Climate change adaptation: Evidence from Austrian farms

178th EAAE Seminar
Future challenges and resilience of farming systems in Europe

Julian Zeilinger[1], Andreas Niedermayr[1], Abdul Quddoos[2] and Jochen Kantelhardt[1]

May 19, 2021

[1]Institute of Agricultural and Forestry Economics, University of Natural Resources and Life Sciences, Vienna
[2]Department of Economics, Government College University Faisalabad, Faisalabad

Background and objectives

– Agriculture is highly influenced by climate change and thus many EU member states employ specific measures to mitigate its effect (EEA, 2019)

– When assessing climate change impacts it is therefore important to account for the possibility of adaptation in order to derive unbiased long-run effects (Schlenker and Roberts, 2009)

– Studies based on the Ricardian approach are prominent among statistical methods of impact assessment as it considers long-term adaptation but imposes the strict assumption of full adaptation (Mendelsohn et al., 1994)

Background and objectives

– Recent literature has identified adaptation as complex process, which requires multiple factors (Smit and Wandel, 2006)

– There is upcoming evidence that farms are not responding sufficiently to climate change (Burke and Emerick, 2016)

– Therefore, this study accounts for potential limitations of climate change adaptation by relaxing the assumption of perfect adaptation and derives the extent of adaptation of Austrian farms

Conceptual framework

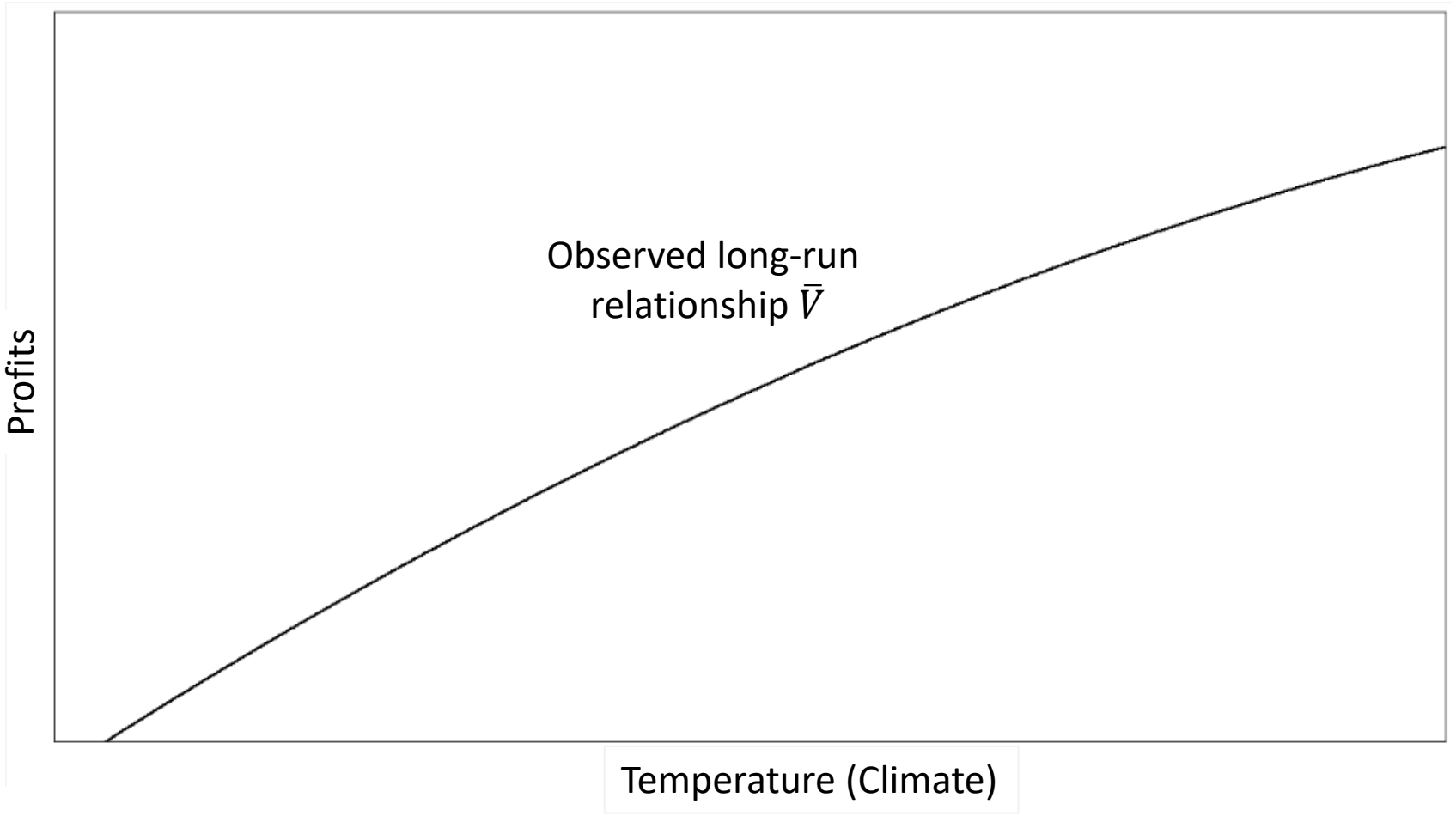
– In the Ricardian approach farmers are assumed to have adjusted production practices in the long-run to their respective climate in order to maximize profits (Mendelsohn et al., 1994)

