



Health and Economic Impacts of High Temperature and Heatwaves in China

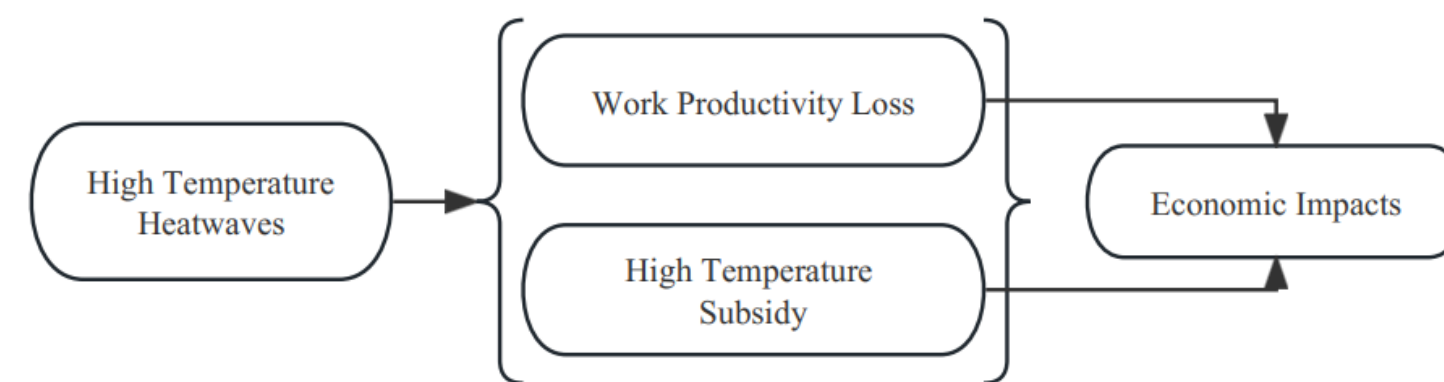


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Background

- In recent years, the world has been widely affected by hot weather, particularly in Asia. From 1951 to 2021, China's annual mean surface air temperature shows a significant upward trend, with an average increase of 0.26°C per decade.
- This study aims to investigate the economic impact of historical and future heatwaves and to analyze the spatial and temporal heterogeneity of economic impacts across different regions of China.
- This paper focuses on the economic impact assessment in terms of labor productivity loss due to heatwaves and high temperature subsidies.



Method

Database

Meteorological data

- The historical data were adopted from the China Meteorological Day-by-Day Station Observation Dataset. Future meteorological data were obtained from the platform of The International Coupled Model Intercomparison Project (CMIP6).

Socio-economic data

- Socio-economic and demographic data were obtained from the National Bureau of Statistics of China.

High-temperature subsidies data

- High-temperature subsidies related data are all sourced from the high-temperature subsidy related documents published by local governments and labor security departments.

Research Scope

Historical Scope:

- Year: 1990-2020
- Geographic scope: Different cities and provinces in China

Future Scope:

- Year :2030, 2040, 2050, 2060, 2070, 2080, 2090,2100
- Geographic scope: Different provinces in China
- Scenario: SSP5_85
- Data Source: CMIP6 CanESM5 Model

Exposure-Response Function

WBGT & Workloss:

$$WBGT = 0.567 \times T_{avg} + 0.393 \times Vapor + 3.94$$

$$Vapor = \frac{RH}{100} \times 6.105 \times \exp\left(\frac{17.27 \times T_{avg}}{237.7 + T_{avg}}\right)$$

$$WA = 0.1 + 0.9 / \left(1 + \left(\frac{WBGT}{\alpha 1}\right)^{\alpha 2}\right)$$

Tavg: Daily air temperature of 2 meters in degrees Celsius

RH: Relative Humidity

Vapor : Partial pressure of water vapor in kilopascals

WA: Work Ability

Results

1. Changes in high-temperature days and heatwaves during historical periods

- The average number of high temperature days in China in 1990 was 17.2 days, but by 2018 it had increased to 23.1 days.
- High temperature days appear most frequently in the East, South, and Central China.
- The South China, East China, and Central China regions are most affected by the number of high temperature days, with a total annual average of 21.6, 20.2, and 20.8, respectively. The Southwest and Northwest regions are less affected by the number of high temperature days, with an annual average of 17.1 and 14.9, respectively

