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to the Financial Supporting Exhibits
of Frank J. Hanley

extraordinary

3 ENTRIES FOUND:

- **extraordinary** (adjective)
- **extraordinary ray** (noun)
- **extraordinary writ** (noun)

ex·traor·di·nary *adj*

\ik-ˈstrȯr-də-ˌner-ē, ˌek-strə-ˈȯr-\

Definition of EXTRAORDINARY

1 **a :** going beyond what is usual, regular, or customary <*extraordinary* powers>

b : exceptional to a very marked extent <*extraordinary* beauty>

c *of a financial transaction* **:** NONRECURRING

2 **:** employed for or sent on a special function or service <an ambassador *extraordinary*>

— **ex·traor·di·nari·ly** *adverb*
— **ex·traor·di·nari·ness** *noun*

See extraordinary defined for English-language learners »
See extraordinary defined for kids »

Examples of EXTRAORDINARY

The researchers made an *extraordinary* discovery.

The race is an *extraordinary* event.

A polymer based on the elastic protein that enables fleas to perform their *extraordinary* jumping feats has been synthesized. The material … is, perhaps unsurprisingly, rubbery and highly resilient; indeed, some of its properties exceed those of a material used to make bouncy balls for the playground. —Rosamund Daw, *Nature*, 13 Oct. 2005

[+] more

Origin of EXTRAORDINARY

Middle English *extraordinarie,* from Latin *extraordinarius,* from *extra ordinem* out of course, from *extra* + *ordinem,* accusative of *ordin-, ordo* order

First Known Use: 15th century

Related to EXTRAORDINARY

Synonyms: aberrant, aberrated, abnormal, anomalous, atypical, especial, exceeding, extraordinaire, exceptional, freak, odd, peculiar, phenomenal, preternatural, rare, singular, uncommon, uncustomary, unique, unusual, unwonted

Antonyms: common, customary, normal, ordinary, typical, unexceptional, unextraordinary, usual

[+] more

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Thesaurus: All synonyms and antonyms for "extraordinary"

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Browse

Next Word in the Dictionary: extraordinary ray
Previous Word in the Dictionary: extraordinaire
All Words Near: extraordinary

"Seen & Heard"

What made you want to look up *extraordinary*? Please tell us where you read or heard it (including the quote, if possible).

6 comments **Add a comment**

Lynette Zweifel Clark · Works at Davis School District
Extraordinary is a strange word. It's meaning is exceptional, better than normal - but is sounds like the opposite. Extra Ordinary -- just More ordinary than usual - which sounds like a bad thing.
Reply · 3 · Like · April 12 at 7:23am

Jana Lloyd
My family has had discussions about words like that. For instance, when they say an airplane had a "near miss" does that mean they nearly missed but unfortunately crashed?
Reply · 1 · Like · April 12 at 7:22pm

Shiella Mae Marcellones
what makEs you an extra ordinary peron?
Reply · 2 · Like · April 12 at 3:35am

Abdullah Osais
Hai
Reply · Like · May 16 at 10:49am

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Joplin, Missouri, tornado was rare 'multi-vortex' with multiple cyclones in funnel

Published: Monday, May 23, 2011, 10:32 PM Updated: Monday, May 23, 2011, 10:36 PM

The Washington Post
By
The Washington Post

Brian Vastag and Ed O'Keefe, Washington Post

JOPLIN, Mo. -- The extraordinary Joplin twister -- the single deadliest tornado since officials began keeping records in 1950 -- was a rare destructive phenomenon known as a "multi-vortex," hiding two or more cyclones within the wider wind funnel.

Associated Press
View full size
Kathleen Kelsey, a canine rescue specialist with the Missouri Task Force One search-and-rescue team, guides a live-find dog named ChicoDog through the wreckage of a public housing complex in Joplin, Mo., Monday, May 23, 2011. A destructive tornado swept through Joplin on Sunday evening, killing at least 116 and injuring hundreds more.

Sunday's storm smashed the southwest Missouri city's hospital, left nothing but splintered trees where neighborhoods once stood, and killed at least 116, with the death toll expected to rise. The storm injured another 500 and damaged or destroyed at least 2,000 buildings.

Added to the record 875 tornadoes that tore across the country in April, this latest disaster has experts asking why 2011 has spawned so many deadly storms. While researchers sort out the causes for this year's record-breaking season, one thing is certain: Unusually big twisters are blasting through heavily populated areas.

"We have had more F4's and F5's than in past years," said Jack Hayes, director of the National Weather Service, referring to the two most destructive categories of tornadoes. And instead of touching down in farms and fields, storms have hit cities like Joplin and Tuscaloosa, Ala.

An emerging body of research points to a cyclical drop in temperatures in the Pacific Ocean as part of the answer. Called La Nina, the cycle lasts at least five months and repeats every three to five years. This year La Nina is pushing a strong North American jetstream east and south, altering prevailing winds. The jetstream's river of cool air high in the atmosphere pulls warmer, more humid air from the ground upwards, forming thunderstorm "super-cells."

Such a pattern drove the outbreak of more than 300 tornadoes that swept from Mississippi to Tennessee in late April, killing at least 365, experts say. But it's too early for them to know whether La Nina alone accounts for what is shaping up to be a disastrously record-breaking tornado season, said tornado expert Grady Dixon of Mississippi State University. "La Nina is probably part of it," he said. "But it's not the only reason."

