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VREMENSKI DERIVATI - INSTRUMENT ZAŠTITE POSLOVANJA OD VREMENSKIH RIZIKA

Rezime

Kasnih 90-ih je razvijeno novo finansijsko tržište - tržište vremenskih derivata, tako da su menadžeri rizika mogli da se zaštite od izloženosti vremenskom riziku. Nakon usporenog starta, vremenski derivati su počeli rapidno da rastu. Menadžeri rizika više nisu mogli da loše finansijske rezultate pravdaju vremenskim nepravilnostima. Vremenski rizik je, uz pomoć hedžinga, mogao biti eliminisan. Ovaj rad će ukatko objasniti šta su vremenski derivati i istaći neke od motiva za njihovu upotrebu. Takođe ćemo baciti pogled na istoriju tržišta vremenskih derivata, kako se ono razvijalo poslednjih godina i ko su trenutni i potencijalni igrači na tom tržištu.

Ključne reči: vremenski derivati, vremenski rizik, upravljanje rizikom, vremenski indeksi, fjučersi, opcije hedžing

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WEATHER DERIVATIVES - BUSINESS HEDGE INSTRUMENT FROM WEATHER RISKS

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Summary

In the late 1990s, a new financial market was developed - a market for weather derivatives, so that the risk managers could hedge their exposure to weather risk. After a rather slow start, the weather derivatives market had started to grow rapidly. Risk managers could no longer blame poor financial results on the weather. Weather risk could now be removed by hedging procedure. This paper will explain briefly what the weather derivatives are and will point out at some of the motives for use of derivatives. Thereafter we will look at the history of the weather risk market, how the weather derivatives market has developed in recent years and also who are the current and potential players in the weather derivatives market.

Key words: weather derivatives, weather risk, risk management, weather indices, futures, options, hedging

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Uvod

Vremenski derivati (*engl. weather derivatives*) predstavljaju alat upravljanja rizikom koji omogućava kompanijama da se zaštite od smanjenja proizvodnje, odnosno potraživanja količine roba i usluga, koje je prouzrokovano nepovoljnim vremenskim prilikama. Pojednostavljeno, upotrebom odgovarajućih vremenskih derivata (forvarda, fjučersa, opcija ili svopova), proizvođači i distributeri energenata se mogu zaštititi od neuobičajeno tople zime kada je potrošnja energenata manja od uobičajene; poljoprivrednici se mogu zaštititi od nedovoljne (ili prekomerne) količine padavina tokom perioda rasta njihovih poljoprivrednih proizvoda itd. Ova vrsta derivata stvorena je kako bi se olakšao prenos rizika nepovoljnih vremenskih prilika na treća lica koja su u mogućnosti da njime efikasno upravljaju (Lazibat, Zupanic, 2010, str. 731).

Vremenski derivati kreirani su u cilju zaštite od nepovoljnih vremenskih prilika. Rizik nepovoljnih vremenskih prilika predstavlja nesigurnost u budućim novčanim tokovima i prihodima kao posledica *nekatastrofalnih vremenskih prilika* (Brockett, Wang, Yang, 2005, str. 128). Nekatastrofalne vremenske prilike označavaju fluktuacije u temperaturi, vlažnosti vazduha, količini padavina, brzini vetra itd., dok s druge strane, zemljotresi, oluje i poplave predstavljaju katastrofalne rizike i kao takvi nisu predmet vremenskih derivata. Vremenske prilike se od ostalih izvora rizika razlikuju po tome što utiču na količinu potražnje za određenim robama i uslugama, a ne na cenu po kojoj se ta roba prodaje (Edrich, 2003, str. 168). Toplije zime, npr., rezultiraju manjom potražnjom za prirodnim energentima, dok hladnija leta npr. rezultiraju manjom popunjenošću kapaciteta u hotelima na moru i manjom potražnjom za sladoledima i hladnim osvežavajućim napitcima. Iako se cena hotelske sobe, osvežavajućeg pića ili neke druge robe može promeniti kao odgovor na neuobičajeno visoku ili nisku potražnju, prilagođavanje cena ne mora nužno da kompenzuje izgubljene prihode. Dalje, rizik vremenskih prilika je jedinstven jer ne postoji fizičko tržište za vreme. Nemoguće ga je skladištiti ili transportovati. Osim toga, rizik vremenskih (ne)prilika geografski je lokalizovan i nemoguće ga je kontrolisati i uprkos velikim

dostignućima meteorološke nauke i dalje ga je nemoguće tačno predvideti (Lazo et al., 2011, str. 709; CME, 2005, str. 2). Rizik nepovoljnih vremenskih prilika najteže pogađa kompanije u čijem poslovanju je izražena izuzetna sezonalnost i koje većinu prihoda ostvaruju iz jednog izvora. Primera radi, malo je verovatno da će robna kuća koja prihode ostvaruje kroz sva četiri godišnja doba koristiti vremenske derivate, dok je za energetske kompanije ovo veoma izgledno. Kompanije se odlučuju na zaštitu od nepovoljnih vremenskih prilika upotrebom vremenskih derivata najčešće u cilju smanjivanja volatilnosti ostvarenih prihoda, pokrića prekomernih troškova, nadoknade troškova, mogućnosti stimulanja prodaje i diversifikacije investicionih portfolija (Leggio, 2007, str. 247).

Razvoj tržišta vremenskih derivata

Vremenski derivati korene vuku iz deregulacije i privatizacije energetskog sektora u SAD-u sredinom 1990-ih. Promenljivost vremenskih uslova je oduvek smatrana jednim od glavnih faktora koji utiču na potrošnju energije, ali u uslovima monopola nije bilo potrebe za hedžiranjem ni cene ni količine (tzv. volumetrički rizik), pošto je sve nepredvidive troškove bilo moguće prebaciti na potrošače. Deregulacijom tržišta postojeći monopoli zamenjuju se konkurentnijim tržišnim strukturama. U takvim uslovima, 1997. godine nastaje prvi vremenski derivat, a transakcija je obavljena između dve velike energetske kompanije - *Koch Industries Inc.* i *Enron Corp.* iz SAD. Ugovor je bio kreiran na bazi temperaturnog indeksa za Milvoki (Milwaukee), Viskonsin (Wisconsin) i strukturiran kao svop (*swap*-zmena), tako da je Enron bio u obavezi da plati Koch-u 10.000 US dolara za svaki °F kada je temperatura pala ispod normalne tokom zime 1997/1998., dok se Koch obavezao da plati Enron-u 10.000 US dolara za svaki °F iznad normalne temperature (CME & Storm Exchange Inc., 2008, str. 10).

Prvi vremenski derivatni ugovori javljaju su se na vanberzanskom tržištu (OTC) kao privatno dogovoreni poslovi između dve strane. Rastom tržišta i sve većom potrebom za transparentnijim utvrđivanjem cena i otklanjanjem kreditnog rizika, paralelno OTC tržištu razvija se organizovano

Introduction

Weather derivatives are a new risk management tool allowing companies to hedge against fall in production, i.e. claims on quantities of goods and services caused by adverse weather conditions. Simply speaking, with the use of corresponding weather derivatives (forwards, futures, options, or swaps) producers and distributors of energy products can hedge against an unusually mild winter when the consumption of heating fuel had fallen below the average; farmers can hedge against deficient (or excessive) amount of rainfall during the period of growth of their agricultural products, etc. This type of derivatives was created in order to facilitate transfer of the adverse weather conditions risk on to the third persons who are able to have it efficiently managed (Lazibat, Zupanec, 2010, p. 731).

Weather derivatives were created with the objective of hedging against the adverse weather conditions. The risk of adverse weather conditions presents insecurity for the future cash flows and revenues as a consequence of non-catastrophic weather conditions (Brockett, Wang, Yang, 2005, p. 128). Non-catastrophic weather conditions designate temperature fluctuations, air moisture, quantity of precipitation, wind velocity, etc., while on the other hand there are earthquakes, storms and floods that are designated as catastrophic risk and as such are not subject to weather derivatives. Weather conditions differ from the other risk sources in the fact that they impact the amount of demand for certain commodities and services, and not the price at which such commodities are being sold (Edrich, 2003, p. 168). Warmer winter weather, for example, result in lower demand for the natural energy fuels, while colder summers are resulting in lower occupancy of the sea-resort hotels capacities, but also in lower demand for ice creams and cold beverages. Although the hotel room price, that of refreshing beverages or some other goods can be repriced in response to an unusually high or low demand, price adjustment does not necessarily have to compensate for the revenue lost. In addition, the weather conditions risk is unique in its features as there is no physical market for the weather as such. It is impossible either to store or transport

weather. Furthermore, weather conditions (calamities) risk is geographically located and is impossible to control, and in spite of great advancements made in the meteorological science it is still impossible to be precisely forecasted (Lazo et al., 2011, p. 709; CME, 2005, p. 2). The risk of adverse weather conditions is having the hardest impact on companies with the business exposed to an extreme seasonality and which are making most of their profit from one and a single source. For example, it is not very probable that a department store which is making profit throughout all of the four seasons in the year will use weather derivatives, while for energy companies this is extremely probable. Companies decide in favour of the weather adverse conditions hedging through the usage of weather derivatives most often for purpose of lowering volatility of gains made, for covering excessive costs, compensation for costs incurred, opportunity to stimulate sales, and for their investment portfolio diversification (Leggio, 2007, p. 247).

