Enhancing livestock herders' welfare in the context of climate change: An analysis of the 2012 harsh winter

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Nicholas Sitko,[1] Valentina Conti,[1] and Tilman Brück [2]

[1]FAO – Agricultural Development Economics Division, Germany
[2]IGZ – Leibniz Institute for Vegetable and Ornamental Crops, Italy

Background

- Livestock play critical economic, social, and cultural roles in Kyrgyzstan

- Some positive growth trends in the sector, driven mostly by domestic demand growth (FAO 2011)

- Kyrgyzstan has experienced a greater frequency of extreme weather events (e.g. droughts, harsh winters, flooding, landslides) which effect livestock sector performance (FAO, 2016)

Objectives

- Impact of a harsh winter in 2012 (weather shock) on livestock owning household's welfare (changes in food consumption valued (log), adjusted for 2013 prices)

- Analyse the effects of herd stocking changes (change in herd size and species composition) on welfare outcomes for HHs living in different market access areas

- Identify policy options to enhance resilience of livestock owning households to the effect of climate change

Data Sources

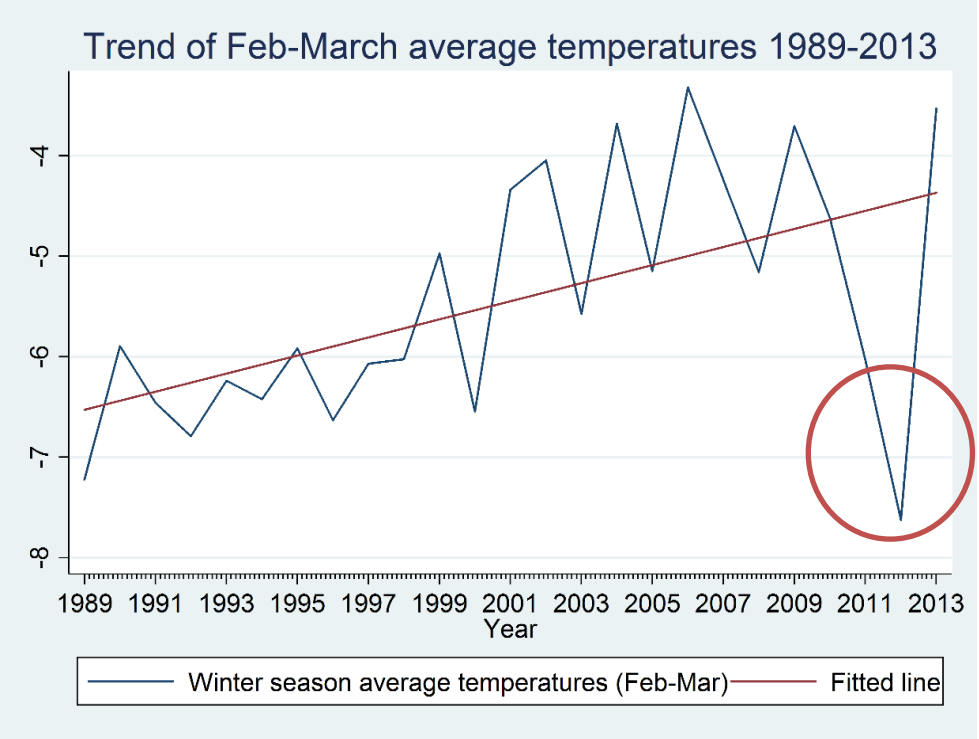
- **Life in Kyrgyzstan (LiK):** multipurpose, unique household panel survey led by IGZ available for years 2010-2013, and 2016 wave
  - Representative at national level (North/South/East/West); 2,815 households (2012); 2,584 (2013)
  - We focus on 2011-2012-2013 data: *1,500* HHs per year
  - Soon exploit LiK 2016 containing detailed info on land & agricultural markets

- **Temperature data**: European Centre for Medium-Range Weather Forecasts (ECMWF) 10-daily rasters at a pixel resolution of 0.25 degree (~25km at the eq)

- **Administrative data** : oblast/rayon variables: pop density, producer prices; info on rural institutions (district level extensions, veterinary services)

