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The local impact of typhoons on economic activity in China: A view from outer space

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ABSTRACT

We examine the impact of typhoons on local economic activity in coastal China. To capture potential damages from an individual typhoon we use historical typhoon track data in conjunction with a detailed wind-field model. We then combine our damage proxy with satellite derived nightlight intensity data to construct a panel data set that allows us to estimate the impact of typhoons at a spatially highly disaggregated level (approx. 1 km). Our results show that typhoons have a negative and significant, but short-term, impact on local activity – a typhoon that is estimated to destroy 50% of the property reduces local economic activity by 20% for that year. Over our period of analysis (1992–2010) total net economic losses are estimated to be in the region of $US 28.34 billion. To assess the damage risk from future typhoons we use simulated probability distributions of typhoon occurrence and intensity and combine these with our estimated effects. Results suggest that expected annual losses are likely to be around $US 0.54 billion.

1. Introduction

Annual global damages arising from tropical cyclones have been estimated to be around $US 26 billion.[1] In this regard China, with on average seven typhoons per year making landfall resulting in annual damages of about $US 5.6 billion according to official figures, has been a major contributor to the global damage estimates.[2] For example, in 2006 China was struck by Typhoon Soamai which subjected the provinces of Zhejiang and Fujian to winds of up to 135 mph and an associated storm surge of up to 10 feet. As a consequence, Typhoon Soamai destroyed thousands of buildings, sunk over 1000 boats, led to power cuts in six cities, and displaced up to 1.7 million people. Total costs were estimated by the Chinese government to be in the region of $US 1.4 billion. Such potentially high losses and the subsequent interruption to economic activity raises the question of what impact typhoons ultimately have had on the Chinese economy and what the future impact maybe.[3] The contribution of this paper is to provide the first detailed study of the economic effects of typhoons for China.[4]

In seeking guidance on how to conduct an analysis for China it is noteworthy that while the literature examining the economic impact of natural disasters is still relatively new, there has been relatively rapid evolution in both the approach and methodology used. The majority of the earlier studies conduct global cross-country analyses of the impact of natural disasters in general and find mixed results; see the reviews by Cavallo and Noy (2011)

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[1] See Mendelsohn et al. (2012). Neumayer and Barthel (2011) point out that over the last 30 years annual global economic losses due to weather-related events have increased at a rate of $US 2.7 billion a year with direct physical damage from natural disasters estimated to be $US 1527.6 billion between 1975 and 2008 (UNISDR, 2009).

[2] See Liu et al. (2001) for a remarkable 1000 year history of typhoon strikes in Guangdong Province and Louie and Liu (2003) for a discussion of the earliest records of typhoon activity in China. Other China specific studies that concentrate on the physical impact of typhoons include Gao et al. (1999), Chen et al. (2009), Meng et al. (2007), Wang et al. (2007), Zhang et al. (2009a,b) and Cao and Wang (2013).

[3] Typhoons are defined as tropical cyclones of the western North Pacific (NWP) that maintain a maximum wind speed for one minute of 33 ms^{-1} or over.

[4] There are two studies that examine the economic impact of natural disasters in general in China, but without specifically identifying the impact of tropical cyclones. Vu and Noy (2013) find that natural disasters, as derived from EM-DAT (Emergency-Events Database), affect both provincial income and investment, although their effect depends on the measure used. Similarly, the results in a province level study of the impact of disasters on output by Vu and Hammes (2010) depends heavily on the measure of natural disaster used.

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and Felbermayr and Gröschl (2013). A small number of studies focus specifically on tropical storms. For example, Strobl (2012) shows that tropical storms in the Central American and Caribbean region cause country growth rates to fall by 0.6 percentage points in the year of the strike. It should also be noted that many of the earlier studies, including Vu and Hammes (2010) and Vu and Noy (2013) for China, tend to use *ex-post* collected data on damages, deaths, and/or the affected area to capture the impact of natural disasters. However, Strobl (2012) shows that these data are likely to introduce measurement and omitted variable bias into the estimation and recommends the use of actual physical characteristics, such as wind speed for tropical storms, to proxy potential damages.

Another important development in the literature has been the recognition that natural disasters are inherently local phenomena, so that their overall impact may be fully or partially 'aggregated out' at the cross-country or large regional level, particularly for large countries. Bouwer (2011) notes when talking about the shortcomings of the existing literature that "*. . .scale of analysis is also an issue, because aggregating to the regional or global level may have the advantage that local variability is eliminated, but one could fail to see trends [. . .] that may vary per location in sign and magnitude*" (pg. 43). This was empirically shown for the US by Strobl (2011) who found hurricanes to have an annual negative impact at the county level, but no effect at the state or national level.[5]

In this paper we set out to identify the economic effect of tropical storms on coastal China by taking into account and refining recent developments in the literature. More specifically, we first combine actual typhoon track data with a wind field model to derive an *ex-ante* index of potential damage due to typhoons at any point relative to the storm. We then, in order to address the potential spatial aggregation bias associated with using national or large regional regions as the unit analysis, use time-varying estimates of night-light intensity from satellite imagery as proxies of economic activity (Chen and Nordhaus, 2011; Henderson et al., 2011). Note that there are now a number of papers that specifically use nightlight imagery to proxy local economic wealth; see, for instance, Harari and La Ferrara (2013), Hodler and Raschky (2014) and Michalopoulos and Papaioannou (2014). As a matter of fact, a recent study of the Caribbean by Bertinelli and Strobl (2013) demonstrated that the level of spatial aggregation of nightlight imagery can more accurately capture the effect of hurricane damage. An additional contribution for China is that we also allow for a different impact of typhoons on nightlights in storm surge prone areas, an aspect that has been previously ignored in the literature. Combining our income proxy with local potential damage measures thus provides us with a large annual panel of data covering nearly twenty years with which we can estimate the impact of typhoons on local net economic activity in China.