Development of the weather derivatives market

Weather derivatives draw their root in the deregulation and privatisation of the energy sector in the USA in the mid-1990s. Unpredictable nature of the weather conditions was always viewed as one of the main factors impacting energy consumption, but in an environment of monopoly there was no need for either hedging the price or the quantity (the so-called volumetric risk), as all the unforeseeable costs could be charged on the consumers. With the market deregulation the existing monopolies were replaced by competitive market structures. Under such conditions, in 1997, what appeared was the first weather derivative, a transaction to be conducted between two large energy companies - Koch Industries Inc. and Enron Corp, USA. The contract was created on the basis of the temperature index for Milwaukee, Wisconsin and was structured as a swap, so that Enron was obliged to pay Koch 10,000 US dollars for every "F" when temperature would fall below normal during the winter time of 1997/1998, while Koch was obliged to pay Enron 10,000 US dollars for every "F" above the normal temperature (CME & Storm Exchange Inc., 2008, p. 10).

terminsko tržište. Čikaška merkantilna berza (CME) uvrštava 1999. godine fjučers ugovore i opcije na fjučers ugovore na temperaturne indekse za deset severnoameričkih gradova među proizvode kojima se trguje na njihovoj elektronskoj platformi. Zbog sve većeg interesa investitora, CME postepeno širi bazu gradova u kojima su smeštene referentne klimatološke stanice. Danas se CME temperaturni ugovori baziraju na observaciji klimatskih prilika u ukupno 47 gradova u svetu i to: 24 stanice u SAD, 6 u Kanadi, 3 u Australiji, 3 u Azijsko-Pacifičkom regionu i 11 stanica u Evropi. Daljim razvojem tržišta raste broj i različitost učesnika, tržište postaje likvidnije i sve više vremenskih varijabli se koristi kao podloga za kreiranje derivata. Uz prvobitne forvarde, fjučerse i opcije razvijaju se naprednije strategije trgovanja i ugovori kao što su svopovi, kolari (collars), *digital* i *floor* opcije.

Prema dostupnim podacima od Weather Risk Management Association (2006; 2008), ukupna vrednost ugovora u 2005/06. godini porasla je za više od 300% u odnosu na 2004/05.

godinu, što analitičari pripisuju velikom učešću hedž fondova na tržištu. Značajan rast u broju i vrednosti vremenskih derivatnih transakcija tokom tih godina posledica je i širenja tržišta na evropske i azijske zemlje, veće različitosti ponuđenih rešenja, veće svesti o postojanju i većeg razumevanja vremenskih derivata među investitorima. Nastankom finansijske krize 2008. i padom finansijskih tržišta značajno opada trgovanje vremenskim derivatima i beleži se pad vrednosti trgovanja za 50% u odnosu na prethodnu 2007. (WRMA, 2008). Tokom narednih godina beleži se dalji pad vrednosti trgovanja i 2011. godine se vidi oporavak i rast vrednosti i obima trgovanja za oko 30%.

Tržište vremenskih derivata, po analizama CME, trenutno predstavlja najbrže rastuće tržište finansijskih derivata. Slika 2. prikazuje stanje tržišta vremenskih derivata 2010. i 2011. godine (broj ugovora fjučersa i opcija - od ukupnog broja lotova trgovanih na CME, 72% pripada vremenskim opcijama). Vidljiv je sve veći rast tržišta i sve veće učešće vremenskih opcija.

Slika 1. Razvoj tržišta vremenskih derivativa i kretanja vrednosti trgovanja u periodu 2003 - 2011

Izvor: Autor na bazi dostupnih podataka sa sajtova CME Group; WRMA, 2006; WRMA, 2008.

Slika 2. Vremenski fjučersi i opcije na CME (2010 i 2011)

Izvor: Brewer, 2012.

The first weather derivative contracts appear on the over-the-counter market (OTC) as privately contracted deals between the two parties. With the growth of the market and an increasing need for transparent pricing and elimination of the credit risk, what developed parallel to the over-the-counter market was also a regulated futures market. Chicago Mercantile Exchange (CME) listed in 1999 futures contracts and futures contract options on temperature indices for ten North-American cities among the products to be traded on their electronic platform. Due to a growing interest amongst the investors, CME gradually expanded its base of cities in which reference climate-monitoring stations were located. Today, CME temperature contracts are being based on the observation of climate conditions in the total of 47 cities in the world, as follows: 24 stations in the USA, 6 in Canada, 3 in Australia, 3 in the Asia-Pacific region, and 11 stations in Europe. Further development of the market was followed by the growth in the number and diversity of the participants, market becomes a liquid one and a growing number of weather variables started to be used as basis for creating derivatives. Together with the initial

forwards, futures and options, more advanced trading strategies are being developed, such as swaps, collars, digital and floor options.

According to the data accessible of the Weather Risk Management Association (2006; 2008) the total value of contracts in 2005/6 grew for over 300% in respect to 2004/5, which was ascribed by the analysts to a large share of the hedge funds in the market. Significant growth in the number and value of weather derivatives transactions during these years was the consequence also of the market expansion on to the European and Asian countries, higher diversification of the solutions offered, higher awareness of the existence and understanding of the weather derivatives amongst the investors. With the eruption of the financial crisis in 2008 and the collapse of financial markets, there was also a significant fall in the weather derivatives trading and the fall was recorded in the value of trading of 50% in respect to the previous 2007 (WRMA, 2008). Over the next few years, further fall was recorded in the trading value, and in 2011 a recovery was observed and the growth in value and volume of trading of some 30%.

Figure 1 - Development of the weather derivatives market and trading value trends in the period 2003 - 2011

Source: Author, on the basis of data accessible at the CME Group sites; WRMA, 2006; WRMA, 2008

Interesantno je i sve veće učešće vremenskih derivatnih ugovora iz Evrope kojima se trgovalo na CME. Po podacima, evropski ugovori učestvuju sa 10% u odnosu na globalno tržište (77.814 ugovora u 2010. i 2011. godini). Navedeno prikazuje Slika 3.

Slika 3. Trgovanje vremenskim derivatima u Evropi (2010/11)

Izvor: Brewer, 2012.

Najveće učešće u obimu trgovanja vremenskim derivatima u Evropi pripada energetske kompanijama. Po podacima, u 2010. i 2011. trgovalo se sa 5.750 letnjih i 24.599 zimskih ugovora. Rast beleži i OTC trgovina vremenskim derivatima. I ovde su najaktivnije evropske energetske kompanije. Po podacima CME, na kraju marta meseca 2011. godine ostvarena je trgovanje 634 OTC sezonskih ugovora: 123 letnja i 511 zimska. Iz prethodno navedenog je vidljivo da se više ugovora sklupa za zimski nego za letnji period i da organizovana trgovina vremenskim derivatima preuzima primat u odnosu na OTC trgovinu.

Slika 4. Broj vremenskih derivata kojima su trgovale evropske energetske kompanije na OTC tržištu u periodu 2007-2011. godini

Izvor: Brewer, 2012.

Osnovne karakteristike vremenskih derivata

Vremenski derivati se definišu kao terminski ugovori (forvardi i fjučersi) ili opcije na terminske ugovore u čijoj podlozi se nalazi

vremenski indeks (temperatura, kiša, sneg, vetar, mraz itd.) koji je dobijen kvantifikovanjem odstupanja klimatskih uslova od izabrane referentne tačke. Odstupanje se izračunava na bazi observacije realnih klimatskih prilika u referentnoj klimatološkoj stanici. Pritom se svakom nivou odstupanja dodeljuje određena novčana vrednost, a ugovori postaju vredni kada stepen izabrane vremenske varijable padne ispod ili naraste iznad referentne vrednosti, zavisno od zauzete pozicije. Na taj način je

vreme pretvoreno u dobro kojim je moguće trgovati, tj. u robu. Vremenski indeks se može uporediti sa robnim indeksima na berzama ili indeksom akcija S&P 500. Vremenski derivati pokrivaju događaje niskog rizika visoke verovatnoće nastupanja, dok osiguranje tipično pokriva događaje visokog rizika za koje postoji mala verovatnoća nastanka (Ali, 2004, str. 75). Vremenski derivati, za razliku od osiguranja, polaze od činjenice da odstupanje od svega nekoliko stepeni temperature može da ugrozi prihode. Tako, npr., gasna kompanija može da koristi vremenski terminski ugovor kako bi se zaštitila od zime za 5°C toplije od

istorijskog proseka (nizak rizik, velika verovatnoća nastanka), dok će ista kompanija za zaštitu od poplave ili zemljotresa (visok rizik, mala verovatnoća nastanka), najverovatnije, kupiti polisu osiguranja. Dalje isplata po osnovu vremenskih derivata zavisi isključivo od toga da li je indeks pao ispod ili porastao iznad izabrane referentne vrednosti pa nije potrebno dokazivati finansijsku štetu što je slučaj kod ugovora o osiguranju. Osiguranje kao takvo ne

Weather derivatives market, according to the CME analyses, at present stands as the fastest growing financial derivatives market. Figure 2 shows the situation on the weather derivatives market in 2010 and 2011 (number of futures and options contracts - from the total number of lots traded on the CME, 72% belongs to the weather options). There is a visible constant growth of the market and a growing share in the weather options.

