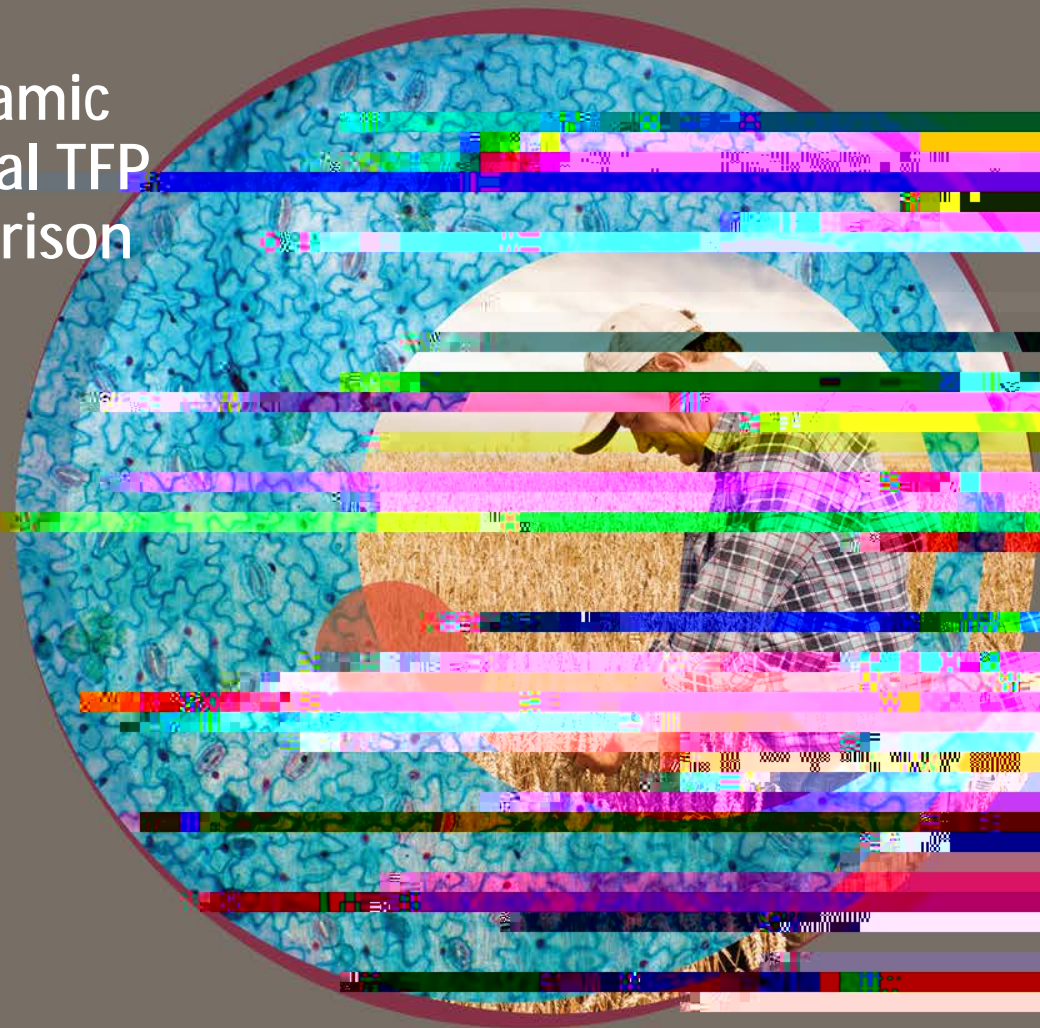


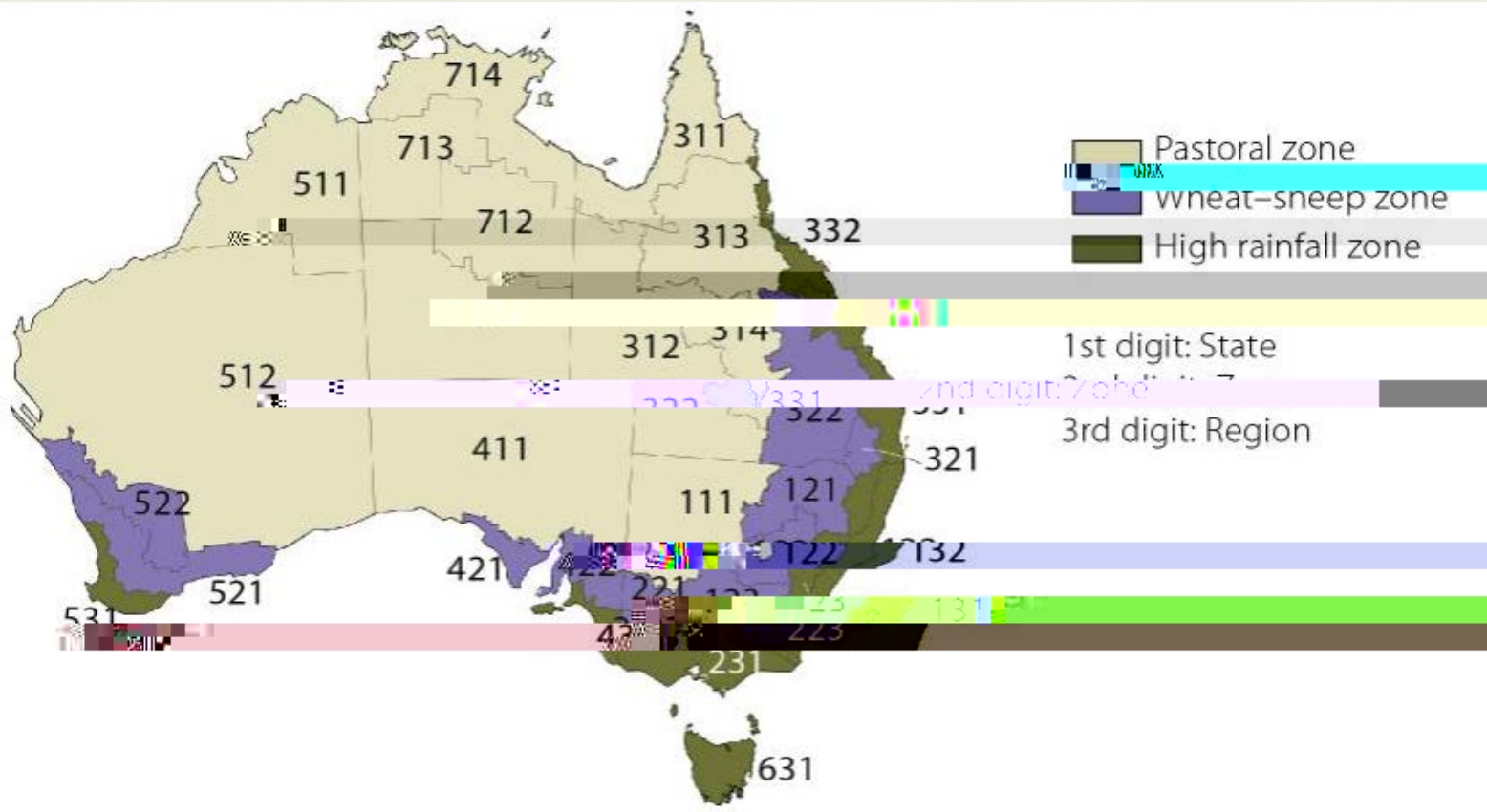
Climate Change and Dynamic Adjustment of Agricultural TFP : A Cross-regional Comparison of Broadacre Farms in Australia



- Our research contributes to the literature in three areas
 - To unravel the dynamic response of agricultural productivity to climatic shocks, and show the spatial pattern of these responses;
 - To investigate the channels through which region-level agricultural productivity adapts to climate change;
 - To provide a way to construct an agricultural production



- Broadacre agriculture is an important primary industry in Australia
 - The broadacre industry accounts for 1.9 per cent of GDP and 2.3 per cent of employment in 2015-16;
 - The industry covers all non-irrigated crop and livestock farms, accounting for around 70 percent of agricultural production;
 - Broadacre farms widely distribute throughout the country, and adopt different production systems in different locations;
- Given the nature of broadacre agriculture, climate conditions heavily influence the productivity of the industry;
 - For simplicity, two aspects are address: water and temperature.



