GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

KFW

3rd International Agricultural Risk, Finance, and Insurance Conference (IARFIC)

Meso-level insurance: Overcoming basis-risk and cost impediments of micro-level weather index insurance?

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23 June 2014

Structure

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1. Motivation

1. Motivation I

- Weather risk negatively affects investment behaviour
- Karlan et al. (2012): insured micro enterprises in Ghana invest more than the uninsured control group
- Rationale of insurance provision and microinsurance pilots for small (agricultural) enterprises in developing countries
- Weather risk might explain the reluctance of MFIs to expand lending to agricultural firms in rural areas (Collier et al., 2011; Collier and Skees, 2012; Miranda and Gonzales-Vega, 2011; Shee and Turvey, 2012)
- Low transaction costs and low moral hazard sensitivity make (weather) index-insurance approaches promising for developing countries

1. Motivation II

- Insurance uptake (especially by farmers) in developing countries remains to be low (Dercon et al., 2014; de Janvry, 2014)
- High transaction costs for small insurance contracts designed to be understood by small scale farmers
- High basis risk (e.g., caused by aggregated yield data, sparse weather data) as one of the main obstacles for scaling-up index insurance
- Overcoming basis risk by the application of better weather data and (more complex) indices, replacement of aggregated yield data by firm level yield data
- Potential of technical advantages limited due to data availability and financial literacy restrictions on customer level (responsible finance)
- Different story if insurance products fit to data and focus on customers which are legal institutions (e.g., financial institutions, agro-industry)

1. Motivation III

- Underwriting pooled risks (meso- or macro-level insurance) also allows reducing administrative underwriting costs (de Janvry, 2014)
- Meso- or macro-level insurance instead of micro-level, i.e., individual farm level insurance is expected to increase efficiency and up-take of weather index-insurance (e.g., Barnett et al., 2008; Binswanger-Mkhize, 2012)
- Insurance for financial intermediaries with most attention (Miranda and Gonzales-Vega, 2011; Collier et al., 2011; Collier and Skees, 2012)
- Pelka et al. (2013) find largely negative effects on agricultural credit risk for an MFI in Madagacar due to excessive rainfall in planting period
- African Union initiated the African Risk Capacity (ARC), an index-based drought insurance scheme on macro level

2. Objectives and Hypothesis

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Objectives

(1) Identifying a weather index for different regions in Tajikistan describing the precipitation cotton-yield relationship and being relevant from an cotton production point of view
(2) Designing an index insurance product based on this weather index
(3) Assessing the risk reduction potential of the index insurance product for different yield-risk aggregation levels (within and between regions)

Hypothesis „Accumulation effect“

Hedging effectiveness of the index-insurance product increases with increasing risk aggregation levels

