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Understanding Risk: Systematic versus Idiosyncratic

Risk is a central concept in finance. Finance theory asserts that the more risk investors bear, the more expected return investors will require. This risk-return relation is fundamental to everything in finance. As such, it is critical to understand what risk is and how to think about it.

This note explores different metrics for risk and related considerations for investors. The note considers measures of volatility, including the difference between systematic risk and idiosyncratic risk, and how diversification reduces idiosyncratic risk. It uses these concepts to motivate the foundations of portfolio risk assessment by rational investors and the theory of the associated risk premium.

As context for this introduction, we consider the situation of Daniel and Julian Kasongo, two brothers facing the challenge of managing a commodity business in central Africa.

The Kasongo Brothers

Three years ago, Daniel and Julian Kasongo made the professional pivot of their lifetimes when they sold their family business in the Congolese capital city of Kinshasa. With the proceeds from the sale, and lured by the investment achievements of their two sisters, the brothers purchased separate mining rights in the eastern part of the Democratic Republic of the Congo (DRC). In the ensuing time, Daniel developed the Boule de Neige cobalt mine, and Julian developed a neighboring copper mining operation called Ours Polaire. While they owned and operated their mines independently, they shared the dream of developing a viable small-scale artisanal mining operation that was community-minded and met family financial needs.

Both brothers had begun to appreciate the volatility of mining profits. While some months brought in great profits, others brought large losses or just broke even. Business revenue, costs, and output were all highly unpredictable. **Table 1** provides a monthly history of the profits for the two mining operations over the past two years of operation. The US dollar was commonly used in the DRC, so the business profits were reported in US dollars. The first month of operation (January, year 1) had gone well, with both brothers pulling in more than $1,000. Then in February, Boule de Neige lost over $1,500, while Ours Polaire brought in more than $1,500. But fortunes quickly reversed in March, with Boule de Neige up over $2,500, while Ours Polaire's profits were negative, and then really negative in April. Overall, Boule de Neige had positive profits of nearly $7,000 in year 1 but was in the negative in year 2. Ours Polaire lost $1,364 in year 1, but made over $4,000 in year 2.

The business volatility bothered both Daniel and Julian, and it caused them to begin to restrict further investment: independently, they each increased their hurdle rates (the hurdle rate was the investment return they required to approve capital investment). When they discussed these decisions, they agreed that they both

felt the need to preserve their capital and were uncomfortable deploying additional resources in such risky ventures. Limiting investment seemed like the right thing to do.

Table 1. Operating profits to date for Boule de Neige and Ours Polaire (in US dollars).

	---------- Year 1 ----------		---------- Year 2 ----------	
	Boule de Neige	**Ours Polaire**	**Boule de Neige**	**Ours Polaire**
January	2,127	1,337	(980)	(1,236)
February	(1,354)	1,542	(276)	922
March	2,594	(509)	(1,281)	(1,034)
April	1,561	(2,067)	(1,357)	1,099
May	2,909	1,475	(1,016)	1,194
June	(1,780)	614	1,936	(3,757)
July	1,359	(1,915)	(1,184)	605
August	284	1,007	648	3,181
September	(545)	1,833	2,046	1,974
October	620	(1,446)	470	(324)
November	(2,297)	(3,196)	(1,227)	(515)
December	1,416	(38)	1,973	2,301
Total	6,893	(1,364)	(248)	4,411

Source: Created by author.

Their sisters, Lilian and Madeleine, saw it otherwise. Over a joint dinner one evening, the subject of investment risk became the center of conversation. While Daniel and Julian were bemoaning their desires to grow their mines, while acknowledging their inability to stomach the monthly booms and busts in business profits, Lilian interrupted the rant with the question, "Have you thought through the source of your business risk?" The brothers were silent, so she continued, "Can you go through the main factors that contribute to your business volatility?"

Julian was quick to answer, "Of course. Our mining costs are actually fairly predictable, so our volatility in costs is driven mainly by transportation costs. Our transportation costs change constantly with substantial fuel price and transportation supply variation. Our revenue is volatile, driven by the variation in the market price of metal and the richness of the veins we discover. Lastly, there are plenty of other random things that happen. I had a front loader break down last week and Daniel's foreman had to move for family reasons. Then of course there is occasional pirating of our shipments. You never really know if your shipment will make it to market. Daniel lost two loads last month, but I got lucky."