- **WB**: Market Access Index (rayon/city level) for year 2010

Key variables - 2012 Harsh winter shock



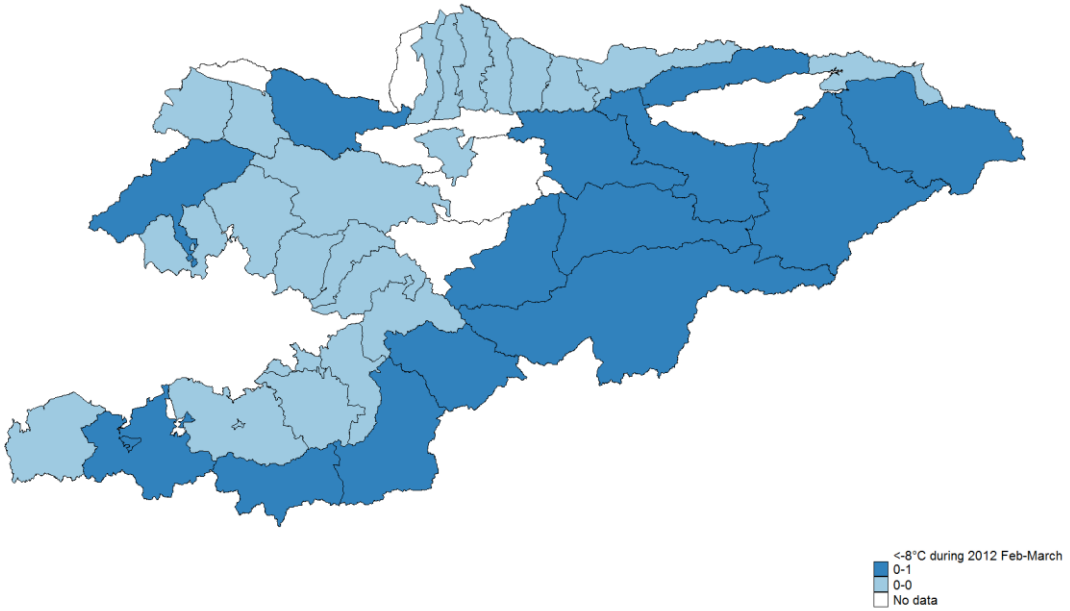
Harsh Winter in 2012: unusually low temperatures, heavy snowfall and ice prevented especially **sheep**, **cows** and **bulls** from reaching grass leading to **animal death** (*Ministry Emergency situations*).

The shock also resulted in *mudflows* and *flash flood* due to melting snow in the early Spring

Key Variables -2012 Harsh winter shock (cont'd)

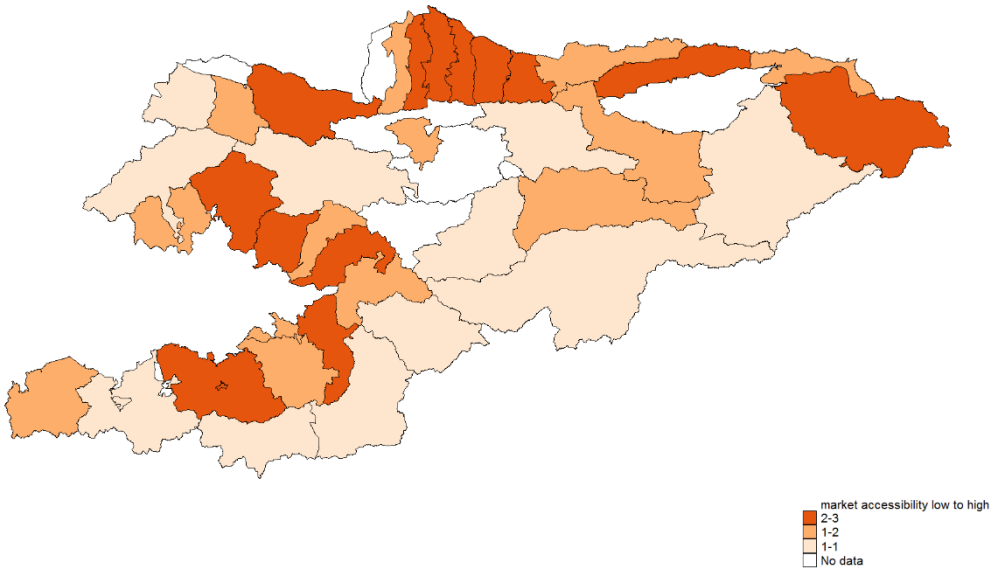
Districts hit by shock: those for which average Feb-March temperature (ECMWF) in 2012 fall below the 25th percentile of the long-term temperature distribution (1989-2011):

$$TAV_{FM(2012)} = 1 \; if \; TAV_{FM(1989-2011)} < p_{25} \cong -8°C$$



Key Variables - Market Access Index

- Districts are divided into **low**, **moderate** and **high** level of market accessibility based of the WB index



