

# Probabilistic Reasoning

## Unit # 10

## Twisted Party Problem (by Ross Shachter)

- Erica wants to celebrate her birthday by throwing a party this coming weekend. After some thinking, she rushes to her dorm to get started with the arrangements.
- At the dorm, she learns that another student is also interested in using of the shared areas of the dorm next Saturday, so she must book the area she wants now.
- “How can I possibly know if I should reserve the garden or the cafeteria?” asks Erica. “What if it rains on Saturday? All the food will get wet! But if instead we stay inside and the Sun shines outside, the boys will leave to play Frisbee and my party will be a disaster!”

## Twisted Party Problem (Cont'd)

- Erica also invited Jane, a girl she met over the summer in a Hockey camp.
- Jane said that she could bring a large tent that could cover and save the party in case Erica chooses the garden and it rains.
- Erica is not sure if Jane will come and in case she comes, whether or not she will remember to bring the tent. "She always forgets everything".

## More issues....

- What is she going to wear?
- What food should she serve? Coffee or Coke?
- Erica also doesn't know what she should ask her parents for a gift.

## Basic Elements of Decision Making

- Values and Objectives
- Decisions to be made
- Uncertain Events
- Consequences

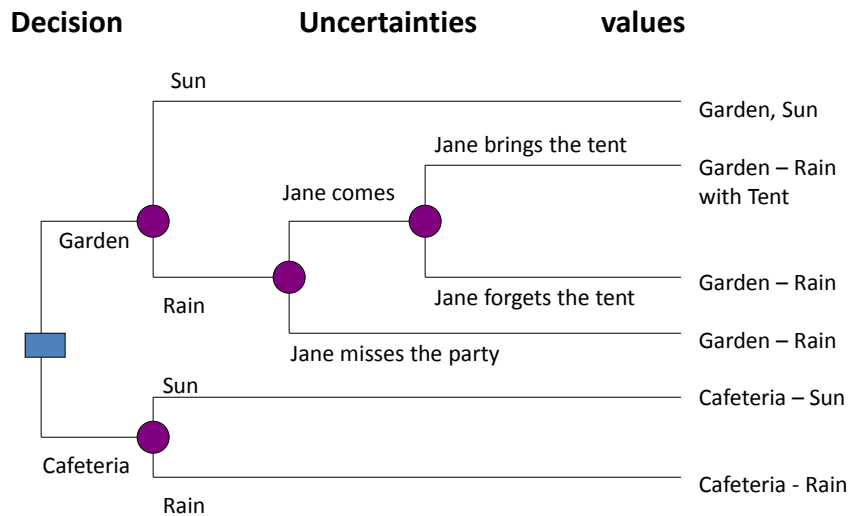
## Structuring & Framing

- Decisions & Alternatives
  - What space to book: garden or cafeteria
  - What to wear?
  - What gift to ask?
- Uncertainties
  - Is it going to rain?
  - Is Jane coming? Is she bringing the tent?
  - Is Erica's party going to be a success?

## Structuring & Framing

- Erica doesn't know how to handle the values.
- "There are no \$\$ attached to any of the alternatives, except for the money I'll have to spend! What should I do?"
- Values: Even though there are no clear values attached to the elemental possibilities, Erica must be able to express her preferences in such a way that she can order the possibilities.

## Twisted Party – Possible Decision Tree



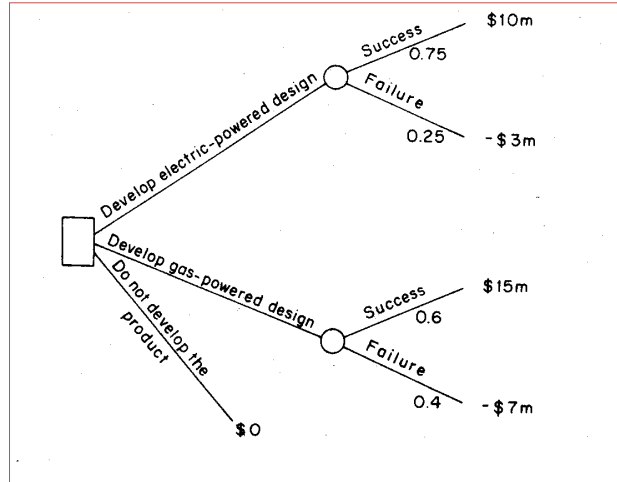
## Techniques for Identifying Objectives

