Extended Abstract

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Paper/Poster Title	**Farm-level responses to weather trends**

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Abstract	***200 words max***
Assessing the effects of climate change on agricultural production is crucial for designing policies related to climate change and climate change mitigation. A large body of literature identified detrimental effects on crop yields around the globe under various climate change scenarios, while farm-level adaptation has been shown to alleviate the adverse climate effects. In this paper, we examine farms' production responses to weather trends considering both expected and realized weather using a structural approach. To this end, we estimate a theoretically consistent system of output supply and input demand functions, controlling for farm heterogeneity and multivariate crop selection. Using panel data on German crop farms from 2005 to 2019, we find that both observed and expected weather affects farmers output and input decisions. Finally, a simulation approach quantifies the immediate and lasting effects of a drought shock.	

Keywords	Adaptation, profit function, structural model, weather shocks
JEL Code	Micro Analysis of Farm Firms, Farm Households, and Farm Input Markets Q12 Climate; Natural Disasters and Their Management; Global Warming Q54

Introduction	***100 – 250 words***

By its very nature, agricultural production heavily depends on weather patterns. Rising mean temperatures along with changing precipitation regimes substantially alter growing conditions for crops (Lobell, Schlenker and Costa-Roberts 2011) and livestock (Gisbert-Queral et al. 2021). The ability of farms to adjust to these environmental changes is crucial for the viability of the agricultural sector in the future.

In this paper, we use a structural approach to examine farms' production responses to both expected and realized weather, using farm-level accountancy data from German crop farms. Specifically, we assess farmers' responses in output supply and input demand to weather trends, both in the short and in the longer run, using a structural profit function approach. The model is applied to German crop farms using farm accountancy data from 2005 to 2019 combined which weather data at the municipality level. The paper contributes to the understanding of climate impacts on agriculture by developing a structural model that takes into account farmers' behavioral responses to experienced weather outcomes in the more distant and the more recent past. This set up allows examining the short- and longer-term effects of extreme weather events, such as the European drought in 2018, on farmer's production decisions.

Methodology	***100 – 250 words***

We assume that farmers choose output (q) and input (x) quantities to maximize expected profits ($E[\pi]$), and that $E[\pi]$ depends on input prices (r), price expectations ($E[p]$), and weather expectations ($E[w]$). Furthermore, farmers form weather expectations based on experiences in the past, distinguishing between the more recent and more distant past (Ramsey et al., 2020):

$$E[w_{i,t}] = \omega_0 + \omega_s W(w_{i,t-1}, w_{i,t-2}, w_{i,t-3}) + \omega_l W(w_{i,t-4}, \dots, w_{i,t-10}),$$

where ω_0 is a reference expectation, ω_s is the farmers' weight put on the recent past (i.e., the last three years), and ω_l is the weight put on the more distant past.

We then formulate the profit function using a normalized quadratic functional form that includes linear and quadratic weather terms as profit shifters. The weather variables are interacted with output prices, since the impact of weather outcomes on farm profits may be more pronounced for some crops than for others (Arora et al. 2020). Based on our theoretical considerations, both expected and realized weather variables are included in the profit function (Sesmero et al. 2018). From this profit function, we derive a system of crop-specific output supply and input demand functions using Hotelling's Lemma, which are empirically estimated accounting for non-random crop selection following the multi-variate crop selection model by Lacroix and Thomas (2011). Finally, we use the estimated parameters to simulate the immediate and lasting effect of a weather shock on farmers' input and output choices, using weather realizations from the 2018 drought as example.

Results	***100 – 250 words***

The model is estimated for 5 crop outputs (cereals, protein crops, oilseed crops, root crops, and fodder crops), 2 variable inputs (fertilizer, other material inputs), and 3 quasi-fixed inputs (land, labor, capital). Weather is described using four variables: growing degree days, precipitation, high degree days, and the number of dry days. Preliminary results indicate that both past and experienced weather outcomes have statistically significant effects on output and input levels. For example, more high degree days the past increases cereal output at the expense of root crops, and warmer temperatures in the current cropping season increase protein supply but decrease cereal and oilseed production. Simulating the short- and long-term effects of the 2018 drought, we find that the shock increases protein supply compared to its long-term average, while output levels of all other crops were below average in the drought year. Fertilizer use is also significantly reduced by the shock, consistent with lower growth potential of crops. Oilseed supply and fertilizer demand remain at reduced levels in the three subsequent years, before oilseed supply returns to its original level and fertilizer use is even increased four years after the shock.

Discussion and Conclusion	*100 – 250 words*
In this paper, we use a structural model to assess farm-level responses to weather trends. We assume that farmers optimize input use and output levels based on the relative (expected) profitability of individual crops. Our results suggest that both past and current weather have significant effects on output and input levels, and that extreme weather events have both an immediate and lasting effect on crop-specific output levels and input usage. An important limitation of our approach is that it does not allow to explicitly disentangle land and yield elasticities, a topic that we will address in further research. As for policy implications, the study highlights that behavioural responses to climate change at the farm-level must be considered to assess the climate damage and to target climate change mitigation and adaptation policies.	

References

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