# TOWARD A BETTER UNDERSTANDING OF ROI

R·D·S
RECOVERY DECISION SCIENCE

## INTRODUCTION

**What good is talking about return on investment, ROI, without knowing what to measure?** Even the best analysts can easily get lost in the numbers and variables and unintentionally reach outcomes that are untrue or inaccurate. In this paper, we will introduce a handful of general guidelines to help you both define and measure this often-elusive phenomenon we call ***success***. Combining these practices will help avoid misguided results and reach higher success.

In the back of our minds, we all have utilities assigned to the options we face. With these utilities, we usually make our decisions with a subconscious cost and benefit analysis. In the business world, the same approach occurs. Here, however, goals, assumptions, and utility functions should be well defined.

Simply put, a well-defined decision-making process gives employees the confidence that management knows what it's doing. Establishing a body of measurements and rules, along with decision protocols, results in increased performance, focused outcomes, and consistency. Perhaps more importantly, poor decisions are less frequent and even measurable if the system is set up appropriately. Spending the time to build, maintain, and implement this system benefits and supports all facets of a business organization.

## SECTION I
## MEASURE THE RIGHT THING

A good place to begin is by looking at future cash flow and how it plays a role in the decision-making process. To that end, let's define four financial measures that all deal with such cash flows.

**NET PRESENT VALUE (NPV)** Following the concept of time value of money, NPV represents the aggregate value of all future cash flows calculated as today's dollars. Time value of money says that \$100 today is worth more than \$100 tomorrow or a week from now. So, the NPV of \$100 a week from now is something less than \$100 today. In order to calculate NPV, we need to know the discount rate in the market i.e. the interest rate that dictates the time value of money. This rate is also called the opportunity cost of capital. For example, if annual interest rate is 10%, then the NPV of a \$110 in a year from now is \$100. Here's the calculation:

**\$110 a year from now is equal to \$100 today plus the accumulated interest for a year, in this case 10%. Therefore \$110 a year from now is the equilavlent of \$100 today.**

Given the same assumption, if you want to choose between two projects whose payoffs are respectively \$105 today and \$110 a year from now, looking at their NPVs, you would be better off choosing the first project as NPV of \$105 today > NPV of \$110 a year from now = \$100 today.

We could also extrapolate the notion of NPV to things other than currency. For instance, to a fisherman, NPV is calculating the value of the fish caught over time, but based on what they are worth today, i.e. a fish caught today is worth more than a fish that has not been caught yet. The longer he has to wait, the less valuable it becomes. **This also illustrates the concept of risk, because we are not certain we will catch a fish.** We can only estimate this based on our past experience of how successful we have been catching fish.

**RETURN ON INVESTMENT (ROI)** There are two types of ROI: simple ROI and discounted ROI. Simple ROI is basically the ratio of net profit to net cost or investment. As you might have guessed already simple ROI does not account for time value of money. This is where discounted ROI becomes important. If we calculate the NPV of our investments for a typical project and compare that with the NPV of our payoffs for that project, we could calculate the return on our investments in present terms (i.e. discounted ROI. Basically, discounted ROI is 100 x NPV (Payoffs)/NPV (Investments). A manager could face two different investment opportunities in an occasion: investing \$45 today in order to receive \$110 two years from now vs. investing \$40 today in order to receive \$100 a year from now. Given the 10% discount rate, the NPV of gains from the two projects is the same and equal to \$90.91. However, the value added of the second project should be higher as the amount of investment is lower for that. Hence, the discounted ROI for the first project is (90.91-45)/45 = 102%, and that for the second project is (90.91-40)/40 = 127%. Clearly, the second project is the better option to choose. Note that NPV and discounted ROI are two sides of the same coin when it comes to decision making. They are both referring to the profitability of projects (i.e. how much money could we extract from each currency unit of our investment). In fact, when it comes to using discounted ROI as a measure to calculate profitability, when the NPV of investments are the same, we only have to compare the NPV of gains from the projects of interest.