It is interesting to note that there is also a growing share of weather derivative contracts from Europe that are being traded on the CME. According to data, European contracts are participating with 10% in respect to the global market (77,814 contracts in 2010 and 2011). The above said is presented in Figure 3.

The highest share in the volume of trading in weather derivatives in Europe belongs to the energy companies. According to data, in 2010 and 2011, trading was done with 5,750 summer and 24,599 winter contracts. Growth is recorded also in the OTC trading in weather derivatives. Here again the most active are the European energy companies. According to the CME data, by the end of March 2011 trading was conducted in 634 OTC seasonal contracts: 123 summer and 511 winter ones. The above stated shows that there are more contracts made for the winter than for the summer period, and that the organized trading in weather derivatives is taking over primacy in respect to the OTC trading.

Figure 3 - Weather derivatives trading in Europe (2010/11)

prepoznaje mogućnost postojanja špekulanata koji čine važan deo tržišta vremenskih derivata (Aleksandridis, Zapranis, 2013).

Vremenski derivati se od klasičnih finansijskih derivata razlikuju po tome što im je svrha zaštita od promene količine (a ne cene) roba i usluga koje kompanije nude, iz tog razloga što u njihovoj podlozi ne stoji aktiva ili dobra koja sama po sebi poseduju vrednost, odnosno za koje postoji fizičko tržište (Ali, 2000, str. 155). Međutim, iako se vremenske prilike ne mogu fizički razmenjivati, moguće je razmenjivati finansijsku izloženost vremenu upotrebom prilagođenih finansijskih derivata. Osim što služe kao instrument hedžinga, vremenske derivate je moguće koristiti u diversifikaciji portfolija zbog niskog stepena korelacije između vremenskih indeksa i standardnih oblika ulaganja kao što su akcije i obveznice (Jewson, 2004, str. 57). Upoređivanjem performansi portfolija koji sadrži i koji ne sadrži vremenske derivate utvrđeno je da uključivanje vremenskih derivata povećava očekivani prinos portfolija sa 6,82% na 8,75%, dok se istovremeno standardna devijacija, kao mera rizika ulaganja, povećava neznatno, sa 7,52% na 7,54% (Van Lennep et al., 2004, str. 72).

Vremenski derivati su investitorima zanimljivi i zbog njihovog visokog nivoa izolovanosti od političkih i ekonomskih događaja. Primera radi, kriza na Bliskom istoku i rast kamatnih stopa ne utiču na vremenske indekse, ali veoma utiču na terminsku cenu nafte i akcija. Vremenskim derivatima, kao i ostalim finansijskim instrumentima, može se trgovati organizovano putem institucionalnog tržišta na berzi ili dogovorno na vanberzanskom tržištu (*over the counter* - OTC) specijalizovanih trgovaca. Ako se trguje na OTC tržištu reč je o *forvard* (*forward*) ugovorima, dok se u slučaju transakcija na organizovanom tržištu radi o *fjučers* (*futures*) i *opcijskim* (*options*) ugovorima. Prvo i najveće organizovano tržište vremenskih derivata jeste Čikaška merkantilna berza (*Chicago Mercantile Exchange* - CME). Organizovana tržišta omogućavaju trgovanje standardizovanim ugovorima, likvidnost, transparentnost cena i svode rizik neispunjenja obaveze druge strane na minimum. S druge strane, na OTC tržištu je moguće kreirati ugovore u potpunosti prilagođene potrebama korisnika, ali pošto se radi o privatno

dogovorenim sporazumima između dve strane, kreditni rizik je visok.

Struktura ugovora vremenskih derivata

Ugovor o vremenskim derivatima definisan je na bazi nekoliko elemenata koje ćemo objasniti u nastavku teksta. Bilo da je reč o *forvardima*, *fjučersima* ili *opcijama* na takve ugovore, svi poseduju određene elemente koji su za vremenske derivate karakteristični.

Klimatska promenljiva (varijabla). Vremenske derivate je moguće kreirati na osnovu svih klimatskih prilika koje je moguće na neki način meriti, a koje u značajnoj meri utiču na poslovanje. Prvi vremenski derivati su kreirani na bazi temperature ali sa razvojem tržišta i rastom različitosti učesnika sve više vremenskih varijabli se koristi kao podloga za kreiranje vremenskih derivata. Na CME trenutno se trguje ugovorima na temperaturu, kišu, sneg, mraz i vetar, dok je na OTC tržištu ponuda daleko šira i uključuje vlažnost i pritisak u vazduhu, naoblačenje, sunčane sate, topljenje snega, temperaturu mora, visinu talasa itd.

Indeks. Pošto klimatskim varijablama nije moguće trgovati potrebna je njihova kvantifikacija. Indeks koji se nalazi u podlozi derivata dobijen je merenjem odstupanja klimatskih varijabli od izabrane referentne tačke u referentnoj klimatološkoj stanici. Najčešće korišćeni indeksi danas su tzv. *heating degree days* (HDD) za zimski period, odnosno *cooling degree days* (CDD) za letnji period. HDD meri za koliko je stepeni prosečna dnevna temperatura ispod referentne tačke, a CDD meri za koliko je stepeni prosečna dnevna temperatura iznad referentne tačke. Prosečna dnevna temperatura predstavlja prosek minimalne i maksimalne temperature tokom dana. Referentna tačka predstavlja unapred izabranu temperaturu koja će služiti kao baza za izračunavanje indeksa, a često se još naziva *izvršna tačka*. Kao referentna temperatura najčešće se uzima 18°C za područje Evrope i Azije, odnosno 65°F za područje Amerike - prigodna sobna temperatura na kojoj teoretski nije potrebno ni grejati ni hladiti. HDD i CDD računaju se prema sledećim formulama (Hull, 2009, str. 574):

Figure 4 - Number of weather derivatives traded by the European energy companies on the OTC market in the period 2007-2011

Source: Brewer, 2012

The main characteristics of the weather derivatives

Weather derivatives are defined as forward contracts (forwards and futures) or futures option contracts where the weather index is embedded (temperature, rainfall, snowfall, wind, frost, etc.) which is obtained by quantification of the deviation of climatic conditions from the selected reference point. Deviation is being calculated on the basis of observations of the real weather conditions at the reference weather location station. In this procedure, every deviation level is being attributed a certain defined money value, and the contracts become valid when the degree of selected weather variable falls below or rises above the reference value, depending on the position taken. In this way weather is transformed into a commodity ready for trading, i.e. into a trading commodity. Weather index can be compared with the commodity exchange indices, or the S&P 500 stock index.

Weather derivatives are covering low risk events with high probability of occurrence, while insurance is typically covering high risk events with low probability of occurrence (Ali, 2004, p. 75). Weather derivatives, opposite of the insurance, are starting from the fact that the deviation of only a few degrees in temperature can jeopardize revenues. Thus, for example, a gas supplying company can use a weather forward contract in order to hedge from the winter that is for 5 degrees Centigrade warmer than the historical mean (low risk, high probability of occurrence), while the same company will hedge

against floods or earthquake (high risk, small probability of occurrence) most probably by buying an insurance policy. Furthermore, payment on the basis of the weather derivatives depends exclusively on whether the index had fallen below or risen above the selected reference value, so it is not necessary to prove that the financial damage had been incurred as is the case with the insurance contracts. Insurance as such does not recognize the option of presence of the speculators, yet they make up for

an important part of the weather derivatives market (Aleksandridis, Zapranis, 2013).

Weather derivatives differ from the classic financial derivatives by having as their ultimate goal hedging from the change in quantity (not the price) of commodities and services that companies are offering, because in their base what stands are not the assets or commodities having their own inherent value, i.e. those that have their own physical market (Ali, 2000, p. 155). However, although weather conditions can not be physically exchanged, it is possible to exchange physical exposure to weather by the use of adjusted financial derivatives. In addition to serving as a hedging instrument, weather derivatives can also be used for portfolio diversification because of the low degree of correlation between the weather indices and the standard forms of investment such as the stocks and bonds (Jewson, 2004, p. 57). By comparing portfolio performances between those containing and those not containing weather derivatives it was found that inclusion of the weather derivatives increases the anticipated portfolio return from 6.82% to 8.75%, while at the same time the standard deviation as the measure of investment risk, increases insignificantly, from 7.52% to 7.54% (Van Lennep et al., 2004, p. 72).