"Daniel, do you agree with Julian's assessment?" queried Madeleine.

"Yes, that's pretty much it," agreed Daniel.

"Good. It seems like we could categorize your business risk into two types: systematic and idiosyncratic," continued Madeleine.

"Huh?" replied Daniel and Julian in unison.

"Ok, we're trying to understand how much of your risk is common to both of you and how much is independent. We'll go through each source of risk and classify them one by one," answered Lilian. "Let's start with an easy one. Is the monthly variation in the richness of the vein you are working each month common across the two mines?"

"No," replied Julian. "The richness of the veins is totally independent. Sometimes I am lucky with a rich vein I'm working and sometimes Daniel is lucky. It just is what it is."

"Good. We'll call vein richness uncertainty an *idiosyncratic risk* then. That's a fancy work for distinctive or independent. Let's keep going. How about transportation cost?"

"I think the variation in transportation costs are pretty common," interjected Daniel. "If the price of transportation is high due to fuel price effects or driver supply concerns, it is high for both of us; and same situation if it's low. Transportation cost variation is a macro thing."

"Very good," continued Madeleine. "We'll classify transportation costs as *systematic risk*, meaning that variation in that factor is common across both of your mines. Variation in transportation cost affects both of your mines. How about the market price of metal?"

"Hmm," countered Daniel, "That's a tough one because we are selling different metals. Some variation in metal price is common. When the world economy is strong, there is demand for both copper and cobalt, and prices rise. But other variation is more independent; for example, some recent rich cobalt discoveries have independently driven cobalt prices down."

"That's good," offered Madeleine. "We'll put metal price variation as both systematic and idiosyncratic. You said that the other factors tend to be random, like breakdowns and pirating. If so, how should we classify those effects?"

"If they are in fact random independent effects, I suppose they must be idiosyncratic, right?" offered Daniel with some statistical swagger.

"That is right, brother. Mother would be so proud," affirmed Lilian. "The good news for both of you is that much of your business risk appears to be idiosyncratic."

"That doesn't sound good to me…all this wild, independent up and down. What's so good about idiosyncratic risk?" countered Julian.

"What's good about it is that it is easy to get rid of," replied Madeleine with a smile.

"Get rid of it? How? I'd give my three best pickaxes to unload all the idiosyncratic risk I have at Boule de Neige," challenged Daniel.

"Thank you Daniel. I could use some good axes," acknowledged Madeleine. "The secret to getting rid of your idiosyncratic risk is simple: diversification. The problem you are both facing is that because you each own your own business, you each bear all your business risk."

"Since I know you don't believe us," continued Lilian, "let me show you a little diversification magic. Let's look back at your erratic profits over the past two years." She worked out some calculations on her phone and produced some additional analysis (see **Table 2**). "I've added a couple of things. The first thing is the average monthly profit for each mine and each year. Next is a measure of total risk called *standard deviation*. This risk

measure tells us how volatile your profits are by measuring how far the monthly profits tend to fall from the monthly average. You can see that Boule de Neige profits were the most volatile in year 1 with a standard deviation of $1,734, while Ours Polaire profits were the most volatile in year 2 with a standard deviation of $1,874. These values are high relative to your average profits. The statistics confirm what you have been living—you've got a lot of volatility in your businesses."

"But where's the diversification magic?" asked Julian impatiently.

"We're getting there, little brother. Let's suppose that you form a partnership with each other to share the profits. In doing so, you are diversifying your investment across two mines rather than one. The monthly payout you'll both receive now is the average, or half of the profits of both mines. We can see how this works with my 50-50 column, where I've calculated the average profits each month. So walk me through—Julian, how does the partnership turn out?"

Table 2. Additional analysis of operating profits for Boule de Neige and Ours Polaire (monetary values in US dollars).

