Carnegie Mellon University

QA: ML Fairness (theoretical) case study

17-313 Fall 2022

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S3D
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Administrativia

- HW4 implementation and Design Doc due today.
- US Election Day

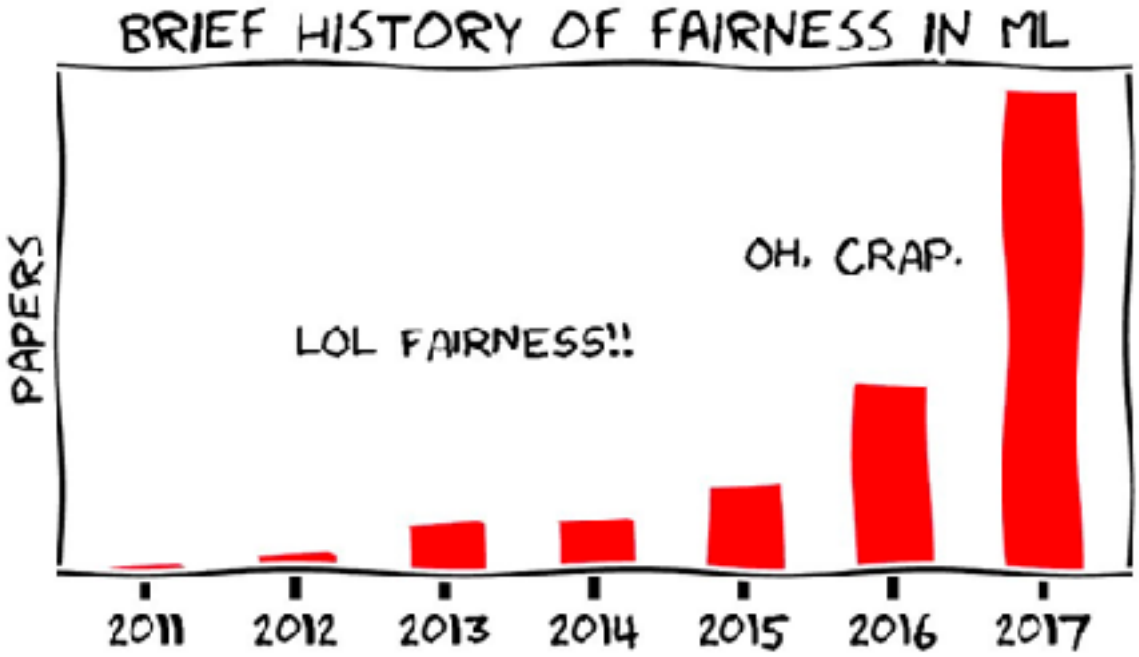
Learning goals

- Understand different fairness approaches
- Describe strengths and weaknesses of fairness approaches
- Reason about tradeoffs in fairness

Fairness

ML Fairness

- Getting answers is the easy part… Asking the right questions is the hard part.



https://towardsdatascience.com/a-tutorial-on-fairness-in-machine-learning-3ff8ba1040cb

Perception:

Life is often not this simple…

Fairness

- Is a deeply technical topic, but we will discuss it at a higher level of abstraction.
- The formulas are important, but knowing which formula to apply is MUCH more important
- This is a special case of how to to test when the desired outcome is hard to measure.

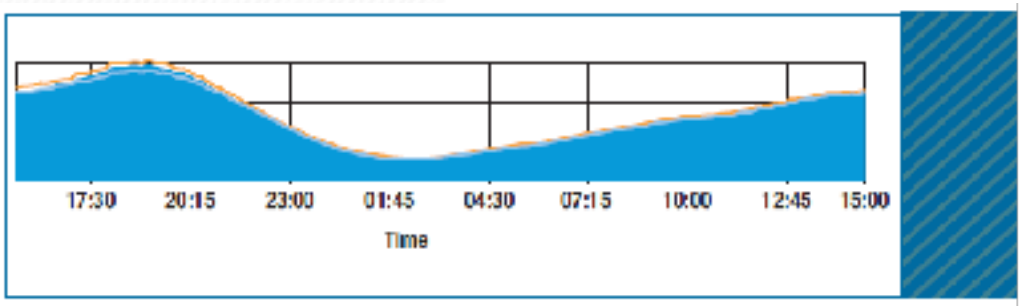


FIGURE 2. A graph of SPS ([stream] starts per second) over a 24-hour period. This metric varies slowly and predictably throughout a day. The orange line shows the trend for the prior week. The y-axis isn't labeled because the data is proprietary.

