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Even Swaps: A Rational Method for Making Trade-offs

by John S. Hammond, Ralph L. Keeney, and Howard Raiffa



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To simplify complex decisions, start by simplifying the trade-offs.



A RATIONAL METHOD FOR MAKING TRADE-OFFS

by John S. Hammond, Ralph L. Keeney, and Howard Raiffa

TOME DECISIONS ARE EASY. If you want to fly from New York to San Francisco as cheaply as possible, you simply find the airline offering the lowest fare and buy a ticket. You have only a single objective, so you need to make only a single set of comparisons. But having only one objective, as any decision maker knows, is a rare luxury. Usually, you're pursuing many different objectives simultaneously. Yes, you want a low fare, but you also want a convenient departure time, a direct flight, an aisle seat, and an airline with an outstanding safety record. And you'd like to earn frequent flyer miles in one of your existing accounts. Now the decision is considerably more complicated. You have to make trade-offs.

Making wise trade-offs is one of the most important and difficult challenges in decision making. The more alternatives you're considering and the more objectives you're pursuing, the more trade-offs you'll need to make. The sheer volume of trade-offs, though, is not what makes decision making so hard. It's the fact that each objective has its own basis of comparison. For one objective, you may compare the alternatives using precise numbers or percentages: 34%, 38%, 53%. For another objective, you may need to make broad relational judgments: high, low, medium. For another, you may use purely descriptive terms: yellow, orange, blue. You're not just trading off apples and oranges; you're trading off apples and oranges and elephants.

How do you make trade-offs when comparing such widely disparate things? In the past, decision makers have relied mostly on instinct, common sense, and guesswork. They've lacked a clear, rational, and easy-to-use trade-off methodology. To help fill that gap, we have developed a system—which we call *even swaps*—that provides a practical way of making trade-offs among any set of objec-

tives across a range of alternatives. In essence, the even-swap method is a form of bartering—it forces you to think about the value of one objective in terms of another. How many frequent flyer miles, for example, would you sacrifice for a \$50 reduction in airfare? How long would you delay your departure time to be assured an aisle seat? Once you have made such value judgments, you can make sense of the variety of different measurement systems. You have a solid, consistent basis for making sensible trade-offs.

The even-swap method will not make complex decisions easy; you'll still have to make hard choices about the values you set and the trades you make. What it does provide is a reliable mechanism for making trades and a coherent framework in which to make them. By simplifying and codifying the mechanical elements of trade-offs, the even-swap method lets you focus all your mental energy on the most im-

SAHID'S CONSEQUENCES TABLE

	Alternatives				
Objectives	Job A	Job B	Job C	Job D	Job E
monthly salary (\$)	2000	2400	1800	1900	2200
FLEXIBILITY	moderate	low	high	moderate	none
BUSINESS SKILLS DEVELOPMENT	computer	people management, computer	operations, computer	organization	time management, multitasking
ANNUAL VACATION DAYS	14	12	10	15	12
BENEFITS	health, dental, retirement	health, dental	health	health, retirement	health, dental
ENJOYMENT	great	good	good	great	boring

portant work of decision making: deciding the real value to you and your organization of different courses of action.

Creating a Consequences Table

Before you can begin making tradeoffs, you need to have a clear picture
of all your alternatives and their
consequences for each of your objectives. A good way to create that picture is to draw up a consequences
table. Using pencil and paper or a
computer spreadsheet, list your objectives down the left side of a page
and your alternatives along the top.
This will give you an empty matrix.
In each box of the matrix, write a
concise description of the consequence that the given alternative

(indicated by the column) will have for the given objective (indicated by the row). You'll likely describe some consequences in quantitative terms, using numbers, and others in qualitative terms, using words. The important thing is to use consistent terminology in describing all the consequences for a given objective; in other words, use consistent terms across each row. If you don't, you won't be able to make rational swaps between the objectives.