- Develop a wish list
- Identify alternatives
- Consider problems and shortcomings
- Predict consequences
- Identify goals, constraints, and guidelines
- Consider different perspectives
- Determine objectives

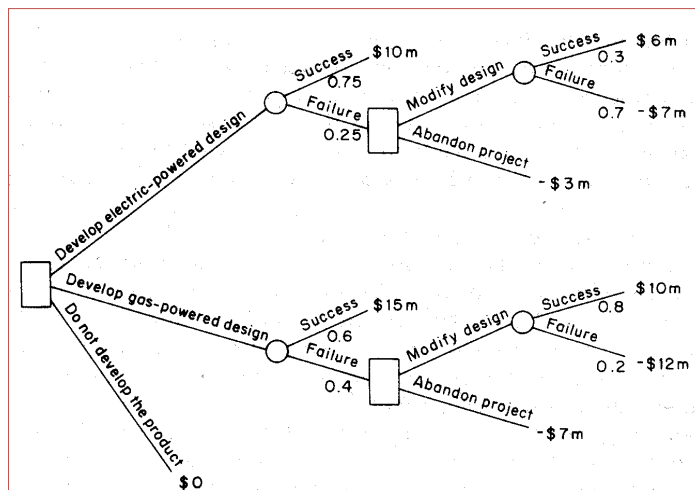
## Food Processor Problem (by Goodwin & Wright)

- An engineer in a food-processing industry has been asked to consider the development of a new kind of processor and make a recommendation.
- Two alternatives power sources could be used for the processor, namely gas and electricity.
- Resource constraints mean that the company will only be able to pursue one of the designs.
- The engineer estimates that there is a 75% chance that the electricity-powered design would be successful and only a 60% chance that the gas-powered design would be a success.

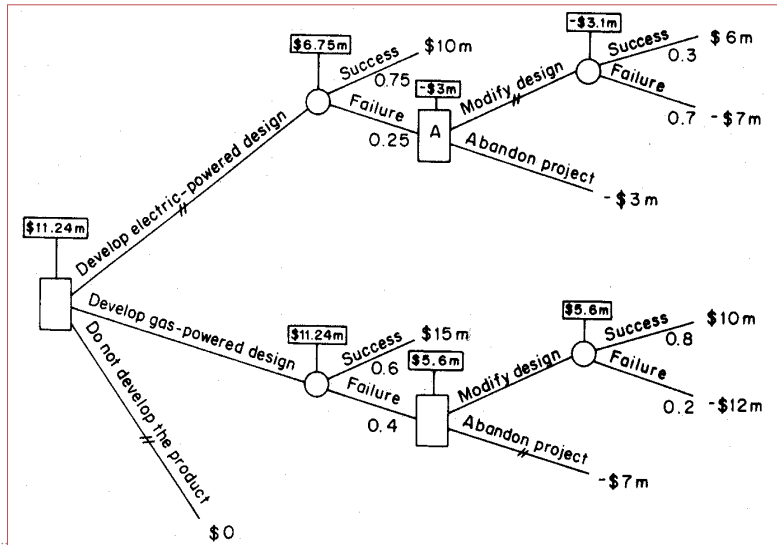
## Food Processor Problem (Cont'd)



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## Food Processor Problem (Cont'd)



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13

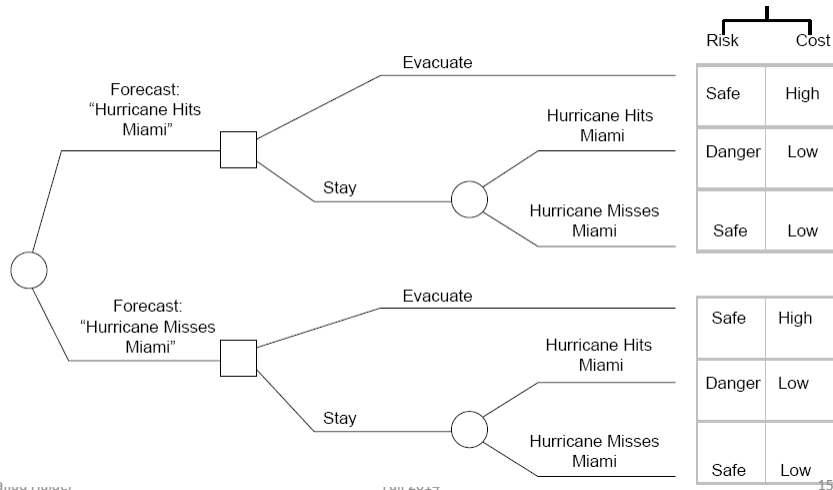
You judge the quality of a decision before knowing the outcome