Weather derivatives have become attractive to investors also for their high level of isolation from the political and economic events. For example, the Middle East crisis and the growth of interest rates do not impact weather indices, but have a high impact on the forward prices of

HDD = Max (0, bazna temperatura - prosečna dnevna temperatura) ili

DailyHDDs = Max\left[\left(T_{Base} - \frac{T_{Max} - T_{Min}}{2}\right), 0\right]

CDD = Max (0, prosečna dnevna temperatura - bazna temperatura) ili

DailyCDDs = Max\left[\left(\frac{T_{Max} - T_{Min}}{2} - T_{Base}\right), 0\right]

Npr. dan sa prosečnom temperaturom od 3°C rezultirao bi HDD indeksom od 15°C dok bi dan sa prosečnom temperaturom od 26°C rezultirao CDD indeksom od 8°C. Ni HDD ni CDD stepeni ne mogu imati negativne vrednosti što znači da ukoliko tokom zimskog perioda temperatura poraste iznad 18°C HDD indeks dobija vrednost nula. U skladu s tim, ukoliko tokom letnjeg perioda temperatura padne ispod 18°C CDD indeks takođe dobija vrednost nula. Ugovori najčešće pokrivaju duže vremenske periode od jedne nedelje, meseca ili cele sezone, pa se u tom slučaju za indeks uzima kumulativ HDD odnosno CDD stepeni. U narednoj tabeli prikazan je primer obračuna kumulativnog HDD indeksa (CumHDD) za sedmodnevni period.

Tabela 1. Proračun kumulativnog HDD indeksa (CumHDD)

Bazna temperatura (18°C)								CumHDD
Prosečna dnevna temperatura	11	9	9	13	10	20	19	-
HDD	7	9	9	5	8	0	0	38

Izvor: Autor

Temperатурne indekse u najvećoj meri koriste energetske kompanije pošto je u sektoru energetike najočigledniji uticaj temperature na potražnju za energijom, bilo gasom u zimskim mesecima ili električnom energijom u letnjim mesecima. Za kompanije koje jednim ugovorom žele da zaštite prihode tokom cele godine postoji tzv. *energy degree days* (EDD) indeks koji se dobije jednostavnim sabiranjem HDD i CDD vrednosti. EDD se dobija na sledeći način:

DailyEDDs = \sum \left[\text{Max}\left(T_{Base} - \frac{T_{Max} - T_{Min}}{2}\right), 0 \right] + \left[\text{Max}\left(\frac{T_{Max} - T_{Min}}{2} - T_{Base}\right), 0 \right]

U primeni je i *variable degree days* (VDD) indeks koji je po svemu istovetan HDD i CDD indeksima sa razlikom da se umesto 18°C (65°F) kao bazna temperatura uzima neka druga vrednost. U ostalim sektorima kao indeks se koriste još i prosečna temperatura, količina padavina (kiše u mm, snega u cm), broj sunčanih sati, brzina vetra, dani u kojima je zabeležen mraz, oblačni dani itd.

Referentna klimatološka stanica. Svi ugovori baziraju se na stvarnom posmatranju klimatskih prilika u jednoj ili više određenih klimatoloških stanica. Lokacija referentne klimatološke stanice naziva se **baza**. Pošto se na OTC tržištu ugovori kreiraju prema konkretnim potrebama učesnika, a cena pregovara, moguće je kreirati ugovor koji glasi gotovo na svaku lokaciju. S druge strane, ako se trguje na organizovanom terminskom tržištu potrebno je odabrati neku od ponuđenih baza. Pošto su vremenske prilike visoko lokalizovane, trgovac koji kupuje zaštitu od nepovoljnih vremenskih prilika za grad koji nije uvršten na terminskom tržištu suočava se sa **baznim rizikom**. Drugim rečima, bazni rizik se javlja kada je ugovor ispisan na lokaciju koja je različita od područja koji trgovac želi da zaštiti (Consodine, 2000,

str. 8). Ako se ugovor bazira na temperaturnom indeksu, npr. na HDD stepenima, bazni rizik će biti razlika u HDD vrednostima između dva grada. U tom slučaju, bazni rizik je moguće

eliminirati kreiranjem novog ugovora, tzv. **baznog derivata**, u čijoj podlozi stoji razlika u HDD vrednostima između dotična dva grada (Rohrer, 2004; Yang, Brockett, Wen, 2009).

Vremensko razdoblje. Svi ugovori imaju definisani početak i kraj vremenskog razdoblja tokom koga se indeks izračunava. Uobičajeni periodi na tržištu su zimski period od 1. novembra do 31. marta i letnji period od 1. maja do 30. septembra. Na organizovanom tržištu kao što je CME, trguje se nedeljnim, mesečnim i sezonskim ugovorima, dok je na OTC tržištu moguće kreirati ugovore koji pokrivaju samo određene dane u nedelji ili koji određenim danima u nedelji ili mesecima u godini pridaju veći ponder. Razvojem tržišta javljaju se i ugovori

oil and stocks. Weather derivatives, as well as the other financial instruments, can be traded in a regulated manner through the institutional market on the stock exchange, or through the dealing procedure on the over-the-counter (OTC) market by the specialized traders. If trading is done on the OTC market it is the matter of the forward contracts, while in case of transactions conducted on the regulated market it is the question of the futures and option contracts. The first and the largest regulated weather derivatives market is the Chicago Mercantile Exchange - CME. Regulated markets allow for trading in the standardized contracts, liquidity, and price transparency, and bring the counterparty defaulting risk down to a minimum. On the other hand, on the OTC market it is possible to create contracts that are fully adjusted to the needs of the beneficiary, but since it is the matter of the privately contracted deals between the counterparties, the credit risk is rather high.

The weather derivatives contract structure

Weather derivatives contract is defined on the basis of several elements which we will explain further in this paper. Whether it is a question of forwards, futures or options contracts all of them must contain certain elements which are characteristic of weather derivatives.

Climate variable: It is possible to create weather derivatives on the basis of all the climatic conditions which are in some way measurable, and which in a significant measure impact business operations. The initial weather derivatives were created on the basis of temperature but with the market development and growth of diversity in participation, the growing number of weather variables was introduced to serve as basis for creating weather derivatives. At present, CME trading is focused on temperature contracts, rainfall, snowfall, frost and winds, while the OTC market is trading in a much larger offer including moisture content and air pressure, overcast days, sunlight hours, snow melting quantities, sea water temperature, wave height, etc.

Index: As the climate variables are not subject of trading as such, what is necessary is to have their quantification. The index to be found embedded in the derivative is obtained by measuring deviations of climatic variables from the selected reference point at the reference climatic station. The most often used indices today are the so-called heating degree days (HDD) for the winter period, i.e. cooling degree days (CDD) for the summer period. HDD is measuring the degrees for which the mean daily temperature is below the reference point, while the CDD is measuring the degrees for which the mean daily temperature is above the reference point. The mean daily temperature is the average between the minimum and the maximum temperature during one day. The reference point is an in advance selected temperature which shall serve as basis for calculating the index, and is often called the executive point. The reference temperature most often used is 18°C for the area of Europe and Asia, i.e. 65°F for the area of America - an appropriate room temperature where, in theory, it is not necessary either to have it heated or cooled. HDD and CDD are being calculated according to the following formulas (Hull, 2009, p. 574):

HDD = Max (0, basic temperature - mean daily temperature), or

$$\text{DailyHDDs} = \text{Max} \left[\left(T_{\text{Base}} - \frac{T_{\text{Max}} - T_{\text{Min}}}{2} \right), 0 \right]$$

CDD = Max (0, mean daily temperature - base temperature), or

$$\text{DailyCDDs} = \text{Max} \left[\left(\frac{T_{\text{Max}} - T_{\text{Min}}}{2} - T_{\text{Base}} \right), 0 \right]$$

For example, the day with a mean temperature of 3°C would result in the HDD index of 15°C, while a day with the mean temperature of 26°C would result in the CDD index of 8°C. Neither the HDD nor the CDD degrees can have negative values, which mean that if during the winter period temperature would raise above 18°C the HDD index would have the zero value. Along this line, if during the summer period temperature would fall below 18°C the CDD index would also have the zero value. Contracts most often are covering longer

koji pokrivaju razdoblje od više godina. Primera radi, u Holandiji je sklopljen ugovor za period od 5 godina vredan ukupno 500 miliona US dolara.

Funkcija isplate. Funkcija isplate pretvara indeks u novčani tok (Jewson, Brix, 2005, str. 4). U većini ugovora isplata je jednaka proizvodu indeksa i novčane vrednosti minimalnog pomeranja vremenske varijable (tzv. tick), odnosno jedinične promene indeksa. Na CME tržištu vrednost minimalnog pomeranja trenutno iznosi 20 \$, dok na OTC tržištu može imati vrednost i od nekoliko desetina hiljada US dolara. Kreiranjem ugovora na OTC tržištu veličina vrednosti minimalne promene tzv. tick-a treba da označava osetljivost prihoda na vremenske prilike.

Limit. Većina vremenskih ugovora ima ograničenu maksimalnu isplatu po ugovoru. Limit može biti postavljen za jednu ili za obe strane u transakciji. Vrednost limita najčešće je izražena u novčanim jedinicama gde može biti određena i kao maksimalna vrednost indeksa.