VS

What does ”fair” mean?

What is Fairness?

- Law
  - fairness includes protecting individuals and groups from discrimination or mistreatment with a focus on prohibiting behaviors, biases and basing decisions on certain protected factors or social group categories.
- Social Science
  - “often considers fairness in light of social relationships, power dynamics, institutions and markets.”3 Members of certain groups (or identities) that tend to experience advantages.

What is Fairness? continued

- Quantitative Fields
  - (i.e. math, computer science, statistics, economics): questions of fairness are seen as mathematical problems. Fairness tends to match to some sort of criteria, such as equal or equitable allocation, representation, or error rates, for a particular task or problem.
- Philosophy:
  - ideas of fairness “rest on a sense that what is fair is also what is morally right.” Political philosophy connects fairness to notions of justice and equity.

Fairness as QA

How can we define “fair”

- For the purposes of creating an oracle
- We must have a better definition than infamous 1964 Supreme Court obscenity test:
  - I shall not today attempt further to define [obscene material], and perhaps I could never succeed in intelligibly doing so. But *I know it when I see it*, and the motion picture involved in this case is not that.[

We don’t need to start from scratch…

Varieties of fairness (names vary)

- **Group unaware**
  - Ignore group data (one group could get excluded)
- **Group thresholds**
  - Different rules per group (rules differ by group)
- **Demographic parity**
  - Same percentage in pool as outcomes (might result in random selection)
- **Equal opportunity**
  - Equal chance out positive outcomes regardless of groups (focus on individual, rules differ per group)
- **Equal accuracy**
  - Equal chance of both outcomes per group (focus on group, rules differ per group)

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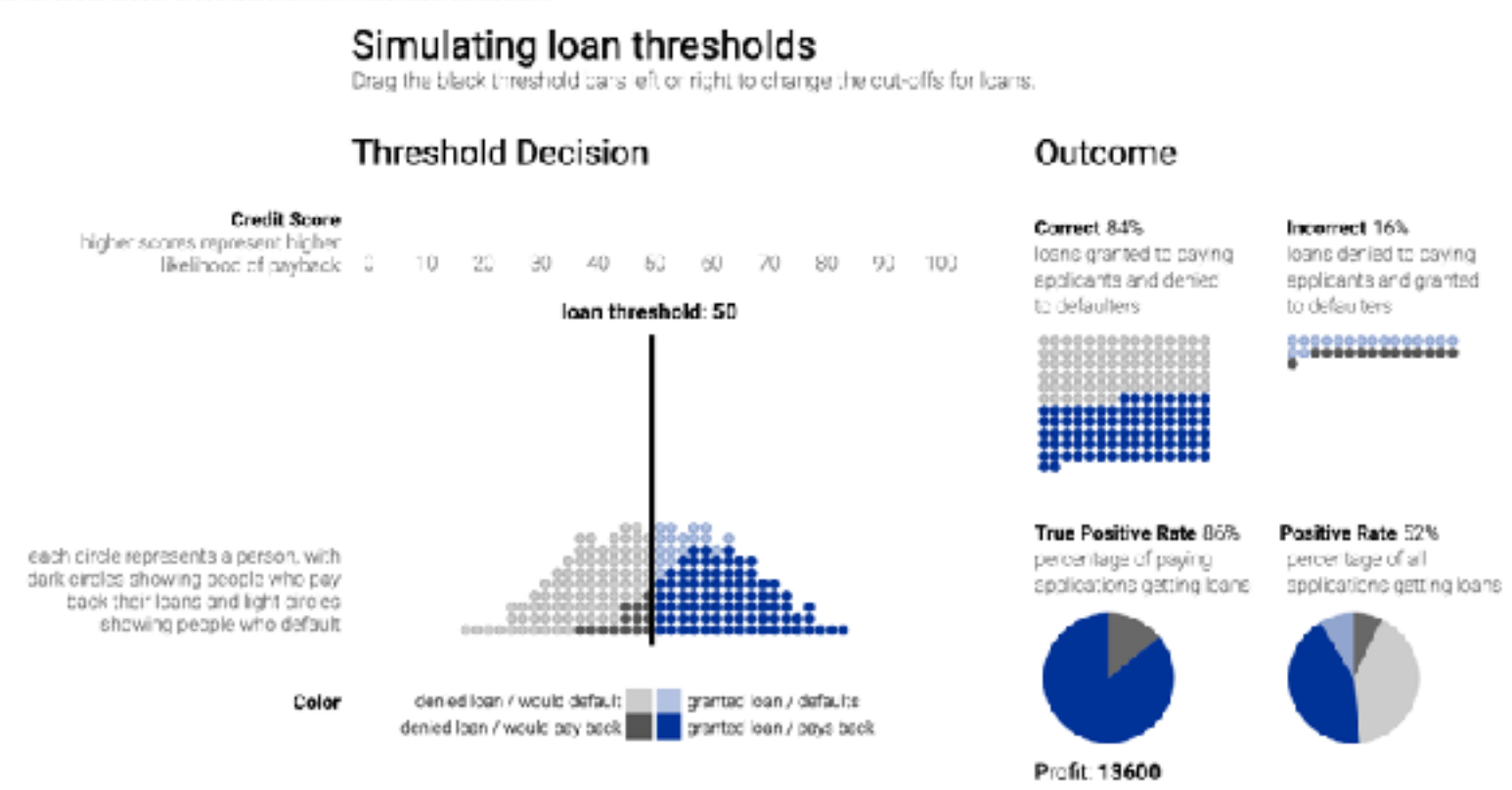
Explainability



