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THE ECONOMICS OF WEATHER AND CLIMATE RISKS IN AUSTRIA

STATUS QUO OF RESEARCH AND INSTITUTIONAL DEBATE

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Introduction

In this paper we briefly discuss past and present research efforts to understand the “Economics of Climate and Weather Risks” in Austria. We give an overview on the general problem (section 1), the issue of data availability (section 2), methodological considerations (section 3), and summarize some sector-specific results (section 4). We conclude with discussing institutional arrangements and policy options (section 5). For more detailed discussions of the range of topics raised in this paper we refer to the corresponding studies. The majority of these studies emerged from the research project “The Economics of Weather and Climate Risks in Austria” and is published in the same named working paper series on the web platform www.klimarisiko.at.

1 The Economic Meaning of Weather and Climate Risks: What is the problem?

Why do the authors of this paper speak about weather and climate risks in the same breath? Do they not know the difference? From a climatologic point of view it is quite straightforward:

The difference between weather and climate is a measure of time. Weather is what conditions of the atmosphere are over a short period of time, and climate is how the atmosphere "behaves" over relatively long periods of time. Weather can change from minute-to-minute, hour-to-hour, day-to-day, and season-to-season. Climate, however, is the average of weather over time and space. An easy way to remember the difference is that climate is what you expect, like a very hot summer, and weather is what you get, like a hot day with thunderstorms (NASA, 2005).

However, while our knowledge about weather is abundant from a climatologic point of view, much less is known about the economic meaning of weather. Many studies intend to gain a full understanding on how changing climate conditions will affect the economy in the more distant future, without having a clear idea of the impact weather (= short-term climate variability) had on business activities in the past and has right now. In other words, it seems that many scholars have a more precise picture what climate change means for sensitive economic sectors in the mid of the 21st century than what risks adverse weather conditions might bear for individual enterprises in the near future. This is somehow paradoxical, although it has it's equivalent in climate science: The global models better and better predict past climate and therefore can be considered to be more and more reliable for future climate projections. But all these efforts do not improve per se our knowledge about the weather on next year's Christmas Eve, however.

It is a conviction of the EWCR (Economics of Weather and Climate Risks) research group that for a better understanding of climate change impacts a deeper understanding of the economic meaning of weather is needed. Therefore, we think it is essential to go bottom up in our analysis in spatial and temporal terms, meaning that we should first focus on how weather influences economic activities particularly on the local scale. Both, an understanding of impacts on the local scale and of the (changing) weather sensitivity (observed over longer time periods) will be helpful to get additional insights for the understanding of economic vulnerabilities. Moreover, it is important to link weather risks to other risk factors, as without doing so we might ultimately not be able to determine the economic consequences both (short-term) weather variability and (long-term) climate change will have. This seems to be especially important in current (2009) economic downturn that might increase the vulnerability of businesses towards weather risks, as the exposure to weather risks add up with a range of business and financial risks.

In general, weather is perceived to have an important impact on business activities. In Austria, weather variability is of particular concern for the tourism industry, agriculture, energy supply and retail. However, while the importance of the weather dependency for the economy and individual businesses is undisputed, the extent of the dependency is little-known. This might explain why the majority of companies do not see an absolute necessity in hedging their weather risks by means of financial risk management instruments (such as weather derivatives, weather-indexed insurances, etc.)

Weather derivatives are thought of as one major strategy – and currently the most recognized and applied one – for hedging weather risks. Thereby, especially in the US a range of products is offered at the moment to deal with financial uncertainties related to weather conditions, while the weather derivatives market has never really started to take off in Europe.

In the light of the current economic crisis it would be all too easy to condemn weather derivatives to be one of those evils of the current financial system, as too little regulation for derivatives of financial products is in general seen to be the trigger of the crisis. Indeed, there is some consensus that the complexity of market instruments seem to matter and this is certainly also an issue when discussing the concept of weather derivatives. Hence, hedging weather risks in the way it has emerged in recent years might just be too complicated for Europe's businesses leaders. It certainly is a good thing if people do not buy this kind of product if they do not understand them. But this does not mean that businesses should not try to understand such products or that they cannot be beneficial.

However, fundamental questions on the implications this has for the future of weather risk management arise. Has the basic concept of hedging weather risks with weather derivatives failed or is it just that hedging is rather associated with dubious financial speculations than the much more "honest" insurance of vulnerable companies by other, usually larger, ones? As so often, it seems that the product name "derivatives" counts more than the contents, which differs widely. Weather derivatives range from individual, insurance-like OTC products to cover some specific companies risk to highly standardized stock exchange products.