Tabela 2. Karakteristike vremenskih ugovora u SAD i Evropi

	USA	Europe
Active since	1996	1998
CME - listed since	1999	2003
Execution	Brokers and CME screen	Brokers, Auctions and CME screen
Main Winter Index	Heating Degree Days (HDD)	Heating Degree Days (HDD)
Main Summer Index	Cooling Degree Days (CDD)	Cumulative Average Temperature (CAT)
Temperature measure	Fahrenheit	Celsius
Treshold	65 F	18 C
Tick size	USD 20	GBP / EUR 20

Izvor: Brewer, 2012.

Tabela 3. Primer vremenskog /temperaturnog ugovora u SAD

Specifikacija ugovora	Vrednosti
Klimatska varijabla	Temperatura (°F)
Indeks	CumHDD
Lokacija	Čikago
Vremenski period	1. novembar 2012 - 31. mart 2013.
Izvršna tačka	4.500 HDD
Vrednost otkućaja	20\$ / HDD
Limit	1.300 HDD

Izvor: Autor na bazi podataka sa sajta CME Group

Iz specifikacije ugovora iz Tabele 3. može se zaključiti da je reč o temperaturnom ugovoru koji se kreira na bazi kumulativnog HDD indeksa. Stvarno merenje temperature sprovedeno je u klimatološkoj stanici smeštenoj u okolini Čikaga, SAD u vremenskom periodu od 1. novembra 2008. do 31. marta 2009. Indeks je jednak odstupanju stvarno izmerenih HDD stepeni od prethodno utvrđene izvršne tačke. Isplata je jednaka proizvodu indeksa i novčane vrednosti otkućaja sa limitom na 1300 otkućaja. Npr., ukoliko je tokom posmatranog perioda zabeleženo 3.520 HDD stepeni, indeks je jednak 980 HDD stepeni (4.500 HDD- 3.520 HDD), a isplata iznosi 19.600\$ (980 HDD × 20\$/HDD).

Vrste vremenskih derivata i primeri hedžinga

Osnovne vrste vremenskih derivata uključuju fjučers ugovore (standardizovane ugovore kojima se trguje na organizovanom terminskom tržištu), forvard ugovore, privatno dogovorene ugovore kojima se trguje na OTC tržištu koji najčešće poprimaju oblik svopova i opcije na fjučers ili forvard ugovore. Kombinacijom pomenutih ugovora moguće je kreirati naprednije strategije trgovanja. Izbor najprikladnijeg ugovora zavisi prvenstveno od averzije kupca i prodavca prema riziku kao i od njihovih očekivanja u budućnosti.

Fjučers/forvard ugovori obavezuju kupca na kupovinu ili prodaju određene aktive u budućnosti. U slučaju vremenskih fjučers ugovora ta aktiva (dobro, roba) označava indeks baziran na klimatskoj varijabli koju nije moguće fizički isporučiti stoga se zauzete pozicije zatvaraju gotovinskim namirivanjem (uplatama) (Gardner, 2003, str. 8). Gotovinsko namirivanje ili uplate se obavljaju po dospeću terminskog ugovora, a predmet kupoprodaje se ne isporučuje fizički već trgovci jednostavno isplaćuju pozitivnu/negativnu razliku koja je ostvarena u poslu. U tom pogledu, vremenski ugovori se ne razlikuju od robnih derivata. Naime, iako robni terminski ugovori

weather periods from one week, a month or the entire season, and in that case the index taken into consideration is the cumulative HDD, i.e. CDD degrees. In the following Table calculation of the cumulative HDD index (CumHDD) is presented for a seven-day period.

Table 1 - Calculation of the cumulative HDD index (CumHDD)

Basic temperature (18°C)								CumHDD
Average daily temperature	11	9	9	13	10	20	19	-
HDD	7	9	9	5	8	0	0	38

Source: Author

Temperature indices are most often used by the energy companies because in the energy sector the most obvious temperature impact occurs in the demand for energy fuels, either gas in the winter months, or electrical power in the summer months. For companies which wish to hedge with one contract their revenues throughout the entire year there is the so-called energy degree days (EDD) index which is obtained through simple adding of the HDD and the CDD values. EDD is obtained in the following manner:

$$DailyEDDs = \sum \left[\text{Max} \left(T_{Base} - \frac{T_{Max} - T_{Min}}{2}, 0 \right) \right]$$
$$\left[\text{Max} \left(\frac{T_{Max} - T_{Min}}{2} - T_{Base}, 0 \right) \right]$$

What is also applied is the variable degree days (VDD) index which is in all aspects identical to the NDD and the CDD indices with the only difference that instead of the 18°C (65°F) as the base temperature some other value is used. In other sectors what is being used as indices are also the mean temperature, quantity of precipitation (rainfall in mm, snowfall in cm), number of sunlight hours, wind force, days experiencing frost, overcast days, etc.

Reference climate station: All the contracts are being based on the real observations of climatic conditions in one or more of the designated climate stations. The location of the reference climate station is called the base. Since the OTC market contracts are being created according to the concrete needs of the participants and the price is negotiated, it is possible to draft the contract that refers to almost every location.

On the other hand, if trading is done on a regulated market it is necessary to select one of the offered bases. Since the weather conditions are highly localized, the trader hedging from adverse weather conditions for a city which is not listed on the futures market is faced with the

basis risk. In other words, basis risk appears when a contract is drafted for a location which is different from the area which the trader wishes to hedge (Consodine, 2000, p. 8).

Although the contract is based on temperature index, for example on HDD degrees, the basis risk will be the difference in HDD values between the two cities. In that case, basis risk can be eliminated by creating a new contract, the so-called basis derivative, where the difference in HDD values between the two respective cities will be embedded (Rohrer, 2004; Yang, Brochett, Wen, 2009).

Weather period: All contracts are having a well defined start and end of the weather period during which the index is being calculated. Customary periods on the market are for the winter period 1 November to 31 March, and the summer period from 1 May to 30 September. On the regulated market such as the CME trading is done in weekly, monthly, and seasonal contracts, while on the OTC market it is possible to create contract covering only certain days in the week, or those which are giving certain days in a week or months in a year weights. With the development of the market what also appears are contracts covering the period of several years. For example, in Netherlands, a contract was made on a period of 5 years worth a total of 500 million USD.

Payment function: Payment function transforms the index into a cash flow (Jewson, Brix, 2005, p. 4). In most contracts payment is equal to the product of index and the money value of the minimal shift in the time variable (the so-called tick), i.e. the index unit change. On the CME market, the value of the minimal instant shift - tick, currently amounts to 20 \$, while on the OTC market it may have a value of even several tens of thousands of US dollars. By creating a contract on the OTC market the size of value of the minimal shift, or the so-called tick, should designate the sensitivity of revenues to the weather conditions.

glase na robu za koju postoji fizičko tržište, tj. moguća je fizička isporuka, pozicije se najčešće zatvaraju gotovinskim uplatama. Utvrđeno je da se od ukupnog broja fjučers ugovora isporukom realizuje svega 1-3% fjučers ugovora. Vremenski fjučers ugovori imaju standardizovanu vrednost minimalne promene ili tik-a, koja na CME iznosi 20\$ po HDD ili CDD stepenu, pa je potrebno kupiti/prodati onoliko ugovora koliko je potrebno da se pokrije izloženost prihoda vremenskim uslovima. Na OTC tržištu vrednost tik-a se ugovara prema konkretnim potrebama korisnika pa je ukupni rizik pokriven jednim ugovorom. Kako bi predstavili hedžing potencijal vremenskog fjučers ugovora uzimamo kao primer distributera gasa smeštenog u Čikagu koji želi da se zaštiti od viših temperatura od uobičajenih u mesecu decembru. Toplija zima znači manju potrebu za grejanjem, a time i niže

ove godine bio za 10°F topliji od istorijskog proseka, zbog čega je došlo do smanjenja kumulativnog HDD indeksa, čega se hedžer i pribojavao. Viša prosečna dnevna temperatura rezultirala je dnevnim HDD indeksom od 30 [65°F - (25°F + 10°F)], odnosno mesečnim od 900 (30 × 30). U januaru će kompanija zatvoriti svoju kratku poziciju kupovinom ugovora po ceni od 18.000\$ (900 × 20\$) i ostvariće dobit od 6.000\$ po ugovoru (24.000\$ - 18.000\$). Pretpostavimo da je kompanija na bazi istorijskih podataka procenila kako svaki porast temperature od 10°F uzrokuje smanjenje prihoda za 120.000 \$ tokom decembra. U tom slučaju kompanija bi kupila 20 ugovora (120.000\$ / 6.000\$). Dobit ostvarena na terminskom tržištu pokriva izgubljene prihode na spot tržištu. U slučaju da je decembar bio neuobičajeno hladan, kompanija bi ostvarila gubitak na terminskom tržištu, ali bi taj gubitak bio pokriven ekstraprofitima na spot tržištu.