Measures the potential economic connectivity between village/towns and big cities using GIS data. Assessment of all possible travel routes using a travel time model between the target city and the origin on a transportation network, and pick the shortest travel time from origin to target city (considers road condition + travel speed)

Conceptual framework

- Livestock play a role in **ex-ante** risk management strategies enabling income and consumption diversification (Ellis, 1998; Niehof, 2004; Megersa et al., 2014)

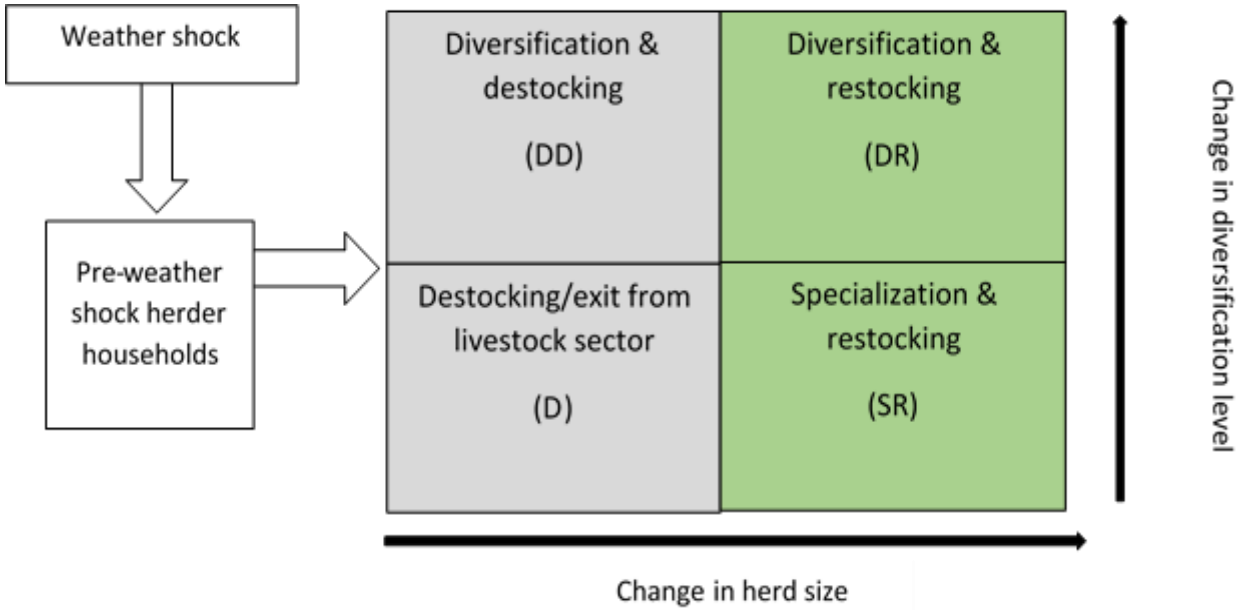
- In **ex-post** disaster recovering livestock is a way to smooth consumption or assets after losses in agricultural production (Carter et al, 2007; Hoddinott, 2006)

- Herders' risk management behavior strongly depends on pre-shock **socio-economic conditions** and **market accessibility**

- Poorer or more isolated herders may lack capacity inside the livestock sector (e.g. veterinary services, restocking) or outside the sector to respond to the shocks (Schoch et al., 2008; Steimann, 2011).