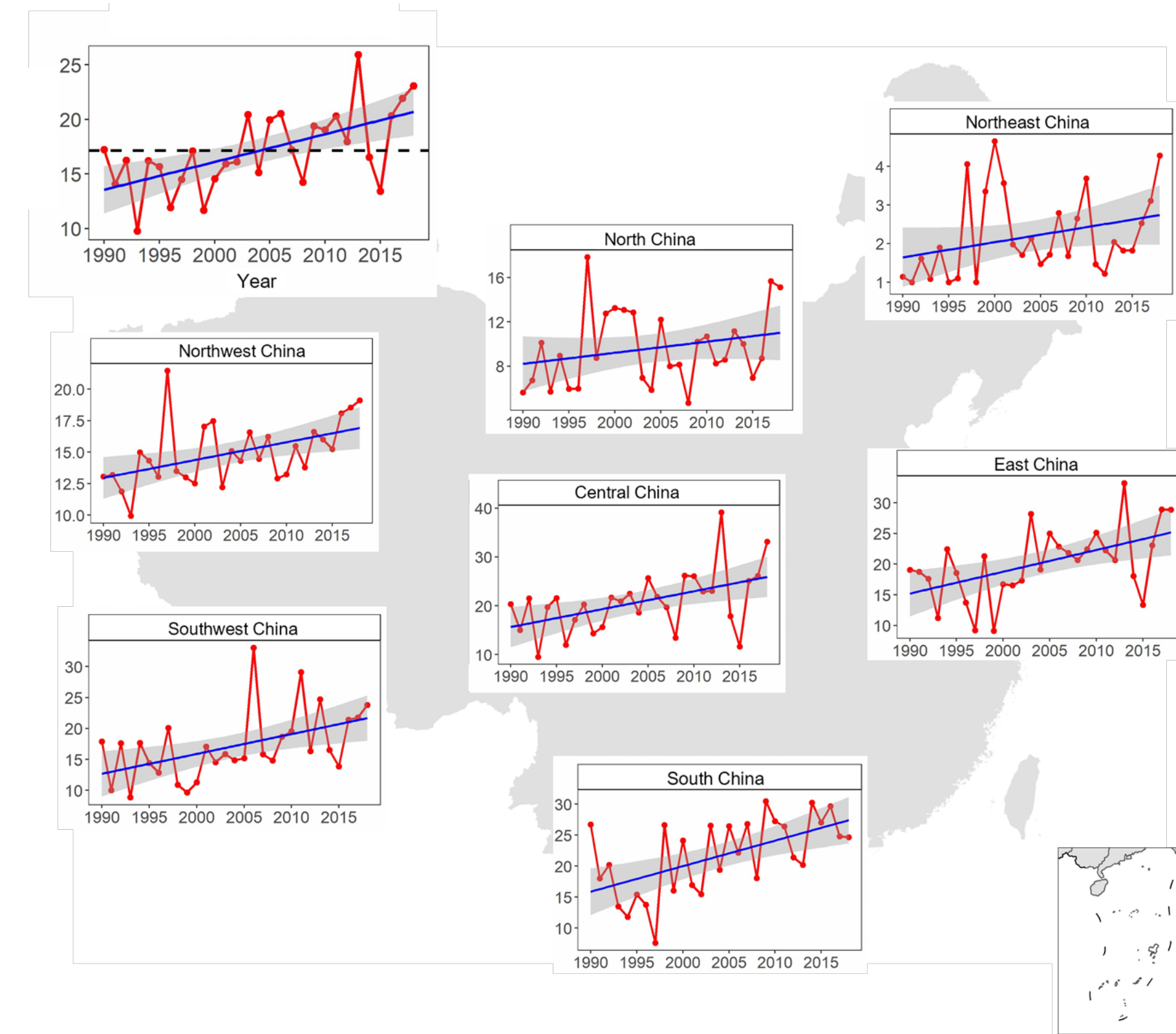


Fig. 1: Change of Annual Average High Temperature Days over Time in China from 1990 to 2020

2. Historical labor productivity losses and relevant economic loss related to high temperature and heat waves

- From 1990 to 2020, Guangdong experienced the highest worktime loss due to heatwaves, with a total of 695.3 billion hours, accounting for 21.3% of the total national loss.
- The economic loss of work productivity loss in China from 1990 to 2020 accounts for 3.4% of the total GDP. The average annual economic loss of was 1085.94 billion CHY.
- The ratio of work productivity economic losses to GDP remained stable at around 3% between 1990 and 2020, and increased to 6.7% during the extreme high temperature weather in 2018 nationwide.