Tornado experts predicted a devastating season this year, and many have begun studying whether global climate change is driving more frequent -- and more intense -- tornado-spawning thunderstorms. Such work is at an early stage, making it difficult to draw conclusions.

"This will be a rich topic of research in the coming years," said Russell Schneider, director of the Storm Prediction Center, part of the National Oceanic and Atmospheric Administration in Norman, Okla.

Warm air, moisture, and specific wind patterns are the deadly ingredients that mix together to form tornadoes, and climate change impacts at least one of them by increasing the amount of moisture the air can hold.

"Climate change could be boosting one of those ingredients (for tornadoes), but it depends on how these ingredients come together," said Robert Henson, a meteorologist at the University Corporation for Atmospheric Research.

The intense twister that whipped through Joplin on Sunday spun with windspeeds approaching 200 miles per hour, ranking it as an F4 , just below the top of the tornado scale. The death toll on Monday stood at 116, according to the Associated Press, increasing to 481 the number killed in tornadoes this spring with five weeks until the traditional end of the season.

"We are now on pace for a record year for tornado fatalities" since national record-keeping began in 1950, said Schneider.

The April total of 875 U.S. tornadoes shattered the previous record of 267 set in April 1974. The first two weeks of May were relatively quiet until this weekend's outbreak of tornadoes.

The extraordinary Joplin twister touched down just west of town at 5:41 p.m. and blasted a path of destruction some three-quarters of a mile wide and six miles long, ripping into a hospital, crushing cars, and leaving nothing but splintered tree trunks where neighborhoods once stood, Reuters reported.

Tornado experts said the huge funnel cloud hid within it two or more swirling cyclones, a phenomenon known as a "multi-vortex" or "wedge vortex" tornado. The centers of such intense wind funnels become unstable, wobble, and spin out two to six smaller twisters from within. The short-lived but intense sub-twisters dance around the edge of the cloud, spinning up to 80 miles per hour faster than the wider mother funnel, said Ernest Agee, a tornado researcher at Purdue University.

Such tornadoes often blaze a peculiar destructive path that flattens buildings on one edge of the funnel while nearby structures survive relatively unscathed.

In an online video filmed by a survivor of the Joplin tornado, the blasting roar of the storm quiets for a few seconds before a second roar arrives - a tell-tale sign of a multi-vortex tornado, Agee said.

Mississippi State's Dixon was following the violent "supercell" thunderstorm with eight students in a van just outside Joplin when they broke off the chase.

"We let it go," said Dixon, an atmospheric scientist. "It was just getting too unsafe."

The windows of their van open, Dixon and the students felt blasts of warm air as they followed the backside of the supercell - a sign of an unusually violent storm, Dixon said. "Normally it's cold air on the backside. So we knew it was going to be a big storm. But when we left it . . . we didn't think it was going to be catastrophic."

Over the past decade, deeper understanding of how tornadoes form and move - coupled with advanced radar that can detect tell-tale swirls at the center of a storm - have lengthened tornado warning lead times broadcasted by the National Weather Service. On Sunday, the service announced a tornado warning for Joplin at 5:17 p.m., with the twister touching down 24 minutes later - a "phenomenal" lead time, Dixon said. The nationwide average is 14 minutes, according to the National Weather Service.

Despite this warning, the huge tornado is likely to set a record for the deadliest single tornado in U.S. history. The previous most deadly tornado on record killed 116 people in Flint, Mich., in 1953, an extraordinary year that also saw 114 die in a tornado in Waco, Texas, while 90 perished in a Worcester, Mass., twister that June.

Sunday's deadly storms come during a busy stretch for the Federal Emergency Management Agency, which is already responding to 11 other tornado-related federal disasters this year.

As of Monday, FEMA said it had paid out $79 million this year to more than 20,000 tornado survivors and another $3.3 million to cities and towns to begin rebuilding schools, libraries, firehouses and other public buildings destroyed by twisters. More requests to rebuild public infrastructure are expected in the coming weeks, a spokeswoman said.

FEMA said survivors of Sunday's storms are already eligible to apply for aid, after two affected counties were added to a previous disaster declaration for Missouri.

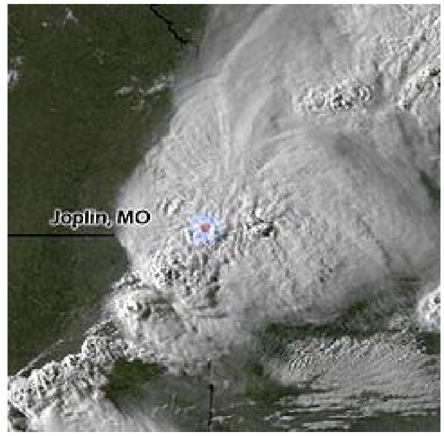
2011 Joplin tornado

Coordinates: 37.060554°N 94.530938°W

From Wikipedia, the free encyclopedia

The **2011 Joplin tornado** was a devastating EF5 multiple-vortex tornado that struck Joplin, Missouri, USA late in the afternoon of Sunday, May 22, 2011. It was part of a larger late-May tornado outbreak sequence and reached a maximum width of in excess of 1 mile (1.6 km) during its path through the southern part of the city.[3] It rapidly intensified and tracked eastward across the city, and then continued eastward across Interstate 44 into rural portions of Jasper County and Newton County.[4] This was the third tornado to strike Joplin since May 1971.[5] Along with the Tri-State Tornado and the 1896 St. Louis -East St. Louis tornado, it ranks as one of Missouri's and America's deadliest tornadoes and is also the costliest single tornado in US history; the cost to rebuild Joplin could reach $3 billion.[6][7] It was the first F5 or EF5 tornado in Missouri since the Ruskin Heights tornado struck south of Kansas City in 1957. It is also only the second F5 or EF5 tornado in Missouri history dating back to 1950. The May 2011 tornado was the deadliest tornado to hit the United States since 1947 - the seventh-deadliest single tornado in U.S. history, and 27th-deadliest in World history. As of July 8, officials reported that 162 people died from the tornado, with another killed by a lightning strike during cleanup operations the next day.[8][9]

