Weather Risk and the Viability of Weather Insurance in Western China

Calum G Turvey
Cornell University

Rong Kong
Northwest Agriculture and Forestry University, PRC

And

Burgen C Belltawn
Cornell University

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Calum Turvey is the W.I. Myers Professor of Agricultural Finance, Applied Economics and Management Cornell University; Rong Kong is Professor of Finance and Management, Northwest Agricultural and Forestry University, Yangling, Shaanxi, PRC, and Burgen Belltawn is a graduate student, Applied Economics and Management, Cornell University. This paper has been partially supported by the W.I. Myers Endowment and the JSL Endowment Funds for Research in China, Cornell University, and by the China National Nature Science Fund with grant number 70873096 and Humanities and Social Science Fund of China Education Department with grant number 07JA790027

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Abstract

This paper presents preliminary results on the possible demand for weather insurance in China. Results from 1,564 farm households from Western and Central China between October 2007 and October 2008 suggest that the greater risk for farmers is drought followed by excessive rain. Heat is less critical as a risk but more significant than cool weather. Results suggest a strong interest in precipitation insurance with 50% and 44% of respondents indicating strong interest in the product. Supplementary results indicate that interest is equal between planting, cultivating, and harvesting. Furthermore results suggest that farmers are willing to adopt new ideas, and where possible already take action to self insure through diversification and other means, The results are encouraging. Examples and discussion of how weather insurance can be implemented is included in the text.

Key Words: Weather insurance, rainfall insurance, China

Introduction

Political reforms in China's rural regions are opening up new avenues for progress and risk management for millions of farms and farm households. The Chinese government has within the past year authorized an investigation into agricultural insurance. The burst of research and applications of weather insurance in both developed countries and developing countries combined with interest from the World Bank (The International Research Group for Climate and Society (IRI) 2009) suggest that a wide array of applications could be feasible in China. In fact with respect to China, weather-linked insurance may be efficient. China's rural areas include millions of farms, the majority of which are between 5 and 10 mu (1 mu = 1/6 acre) in size and very poor (about 4,000 RMB per capita or $600 U.S / year). The sheer number of farms suggests that conventional crop insurance would not be feasible because of the underwriting costs, and broader based area yield insurance might not be feasible because yield history is scarce. Providing insurance against specific weather events such as drought or extreme heat may be a cost effective means to providing risk management strategies.

The relationship between specific weather events and agricultural productivity has not been studied extensively in China. However, this study can not be more prescient as parts of China faced the most severe drought in late 2008 and early 2009 in more than 50 years. As of February 2009 the drought, nearing 100 days, affected at least 3,385 million acres across 12 provinces, including the wheat-producing areas in Henan, Anhui and Shandong provinces. Deficits in some areas are 80% below average rainfall. So desperate was the need for rain that Chinese soldiers loaded rockets with cloud-seeding chemicals and fired them into the sky over drought-stricken areas in the effort to produce rain, and had plans in place to divert water from its two longest rivers to drought-stricken areas. However, the remoteness of some areas and the lack of irrigation technology suggests that not all farmers will benefit from these actions (CNN 2009). Beijing has set aside 100m Yuan ($ 14m) of funding to help farmers combat the problem In Anhui Province estimates put losses at 1.6bn Yuan requiring the Provincial government to provide millions of Yuan in aid to farmers(Guardian 2009).

In 2008 a drought in China's northeast Liaoning province left nearly 700,000 people without drinking water after rainfall between January and March fell to 20% of its normal value, threatening maize and rice farming. From January to the end of March 2008, Liaoning had received less than 2 centimeters (less than an inch) of rain with 66 reservoirs drying up, and a rush to build 1,700 new wells so that spring planting could proceed (Reuters 2008). In 2006 the worst drought in 51 years was reported for Chongqing, Sichuan and Liaoning. In Chongqing there was no rain for more than 70 days, and two-thirds of the rivers had dried up and there were reports of residents in some mountain villages having to walk up to 2km (1.25 miles) to get water. Estimates put losses from the 2006 drought at 11.74bn Yuan ($1.24bn) (BBC 2006).

The recent droughts in 2006, 2008 and 2009 are not, however a new phenomenon. Buck (1936) asked farmer respondents throughout China to report the number of droughts and other natural calamities that could be recalled between the years of 1904 and 1929. Across China there were 5.5 droughts resulting in a crop loss of more than 20% with the highest being in the wheat growing regions. The average crop loss during these periods of drought was 46%. In the same time frame farmers reported an average of 1.8 droughts that led to wide-spread famine. While China’s social safety-net and a developing infrastructure will avoid problems of famine in the modern day, then as now drought can cause a reduced standard of living, a spread in income inequality, local price hikes, and mass migration. The current regime of land user rights constrains the ability of many if not most of Chinese farmers to achieve a scale of operation that can absorb drought events. Thus in Buck's study the average cultivated land in 1929-1933 was 4.17 acres. Fei and Chang (1945) report (1933) land size per household as 5.7 Mu or 0.87 acres in Luts'un. In 1917 Liberty Hyde Bailey recorded a household standard of one mu per person (Dorf 1956) leading to a life of toil and poverty that he found incomprehensible. To place this historical context in perspective to the current study, our surveys record average farm size per household of 5.52 Mu or 1.36 mu per household member (Table 2). The average household income of 11,477 Yuan represents approximately 31 Yuan/day per household or approximately $4.62/day per household or $1.13/day per capita.

For households that are barely above poverty levels weather calamities can rapidly cause deteriorating conditions for Chinese farmers. Crop losses arise from delays in planting or harvest or poor growing conditions. Inexpensive weather insurance may provide sufficient reward under extreme drought or heat conditions, but there is no baseline information on which to determine what types of weather risk are more important for Chinese farmers or whether Chinese farmers would have an interest in purchasing weather insurance. The purpose of this paper is to investigate weather risks facing Chinese farmers, and to determine whether farmers would have a preference for weather insurance over other types of agricultural insurance. In addition we gather information on how farmers obtain weather information including, if known, the distance to the closest weather station. Our data is based on 1,564 farm households surveyed in Shaanxi, Henan and Gansu provinces in Central China between October 2007 and October 2008. Table 2 provides a general overview of the sample.

Background and Literature Review on Using Weather Insurance in Developing Economies

The design and application of weather risk management products for development agriculture is becoming very popular (Barret et al 2007) and follows from a significant trade in weather insurance in global markets. Roth et al (2008) citing a study by Price-Waterhouse-Coopers (2007) indicate that the notional value of weather insurance world-wide had a notional value of $U.S. 19.2 billion in 2006/2007 but had reached as high as $U.S.45 billion in 2005/6. The most visible applications have been sponsored by the Commodity Risk Management Group (CRMG) at the World Bank which has been piloting index-based weather insurance for developing country producers, agricultural businesses, and banks in India, Peru, Ukraine, Ethiopia and Malawi IRI (2009) (see also Skees at al 2008;Skees (2008a,b). Using weather insurance to fund famine relief in Africa has been proposed by Chantarat et al (2007,2008) and risk-contingent credit applied to weather events has been proposed by Turvey (2008).

