x_{ij1}, L_{ij1}, x_{ij2}(\theta_{ij}), L_{ij2}(\theta_{ij}))$
  - Adding environmental factors, capital, and inputs' quality:

$$y_{ij} = f(x_{ij1}, L_{ij1}, x_{ij2}(\theta_{ij}), L_{ij2}(\theta_{ij}), \xi_{ij}, k_i, q_{ij}) + \upsilon_{ij}$$

2. <u>Two-fields production portfolio variance:</u>

$$Y_i = (y_{i1}, y_{i2})$$

$$Var(y_{i1}) = \sigma_{i1}^2, Var(y_{i2}) = \sigma_{i2}^2$$

$$Var(Y_i) = \mathrm{var}(y_{i1}) + \mathrm{var}(y_{i2}) = \sigma_{i1}^2 + \sigma_{i2}^2 + \rho\sigma_{i1}^2\sigma_{i2}^2$$

- Portfolio variance is reduced if ρ is negatively correlated which can be concretely achieved by:
  - Activity diversification:
  - Environmental diversification

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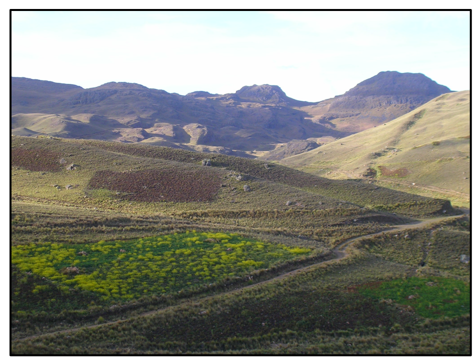
Theoretical framework

- Activity diversification:
  - Crops respond differently to the same microclimatic shock
  - Lima beans, cereals, and livestock
  - Inefficiency:
    - Limit gain from specialization

- Environmental diversification:
  - Environmental shocks between regions are negatively correlated
  - Sloped versus flat fields
  - Higher altitude
  - Inefficiency:
    - Field scattering
    - Higher transportation costs
    - Cultivation of remote land



Empirical framework

- To study the relationship between risk mitigation strategies and technical efficiency, an inefficiency term is added to the production function ⇨ Stochastic production frontier:

$$y_{ij} = f(x_{ij1}, L_{ij1}, x_{ij2}(\theta_{ij}), L_{ij2}, \xi_{ij}, k_i, q_{ij}) + \upsilon_{ij} + \mu_{ij}$$

- Assumptions about the errors terms:

$$\upsilon_{it} \sim N\left[0, \sigma_{it}^2\right]$$

$$\mu_{it} \sim N\left[\alpha' z_{ij}, \sigma_{it}^2\right]^+$$

- Cobb-Douglas production function is estimated jointly with inefficiency model, which is a function of:
  - Household head characteristics
  - Risk mitigation outcomes

Empirical framework

- Spatial analysis of household-level and field-level efficiency
  - General Moran I statistical test to detect for spatial autocorrelation
  - Getis-Ord General G statistical test to detect for clustering
  - Hot-spot analysis

- Efficiency comparison between households that have the option to spatially diversify and those that do not

- Efficiency comparison between households that have low level of activity diversification and those that have high level of activity diversification

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Data

- Random household survey in 2006-2007:
  - Data gathered on 389 households about agricultural activities, revenues, expenses, environmental and gender issues, etc.

- GIS Data:
  - Additional fieldwork in 2009 resulting in 287 georeferenced potato fields belonging to 123 households
  - DEM and soil maps
  - Roads network digitalized

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Production data

	Mean	Std. Dev	Minimum	Maximum
Yield (kg/ha)	10,647.47	5,377.10	640.00	30,000.00
Seed (kg/ha)	1,383.31	300.64	555.56	2,520.00
Fertilizer (N-K-P kg/ha)	339.54	242.42	0.00	1,749.60
Labor period 1 (hours/ha)	496.68	314.14	60.80	2,240.00
Labor period 2 (hours/ha)	605.96	345.45	53.28	2,086.40
Women-children labor ratio	0.32	0.16	0.00	1.00
Number of pesticide application	3.74	1.59	0.00	10.00
Farm asset (Bolivianos)	1,237.50	950.11	0.00	5,318.00
Elevation (m)	3,652.23	151.39	3,206.73	3,961.51
Slope (percent)	14.23	10.07	0.28	51.55
DFallow (previous land use)	0.27	0.45	0.00	1.00
DErosion (if erosion is heavy)	0.17	0.38	0.00	1.00
DTractor (land preparation)	0.17	0.37	0.00	1.00
DSeed2 (if seed size is 2)	0.05	0.21	0.00	1.00
DSeed45 (if seed size is 4 or 5)	0.61	0.49	0.00	1.00