Furthermore, what are possible alternatives to weather derivatives? Is non-action – also in the context of global climate change and its impacts on local climate conditions – the most-efficient solution for the individual company? Certainly not, but frequently companies are in the situation that technical adaptation strategies – the only alternative to financial products – are not available or not cost-efficient.

Hence, in our view it seems that there are three particular important issues, when dealing with financial products for let us say "covering" or "insuring" weather risks.

(1) The issue of **understanding and quantifying the weather impacts on economic activities** is crucial in order to be able to judge whether financial risk management strategies should be deployed. We find that especially here a large research gap exists (see section 3).

(2) The **complexity of the financial instruments** (structure, valuation, etc.) definitely matters for the acceptance amongst users. The current discussions about the rearrangements of the financial markets show the necessity that not solely the efficiency of financial strategies might matter, but also their complexity. These aspects are not discussed further in this paper, but should be definitely more focused on in future research.

(3) **The institutional or regulatory framework** plays a decisive role, whether and which kind of financial risk management strategies are applied and how high the implementation and transaction costs are. In the financial market, regulatory measures can aim at both, the market for derivatives and the market of the underlying stocks. The underlying for the weather market is weather per se, which of course is not subject to regulation. What is heavily regulated in some countries though is knowledge about weather, i.e. weather data, and this amounts to the same. In the weather market above all the

access and costs of weather data influences the market development. Here, major differences do not only exist between the US and Europe, but also amongst European countries, whereby Austria seems to be rather in the middle between the extremes of complete free access of weather data and no access at all (see Chapter 5 and Beck at al. 2009). Moreover, the different regulations concerning financial products, such as other risk transfer regulations and the subsidies paid for other weather related insurance products and catastrophic payment mechanisms, need to be discussed in more detail (for further details see Prettenthaler et al., 2006).

We are grateful to an anonymous referee who suggested to investigate the link between weather derivatives and the even less well working cat bond market. A lack of resources unfortunately kept us from treating this question in a more formal way.

But: Cat bond markets seem to have problems because also the cat insurance market is instable and affected e.g. by the notion that we talk about changing risks etc. In any case, market failure calls for State intervention, that is being implemented widely in the U.S. and many European economies. As far as we can see, some of the reasons for market failure in cat insurance also hold for the cat bond bond market. We believe the practical problems of cat bonds therefore to be closer related to those problems than to those of the weather market to which we want to turn now.

2 It all starts with data availability

While for some sectors human response to weather is instantaneous and the relationship is clear (e.g. the energy sector), for other activities analysis is more difficult and there is little awareness of the related weather dependencies. As Subak et al. (2000) state, the awareness of weather dependencies is particularly weak for tertiary activities, which are often not included in assessments of the potential impacts of weather on the economy. In fact, as these activities are very important to developed economies, even small perturbations in output due to weather variability may have significant impacts. Hence, in addition to the primary sector (e.g. agriculture) and secondary sector (e.g. energy), there should be more focus on activities of the tertiary sector.

For some sectors especially weather data availability is considered to be a constraint to comprehensive demand analysis. While a fast growth in the field of meteorological services - mainly distributed by the internet - can be observed, this does not necessarily mean that data is available for analyzing the weather dependency of business activities. In most cases the free available data comprises forecasts, recent day data and long term climatological values. However, longer time series data, as it would be needed for weather sensitivity analysis, is chargeable. Furthermore, even when there is the option to access restricted data for paying users, data is not always directly available in the needed way.

Consider for example the case of the Austrian tourism industry and its snow dependency. Indeed, there exists a variety of applications to get information about the ski area specific present day and forecasted snow conditions. However, for analyzing the historic snow sensitivity of skiing activities the availability of snow data becomes a crucial issue. The main problem is that consistent snow measurements for longer time series, as needed for the analysis, can only be provided for a limited number of measurement stations, disregarding the regional variability of snow conditions in the Alps. In addition, meteorological stations are commonly not located in altitudes, which are representative for skiing activities.