The methodology behind weather insurance has been described in detail by numerous authors including Turvey (2001, 2006), Richards et al (2004) and Odening et al (2006). These methods are evolving under two distinct approaches. First the burn rate approach, by far the most popular, establishes criteria for a specific event risk and uses historical data on an annual basis to determine the frequency at which the specific event occurs and when it does occur, by how much. The burn rate approach can be applied to both precipitation and heat related events. The second approach is to follow along the lines of equilibrium option pricing. This approach is not practical for precipitation but various models based on cooling or growing degree-days have been suggested including Turvey (2006), Richards et al (2005) and Xu et al (2008). It should be noted however that weather insurance can be applied to any type of specific event risk including daily precipitation, accumulated precipitation, daily temperature maxima or minima, average temperatures, or heating, cooling or growing degree days. Payoffs can be binary, in which the farmer receives a lump sum payout if the specific event occurs, or can be graduated paying an indemnity that increases linearly with the intensity of the weather event. Turvey and Norton (2008) describe a computer program that calculates weather insurance premiums under these alternatives. However, there is also emerging some ideas tying weather insurance to the emergence of insect infestations (Richards et al 2006, 2008) or plant disease (Norton and Turvey 2008; Workneh et al 2008). Regardless of what problem is taken the basic element of weather insurance is to establish a time dependent boundary condition at which the specific event is measured. This boundary condition is given by

(1) $$v_{call} = Max\left[x_T - Z, 0\right]$$

(2) $$V_{call} = e^{rT}\phi E\left[Max\left[x_T - Z, 0\right]\right]$$

for a weather insurance with 'call option' features, and

(3) $$v_{put} = Max\left[Z - x_T, 0\right]$$

(4) $$V_{put} = e^{rT}\phi E\left[Max\left[Z - x_T, 0\right]\right]$$

for weather insurance with 'put option' features. Weather insurance can also include multiple events where an indemnity can be paid over multiple outcomes. For multiple events we can break time into n periods of fixed length, e.g 20 days or 40 days.

(5) $$V_{put}^{N} = e^{rT}\sum_{n=1}^{N}\theta_n\phi E\left[Max\left[Z - x_n, 0\right]\right]$$

Where each n represents a specific event that is non-overlapping with any preceding or subsequent event, and θ_n is the probability of the n^{th} event occurring and $\sum_{n=1}^{N}\theta_n = 1$.

The random variable x can take on any weather measure. Most often the metric used is cumulative rainfall

(6) $$x = \sum_{t=1}^{T} r_t$$

or growing degree days

(7) $$x = \sum_{t=1}^{T} Max\left[h_t - H, 0\right]$$

Where h_t is the temperature measure of day t and H is a target. $H = 65$ degrees Fahrenheit is the common measure used in the energy industry for cooling degree days, and $H = 50$ degrees Fahrenheit is a common target for measuring crop or corn heat units.

Examples of Heat and Precipitation Insurance

Obtaining climate data from China is difficult; however we can at least provide an example of how weather insurance operates by using U.S. data from a region with climatological similarities to China. We choose the weather station at Ashland Kansas because not only is it centrally located in the United States but also in Kansas' wheat belt, just north of Cimarron county on the Oklahoma panhandle. This area of wheat is subject to extreme heat conditions as well as periodic droughts, including a 1979 drought that saw less than 1" of rain in 79 days. Although extended droughts of this length are rare, 1 in 100 years, the area is subject to drought conditions up to 40 days in 4 of every 10 years, and 30 days in almost 3 of every 4 years. It is also subject to extreme heat conditions. Between May 1 and August 31 the historical degree-days above 80F is 1,320.18 with a high of 2,069 degree days recorded in 1934. According to Buck's study discussed in the introduction, drought with crop loss occurs about 1 in every 5 years in the major crop growing areas of China, which by our standards would suggest a range between 45 and 50 days with less than 1” of rain. The 2006, 2008 and 2009 droughts in China were reported as the worst in 50 years and were approximately 70 days or more in length. In Ashland three 75-day droughts were observed between 1901 and 2006 for a percentage rate of 2 to 3 times a century, within the range of the dramatic droughts found in China in recent years.

Table 1 provides results from Turvey and Norton’s (2008) computer program (www.weatherwizard.us) for specific event precipitation insurance. Days of drought are defined and up to 5 non-overlapping drought events can be insured where arithmetically possible. The table provides the event frequencies, the insurance premium based on a tic value of 100 Yuan, and the maximum payout. As is familiar multiple events of short drought durations (e.g 20 day droughts) are far more likely to occur than extended droughts of 40 or 70 days and consequently come at higher premiums. For example a 30-day drought does not occur 23.6% of the time, occurs once 47.2% of the time, twice 25.5% of the time and three times only 3.8% of the time. The cost of this insurance would be 248 Yuan and the maximum payout would have been 1,380 Yuan. The relationship between Indemnity and coverage is provided in Figure 1, which shows a logarithmic reduction in premium as the rarity in event risk increases.

Heat risk is presented in Figure 2 with the premiums recorded on the Y axis and the degree-day strike on the x-axis. This insurance profile is for extreme heat in which the actual degree-days in any year exceed the coverage level (features of a call option). Undiscounted premiums range from 10,713 Yuan for a strike equal to mean degree days, but this premium falls rapidly as the strike increases. For a strike of 1,700 degree days the premium is 946 Yuan, and for a strike of 2,000 it is only 67 Yuan.

Finally we also consider a joint risk contract which combines specific events on precipitation (less than 1” of rain in 40 days) as well as heat (degree-days in excess of 1,600.

Historically, degree days in excess of 1,600 occurred in 13 of 102 years or 12.7% of the time, while a 40 day drought occurs at least once in 34% of the years. The joint occurrence of both the heat and precipitation event occurs in only 9 of 102 years or 8.8% of the time. If a farmer wanted to receive 1,000 Yuan should the joint event occur, the undiscounted fair premium would be 88 Yuan.

China Survey Data and Results

This section of the paper reports survey results from 1564 farm households surveyed between October 2007 and October 2008 in Gansu, Henan and Shaanxi China. Questions on risk attitudes, risk management practices, weather risk, interest or use of insurance products, and interest in weather insurance were asked as a subsection to a much broader range of questions dealing with risk, livelihood and credit. Little is known about the specific event weather risks faced by Chinese farmers, and even less is known about their attitudes towards or willingness to consider purchasing agricultural insurance.

The sample profile is presented in Table 2. Average household income was 11,477 Yuan with the poorest farmers being in Henan Province. Farm size is on average 5.52 mu where 1 mu is approximately 1/6th of an acre. In other words the agricultural livelihood was derived from growing mostly corn and wheat on about 1 acre of land. The smallest farms were in Henan, and although 58.7% of household income was derived from farming activities on average, in Henan limited off-farm opportunities restricted income from farming to 71% of household income.