To illustrate what a consequences table actually looks like, let's examine one created by a young man we'll call Vincent Sahid. The only child of a widower, Vincent plans to take time off from college, where he's majoring in business, to help his father recover from a serious illness. To

John S. Hammond, a former professor at the Harvard Business School in Boston, Massachusetts, is a consultant on decision making who assists companies with negotiations and strategy development. Ralph L. Keeney is a professor of management and engineering affiliated with the Center for Telecommunications Management at the University of Southern California in Los Angeles. Howard Raiffa, a pioneer in decision and negotiation analysis, is the Frank Plumpton Ramsey Professor of Managerial Economics Emeritus at the Harvard Business School. The authors' book, Smart Choices: A Practical Guide to Making Better Decisions, will be published in October by the Harvard Business School Press.

make ends meet while away from school, he will need to take a job. He wants a position that pays adequately, has good benefits and vacation allowances, and involves enjoyable work, but he'd also like to gain some experience that will be useful when he returns to school. And, given his dad's frail condition, it is very important that the job give him the flexibility to deal with emergencies. After a lot of hard work, Vincent identifies five possible jobs. Each has very different consequences for his objectives, and he charts those consequences in a consequences table. (See "Sahid's Consequences Table.")

As we see, a consequences table puts a lot of information into a concise and orderly format that allows you to compare your alternatives easily, objective by objective. It gives you a clear framework for making trade-offs. Moreover, it imposes an important discipline, forcing you to define all alternatives, all objectives, and all relevant consequences at the outset of the decision process. Although a consequences table is not too hard to create, we're always surprised at how rarely decision makers

take the time to put down on paper all the elements of a complex decision. Without a consequences table, important information can be overlooked and trade-offs can be made haphazardly, leading to wrongheaded decisions.

Eliminating "Dominated" Alternatives

Once you've defined and mapped the consequences of each alternative, you should always look for opportunities to eliminate one or more of the alternatives. The fewer the alternatives, the fewer trade-offs you'll ultimately need to make. To identify alternatives that can be eliminated. follow this simple rule: if alternative A is better than alternative B on some objectives and no worse than B on all other objectives, B can be eliminated from consideration. In such cases, B is said to be dominated by A-it has disadvantages without any advantages.

Say you want to take a relaxing weekend getaway. You have five places in mind, and you have three objectives: low cost, good weather, and short travel time. In looking at your options, you notice that alter-

native C costs more, has worse weather, and requires the same travel time as alternative D. Alternative C is dominated by D and therefore can be eliminated.

You need not be rigid in thinking about dominance. In making further comparisons among your options, you may find, for example, that alternative E also has higher costs and worse weather than alternative D but has a slight advantage in travel time – it would take half an hour less to get to E. You may easily conclude that the relatively small time advantage doesn't outweigh the weather and cost disadvantages. For practical purposes, alternative E is dominated-we call this practical dominance-and you can eliminate it as well. By looking for dominance, you have just made your decision much simpler - you only have to choose among three alternatives, not five.

A consequences table can be a great aid in identifying dominated alternatives. But if there are many alternatives and objectives, there can be so much information in the table that it gets hard to spot dominance. Glance back at Vincent Sahid's consequences table and

you'll see what we mean. To make it easier to uncover dominance, you should create a second table in which the descriptions of consequences are replaced with simple rankings. Working row by row – that is, objective by objective – determine the consequence that best fulfills the objective and replace it with the number 1; then find the second-best consequence and replace it with the number 2; and continue in this way until you've ranked the consequences of all the alternatives. When Vincent looks at the vacation objective in his table, for example, he sees that 15 days ranks first, 14 days ranks second, the two 12 days tie for third, and 10 days ranks fifth. When he moves from the quantitatively measured objectives to the qualitatively measured ones, he finds that more thought is required because the rankings need to be based on subjective judgments rather than objective comparisons. In assessing the benefits packages, for example, he decides that dental coverage is more important to him than a retirement plan, and he makes his rankings on that basis. (See "Sahid's Ranking Table.")

SAHID'S RANKING TABLE

Alternatives					
Objectives	ob A	Job B	Job C	Job D	Job E
MONTHLY SALARY 3		I	5	4	2
flexibility 2	(tie)	4	I	2 (tie)	5
BUSINESS SKILLS DEVELOPMENT 4		I	3	5	2
ANNUAL VACATION 2		3 (tie)	5	1	3 (tie)
BENEFITS		2 (tie)	5	4	2 (tie)
enjoyment I	(tie)	3 (tie)	3 (tie)	/ (tie)	\$

Dominance is much easier to see when you're looking at simple rankings. Vincent sees that Job E is clearly dominated by Job B: it's worse on four objectives and equivalent on two. Comparing Job A and Job D, he sees that Job A is better on three objectives, tied on two, and worse on one (vacation). When an alternative has only one advantage over another, as with Job D, it is a candidate for elimination due to practical dominance. In this case, Vincent easily concludes that the one-day vacation advantage of Job D is far outweighed by its disadvantages in salary, business-skills development, and benefits. Hence, Job D is practically dominated by Job A and can also be eliminated.

