Climate Change Adaptation and Economic Tipping Points

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Abstract. **Keywords:** Climate change adaptation · Tipping points · Agent-based Economics.

Whilst the consequences of climate change (CC) are getting more apparent, it is still unclear how it will affect the behavior of socio-economic systems. Are societal actors able and willing to conduct climate change adaptation (CCA)? And how effective will CCA be? Projections of how economies react to natural disasters range from 'creative destruction' growth increases to 'no recovery' permanent damages [17], leaving the actual adaptive societal response to be uncertain. This also holds for sea level rise (SLR), which threatens development of fast growing coastal cities [16]. It is not clear whether attractiveness and productivity of the coastal regions can be maintained through protective actions or relocation [18], or capital losses cause permanent welfare losses [15]. It is also anticipated that a retreat could be a necessary option in the future [14], and initial evidence from the stylized models suggests that there agglomeration forces driving urbanization and economic development might be reversed in light of accelerating climate-induced hazards [25]. Therefore, this research aims to give more insight in the adaptive responses of socio-economic systems to climate change.

The difficulty of studying adaptive behavior stems from the fact that it forms a recursive loop where agents observe their environment, act, and thereby again augment their environment. This recursive loop makes the economy a complex system [1]. In the context of CCA, this complexity enables that climate shocks can trigger nonlinear structural shifts in the socio-economic system, or tipping points [23]. For example, climate change can cause structurally lower output and growth rates [4, 24, 19], and instability of the financial sector [6, 10, 22] and government finances [8, 21, 3]. These factors not only have a direct impact, but can also amplify each other and can cause sharp changes at the system level that are difficult to forecast (also known as 'green swans' [5] for the financial sector). However, tipping dynamics can also potentially be used to instigate structural change towards a better adapted state [26], which can constitute *transformational* CCA [20].

While the relevance of studying such tipping dynamics is apparent, the general equilibrium framework that is dominant in economics is not well-equipped to capture the required adaptive behavior. Instead, agent-based models (ABMs) are often regarded as a promising candidate to capture the complex interaction

between environmental and socio-economic systems [11, 2, 9]. In these models, the macro dynamics emerge from the boundedly rational, heterogeneous behavior and interactions of agents [1]. As such, they are a natural candidate to capture complex adaptive economic dynamics and tipping across states [12, 13].

Therefore, we use the Climate-economy Regional Agent-Based (CRAB) model [25] to test where we can detect tipping points for increasing climate risks and their trade-offs with agglomeration forces. This model consists of multiple regions, each containing households and producers that produce and consume goods, and that can move between the regions. Furthermore, the regions are subject to a heterogeneous level of flood risk, where floods affect production by decreasing the productivity level and damaging capital and inventory stocks. We then study how (repeated) climate shocks of various sizes can lead to tipping behavior. Here, we are interested in rapid changes in the agglomeration dynamics between regions, and shifts of the macroeconomic regime. Furthermore, we study how this tipping is enabled or stalled by various socio-economic factors. These include the ease of migration, damage compensation by the government and credit availability for repairs and protection [7]. As such, we want to give a better insight in how adaptive responses to climate change may affect macroeconomic dynamics.

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