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14

## Evacuation Problem (by Clemen & Reilly)

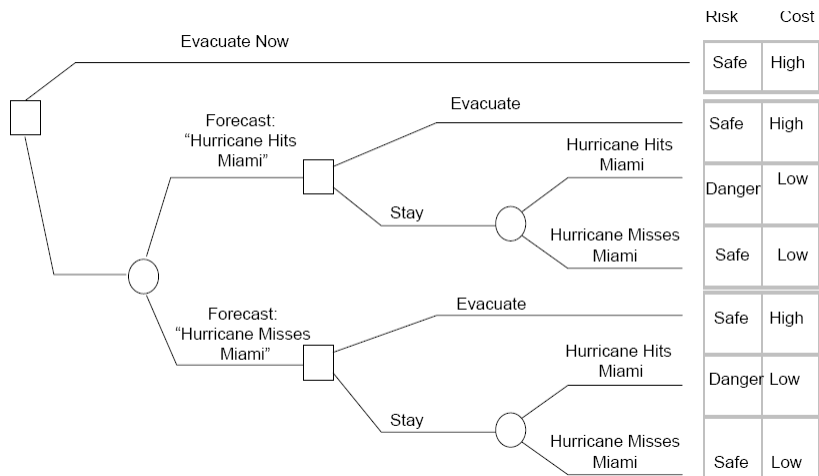


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15

## Evacuation Problem (Cont'd)



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16



## Drilling Example (by Hillier & Lieberman)

- The ALPHA COMPANY owns a tract of land that may contain oil. A consulting geologist has reported to management that she believes there is 1 chance in 4 of oil.
- Because of this prospect, another oil company has offered to purchase the land for \$90,000. However, Alpha is considering holding the land in order to drill for oil itself.
- The cost of drilling is \$100,000.
- If oil is found, the resulted expected revenue will be \$800,000.

## Texaco vs. Pennzoil (Clemen & Reilly)

- In early 1984, **Pennzoil and Getty Oil agreed to the terms of a merger.** But before any formal documents could be signed, **Texaco offered Getty a substantially better price,** and Gordon Getty, who controlled most of the Getty Stock, reneged on the Pennzoil deal and sold to Texaco.
- Naturally, **Pennzoil felt as if it had been dealt with unfairly and immediately files a lawsuit against Texaco** alleging that Texaco had interfered illegally in the Pennzoil-Getty negotiations.
- **Pennzoil won the case:** in late 1985, it was awarded **\$11.1 billion**, the largest judgment ever in the United States.
- A Texas appeal court reduced the judgment to **\$2 billion**, but interest and penalties drove the total back up to **\$10.3 billion.**

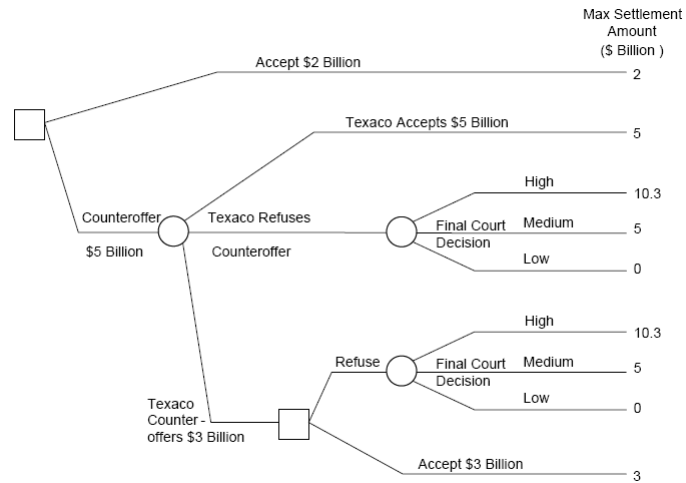
## Texaco vs. Pennzoil (Cont'd)