Using a ranking table to eliminate dominated alternatives can save you a lot of effort. Sometimes, in fact, it can lead directly to the final decision. If all your alternatives but one are dominated, the remaining alternative is your best choice.

Making Even Swaps

Although it's possible that you'll be down to a single alternative at this point, it's far more likely that you'll still have a number of alternatives to choose from. Because none of the remaining alternatives are dominated, each will have some advantages and some disadvantages relative to each of the others. The challenge now is to make the right trade-offs between them. The even-swap method offers a way to even out the advantages and disadvantages systematically until you are left with a clear choice. (See the insert "Benjamin Franklin's 'Moral or Prudential Algebra.'"

What do we mean by even swaps? To explain the concept, we need to state an obvious but fundamental tenet of decision making: If every alternative for a given objective is rated equally—for example, if they all cost the same—you can ignore that objective in making your decision. If all airlines charge the same fare for the New York to San Francisco flight, then cost doesn't matter. Your decision will hinge on only the remaining objectives.

The even-swap method provides a way to adjust the values of different

CHARTING THE CONSEQUENCES

Alternatives				
Objectives	Franchising	Not franchising		
PROFIT (IN MILLIONS OF \$)	10	25		
market share (%)	26	21		

MAKING THE EVEN SWAP

Alternatives				
Objectives	Franchising	Not franchising		
PROFIT (IN MILLIONS OF \$)	10	25 10		
market share (%)	26	义 24		

alternatives' consequences in order to render them equivalent and thus irrelevant. As its name implies, an even swap increases the value of an alternative in terms of one objective while decreasing its value by an equivalent amount in terms of another objective. If, for example, American Airlines charged \$100 more for a New York to San Francisco flight than did Continental, you might swap a \$100 reduction in the American fare for 2,000 fewer American frequent-flyer miles. In other words, you'd "pay" 2,000 frequent flver miles for the fare cut. Now American would score the same as Continental on the cost objective, so cost would have no bearing in deciding between them. Whereas the assessment of dominance enables you to eliminate alternatives, the evenswap method allows you to eliminate objectives. As more objectives are eliminated, fewer comparisons need to be made, and the decision becomes easier.

The even-swap method can be a powerful tool in business decision making. Imagine you're running a Brazilian cola company and several other companies have expressed interest in buying franchises to bottle and sell your product. Your company currently has a 20% share of its market, and it will earn \$20 million in the fiscal year just ending. You have two key objectives for the coming year: increasing profits and expanding market share. You estimate that franchising would reduce your profits to \$10 million due to start-up costs, but it would increase your share to 26%. If you don't franchise, your profits would rise to \$25 million, but your share would increase only to 21%. You put this all down in a consequences table.

Which is the smart choice? As the table indicates, the decision boils down to whether the additional \$15 million profit from not franchising is worth more or less than the additional 5% market share you would gain from franchising. To resolve that question, you can apply the even-swap method following a straightforward process.

First, determine the change necessary to cancel out an objective. If you could cancel out the \$15 million profit advantage gained by not franchising, the decision would depend only on market share.

Second, assess what change in another objective would compensate

for the needed change. You must determine what increase in market share would compensate for the profit decrease of \$15 million. After a careful analysis of the long-term benefits of increased share, you determine that a 3% increase would make up for the lost \$15 million.

Third, make the even swap. In the consequences table, you reduce the profit of the not-franchising alternative by \$15 million while increasing its market share by 3%. The restated consequences (a \$10 million profit and a 24% market share) are equivalent in value to the original consequences (a \$25 million profit and a 21% market share). (See the tables "Charting the Consequences" and "Making the Even Swap.")

Fourth, cancel out the now-irrelevant objective. Now that the profits for the two alternatives are equivalent, profit can be eliminated as a consideration in the decision. It all boils down to market share.

Finally, select the dominant alternative. The new decision is easy. The franchising alternative, better on market share than not franchising, is the obvious choice.

For the cola company, only one even swap revealed the superior alternative. Usually, it takes more often many more. The beauty of the even-swap approach is that no matter how many alternatives and objectives you're weighing, you can methodically reduce the number of objectives you need to consider until a clear choice emerges. The method, in other words, is iterative. You keep eliminating objectives by making additional even swaps until one alternative dominates all the others or until only one objective—one basis of comparison—remains.

Simplifying a Complex Decision

Now that we've discussed each step of the process, let's apply the whole thing to a more complex business problem. 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.