2011 Joplin tornado



Storm over Joplin as the tornado struck the city

Date:	May 22, 2011
Time:	5:34 – 6:12 p.m. CDT (2234 – 2312 UTC)
Rating:	EF5 tornado
Damages:	$2.8 billion (2011 USD)
Casualties:	159 (+3 indirect, 1 non-tornadic)[1][2]
Area affected:	Joplin, Missouri (part of a larger outbreak)

The insurance payout is expected to be $2.2 billion—the highest insurance payout in Missouri history and higher than the previous record of $2 billion in the April 10, 2001 hail storm (which has been billed as the costliest hail storm in history as it swept along the I-70 corridor from Kansas to Illinois).[10] Estimates earlier stated Joplin damage could be $3 billion. Through July 15, 2011, there were 16,656 claims.[11]

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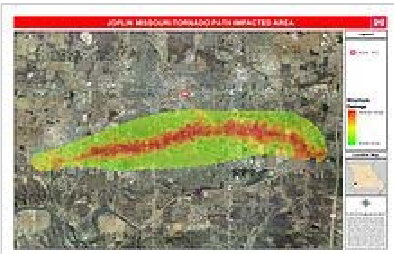
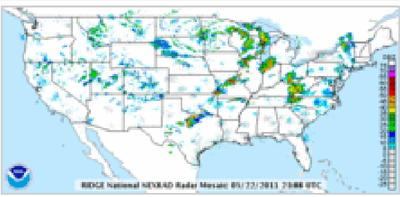
Impact



US Army Corps of Engineers map showing the extent of damage.



Radar map (http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwNexrad~SelectedImage~20110522~ at 6:08 PM local

US Weather Service precipitation map for the 24 hours ending 7 am, May 23. Joplin is in the red/yellow area in southwest Missouri

A preliminary survey of the tornado damage by the National Weather Service office in Springfield, Missouri, began on May 23. The initial survey confirmed a violent tornado rated as a high -end EF4. Subsequent damage surveys, however, found evidence of more intense damage, and so the tornado was upgraded to an EF5[3] with estimated winds over 200 mph (320 km/h), peaking at 225 to 250 mph (362 to 402 km/h).[12]

The tornado initially touched down just east of the Kansas state line near the end of 32nd Street (37.056958°N 94.588423°W) at 5:34 p.m. CDT (2234 UTC) and tracked just north of due east.[13] Damage was minor in the rural areas southwest of Joplin, with only minor tree damage. As the tornado tracked into the southwest corner of Joplin near Twin Hills Country Club, damage was generally moderate with some severe damage. Many houses sustained significant damage in the area, including total roof loss. Damage in that area was rated EF2 to EF3.[13]

The tornado intensified greatly as it entered a more densely populated portion of the city at about 5:41 p.m. CDT (2241 UTC) and damage became very widespread and catastrophic as it entered residential subdivisions in southwest Joplin. In addition, St. John's Regional Medical Center (37.060554°N 94.530938°W) in the same area was heavily damaged with many windows and the exterior walls damaged and the upper floors destroyed. Several fatalities were reported there. While it has been reported that the entire hospital was shifted 4 inches (100 mm) off its foundation,[14] the hospital's president has been unable to confirm this as fact.[15] Virtually every house in that area near McClelland Boulevard and 26th Street was flattened, and some were blown away in the area as well. Trees sustained severe debarking, a nursing home and a church school in southwest Joplin were also

Damage to St. John's hospital

flattened and several other schools were heavily damaged. At and just north of St. John's is the beginning of the EF5 damage corridor, with EF4 damage elsewhere in the area.[13]


Aerial view of the St. John's hospital Campus


Destroyed area in tornado path.

As the tornado tracked eastward, it intensified even more as it crossed Main Street between 20th and 26th Streets. Virtually every business along that stretch was heavily damaged or destroyed and several institutional buildings were destroyed. It tracked just south of downtown, narrowly missing it. More houses were flattened or blown away and trees continued to be debarked. Two large apartment buildings were destroyed, as well as Franklin Technology Center and Joplin High School. No one was in the high school at the time and the high school graduation ceremonies held about 3 miles (4.8 km) to the north at Missouri Southern State University had concluded shortly before the storm.[16] It approached Range Line Road, the main commercial strip in the eastern part of Joplin, near 20th Street. Damage in this area was rated as a low-end EF5.[13]