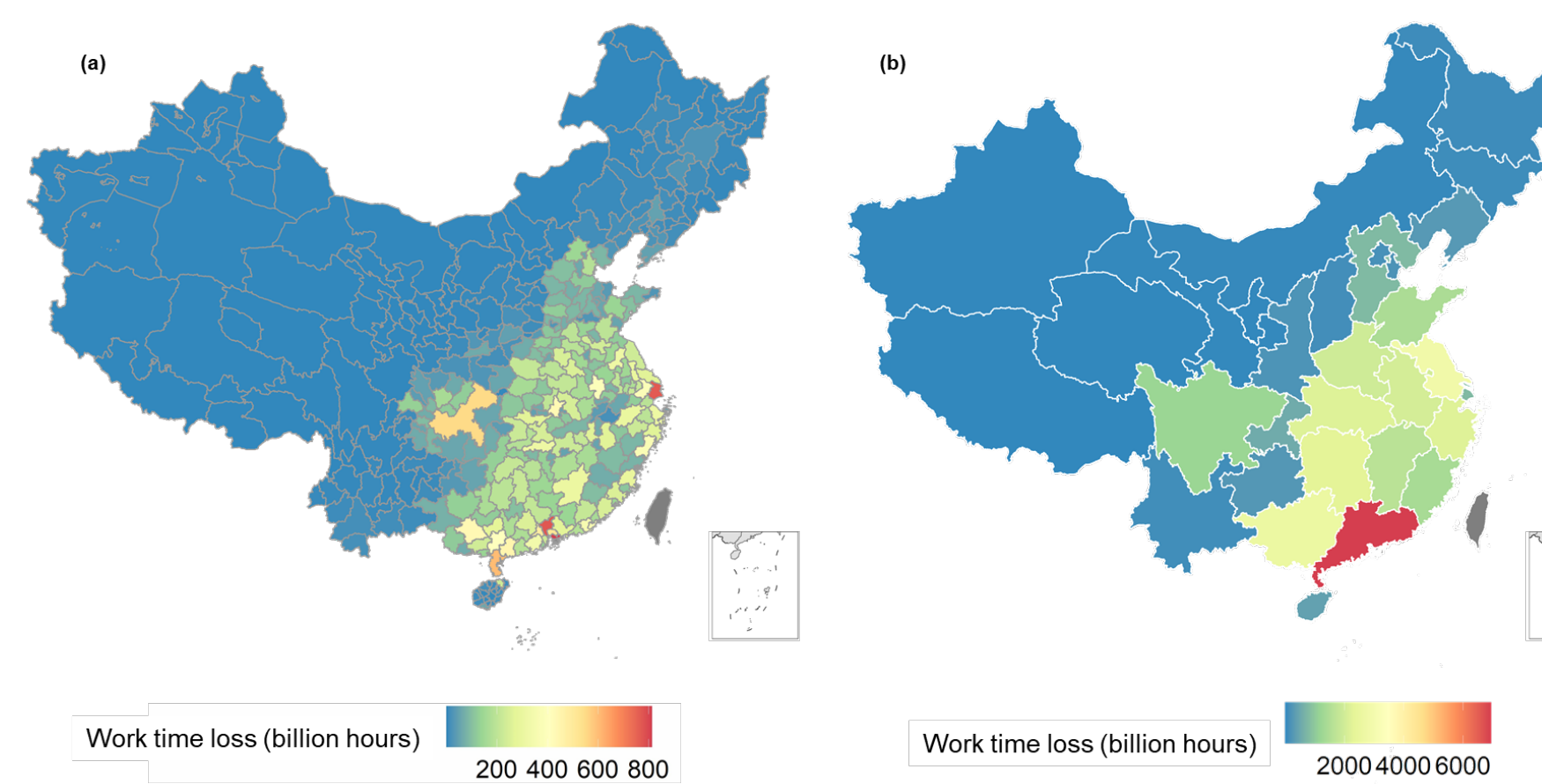


Fig. 2: Distribution of Total Labor Time Loss at the Urban (a) and Provincial (b) Levels in China from 1990 to 2020