Tabela 4. Primer nekih HDD fjučers ugovora sa osnovnim karakteristikama na CME

Exchg	Asset Class	Product	Product Code	Start Period	End Period	Initial	Maint.	Initial Vol. Scan	Maint. Vol. Scan
CME	WEATHER	LONDON MONTHLY HDD FUTURES	D0	01/2014	12/2016	8.1%	6.0%	40.5	3
CME	WEATHER	ROME MONTHLY HDD FUTURES	D9	01/2014	12/2016	6.6%	4.9%	40.5	3
CME	WEATHER	PARIS HDD MONTHLY FUTURES	D1	01/2014	12/2016	6.6%	4.9%	40.5	3
CME	WEATHER	AMSTERDAM HDD MONTHLY FUTURES	D2	01/2014	12/2016	7.6%	5.6%	40.5	3
CME	WEATHER	BERLIN HDD MONTHLY FUTURES	D3	01/2014	12/2016	6.8%	5.0%	40.5	3
CME	WEATHER	PRAGUE MONTHLY HDD FUTURES	D7	01/2014	12/2016	6.8%	5.0%	40.5	3

Izvor: CME Group, 2013, http://www.cmegroup.com/trading/weather/snowfall/monthly-snowfall_performance_bonds.html

prihode za kompaniju. Neuobičajeno visoke temperature rezultiraće nižim kumulativnim HDD indeksom, pa distributer gasa treba da izabere strategiju kojom će se zaštititi od smanjenja indeksa. Kompanija se odlučuje na prodaju temperaturnog fjučers ugovora u čijoj osnovi stoji kumulativni HDD indeks. Pretpostavimo da je istorijska prosečna dnevna temperatura u decembru u Čikagu iznosila 25°F što daje dnevni HDD indeks od 40, odnosno kumulativni mesečni HDD indeks od 1.200. Transakcija se odvija na CME tržištu gde se svakom stepenu odstupanja pridaje novčana vrednost od 20\$, pa prema tome kompanija ugovor prodaje za 24.000\$ (1.200 × 20\$). Po dospeću ugovora ispostavlja se da je decembar

Fjučers i forward ugovori predstavljaju osnovu ugovora o **opcijama**. Opcijom na terminske ugovor kupac stiče pravo, ali ne preuzima obavezu kupovine ili prodaje opcijom određenog terminskog ugovora na određeni dan u budućnosti. U zamenu za to pravo, kupac prodavcu plaća određenu cenu, tj. premiju. Ako se trguje opcijama na organizovanom tržištu, u njihovoj podlozi stajace standardizovani fjučers ugovori. U slučaju transakcija na OTC tržištu, opcije će se kreirati na bazi forward ugovora. S obzirom na način iskorišćavanja, vremenske opcije su evropskog tipa (evropske opcije) što znači da ih imalac može iskoristiti tek na dan dospeća (Russ, 2004, str. 299). S obzirom na prirodu prava koja se stiču ugovorom,

Limit: Most of the weather contracts are having a limited maximum payment after the contract. Limit may be set for either one or both of the counterparties in transaction. Limit value is most often expressed in monetary units where it may be designated also as the maximum index value.

Table 2 - Weather contract characteristics in the USA and Europe

	USA	Europe
Active since	1996	1998
CME - listed since	1999	2003
Execution	Brokers and CME screen	Brokers, Auctions and CME screen
Main Winter Index	Heating Degree Days (HDD)	Heating Degree Days (HDD)
Main Summer Index	Cooling Degree Days (CDD)	Cumulative Average Temperature (CAT)
Temperature measure	Fahrenheit	Celsius
Treshold	65 F	18 C
Tick size	USD 20	GBP / EUR 20

Source: Brewer, 2012

Table 3 - An example of a weather/temperature contract in the U.S.

Contract specification	Values
Climate variable	Temperature (°F)
Index	CumHDD
Location	Chicago
Time period	1. November 2012 - 31. March 2013
Execution point	4.500 HDD
Tick value	20\$ / HDD
Limit	1.300 HDD

Source: Author on the basis of data from the CME Group site

Table 3 contract specification leads to the conclusion that it is a question of the temperature contract which is created on the basis of a cumulative HDD index. Real temperature measurement was conducted at the climate station located in the vicinity of Chicago, USA, in the weather period from 1 November 2008 to 31 March 2009. Index is equal to the variability of really measured HDD degrees at the previously determined execution point. Payment is equal to the product of index and the money value of ticks with the limit on 1300 ticks. For example, if during the observed period 3,520 HDD degrees were recorded, the index is equal to 980 HDD degrees (4.500 HDD - 3,520 HDD), and the payment amounts to 19,600 \$ (980 HDD - 20 \$/HDD).

Weather derivatives types and hedging examples

The basic types of weather derivatives include futures contracts (standardized contracts traded on the regulated futures market), forwards contracts, privately contracted contracts traded at the OTC market which are most often acquiring the form of swaps and options on futures or forwards contracts. With the combination of the said contracts it is possible to create more advanced trading strategies. The selection of the most appropriate contract depends primarily on the buyer and seller risk aversion, but also on their future expectations.

Futures/forward contracts are binding the buyer to buy or sell certain assets in the future. In case of weather futures contracts such assets (goods, commodities) designate the index based on climate variable which cannot be physically delivered, thus the positions taken are closed through cash settlement (payment) (Gardner, 2003, p. 8). Cash settlement or payment is being done on maturity of the futures contract, and the subject of sale is not being delivered in a physical form but the traders simply pay out the positive/negative difference present in the deal contracted. In this respect, weather contracts are not different

from the commodity derivatives. Namely, although the commodity futures contracts are made for the given merchandize for which there is a physical market present, i.e. physical delivery is possible, the positions most often are being closed with the cash payments. It was determined that from the total number of futures contracts only 1-3% of futures contracts are being realized through a delivery. Weather futures contracts have a standardized value of the minimal change or tick, which on the CME amounts to 20\$ for a HDD or CDD degree, so it is necessary to buy/sell so much contracts that would cover the exposure of revenues to the weather conditions. On the OTC market the tick value is being contracted according to the concrete needs of the user, so that the entire

razlikujemo kol (call) i put (put) opcije. Kol opcija daje imaoocu pravo kupovine, a put opcija pravo prodaje terminskog ugovora. Kupac vremenske kol opcije kupuje opciju sa namerom da se zaštititi od previsokog rasta indeksa, dok se kupac vremenske put opcije želi zaštititi od preniske vrednosti indeksa. Npr., proizvođač osvežavajućih pića u nameri da stabilizuje svoje prihode tokom leta može kupiti CDD put opciju koja mu osigurava isplatu u slučaju hladnijih leta. Na sličan način gradske vlasti koje plaćaju usluge čišćenja snega se mogu zaštititi od prevelikih količina snega. U tom slučaju će gradske vlasti kupiti kol opciju, a opcija će postati profitabilna kada stvarni nivo snega premaši prethodno utvrđenu izvršnu tačku ili nivo. Rizik kupca ograničen je premijom opcije. Kako bi se ograničio i rizik prodavca, vremenske kol i put opcije često postavljaju limite na isplate. Takvi limiti se nazivaju „caps“ u slučaju kol opcija, odnosno „floors“ u slučaju put opcija. Efikasnost vremenskih opcija kao sredstva hedžinga kao i način funkcionisanja limita prikazaćemo na primeru zimskog ski centra koje se želi zaštititi od preblage zime. Zimski ski centar se želi zaštititi od nedostatka snega u odnosu na očekivane i istovremeno želi zaraditi ukoliko zima rezultira velikim količinama snega. Logično rešenje ovog problema jeste kupovina put opcije u čijoj podlozi se nalazi indeks nivoa snega. Menadžment skijališta odlučuje da sklopi ugovor na OTC tržištu pošto je skijalište previše udaljeno od najbliže referentne klimatološke stanice da bi bazni rizik bio zanemarljiv. Proučavanjem istorijskih podataka utvrđeno je da je tokom sezone potrebno ukupno 80 cm snega da bi skijalište ostvarilo profit, kao i da svakih 10 cm snega ispod tog nivoa smanjuje prihod za oko 300.000\$. U tom cilju, kreirana je put opcija na izvršnu tačku od 80 cm, postavljen tik na nivou od 10 cm snega i tik-u dodeljena novčana vrednost od 300.000\$. Kako bi se smanjila finansijska izloženost pisca opcije usled ekstremnih vremenskih prilika postavljen je limit isplate, tzv. *floor* na 2

miliona US dolara. Kupcu odgovara limitirana isplata pošto ne očekuje ekstremna odstupanja od istorijskog proseka, a očekuje se da će limitirane opcije, uz sve ostale nepromenjene uslove, imati manju premiju od nelimitiranih, pošto limiti smanjuju profitni potencijal opcije. Navedena prava kupac kupuje za 450.000 \$. Grafički prikaz transakcije prikazan je na Slici 6. Po završetku sezone utvrđeno je da je stvarni nivo snega bio za 40 cm ispod tačke pokrića što znači da je menadžment skijališta odlučio da iskoristi opciju. Ostvareni finansijski rezultat je jednak proizvodu minimalnih promena tj. tik-ova i novčane vrednosti tik-a umanjenom za vrednost premije, odnosno $750.000\$ (4 \times 300.000\$ - 450.000\$ = 750.000\$)$.