- Rainfall (or soil moisture)
 - Australia is a relatively dry continent and for broadacre agriculture, rainfall is the main source of soil moisture
 - Rainfall determines the growth of crops (i.e. wheat and barley etc.);
 - Rainfall also affects pastoral grassland and livestock production
- Air temperature
 - Temperature affects the growth of plant in different development stages, together with other climate factors such as water, CO₂;
 - Temperature assists crop growth and livestock raising through a non-linear way, with extremely high temperature doing harm to farm production;



- Over time, broadacre farms have demonstrated a remarkable adaptive capacity to cope with climate change.
 - A strong productivity growth of 2 % a year over the long run;
- In practice, farmers can adapt to climate change through many alternative channels, e.g.
 - Change the production technology by optimising the use of capital and labor;
 - Adjust the output mixture to diversify the risk from climate change;
- Many adaptation activities require a significant amount of time and incur additional costs.

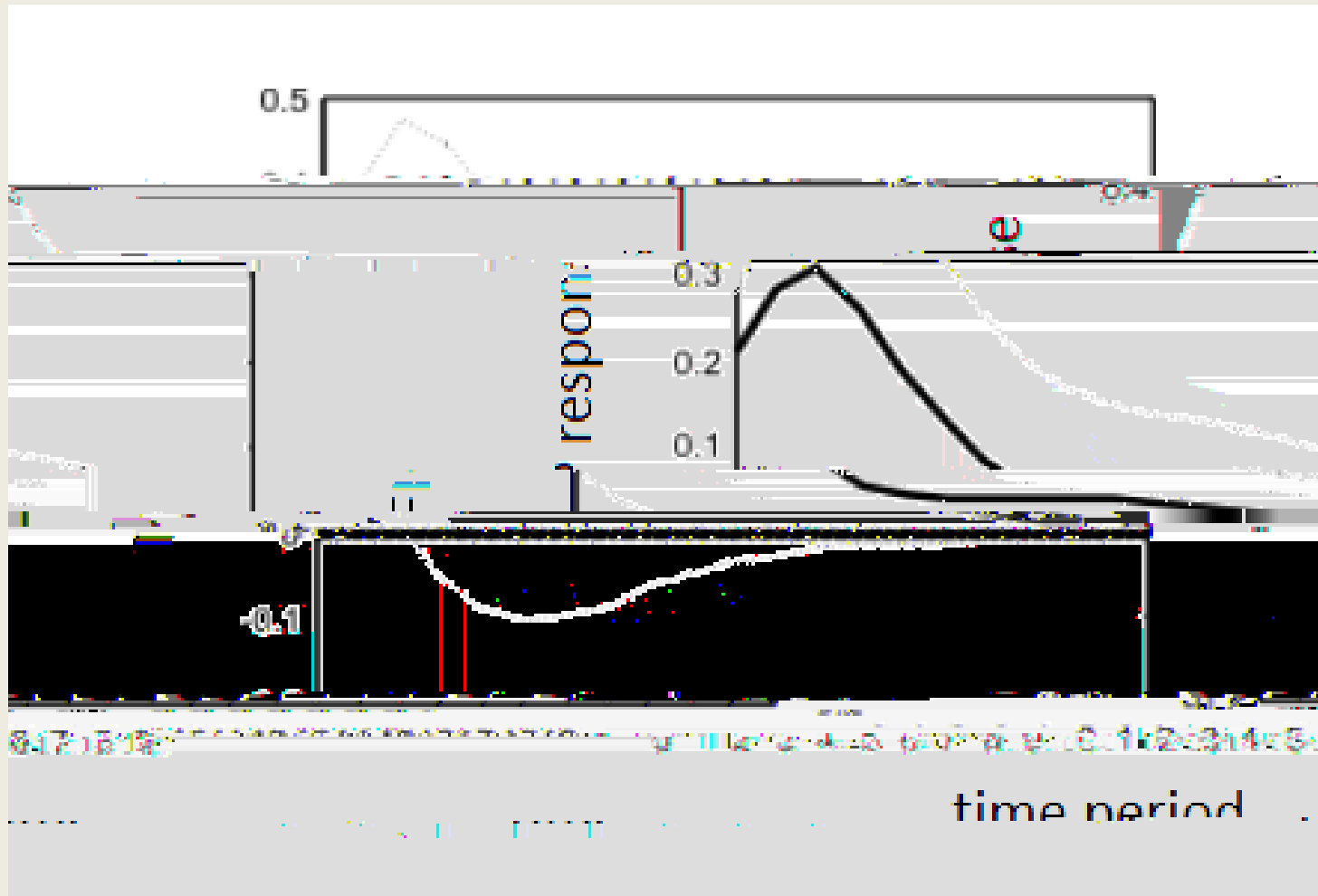




- If two conditions hold
 - Regional agricultural TFP and its determinants are integrated of order one I(1);
 - The error term is integrated of order zero I(0) for all regions;

$$\Delta \ln TFP_{it} = \phi_i [\ln TFP_{it-1} - \theta'_i f_{it-1}(W_{it}, T_{it}, Z_{it}, E_{it}, F_{it})] + \epsilon_{it}$$

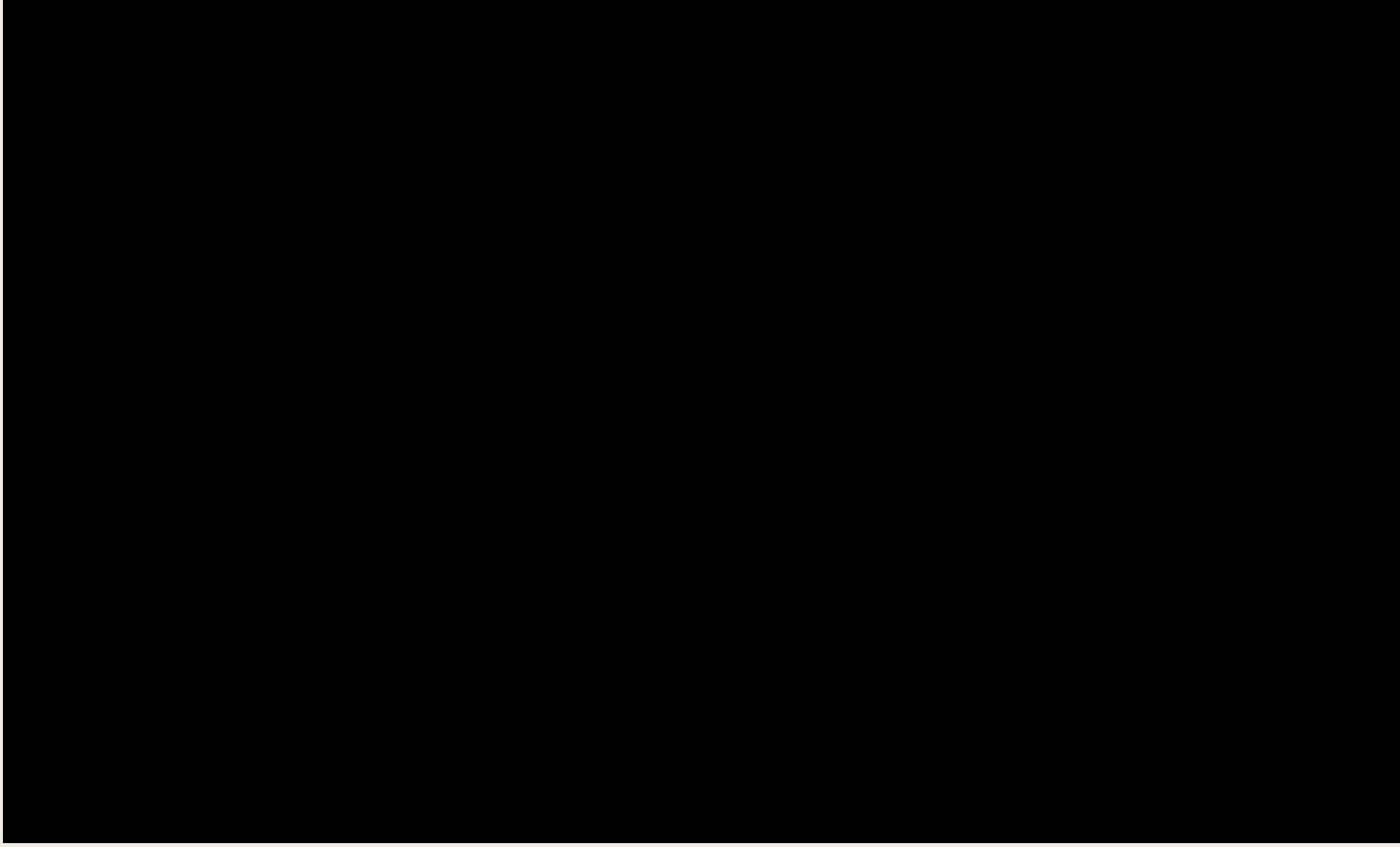
- ϕ_i is the error-correcting speed of adjustment term
- λ_i are the long-term and the short-term effects of... • θ_i an