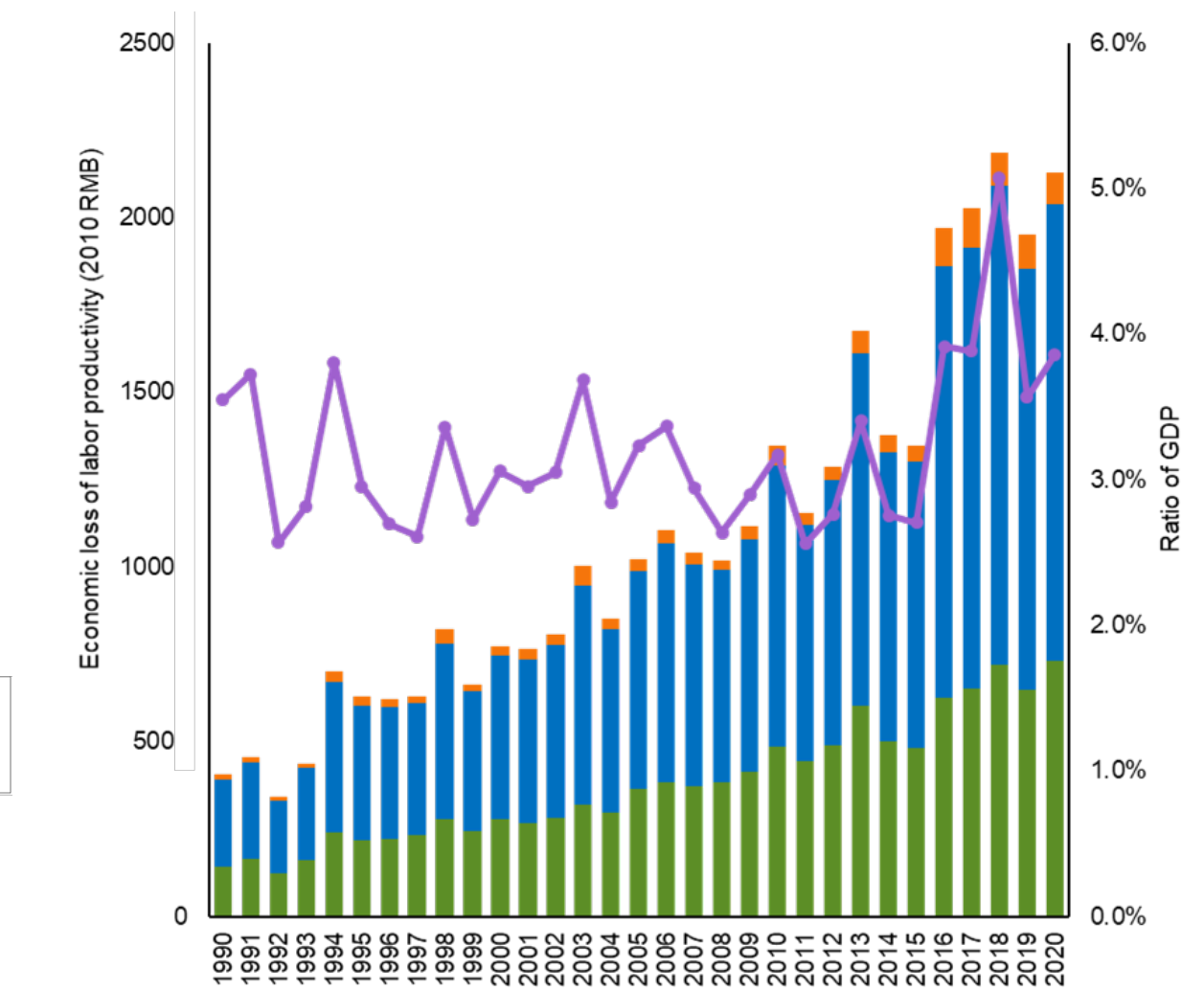


Fig. 3: Economic Impact and GDP Ratio in China. Green: High Intensity Work, Blue: Medium Intensity Work, Orange: Light Intensity Work

3. Historical high temperature subsidies

- The total subsidies in East China and Central China account for the highest proportion in the country, with 32.1% (2335.6 billion) and 26% (1889.8 billion), respectively.
- High-temperature subsidy in South, North China, and Southwest China is at a moderate level, with a total of 1196.4 billion (16.5%), 638.1 billion (8.8%), and 858.9 billion (11.8%), respectively.