Returning to our fisherman example, ROI is calculating the value of all of the fish vs. the cost of the fishing pole, the bait and the fishing permit.

**PROFITABILITY INDEX (PI)** Looking at the definition of PI, we would see that PI and discounted ROI essentially contain the same amount of information. Profitability index is the present value of cash inflow divided by the present value of cash outflow, which accounts for the time value of money for each. In other words:

**PI = Discounted ROI/100 + 1**

PI is useful for ranking projects based on the cost and benefit of each project. It is a ratio of the benefit vs. the cost. A profitability index of 1.0, which is discounted ROI of zero, is therefore the equilibrium point for making enough money on a present value basis to cover the cost of the project. The higher the profitability index, there is more present value cash vs. the cost of the project.

When working on complex projects with past and future cash flows, it is not suggested to use the simple ROI at all since it does not account for the time value of money. Thus, PI and discounted ROI are preferred to simple ROI. Thus, in summary we can compare the profitability Index vs. ROI as follows:

- Simple ROI does not take into account the time value of money. An investment with a 90% return looks much better than an investment with a 10% return. However, what if it took 20 years to get a 90% return vs. 1 year to get a 10% return? In this case the simple ROI is too simple a measure to make a comparison.
- ROI subtracts costs and multiplies by 100 to turn it into a "rate". The profitability index does not subtract the costs in the numerator and does not multiply by 100 so represents an index over the cost. There a 1.0 becomes a 100% ROI, because costs have been subtracted.
- If you spent $100 and recovered it a year later then the simple ROI would be 0%. In contrast, the profitability index might be 0.9, showing that you did not get your money back. This is due to the time value of money.
- Profitability index measures the present value of the fish (similar to the NPV), but divides it by the cost. If greater than 1.0 then you caught enough fish to pay for the fishing pole, the bait and the fishing permit.

**INTERNAL RATE OF RETURN (IRR)** Unlike the two previous measures that calculate profitability, IRR calculates *efficiency*. Imagine you calculate the NPV of the gains in a project for a range of interest rates as well as that of the expenses (investments) for the same range. The interest rate that sets those two NPV values equal is IRR. When you compare two projects using IRR, the one with higher IRR is the more efficient one. For instance, if you invest $100 today and gain $110 in a year from now, the interest rate that set the NPV of $110 a year from now equal to $100 (NPV of your investment) is 10%. Hence, the IRR in that case is 10%. Now, if we had a second project that requires $1,000 worth of initial investment to gain $1,050 in a year after the investment, then the IRR will be 5%. In case of having a 2% discount rate in the market, the NPV of the first project's gain is $107.84, and that for the second one is $1,029.41. Thus, the second project is more profitable than the first one as $1,029.41-$1,000 > $107.84-$100. However, the first project is more efficient (i.e. if we could invest $1,000 in the first project with the same IRR, then having the same amount of initial investment as the second project and being more efficient make the first project even more profitable). Back to our fisherman example, IRR is the measure of speed, i.e. how fast we are catching fish measuring the growth rate of our pile of fish.

**IRR: NPV (x, Investments) = NPV (x, Returns); solve for x**

The three measures mentioned above are examples of choosing the right measure to assess success or weigh your options in decision making process. Is your success dependent on the amount of profit you gain (NPV) or on how fast you could gain the first dollar from your investment (IRR)? The answer to that question will lead you to the right measure. They both could be applicable to any business or industry. Sometimes, for a manager short term gains and value creation are important and the focus; like situations where that manager needs fast cash flow come in to the business. That is a place to use IRR to weigh your options. On the hand, you might want to choose among different options, but there is no immediate need for cash in hand. So, you could freely invest your money in the project that would give you the highest amount of profit. Then, you should look at the NPVs of your options.