Thus, within the research project “The Economics of Weather and Climate Risks in Austria”, together with our meteorological partners, we set a clear focus on providing a dataset for an enhanced analysis of local weather dependencies in Austria. In this regard, a long-term (1971-2006) local database, called “EWCR weather data set” has been created. This data set aims on relieving the analysis of interactions between weather and economic performance. On the one hand, climate parameters relevant for winter sports (including artificial snow indices) are stated for those sea levels, at which alpine ski sports is carried out. On the other hand, the data set contains selected weather and climate indicators on a municipal basis. These indicators are reported for the centers of the municipalities, or in other words for those points, where the bulk of economic activities takes place. Besides creating the described weather data set (see Beck et al., 2009), a climatologic analysis – investigating historic means, variability and trends - has been conducted (see Themessl, Gobiet and Toeglhofer, 2009).

3 And we need better methods, too

Dealing with weather risks requires methods both for identifying the weather dependency of companies and for finding the best financial strategy to deal with these risks. We think that there is a substantial lack of a methodological framework to determine the weather dependency of companies, while this would be an important pre-condition for applying financial instruments such as weather derivatives, weather insurances, etc.

Although dozens of studies have been published discussing the appropriate valuation and pricing of weather derivatives (see e.g. Alaton, Djehiche and Stillberger, 2002, Cao and Wei, 2004, Benth and Benth, 2007, or Svec and Stevenson, 2007), to our knowledge none of these studies covers the often mentioned ‘first step’, namely the ‘identification of weather dependencies’, more closely. Comprehensive books covering this topic like Dischel (2004) and Jewson, Brix and Ziehmann (2005) solely give blank numbers (company A faced weather related losses in year B in the amount of X million dollar), without mentioning how they have derived these numbers. Some academic publications examining the application of weather derivatives in the agricultural sector (see e.g. Berg et al. 2004) use static regression analysis to determine the weather sensitivity, while others do not even deal with the topic. All in all, it seems that in most sectors (the energy sector might be an exemption) simple comparisons to previous years and static regression analyses dominate, with no publicly available guidelines on how ones weather dependency could be estimated more precisely.

The reasons for the poor coverage of this methodological issue seem to be plentiful. Firstly, suppliers of weather derivatives might think that companies themselves know best how dependent they are. Secondly, estimating the weather sensitivity requires sensitive business data and the results might also be confidential, therefore data, methods and results are rarely published. Thirdly, in many cases complex price-quantity interactions as well as time-delayed effects make the estimation challenging. Fourthly, the application of appropriate statistical tools might be disillusioning, as it can be shown very often that the seemingly high relationship, usually measured in R-squared, is caused by the few observations at hand or spurious correlation. Hence, the detected weather dependencies might not be suitable for planning future hedging programs.

This methodological gap can be seen as one major obstacle for the development of weather risk markets. Companies do not have any recommendations how to appropriately and easily estimate their weather dependency and this avert increasing awareness. Indeed, the weather risk markets have developed by far the most in the energy sector, where the relationship between weather and demand is clear and well known, and profound statistical methods are already used for demand forecasting, including the effects of weather anomalies.

Therefore, we discuss a range of statistical and mathematical methods, which can be useful in quantifying and managing weather risks. These include (1) econometric approaches that go beyond static regression analysis as well as (2) mathematical tools and statistic modeling.

Concerning the first point, different econometric approaches are applied in order to analyze the snow dependency of ski areas and they are evaluated with respect to their adequacy. An overview of the discussed models is given in Toeglhofer and Prettenthaler (2009a). Autoregressive Distributed Lag (ADL) Models (see Toeglhofer and Prettenthaler, 2009b), Panel Data Models (see Eigner, Toeglhofer and Prettenthaler, 2009) as well as Error Correction Models (ECM) (see Schiman, Toeglhofer and Prettenthaler, 2009) are investigated in further detail. The latter approach is beneficial as the error correction/co-integration framework enables to estimate long term demand functions, while correcting for the non-stationary features of the economic time series. The empirical results of the investigations are briefly discussed in chapter 4.

As regards the second point, various mathematical tools for quantifying and managing weather risks are surveyed. An overview of mathematical tools like utility theory and no arbitrage pricing, with a special focus on the use of weather derivatives as a tool of weather risk management, is given. Furthermore, a brief overview of statistical models that can be used for weather risk, with an emphasis on the modeling of dependence of random variables, is provided (see Kortschak, 2009). One of the most important findings within this overview is the high importance of the determination of the risk distribution as well as the relation between the risk and the associated weather index. Therefore, using the example of flood risk, the distribution of flood losses is calculated for Austria by applying the river water level as weather index (see Kortschak and Lautscham, 2009). In another effort, mathematical and statistical tools are used to model temperature by means of stochastic processes, which is necessary for further developing pricing models (see Zahrnhofer, 2009).