Inefficiency data

	Mean	Std. Dev	Minimum	Maximum
Number of fields	2.37	1.40	1.00	8.00
Household head age	45.34	14.13	20.00	80.00
Household head literacy	0.85	0.36	0.00	1.00
Household head gender	0.16	0.37	0.00	1.00
Potato revenue over total crop revenue	0.87	0.24	0.00	1.00
Dummy for livestock revenue	0.51	0.50	0.00	1.00
Field area (ha)	0.32	0.29	0.03	2.50
Distance field-household (km)	1.62	1.98	0.03	12.35
Distance field-dirt road (km)	0.10	0.08	0.01	0.63
Distance field-paved road (km)	2.43	1.70	0.03	9.12

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Results

	Coefficients	Std. errors
Ln (Yield)		
Ln (Seed)	0.903***	0.102
Ln (Fertilizer)	0.037	0.039
Ln (Labor1)	-0.056	0.065
Ln (Labor2)	0.146**	0.060
Women-children labor ratio	-0.188	0.157
Ln (pesticide application)	25.528**	9.986
Ln (Farm asset)	0.047*	0.025
Ln (Elevation)	4.847***	1.368
Ln (Slope)	-0.011	0.032
DFallow	-0.103*	0.054
DErosion	-0.022	0.068
DTractor	0.137*	0.075
DSeed2	-0.197	0.130
DSeed45	0.124**	0.058
Ln(elevation)*Ln(pesticide appl.)	-3.123**	1.214
Constant	-37.326***	11.043