	Year 1			Year 2		
	Boule de Neige	**Ours Polaire**	**50-50 Partnership**	**Boule de Neige**	**Ours Polaire**	**50-50 Partnership**
January	2,127	1,337	1,732	(980)	(1,236)	(1,108)
February	(1,354)	1,542	94	(276)	922	323
March	2,594	(509)	1,043	(1,281)	(1,034)	(1,158)
April	1,561	(2,067)	(253)	(1,357)	1,099	(129)
May	2,909	1,475	2,192	(1,016)	1,194	89
June	(1,780)	614	(583)	1,936	(3,757)	(911)
July	1,359	(1,915)	(278)	(1,184)	605	(290)
August	284	1,007	645	648	3,181	1,915
September	(545)	1,833	644	2,046	1,974	2,010
October	620	(1,446)	(413)	470	(324)	73
November	(2,297)	(3,196)	(2,747)	(1,227)	(515)	(871)
December	1,416	(38)	689	1,973	2,301	2,137
Total	6,893	(1,364)	2,765	(248)	4,411	2,082
Average	574	(114)	230	(21)	368	173
Std. Deviation	1,734	1,691	1,271	1,379	1,874	1,217
Correlation	0.10			0.10		

Source: Created by author.

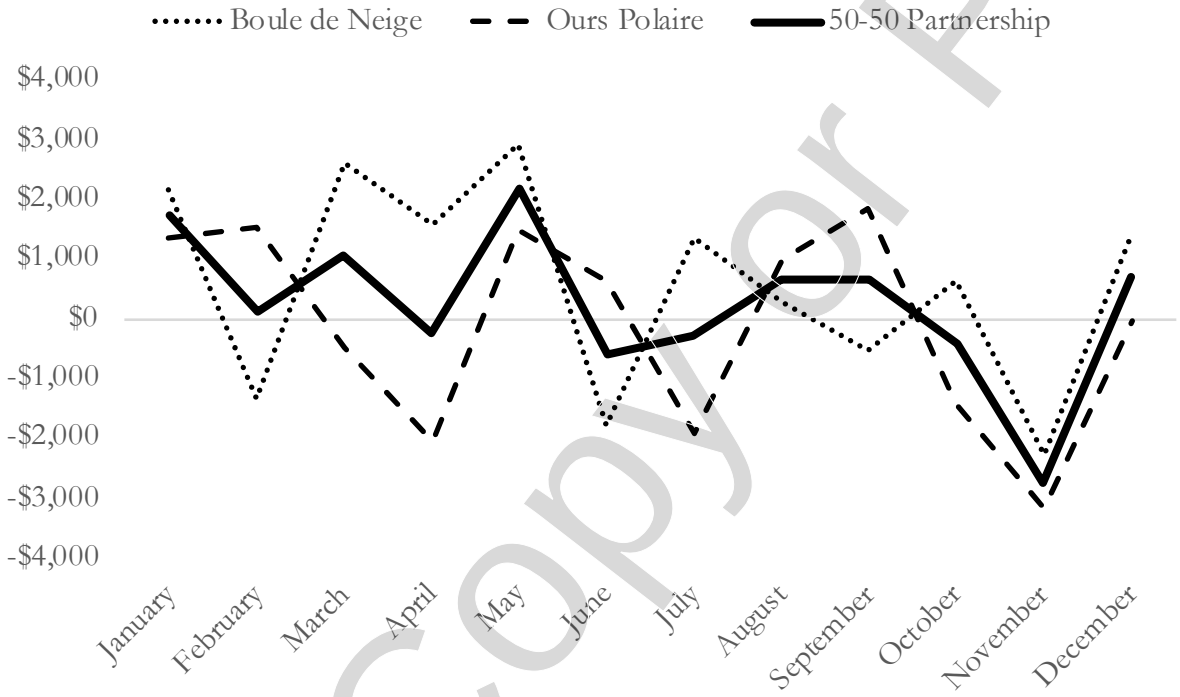
Julian looked closely at Lilian's calculations. "Well, in January of the first year, Daniel had a great month with $2,127, and I had a decent month with $1,337. When we share profits, we both get $1,732, a good month for both. In February, Daniel had a crummy month with −$1,354, while I had another decent month with $1,542. In the partnership, my good luck offsets his bad luck and we both break even with $94. In March, Daniel does really well and I do poorly, so the partnership does well with $1,043 each."

"You got it."

Daniel quickly followed up with a graph of the three profit outcomes (see **Figure 1**), where he suggested that the dark "partnership" line was less volatile than either of the single mine lines. "So what you are

proposing," he said, "is that by diversifying our investment we can reduce business risk because my good months will tend to offset my brother's bad months and vice versa, right?"