SECTION II

## HOW TO PICK THE RIGHT MEASURING TOOLS

Imagine you are given the task to measure the length of the street you live on, and you are only allowed to use either a tape measure or a school ruler. Which one would be your choice? We know that we have higher precision using the school ruler (let's assume that precision for the school ruler is ±0.01" versus ±1" for the tape measure). But, does that mean the school ruler is the right choice?

Some simple math could give us the answer. A normal school ruler is 12 inches while a typical tape measure is 300 ft. So, if your street is about a mile, you have to use the full length of tape measure about 18 times. However, in case of using the school ruler that number rises to 5,280 times. You might think that the point is: "it is definitely faster and more convenient to use the tape measure and that is why we should choose the tape measure over the school ruler." But, what if speed was not an issue?

An analogy of that in today's analytics world is that computers are so fast that it really does not matter if you choose "school ruler" over "tape measure". Nevertheless, we should not forget that, overall, the street is long enough that the tape measure would give us an even more accurate estimate of the street length than the school ruler.

**Total Error Using the Tape Measure = 18 x (±1″) = ±18**

**Total Error Using the School Ruler = 5,280 x (±0.01″) = ±52.8**

We see that not only using the tape measure is faster, but will also give us more accurate results. However, if the length of your street was about one hundredth of a mile, then the school ruler would have given you more accurate results. Yet, you still might spend a lot of time and end up with major backache just for the sake of slightly more accuracy in measuring a length that could be measured using a tape measure only once.

That is why analysts should pick their choice of aggregation level of observations used in their models based on the *final accuracy level* that they expect from those models, not on the accuracy level that they gain from the choice of their observations, e.g. your weekly forecast is less volatile than your daily forecast.

***NOTES:***

- In the example presented in the post, the measurement error is the combination of tool accuracy (we don't have tape measures or rulers that have tick marks for every possible granular unit) and user error. However, for the sake of simplicity let's assume that user error is ZERO here. Either way we have two devices which give us ±0.01″ and ±1″ of error in each measurement they are used.
- Now, if we have to measure something that is 6″ which is less than the length of both devices, we still will end up with the same amount of error we get in a full measurement. That is why when we divide the length of the street by the length of the devices, we have to ROUNDUP that number to get the number of measurements.
- A full mile is 5280 ft. So, 1.88% of the full mile has a length of 99.264 ft, which requires 100 times of measurement using the ruler and one measurement using the tape measure. That is our break-even point between the two devices when it comes to total error.


SECTION III

## MAKING THE RIGHT INTERPRETATION

It has been said that math is the language of the universe. Or, that the universe talks to us through numbers! Either way, before understanding any language we should first learn the basics and rules in that language.

### RELATIVE VS. ABSOLUTE NUMBERS

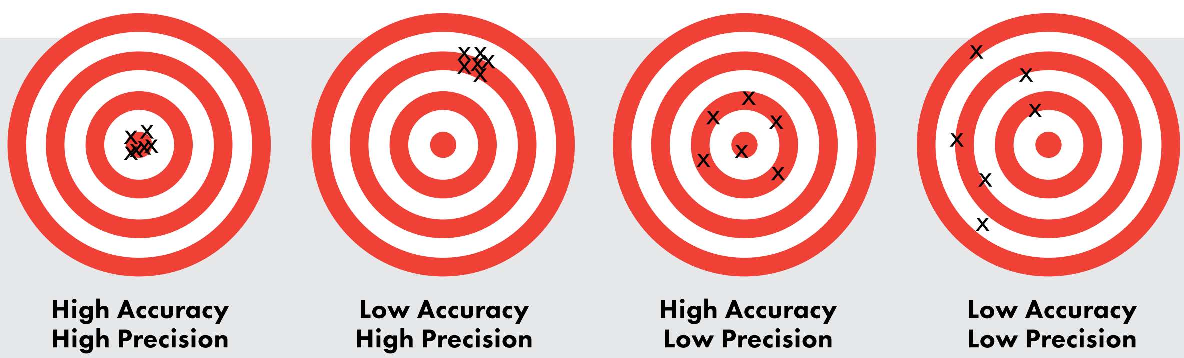
Like any language that defines words and concepts relative to the other words and concepts, the language of the universe is relative too. Basically, relativity brings more information than absolute cases. Think about the number ***two***. Well, "two apples" has more information than just "2"! Also, "two apples today and one apple yesterday" has more information than just "two," or "two apples today." Using the correct level of relativity based on problems we are working with is essential to measuring success. A simple example of that is using rates rather than absolute numbers. For instance, if you are looking at the results of your marketing campaign by state in the U.S., it is best to use ***rates of successful hits*** rather than absolute number of hits. If your campaign was homogenously implemented across the U.S., we'd expect the absolute number of successful hits to be higher in densely populated states versus the others. However, that does not really point you to the states with the best campaign outcome. In order to measure that, you need to divide your successful hits in each state by the population of that state (more correctly, campaign target population in that state). That measure represents the ***relative performance*** of your campaign by state more accurately than the case of using absolute numbers.