- James Kinnear, Texaco's Chief executive officer, had said that **Texaco would file for bankruptcy** if Pennzoil obtained court permission to secure the judgment by filing liens against Texaco's assets.
- Furthermore, Kinnear had promised to fight the case all the way to the **U.S. Supreme Court** if necessary, arguing in part that Pennzoil had not followed Security and Exchange Commission regulations in its negotiations with Getty.
- In April 1987, just before Pennzoil began to file liens, **Texaco offered to Pennzoil \$2 billion dollars** to settle the entire case.
- Hugh Liedtke, chairman of Pennzoil, indicated that his advisors were telling him that a settlement **between \$3 billion and \$5 billion would be fair.**

## Texaco vs. Pennzoil (Cont'd)

- **What should Hugh Liedtke do?**
  - Accept \$2 Billion
  - Refuse \$2 Billion and counter offer \$5 Billion

## Texaco vs. Pennzoil (Cont'd)



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21

## Texaco vs. Pennzoil (Cont'd)

- Given tough negotiation positions of the two executives, it could be **an even chance (50%)** that Texaco will refuse to negotiate further.
- Liedtke and advisor figure that it is **twice as likely** that Texaco would counter offer \$3 billion than accepting the \$5 billion.
- Hence, because there is a **50% of refusal**, there must be a **33% chance** of a Texaco counter offer and a **17% chance** of Texaco accepting \$5 billion.

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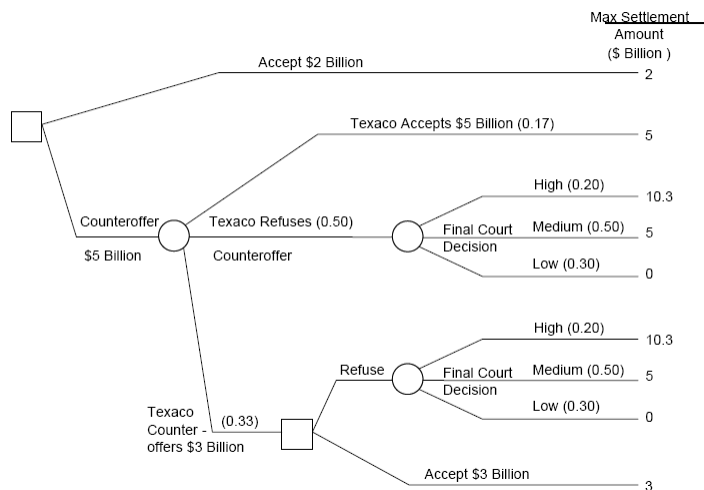
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22

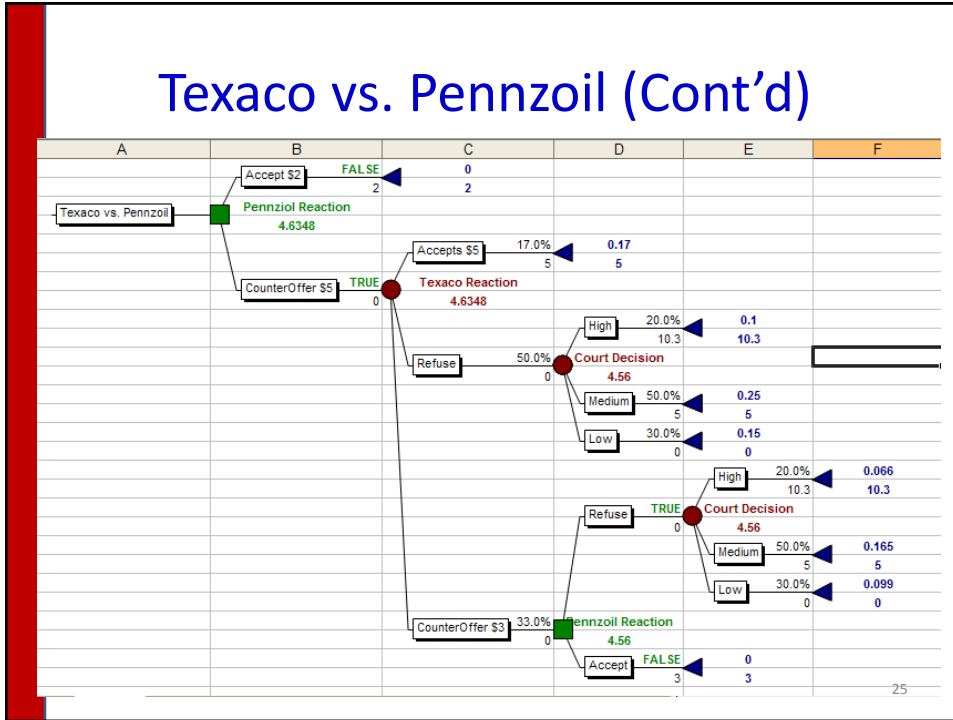
## Texaco vs. Pennzoil (Cont'd)