4 Sector specific results

Recent studies quantified the weather sensitivity for economic sectors which are well-known for being exposed to weather conditions. In the following, we discuss these studies and their implications for managing weather risks in the specific sectors.

Energy demand

Most notably, the demand for heating and cooling services is heavily affected by temperature conditions. It is likely that the effects of weather related changes in heating and cooling energy demand are much more pronounced than the effects of changing weather conditions for energy supply such as hydro and wind power. Prettenthaler et al. (2007) show, that for the current Austrian building stock a 2°C increase in winter temperatures lowers the heating energy demand by approximately 10,000 gigawatt hours. In comparison, hydro power production decreases by approximately 3,500 gigawatt hours in dry and hot years like 2003 (see Toeglhofer, 2007).

As Prettenthaler et al. (2008) highlight, the demand for cooling is becoming more and more important in Austria, with a roughly estimated three percent annual increase in electricity demand for cooling services. The effect of hot days on electricity demand, a phenomenon which until recently was only discussed related to Southern European countries or the USA, can be also observed for the Austrian grid. The study, for instance, reveals an additional electricity load of 40 megawatt for the province of Lower Austria for particularly hot days (30°C daily mean) compared to average conditions. Thereby a peak is found for the late afternoon (+100 MW additional load).

From a risk management perspective it is comparatively easy to hedge variations in heating and cooling energy demand. Firstly, it is simple to transform temperature into heating and cooling degree days and the relationship between energy demand and these indices is relatively straightforward. Secondly, the regional distribution of temperature is seen to be homogenous compared to other weather indices, which encourages the offering of standardized risk management products. Thirdly, energy companies are generally larger and have more risk management expertise than other companies. Thus, it is not surprising that the weather derivatives market is most developed in this sector.

Energy supply

For energy supply Prettenthaler et al. (2006) and Toeglhofer (2007) discuss the weather dependency of hydro- and wind power production and the possibility for hedging these risks with weather derivatives. **Small hydro power** plants face major precipitation risks. Therefore, the application of weather derivatives seems to be useful for companies, which are not affiliated to larger energy supply companies. Since potential transaction sizes are relatively low the most crucial point is to provide derivatives with low transaction costs, which use adequate weather indices at the same time.

In the field of **large hydro power** in theory a huge potential exists for the application of weather derivatives. However, there are several factors, which may lower the benefits from hedging in this field: Firstly a negative correlation between market prices and hydropower generation reduces the exposure to precipitation risk in markets with a high share of hydropower. Secondly, if storage power plants are available, reservoir management optimization can help to reduce losses. Thirdly, hydro power frequently contribute only to a relative modest share of total turnover, as energy supply companies hold diversified generation portfolios and engage in several business fields. Thus, if weather derivatives are used, they should rather be integrated in the company's risk portfolio than solely be seen in the context of hydrological risk.

In the field of **wind power** weather derivatives are sometimes used to hedge wind risks of newly built wind farms. While transaction sizes are comparable to small hydro power, the creation of adequate wind derivatives currently provides a major challenge. Hence, a (further) development of reliable wind indices would presumably lead to an increased application of weather derivatives in this fast growing industry.

Agriculture

The weather dependency of agriculture is obvious, but varies largely amongst crops and climate regions. In addition, it is heavily influenced by crop management practices, soil conditions, fertilization practices etc. Another challenge for the quantification of agricultural weather risks arises due to the fact that the relationship between weather and crop yields is not straightforward at all, as both the timing of weather patterns and the combination of weather parameters (e.g. hot and dry) is decisive. Therefore, it is common practice to investigate the dependency towards complex weather indices rather than climate parameters like temperature or precipitation indices.

In example, Heinrich (2008) investigates in detail to what extent drought indices can be linked to crop yield data for the province of Styria. For that purpose, he calculates correlations between drought indices and crop yield data of the most important crop plants in Styria (grain maize incl. CCM, green- and silo maize, spring barley, winter barley, permanent grassland). The correlation analysis shows that the crop yields of grain maize incl. CCM, green- and silo maize, winter barley and permanent grassland are more sensitive to changes of the drought indices in the more southern climate regions of Styria. The most statistically significant correlations were reached for the crop yields of grain maize incl. CCM, winter barley and permanent grassland. The highest correlations were obtained for the crop yield of permanent grassland in the climate regions Vorland, Randgebirge and Murtal, where the combined temperature-precipitation indices explain more than 40% of the total variability of the crop yield.