Slika 5. Floor opcija

Izvor: Autor

Svop (Swap) ugovori predstavljaju dogovorene privatne aranžmani između dve strane o zameni novčanih tokova u budućnosti prema unapred utvrđenoj formuli. Osnovne vrste svopova su kamatni i valutni svop. Vremenski svop predstavlja dogovor između dve strane o razmeni rizika vremenskih prilika. Rizik vremenskih prilika u tom slučaju treba da ima suprotan uticaj na poslovanje uključenih strana. Drugim rečima, određene vremenske prilike treba da budu pozitivno korelisane sa prihodima jedne strane i istovremeno negativno korelisane sa prihodima druge strane. Ukoliko je indeks manji od referentne vrednosti, koja se naziva izvršna tačka, strana koja je zauzela dugu poziciju (kupila ugovor) isplaćuje strani koja je zauzela kratku poziciju (prodala ugovor) određenu svotu novca. I obrnuto, ukoliko je indeks veći od referentne vrednosti, strana u

risk is covered by a single contract. In order to show the hedging potential of the weather futures contract we shall take as an example the case of a gas distributor located in Chicago who wishes to hedge against higher temperatures than the usual ones in the month of December. Milder winter would mean lower demand for heating, thus lower revenues for the company. Unusually high temperatures would result in lower cumulative HDD index, so the gas distributor should select such a strategy that would hedge him from the fall in the index. The company decides to sell temperature futures contract with embedded cumulative HDD index. Let us assume that the historical daily temperature in December, in Chicago, was 25°F that would yield a daily HDD index of 40, i.e. a cumulative monthly HDD index of 1,200. Transactions are taking place on the CME market where every variation degree is assigned money value of 20 \$, and thus the company is selling the contract for a price of 24,000 \$ (1,200 x 20\$). Upon maturity of contract it turns out

that the month of December of this year was for 10°F warmer than its historical average, thus causing the reduction of the cumulative HDD index, which was just what the hedger was afraid of. The higher daily temperature resulted in the daily HDD index of 30 [65°F - (25°F + 10°F)], i.e. monthly of 900 (30 x 30). In January, the company will close its short position by buying the contract at the price of 18,000 \$ (900 x 20 %) and will make a profit of 6,000 \$ on the basis of the contract (24,000 \$ - 18,000 \$). Let us assume that the company on the basis of historical data has found that every rise in temperature of 10°F will cause fall in revenues for 120,000 \$ in December. In that case, company would buy 20 contracts (120,000 \$ / 6,000 \$). The profit made on the futures market would cover the loss incurred on the spot market. In case the month of December would be unusually cold, the company would incur loss on the futures market, but would cover that loss with extra profit made on the spot market.

Table 4 - Example of some HDD futures contracts with the basic characteristics on the CME

Exchg	Asset Class	Product	Product Code	Start Period	End Period	Initial	Maint.	Initial Vol. Scan	Maint. Vol. Scan
CME	WEATHER	LONDON MONTHLY HDD FUTURES	D0	01/2014	12/2016	8.1%	6.0%	40.5	3
CME	WEATHER	ROME MONTHLY HDD FUTURES	D9	01/2014	12/2016	6.6%	4.9%	40.5	3
CME	WEATHER	PARIS HDD MONTHLY FUTURES	D1	01/2014	12/2016	6.6%	4.9%	40.5	3
CME	WEATHER	AMSTERDAM HDD MONTHLY FUTURES	D2	01/2014	12/2016	7.6%	5.6%	40.5	3
CME	WEATHER	BERLIN HDD MONTHLY FUTURES	D3	01/2014	12/2016	6.8%	5.0%	40.5	3
CME	WEATHER	PRAGUE MONTHLY HDD FUTURES	D7	01/2014	12/2016	6.8%	5.0%	40.5	3

Source: CME Group, 2013, http://www.cmegroup.com/trading/weather/snowfall/monthly-snowfall_performance_bonds.html

kratkoj poziciji isplaćuje dugu poziciju. Prilikom konstrukcije vremenskog svopa ključno pitanje je izračunavanje naplate iz svopa. Struktura naplate iz vremenskog svopa (N_{VS}) dobija se kada se razlika ugovorenog graničnog nivoa (R) i realizovanog vremenskog indeksa (x) pomnoži sa novčanom vrednošću indeksa (O). Struktura naplate iz vremenskog svopa za obe strane može se predstaviti na sledeći način (Schmitz, 2007):

$$N_{VS}^{DP} = O \cdot (R - x)$$

$$N_{VS}^{KP} = O \cdot (x - R)$$

U slučaju da je vremenski indeks niži od graničnog nivoa, kupac isplaćuje određenu sumu prodavcu. Sa druge strane, ako je vremenski indeks veći od graničnog nivoa, strana koja je zauzela kratku poziciju (prodavac) isplaćuje određenu sumu strani koja je zauzela dugu poziciju (kupac). Uzmimo primer ugovor između hidroelektrane (HE) i osiguravajuće kuće kreiran na bazi količine padavina - kiše. HE želi da osigura stabilnost svojih prihoda tokom godine i želi da se zaštiti od malih količina padavina. Na bazi proučavanja odnosa između prihoda od prodaje i istorijskih klimatskih prilika utvrđeno je da svako odstupanje od 10mm od normalne godišnje količine od 10.000 mm kiše utiče na prihode u iznosu od 2.000\$. U nemogućnosti da pronađe hedžera koji je voljan da preuzme po veličini isti a po smeru suprotan rizik, HE odlučuje da sklopi svop ugovor sa osiguravajućom kućom. Kao izvršna tačka određena je količina od 10.000 mm kiše - uobičajena godišnja količina padavina, određeno minimalno odstupanje tj. tik od 10 mm kome je dodeljena novčana vrednost od 2.000\$. Novčana vrednost tik-a određena je tako da pokriva osetljivost prihoda HE na količinu padavina. HE želi da se zaštiti od niskih količina padavina i zauzima kratku poziciju. U slučaju da po isteku ugovora stvarna količina padavina bude manja od 10.000mm, HE prima isplatu od 2.000\$ za svakih 10 mm kiše odstupanja, i obrnuto, u slučaju da stvarna količina padavina bude iznad 10.000mm, HE plaća osiguravajućoj kući 2.000 \$ za svakih 10 mm odstupanja.

Slika 6. Vremenski svop

Zaključak

Usled sve većih uticaja klimatskih promena na poslovanje kompanija direktno zavisnih od vremenskih uslova, ali i uticaja na društvo u celini, evidentno je da su već i da će još više u narednim godinama neke industrije biti direktno pogođene - sigurnost ishrane, poljoprivreda, ribna industrija, stočarstvo, šumarstvo. Procene su različite za različite geografske oblasti, ali je konsenzus da će zemlje u razvoju imati štete veće od razvijenih zemalja, što će podstaći dalje ekonomsko raslojavanje i nove političke probleme. Sve vremenski osetljive industrije počev od transporta, proizvodnje, usluga, osiguranja i maloprodajnog sektora biće pogođene, ali ne podjednako. Pojačavanje snage uragana, npr. će imati posledice na industriju osiguranja, građevinski sektor i turizam. Na berzama bi sezonski vremenski derivati mogli postati veoma privlačni za industrije koje žele da se obezbede od atmosferske ranjivosti. Neki sektori, dakle, mogu imati zaradu - investicioni fondovi, instrumenti transfera rizika, ekološki zajmovi, ili privatni „equity“ fondovi koji ulažu u štete. U septembru 2010 godine je, recimo, indeks maloprodaje odevanja u Velikoj Britaniji skočio zbog preranog zahlađenja, a vest o privrednom porastu od 1 procenta u trećem kvartalu je dovedena u vezu sa lepim vremenom u toku Olimpijskih igara. Ovo govori da ne postoji definitivni ni jednoznačan obrazac koji povezuje ekonomske i klimatske pokazatelje - oni zavise od lokacije, postojeće privrede, regulative, i raspodele investicija po sektorima (<http://bif.rs/2012/12/ekonomska-kriza-i-klimatske-promene-klimatski-kapitalizam/#sthash.50hcGRnj.dpuf>).