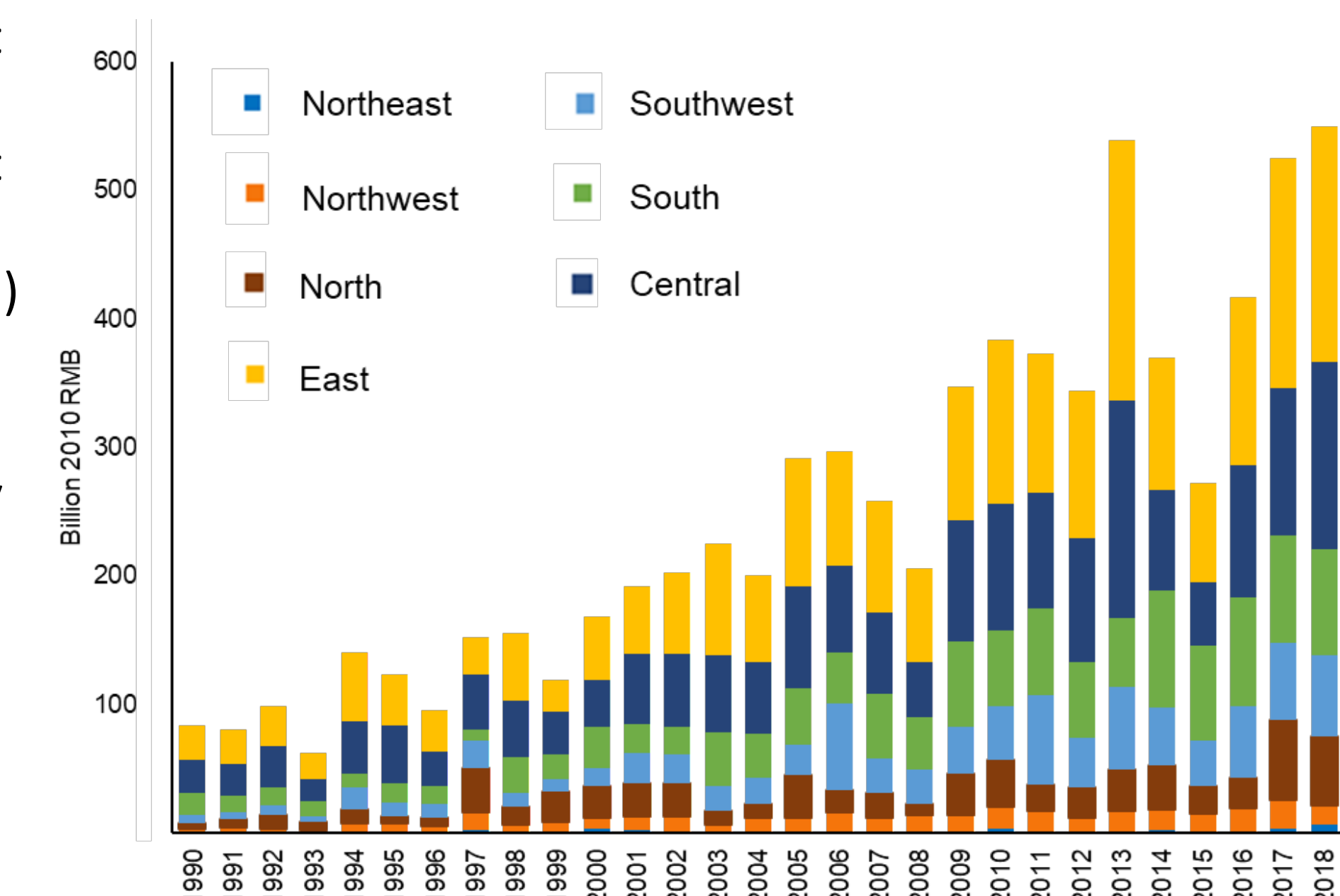


Fig. 4: Changes in high-temperature subsidies in seven major regions from 1990 to 2018

4. Future trend of high temperature days and economic losses change

- Future average annual number of total heatwaves in China is 144.5. The total number of heatwaves in 2100 is the highest 194.
- In future year from 2030 to 2100, the average annual frequency of light, medium, and high heat waves in the country will be 53.5, 37.4, and 53.6, respectively.