- What are the probabilities of the final court decision?
  - Liedtke **admitted** that Pennzoil could lose the case. Thus there is a significant possibility the outcome would be zero. It's probability is assessed at **30%**.
  - Given the strength of the Pennzoil case it is also possible that the court will **upheld the judgment** as it stands. It's probability is assessed at **20%**.
  - Finally, the possibility exists that the judgment could be **reduced somewhat to \$5 billion**. Thus there must be a chance of **50%** of this happening.

## Texaco vs. Pennzoil (Cont'd)



## Texaco vs. Pennzoil (Cont'd)



## Texaco vs. Pennzoil (Popularity)

Google search results for "texaco pennzoil".

Search:  Search [Advanced Search](#) [Preferences](#)

Search:  the web  pages from Pakistan

Web Results 1 - 10 of about 110,000 for texaco pennzoil. (0.17 seconds)

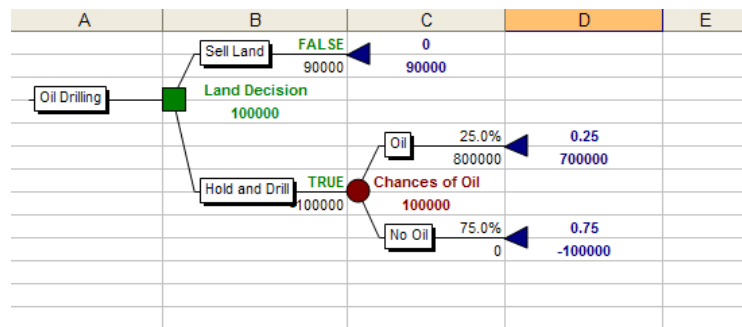
- [Pennzoil - Wikipedia, the free encyclopedia](#)  
Texaco. In 1984, Pennzoil made an informal, yet still binding, contract with the Getty Oil company to purchase the company. ...  
[en.wikipedia.org/wiki/Pennzoil - 35k - Cached - Similar pages - Note this](#)
- [Case Study: Texaco versus Pennzoil In early 1984, Pennzoil and ...](#)  
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In early 1984, Pennzoil and Getty Oil agreed to the terms of a merger. But before any formal documents could be signed, Texaco offered Getty ...  
[www.agsm.edu.au/bobm/teaching/SGTM/pennzoil.pdf - Similar pages - Note this](#)
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shares, reneged on the Pennzoil deal and sold to Texaco. ... In April 1987, just before Pennzoil began to file the liens, Texaco offered to ...  
[www.agsm.edu.au/bobm/teaching/MDM/pennzoil.pdf - Similar pages - Note this](#)
- [Texaco vs. Pennzoil: Modeling a Settlement in PrecisionTree - Palisade](#)  
Pennzoil immediately sued Texaco, alleging Texaco had illegally interfered in the negotiations. ... \$2 billion if Pennzoil accepts Texaco's initial offer. ...  
[www.palisade.com/articles/ptree\\_texpen.asp - 26k - Cached - Similar pages - Note this](#)
- [729 S.W.2d 768 \[Excerpts from Texaco v. Pennzoil\] Court of Appeals ...](#)  
File Format: PDF/Adobe Acrobat - [View as HTML](#)  
Pennzoil and Texaco presented conflicting evidence. at trial on the common business usage and ... Texaco points out that Pennzoil amended its tender ...  
[ncw.mit.edu/NB/rdjnlvres/Sloan-School-of-Management/15-649TheLaw-of-Contract-Case-Studies/729-SW-2d-768-Excerpts-from-Texaco-v-Pennzoil-Court-of-Appeals-1980-1981-1982-1983-1984-1985-1986-1987-1988-1989-1990-1991-1992-1993-1994-1995-1996-1997-1998-1999-2000-2001-2002-2003-2004-2005-2006-2007-2008-2009-2010-2011-2012-2013-2014-2015-2016-2017-2018-2019-2020-2021-2022-2023-2024-2025-2026-2027-2028-2029-2030-2031-2032-2033-2034-2035-2036-2037-2038-2039-2040-2041-2042-2043-2044-2045-2046-2047-2048-2049-2050-2051-2052-2053-2054-2055-2056-2057-2058-2059-2060-2061-2062-2063-2064-2065-2066-2067-2068-2069-2070-2071-2072-2073-2074-2075-2076-2077-2078-2079-2080-2081-2082-2083-2084-2085-2086-2087-2088-2089-2090-2091-2092-2093-2094-2095-2096-2097-2098-2099-2100-2101-2102-2103-2104-2105-2106-2107-2108-2109-2110-2111-2112-2113-2114-2115-2116-2117-2118-2119-2120-2121-2122-2123-2124-2125-2126-2127-2128-2129-2130-2131-2132-2133-2134-2135-2136-2137-2138-2139-2140-2141-2142-2143-2144-2145-2146-2147-2148-2149-2150-2151-2152-2153-2154-2155-2156-2157-2158-2159-2160-2161-2162-2163-2164-2165-2166-2167-2168-2169-2170-2171-2172-2173-2174-2175-2176-2177-2178-2179-2180-2181-2182-2183-2184-2185-2186-2187-2188-2189-2190-2191-2192-2193-2194-2195-2196-2197-2198-2199-2200-2201-2202-2203-2204-2205-2206-2207-2208-2209-2210-2211-2212-2213-2214-2215-