https://research.google.com/bigpicture/attacking-discrimination-in-ml/

Activity

Consider the different approaches to fairness. Can you come up with different scenarios where each fairness approach might or might not be appropriate?

Remember the fairness approaches are:

- Group unaware
- Group thresholds
- Demographic parity
- Equal opportunity
- Equal accuracy

Resources

- Fairness Textbook:
- https://fairmlbook.org/testing.html

Decision Making/ Tradeoffs

Life is all about tradeoffs

In this course, we have talked a lot about tradeoffs.

Some tradeoffs we have discussed:

Writing Tests vs writing more features

Choosing a familiar tech stack vs a “trendy one”

Other tradeoffs…?

Think about structured ways to make decisions

Do what is ethical, legal, moral, obvious

Sometimes, there are multiple (legitimate) options, that all seem to have positives and negatives.

What to do?

People have studied this before...

Economics

Biology + Microbiology

Sociology

Engineering

Computer Science

Strategy Games

Ethics

Medicine

Politics

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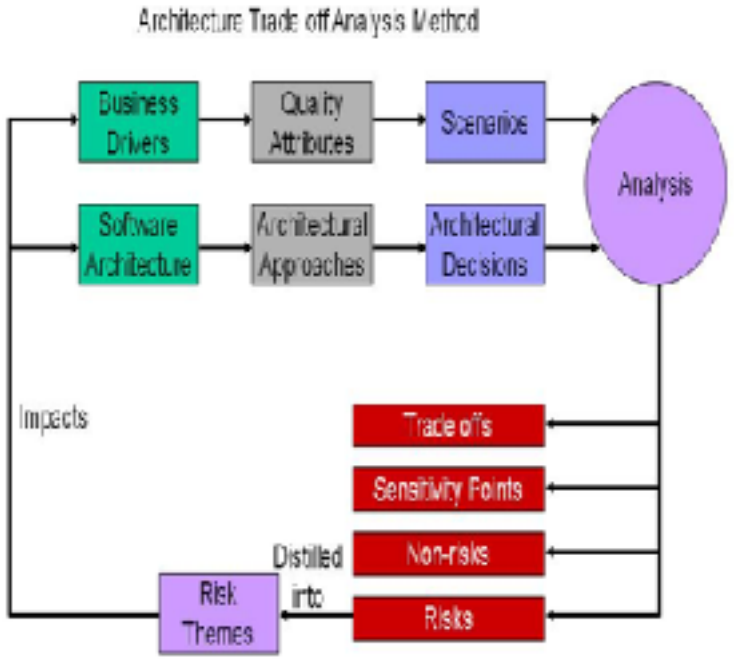
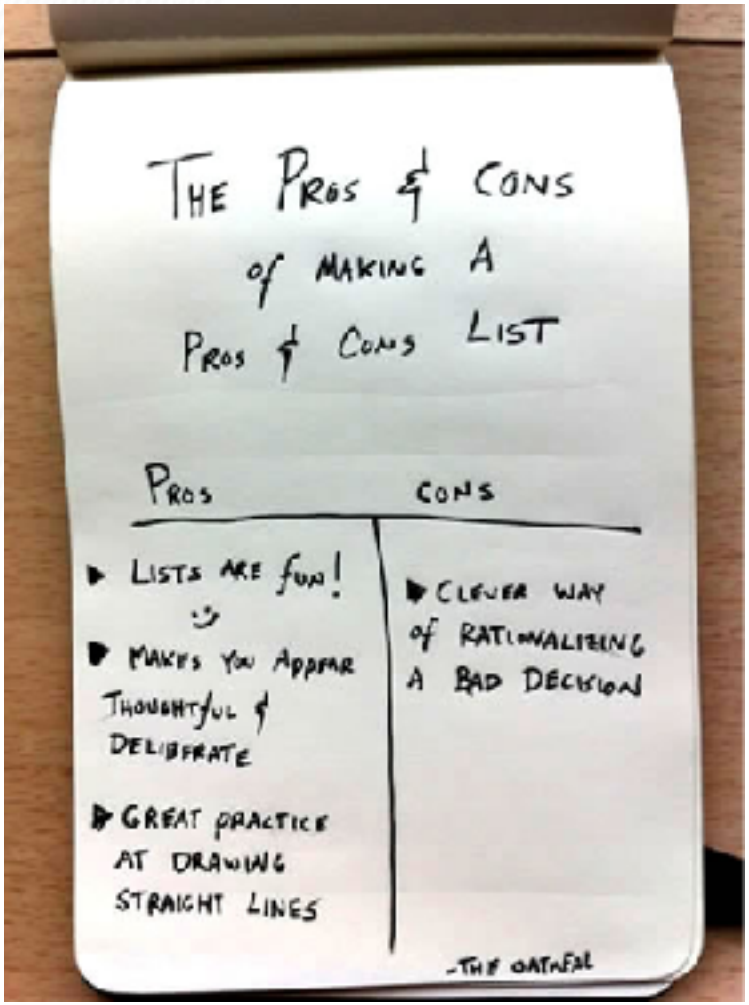
Architecture Tradeoff Analysis Method

1. Present the ATAM.
2. Present business drivers.
3. Present architecture.
4. Identify architectural approaches.
5. Generate quality attribute utility tree.
6. Analyze architectural approaches.
7. Brainstorm and prioritize scenarios.
8. Analyze architectural approaches.
9. Present results.



https://concisesoftware.com/architecture-tradeoff-analysis-method-atam/

Pros and cons



https://theoatmeal.com/blog/pros_cons_list

Moral or Prudential Algebra

1. Make a list of Pros and Cons