Note: *** p<0.01, ** p<0.05, * p<0.1

Results

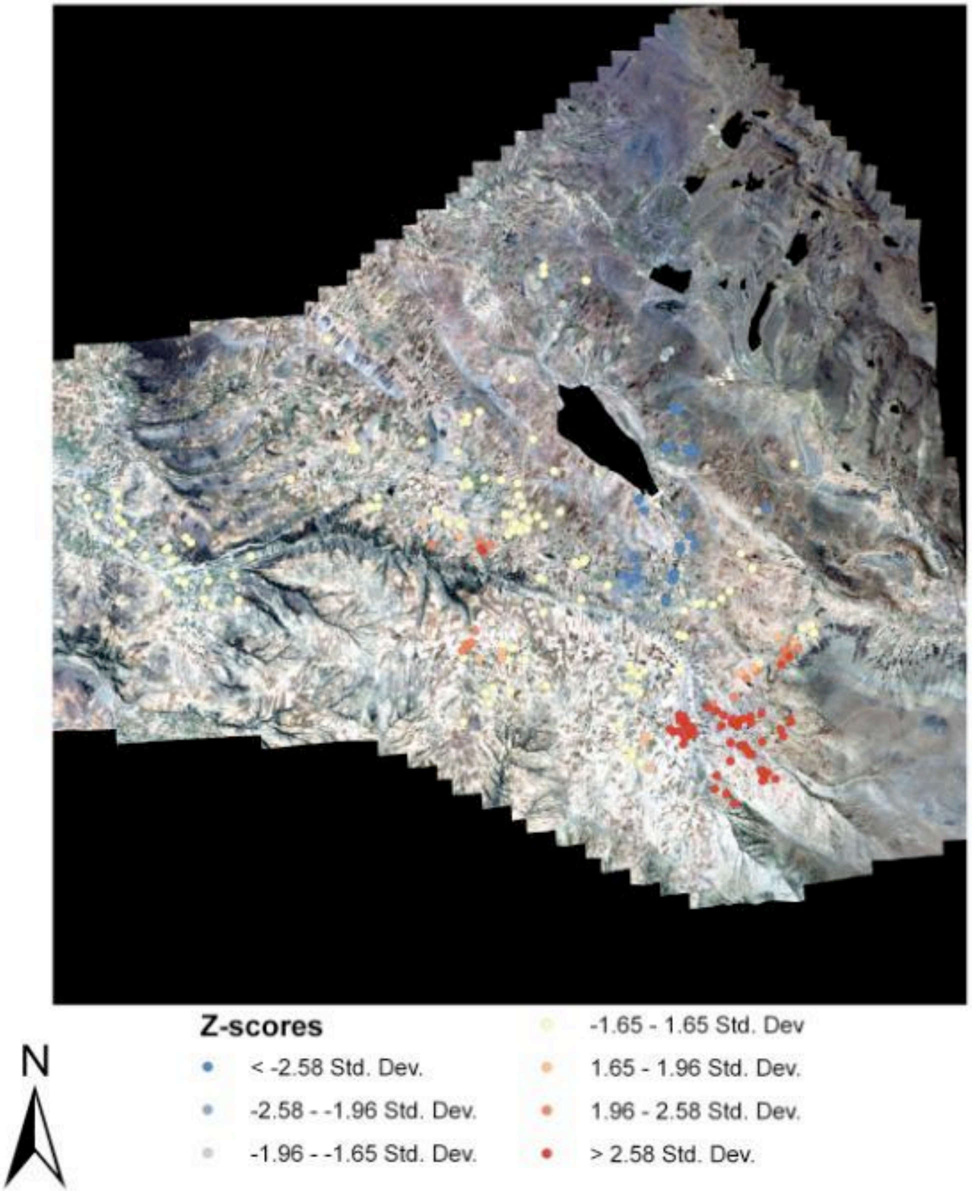
	Coefficients	Std. errors
Inefficiency model		
Potato revenue over total crop revenue	-0.568***	0.187
DLivestock revenue	-0.165**	0.083
Plot size	0.888***	0.152
Number of field	-0.047*	0.027
Household head age	0.008***	0.003
Household head literacy	-0.252*	0.142
Household head gender	-0.195	0.153
Distance field-household (km)	0.046**	0.022
Distance field-dirt road (km)	-0.545	0.510
Distance field-paved road (km)	-0.001	0.029