Conceptual framework - HHs risk MGMT behavior

- Herd changes in response to weather shocks occur along two dimensions: **herd size** (measured in livestock units) and **species composition**:



- **Boxes in green** reflect post-shock HHs decision to restock their herds and opt for animal diversification vs. specialization
- **Boxes in grey** households that lost animals and lacked resources to recover or HHs moving out of livestock to non-farm sectors

Descriptive Statistics (livestock mgmt. strategies)

	Stocking Behavior in Response to Shock			
	Divers. Restock	**Specializ. Restock.**	**Divers. Destock**	**Destocking Exit**
Share of all herders (row-wise sum to 100)	35.51	31.24	6.52	26.74
Change in value of food consumption pre- to post-shock	-11.29%	-15.9%	-22.84%	-34.9%
Market Access				
- High	6.7	3.6	7	50
- Medium	22.1	51.8	17.2	48.3
- Low	71.2	44.6	75.8	1.7
Avg herd size (in LU)	4.29	5.3	3.81	3.38
Change in herd size	51.1%	34.8%	-18.8%	-21.28%

- Most of HHs in restock & diversification live in low market access areas (71%), 52% of restock & specialization come from moderate market access (52%)
- Relevant increase in herd size especially for HH adopting restock & diversification
- The two categories (green columns) feature a lower change in food consumption than other categories (relatively higher welfare)

Empirical Model (1)

- Herder HHs may respond differently to the shock according to **welfare conditions**.

- Standard Diff-in-Diff estimation (DID) approach to measure the **average** shock effect as well as a **non-linear** quantile diff in diff model to study **heterogeneity** of the shock impact:

$$\log Y_{it} = \alpha + \delta_t + \boldsymbol{\beta}\left(S_t^{post} * HShock_i\right) + X_{it}\delta + \varepsilon_{it}$$

Results – shock impact by consumption quantile

VARIABLES	(1) (mean)	(2) (q10)	(3) (q25)	(4) (q50)	(5) (q75)	(6) q(90)
Effect of 2012 Feb-March shock	-0.0492	0.0238	0.0888	-0.00260	**-0.0986****	**-0.222*****
	(0.0812)	(0.0481)	(0.0378)	(0.0321)	(0.0386)	(0.0464)
Family size	-0.0952***	-0.0897***	-0.0933***	-0.0951***	-0.0905***	-0.0877***
	(0.00594)	(0.00468)	(0.00368)	(0.00312)	(0.00376)	(0.00452)
Head is female	-0.0298*	-0.0541**	-0.0298	-0.0382**	-0.0320	-0.0303
	(0.0160)	(0.0260)	(0.0204)	(0.0173)	(0.0208)	(0.0251)
Age of household head	0.00151**	0.00103	0.00137**	0.00160***	0.00180***	0.00194***
	(0.000682)	(0.000767)	(0.000603)	(0.000512)	(0.000615)	(0.000741)
Highest edu household head	0.0605**	0.0291	0.0627***	0.0672***	0.0424**	0.0517**
	(0.0246)	(0.0261)	(0.0205)	(0.0174)	(0.0210)	(0.0252)
Market access	0.00241	0.00237	0.000466	0.00307	0.00541	-0.00365
	(0.00782)	(0.00561)	(0.00442)	(0.00375)	(0.00450)	(0.00542)
Herd size (LU)	0.00319***	0.00147	0.00143	0.00385***	0.00399***	0.00513***
	(0.000819)	(0.00128)	(0.00100)	(0.000852)	(0.00103)	(0.00123)
Number livestock species	0.0426***	0.0517***	0.0551***	0.0380***	0.0257***	0.0347***
	(0.0128)	(0.0103)	(0.00814)	(0.00691)	(0.00830)	(0.01000)
HH has a tractor	0.0976***	0.126***	0.135***	0.115***	0.0996***	0.0664*
	(0.0254)	(0.0416)	(0.0327)	(0.0278)	(0.0334)	(0.0402)
Technology asset index	0.0841***	0.0920***	0.0858***	0.0805***	0.0806***	0.0691***
	(0.0102)	(0.0111)	(0.00877)	(0.00744)	(0.00894)	(0.0108)
Constant	7.253***	6.498***	6.668***	7.109***	7.532***	7.566***
	(0.437)	(0.369)	(0.290)	(0.246)	(0.296)	(0.356)
Oblast fixed effects	YES	YES	YES	YES	YES	YES
Observations	4,383	4,383	4,383	4,383	4,383	4,383
R-squared	0.333					

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Results

- Negative and significant effect of the shock for HHs with higher food consumption (q75-q90):

i) Top quantiles probably shift from more high-value food items to lower value staple food in post-shock

ii) HHs with higher food consumption lose more: positive significant correlation between herd size and food consumption valued