In this context, Prettenthaler et al. (2006) discuss financial and technical strategies to deal with agricultural weather risks and in particular drought risks. They find, that the frequent covering of drought events by the catastrophe fund in recent decades hamper the spread of alternative insurance strategies like weather-linked insurances or weather derivates. The application of such instruments is presumed to be more efficient than ad-hoc payments. However, under the current distorted market conditions, heavy subsidization would be needed for those instruments in order to break through. Furthermore, in the case of drought risks technical adaption strategies, such as irrigation, seems to be economically inefficient for most crops.

Tourism

In recent years, researchers and the public have become increasingly concerned about the consequences of climate change on the tourism industry, in Austria as well as in other countries with a substantial skiing industry (Switzerland, France, Italy, US, Canada etc). Numerous studies have focused on understanding the past and possible future changes in winter temperature and precipitation patterns on ski seasons length and snowmaking conditions. These studies have extensively described the changes in climatic conditions and the overwhelmingly negative effects for ski areas. However, little efforts have been spent on systematically quantifying the relationship between past weather conditions and the performance of ski areas. In other words, while the climate is recognized to be an important component of tourism supply, it is hardly understood to what extent the variability in climate has affected tourism demand in past decades.

In Toeglhofer and Prettenthaler (2009b) we introduce an approach for determining the year-to-year snow sensitivity of tourism demand in Austrian ski areas. The estimation is done based on an extensive dataset containing localized tourism, economic and meteorological data, which allows considerations both for a high number of cases (n=185) and a considerable number of seasons (t=34). A general-to-specific modeling approach is applied, starting from an autoregressive distributed lag (ADL) model. We find that in the examined period 1973 to 2006 the number of tourist nights in the ski areas is highly dependent on snow conditions. Significant positive coefficients are found for 44 areas, while negative coefficients are found for 3 areas. Thereby, a change in the snow days index by the standard deviation results in an up to ten percent change in tourist nights, with a four percent change in the median ski area (with a significant coefficient). A clear relationship can be depicted between the sensitivity and the altitude and size of the areas. The most sensitive regions are typically characterized by both low lying mean altitudes and below average size. In contrast, negative coefficients are found for two particularly snow reliable areas. We further discuss the issue of changing snow sensitivities (e.g. due to recent developments like snow making) and related implications for climate research.

In Eigner, Toeglhofer and Prettenthaler (2009) we extend the area specific ADL models and use panel data techniques for estimating both the sensitivity and its temporal evolution on the aggregate level. Panel data analyses are conducted with the bias corrected two-way fixed effects model proposed by Bruno (2005) and the System-GMM estimator described by Blundell and Bond (1998). Estimations point out that additional 10 days with a snow height of more than 1 cm lead to an overall increase of overnight stays to an extent of 0.7 to 1 percent. For the last decade the panel estimate for snow is substantially lower than in previous years. We suppose that this decline can be attributed to the major increase in snowmaking in recent years. These results also highlight the necessity to further deal with the issue of varying weather sensitivities over time, since currently the assumption of constant sensitivities is prevailing in related studies.

5 Institutional arrangements and policy options

There are a number of factors restraining the market for weather risks in Austria. Some of them have already been identified by Prettenthaler et al. (2006) or Wunsch (2008). This section takes a look at the current restraints dominating the market for weather risks and tries to identify possible institutional as well as regulatory measures that could help eliminate these barriers and improve the efficiency of the market. To avoid duplications of work with the study of Wunsch (2008), who carried out an empirical analysis of the Austrian weather derivative market and its development, we have foregone some of the analysis and refer partly to the results of her work.

5.1 FACTORS RESTRAINING THE DEVELOPMENT OF THE AUSTRIAN MARKET FOR WEATHER RISKS

1.) Missing awareness

To some extent, there is a lack of awareness regarding the weather dependency of the own company and the involved risks as well as the available possibilities for hedging against weather risks. According to Wunsch (2008) the bulk of Austrian entrepreneurs are, for instance, not familiar with the concept of weather derivatives. Furthermore, the majority of enterprises either do not see an absolute necessity in hedging their weather risks by means of financial risk management instruments (such as weather derivatives, weather-indexed insurances, etc.) or regard such products as too exotic and complex.