Figure 1. Graph of year 1 operating profits for Boule de Neige and Ours Polaire.



Source: Created by author.

"That's right!" answered Lilian. "You can see the risk reduction effect in the standard deviation of the partnership. Notice how the partnership standard deviation is just $1,271. The diversification effect has resulted in you both getting the average of the profits with substantially less than the average of the risk."

"Very impressive!" exclaimed Julian with his customary vigor and backslapping. "But how does the diversification trick work?"

"To answer your question, Julian, I have a question for you. Is the risk reduction observed in the partnership due to a reduction of systematic risk or idiosyncratic risk?"

"I believe it is the idiosyncratic risk," offered Julian. "I notice that we don't get much risk reduction in November. We both had a bad month because of the high transportation costs we had to pay. It was a systematic risk event that affected both of us."

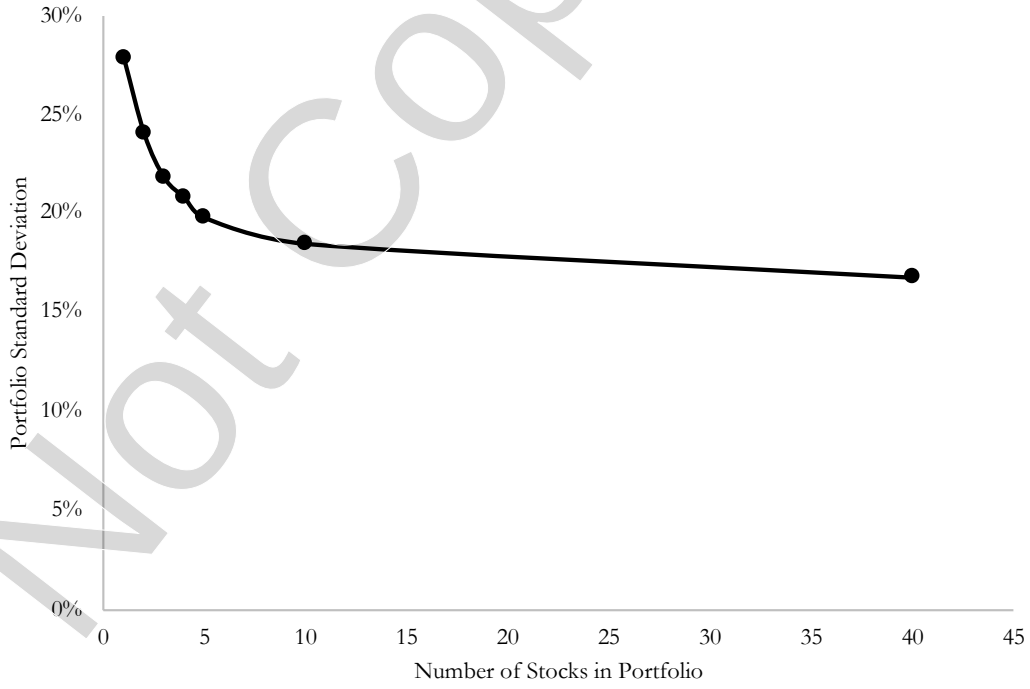
"Brilliant!" responded Madeleine. "The risk reduction comes from the fact that you have a large amount of idiosyncratic risk in your business. That means that by diversifying, you are able to eliminate a large amount of that risk by sharing it between the two of you. With the systematic risk, you don't get the offsetting effect, as you both bear it in the same way. You can get a sense of the amount of systematic risk by looking at the correlation in your returns. The correlation coefficient is a statistic that measures how much correlation there is between the two series, with the value of 0 meaning no average correlation and the value of 1 meaning

proportional correlation. For both year 1 and year 2, the correlation coefficient of your profits was 0.1, which is small."

"That is very helpful. I think I'm beginning to understand what the two of you have done," observed Daniel, addressing both his sisters. "You never really wanted to own a single business. Rather, the two of you through your investment fund have bought up small positions in just about every responsibly run business in the country. With small investments in hundreds of businesses, you've reduced your idiosyncratic risk to effectively nothing. All that risk is washed out."