The first step was to identify the relative risk of specific weather events. Based on a 5-Point scale farmers were asked in which months the risk of low rainfall, high rainfall, low temperature, and high temperature was important with a 1 being not important and 5 being extremely important. The results are summarized in Figures 3-6. Precipitation is the most significant risk, with low precipitation or drought being slightly more important than excessive rain. Drought risk is bimodal with two peaks, in the spring (March) and in the summer (July). Excessive rain also has twin peaks, with the most severe risk in June and then in the harvest months of September and October. Temperature does not appear to be as important but respondents indicated that excessive heat in July was an important risk factor. Cool temperatures had a fairly neutral response.

To gain some perspective on attitudes towards risk and risk management we asked farmers about their willingness to adopt new technologies and management practices. The reasoning for asking these questions was to gain insights into whether or not they would be averse to a new insurance product. The results in Table 3 indicate that the farmers are willing to accept the risks of new production risks, new technologies and new management practices. About 64% were moderately willing or willing to take new production risks. This is slightly less than about 74% willing to accept risks on new technologies and 71% for new management practices. The main point to take from this is that these farmers are not closed out to ideas, and are not overly fearful of new management technologies that they do not fully understand. It also reveals a willingness to adapt and improve the farming business, a characteristic which we believe is critical to the successful adoption of weather insurance.

Table 4 shows results from inquiries into current risk management practices. About 65% of farmers believe that diversification is an important risk management tool although about 17% indicated that they do not diversify. About 43% of farmers indicate that spatial diversification is important; that is having farm plots in different locations is important. In China, many farms are non-contiguous because of the allocation of land among family members, but in most cases the land will be within an operational walking distance. Irrigation is of importance to 64% of farmers although 24% do not have access to irrigation. It is easy to presume that those that do not use irrigation is because they do not have access rather than because they do not deem it important. Irrigation is widely available in Yangling in Shaanxi with nearly 90% having access to irrigation, whereas 42% of Gansu farmers do not have access to irrigation. While important, the atomistic nature of Chinese agriculture limits the ability of farmers to forward sell or spread sales throughout the year. The majority of farmers in our sample grow wheat followed by corn. Storage facilities are virtually non existent. In addition both corn and wheat are harvested at the same time in the study area. Other products such as nuts and peppers for example can be harvested over a longer period of time, but in general the pepper harvest occurs at the same time as the corn harvest, with stone milling done by some farm households in the village itself. Although government support is deemed important by most farmers, access to support is not universal with 35% of farmers indicating that they do not use government programs. Farmers also recognize the importance of precautionary savings and investments with 53% and 55% of farmers indicating so. About 20% of farmers do not use precautionary savings but just over 71% do use some form of off-farm investment to generate cash, although the nature of these investments was not asked.

In Table 5 we queried farmers on their insurance decisions. First we described what a crop insurance product was, and then asked them about their interest in purchasing crop insurance.

> "*Crop insurance is a common tool used by western farmers. Crop insurance will pay you if your crop yield falls below some percentage of your average yields. For example if your yield is 1,000 kg/ Mu for a particular crop, insurance may provide a payment if actual crop yield falls below 70% of this average. For example if actual yield is 500Kg then you would receive a payment based on the difference between 700kg and 500 kg (200kg) times the average harvest price. If*

the price is 5Yuan then you would receive 5(700-500)=RMB1,000 but if yields are above 700kg you receive nothing."*

About 40% for farmers indicated that they would regularly purchase a crop insurance product regularly with 63% indicating at least occasionally. Only 25% of farmers indicated that they would not purchase crop insurance. We then asked if there was any other type of insurance that they purchased; 39.2% purchased life insurance, 8.2% had fire insurance, 6% had automobile insurance (there are in fact very few automobiles in the survey districts), and 88.2% purchase health insurance. We also asked about current purchases of crop and livestock insurance an 17% and 10% of farmers indicated that they had purchased some form of agricultural insurance, but with rather incomplete agricultural insurance markets in China we are unsure as to how they interpreted 'crop' or 'livestock' insurance. Nonetheless, these results indicate that Chinese farmers are not entirely adverse to purchasing insurance products. More important is the recognition of the importance of crop insurance and a willingness to purchase crop insurance occasionally or regularly.

Table 6 responds to a general question of weather insurance. The preamble included the following statement which was read to all respondents;

"*New types of insurance products based on excessive rainfall, deficit rainfall, excessive heat or cold weather are being evaluated for potential use in agriculture. For example, if you buy deficit rainfall insurance, you will receive a payment if the number of inches of rain that fall in your farm during a month or a season is less than what you expected. The money you will get is based only on how much shortfall in rainfall you will experience. It is not based on how much yield shortfall you experience. Your insurance contract will be written based on the historical rainfall data at your local weather station or if possible on a weather station on your farm*".

Farmers were then asked to indicate interest in five possible weather products. These farmers show a much stronger affinity towards precipitation insurance than heat-based insurance; 50.8% of farmers are at least somewhat interested in low rainfall insurance, while 44.2% would have interest in excessive rainfall (only 26% would not at all be interested); 35.3% are at least somewhat interested in excessive heat insurance, but the interest is much lower for cool-weather insurance with about 30% showing interest. For these farmers there was not a great interest in wind insurance either.

We were interested in the timing of weather insurance and asked the respondents at which time in the production process would weather insurance be of most interest. There is little difference in interest between planting, cultivating and harvesting the crops, which is consistent with the bi-modality of the importance of weather risk in Figures 3 and 4. These results suggest that should weather insurance be offered in China, the insurer could offer a variety of products, most likely tied to precipitation, throughout the year. Because the significance of the weather risk, and the underlying crop potential changes throughout the growing period such products would need to be targeted. For example the indemnity of drought insurance during planting can be tied to reseeding and planting; during the growing season where significant reduction in yield is a potential hazard but reseeding not a viable option, the indemnity would be higher. In the harvest months, losses from weather risk could be tied to lateness of harvest or degradation in quality and quantity of harvested crops.

Discussion and Conclusions

The development and distribution of weather insurance products to farmers in China has several points of merit. First with small farms of between 1 and 2 acres the application of traditional crop insurance with its associated underwriting costs would be virtually impossible without a significant bureaucracy and public cost. One alternative that has had significant interest and impact over the past decade has been weather insurance. Weather insurance requires recording climatological data at a specific weather station over a period of time and thus resolves the problem of underwriting what could be tens of millions of micro insurance contracts. The added benefit is that the weather insurance does not discourage best management practices because there are no adverse incentives or asymmetric information issues. This study surveyed over 1,500 farmers in Western China (Gansu and Shaanxi) and Central China (Henan),to identify several related factors to risk management and to establish whether or not there would be a general interest in weather insurance. The results suggest that farmers are not overly averse to adopting new technologies or practices to improve farm conditions even if these come with added risk or unknown outcomes. There is a general consensus that rainfall insurance during planting and cultivation and heat insurance during cultivation and harvesting could be of interest, but so too would be an excessive rainfall insurance contract. Respondent farmers were equally as interested in weather insurance at planting, growing and harvest suggesting that any pilot program should target multiple contracts throughout the year. Overall, perhaps as many as 40% of farmers would be interested in a weather-risk insurance contract which indicates a significant potential demand.