2.) Availability and costs of high-quality weather data

Another restraint arises in connection with the availability and costs of high-quality weather data. Weather data is needed for both, the determination of the company-specific weather exposure, which forms the precondition for hedging against the weather risks a company is facing, and the construction of weather derivatives and weather-indexed insurance contracts, respectively. For these purposes, longtime high-quality data and a high correlation between the location of the company that is going to be hedged and the (next) weather station are required. However, the availability of consistent longtime data is partly limited as several weather stations do not provide long enough time series. Another critical point is the density of the weather station net. If none of the available weather stations shows enough correlation with the location of the company that wants to hedge its weather risk, the use of weather derivatives and weather-indexed insurance, respectively, is not viable (this problem could be especially relevant for skiing regions). Last but not least, a further restraining factor arises due to the circumstance that, in contrast to countries such as the USA, Japan or Germany, weather data for commercial use is with costs in Austria. Long data sets can amount to up to some thousand Euros. Thus, for some companies determining their individual weather exposure represents a too expensive undertaking. Moreover, weather risk hedging instruments are more costly in the case of chargeable weather data.

By way of example, Table 1 shows the amounts that would be charged by the ZAMG for some selected weather data in case of their commercial use. Case A would be typically needed for the stochastic modeling of temperature, which is necessary for further developing pricing models (see also Zahrnhofer, 2009). Case B and C could represent data requests from ski area operators for analyzing the natural snow reliability in their own area. Case D could be needed for a more general examination of regional or province-specific snow dependency (see also Schiman, Toeglhofer and Prettenthaler, 2008). Case E is used for determining the ski area specific snow dependencies (see also Toeglhofer and Prettenthaler, 2009). Of course, it might also be beneficial as a decision making and planning tool for banks and insurances companies. For example, banks could consider the data to systematically decide which ski area operators and related companies should be granted access to loan capital, while insurance companies would need it for pricing weather-index insurances. However, the given data cost in case E is likely to prevent them to consider the relevant meteorological data for decision making or to develop weather-related insurance products. Similarly, Case F gives a dataset, which could be required by a national energy supplier for analyzing and forecasting energy demand on a regional scale.

Table 1: Costs of some selected weather data (data source: ZAMG, 2009)

CASE	Number of weather stations, raster cells or communities	Parameter	Temporal resolution	Time period	Costs
A	1 weather station	daily mean temperature	daily	01.01.1961-16.02.2009	€ 1,182.67
B	1 weather station	snow	daily (for 6 winter months)	01.01.1971-31.12.2006	€ 635.67
C	1 weather station	snow	monthly (for 6 winter months)	01.01.1971-31.12.2006	€ 209.67
D	18 weather stations	snow	monthly (for 6 winter months)	01.01.1971-31.12.2006	€ 1,814.01
E	404 raster cells	snow (raster data snow model)	monthly (for 6 winter months)	01.01.1971-31.12.2006	€ 48,000.00
F	2,358 communities	heating degree days (HDD)	monthly (for 6 winter months)	10 years	€ 22,500.00

3.) Missing know-how

Besides high-quality weather data, companies are in need of special methods and know-how in order to determine their individual weather risk. However, there seems to be a large gap in this regard, since to our knowledge there is no publicly available, guideline or tool-kit for practitioners on how weather dependency can be estimated exactly. In most sectors (the energy sector might be an exemption) simple comparisons to previous years and static regression analyses dominate, with several possible statistical pitfalls (see Toeglhofer and Prettenthaler, 2009).

In addition, the handling of weather risk hedging instruments, such as weather derivatives, represents a complex task that also requires special know-how. Especially small and medium sized companies often lack such knowledge. Thus, in the context of determining the company-specific weather exposure and hedging against weather risk expertise has to be bought in addition. However, missing know-how does not only represent a limiting factor on the demand but as well on the supply side. As currently weather derivatives are not very common in Austria, potential suppliers are lacking experience. Thus, they either ask for a higher risk premium in case of an underwriting or buy weather derivatives in addition and thereby charge further margins.

4.) Too high transaction costs in case of small enterprises

Especially for small and medium sized companies transaction costs are often too high to make products such as weather derivatives profitable. According to Wunsch (2008) the transaction volume should at least account for 50,000 – 100,000 Euros as otherwise transaction costs are too high. Thus, a certain company scale or transaction volume seems to be a precondition for the usage of weather derivatives.