After considerable thought about his business and its prospects, Alan defines five overriding objectives that he needs his office to fulfill: a short commute from home, good access to his clients, good office services (clerical assistance, copiers and fax machines, and mail service), sufficient space, and low costs. He surveys more than a dozen locations and, dismissing those that clearly fall short of his needs, he settles on five viable alternatives: Parkway, Lombard, Baranov, Montana, and his current building, the Pierpoint.

He then develops a consequences table, laying out the consequences of each alternative for each objective. He uses a different measurement system for each objective. He describes commuting time as the average time in minutes needed to travel to work during rush hour. To measure access to clients, he determines the percentage of his clients whose business is within an hour's lunchtime drive of the office. He uses a simple three-letter scale to describe the office services provided: "A" means full service, including copy and fax machines, telephone answering, and for-fee secretarial assistance; "B" indicates fax machines and telephone answering only; and "C" means that no services are available. Office size is measured in square feet, and cost is measured by monthly rent. (See "Miller's Consequences Table.")

With so many alternatives to compare, Alan immediately seeks to eliminate some by using dominance

MILLER'S CONSEQUENCES TABLE

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

Alternatives					
Objectives	Parkway	Lombard	Baranov	Montana	Pierpoint
COMMUTE	5	2 (tie)	I	2 (tie)	4
CUSTOMER ACCESS	5	2	4	ı	3
OFFICE SERVICES	I (tie)	3	4 (tie)	l (tie)	4 (tie)
OFFICE SIZE	2	3 (tie)	5	I	3 (tie)
MONTHLY COST	A	2	I	5	3

or practical dominance. To make that easier, he uses the descriptions in the consequences table to create a ranking table. (See "Miller's Ranking Table.")

Scanning the columns, he quickly sees that the Lombard office dominates the current Pierpoint site, outranking it on four objectives and tying it on the fifth. He eliminates Pierpoint from further consideration. He also sees that Montana almost dominates Parkway, falling behind in cost only. Can he eliminate Parkway, too? He flips back to his original consequences table and notices that for the small cost disadvantage of Montana - only \$50 per month - he would gain an additional 150 square feet, a much shorter commute, and much better access to clients. He eliminates Parkway using practical dominance.

Alan has reduced his choice to three alternatives – Lombard, Baranov, and Montana – none of which dominates any other. He redraws his consequences table.

To clarify his choice further, Alan needs to make a series of even swaps. In scanning the table, he sees considerable similarity in the commuting times for the three remaining alternatives. If the Baranov's 20-minute commute were increased to

25 minutes using an even swap, the commuting time of all three alternatives would be equivalent, and that objective could be dropped from further consideration. Alan decides that this 5-minute increase in Baranov's commuting time can be compensated for by an 8% increase in Baranov's client access, from 70% to 78%. He makes the swap, render-

ing commuting time irrelevant in his deliberations. (See the table "Miller's Even Swaps 1.")

Alan then eliminates the office services objective by making two even swaps with monthly cost. Using the Lombard service level (B) as a standard, he equates an increase in the level of service from C to B for Baranov with a \$200 increase in

MILLER'S EVEN SWAPS 1

Alternatives				
Objectives	Lombard	Baranov	Montana	
COMMUTE IN MINUTES	25	2 Q 25	25	
CUSTOMER ACCESS (%)	80	7Q 78	85	
OFFICE SERVICES	В	С	Α	
OFFICE SIZE (SQUARE FEET)	700	500	950	
MONTHLY COST (\$)	1700	1500	1900	

monthly costs. He also equates a decrease in the level of service from A to B for Montana with a savings of \$100 per month.

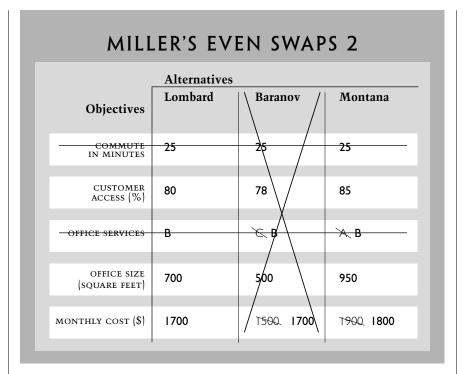
Each time Alan makes an even swap, he changes the way the alternatives match up. Having eliminated the office services objective, he finds that the Baranov alternative is now dominated by the Lombard alternative and can be eliminated. That move highlights an important process consideration. In making even swaps, you should always seek to create dominance where it didn't exist before, thus enabling you to eliminate an alternative. In your decision process, you will want to keep switching back and forth between examining your columns (alternatives) and your rows (objectives), between assessing dominance and making even swaps. (See the table "Miller's Even Swaps 2.")