"Yes, now you know our secret," admitted Lilian. "And you should also know that it makes a difference to our appetite to invest. Our diversified position eliminates much of the risk in any single investment. So, while investments with high idiosyncratic risk might make the two of you nervous, Madeleine and I take them on with little concern because our portfolio of investments works together to reduce risk. Because of the risk reduction, we are more willing to invest our money. While the two of you face considerable idiosyncratic risk, as diversified investors our total risk exposure is substantially less. Since we are only exposed to the systematic risk, we are willing to accept lower expected returns on investments."

Figure 2. Portfolio standard deviation of returns for random portfolios of French CAC 40 stocks (2015–19).



Note: The CAC 40 is the primary index of the French stock market.
Source: Created by author using stock return data from Yahoo! Finance.

Lilian continued, "As an example, I've done some analysis on a sample of 40 large French stocks. If you pick any one of those stocks at random to hold, the standard deviation of your return will be about 28%. But if you combine that stock 50-50 with another random stock, the standard deviation of your 50-50 portfolio

return drops to 24%. If you add eight more random stocks, so that you have 10% invested in 10 of the French stocks, the standard deviation of your portfolio return drops to 19%. Lastly, if you simply hold the entire index of 40 stocks, the standard deviation of your portfolio return drops to 17%. As you can see from this graph (see **Figure 2**), the more you diversify with additional assets in your portfolio, the lower is the total risk of your return."

Madeleine added, "But know that it's not that we don't care about risk, because we do. Our concern is simply about systematic risk rather than idiosyncratic risk. We get nervous about investments where the variation is highly correlated with macro movements. And in those instances, we'll definitely require more return, but idiosyncratic risk doesn't bother us."

Daniel filled his sisters' glasses, then turned to Julian and said, "Julian, maybe it is time we stop putting all our eggs in one basket."

Concept Review

A common metric of risk, standard deviation measures the amount of variation there is from the average. The statistical formula for the standard deviation of a sample of numbers is

$$\textit{Standard Deviation} = \tfrac{1}{N}[(x_1 - \bar{x}) \ + \cdots + (x \ - \bar{x}) \ ]^{1/} \ ,$$

where N is the number of observations, $\bar{x}$ is the average of the observations, x_1 is the first observation, and x is the last observation. The standard deviation is calculated by squaring the difference between each observation and the average, adding them up, and then taking the square root of that sum. It can be interpreted as the average distance from the average observation.

But while the standard deviation is a reasonable metric for total variation or risk, it overstates the risk to investors who hold portfolios of assets. This is because in portfolios, any risk that is idiosyncratic or independent of the movements of other risky assets can be eliminated through diversification. By adding together different risky assets, any risk that is non-systematic is washed out, since the random ups of some assets are offset by the random downs of other assets.

Because there are large risk reduction gains to diversified portfolios, there is a strong incentive for investors to build large portfolios that collectively eliminate idiosyncratic risk across the portfolio. Because of the ease associated with idiosyncratic risk reduction, portfolio theory argues that investors in equilibrium will not require a risk premium for idiosyncratic risk.

Systematic risk is the portion of total risk that cannot be eliminated through diversification. This risk is the variation due to systematic factors that affect most risky assets. Because of the difficulty in reducing systematic risk, portfolio theory argues that investors in equilibrium will demand a risk premium for systematic risk.[1] The capital asset pricing model (CAPM) provides a model of the risk premium associated with investors bearing only systematic risk. This simple model of the risk premium associated with any risky asset is defined as

$$R_i = R_f + \beta_i \times \lambda,$$

[1] Note that the term "systematic risk" is also commonly called "market risk," and the term "idiosyncratic risk" is also called "diversifiable risk" or "non-systematic risk."

where R_i is the required return for asset *i*, R_f is the return on the risk-free asset, β_i is the measurement of systematic risk for asset *i*, and λ is the market risk premium, or risk premium associated with holding a unit of systematic risk. The CAPM makes the bold predication that with normally distributed returns, rational and diversified investors, and competitive and frictionless markets, the only investment attribute that will justify a risk premium is the measure of systematic risk, or beta. In other words, when an investor considers the expected return associated with any stock, for example, beta captures all the relevant aspects of risk.