– The expected long-run profits $\overline{V}$ are thus a function only of the exogenous variables relevant for the production decisions the farmer makes:

$$\overline{V} = f_1(\overline{W}, \Xi)$$

Climate Additional controls

Conceptual framework



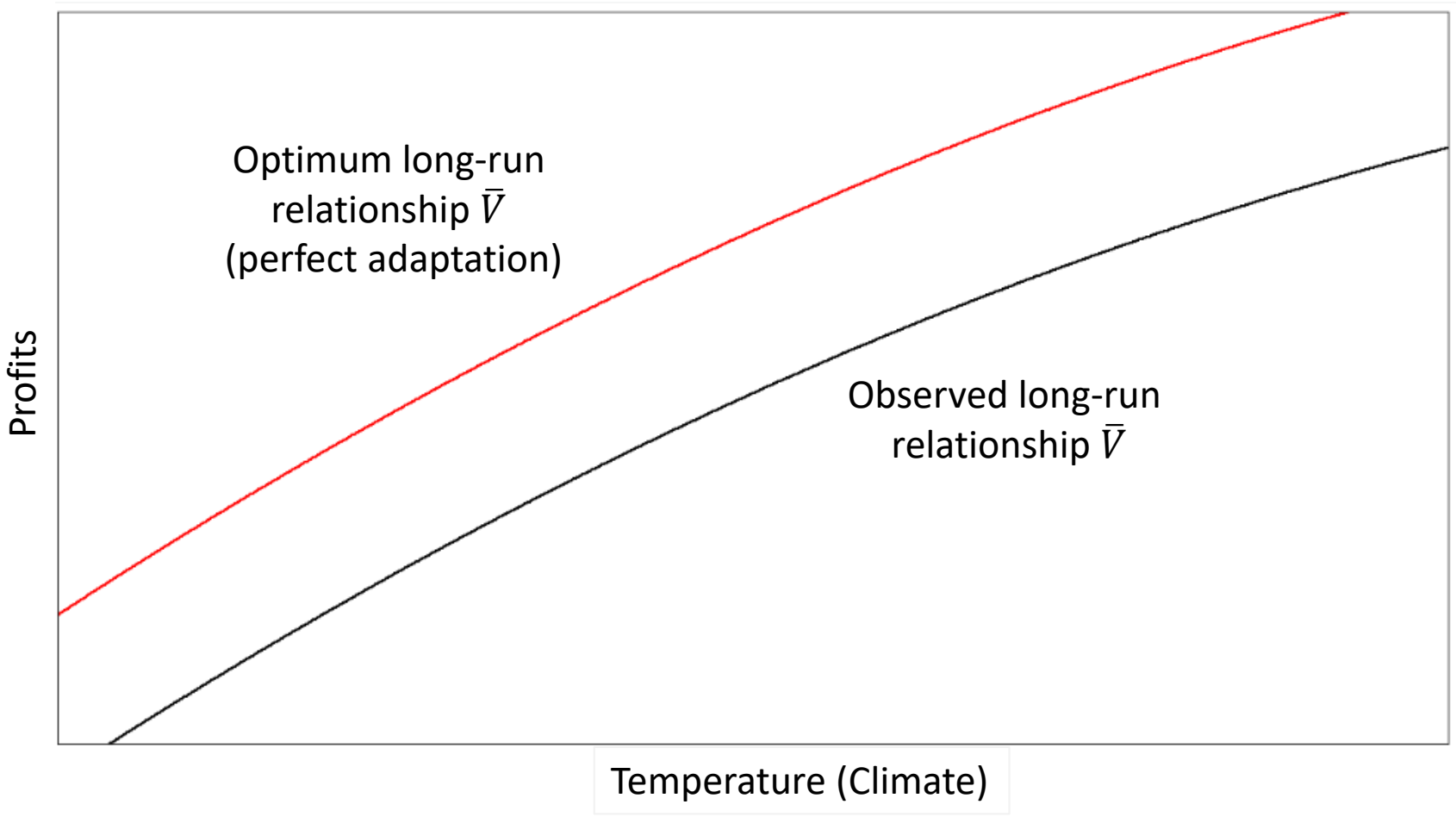
Conceptual framework

– In order to perfectly adapt farms have to constantly adjust as they are exposed to continuous climate change over the last decades

– However, farms face certain limits which can hamper adaptation and thus lead to a slower process of adaptation (Smit and Wandel, 2006)

– Hence, we expect farms are lacking adaptation to some extent, due to missing information, resources and/or technologies

Conceptual framework



Conceptual framework

– Although the expected profit in a particular year is given by $\bar{V}$, the actual realized profit V also depends on unforeseeable annual deviations of weather W from climate $\bar{W}$ in these variables for a given year:

$$\boldsymbol{V = \bar{V} + f_2(W - \bar{W})}$$

– From there it is possible to distinguish between two responses:

1. **Long-run ($\bar{V}$):** denotes how profits will change if farmers are able to (partially) adjust their farming practices and investments
2. **Short-run (V):** denotes how profits will change with different weather conditions, given a certain climate (in this case little to no available adaptation measures are assumed)

Conceptual framework

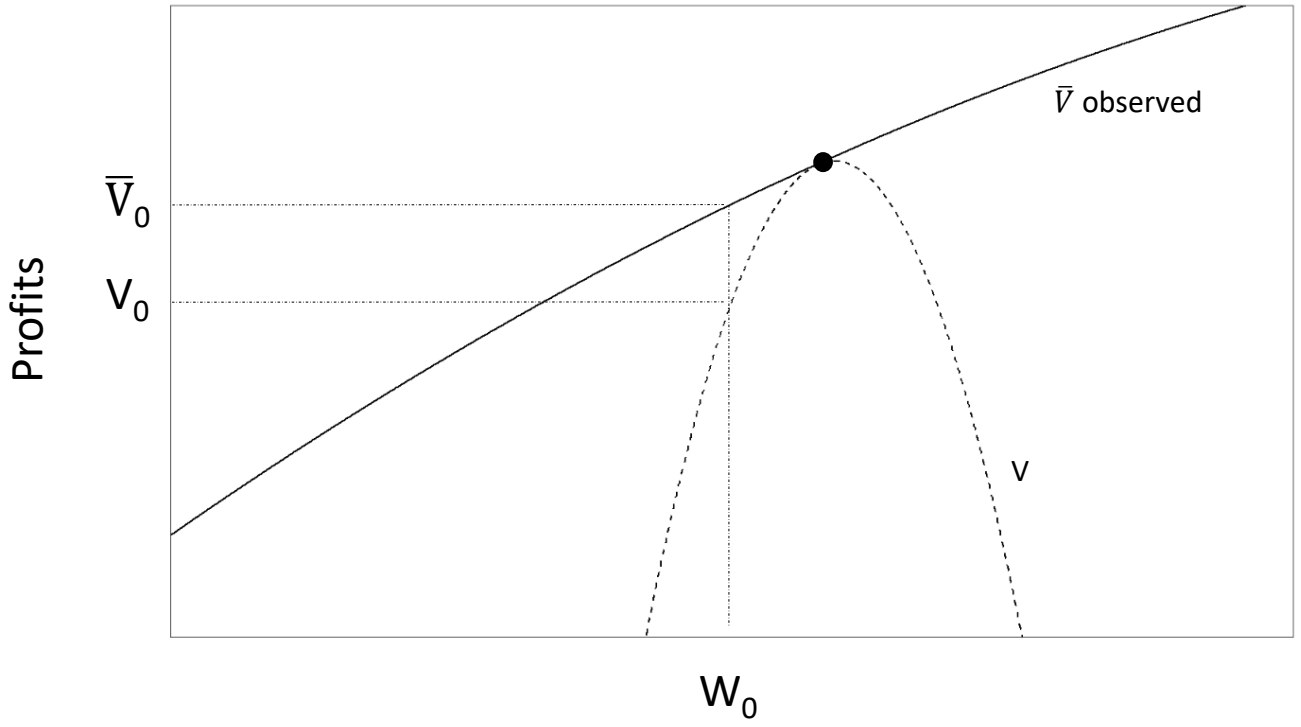
Relying on long- and short-run responses simultaneously provides an identification strategy for climate change adaptation:

(1) In the case of perfect adaptation, each short-run response induced by weather would always lead to diminishing profits ($\overline{V} > V$)