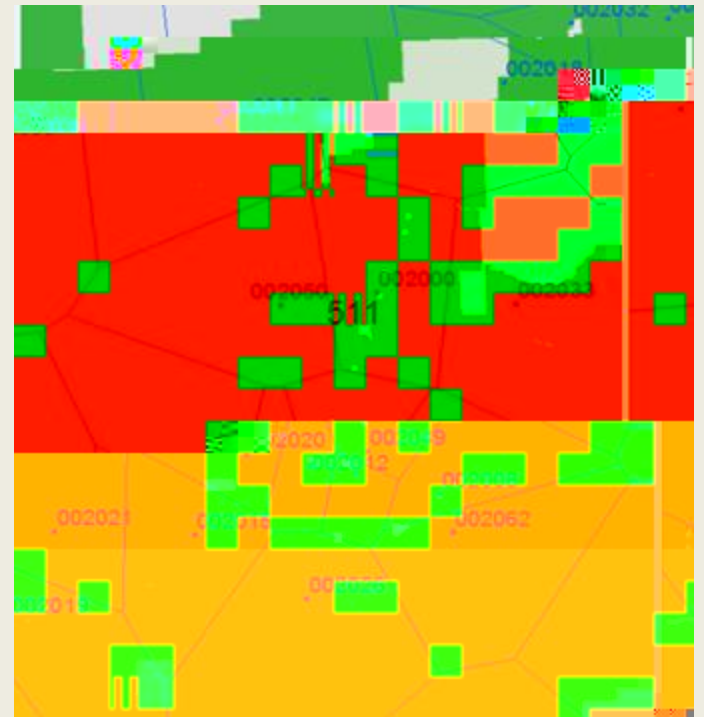
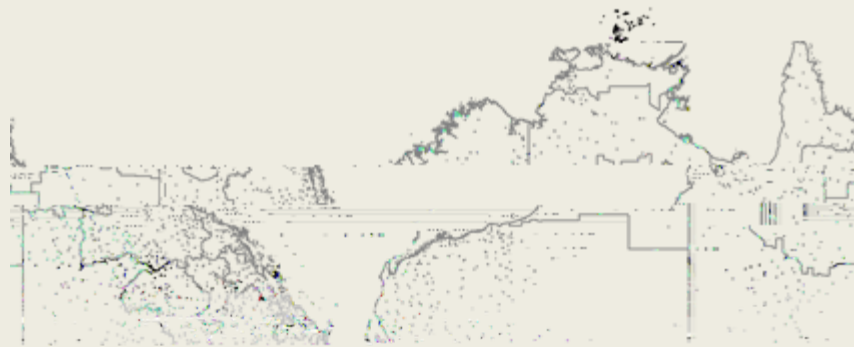
- The data used in this paper come mainly from four sources
 - Australian Agricultural and Grazing Industry Survey (AAGIS): regional TFP measures;
 - The Queensland University and the government of Queensland: soil moisture and air temperature;
 -