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

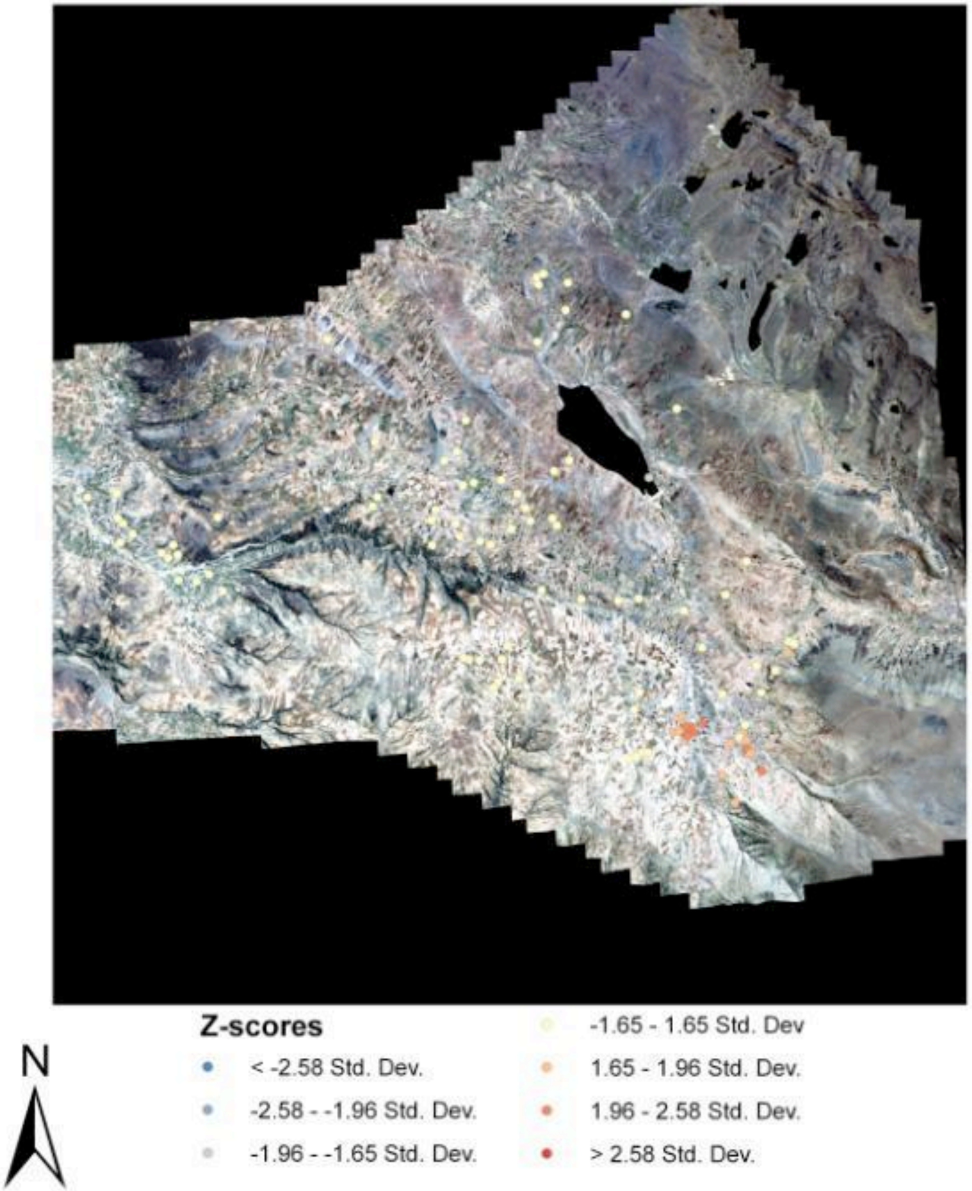
Spatial statistical tests

	Global Moran's I for spatial autocorrelation	
	Field-level efficiency	Household-level efficiency
Moran's Index	0.06	0
Z-score	4.89	0.42
Meaning	Clustered patters	Random
	Getis-Ord General G for High/Low Clustering	
	Field-level efficiency	Household-level efficiency
General G Index	0	0.01
Z-score	2.39	0.83
Meaning	High cluster	No clustering detected

Hot spot analysis of field-level efficiency



Hot spot analysis of household-level efficiency



Comparison: environmental diversification

	Mean	Std. Dev	N
Technical efficiency			
Do not spatially diversify	0.511	0.204	39
Do spatially diversify	0.496	0.161	84
Test for equality (P-value)	0.345	0.037**	.
Labor1 (hours/ha)			
Do not spatially diversify	538.205	349.288	39
Do spatially diversify	510.030	324.589	84
Test for equality (P-value)	0.336	0.286	.
Labor2 (hours/ha)			
Do not spatially diversify	628.314	397.733	39
Do spatially diversify	600.943	332.356	84
Test for equality (P-value)	0.355	0.088*	.

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Comparison: activity diversification

	Mean	Std. Dev	N
Technical efficiency			
Low activity diversification	0.516	0.181	88
High activity diversification	0.463	0.153	35
Test for equality (P-value)	0.051*	0.132	.
Labor1 (hours/ha)			
Low activity diversification	531.565	363.169	88
High activity diversification	487.280	235.040	35
Test for equality (P-value)	0.213	0.003***	.
Labor2 (hours/ha)			
Low activity diversification	627.328	380.874	88
High activity diversification	565.102	270.174	35
Test for equality (P-value)	0.156	0.013**	.

Note: *** p<0.01, ** p<0.05, * p<0.1

Conclusions

- Seed, pesticide, labor in period two, and elevation are important determinants of potato yield
- Inefficiency increases with the distance between the field and the household but decreases with the number of potato fields a household cultivates
- Alternative crop revenues increases inefficiency while livestock revenues decreases inefficiency
- Environmental diversification helps mitigate environmental risk with no significant lost in efficiency
- With a technical efficiency of 51.4%, there is a great potential to increase potato production in the study area

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THANKS
COMMENTS?

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