3. Data and methods

3. Data

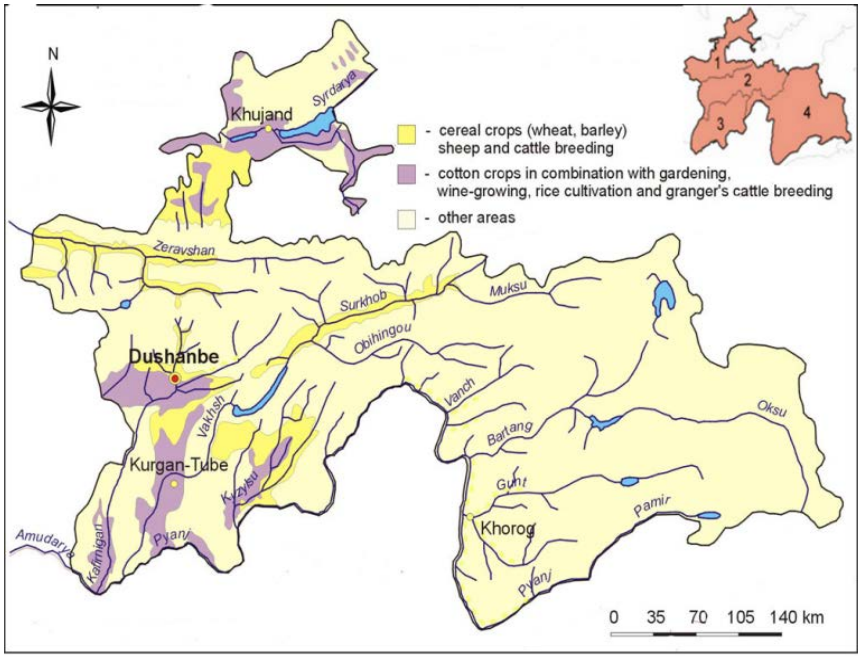
Yield Data

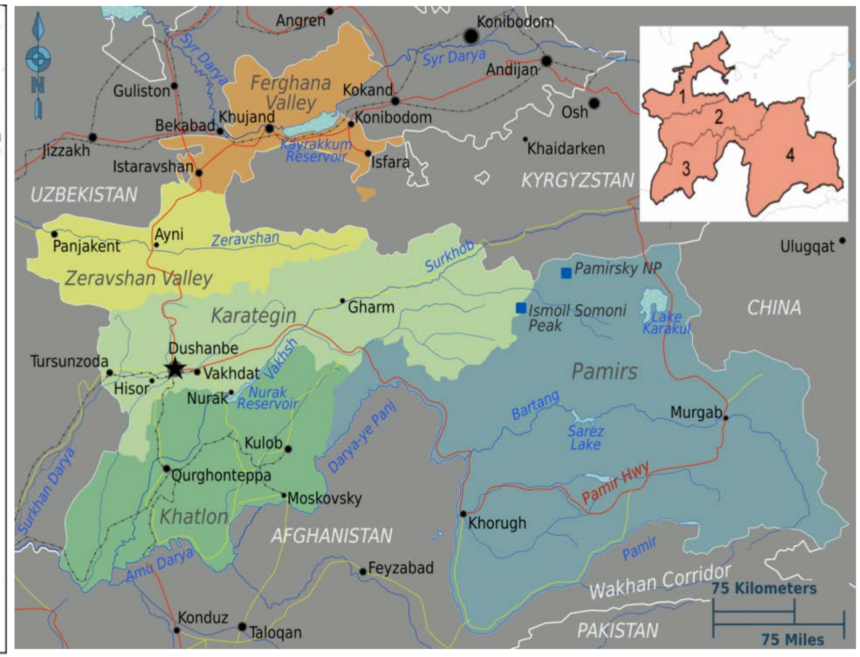
- Cotton production data provided by the Government of Tajikistan
- Covering the time period 2000-2010
- Covering all regions (Kathlon, Sogd, RSS) and 34 sub-regions where cotton is produced

Weather Data

- Provided by the Government of Tajikistan
- Six weather stations in Tajikistan (two in each region)
- Covering the time period 1985-2010, but only the period 2000-2010 consistently

3. Data - Cotton production in Tajikistan by regions





Numbers denote: (1) Sogd, (2) the Regions of Republican Subordination (RRS), (3) Khatlon, and (4) Gorno-Badakhshan Autonomous Oblast (GBAO).
Source: http://www.weltkarte.com/uploads/pics/karte-regionen-Tadschikistan.png (modified)

- Cotton sown in ha: 100,595 (Kathlon), 53,977 (Sogd), 7,812 (RRS)

3. Methods – Specification of a weather index

- Cumulation index:

$$I_t = \sum_{d=1}^{x} R_d$$

- I_t = Precipitation sum inherent in a cumulation period x of a year t
- x = cumulation period
- t = year
- R = precipitation
- d = day

3. Methods – Finding the weather event

Correlation between cumulative precipitation in mm/month and yield/ha for RRS					
month/subregion	1	2	3	4	5
Jan	-0,00791198	-0,06493454	-0,03091943	0,3274502	0,15991159
Feb	-0,25818119	-0,19367778	-0,51025376	-0,69981	-0,62274768
Mrz	0,08322248	0,15219053	-0,16710917	-0,18208331	-0,04950342
Apr	0,61420668	0,59203533	0,07389376	0,22635928	0,31076622
Mai	0,22809708	-0,00482224	-0,41478989	-0,46323052	-0,2896628
Jun	-0,33590483	-0,42351437	-0,70757808	-0,83707064	-0,67991405
Jul	-0,01545626	-0,21591109	-0,25356528	0,0650035	0,28753075
Aug	0,6910203	0,41495678	0,29605254	0,45639455	0,4906101
Sep	-0,27381137	-0,72969508	-0,72287551	-0,61207579	-0,73874414
Okt	0,72585382	0,49826266	0,53484353	0,75874226	0,5030962
Nov	0,78304117	0,6101496	0,19120627	0,43217962	0,28579723
Dez	0,06007933	0,43825345	0,1976236	0,25497624	0,6002265

3. Methods – Finding the weather event

	RSS - Hedging effectiveness (reduction of yield variance)					
Month	subregion 1	subregion 2	subregion 3	subregion 4	subregion 5	RSS total
February	-8,13	-0,69	-2,70	0,53	1,30	-1,22
May	-0,10	0,06	0,00	-0,03	0,04	0,00
June	-1,91	1,01	0,66	0,72	1,23	0,87
August	13,48	-10,18	-14,45	-10,60	-9,64	-11,92