Although the literature on the economic impact of tropical storms, and natural disasters in general, has improved in terms of methodology and data in recent years, one shortcoming has been that the implications of the results for risk analysis is still relatively limited. More specifically, tropical storms, like most natural disasters, particularly the extreme ones, tend to be relatively infrequent events. Thus, while one may obtain an accurate estimate of the economic impact of tropical cyclones with available historical data, these data do not provide enough observations to derive reliable probability distributions of tropical storms' intensity and occurrence. Traditionally this problem has been addressed by using extreme value theory or other statistical methods. However, since the historical data typically contain only a few very strong tropical storm strikes the estimated probabilities can be very sensitive to the tail of the assumed distribution, making direct inference fairly unreliable, particularly for local areas. Here we follow Emanuel et al. (2008) and instead rely on a large set of synthetic tracks generated from a random draw using a space time probability density function of tropical cyclone formation based on a coupled ocean–atmosphere tropical storm model. This allows us to derive a statistically sound distribution of hypothetical hurricane storms and accompanying wind strengths near the Chinese coast according to recent climatological features. We then combine these synthetic tracks with our econometric estimates of a typhoon's local impact to provide local typhoon damage risk measures for coastal China.

Arguably China is a particularly attractive case study. First, growth in exposure to typhoons as a result of rapid economic development and migration patterns and a growing insurance market in China has increased the interest from policymakers and the insurance industry to better understand the risks associated with typhoons (Freeman et al., 2003; Ward et al., 2008; Neumayer and Barthel, 2011).[6] According to ADRC (2013), over 70% of China's cities and 50% of the population are located in regions that frequently experience major natural disasters. Second, although the science is currently inconclusive, the possibility that global warming will result in more numerous or more intense typhoons in the future increases the need for policymakers to gain a better understanding of the current relationship between typhoons and economic costs (Webster et al., 2005; Landsea et al., 2006; Elsner et al., 2008; Li et al., 2010). Finally, the net economic impact caused by any natural disaster is closely linked to a country's disaster preparedness (Kahn, 2005). In China, disaster management falls under the China National Committee for Disaster Reduction (NCDR), which is comprised of 34 ministries and departments and includes the relevant military agencies and social groups and its main function is to coordinate across agencies and to instigate plans and policies for disaster mitigation.[7] Importantly, disaster management strategies in China are often considered to be remarkably successful, which may have dampened any negative impact on economic activity due to typhoons.[8,9]

[5] As typhoons are part of the atmospheric and hydrological process typhoons are also likely to reoccur and hence have a cumulative effect on development (Benson et al., 2000).

[6] Zhang and Zhu (2005) discuss the development of the insurance industry in China. According to Swiss Reinsurance Company (2005) China's premium income was $US 52.17 billion (3.26% of GDP) in 2004 up from $US 1.37 billion (0.7% of GDP) in 1986 (Swiss Reinsurance Company, 2005). The number of firms in the property insurance industry has also increased from 8 in 1996 to 26 in 2004 (Wu, 2004). China is currently testing a new insurance system to fund reconstruction work after natural disasters which will share the cost between the government, insurance and reinsurance firms and individuals.

[7] The first national disaster reduction plan was written in conjunction with the ninth five-year plan and a state emergency response system built and developed as part of the twelfth five-year plan (2011–2015). The priority areas are disaster prevention and relief management which includes scientific research, technological advances and education. Coordination across local and central government is also an important element of disaster management (ADRC, 2013). Satellites for remote sensing have also recently been launched for disaster monitoring and assessment.

[8] The Ministry of Civil Affairs is currently responsible for disaster relief. The contingency plan for disaster relief includes plans issued at the province, city and county-level, as well as for individual towns, schools and factories. In addition stockpiles for disaster relief have been built up across 22 cities and smaller disaster prone localities in China. A campaign of public awareness has also been undertaken and a booklet "Handbook of Disaster Prevention and Self-Rescue" has been published. There are also plans for a well-equipped national chain of emergency shelters that will include schools and stadiums and other public buildings. Moreover, rural and urban communities will have their own emergency response plan (ADRC, 2013). Following the Sichuan (2008) earthquake the Chinese government obtained resources from across the country and a three-year target was announced that all homeless households would be rebuilt. Grant were also provided to households that were homeless and could also apply for additional loans. The subsidy and loan system was directed by the central government but the implementation was at the discretion of county governments and village committees (Tse et al., 2013).

[9] One example is the adaptation of capital (housing and infrastructure) in disaster prone areas which has led to casualties from China's frequent floods falling dramatically from over 140,000 and 33,000 lives in 1931 and 1954 respectively to 3000 for a similar flood in 1998 (Annan, 1999).