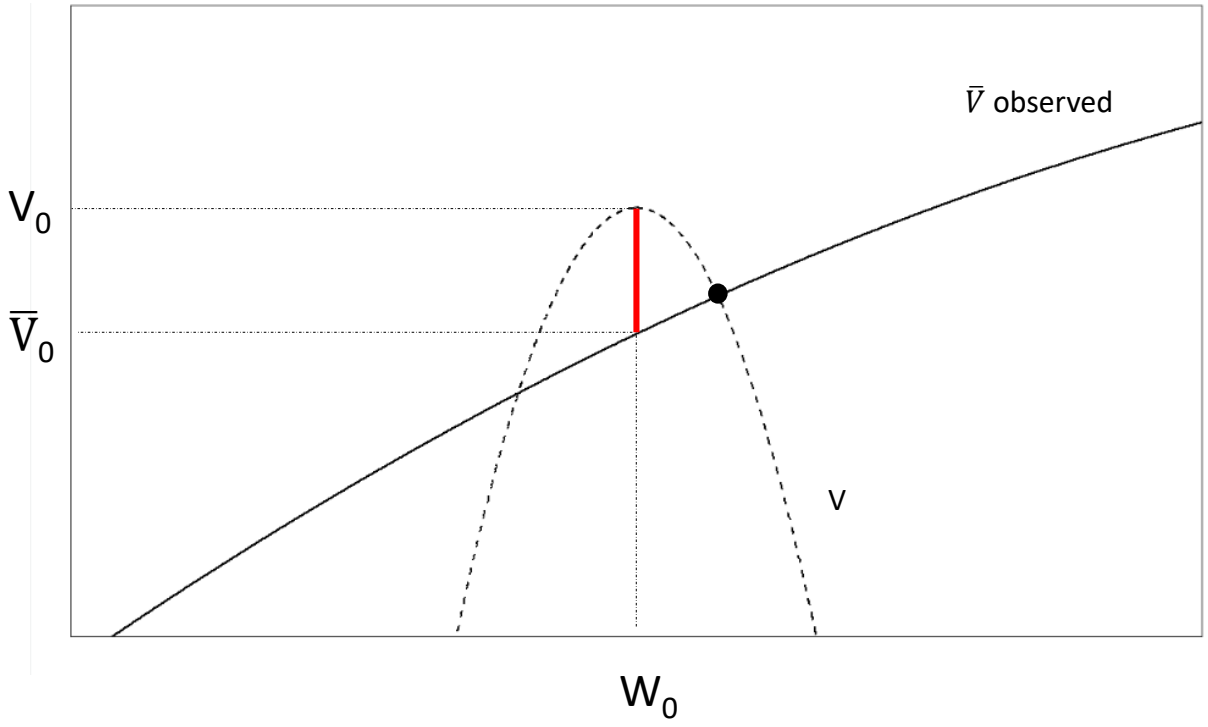
(2) In the case of imperfect adaptation, unexpected short-run weather deviations could also result in higher profits than those attainable in the long-run ($\overline{V} < V$)

Conceptual framework

Perfect adaptation:



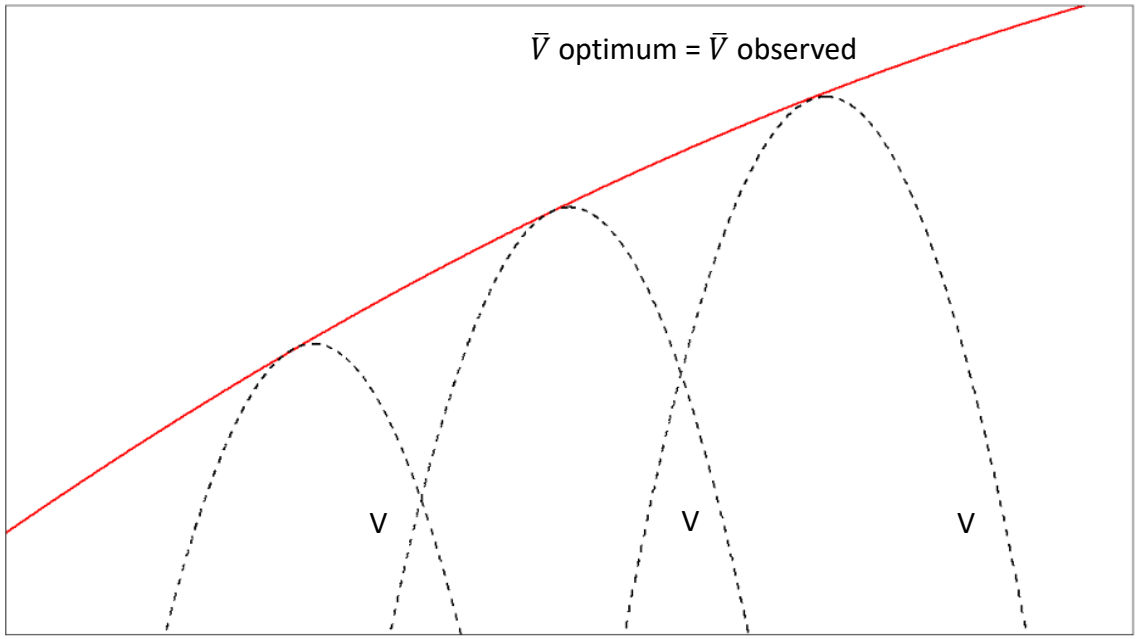
Imperfect adaptation:



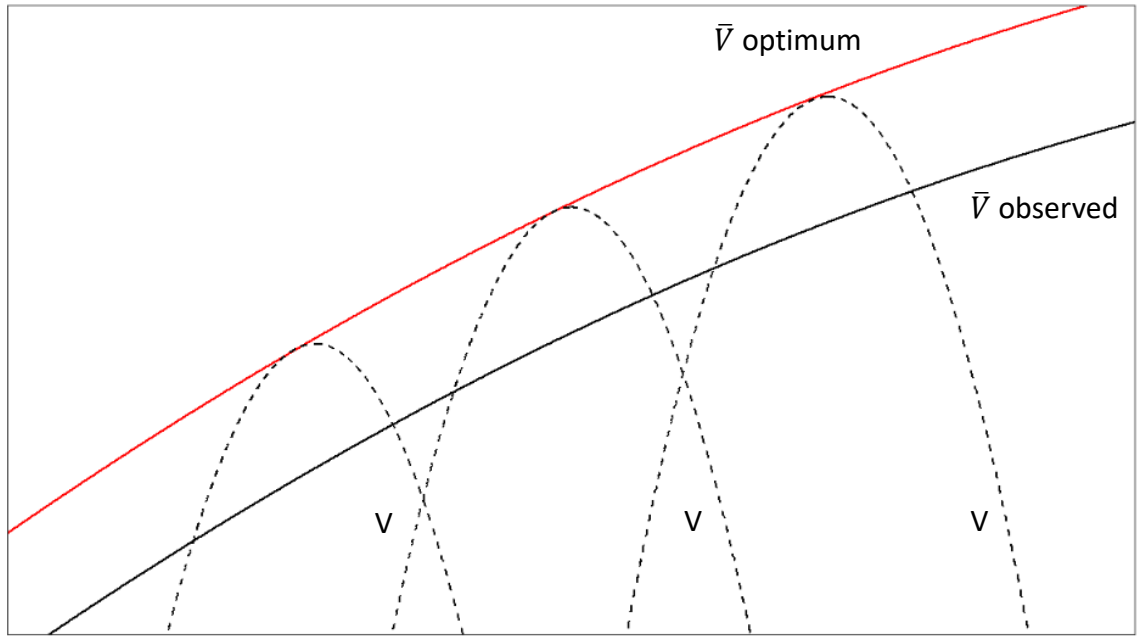
Temperature (Climate, Weather)

Conceptual framework

Perfect adaptation:



Imperfect adaptation:



Temperature (Climate, Weather)

Econometric estimation

We extend the framework of Moore and Lobell (2014) and estimate an econometric model using panel data, which relies on both, cross-sectional variation in climate and inter-annual variation in weather:

$$V_{it} = \bar{W}_{it}\ \beta_1 + \bar{W}_{it}^2\ \beta_2 + D_{it<0}\,\beta_3 + D_{it>0}\,\beta_4 + D_{it<0}^2\,\beta_5 + D_{it>0}^2\,\beta_6 + (\tau\ \times \bar{W}_{it})\beta_7 + \beta_8 X_{it} + \alpha_i + v_t + \varepsilon_{it}$$

Farm profits per hectare

Econometric estimation

We extend the framework of Moore and Lobell (2014) and estimate an econometric model using panel data, which relies on both, cross-sectional variation in climate and inter-annual variation in weather:

$$V_{it} = \bar{W}_{it}\ \beta_1 + \bar{W}_{it}^2\ \beta_2 + D_{it<0}\,\beta_3 + D_{it>0}\,\beta_4 + D_{it<0}^2\,\beta_5 + D_{it>0}^2\,\beta_6 + (\tau\ \times \bar{W}_{it})\beta_7 + \beta_8 X_{it} + \alpha_i + v_t + \varepsilon_{it}$$

Long-term climate
20-year moving average

Yearly weather deviations
Differences between annual weather and climate

Econometric estimation

We extend the framework of Moore and Lobell (2014) and estimate an econometric model using panel data, which relies on both, cross-sectional variation in climate and inter-annual variation in weather:

$$V_{it} = \bar{W}_{it}\ \beta_1 + \bar{W}_{it}^2\ \beta_2 + D_{it<0}\,\beta_3 + D_{it>0}\,\beta_4 + D_{it<0}^2\,\beta_5 + D_{it>0}^2\,\beta_6 + (\tau\ \times \bar{W}_{it})\beta_7 + \beta_8 X_{it} + \alpha_i + v_t + \varepsilon_{it}$$

Interaction terms between weather deviations and climate

Econometric estimation

We extend the framework of Moore and Lobell (2014) and estimate an econometric model using panel data, which relies on both, cross-sectional variation in climate and inter-annual variation in weather:

$$V_{it} = \bar{W}_{it}\ \beta_1 + \bar{W}_{it}^2\ \beta_2 + D_{it<0}\,\beta_3 + D_{it>0}\,\beta_4 + D_{it<0}^2\,\beta_5 + D_{it>0}^2\,\beta_6 + (\tau\ \times \bar{W}_{it})\beta_7 + \beta_8 X_{it} + \alpha_i + v_t + \varepsilon_{it}$$