We are, of course under no illusion as to how complex the introduction of weather insurance would be in China. Agricultural insurance itself is underdeveloped so the conceptual basis of weather insurance may not so easily be understood by farmers. In addition there is no general infrastructure for selling agricultural insurance, although it would be reasonable to suggest that any such product could be sold through the existing network of Rural Credit Cooperatives or the emerging network of Postal Savings Banks. Even if weather insurance could be sold through Rural Credit Cooperatives, there still needs to be put in place a reinsurance mechanism to cover excess exposure to systemic risks (Roth et al 2008). As discussed in the introduction there have been significant droughts across the agricultural regions of China in 2006, 2008 and 2009 that have been described in term s of 50-year events. Losses for such expansive loss would need to be layered between the local insurer and a global reinsurer which could transfer such risks into the capital markets. The legal and regulatory environment in China would have to be adapted to account for this.

The survey results are encouraging in that it signals a desire for agricultural insurance, a willingness amongst Chinese farmers to adopt new ideas when presented to them, and an openness to purchase insurance in general. But how would weather insurance work? Skees, Barnett and Murphy (2008) describe a three-tiered model used for livestock index insurance. Assuming that RCCs can obtain regulatory approval to underwrite insurance or operate as an agent of an insurance company a special purpose vehicle (SVP) would be established into which all participating insurers would deposit initial capital equal to 40% of expected insurance premiums, net of loading (administrative) costs. Shares would be issued and profits, if any, distributed to the insurers on a pro rata basis. The actual premiums collected from farmers would then be added to the original capital. This makes up the first tranche of indemnity financing. The second tranche is obtained from reinsurers who can access capital markets. For example in Skees et al (2008) the reinsurers cover a layer of loss above 105% of premiums and SVP capital. The insurers will use a portion of the funds available to purchase reinsurance. The reinsurers in turn would establish a fund from which indemnity payments in excess of 105% loss would be paid up to a maximum amount which could be the capital in the reinsurance fund or some negotiated amount. Should losses deplete both the insurers funds and the reinsurer funds, a third tranche is established using commitments from the Chinese government, the World Bank, Asian Development Bank or some other institution that could cover the losses. For example consider the example in Table 1. 55 days-in-drought is approximately a 1 in 10 year event (9.4% chance of a 55-day drought). The cost of this is 14 Yuan with a maximum (catastrophic) payout historically being 570 Yuan. The first tranche funds on a single contract would be 40% contributed under the SPV (5.6 Yuan) plus the premium for a total indemnity fund of 19.6 Yuan. The insurer may request the reinsurer to cover all or a portion of the indemnities above 105% of premiums (14.7 Yuan) as in the Mongolian model, or they can sell a portion of extreme risks. Suppose that the insurers requested that the reinsurer cover losses above a 70-day drought. The insurers will pay the reinsurers 8 Yuan in order to place the second tranche. To avoid complete depletion of reinsurance funds, the third tranche may be requested to cover losses equal to or above 79 days. The expectation that the third tranche will be used is about 0.9% with an expected payout of 1 Yuan per insurance contract.

Even if the distribution of insurance and the layering of risk between farmer, insurer and reinsurer can be resolved, we do not claim that weather insurance will solve all the problems of production risk in China. For small risks with less than 20% it would be more prudent for farmers to hold precautionary savings because, as illustrated in the example provided in this paper, the cost of high frequency events is prohibitive. We agree with Skees (2008a,b) that weather insurance should be designed to cover low frequency high loss catastrophic events. Not only are these products more cost affective but we cannot ignore the household characteristics of the Chinese farmer either. With an average per capita income of just over $1.00/day the sample of farmers in our survey could not so easily purchase weather insurance ex ante without having to give some other consumer/production item up in return. On the other hand should the insurance be purchased and a catastrophic event occurs, the insurance itself can transfer significant risk and provide the household with a liquid source of cash when it is needed the most. There needs to be some effort to determine a willingness to pay for weather insurance (Musshoff et al 2008) and tools would have to be constructed to price weather risk to a local weather station and would also have to recognize the basis risk between the weather events at the farm and the weather events recorded at the local weather station (Woodward and Garcia 2008; Roth et al 2008)

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Table 1: Specific-Event Precipitation Premiums for China Proxy Weather at Ashland Kansas, 1901-2006. The insurance allows for up to 5 non-overlapping drought events with a tick value of 1,000 Yuan. (Source Turvey and Norton 2007; www.weatherwizard.us)

	Number of Events in Year							
Days in Drought	0	1	2	3	4	5	Premium	Maximum Payout
20	0.038	0.057	0.255	0.359	0.217	0.076	1,228	3,040
25	0.151	0.264	0.412	0.132	0.037	-	656	2,040
30	0.236	0.472	0.255	0.038	-	-	388	1,380
35	0.415	0.491	0.094	-	-	-	248	1,230
40	0.594	0.349	0.057	-	-	-	119	930
45	0.764	0.226	0.094	-	-	-	57	760
50	0.868	0.132	-	-	-	-	28	500
55	0.906	0.094	-	-	-	-	14	570
60	0.934	0.066	-	-	-	-	10	490
65	0.943	0.057	-	-	-	-	9	300
70	0.962	0.038	-	-	-	-	8	510
75	0.972	0.028	-	-	-	-	7	510
79	0.991	0.009	-	-	-	-	1	100

Table 2: Sample Overview

Region Province		Household Income (RMB)	% Income From Farming	Farm Size (Mu)	Years Farming	Income/ Person (RMB)	Land/ Person (Mu)
Gansu	Mean	11186.68	45.33	7.82	26.88	2609.46	1.81
Henan	Mean	6176.88	71.17	3.43	27.42	1732.68	0.96
Qianyang	Mean	15308.25	48.30	6.11	26.98	3730.16	1.56
Yangling	Mean	13214.01	68.58	4.90	28.23	3112.93	1.16
Total	Mean	11477.46	58.71	5.52	27.39	2799.80	1.36

Table 3: Aversion To Technology Adoption. We asked this question to obtain some idea of the risk attitudes of respondents. The results indicate that there are differences by region, but in terms of adopting new technologies or management practices these farmers are more likely to accept the risk than be adverse to it.