With Baranov out of the picture, only the Lombard and Montana alternatives remain. They have equivalent scores in commuting time and services, leaving only three objectives to consider. Alan next makes an even swap between office size and monthly cost. Deciding that the 700-square-foot Lombard office will be cramped, he equates Montana's additional 250 square feet with a substantial cost increase - \$250 per month. That swap cancels the office-size objective, revealing Montana to be the preferred alternative, with advantages in both the remaining objectives - cost and access to clients. Montana now dominates Lombard. (See the table "Miller's Even Swaps 3.")

Alan signs the lease for space at Montana, confident that he has thought through the decision carefully, considered every alternative and objective, and made the right choice in the end.

The Art of the Swap

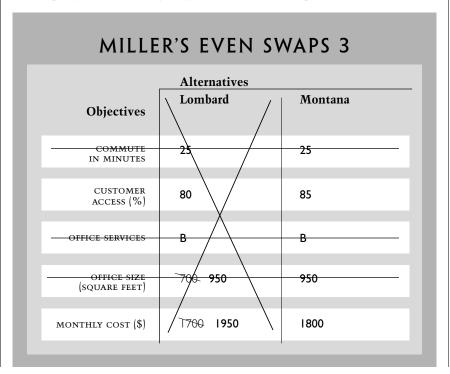
Once you get the hang of it, the mechanical part of the even-swap method becomes easy, almost a game. Determining the relative value of different consequences—the essence of any trade-off process—is the hard part. By design, the even-swap approach allows you to con-



centrate on the value determinations one at a time, giving each careful thought. While there's no easy recipe for deciding how much of one consequence to swap for some amount of another consequence – every swap is unique, requiring subjective judgment—you can help ensure that your trade-offs are sound by keeping the following sugges-

tions in mind as you go through the process.

Make the easier swaps first. Determining the value of some consequences will be more difficult than determining the value of others. In choosing among airlines, for example, you may be able to calculate, in fairly precise terms, the monetary value of frequent flyer miles. After



BENJAMIN FRANKLIN'S "MORAL OR PRUDENTIAL ALGEBRA"

People have always struggled with the difficulties of making trade-offs. More than 200 years ago, Ben Franklin outlined his approach to the challenge in a letter to the noted scientist Joseph Priestly, who was trying to choose between two alternatives.

London Sept. 19, 1772

Dear Sir,

In the affair of so much importance to you, wherein you ask my advice, I cannot, for want of sufficient premises, advise you *what* to determine, but if you please I will tell you *how*.

When those difficult cases occur, they are difficult, chiefly because while we have them under consideration, all the reasons *pro* and *con* are not present to the mind at the same time; but sometimes one set present themselves, and at other times another, the first being out of sight. Hence the various purposes or inclinations alternatively prevail, and the uncertainty that perplexes us.

To get over this, my way is to divide half a sheet of paper by a line into two columns; writing over the one *Pro*, and over the other *Con*. Then, during three or four days consideration, I put down under the different heads short hints of the different motives, that at different times occur to me, *for* or *against* the measure.

When I have thus got them all together in one view, I endeavor to estimate their respective weights; and where I find two, one on each side, that seem equal, I strike them both out. If I find a reason *pro* equal to two reasons *con*, I strike out the three. If I judge some two reasons *con*, equal to some three reasons *pro*, I strike out the five; and thus proceeding I find at length where the balance lies; and if, after a day or two of further consideration, nothing new that is of importance occurs on either side, I come to a determination accordingly.

And, though the weight of reasons cannot be taken with the precision of algebraic quantities, yet, when each is thus considered, separately and comparatively, and the whole lies before me, I think I can judge better, and am less liable to make a rash step; and in fact I have found great advantage from this kind of equation, in what may be called *moral or prudential algebra*.

Wishing sincerely that you may determine for the best, I am ever, my dear friend, yours most affectionately,

B. Franklin

Franklin proposed a wonderful way of using trade-offs to simplify complexity. Each time he eliminated an item from his list of pros and cons, he replaced his original problem with an equivalent but simpler one, ultimately arriving at a clear choice.