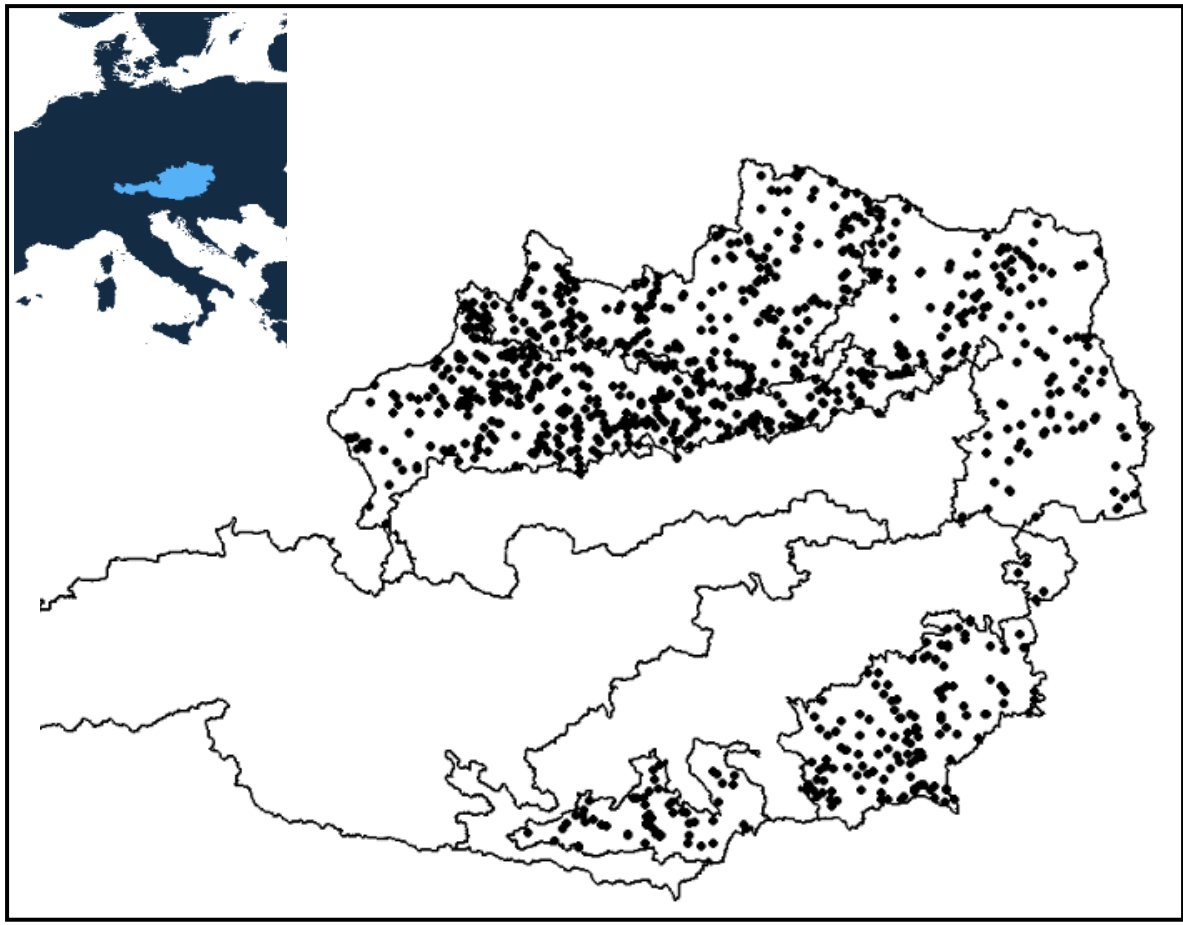
Subsidies per hectare

Data

- An unbalanced panel of 1,716 Austrian farms in arable regions between 2003 and 2016 derived from the Austrian FADN data set is used

- Farm profits and subsidies are corrected using an agricultural price index from ‘Statistics Austria‘

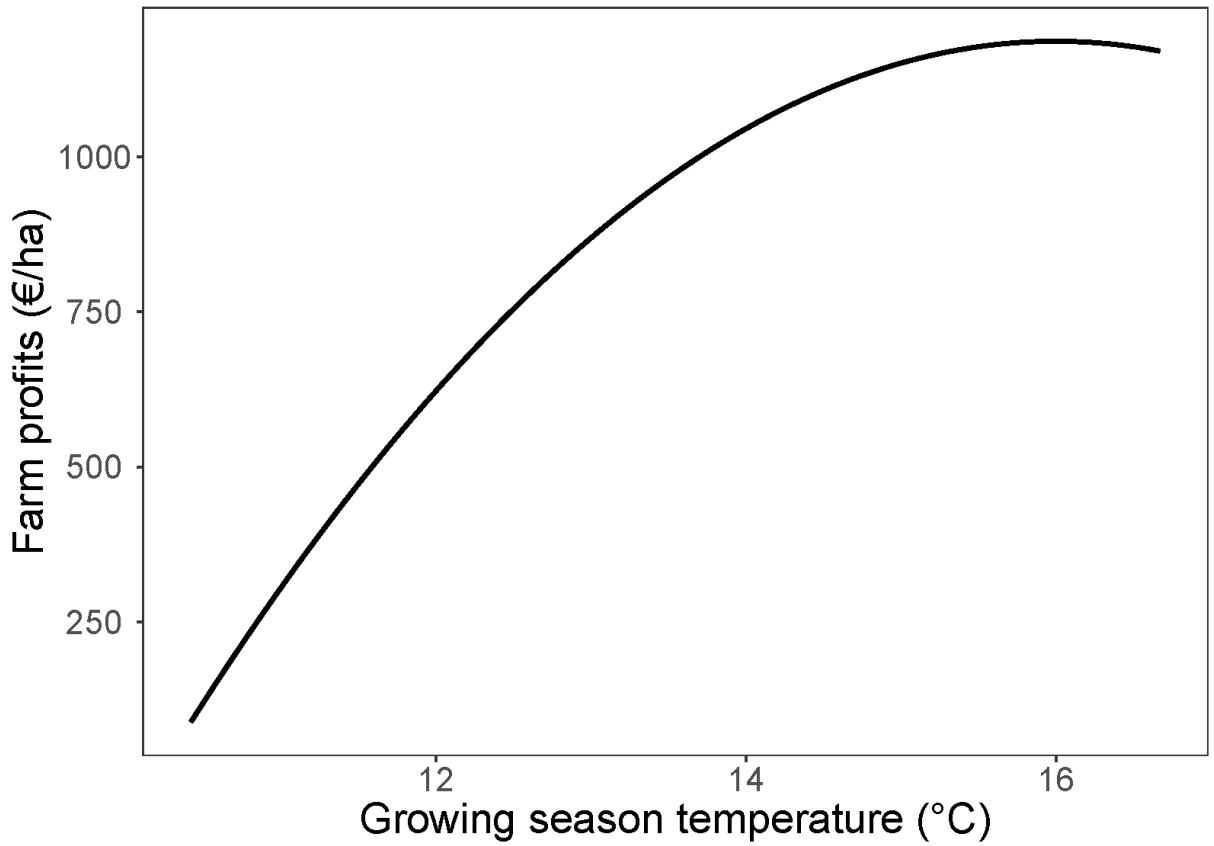
- Meteorological data are obtained from the Austrian governmental agency ZAMG at a resolution of 1x1 km^2