- Region

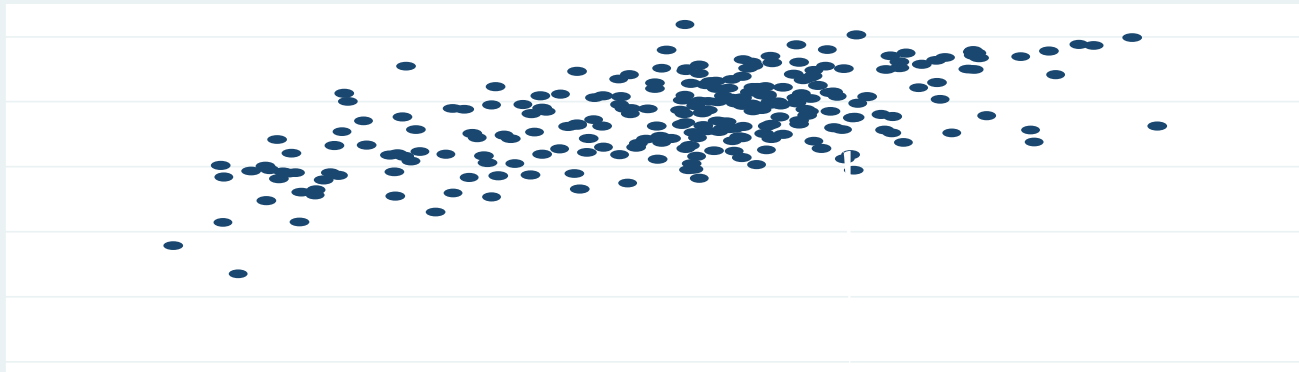
- Water availability measure
 - The index is measured by using three agro-climatic indicators called “wheat water-stress index”, “sorghum water index” and “pasture growth index”.
 - Wheat and sorghum water-stress indexes are derived from a water-balance model (Potgieter et al. 2005, 2006).
 - The pasture growth index is also calculated based on a water balance model (Carter et al 2000, Rickert et al 2000).
- We aggregate the indexes up to the regional level using land areas for cropping and grazing as weights.
 - The three indexes, in their original form, are annual time series defined at sub-regional (shire) level.
- Total rainfall has also been used as a robustness check



- Two indicators are used to measure temperature / radiation:
 - degree-days accumulated over the growing seasons;
 - average daily temperature;
- A base of 8 C and a ceiling of 32 C are used as the temperature threshold (Schlenker et al., 2006 and Deschenes and Greenstone, 2007)
 - 1st April to 31st October for the winter season;
 - 1st November to 31st March for the summer season;
- The daily average temperature and rainfall are
 - obtained at the 8, 023 weather stations of the Australian Bureau of Meteorology (BoM);
 - Matched with each farm in our survey;