5.) Missing market transparency and liquidity in case of weather derivatives

One reason for the lacking transparency and liquidity on the weather derivative market arises from the absence of a uniform and generally accepted pricing model. Thus, end-users are not able to relate to prices and have difficulty in comparing various offers. Hence, market transparency is negatively influenced by the absence of a uniform pricing model. Missing market transparency in turn harms the attractiveness of weather derivatives and represents a poor condition for the necessary market liquidity. Another reason for the lack of transparency is the individuality of weather derivatives dealt on "over-the-counter" (OTC) markets and their dependency on specific quantitative and qualitative data, making it almost impossible to compare different contracts. However, this individuality is necessary to provide optimal contracts for the end-users.

6.) Companies prioritize other tasks

The resources of companies are limited and often other tasks than the determination of the company's individual weather exposure and the hedging of weather risks are given priority. Currently, many companies are for instance busy in handling the economic crises. A further example for circumstances causing the prioritization of other tasks is the introduction of the EU Emission Trading Scheme, which led to a decline in the resources companies spend for examining their weather exposure, as they rather focused on their emission trading activities.

5.2 POSSIBLE SOLUTIONS

Having identified the current restraints that dominate the market for weather risks in Austria it is time to raise the question, if there are measures that could help eliminate the mentioned barriers and thereby improve the efficiency of the market.

1.) Missing awareness

Since there is missing awareness regarding weather risks as well as weather risk hedging instruments broad information campaigns and platforms could help to create a well-founded decision basis for companies. Furthermore, the development of new as well as easier products may improve the acceptance of weather risk hedging instruments[5].

[5] Concerning new products see e.g. www.stormx.com and www.celsiuspro.com/home/ tabid/36/language/de-DE/Default.aspx.

2.) Availability and costs of high-quality weather data

Regarding the restraints arising due to the costs of weather data, the results of scientific research projects determining the weather sensitivity of single sectors and conducting preliminary investigations concerning the usage of e.g. weather derivatives could serve as a first decision basis for companies. As for scientific purposes weather data is free of charge, such pre-investigations could be run at small costs.

3.) Missing Know-how

Quantifying the weather impacts on economic activities is crucial in order to be able to judge whether financial risk management strategies should be deployed. We find that the often used approach of simple static regression analysis might be misleading, even when time trends are included in the models. In fact, it needs to be supposed that trend-stationarity is not given for many of the examined economic parameters and autocorrelation lowers the forecasting quality of the found weather dependency. In other words, we can not assume that the found relationship by simple static models really represents the future weather dependency, which should be hedged. Alternatively, either growth rate models, dynamic models like autoregressive distributed lag (ADL) models or error correction models (ECM), or some form of Time Varying Parameter (TVP) models could be applied. This is discussed in more detail in Toeglhofer and Prettenthaler (2009a).

4.) Too high transaction costs in case of small enterprises

To overcome the restraint of too high transaction costs in case of small enterprises, risks of the same kind could be aggregated to risk communities, i.e. several companies could sign a contract together. For instance, in the case of wind parks, the transaction volume of weather derivatives might be reached by forming clusters of several wind parks and hedge them with a common index. This possibility seems reasonable as most wind farms are concentrated on a few locations. For example, approximately half of the wind power capacity totally installed in Austria is located in the region northwest of the Neusiedlersee. Whether this idea is actually practicable depends primarily on the structure of possession as well as on to what extent coverage against weather risk is considered necessary by the concerned companies of a cluster (Toeglhofer, 2007).

5.) Missing market transparency and liquidity in case of weather derivatives

Besides a broad and reliable data base, computer programs that provide a weather forecast with sufficient precision and institutions that publish or purchase these data, a uniform pricing model is required for adequate market transparency. Thus, the promotion of communication and information transfer among the suppliers of weather derivatives is important for market transparency. The creation of investment funds and index certificates investing in weather derivatives is another possibility of improving the acceptance of weather derivatives and raising the market liquidity (see Wunsch, 2008).

6.) Companies prioritize other tasks

Companies may see that especially in times of economic and financial turmoil they could at least reduce one potential risk factor – namely weather risks – which may otherwise amplify further risk factors. Poor snow conditions, for instance, could reinforce the affects of the weak economic conditions in tourism, amplifying liquidity problems and high debt-equity ratios. In hedging against weather risks, companies would be able to avoid such reinforcements in times of economic and financial turmoil.

6 Bibliography

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