2216-2217-2218-2219-2220-2221-2222-2223-2224-2225-2226-2227-2228-2229-2230-2231-2232-2233-2234-2235-2236-2237-2238-2239-2240-2241-2242-2243-2244-2245-2246-2247-2248-2249-2250-2251-2252-2253-2254-2255-2256-2257-2258-2259-2260-2261-2262-2263-2264-2265-2266-2267-2268-2269-2270-2271-2272-2273-2274-2275-2276-2277-2278-2279-2280-2281-2282-2283-2284-2285-2286-2287-2288-2289-2290-2291-2292-2293-2294-2295-2296-2297-2298-2299-2300-2301-2302-2303-2304-2305-2306-2307-2308-2309-2310-2311-2312-2313-2314-2315-2316-2317-2318-2319-2320-2321-2322-2323-2324-2325-2326-2327-2328-2329-2330-2331-2332-2333-2334-2335-2336-2337-2338-2339-2340-2341-2342-2343-2344-2345-2346-2347-2348-2349-2350-2351-2352-2353-2354-2355-2356-2357-2358-2359-2360-2361-2362-2363-2364-2365-2366-2367-2368-2369-2370-2371-2372-2373-2374-2375-2376-2377-2378-2379-2380-2381-2382-2383-2384-2385-2386-2387-2388-2389-2390-2391-2392-2393-2394-2395-2396-2397-2398-2399-2400-2401-2402-2403-2404-2405-2406-2407-2408-2409-2410-2411-2412-2413-2414-2415-2416-2417-2418-2419-2420-2421-2422-2423-2424-2425-2426-2427-2428-2429-2430-2431-2432-2433-2434-2435-2436-2437-2438-2439-2440-2441-2442-2443-2444-2445-2446-2447-2448-2449-2450-2451-2452-2453-2454-2455-2456-2457-2458-2459-2460-2461-2462-2463-2464-2465-2466-2467-2468-2469-2470-2471-2472-2473-2474-2475-2476-2477-2478-2479-2480-2481-2482-2483-2484-2485-2486-2487-2488-2489-2490-2491-2492-2493-2494-2495-2496-2497-2498-2499-2500-2501-2502-2503-2504-2505-2506-2507-2508-2509-2510-2511-2512-2513-2514-2515-2516-2517-2518-2519-2520-2521-2522-2523-2524-2525-2526-2527-2528-2529-2530-2531-2532-2533-2534-2535-2536-2537-2538-2539-2540-2541-2542-2543-2544-2545-2546-2547-2548-2549-2550-2551-2552-2553-2554-2555-2556-2557-2558-2559-2560-2561-2562-2563-2564-2565-2566-2567-2568-2569-2570-2571-2572-2573-2574-2575-2576-2577-2578-2579-2580-2581-2582-2583-2584-2585-2586-2587-2588-2589-2590-2591-2592-2593-2594-2595-2596-2597-2598-2599-2600-2601-2602-2603-2604-2605-2606-2607-2608-2609-2610-2611-2612-2613-2614-2615-2616-2617-2618-2619-2620-2621-2622-2623-2624-2625-2626-2627-2628-2629-2630-2631-2632-2633-2634-2635-2636-2637-2638-2639-2640-2641-2642-2643-2644-2645-2646-2647-2648-2649-2650-2651-2652-2653-2654-2655-2656-2657-2658-2659-2660-2661-2662-2663-2664-2665-2666-2667-2668-2669-2670-2671-2672-2673-2674-2675-2676-2677-2678-2679-2680-2681-2682-2683-2684-2685-2686-2687-2688-2689-2690-2691-2692-2693-2694-2695-2696-2697-2698-2699-2700-2701-2702-2703-2704-2705-2706-2707-2708-2709-2710-2711-2712-2713-2714-2715-2716-2717-2718-2719-2720-2721-2722-2723-2724-2725-2726-2727-2728-2729-2730-2731-2732-2733-2734-2735-2736-2737-2738-2739-2740-2741-2742-2743-2744-2745-2746-2747-2748-2749-2750-2751-2752-2753-2754-2755-2756-2757-2758-2759-2760-2761-2762-2763-2764-2765-2766-2767-2768-2769-2770-2771-2772-2773-2774-2775-2776-2777-2778-2779-2780-2781-2782-2783-2784-2785-2786-2787-2788-2789-2790-2791-2792-2793-2794-2795-2796-2797-2798-2799-2800-2801-2802-2803-2804-2805-2806-2807-2808-2809-2810-2811-2812-2813-2814-2815-2816-2817-2818-2819-2820-2821-2822-2823-2824-2825-2826-2827-2828-2829-2830-2831-2832-2833-2834-2835-2836-2837-2838-2839-2840-2841-2842-2843-2844-2845-2846-2847-2848-2849-2850-2851-2852-2853-2854-2855-2856-2857-2858-2859-2860-2861-2862-2863-2864-2865-2866-2867-2868-2869-2870-2871-2872-2873-2874-2875-2876-2877-2878-2879-2880-2881-2882-2883-2884-2885-2886-2887-2888-2889-2890-2891-2892-2893-2894-2895-2896-2897-2898-2899-2900-2901-2902-2903-2904-2905-2906-2907-2908-2909-2910-2911-2912-2913-2914-2915-2916-2917-2918-2919-2920-2921-2922-2923-2924-2925-2926-2927-2928-2929-2930-2931-2932-2933-2934-2935-2936-2937-2938-2939-2940-2941-2942-2943-2944-2945-2946-2947-2948-2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## Drilling Example (by Hillier & Lieberman)