Franklin's approach assumes that equivalences—balanced pros and cons—will exist, when in fact they may not. The even-swap approach, by requiring the decision maker to list his or her objectives explicitly and by providing a mechanism for creating equivalence among them, overcomes that flaw. As a result, the approach is applicable to all decisions, not just a few.

all, you know how many miles it would take to earn a free flight. Swapping fares and miles will therefore be a straightforward process. Swapping safety records and flight departure times, however, will be much less clear-cut. In that case, you should make the swap between fares and miles – the easier swap – first. Often you will be able to reach a decision (or at least eliminate some alternatives) just by making the easy swaps, and you won't have to wrestle with the hard ones at all.

Concentrate on the amount of the swap, not on the apparent importance of the overall objective. It doesn't make sense to say that one objective is more important than another without considering the actual degree of variation among the consequences of the alternatives under consideration. Is salary more important than vacation? It depends. If the salaries of all the jobs are similar but their vacation times vary widely, the vacation objective may be more important than the salary objective.

Concentrating on an objective's overall importance can get in the way of making wise trade-offs. Consider the debate that might go on in a town trying to decide whether public library hours should be cut to save money. The library advocate declares, "Preserving current library hours is much more important than cutting costs!" The fiscal watchdog counters, "No, we absolutely have to cut our budget deficit! Saving money is more important." If the two sides focused on the actual amounts of time and money in question, they might find it easy to reach an agreement. If cutting two hours one morning a week saves \$250,000 annually, the library advocate might agree that the harm to the library would be small compared with the amount saved, especially considering other possible uses for the money. If, instead, the savings were a mere \$25,000 annually, even the fiscal watchdog might agree that the harm to the library wouldn't be worth the savings. The point is this: when you make even swaps, concentrate not on the importance of the objectives but on the importance of the amounts in question.

Remember that the value of an incremental change depends on what you start with. When you swap a piece of a larger whole - for example, a portion of an office's square footage-you need to think of its value in terms of the whole. For example, adding 300 square feet to a 700square-foot office may make the difference between being cramped and being comfortable, whereas adding 300 square feet to a spacious 1,000square-foot office may not be nearly as valuable to you. The value of the 300 square feet, like the value of anything being swapped, is relative to what you start with. It's not enough to look only at the size of the slice; you also need to look at the size of the pie.

Make consistent swaps. Although the value of what you swap will be relative, the swaps themselves should be logically consistent. If you would swap A for B and B for C, you should be willing to swap A for C. Let's say you're leading an environmental protection program charged with preserving the wilderness and expanding salmon-spawning habitats for as low a cost as possible. In a cost-benefit analysis, you might calculate that one square mile of wilderness and two miles of spawning habitat along a river both have values equivalent to \$400,000. In making your swaps, you should therefore equate one square mile of wilderness with two miles of the river. From time to time, check your swaps for consistency.

Seek out solid information. Swaps between consequences require subjective judgments, but those judgments can be buttressed by solid information and analysis. In making trade-offs involving spawning habitat, for example, you might ask a fish biologist to provide information about how many salmon would use a mile of newly created habitat, how many eggs might eventually hatch,

how many fish would survive to swim downstream, and how many would return to spawn in the river years later. Whether a mile of new spawning habitat would result in an increase in

the annual salmon run of 20 or 2,000 adult salmon will likely make a big difference in the value you assign to that habitat.

For some decisions, you yourself will be the source of much of the relevant information. If you are trading off vacation time and salary in choosing among job offers, for example, only you can know how you would spend to days versus 20 days of vacation and the value of that difference to you. You should be as rigorous in thinking through your own subjective inputs as you are in assessing objective data from outside sources. No matter how subjective a trade-off, you never want to be guided by whim - you must think carefully about the value of each consequence to you.

Our final and perhaps most impor-

tant bit of advice is an old adage: Practice makes perfect. Like any new approach to an old problem, the even-swap method will take some getting used to. The first few times you make swaps, you may struggle with the overall process as well as with each assessment of value. Fortunately, the process itself is relatively simple, and it always works the same way. Once you get the hang

The process helps you zero in on the real sources of value to your company.

of it, you'll never have to think about it again. Deciding on appropriate swaps, however, will never be easy – each swap will require careful judgment. As you gain experience, though, you'll also gain understanding. You'll become more and more skilled at zeroing in on the real sources of value to you and your company. You'll know what's important and what's not. Perhaps the greatest benefit of the even-swap method is that it forces you to think through the value of every trade-off in a rational, measured way. In the end, that's the secret of making smart choices.

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