### CAUSE AND EFFECT ANALYSIS VS. JUST NUMBERS AND STATS

The field of statistics was initially developed to help us understand and explain physical phenomena around us. For instance, at some point in the past, scientists dropped a ball 100 times off a roof of a building and measured the time of the free falls before impact. Then, using the stats (times) they measured and the constant height of the building they could estimate the gravity force, e.g. Long before that, Newton had discovered that Earth has a gravitational force after the apple struck his head! Scientists only have to model the problem based on Newton's finding and estimate the gravitational force in that model by using the stats they measured. Unfortunately, because of data mining techniques and faster computing time, this process is not exactly happening today. The speed of computers to compute and find correlations between variables has lured us away from the physical relations behind a process, or in other words cause and effect analysis. As an example, you might find a correlation between the number of bathrooms in a property and whether that property was foreclosed or not. But, in fact, the number of bathrooms has nothing to do with the foreclosure outcome. If you'd like to see more examples of spurious correlations, check out this site: examples: http://www.tylervigen.com/.

### ACCURACY VS. PRECISION

If you believe that a picture is worth a thousand words, then look at the graph below, which depicts the difference between accuracy and precision.




*Courtesy of http://climatica.org.uk/climate-science-information/uncertainty*

Any statistical analysis tries to estimate a parameter. Two attributes of our estimates are ***accuracy and precision***. When the average value of our estimates is landing around the TRUE value of the parameter (bull's eye), we can say that we have an accurate estimate. On the other hand, precision tells us how dispersed our estimates are from each other. Obviously, a model with low accuracy and low precision is not reliable at all. On the other end of the extreme, a model with high accuracy and high precision is what we are all looking for. But, how about the cases in the middle? Well, a model with high accuracy and low precision is not robust as it only could give you reliable information about the mean (average value) of the parameter of the interest. However, on the other hand, the low accuracy and high precision model is much better. It is just biased (i.e. the mean of the estimates is systematically different from the TRUE value of the parameter). Once the bias is discovered, you can correct your model by incorporating the bias and basically convert your model to a high accuracy and high precision model.

Precision basically shows how specific your estimates are. Looking at the area covered by the hits on the target boards in the left two pictures, we can see the X's are more specific than those in the right two pictures. The lack of attention to specificity of your model is easier to identify when we try to model categorical variables.

For instance, imagine that we have a binary outcome variable like consumers defaulting on loans. Let's say you own a company that offers loans to consumers. You can borrow money at a 4% interest rate, and can loan it out at a 7% interest rate. Let's also assume that in any random population, 5% of people will default on their loans. Now let's consider two models we might use in deciding whether to offer loans:

- **Model 1:** Pull a credit bureau report, and assume everyone whose FICO score is below 600 is likely to default
- **Model 2:** Assume everyone will pay back his or her loan

Model 1 will not perfectly predict which consumers will default. Let's say it is only 80% accurate – it finds 80% of the defaulters, and lets 20% of defaulters through. Your company will net 3% in interest, and lose 1% to defaults, leaving you with a 2% profit margin.