The tornado peaked in intensity as it crossed Range Line Road. In that corridor between about 13th and 32nd Streets (37.05528°N 94.478452°W), the damage continued to be very intense and the tornado was at its widest at this point, being nearly 1 mile (1.6 km) wide. As the tornado hit the Pizza Hut at 1901 South Range Line Road (37.070451°N 94.477272°W) store manager Christopher Lucas herded four employees and 15 customers into a walk in freezer. Since the door could not be shut Lucas wrapped a bungee cable holding the door shut around his arm until being sucked into the tornado where he died.[17][18] Some of the many severely affected buildings include Walmart Supercenter #59, a Home Depot store, and numerous other restaurants, all of which were flattened. Engineers later criticized the tilt up construction practice in the Home Depot in which all but two of its walls collapsed in domino effect after the tornado lifted the roof—killing seven people in the front of the store although 28 people in the back of the store survived when those walls collapsed outwards. The Walmart and nearby Academy Sports had a different concrete block construction and their walls survived although they lost their roofs. Three people died in the Walmart but 200 survived. Home Depot officials said they disagreed with the study published by The Kansas City Star and said they would use the tilt up practice when they rebuild the Joplin store.[19] Heavy objects, including concrete bumpers and large trucks, were tossed a significant distance, as far as 1/8 mile (200 m) away from the parking lots along Range Line. Many fatalities occurred in this area. Damage in this area was rated as a high-end EF5.[12][13]

Extreme damage continued in the area of Duquesne Road in southeast Joplin. Many houses and industrial and commercial buildings were flattened in this area as well. The industrial park near the corner of 20th and Duquesne was especially hard hit with nearly every building flattened. One of the many warehouses affected was a Cummins warehouse, which was a concrete block and steel building which was destroyed. Damage in this area was mostly rated EF4, with the EF5 damage area ending in the western part of the industrial park.[13]

It then continued on an east to east-southeast trajectory towards Interstate 44 where it weakened; nonetheless, vehicles were flipped and mangled near the U.S. Route 71 (Exit 11) interchange. The weakened tornado continued to track into the rural areas of southeastern Jasper County and northeastern Newton County where damage was generally minor to moderate. The tornado lifted east of Diamond at

6:12 p.m. CDT (2312 UTC) according to aerial surveys. The tornado's total track length was at least 22.1 miles (35.6 km) long.[3] A separate EF2 tornado touched down near Wentworth from the same supercell about 25 miles (40 km) east-southeast of Joplin.[13]

Many people were reported to have been trapped in destroyed houses. Seventeen people were rescued from the rubble the day after the tornado struck.[20]

According to the local branch of the American Red Cross, about 25% of Joplin was destroyed, but the town's emergency manager stated that the number was between 10% and 20%, with roughly 2,000 buildings destroyed.[21][22] According to the National Weather Service, emergency managers reported damage to 75% of Joplin.[23] Communications were lost in the community and power was knocked out to many areas.[24][25] In total, nearly 7,000 houses were destroyed (most of which were flattened or blown away) and over 850 others were damaged.[13]

The catastrophe and risk modeling firm Eqecat, Inc. has estimated the damage at one billion to three billion USD, but noted that the true damage is not yet known, since the firm does not have access to data on uninsured losses.[26]

Casualties


Damage in Joplin one day after the tornado.

As of September 20, 2011, the death toll from the tornado is up to 162 known deaths directly linked to the tornado. In addition to the tornado deaths, a policeman was struck by lightning and killed while assisting with recovery and cleanup efforts the day after the storm.[9][27] Shortly after the tornado, authorities had listed 1,300 people as missing, but the number quickly dwindled as they were accounted for.[28][29][30]

The Missouri Emergency Management Agency reported more than 990 injured.[31][32] Out of 146 sets of remains recovered from the rubble, 134 victims had been positively identified on June 1.[29] Due to the horrific injuries suffered by some victims, some different sets of remains were from a single person.[31] On June 2 it was announced that four more victims had died.[33] It was the deadliest U.S. tornado since that of April 9, 1947 in Woodward, Oklahoma and surrounding locations, and the seventh deadliest tornado in U.S. history.[34] It was also the first single tornado since the June 8, 1953 tornado in Flint, Michigan, to have 100 or more associated fatalities.[35]

Six people were killed when the hospital was struck by the tornado. Five of those deaths were patients on ventilators who died after the building lost power and a backup generator did not work.[36] The sixth fatality was a hospital visitor.[37]

The *Joplin Globe* reported that 54 percent of the people died in their residences, 32 percent died in non-residential areas and 14 percent died in vehicles or outdoors. Joplin officials after the tornado announced plans to require hurricane ties or other fasteners between the houses and their foundation (devices add about $600 to the construction costs). Officials rejected a proposal to require concrete basements in new houses. Officials noted that only 28 percent of Joplin's new homes had basements as of 2009 compared with 38 percent two decades before.[38]

In addition to the deaths directly attributed to the tornado a Riverside, Missouri police officer assisting in the response was killed on May 23 a day after when he was struck by lightning.[39]

Officials said they rescued 944 pets and reunited 292 with owners.[40]

On 10 June 2011, it was announced that a week after the tornado, a rare fungal infection, Zygomycosis, has been noted to cause at least eight serious cases of wound infection among the injured survivors, confirmed by reports to the Missouri Department of Health and Senior Services.[41]

Response

Immediately following the disaster, emergency responders were deployed within and to the city to undertake search and rescue efforts. Governor Jay Nixon declared a state of emergency for the Joplin area shortly after the tornado hit, and ordered Missouri National Guard troops to the city.[24] By May 23, Missouri Task Force One (consisting of 85 personnel, four dogs, and heavy equipment) arrived and began searching for missing persons. Five heavy rescue teams were also sent to the city a day later. Within two days, numerous agencies arrived to assist residents in the recovery process. The National Guard deployed 191 personnel and placed 2,000 more on standby to be deployed if needed. In addition, the Missouri State Highway Patrol provided 180 troopers to assist the Joplin Police Department and other local agencies with law enforcement, rescue, and recovery efforts which also included the deployment of five ambulance strike teams, and a total of 25 ambulances in the affected area on May 24.[32]

President Obama greets Hugh Hills, 85, in front of his home on May 29, 2011. Hills hid in a closet during the tornado, which destroyed the second floor and half the first floor of his house.