- HHs with higher technology assets (e.g. radio, laptop, internet) are associated with higher value of food consumption
- Tractor ownership significant and positive sign across all food consumption quantiles, with coefficients being higher in magnitude for the poor
- Number of livestock species positive and significant, higher coefficients for bottom quantiles

Empirical Model (2)

- Diff-in-Diff-in-Diff (DDD) to separately analyze the role of i) **market access**, ii) **cash flows** availability in presence of a shock, and iii) post-shock **diversification** and **specialization** dynamics:

$$\log Y_{it} = \alpha + \delta_t + Z_i^{cop} + \beta_1\left(S_t^{post} * HShock_i\right) + \beta_2\left(HShock_i * Z_i^{cop}\right) + \beta_3\left(S_t^{post} * Z_i^{cop}\right) + \boldsymbol{\beta_4}\left(S_t^{post} * HShock_i * Z_i^{cop}\right) + \epsilon_{it}$$

Results – shock impact by market access

	Food consumption (valued)			
VARIABLES	(1)	(2)	(3)	(4)
	Mean estimates	Low food cons.	Mid food cons.	High food cons.
Effect of 2012 Feb-March shock in low- vs. mid to high market areas	-0.0848	**-0.161****	-0.0563	0.164
	(0.188)	(0.0924)	(0.0390)	(0.118)
Constant	7.189***	5.632***	6.169***	7.132***
	(0.501)	(0.282)	(0.143)	(0.308)
Oblast fixed effects	YES	YES	YES	YES
Observations	4,383	1,151	2,343	889
R-squared	0.308	0.149	0.098	0.269

- Negative estimates for low food consumption HHs suggest that poor HHs hit by the shock living in low market accessible areas further worsen their welfare with respect to the poor living in more accessible areas

Results – shock impact by remittances availability

VARIABLES	(1)	(2)	(3)
	ALL HERDER HHs	Female-headed HHs	Male-headed HHs
Effect of receiving remittances after the 2012 Feb-March shock	0.0284	**0.364****	-0.0871
	(0.103)	(0.225)	(0.0927)
Constant	7.312***	7.117***	7.317***
	(0.430)	(0.608)	(0.426)
Oblast fixed effects	YES	YES	YES
Observations	4,383	877	3,506
R-squared	0.304	0.355	0.297

- Results of the impact shock show that female-headed HHs are more vulnerable than male-headed households, especially from median to bottom quantiles. We therefore see the effect of remittances by HH category
- Remittances availability are used as a proxy for cash flows. Positive estimates suggest that female-headed HHs hit by the shock relying on remittances in the pre-shock period, had 34% increase in food consumption with respect to female-headed households w/o remittances

Results – shock impact by herd management

	(1)	(2)	(3)	(4)
Livestock management strategies	ALL HERDER HHs	LOW MK ACCESS	MODERATE MK ACCESS	HIGH MK ACCESS
Diversification & restocking	0.0397	-0.0884	**0.241****	-0.172**
	(0.0479)	(0.158)	(0.116)	(0.0678)
Specialization & restocking	0.0173	0.0574	-0.121	**0.354*****
	(0.0566)	(0.0790)	(0.108)	(0.0868)
Oblast fixed effects	YES	YES	YES	YES
Observations	4,376	1,143	2,099	1,134
R-squared	0.308	0.35	0.33	0.39

- Post-shock **diversification & restocking** in **moderate market access** areas leads to a 24% food consumption increase relative to HHs not following this strategy
- Post-shock **specialization & restocking** in **high market access** areas leads to a 35% food consumption increase relative to HHs living not following this strategy
- When market accessibility is high specialization is preferred over speices diversification

Conclusions

- Effect of winter shock on consumption concentrated among better off HHs
- Pre-shock welfare conditions matter:

i) living in **low market access** areas decrease welfare of poor HHs (25th pctile) hit by the shock compared to poor HHs living in less remote areas

ii) Relying on **remittances** from labor migrants mitigates the shock effect for female-headed HHs

- Herders' post-shock risk management behavior:

1) **Livestock specialization** improves food consumption outcomes in high market access areas. When market opportunities increase, herders can tailor their production and marketing behaviors to meet market demands better than diverse livestock systems
2) **Livestock diversification** after a climate shock increases welfare in moderate market access areas

Policy Implications

- Improved market access conditions (e.g. rural roads and livestock infrastructures) mitigate the deleterious effects of climate shocks and enable herders to capture welfare benefits from livestock specialization
- In more accessible regions, supporting herders to specialize in the management of specific animal species enhances post-shock welfare outcomes.
- In more remote regions returns to diversification in the context of weather shocks is high.
- Public investments in extension messaging, animal stocking activities, and market and veterinary services should be tailored to specific market conditions.
- Targeted cash transfers may enhance resilience for female-headed herder HHs.