2. Take a few days to think, forcing your brain to come up with all of the positive and negative aspects of taking the measure you're considering.
3. Assign weights to each item on your list depending on its importance.
4. When the weight of a item on your "pro" list is equal to the weight of an item on your "con" list, strike both of them out.
5. What is left in the balance is the choice you need to make. Wait a few more days and, if nothing new occurs to you, act on the decision you've made.

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Even Swaps

Premise:

It is easy to make decisions when there is only one objective.

But having only one objective, as any decision maker knows, is a rare luxury.

Even swaps provides a practical way of making trade-offs among any set of objectives across a range of alternatives.

Overview - 3 step process

1. Create a Consequences Table

2. Eliminate “Dominated” Alternatives

3. Make Even Swaps

Running Example from research paper

Example: Alan Miller is a computer scientist who started a technical consulting practice three years ago.

For the first year, he worked out of his home, but as his business grew he decided to sign a two-year lease on some space in the Pierpoint office park.

Now that lease is about to expire. He needs to decide whether to renew it or move to a new location.

Define the objectives

Alan defines five overriding objectives that he needs his office to fulfill:

1. a short commute from home
2. good access to his clients
3. good office services (clerical assistance, copiers and fax machines, and mail service)
4. sufficient space
5. low costs

He finds five viable alternatives: Parkway, Lombard, Baranov, Montana, and his current building, the Pierpoint.