		Region Province				
		Gansu	Henan	Qianyang	Yangling	Total
		Column N %	Column N %	Column N %	Column N %	Column N %
I am willing to accept greater production risks to increase the chance of higher profits	Adverse To Risk	17.7%	17.5%	23.8%	12.6%	17.9%
	Moderately Adverse to Risk	10.7%	6.5%	14.8%	9.0%	10.2%
	Neutral Towards Risk	9.0%	6.0%	5.8%	6.5%	6.8%
	Moderately Willing To Take Risk	30.1%	24.1%	24.5%	25.1%	25.8%
	Willing To Take Risk	32.6%	45.9%	31.3%	46.7%	39.3%
I am willing to take risks with new technologies before I see good results in other farms	Adverse To Risk	18.3%	9.8%	15.0%	5.5%	12.0%
	Moderately Adverse to Risk	8.1%	5.0%	12.8%	5.8%	7.9%
	Neutral Towards Risk	10.7%	5.5%	7.0%	2.3%	6.2%
	Moderately Willing To Take Risk	25.8%	25.1%	25.0%	25.6%	25.4%
	Willing To Take Risk	37.1%	54.6%	40.3%	60.8%	48.5%
I am willing to take risks with new management practices before I see good results in other farms	Adverse To Risk	18.3%	9.3%	11.5%	6.6%	11.2%
	Moderately Adverse to Risk	8.1%	5.0%	12.5%	9.8%	8.9%
	Neutral Towards Risk	11.8%	10.1%	7.5%	6.8%	9.0%
	Moderately Willing To Take Risk	26.4%	25.9%	27.3%	27.8%	26.8%
	Willing To Take Risk	35.4%	49.7%	41.3%	49.0%	44.1%

Table 4: Risk Management Strategies

		Region Province				
		Gansu	Henan	Qianyang	Yangling	Total
		Column N %	Column N %	Column N %	Column N %	Column N %
More than one crop, animal, or enterprise diversification	Don't Use	19.44%	19.30%	15.00%	13.82%	16.82%
	Not Important	4.23%	4.01%	4.50%	6.53%	4.83%
	Somewhat Important	6.20%	1.75%	5.25%	7.79%	5.22%
	Important	9.30%	8.52%	6.75%	6.78%	7.80%
	Quite Important	36.62%	38.85%	35.75%	35.18%	36.60%
	Very Important	24.23%	27.57%	32.75%	29.90%	28.74%
Fields or farms in different locations (geographic diversification)	Don't Use	26.40%	34.34%	21.00%	19.14%	25.19%
	Not Important	13.20%	4.26%	12.50%	10.33%	9.99%
	Somewhat Important	8.99%	2.01%	8.00%	8.82%	6.89%
	Important	14.04%	14.54%	8.75%	18.14%	13.85%
	Quite Important	27.25%	31.33%	30.00%	29.47%	29.57%
	Very Important	10.11%	13.53%	19.75%	14.11%	14.50%
Irrigation	Don't Use	42.82%	20.55%	24.75%	9.82%	23.98%
	Not Important	8.73%	.75%	4.75%	1.76%	3.87%
	Somewhat Important	5.92%	.00%	1.75%	4.53%	2.97%
	Important	12.11%	1.75%	2.75%	8.06%	6.00%
	Quite Important	16.34%	18.05%	20.50%	25.94%	20.31%
	Very Important	14.08%	58.90%	45.50%	49.87%	42.88%
Spreading sales: selling each product over a period of time rather than all at once (diversified marketing)	Don't Use	35.96%	40.45%	35.25%	21.86%	33.31%
	Not Important	8.71%	11.31%	7.25%	9.55%	9.21%
	Somewhat Important	6.18%	4.02%	4.25%	5.28%	4.90%
	Important	18.82%	18.34%	10.50%	13.07%	15.08%
	Quite Important	16.85%	18.34%	19.75%	30.65%	21.52%
	Very Important	13.48%	7.54%	23.00%	19.60%	15.98%
Using contracts to market your crop in advance at a fixed price	Don't Use	44.94%	66.92%	55.75%	44.47%	53.25%
	Not Important	7.30%	3.76%	8.50%	5.78%	6.31%
	Somewhat Important	5.06%	1.00%	2.25%	6.03%	3.54%
	Important	14.33%	5.26%	6.25%	14.07%	9.85%
	Quite Important	18.54%	14.54%	14.75%	18.34%	16.48%
	Very Important	9.83%	8.52%	12.50%	11.31%	10.56%
Government programs	Don't Use	28.93%	46.37%	46.37%	18.64%	35.27%
	Not Important	4.21%	1.75%	5.26%	4.03%	3.80%
	Somewhat Important	5.06%	3.01%	4.26%	5.29%	4.38%
	Important	13.48%	3.76%	6.27%	10.33%	8.32%
	Quite Important	27.81%	23.81%	22.31%	33.25%	26.76%

		Region Province				
		Gansu	Henan	Qianyang	Yangling	Total
		Column N %	Column N %	Column N %	Column N %	Column N %
	Very Important	20.51%	21.30%	15.54%	28.46%	21.47%
Maintaining financial reserves: having cash and readily convertible assets(e.g. machineries, livestock)	Don't Use	25.00%	23.81%	18.75%	12.06%	19.77%
	Not Important	5.34%	8.02%	5.75%	6.53%	6.44%
	Somewhat Important	4.49%	5.01%	5.50%	4.77%	4.96%
	Important	19.10%	11.28%	10.25%	13.82%	13.46%
	Quite Important	30.06%	42.11%	34.75%	38.69%	36.57%
	Very Important	16.01%	9.77%	25.00%	24.12%	18.80%
Investing off-farm for other sources of income	Don't Use	26.27%	41.85%	24.25%	21.61%	28.56%
	Not Important	4.24%	5.26%	5.00%	5.53%	5.03%
	Somewhat Important	5.08%	2.76%	3.75%	5.78%	4.32%
	Important	12.99%	6.52%	8.00%	5.78%	8.19%
	Quite Important	28.81%	16.04%	24.75%	20.35%	22.31%
	Very Important	22.60%	27.57%	34.25%	40.95%	31.59%

Table 5: Crop and Other Forms of Insurance

		Region Province				
		Gansu	Henan	Qianyang	Yangling	Total
		Column N %	Column N %	Column N %	Column N %	Column N %
Interest in buying crop insurance	Regularly	34.83%	42.86%	33.42%	48.74%	40.10%
	Occasionally	18.26%	20.80%	29.90%	23.37%	23.21%
	In some years	16.29%	11.78%	13.32%	6.28%	11.80%
	Never	30.34%	24.56%	23.37%	21.36%	24.76%
Currently buy life insurance	No	54.24%	75.94%	57.14%	55.03%	60.77%
	Yes	45.76%	24.06%	42.86%	44.97%	39.23%
Currently buy fire insurance	No	87.64%	97.24%	87.00%	94.72%	91.76%
	Yes	12.36%	2.76%	13.00%	5.28%	8.24%
Currently buy auto insurance	No	93.26%	96.49%	89.72%	96.21%	93.94%
	Yes	6.74%	3.51%	10.28%	3.79%	6.06%
Currently buy health insurance	No	17.98%	9.52%	7.25%	12.78%	11.71%
	Yes	82.02%	90.48%	92.75%	87.22%	88.29%
Currently buy crop insurance	No	78.93%	81.95%	80.50%	89.47%	82.82%
	Yes	21.07%	18.05%	19.50%	10.53%	17.18%
Currently buy livestock insurance	No	87.08%	91.23%	87.75%	91.96%	89.57%
	Yes	12.92%	8.77%	12.25%	8.04%	10.43%

Table 6: General Interest in Weather Insurance. The table shows that farmers would have a modest overall interest in weather insurance. Excessive and deficit rainfall would be more attractive than policies against heat extremes or winds.

