Extended Abstract
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Paper/Poster Title	**Pre-harvest weather effects on the probability of wheat downgrading**

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Abstract	***200 words max***

Crop yield quality depends on weather conditions and affects producer prices. The economically most important quality risk in wheat production is low baking quality due to the activation of undesired proteins. Bread and biscuit wheat of low baking quality is downgraded to animal feed and marketed at a much lower price. In this paper, we estimate precipitation and temperature effects on the probability of such a downgrading and assess its economic relevance at the field-level. To this end, we use a linear probability model and simulate economic losses. We exploit a large dataset consisting of 1'696 observations from the official Swiss wheat varieties trail network. Our results show that precipitation some days prior to harvest increases the risk of a downgrading and moderate temperatures some days prior to harvest decrease the risk of a downgrading. Downgrading of bread and biscuit wheat occurs frequently and decreases revenues by up to 33%. Thus, unfavourable weather some days prior to harvest can cause severe losses. This paper highlights the economic importance of wheat quality, provides important information about the underlying risk to various actors in the food system and builds a basis for improved risk management.

Keywords	Crop quality, weather effects, wheat
JEL Code	Q15

Introduction	***100 – 250 words***

Adverse weather conditions can reduce crop quality (Kawasaki and Uchida 2016; Ramsey et al. 2020). Low quality puts food security at risk and affects farmers' profitability because quality determines producer prices (Dalhaus et al 2020). The assessment and management of weather-dependent quality risks is therefore essential to ensure food systems that provide high-quality foods for a growing population and farmers' financial well-being.

Wheat is among the most widely grown crops in the world and a low baking quality due to the activation of undesired proteins is the most important quality risk in temperate regions because affected wheat is downgraded to feed wheat and marketed at a much lower price.

Here we estimate overall precipitation and temperature effects on the probability of a downgrading of bread and biscuit wheat to animal feed wheat due to low baking quality and we assess the economic relevance of such a downgrading at the field-level. To this end, we use a panel dataset from the official Swiss wheat varieties trial network consisting of 1'696 observations from 2008 to 2019. Moreover, we discuss possible risk management tools to cope with the risk of a downgrading in wheat production.

This paper presents the first economic assessment of weather effects on wheat quality, and in particular of low baking quality. Our results highlight the economic importance of quality risks and inform various actors such as farmers, researchers, insurers, etc. about the underlying risk exposure. Moreover, our results provide a basis to improve risk management at farm-level and breeding efforts.

Methodology	***100 – 250 words***

We use an econometric model to estimate precipitation and nonlinear temperature effects on the probability of a downgrading of bread and biscuit wheat to feed wheat. More specifically, we use a linear probability model with two fixed effects (variety and location) to estimate the effects of cumulative precipitation, growing degree-days and heat degree-days (d) days prior to harvest on the probability of a downgrading while controlling for the same weather variables between sowing and the (d) days prior to harvest. The dependent variable is dichotomous (1=downgrading; 0=no downgrading).

For the number of days prior to harvest (d), we consider values from 1 to 60 because literature shows that weather effects a few weeks prior to harvest have the largest impact on the probability of a downgrading (Barnard and Smith 2012). For the calculation of growing- (temperature load from 5°C to a heat threshold) and heat- (temperature load above the heat threshold) degree-days, we consider heat thresholds from 25°C to 32°C because literature has not identified suitable thresholds yet. We run the econometric model for each d (number of days prior to harvest) and heat threshold combination. Finally, we pick to model with largest goodness of fit using the Akaike Information Criterion.

We use a linear probability model because of the incidental parameter problem and cluster standard errors by variety. As robustness checks, we estimate the same model with logit, probit and poisson regression.

In the economic analysis, we simulate revenues, comprising wheat yields times historical producer prices, under consideration of a downgrading to feed wheat that causes an abrupt price cut.

Results	*100 – 250 words*

We find cumulative precipitation some days prior to harvest to increase the risk of a downgrading and exposure to moderate temperatures some days prior to harvest to decrease the probability of a downgrading.

More specifically, the model with largest goodness of fit is the one with (d) equal to 31 days prior to harvest and a heat threshold equal to 27°C. For this model, cumulative precipitation 31 days prior to harvest significantly increases the probability of a downgrading by approximately 0.1% for each additional millimetre. Growing degree-days (5°C-27°C) measured 31 days prior to harvest are beneficial and significantly reduce the probability of a downgrading by 0.04% for each additional degree-day unit.

For our control variables, we find no significant effects of precipitation and a positive effect of temperature loads from sowing to 31 days before harvest on the probability of a downgrading. Both fixed effects, and especially the variety fixed effect, increase the model fit.

In our economic analysis, we find large economic consequences of a downgrading of bread and biscuit wheat to feed wheat. Downgrading of yields due to low baking quality occurs regularly and is in some years systematic (i.e. a large share of yields is downgraded across Switzerland). A downgrading causes a large loss in revenues. The median loss for biscuit wheat (lowest prices) is approximately 25% and for the best bread wheat (highest prices) approximately 33%.

Discussion and Conclusion	*100 – 250 words*

We find a downgrading due to poor baking quality to cause large economic losses and to be variety and weather dependent. Especially precipitation some days prior to harvest increases the risk of low baking quality. This has implications for various actors in the food system.

Farmers have no short-term adaptation capabilities (e.g. use of pesticides) because the most relevant weather risk exposure is too close to the harvest date so that no more inputs can be applied. However, farmers can reduce the probability of a downgrading by using robust varieties but there might be trade-offs with other relevant traits (e.g. yield potential, robustness to other diseases, etc.).

Insurance products that cover the risk of a downgrading exist and can reduce financial losses. However, insurers should be aware that farmers can provoke payouts by using vulnerable varieties and deliberately delaying harvests. Such moral hazard problems can cause insurance market failure. Our results suggest that weather index insurance,

which can overcome moral hazard problems, might also be an option to cover the risk of a downgrading.

Research can support data collection required for accurate risk assessments (e.g. real world data that is currently not available), improve risk management strategies and develop new breeding programmes that better reflect the risk of low baking quality.

Policymakers can support researchers in their efforts to improve risk assessments and risk management. Moreover, they can support the public provision of such data to improve general risk management, insurance solutions and breeding programmes.

Barnard, A., & Smith, M. F. (2012). Determination of the influence of climate on falling number of winter wheat in the dryland production areas of the Free State Province of South Africa. *Euphytica*, *188*(1), 15-24.

Dalhaus, T., Schlenker, W., Blanke, M. M., Bravin, E., & Finger, R. (2020). The effects of extreme weather on apple quality. *Scientific reports*, *10*(1), 1-7.

Kawasaki, K., & Uchida, S. (2016). Quality Matters more than quantity: asymmetric temperature effects on crop yield and quality grade. *American Journal of Agricultural Economics*, *98*(4), 1195-1209.

Ramsey, A. F., Tack, J. B., & Balota, M. (2020). Double or Nothing: Impacts of Warming on Crop Quantity, Quality, and Revenue. *Journal of Agricultural and Resource Economics*, 1-22.