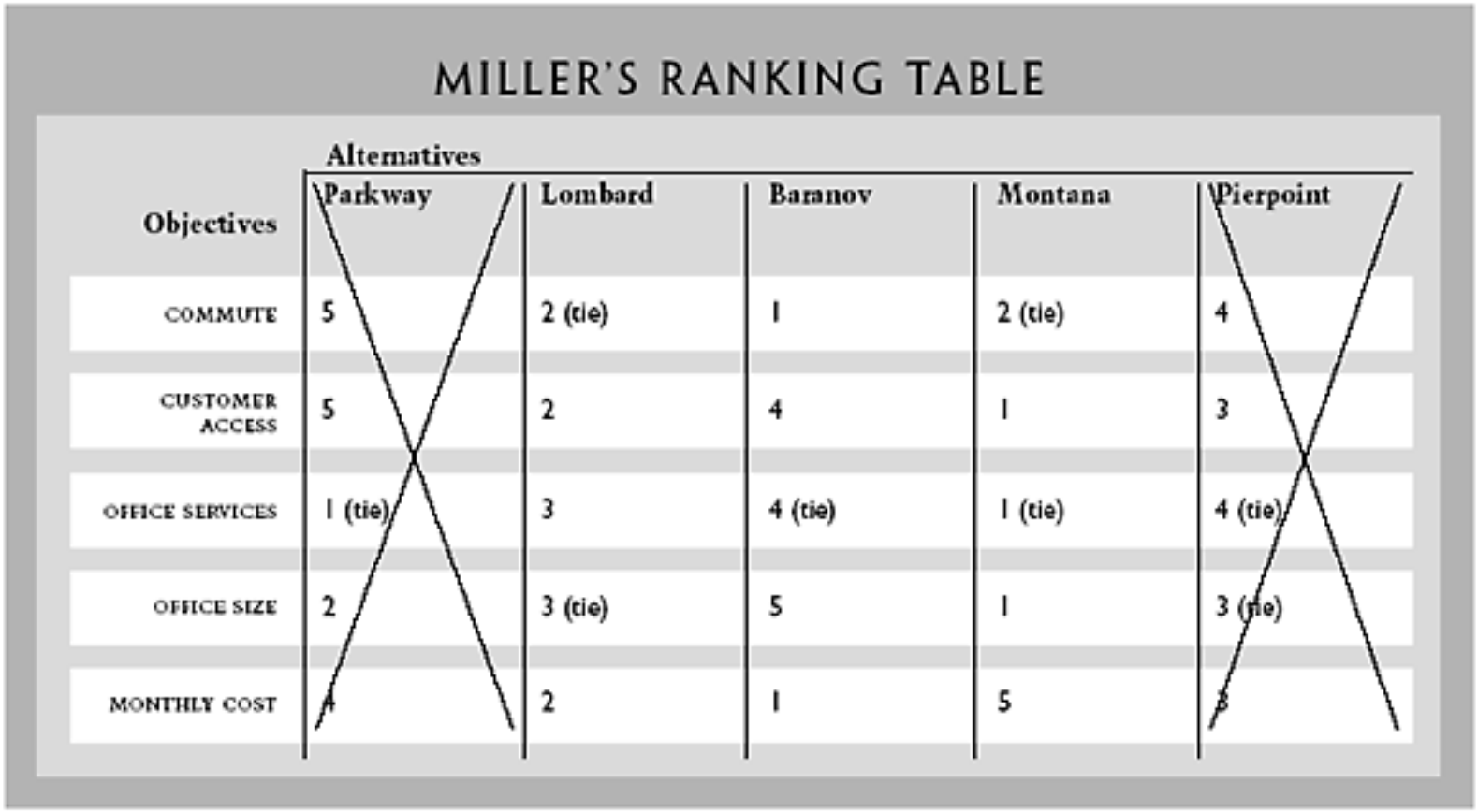
Create Consequences Table

MILLER'S CONSEQUENCES TABLE

Objectives	Alternatives				
	Parkway	Lombard	Baranov	Montana	Pierpoint
COMMUTE IN MINUTES	45	25	20	25	30
CUSTOMER ACCESS (%)	50	80	70	85	75
OFFICE SERVICES	A	B	C	A	C
OFFICE SIZE (SQUARE FEET)	800	700	500	950	700
MONTHLY COST ($)	1850	1700	1500	1900	1750

https://hbr.org/1998/03/even-swaps-a-rational-method-for-making-trade-offs

Eliminate “Dominated” Alternatives



MILLER'S RANKING TABLE

Objectives	Alternatives: Parkway	Lombard	Baranov	Montana	Pierpoint
COMMUTE	5	2 (tie)	1	2 (tie)	4
CUSTOMER ACCESS	5	2	4	1	3
OFFICE SERVICES	1 (tie)	3	4 (tie)	1 (tie)	4 (tie)
OFFICE SIZE	2	3 (tie)	5	1	3 (tie)
MONTHLY COST	4	2	1	5	3

Make Even Swaps

1. Determine the change necessary to cancel out an objective.
2. Assess what change in another objective would compensate for the needed change.
3. Make the even swap.
4. Cancel out the now-irrelevant objective.
5. Select the dominant alternative.