	No At All Interested	Not Very Interested	Interested	Somewhat Interested	Very Interested
Interest in a risk management tool-excessive rainfall	34.40%	9.40%	12.00%	20.30%	23.90%
Interest in a risk management tool-excessive heat	40.30%	10.40%	14.20%	19.40%	15.80%
Interest in a risk management tool-deficit in rainfall	26.00%	9.10%	14.00%	21.40%	29.40%
Interest in a risk management tool-cold weather	41.60%	11.20%	16.90%	16.60%	13.60%
Interest in a risk management tool-high winds	45.60%	11.00%	14.30%	15.90%	13.20%

Table 7: Relationship Between Farming Activity And Weather Insurance. The table indicates that should weather insurance be made available, farmers would have interest throughout the growing year

		Table 1			
	Not Important	**Somewhat Important**	**Important**	**Quite Important**	**Very Important**
	Row N %	Row N %	Row N %	Row N %	Row N %
Importance of weather insurance in planting	8.90%	3.90%	11.90%	32.40%	43.00%
Importance of weather insurance in growing	5.40%	3.40%	12.70%	34.60%	43.90%
Importance of weather insurance in harvesting	7.80%	3.30%	10.60%	30.00%	48.30%

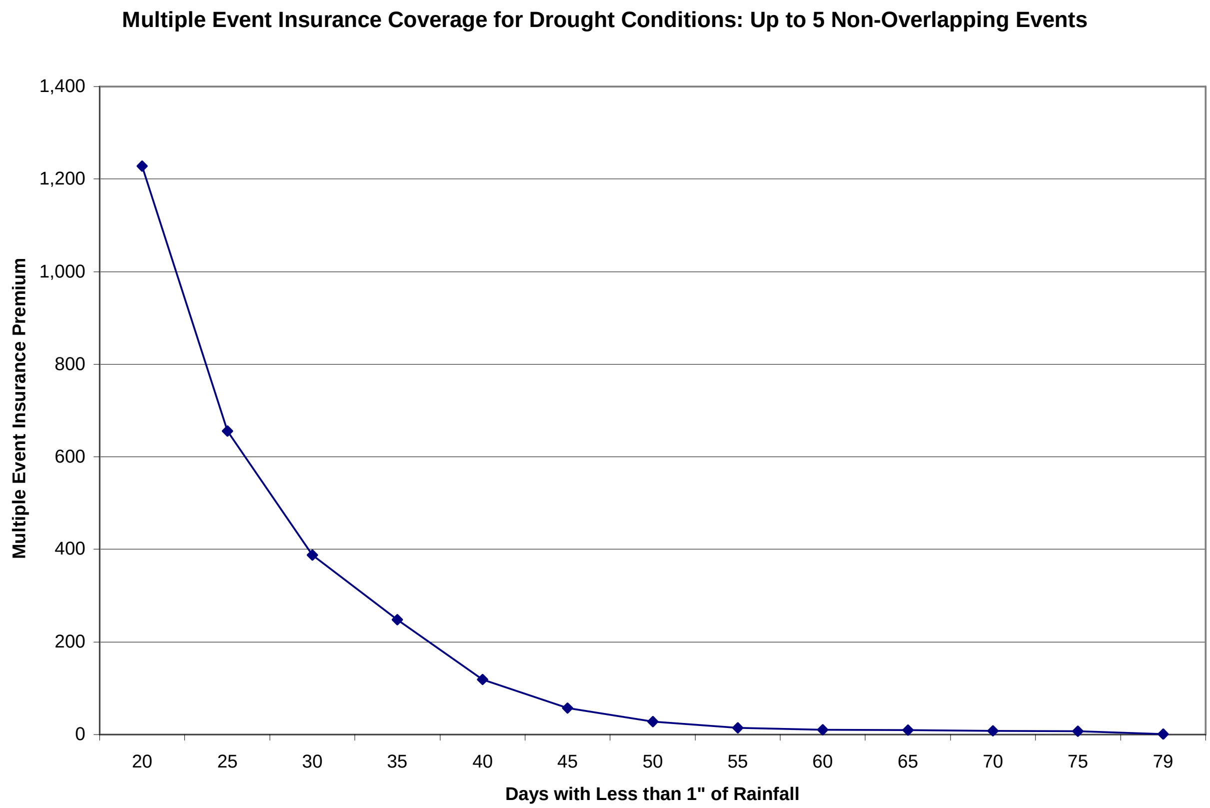

Figure 1: Insurance Indemnity Profile for Multiple-Event Precipitation Insurance. China Proxy at Ashland KS 1901-2006

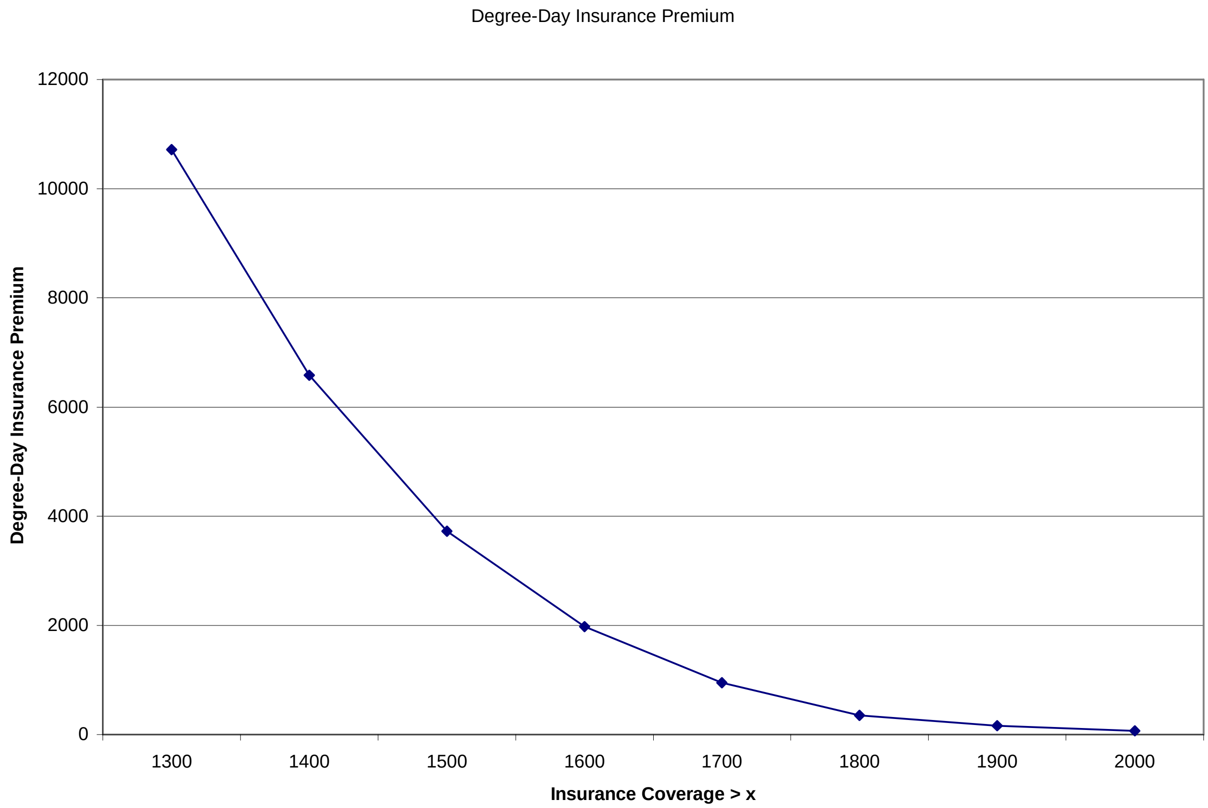

Figure 2: Insurance Indemnity Profile for Degree-Day Heat Insurance based on 80F. China Proxy at Ashland KS 1901-2006