With communications down, temporary cell towers had to be constructed. By May 24, three towers owned by AT&T and Sprint had been restored.[32]

East of Joplin, a Risk Management Plan facility released 3,000 to 5,000 pounds (1,400 to 2,300 kg) of anhydrous ammonia; it was contained within two days.[32]

President Barack Obama toured the community on May 29, flying into Joplin Regional Airport and speaking at a memorial at the Taylor Performing Arts Center at Missouri Southern State University about two miles (3 km) north of the worst of the devastation.[42] Obama had been on a state visit to Europe at the time of the storm. Members of the controversial Westboro Baptist Church were also scheduled to protest the same day in Joplin, but they did not show up. There was a massive counter protest that was organized in response to the Westboro protest, in which thousands of protesters showed up holding signs saying, "God Loves Joplin" and "We Support You Joplin."[43]

On June 1 Home Depot said it would have a new temporary 30,000-square-foot (2,800 m^2) building built and operational within two weeks. In the meantime, it had opened for business in the parking lot of its demolished building.[44] On June 20 it opened a temporary 60,000-square-foot (5,600 m^2) building constructed by Home Depot's disaster recovery team.[45]

More than 17,000 insurance claims had been filed by mid-June. The impact on the insurance industry is not so much the number of claims, but the cumulative effect of such a large number of total losses. More than 2500 local people employed in insurance have been involved in some capacity. It is assumed that State Farm will assume the largest share of these losses, having market share of 27% for homeowners insurance and 21% for automobile insurance.[46]

See also

- List of F5 and EF5 tornadoes
- List of North American tornadoes and tornado outbreaks
- List of tornadoes causing 100 or more deaths
- Tornado intensity and damage
- Tornado records
- Tornadoes of 2011

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External links

- Time-lapse visualization of the May 22nd tornado outbreak (http://www.stormtimemachine.com/20110522.html)
- Radar loop of the Joplin tornado (http://www.youtube.com/watch?v=OVq3dyNiyBo)
- NOAA's Aerial Survey of Joplin, Missouri (http://ngs.woc.noaa.gov/storms/joplin/)
- Slideshow of damage from the tornado (http://www.life.com/gallery/60881/joplin-missouri-tornados-wrath#index/0)
- Google Maps aerial view of tornado damage (http://maps.google.com.au/maps?hl=en&ll=37.064013,-94.507914&spn=0.03719,0.117245&t=k&z=14&vpsrc=6)

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F I F T H E D I T I O N

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9

Capital Budgeting and Risk

Long before the development of modern theories linking risk and expected return, smart financial managers adjusted for risk in capital budgeting. They realized intuitively that, other things being equal, risky projects are less desirable than safe ones. Therefore financial managers demanded a higher rate of return from risky projects, or they based their decisions on conservative estimates of the cash flows.

Various rules of thumb are often used to make these risk adjustments. For example, many companies estimate the rate of return required by investors in their securities and use the **company cost of capital** to discount the cash flows on all new projects. Since investors require a higher rate of return from a very risky company, such a firm will have a higher company cost of capital and will set a higher discount rate for its new investment opportunities. For example, in Table 8-1 we estimated that investors expected a rate of return of .163 or about 16.5 percent from Microsoft common stock. Therefore, according to the company cost of capital rule, Microsoft should have been using a 16.5 percent discount rate to compute project net present values.[1]

This is a step in the right direction. Even though we can't measure risk or the expected return on risky securities with absolute precision, it is still reasonable to assert that Microsoft faced more risk than the average firm and, therefore, should have demanded a higher rate of return from its capital investments.

But the company cost of capital rule can also get a firm into trouble if the new projects are more or less risky than its existing business. Each project should be evaluated at its *own* opportunity cost of capital. This is a clear implication of the value-additivity principle introduced in Chapter 7. For a firm composed of assets A and B, the firm value is

$$\text{Firm value} = \text{PV(AB)} = \text{PV(A)} + \text{PV(B)} = \text{sum of separate asset values}$$

Here PV(A) and PV(B) are valued just as if they were mini-firms in which stockholders could invest directly. Investors would value A by discounting its forecasted cash flows at a rate reflecting the risk of A. They would value B by discounting at a rate reflecting the risk of B. The two discount rates will, in general, be different.

[1]Microsoft did not use any significant amount of debt financing. Thus its cost of capital is the rate of return investors expect on its common stock. The complications caused by debt are discussed later in this chapter.