- The ALPHA COMPANY owns a tract of land that may contain oil. A consulting geologist has reported to management that she believes there is 1 chance in 4 of oil.
- Because of this prospect, another oil company has offered to purchase the land for \$90,000. However, Alpha is considering holding the land in order to drill for oil itself.
- The cost of drilling is \$100,000.
- If oil is found, the resulted expected revenue will be \$800,000.

## Sensitivity Analysis



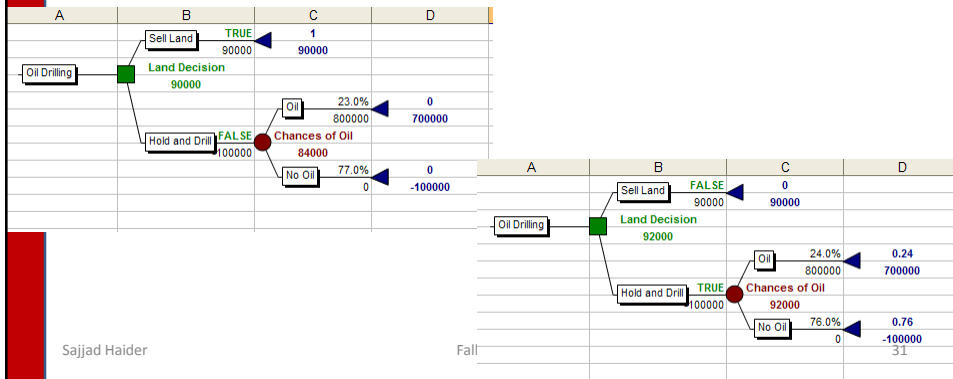
- What if the probability of oil is unknown?
- How sensitive is the decision to the probability of oil?