Futures and forward contracts serve as basis for the options contracts. Option on a forward contract grants buyer the right, but not an obligation, to buy or sell through the option determined forward contract on a certain fixed day in the future. In exchange for that right the buyer is paying the seller a certain price, i.e. premium. If trading is done in options on a regulated market they will have embedded standardized futures contracts. In case of transactions conducted on the OTC market, options will be created on the basis of the forwards contract. In view of the way of usage, time options are of a European type (European options) which means that the holder may use them only on the maturity date (Russ, 2004, p. 299). In view of the nature of the right acquired through the contract, we can differentiate between the call and the put options. In case of the call options the holder is granted the buying right, and in case of the put option the holder is granted the right to sell the forward contract. Buyer of the weather call option is buying the option with the intent of hedging against too high growth of the index, while the buyer of the weather put option is wishing to hedge against too low index value. For example, manufacturer of soft drinks in the intent to stabilize his revenues during summer can buy a CDD put option which insures for him the payment in case of colder summers. In the similar manner, city authorities that are paying snow removal services can hedge against excessive quantities of snowfall. In that case city authorities will buy the call option, and the option will become more profitable when the real level of snowfall exceeds previously determined execution point, or level. The buyer risk is limited by the option premium. In order to limit also the risk of the seller, weather call and put options are often placing limits on the payments. Such limits are called “caps” in case of call options, or “floors” in case of put options. The efficiency of the weather options as the hedging tool and the way in which limits function we shall present in the case of the winter skiing center wishing to hedge against too mild a winter. The winter skiing center wishes to hedge against shortage of snowfall in respect to the expected one and at the same time aims to make profit if

the winter brings about large amounts of snowfall. Logical solution to this problem is buying the put option where there is an embedded index of the snowfall level. Skiing resort management decides to make a contract on the OTC market as the skiing resort location is too far removed from the nearest reference climate station so that the basis risk would be negligible. By studying historical data it was found that during the season it is necessary to have the total of 80 cm of snow in order for the skiing resort to make profit, but also that every 10 cm of snow cover below that level would decrease earnings for some 300,000 \$. To that end, a put option was created for the execution point of 80 cm, with the tick placed at the level of 10 cm of snow, and the tick-unit was assigned the cash value of 300,000\$. In order to lower financial exposure of the option author due to extreme weather conditions, limit was placed on the payment, the so-called floor on 2 million US dollars. Buyer was happy with the limited payment as he was not expecting extreme variations from the historical average, and it is expected that limited options, provided all other conditions remaining unchanged, will have lower premium than the unlimited ones, as the limits are lowering profit potential of the option. The above stated rights the buyer is buying for the amount of 450,000 \$. Graphic presentation of the transaction is given in Figure 6. Upon completion of the season it was determined that the real level of snow cover was for 40 cm below the coverage point, which means that the skiing resort management decided to use this option. The achieved financial result is equal to the product of minimum changes, i.e. ticks and the cash value of the tick-unit reduced for the premium value, i.e. $750,000 \$ (4 \times 300,000 \$ - 450,000 \$ = 750,000 \$)$.

Figure 5 - Floor option

Source: Author

Kao novo rešenje prevashodno za probleme zaštite od uticaja rizika vremenskih prilika na poslovanje i zaštite poslovnog rezultata, krajem prošlog veka kreirani su vremenski derivati kao novi alat za upravljanje rizikom. Vremenski derivati omogućavaju kompanijama iz „ugroženih“ privrednih sektora da stabilizuju i osiguraju svoje prihode u uslovima neizvesnosti vremenskih prilika u smislu zaštite od rizika količine u odnosu na klasični hedžing. Osnovna karakteristika vremenskih derivata je ta što u njihovoj osnovi ne stoji roba ili aktiva koja ima vrednost i za koje postoji fizičko tržište, već indeks kreiran na osnovu velikog broja klimatskih varijabli. Indeksi se mogu vezati za jednu ili više lokacija i za period od nekoliko dana do nekoliko godina. Utvrđivanjem niske korelacione veze vremenskih prilika sa standardnim oblicima ulaganja u akcije i obveznice, tržište vremenskih

derivata postaje sve interesantnije tržištu kapitala u svetu. Koristeći savremene finansijske derivate kao što su fjučersi i opcije u razvoju proizvoda vremenskih derivata, sve ih je više na svetskim berzama (npr. pored već pomenute CME u SAD, u Evropi izdvajamo Londonsku berzu finansijskih derivata - LIFFE). Imajući u vidu činjenicu da tržište vremenskih derivata trenutno predstavlja nabrže rastuće tržište izvedenih finansijskih instrumenata, zatim činjenicu o rastu rizika nepredviđenih klimatskih i vremenskih prilika, sigurno je da će ova vrsta derivata zainteresovati mnoge kompanije i investitore. Svakako da će veliki broj njih biti u ulozi hedžera u cilju zaštite svog poslovanja, ali biće i onih investitora - špekulanata koji će stremiti ostvarenju visokih profita trgujući vremenskim derivatnim ugovorima.

Swap contracts are long-term private arrangements between the two sides on the swap of cash flows in future according to an in advance determined formula. The basic types of swaps are the interest swaps and currency swaps. Weather swap is an agreement between the counterparties on the swap of weather condition risk. Weather condition risk in that case should have an opposite effect on the business of the parties concerned. In other words, certain weather conditions should be positively correlated with the revenues of one party and at the same time negatively correlated with the revenues of the other party. If the index is to be lower than the reference value, which is called the executive point, the party which had taken long position (buyer of the contract) will pay to the party that had taken a short position (seller of the contract) a certain amount of money. And vice versa, if the index is higher than the reference value, the party which is in the short position will pay to the party taking the long position. When constructing the weather swap the key question is calculation of the collection of payment from the swap. Structure of the weather swap payment (Wsp) is obtained when the difference between the contracted limiting level (R) and the realized weather index (x) is multiplied by the cash value of the index (O). Payment structure from the weather swap for both counterparties may be presented in the following manner (Schmitz, 2007):

$$N_{VS}^{DP} = O \cdot (R - x)$$

$$N_{VS}^{KP} = O \cdot (x - R)$$

In case the weather index is lower than the limit level, buyer is paying a certain amount to the seller. On the other hand, if the weather index is higher than the limit value, the counterparty taking short position (seller) will pay a certain amount to the counterparty that had taken the long position (buyer). Let us take as an example the contract concluded between a hydro electric power plant (HE) and the insurance company, created on the basis of the quantity of precipitation - rainfall. HE wishes to

insure stability of its revenues during the year and wishes to hedge against the low amount of rainfall. On the basis of studies made in the ratio between sale revenues and historical climate conditions it was determined that every variation of 10 mm from the normal annual quantity of 10,000 mm of rainfall will impact revenues in the amount of 2,000 \$. Being unable to find the hedger willing to takeover in size the same but in the direction the opposite risk, HE decides to conclude a swap contract with the insurance company. As the execution point the quantity of 10,000 mm of rainfall was designated - the usual annual amount of precipitation, minimum variation was determined i.e. the tick of 10 mm which was assigned a cash value of 2,000 \$. Cash value of tick was determined in such a way that it covers sensitivity of HE revenues on the quantity of rainfall. HE wishes to hedge from low quantities of precipitation and takes a short position. In case upon expiry of the contract the real quantity of precipitation would be below 10,000 mm, HE is to receive the payment of 2,000 \$ for every 10 mm of rainfall deviation, and vice versa, in case the real quantity of precipitation should be above 10,000 mm HE is to pay the insurance company 2,000 \$ for every 10 mm of variation.

Figure 6 - Weather swap

Conclusion

Due to a growing impact that climate change has on the business of the companies that are directly dependent on the weather conditions, but also the impact on the society in general, it is evident that already, and even more so in

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the years to come, some of the industries will be directly affected - food safety, agriculture, fishing industry, livestock breeding, forestry. Forecasts differ for different geographic areas, but there is a consensus that the developing countries will have heavier losses than the developed countries that will enhance further economic divisions and cause new political problems. All the weather sensitive industries, starting from transport, production, services, insurance and the retail sales sector will be impacted, but not on equal terms. Stronger hurricane gale force, for example will have an impact on the insurance industry, construction sector, and tourism. On the world exchange markets seasonal weather derivatives may become very attractive for industries wishing to hedge against atmospheric vulnerability. Some of the sectors therefore may make gains - investment funds, risk transfer instruments, ecologic loans, or private "equity" funds investing in damage. In September 2010, for example, clothing ready-mades retail sales index in United Kingdom jumped because of an early advent of cold weather, and the news on the economic growth of 1 percent in the third quarter was brought in connection with the nice weather prevailing during the Olympic Games. This shows that there is no definite and neither a uniform formula that could link together economic and climatic indicators - they rather depend on location, the economy already in place, regulatory framework, and investment allocations per sectors. (<http://bif.rs/2012/12/ekonomska-kriza-i-klimatske-promene-klimatski-kapitalizam/#sthash.S0hcGRnj.dpuf>).

As a novel solution primarily dealing with the problem of protection from impact of weather condition risks on business and protection of business result, by the end of

the last century weather derivatives were created as a new tool for risk management. Weather derivatives allow companies from "endangered" economic sectors to stabilize themselves and insure their revenues in condition of uncertain weather conditions in the sense of protection from the quantity risk in respect to the classic hedging. The main characteristic of the weather derivatives is that in their basis there are no goods or assets having their value and already trading on the physical market, but the index created on the basis of a large number of climate variables. Indices can be linked with one or more locations, and for a period of several days, and up to several years. By determining low correlation links between weather conditions and standard forms of investment into stocks and bonds, the weather derivatives market becomes a growingly interesting capital market in the world. Using modern day financial derivatives such as futures and options in the development of weather derivatives, their number is growing on the world exchange markets (for example, in addition to the already mentioned CME in the USA, we underline the London International Financial Futures and Options Exchange - LIFFE). In view of the fact that the weather derivatives market represents, at present, the fastest growing market of financial derivative instruments, but also the fact of the growing forecasting risk of climate and weather conditions, it is certain that this type of derivatives will be interesting and attract many companies and investors. Certainly a large number of them will be in the role of hedgers wishing to protect their businesses, but there will also be some investors - speculators who will strive for making high profits through the weather derivatives contract trading.