3. Methods – Designing the insurance product

- Put option
- Index: Cumulative precipitation for May (Kathlon) and August (Sogd, RSS)
- Strike-level: ten year average precipitation
- Tick-size: optimized for maximum hedging effectiveness, i.e., difference of standard deviation between annual returns with and without insurance
- Pay-Out: tick-size/mm x precipitation (mm) below strike-level
- Premium: Fair-price, i.e., ten year average pay-out

4. Results

4. Results

Aggregation Level	avrg. yield/ha	yield SD	yield max	yield min	index month	avrg. precipitation in index month in mm	tick size	avrg. pay-off	hedging effectiveness (in % reduction of SD)	ha insured	contract premium in USD p.a.
Kathlon	16.78	2.37	19.17	11.99	May	24.07	20.13	196.2	20.16%	153,712	607,086,466
3 riskiest subregions	16.08	3.59	20.73	11.03	May	24.07	20.13	196.2	13.44%	23,306	92,048,264
5 riskiest subregions	15.71	3.43	20.31	13.12	May	24.07	20.13	196.2	20.34%	40,780	161,060,137
7 riskiest subregions	16.74	3.14	20.59	11.10	May	24.07	20.13	196.2	17.86%	56,644	223,715,459
Sogd	17.08	1.48	19.27	13.91	August	1.56	141.11	107.11	12.22%	73,873	1,116,538,100
3 riskiest subregions	18.78	2.30	22.77	14.42	August	1.56	141.11	107.11	16.74%	29,795	450,333,081
5 riskiest subregions	17.81	1.98	20.34	13.52	August	1.56	141.11	107.11	15.30%	51,471	777,944,981
7 riskiest subregions	17.08	1.48	19.27	13.91	August	1.56	141.11	107.11	12.22%	73,873	1.116.538,100
RSS	20.58	3.05	24.08	14.41	August	2.09	205.26	273.21	11.92%	19,045	1,068,026.166
3 riskiest subregions	20	3.63	23.61	12.74	August	2.09	205.26	273.21	13.20%	11,593	650,119,730
5 riskiest subregions	20.58	3.05	24.08	14.41	August	2.09	205.26	273.21	11.92%	19,073	1,069,596,381
7 riskiest subregions	n.A	n.A	n.A	n.A	n.a	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Tajikistan total (Kathlon, Sogd, RSS)	18.15	2.30	20.84	13.44	May/August	n.a.	n.a.	n.a.	14.69%	246,630	2,791,650,733
3 riskiest subregions	16.08	3.59	20.73	11.03	May/August	n.a.	n.a.	n.a.	13.43%	23,306	92,048,264
5 riskiest subregions	16.51	3.03	20.60	12.24	May/August	n.a.	n.a.	n.a.	17.15%	38,948	543,196,836
7 riskiest subregions	16.94	2.96	20.48	11.53	May/August	n.a.	n.a.	n.a.	18.38%	54,419	604,297,489
10 riskiest subregions	17.86	2.21	20.65	13.93	May/August	n.a.	n.a.	n.a.	18.71%	82,732	2,192,085,003

5. Conclusions and outlook

5. Conclusions

- Acceptance of hypothesis „Aggregation effect“
- Risk aggregation increases hedging effectiveness considerably (over regions) and, hence reduces basis risk
- Yield variance differs considerably over and within regions
- Aggregation within regions reduces hedging effectiveness
- Marginal increase of hedging effectiveness over regions smaller with each additionally considered region
- Increased hedging effectiveness and insured area comes to relatively higher total costs but lower costs per ha insured
- High premiums p.a. for single insurance contracts suggests inclusion of deductibles or adjustment of strike levels on „extreme“/knock out levels for parties insured

5. Outlook

- Risk aggregation along geographical characteristics and yield variance but not institution specific yet
- Regional risk exposition of specific risk aggregator likely to vary, i.e., individual aggregator‘s risk exposition for contract design
- No information about farm-level yields yet (getting them)
- Calculations for sub-regions not based on optimal weather station (i.e., weather station with highest hedging effectiveness)
- Premium based on fair-price calculation (average compensation = insurance premium), no load assumed
- Average cotton price of 150 USD/metric ton for all calculations
- Strike-level = average precipitation might not reflect different insurance needs (e.g., catastrophic insurance for governments vs. exact yield-loss compensation for agro-industry)

Thanks for listening!

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