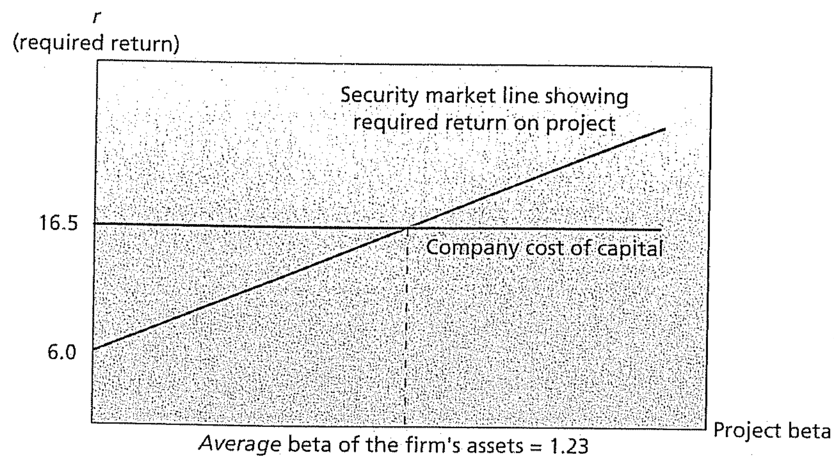

Figure 9-1 A comparison between the company cost of capital rule and the required return under the capital asset pricing model. Microsoft's company cost of capital is about 16.5 percent. This is the correct discount rate only if the project beta is 1.23. In general, the correct discount rate increases as project beta increases. Microsoft should accept projects with rates of return above the security market line relating required return to beta.

If the firm considers investing in a third project C, it should also value C as if C were a mini-firm. That is, the firm should discount the cash flows of C at the expected rate of return that investors would demand to make a separate investment in C. *The true cost of capital depends on the use to which the capital is put.*

This means that Microsoft should accept any project that more than compensates for the *project's beta*. In other words, Microsoft should accept any project lying above the upward-sloping line that links expected return to risk in Figure 9-1. If the project has a high risk, Microsoft needs a higher prospective return than if the project has a low risk. Now contrast this with the company cost of capital rule, which is to accept any project *regardless of its risk* as long as it offers a higher return than the *company's* cost of capital. In terms of Figure 9-1, the rule tells Microsoft to accept any project above the horizontal cost-of-capital line, i.e., any project offering a return of more than 16.5 percent.

It is clearly silly to suggest that Microsoft should demand the same rate of return from a very safe project as from a very risky one. If Microsoft used the company cost of capital rule, it would reject many good low-risk projects and accept many poor high-risk projects. It is also silly to suggest that just because Duke Power has a low company cost of capital, it is justified in accepting projects that Microsoft would reject. If you followed such a rule to its seemingly logical conclusion, you would think it possible to enlarge the company's investment opportunities by investing a large sum in Treasury bills. That would make the common stock safe and create a low company cost of capital.[2]

The notion that each company has some individual discount rate or cost of capital is widespread, but far from universal. Many firms require different returns from different categories of investment. For example, discount rates might be set as follows:

[2] If the present value of an asset depended on the identity of the company that bought it, present values would not add up. Remember, a good project is a good project is a good project.

Category	Discount Rate
Speculative ventures	30%
New products	20%
Expansion of existing business	15% (company cost of capital)
Cost improvement, known technology	10%

The capital asset pricing model is widely used by large corporations to estimate the discount rate. It states

$$\text{Expected project return} = r = r_f + (\text{project beta})(r_m - r_f)$$

To calculate this, you have to figure out the project beta. Before thinking about the betas of individual projects, we will look at some problems you would encounter in using beta to estimate a company's cost of capital. It turns out that beta is difficult to measure accurately for an individual firm: Much greater accuracy can be achieved by looking at an average of similar companies. But then we have to define *similar*. Among other things, we will find that a firm's borrowing policy affects its stock beta. It would be misleading, e.g., to average the betas of Chrysler, which has been a heavy borrower, and General Motors, which has generally borrowed less.

The company cost of capital is the correct discount rate for projects that have the same risk as the company's existing business but *not* for those projects that are safer or riskier than the company's average. The problem is to judge the relative risks of the projects available to the firm. To handle that problem, we will need to dig a little deeper and look at what features make some investments riskier than others. After you know *why* AT&T stock has less market risk than, say, Ford Motor, you will be in a better position to judge the relative risks of capital investment opportunities.

There is still another complication: Project betas can shift over time. Some projects are safer in youth than in old age; others are riskier. In this case, what do we mean by *the* project beta? There may be a separate beta for each year of the project's life. To put it another way, can we jump from the capital asset pricing model, which looks out one period into the future, to the discounted-cash-flow formula that we developed in Chapters 2 and 6 for valuing long-lived assets? Most of the time it is safe to do so, but you should be able to recognize and deal with the exceptions.

We will use the capital asset pricing model, or CAPM, throughout this chapter. But don't infer that the CAPM is the last word on risk and return. The principles and procedures covered in this chapter work just as well with other models such as arbitrage pricing theory (APT). For example, we could have started with an APT estimate of the expected rate of return on Microsoft stock; the discussion of company and project costs of capital would have followed exactly.

9-1 MEASURING BETAS

Suppose that you were considering an across-the-board expansion by your firm. Such an investment would have about the same degree of risk as the existing business. Therefore you should discount the projected flows at the company cost of capital. To estimate that, you could begin by estimating the beta of the company's stock.