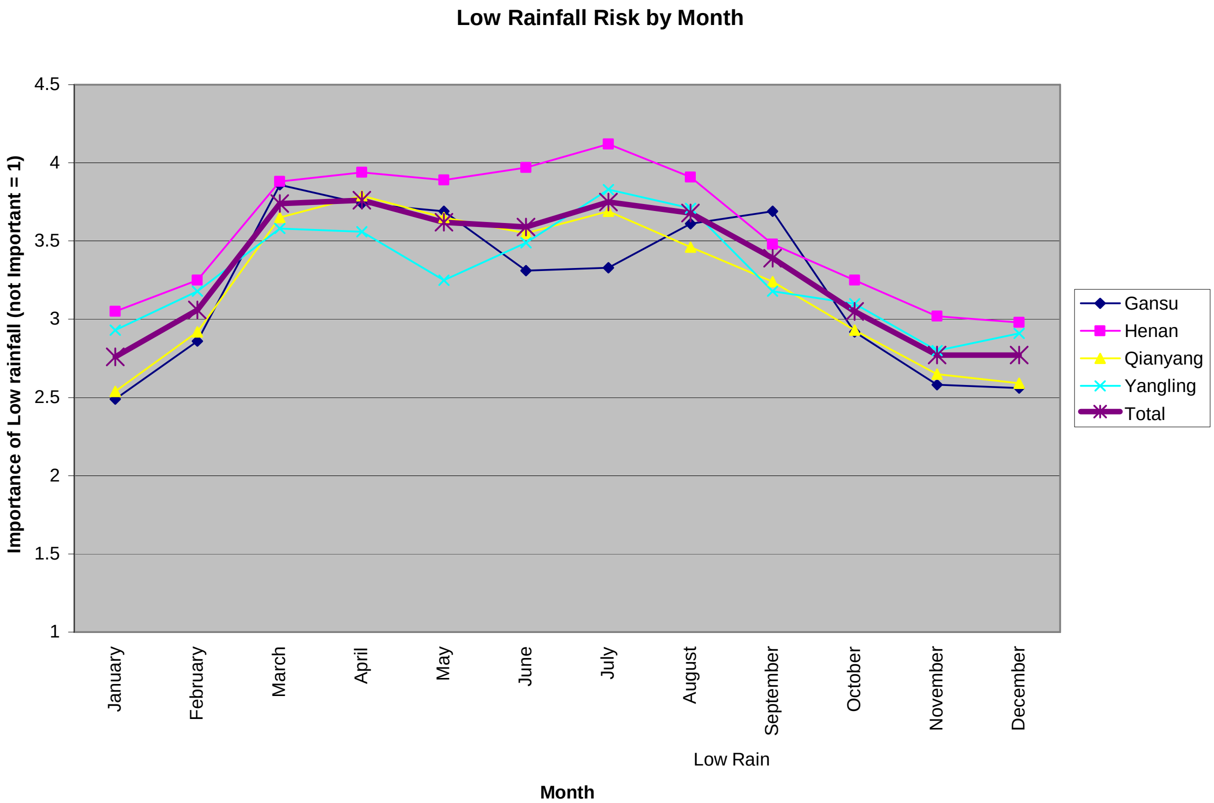

Figure 3: Relative Importance of Precipitation Risk. Graph shows farmers' response to questions about the importance of precipitation risk (drought) throughout the production year. Henan shows a greater propensity to drought risk than other study areas,

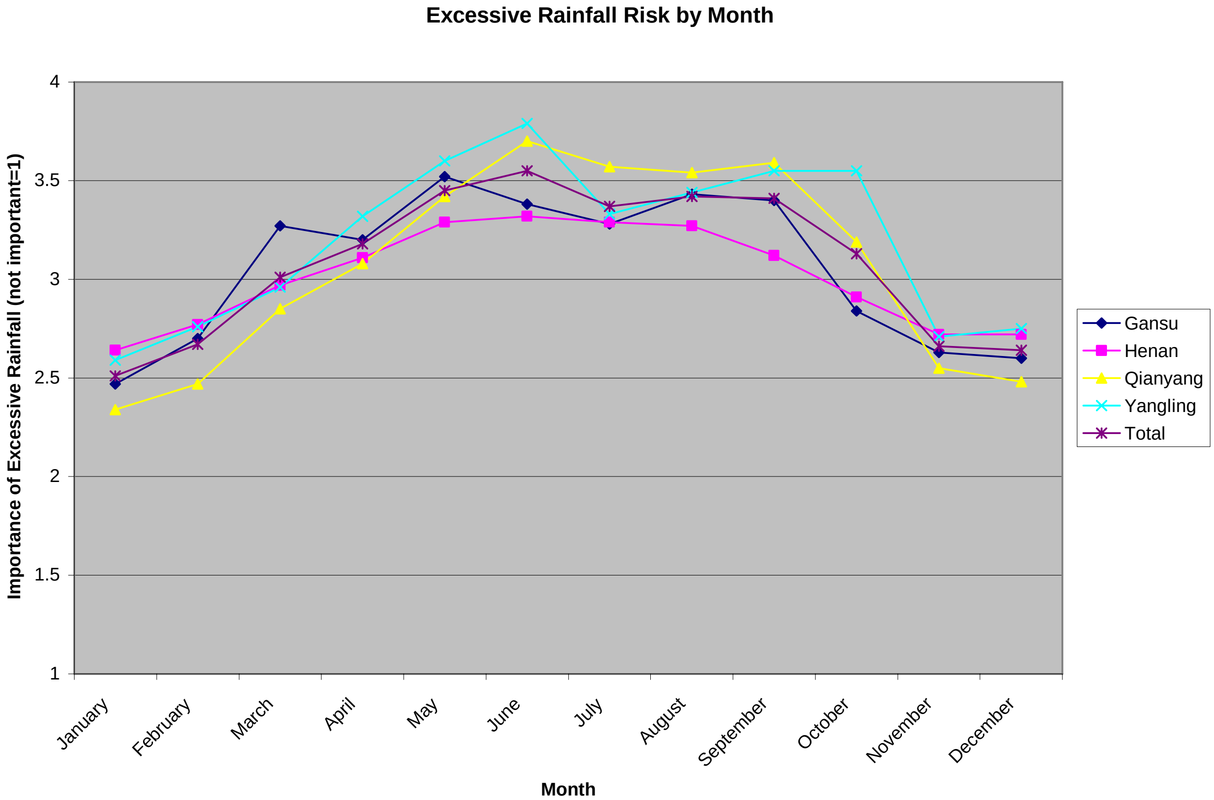

Figure 4: Relative Importance of Excessive Precipitation Risk.

