

Physical Climate Risk and Firms' Adaptation Strategy

From American utilities to Australian builders, from Asian manufacturers to European winemakers, many companies are facing increasing physical climate risk – that is, risk arising from the physical effects of climate change. Climate related extreme weather events, such as wildfire and floods, damage firms' properties and disrupt their operations. More gradual changes, such as water and heat stress, affect firms' resource availabilities and reduces their productivities. Increasing physical climate risk also impacts firms indirectly, such as raising insurance premiums and cost of debt.

Faced with these threats, firms can seek to *mitigate* and *adapt* to climate change. Climate change mitigation addresses the causes of climate change and focuses on greenhouse gas (GHG) emissions reduction. Climate change adaptation focuses on adjustment to climate and its effects and addresses the consequences of climate change. As many impacts of past and future GHG emissions are irreversible for centuries, firms are inevitably exposed to physical climate risk and need to adapt to a changing planet, regardless of their own GHG emissions.

Despite the importance of climate change adaptation, little is known about firms' adaptation strategies. Management scholars have primarily focused on firms' climate change *mitigation* strategies. Evidence on firms' climate change *adaptation* has been called for by scholars but remains sparse. This paper advances the literature of climate change and firm strategy by focusing on firms' adaptation strategies. Specifically, I explore whether, how, and under which conditions firms adapt to physical climate risk.

A priori, it may appear that firms would initiate adaptation strategies as an obvious preventative measure. Adaptation helps firms reduce damages and business interruptions, improve corporate governance and overall financial performance. However, adaptation strategies can be costly and may compete with other firms' operational and strategic objectives. Also, firms may not have the capacity to fully evaluate the physical impacts of climate change because they cannot be easily calculated based on historical data. Moreover, climate risk is long-term, and thus it lies beyond the time horizon of most managers and business cycles. As such, the upsides of adaptation are usually materialized in the long run, while the downsides of it tend to manifest in the short term. As individuals (including

managers) are usually myopic and favor short-term rewards over long-term rewards, they may tend to underinvest in adaptation that pay off in the long term. Therefore, from a purely theoretical perspective, it is difficult to predict whether firms will adapt to climate risk or how. Also, the impacts of different levels and types of physical climate risk on firms' adaptation strategies have yet to be tested. I therefore take these questions to the data, and explore empirically whether and how firms adapt to climate risk.

To explore whether and how firms adapt to physical climate risk empirically, I developed a novel dataset on firms' adaptation strategies by manually encoding the climate disclosure text that publicly traded companies report with CDP. To measure corporate physical climate risks, I collected and used data based on geospatial, historical, and projection models developed by Four Twenty Seven (a Moody's affiliate). I merged the disclosed adaptation data with physical climate risk scores at the firm-climate risk-year level. The final sample covers 1,068 public companies headquartered in 43 countries between 2011 and 2017. To the best of my knowledge, this is the first longitudinal database of firms' various adaptation strategies to different climate risk drivers, including heat stress, water stress, sea level rise, floods, and hurricanes/typhoons.

The empirical results paint a nuanced picture of firms' adaptation strategies across countries and industries over time. I start by documenting a series of stylized facts pertaining to climate risk and firms' disclosed adaptation strategies. Perhaps surprisingly, most firms don't adapt to different climate risk drivers. The average adaptation rate across firms and climate risk drivers is 23%. The percentages of firm adaptation through business strategy, i.e., transformative strategic changes to firms' core businesses, are lower than that of risk management, although increasing faster over time.

I then examined under which conditions firms adapt, and how. I found that, on average, firms facing higher level of climate risks are more likely to adapt and with broader ranges of adaptation strategies. The results are statistically significant both within firm between climate risk drivers and across firms and risks. I further explored the mechanism and find that higher climate risk increases managers' risk perception, which triggers the increased firm adaptation. Also, the impact of climate risk on adaptation strategies increases over time, particularly for business strategy.