## Sensitivity Analysis (Cont'd)

- Solving the equation

$$8p + 0(1-p) - 1 > 0.9$$

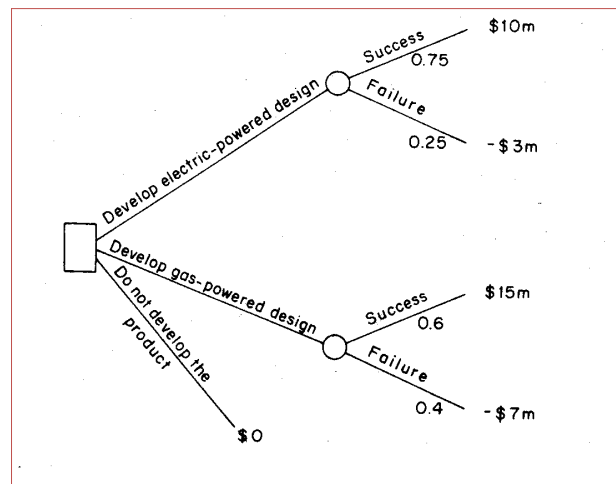
$$\Rightarrow p > 0.2375$$



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Fall

## Food Processor Problem (Cont'd)



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Fall 2014

32

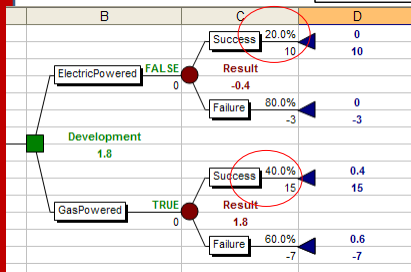
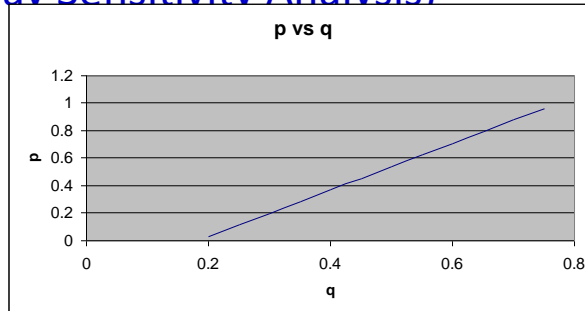


## Food Processor Example (Two-way Sensitivity Analysis)

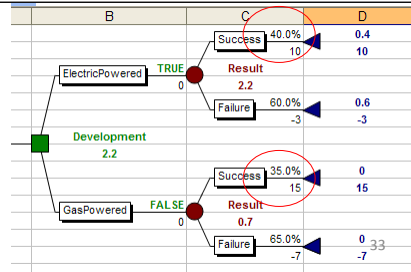
$$10p - 3(1-p) >$$

$$15q - 7(1-q)$$

$$\Rightarrow P > \frac{22}{13}q - \frac{4}{13}$$



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## Sensitivity Analysis in BNs

- The analysis of how sensitive the Bayesian network is to changes in parameters or inputs is called sensitivity analysis.
- The network output is the posterior probability of the query node(s).
- The changes to be tested may be variations in the evidence provided or variations in the network parameter.

## Two Metrics to Gauge Uncertainty

- Entropy
  - $H(X) = - \sum P(x) \log P(x)$
- Variance
  - $\text{Var}(X) = \sum (x - \mu)^2 P(x)$

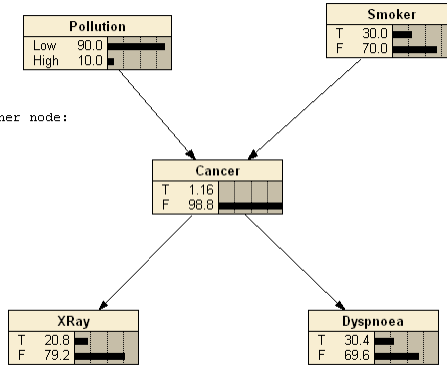
## Entropy and Variance Computation

P(Z = 1)	P(Z = 2)	P(Z = 3)	P(Z = 4)	H(Z)	Var(Z)
1	0	0	0	0	0
0.25	0.25	0.25	0.25	1.39	1.25
0	0.5	0.5	0	0.69	0.25

# Sensitivity Analysis in Netica

Sensitivity of 'Cancer' due to a finding at another node:

Node	Mutual Info	Variance of Beliefs
Cancer	0.09142	0.0114947
XRay	0.01893	0.0003928
Smoker	0.01008	0.0001778
Dyspnoea	0.00431	0.0000765
Pollution	0.00156	0.0000335



# Recap of the Course