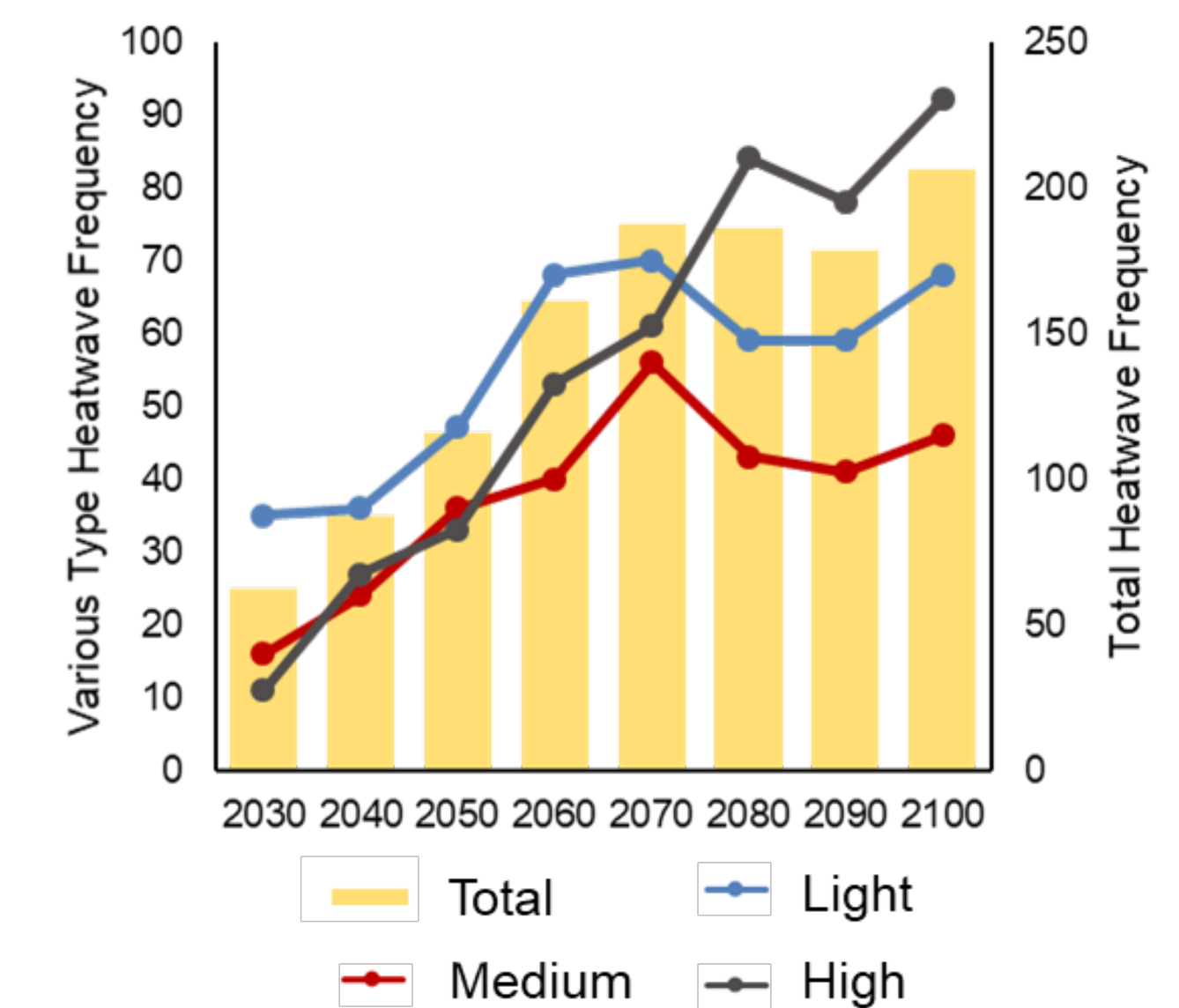


Fig. 5: Future changes in different types of heatwaves

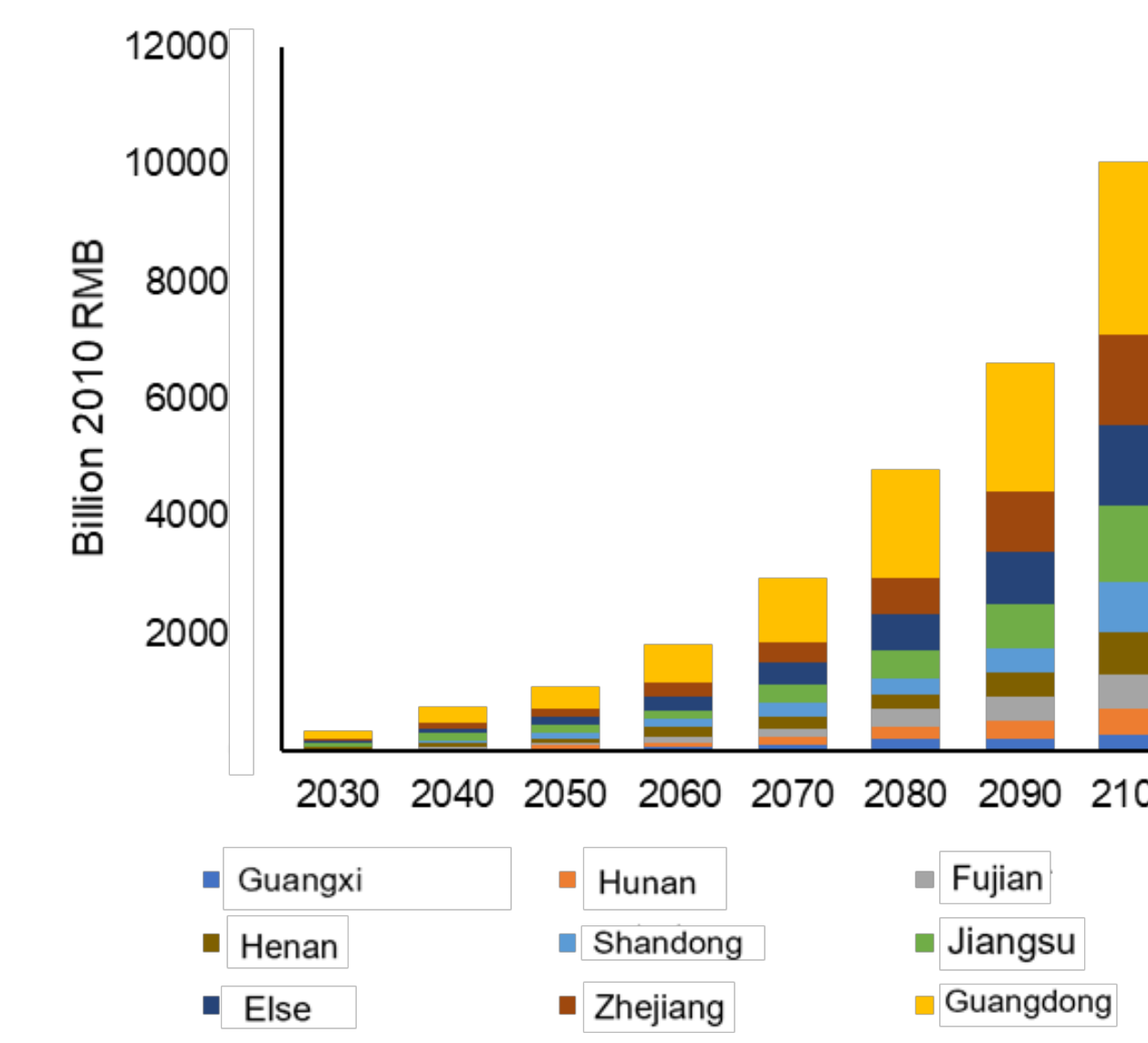


Fig. 6: Future economic loss of worktime loss in different provinces

- The total work time loss in Guangdong is much higher than that of other provinces, with a total labor time loss of 245.1 billion hours between 2030 and 2100, accounting for 42.9% of the national total.
- The average annual economic loss caused by work productivity loss in the future is 3545.12 billion CHY in China.
- Among all provinces in China, Guangdong, Zhejiang, and Jiangsu possess the highest labor economic losses, with 9489.7, 4038.4, and 3296.7 billion 2010 RMB respectively, accounting for 33.46%, 14.24%, and 11.62% of the total economic losses in the country.

Summary & Conclusion

1. Both the historical and future period witnesses the continuous growth of high-temperature days as well as heatwaves and related economic losses.

2. In the historical period, the annual amount of work productivity economic loss is 1085.94 billion CHY, and the high-temperature subsidy is 250.7 billion. While in the future , the number rises to 2592.8 billion and 3545.1 billion, respectively.

3. As for the regional differences, the region of East, Central and South China suffers the most sever economic losses. Especially in Guangdong Province, the monetized work time loss and subsidy account for 33.5% and 20% of China.