Thank you!

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Results – shock impact big herder (50 sheep/goats+)

VARIABLES	(1) (mean)	(2) (q10)	(3) (q25)	(4) (q50)	(5) (q75)	(6) q(90)
Effect of 2012 Feb-March shock	**-0.196***	**0.0644**	**-0.00660**	**-0.201*****	**-0.366*****	**-0.426*****
	(0.0997)	(0.0859)	(0.0798)	(0.0760)	(0.0756)	(0.0781)
Family size	-0.108***	-0.120***	-0.110***	-0.113***	-0.102***	-0.0977***
	(0.00839)	(0.00706)	(0.00656)	(0.00625)	(0.00621)	(0.00642)
Head is female	-0.0603**	-0.132***	-0.0439	-0.0365	-0.0168	-0.0274
	(0.0274)	(0.0388)	(0.0360)	(0.0343)	(0.0341)	(0.0352)
Age of household head	0.00213*	0.00404***	0.00172	0.00153	0.000868	0.00280**
	(0.00106)	(0.00128)	(0.00119)	(0.00113)	(0.00113)	(0.00116)
Highest edu household head	0.0956***	0.0338	0.0989***	0.0936***	0.0996***	0.0838**
	(0.0308)	(0.0404)	(0.0375)	(0.0358)	(0.0355)	(0.0367)
Number livestock species	0.0794***	0.0629***	0.0781***	0.0813***	0.0682***	0.0752***
	(0.0142)	(0.0195)	(0.0181)	(0.0173)	(0.0172)	(0.0177)
Market access	0.0226**	0.0254**	0.0224**	0.0202**	0.0243**	0.0442***
	(0.00965)	(0.0112)	(0.0104)	(0.00991)	(0.00985)	(0.0102)
Technology asset index	0.0915***	0.103***	0.0970***	0.0972***	0.0797***	0.0685***
	(0.0132)	(0.0172)	(0.0160)	(0.0152)	(0.0152)	(0.0157)
Animal population	-4.39e-07*	2.04e-07	-2.19e-07	-3.15e-07	-6.24e-07***	-9.34e-07***
	(2.28e-07)	(2.60e-07)	(2.41e-07)	(2.30e-07)	(2.28e-07)	(2.36e-07)
Constant	7.344***	5.603***	6.613***	7.131***	7.941***	8.716***
	(0.484)	(0.502)	(0.466)	(0.444)	(0.441)	(0.456)
Oblast fixed effects	YES	YES	YES	YES	YES	YES
Observations	1,293	1,293	1,293	1,293	1,293	1,293
R-squared	0.474					

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Results – shock impact big herders by market access

VARIABLES	(1)	(2)	(3)
	(mean)	Food cons.below median	Food cons. above median
Effect of 2012 Feb-March shock in low- vs. higher market areas	**-0.270****	**-0.174**	**0.126***
	(0.120)	(0.139)	(0.0669)
Constant	7.241***	5.853***	7.342***
	(0.479)	(0.341)	(0.401)
Observations	1,295	647	648
R-squared	0.475	0.199	0.413

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, *p<0.1

- Living in low market areas decreases food consumption valued of big HHs by 27% compared to those living in more accessible areas
- When running the analysis by food consumption level, the effect is positive and significant for relatively better-off HHs

Results – shock impact big herders

- Model confirms big HH herders suffer the most from the harsh winter shock. Shock effect estimates in magnitude are the same at **mean** and a **median** level, suggesting robustness of the results
- Number of livestock species is positively correlated with food consumption valued across all quantiles
- Technological assets are significant for all quantiles but coefficients magnitude is higher for bottom quantiles
- Female-headed HHs are the most vulnerable and this is especially true for the poorest quantile