Results

– The long-run response (solid line) denotes how profits evolve with changing climate

– We find an inverted U-shape with a maximum at 16 °C

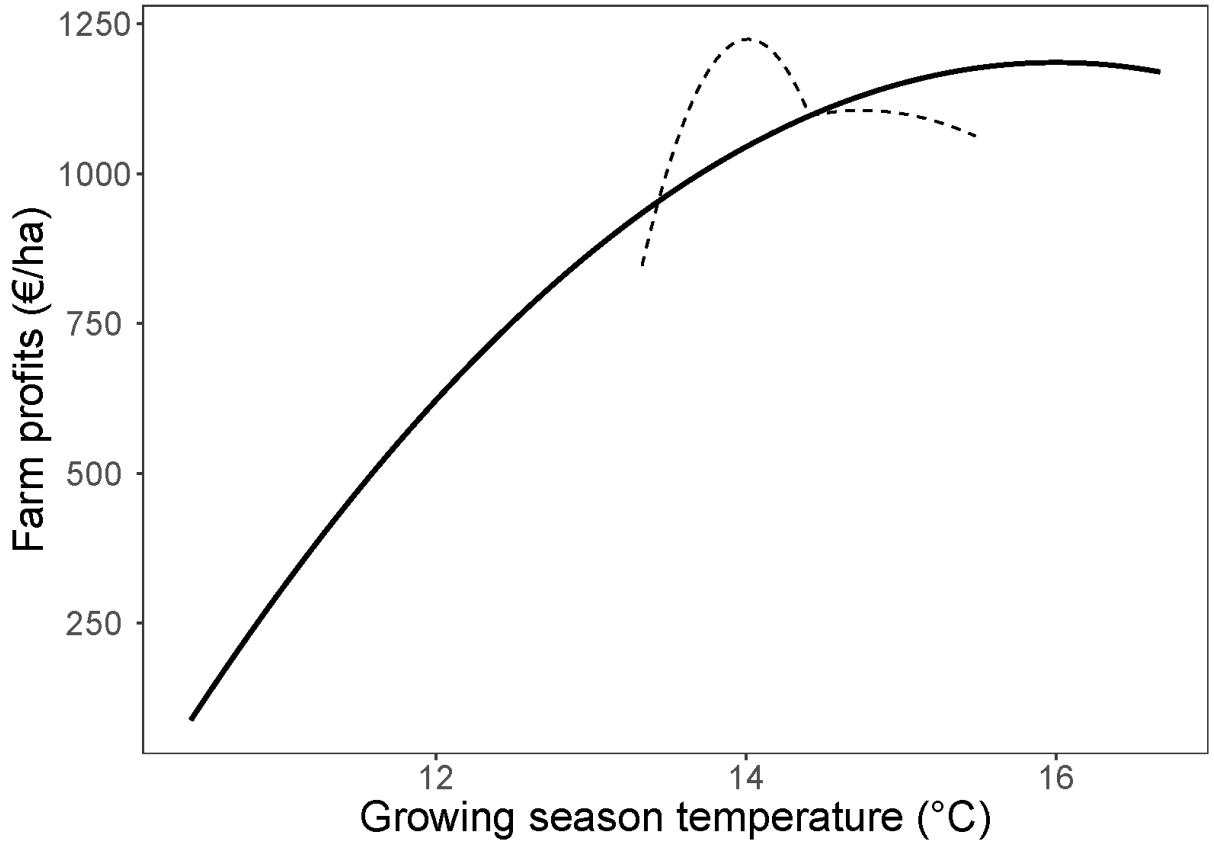


Results

– In the case of cooler weather, the short-run response (dashed lines) lies above the long-run response, denoting higher profits

– This is in line with our expectations of a higher optimum than observed, indicating lacking adjustment