An obvious way to measure the beta of the stock is to look at how its price has responded in the past to market movements. For example, in Figure 9-2*a* and *b* we have plotted monthly rates of return from AT&T and Hewlett-Packard against mar-

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17

Defining the Cost of Capital

In the preceding chapter we concluded that, up to a limit, the use of financial leverage can potentially increase the value of the firm. If we denote the proportions of debt and equity which correspond to this limit by the letter L^*, the latter represents the firm's *optimal* capital structure. And as we have assumed that the goal of the firm is to maximize its market value (thereby maximizing the market value of the stockholders' equity as well), it follows that the firm should strive to achieve that financing mix which it believes to be optimal in the long run.

In this chapter we turn our attention to the problem of defining the cost of capital, that is a firm's minimum required rate of return on new investment. Initially we shall set out the theoretical arguments supporting the use of a *weighted average* of the various sources of financing as the measure of the cost of capital, the weights being determined by the proportion of each source in the optimal capital structure, L^*. In the following chapter we shall discuss the ways in which each individual type of financing (debt, preferred stock, common stock, retained earnings, etc.), can be measured, and conclude the discussion by setting out a practical method for calculating the cost of capital using General Motors Corporation and IBM as examples.

We concentrate in this chapter and in the next one on defining and measuring the cost of equity, debt and preferred stocks. The analysis of cost of other sources of funds (e.g., accounts payable) is left to the end-of-chapter problems.

FIRM'S COST OF CAPITAL VS INDIVIDUAL PROJECT'S COST OF CAPITAL

The cost of capital and the discount rate are two concepts which are used throughout the book interchangeably. However, there is a distinction between the *firm's* cost of capital and *specific project's* cost of capital. Let us elaborate:

Firm's Cost of Capital

The firm's cost of capital is the discount rate employed to discount the firm's average cash flow, hence obtaining the value of the firm. It is also the weighted average cost of capital, as we shall see below. The weighted average cost of capital should be employed for project evaluation (i.e., calculating the *NPV*) only in cases where the risk profile of the new project is a "carbon copy" of the risk profile of the firm.

Specific Project's Cost of Capital

In any case where the risk profile of the individual projects differ from that of the firm, an adjustment should be made in the required discount rate, to reflect this deviation in the risk profile. To illustrate, suppose that the firm's weighted average cost of capital is 20% and the risk-free interest rate is 10%. The firm should discount the project's average cash flows, in general, at the 20% discount rate. However, consider a case where the firm faces a project whose cash flow is certain. What is the minimum required rate of return on this certain project? In this case it is clearly the 10% rate which reflects the opportunity cost that the firm could earn by investing its money in other safe assets. Similarly, if the project under consideration is characterized by a very high risk, the 20% discount rate may be insufficient and a higher discount rate should be employed.

A Formal Analysis

For simplicity we assume a perpetual cash flow stream and no taxes. However, the same results can be obtained for a non-perpetual cash flow stream and when taxes exist. Let the firm's average cash flow be $\bar{X}$ and its market value be V. Hence there is some discount rate k which fulfills the following equality

$$V = \frac{\bar{X}}{k}$$

Suppose now that the firm is considering a new investment whose initial outlay is I. Should the firm accept the new project? The decision is, of course, dependent on the average additional cash flow $\Delta\bar{X}$ due to the new project as well as its risk profile. Suppose that as a result of accepting the new project, we obtain a new value for the firm V_1 given by,

$$V_1 = \frac{\bar{X}_1}{k_1} = \frac{\bar{X} + \Delta\bar{X}}{k + \Delta k}$$

where $\bar{X}_1 = \bar{X} + \Delta\bar{X}$ and $k_1 = k + \Delta k$ is the appropriate new average cash flow of the firm and its new discount rate.

The condition $V_1 \geqslant V_0$ is not a sufficient condition to accept the project. The reason is that the firm invested $\$I$, hence the project should be accepted only if the value of the firm increases at least by I. Thus, the project should be accepted if, and only if,

$$V_1 = \frac{\bar{X} + \Delta\bar{X}}{k + \Delta k} \geqslant V_0 + I \qquad (\text{or if } V_1 - V_0 \geqslant I)$$

This condition can be rewritten as

$$\bar{X} + \Delta\bar{X} \geqslant kV_0 + kI + \Delta k V_0 + \Delta k I$$

Dividing all terms by I we obtain,

$$\frac{\bar{X}}{I} + \frac{\Delta\bar{X}}{I} \geqslant \frac{kV_0}{I} + k + \frac{\Delta k V_0}{I} + \Delta k$$

However, by definition we have, $V_0 = \bar{X}/k$ which implies that $kV_0 = \bar{X}$. Substitute $\bar{X}$ for kV_0 to obtain,

$$\frac{\bar{X}}{I} + \frac{\Delta\bar{X}}{I} \geqslant \frac{\bar{X}}{I} + k + \frac{\Delta k}{I} V_0 + \Delta k$$

Cancelling out $\bar{X}/I$ from both sides finally yields,

$$\frac{\Delta\bar{X}}{I} \geqslant k + \Delta k + \frac{\Delta k}{I} V_0$$

Since $\Delta\bar{X}/I$ is the additional required return on the new investment, we can write an equality sign to obtain the *minimum required rate of return* on the new investment:

$$\frac{\Delta\bar{X}}{I} = k + \Delta k + \frac{\Delta k}{I} V_0$$

To sum up, if $\Delta\bar{X}/I$ is equal to the sum of right hand side terms, one is exactly indifferent regarding accepting or rejecting the project since in this case V_1 is exactly equal to $V_0 + I$. In other words, the *NPV* of the project given by $(V_1 - V_0) - I$ is precisely zero. If $\Delta\bar{X}/I$ is greater than this value we obtain a positive *NPV*, namely $V_1 > V_0 + I$ and the project should certainly be accepted.