First Even Swaps

MILLER'S EVEN SWAPS 1

Objectives	Alternatives		
	Lombard	Baranov	Montana
~~COMMUTE IN MINUTES~~	~~25~~	~~20~~ 25	~~25~~
CUSTOMER ACCESS (%)	80	~~70~~ 78	85
OFFICE SERVICES	B	C	A
OFFICE SIZE (SQUARE FEET)	700	500	950
MONTHLY COST ($)	1700	1500	1900

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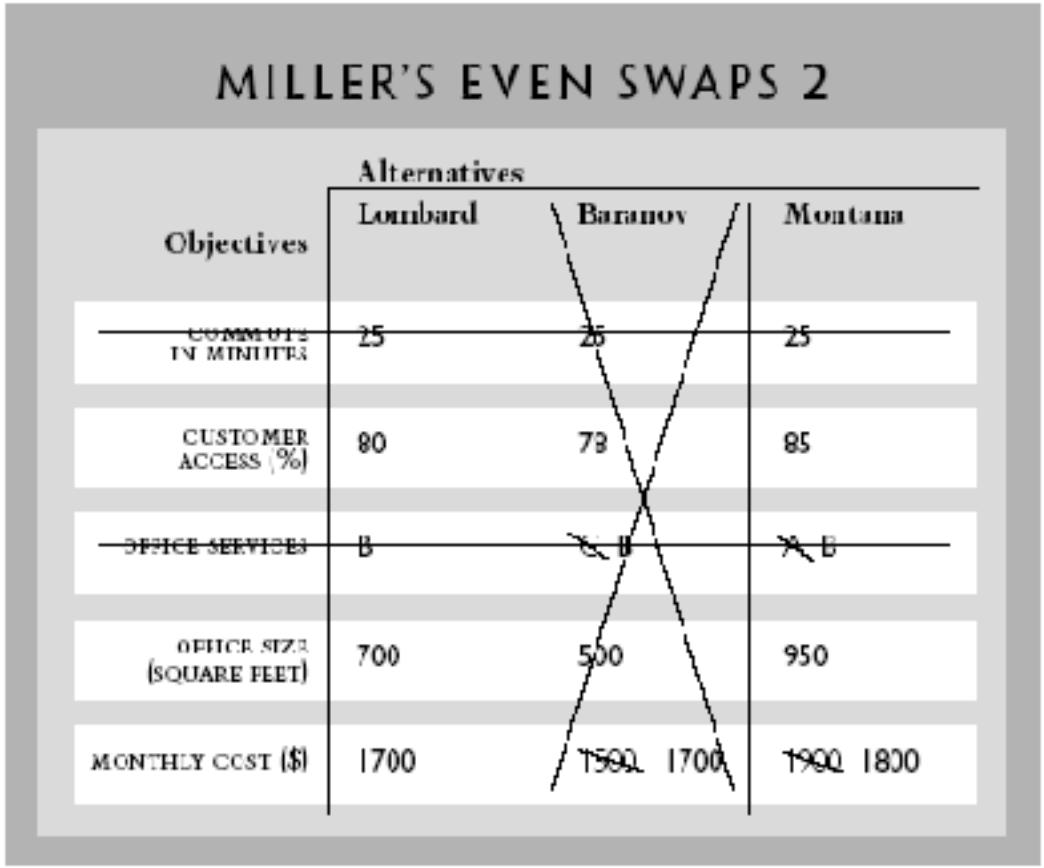
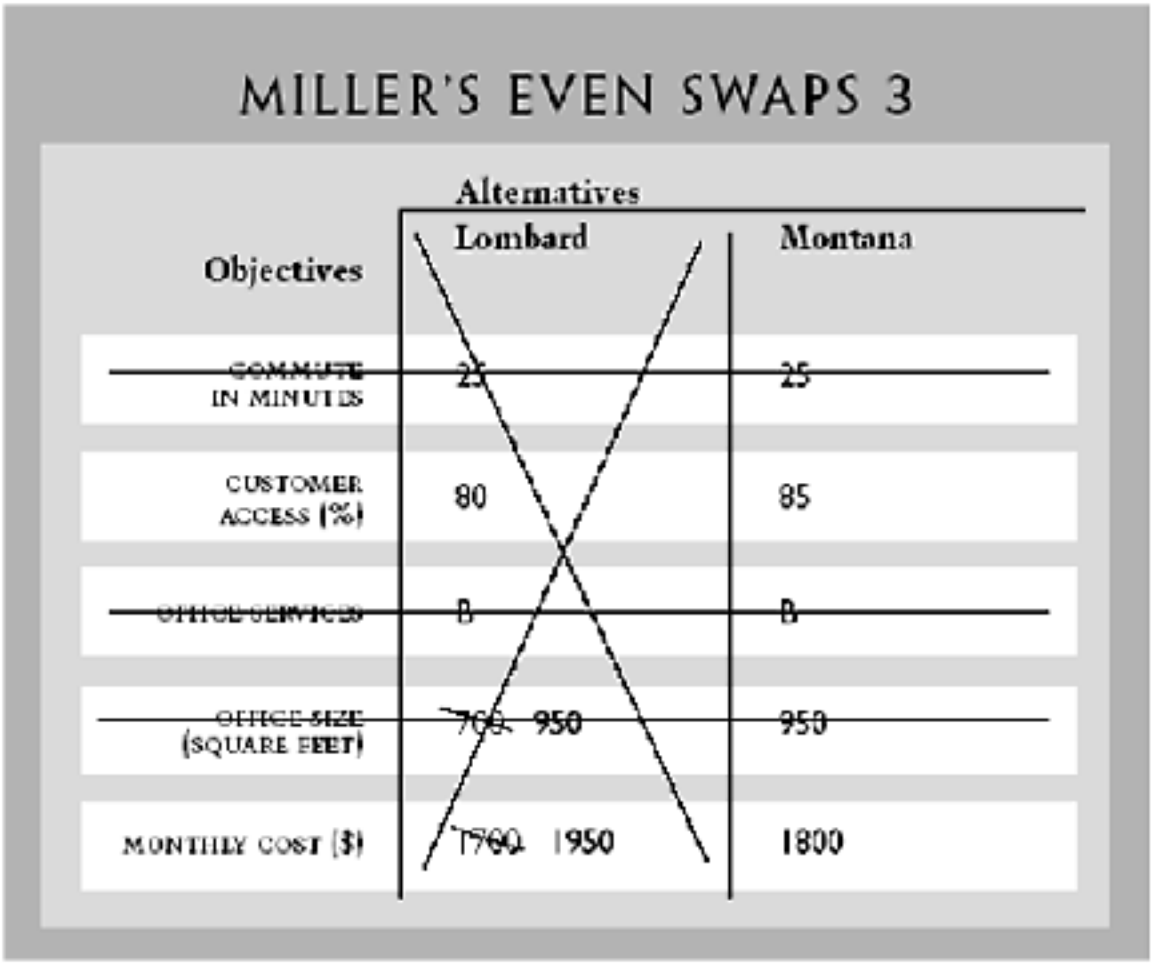
Second Even Swaps



MILLER'S EVEN SWAPS 2

Objectives	Alternatives: Lombard	Baranov	Montana
~~COMMUTE IN MINUTES~~	25	~~25~~	25
CUSTOMER ACCESS (%)	80	73	85
~~OFFICE SERVICES~~	B	~~C~~ B	~~A~~ B
OFFICE SIZE (SQUARE FEET)	700	500	950
MONTHLY COST ($)	1700	~~1500~~ 1700	~~1900~~ 1800

Final Swap



MILLER'S EVEN SWAPS 3

Objectives	Alternatives: Lombard	Alternatives: Montana
~~COMMUTE~~ IN MINUTES	~~25~~	~~25~~
CUSTOMER ACCESS (%)	80	85
~~OFFICE SERVICES~~	~~B~~	~~B~~
~~OFFICE SIZE~~ (SQUARE FEET)	~~700~~ 950	~~950~~
MONTHLY COST ($)	~~1760~~ 1950	1800

Advice for swaps

- Make the easier swaps first
- Concentrate on the amount of the swap, not on the apparent importance of the overall objective.
- Remember that the value of an incremental change depends on what you start with.
- Make consistent swaps.
- Seek out solid information.