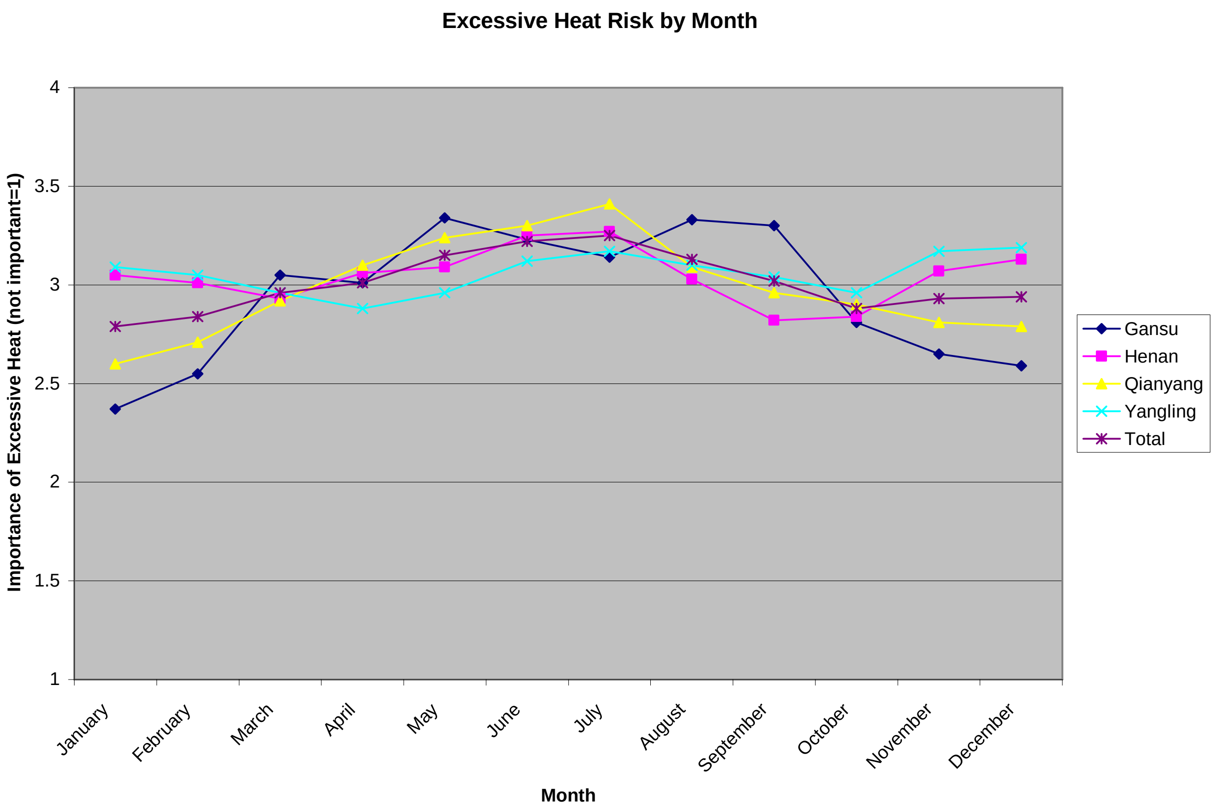

Figure 5: Relative Importance of Excessive Heat.

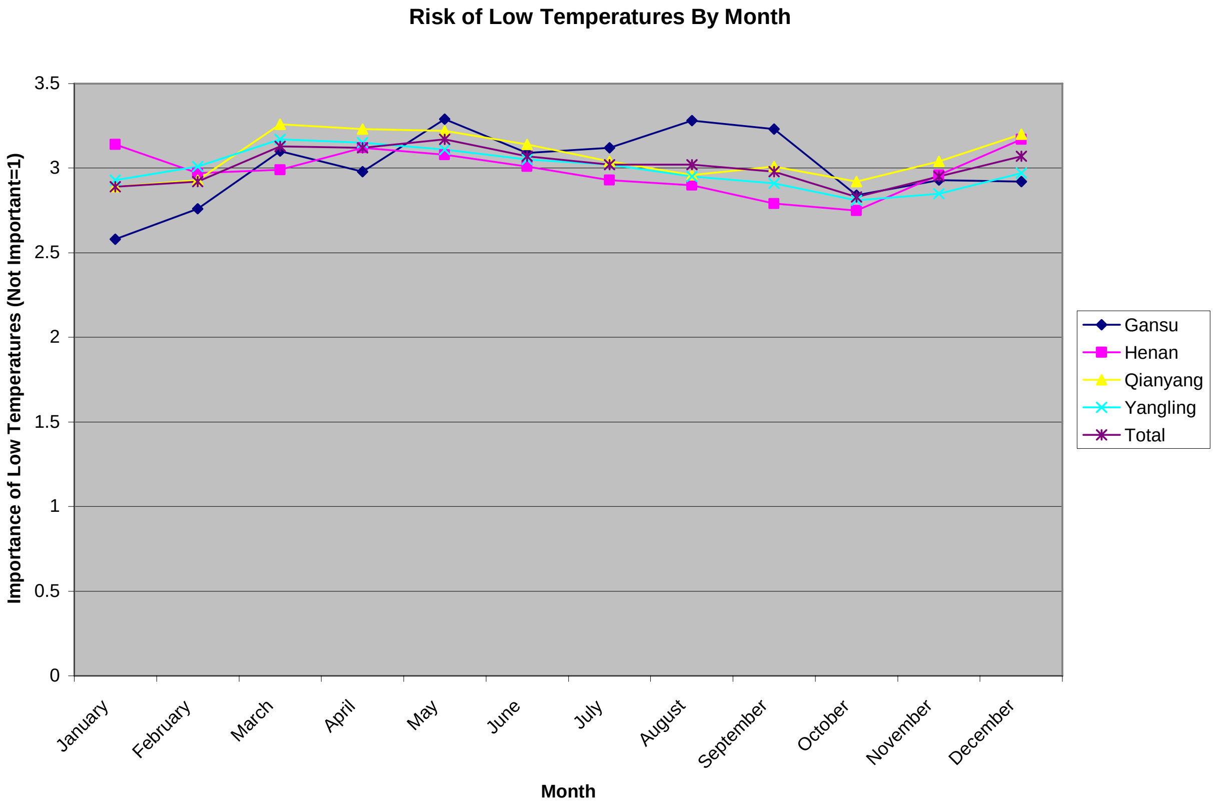

Figure 6: Relative Importance of Low Temperature Risk.