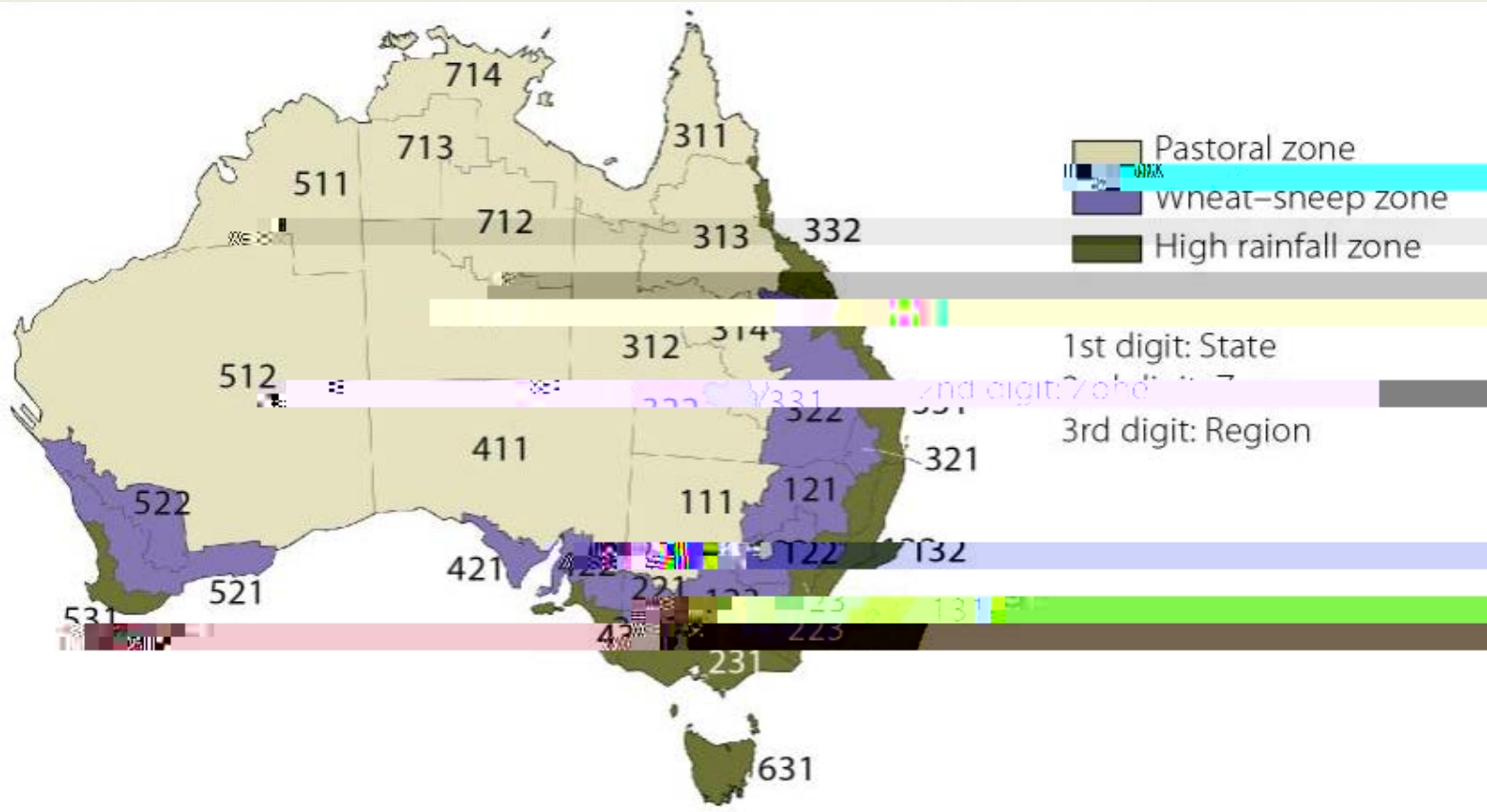
- A descriptive statistics shows the relationship between region-level agricultural TFP and climate conditions.
 - There are monotonic relationship between water-stress index and regional TFP;
 - The relationship between degree-day measures and regional TFP is non-linear;
- Panel-data co-integration test has been conducted
 - I(1) stationary tests have been conducted for all variables used in the model
 - A co-integration relationship has been identified between region-level TFP and climate variables





- There is a significant long-term relationship between climate condition and region-level agricultural productivity.
 - Water availability positively contributes to regional TFP growth in the long run;
 - Degree-days will positively contribute to regional TFP initially but its marginal contribution tends to decline when the degree-day measure reach a threshold;
- In the short run, water availability also generate the short





- Region-level TFP is re-measured by using an alternative index formulas
 - The Fisher index adjusted by the EKS formula is used instead;
- Climate variables are re-defined by directly using
 - the total rainfall over the growing season
 - the daily average temperature over the growing season
- Stability of the PECM model has been double-checked.

- We investigate the dynamic impact of climate change on agricultural TFP in Australia through
 - Using a vector error correction model to the panel data;
 - Allowing for regional heterogeneity and other control variables;
- Climate change generates a complex impact on agricultural productivity across regions
 - In the long run, water availability and temperature
 - In the short run, water availability matters more
- Farmers are able to adopt to climate change through
 - Optimising the capital-labor ratio;
 - Adjusting the output mix