– Consequently, the assumption of perfect adaptation does not hold

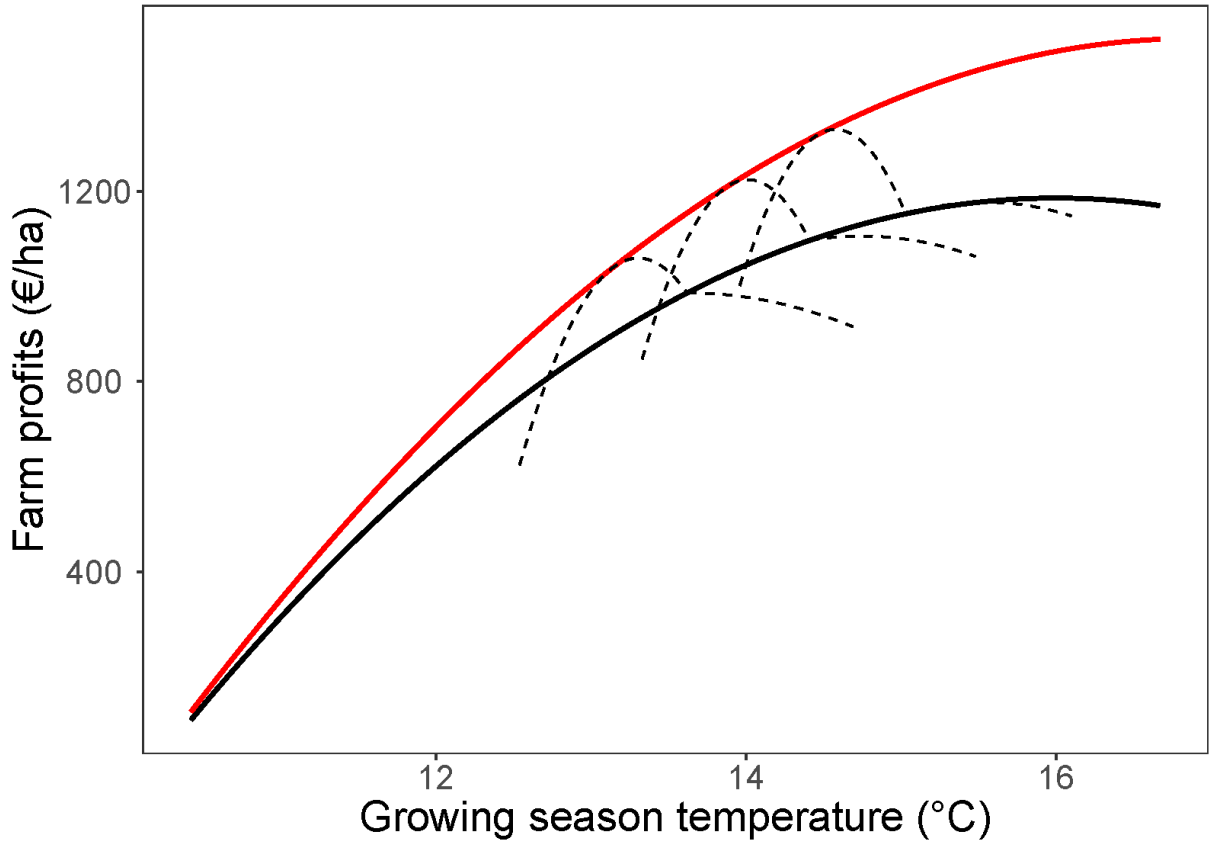


Results

– The interaction terms between weather deviation and climate denote how the short-run responses vary with changing climate

– Potential gains are found to be much higher with warmer climates

– A possible explanation might be that imperfect adjustment leads to higher impacts due to heat



Conclusion

– Farms do not seem to be perfectly adjusted to the climate they are facing, suggesting that the very common assumption of perfect adaptation does not prevail

– Potential gains of additional adaptation are found to increase substantively with increasing temperature

– In order to ensure the competitiveness of agricultural holdings throughout Europe, development and implementation of effective adaptation measures is therefore crucial

Thank you for your attention!

References

(1) Burke, M. and Emerick, K. (2016). Adaptation to climate change: Evidence from US agriculture. *American Economic Journal Economic Policy* 8(3):106–40.

(2) European Environment Agency (EEA). (2019). *Climate change adaptation in the agriculture sector in Europe*, 8/2019 Luxembourg: Publications Office of the European Union.

(3) Mendelsohn, R., Nordhaus, W.D. and Shaw, D. (1994). The Impact of Global Warming on Agriculture: A Ricardian Analysis. *The American Economic Review* 84(4):753–771.

(4) Moore, F.C. and Lobell, D.B. (2014). Adaptation potential of European agriculture in response to climate change. *Nature Climate Change* 4(7):610-614.

(5) Schlenker, W. and Roberts, M.J. (2009). Nonlinear temperature effects indicate severe damages to US crop yields under climate change. *Proceedings of the National Academy of sciences* 106(37):15594–15598.

(6) Smit, B. and Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change* 16(3):282–292.