Let us analyze this implied project's cost of capital. First note if $\Delta k = 0$, it means that the new project is very similar in its risk profile to the firm's risk, hence, the stockholders do not change their required discount rate. In this specific case where the project's risk is a carbon copy of the firm's risk we have $\Delta\bar{X}/I = k$ and the firm's discount rate which prevailed before taking the new investment also serves as the project's cost of capital.

If, on the other hand, $\Delta k > 0$, in order to justify the acceptance of the project we should earn in addition to k also a risk premium equal to

$\Delta k + \frac{\Delta k}{I} V_0$, to compensate for the additional risk due to the new project.

EXAMPLE

Assume that $k = .10$, $\bar{X} = \$10$, hence $V_0 = \bar{X}/k = 10/0.10 = \$100$. The firm considers a new investment whose initial cash flow is $I = \$50$. It is further known that this project is very risky which will cause stockholders to increase their discount rate from .10 to $k_1 = k + \Delta k = .10 + .05 = .15$. What is the *minimum* required rate of return that the firm would require from the new project?

Using our formula we obtain,

$$\frac{\Delta \bar{X}}{I} = k + \Delta k + \frac{\Delta k}{I} V_0$$

$$= .10 + .05 + \frac{0.05}{50} 100 = .15 + .10 = .25$$

Since the firm invests $I = \$50$, a 25% return implies that $\Delta \bar{X}$ should be at least \$12.5 (since \$12.5/\$50 = .25) in order to make the project acceptable. Let us check this result. If indeed $\Delta \bar{X} = 12.5$, we obtain,

$$V_1 = \frac{\bar{X}_1}{k_1} = \frac{\bar{X} + \Delta \bar{X}}{k + \Delta k} = \frac{10 + 12.5}{.10 + .05} = \frac{22.5}{.15} = \$150$$

where V_1 is the value of the firm in the case where the new project is executed.

Thus, we indeed observe that at this critical point where the project's *NPV* is exactly equal to zero $V_1 = V_0 + I = 100 + 50$. If $\Delta \bar{X} > \$12.5$ the project is characterized by a positive *NPV* which implies that $V_1 > V_0 + I$, and the firm should accept the project.

The above analysis reveals that if the specific project's cost of capital is given by $\Delta \bar{X}/I$ which varies from one project to another in accordance with the project's risk profile. However, if the new project does not change the firm's risk profile, we obtain

$$\frac{\Delta \bar{X}}{I} = k \qquad (\text{where } V_0 = \frac{\bar{X}}{k})$$

Hence, the discount rate (which we shall identify later on as the firm's weighted average cost of capital) is also the project's cost of capital.

While academicians as well as practitioners agree that each project has its own risk profile and hence its own discount rate, it is equally agreed upon that it is difficult, if not impossible, to estimate a separate cost of capital to each individual project, in particular in light of the fact that the future variability of the cash flow of a potential project is unknown (namely, Δk is unknown). Thus, it is common to estimate the weighted average cost of capital of the firm, as a first benchmark. In many cases (where $\Delta k = 0$) this estimate of the weighted average cost of capital is the suitable discount rate to be employed. However, when management considers a project to be relatively risky ($\Delta k > 0$), an additional risk premium should be added to the weighted average cost of capital. Similarly, if a project is less risky than the firm's risk ($\Delta k < 0$), a "safety premium" should be deducted from the firm's weighted average cost of capital. While we state various statistical methods (in the next chapter) to estimate the firm's cost of capital, the additions or reductions from it due to a specific risk profile of the project under consideration, remains mainly an art, which is made by management, based on intuition and experience rather than scientific statistical methods.

In most of the chapter we assume that the project has the same risk profile as characterizes the firm (i.e., $\Delta k = 0$). We explain why the weighted average cost of capital is the appropriate discount rate, keeping in mind some changes in the figure may be needed to reflect the specific risk profile of the project under consideration.

The relationship between the cost of capital and firm's capital structure is analyzed by means of a numerical example in the next section.

THE WEIGHTED AVERAGE COST OF CAPITAL

Numerical Example

For simplicity, let us first assume that all new investments are financed in the exact proportions of debt and equity given by the optimal financial structure, L^*. What is the cost of capital (discount rate) that the firm should use when evaluating a new project? Table 17.1 illustrates the case of a firm which has adopted a policy of financing investments with 40% debt and 60% equity, presumably on the assumption that this capital structure is optimal, given the firm's risk-return profile. Thus its initial capital structure (column 1 of Table 17.1) is comprised of $6 million of common stock yielding 15% in dividends, and $4 million of bonds on which it pays 5% interest. To simplify the discussion

Table 17.1

	Before the New Investment	*New Investment*	*After the New Investment*
	$	$	$
Capital Structure:			
Bonds (5%)	4,000,000	400,000	4,400,000
Stock	6,000,000	600,000	6,600,000
Total	10,000,000	1,000,000	11,000,000
Cash Flows:			
Net Operating Income	1,100,000	110,000	1,210,000
Interest	200,000	20,000	220,000
Dividends	900,000	90,000	990,000