Model 2 assumes everyone will pay back the loan. Since we know the default rate is 5%, this model is 95% accurate! But your company nets 3% in interest, and will lose 5% to defaults, leaving you under water by 2%.

In this case, Model 2 is much more accurate, but it's not solving your problem. Model 1 may be less accurate, but it's much more useful once you run the cost and benefit analysis. So the moral of the story is: do not let 95% accurate models fool you!

SECTION IV

## SEEK HARMONY AMONG THE MEASURES

Constantly remember your goal. Even redefine it if necessary. If we do not know our destination, then all measurements that are supposed to get us there will be useless.

A business analyst definitely should be familiar with the domain of the business they work at in order to choose success measures that are consistent with the goal and vision of that business. For instance, in the manufacturing industry, the goal is to manufacture what the market is buying. The more of those products getting out of factory's gate, the more successful that factory is. Also, a successful factory is always after efficiency. So, a typical plant manager may introduce several KPIs (key performance indicators) for the workshops and assembly line in his factory to acquire and maintain desirable efficiency levels. But, he should be aware that all those workshops are part of a bigger body, which is the factory, a body that has inflow of raw material and outflow of its product. So, at the end of the day, the efficient factory is what he should be looking for, not efficient individual workshops. Basically, in terms of mathematics, if you go for efficiency at the workshop level, then you are finding local optimums. But, if you seek efficiency at the factory level, you are finding the global optimum.

What should be important for the plant manager are the macro picture and the global optimum. At the global optimum level, the factory is supposed to have the fastest flow from input point to the output point, and to keep the inventory levels as low as possible.

For instance, workshop A is set for producing parts for product Alpha. But, today's market demand is product Beta. And there might not be an order for Alpha within a month. Although setting up workshop A for producing Beta will cost time and money, that is more efficient than making Alpha units for possible sale one month in the future. Finishing some more Alpha units instead of immediately changing to Beta set up has more efficiency at the workshop level, but at the same time causes more Beta work in process inventory sitting before workshop A and adds incremental inventory costs. Besides, it will add opportunity cost by not selling Beta units in the market in time. In order to achieve such efficiency, fluctuations in each part of production should be measured to assess the global fluctuation at the plant. Moreover, the bottlenecks should be identified, as those are the points in the manufacturing process that have the largest effect on the process flow. Those measures will help management assign confident inventory levels before each workshop in order to maintain the desired global flow in the factory.


SECTION V

## TAILORING THE REPORT FOR THE AUDIENCE

As we discussed at the beginning of this paper, all the measurements are designed to give us insights about how we are doing compared to our goal; insights that can give us a more accurate picture of our business. Reporting is the phase during which the mined insights are communicated to key stakeholders within the organization. Hence, analysts should recognize the interests and motivations of the different audiences to whom their reports will be sent. Thus, both the language and format of the report should be tailored specifically for those audiences.

For instance, in a business, let's say our analysis reveals that 82.5% of consumers are coming from two specific demographics. Depending on for whom the report is being prepared, you may choose to position your insights a little differently.

- The best way to report that insight to the CEO might be to say: ***4 out of 5 consumers are from these two demographics***. The CEO needs a simple, top line report that offers an overview of the insights gained during analysis.
- On the other hand, the marketing team requires a different perspective on the success metrics. You may need to provide a more detailed breakdown of the two demographic groups, with specific suggestions as to the reasons why each contributed to the results. Such demographic insights are valuable to assist in more accurate planning for future efforts.

The key is to ensure that the final report provides a clear, succinct interpretation of the analysis, one that is relevant and actionable for the specific audience for whom the report is intended.

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