The Foundations of Factor Investing

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Asset Pricing Background

Market Anomalies

- The academic finance literature, and long investing experience, have identified classes of equities that have consistently higher (or lower) average returns than the stock market portfolio
- These are designated as market or **CAPM anomalies** as the baseline Capital Asset Pricing Model (CAPM) cannot explain those patterns in average stock returns: the model produces **statistically significant** (positive or negative) **alphas** (pricing errors) for each of those return spreads:

$$E(R_i^e) = \alpha_i + \beta_i E(R_m - R_f),$$

  where $E(R_i^e)$ is the expected excess return associated with anomaly i; $E(R_m - R_f)$ is the expected excess market return (relative to the risk-free rate); and α_i is the **pricing error** for anomaly i
- Hou, Xue, and Zhang (2020) identify about **158 significant anomalies** in the U.S. stock market—equity characteristics that are significantly correlated (with either sign) with average stock returns

- There are strong correlations among several anomalies ⇒ Hou, Xue, and Zhang (2020) aggregate those 158 anomalies into **6 major categories**:
  - **Momentum**: Stocks with high returns/earnings in the previous year tend to subsequently outperform stocks with low returns/earnings
  - **Value-growth**: Value stocks (high fundamentals-to-price ratios), low-duration stocks, stocks with low returns in the previous 3 to 5 years subsequently outperform growth stocks (low fundamentals-to-price ratios), high-duration stocks, and past long-term winners, respectively
  - **Investment**: Stocks of firms that invest less subsequently outperform stocks of firms that invest more
  - **Profitability**: Stocks of more profitable firms subsequently outperform less profitable firms
  - **Trading frictions**: Stocks with low volatility/beta subsequently outperform stocks with high volatility/beta; but there are other unrelated anomalies
  - **Intangibles**: All other anomalies (lots of heterogeneity inside this group)

- There are several competing theories for many of these anomalies
- For example, Fama and French (2015) rely on the **present-value model** of Miller and Modigliani (1961) for the market-to-book ratio:

$$\frac{M_t}{B_t} = \frac{\sum_{\tau=1}^{\infty} E(Y_{t+\tau} - dB_{t+\tau})/(1+r)^{\tau}}{B_t}$$

  - Ceteris paribus, lower market value (M), or equivalently a **higher book-to-market ratio** (B_t/M_t), implies a **higher expected return** (r)
  - Ceteris paribus, **higher expected earnings** (Y) implies a **higher expected return**
  - Ceteris paribus, **higher** expected growth in book equity (db, **investment**) implies a **lower expected return**
- Alternatively, Hou, Xue, and Zhang (2015) rely on the q-theory of corporate investment to justify the investment and (net) profitability anomalies

Multifactor Models: Empirical Factors

- However, these explanations are merely **qualitative**: they only postulate the sign of the correlation between a given equity characteristics (e.g., profitability) and average stock returns

- They do not explain the magnitude of the expected return associated with each anomaly portfolio

- In mainstream Finance, if a given security (or portfolio) offers a **higher expected return** than another security, this represents a **risk premium**—a compensation for higher systematic risk associated with the former security

- **Asset Pricing**, traditionally the most important and larger field of Finance (producing several Nobel Laureates in Economics), studies the **risk-return trade-off**: **higher risk $\Rightarrow$ higher expected return**

- **Systematic risk**:
  - A risk factor is a variable that affects the returns of **all** assets (only the exposure varies from asset to asset)
  - **Cannot be diversified** away (eliminated) by forming large portfolios
  - There is a **reward** (in the form of higher expected returns)
- **Idiosyncratic risk**:
  - It is **specific** to each asset
  - **Can be diversified** away (eliminated) by forming large portfolios
  - There is **no reward** (no higher expected returns)

- The risk-return trade-off is often postulated in the form of a **linear multifactor model**, with the following **expected return-beta representation**:

$$E(R_i^e) = \beta_{i,1}\lambda_1 + ... + \beta_{i,K}\lambda_K + \alpha_i$$

  - $E(R_i^e)$: risk premium for asset i or expected return of asset i in excess of another asset (often the risk-free rate)
  - $\beta_{i,j}$ **quantity of risk** of factor $j, j = 1, ..., K$; it measures the exposure of each asset to each risk factor (source of systematic risk); it varies from stock to stock (some stocks are riskier than others)
  - λ_j **price of risk** of factor $j, j = 1, ..., K$; It is constant across stocks; it represents the premium for one unit of risk for a given factor
  - The total risk premium of a stock (or a portfolio), $E(R_i^e)$, represents the sum of factor risk premiums
  - α_i is the **pricing error** for asset i: component of expected return that, according to this model, should not exist
  - α_i represents a failure of the model: if the model is true $\Rightarrow \alpha_i = 0$ from a statistical viewpoint

- We **do not observe expected returns**: A common approach is to use the sample average of realized returns over a relatively long period
- More importantly, we **do not observe risk**, or more specifically, we do not know how many and the identity of the "true" risk factors
- Asset pricing researchers derive and test **linear asset pricing models—selection and identification of risk factors**

- The average investor in the economy is **risk averse** $\Rightarrow$ he/she requires a **positive risk premium** to be exposed to riskier assets
- **Riskier assets** are assets that tend to perform poorly when factor realizations (returns) are adverse ("**bad**")
- Each factor has its own definition of "bad times"
- Assume that the factor carries a positive risk price ($\lambda_j > 0$) (this does not have to be always the case)
- When a stock covaries more with that factor (**high factor beta**) $\Rightarrow$ unattractive stock to hold because it tends to have low payoffs (realized returns) during the bad times defined by that factor's negative realizations $\Rightarrow$ this stock has to offer **high** returns on average (**expected returns**) to compensate risk-averse investors (for the higher risk)
- Exposure to factor risk over the long run yields a positive risk premium, but the premium does not come for free: it represents a compensation for bearing **losses** during bad times (high risk)

- Historically, the first asset pricing model was the Sharpe-Lintner **CAPM**:

$$E(R_i^e) = \beta_i E(R_m - R_f)$$

- The sole factor is the **market risk premium** (expected market return in excess of the risk-free rate)
- The sole measure (quantity) of risk is the **market beta** (β_i)
- The factor is **traded** (it represents an excess return) $\Rightarrow$ the **risk price** (λ) estimate is exactly equal to the mean of the factor, $E(R_m - R_f)$
- Under the CAPM, the definition of "**bad times**" are periods with low (negative) realized market returns

- Due to the tremendous empirical failure of the CAPM (e.g., Fama and French, 1992), **Fama and French** (1993, 1996, FF3) proposed the following 3-factor extension of the CAPM:

$$E(R_i^e) = \beta_i E(R_m - R_f) + s_i E(SMB) + h_i E(HML)$$

  - Similarly to the market factor, both SMB and HML are traded factors (excess stock returns); hence, they represent **zero-cost portfolios**
  - SMB (small-minus-big): return on a portfolio of small caps minus the return on a portfolio of large caps
  - HML (high-minus-low): return on a portfolio of value stocks minus the return on a portfolio of growth stocks
  - SMB captures the **size** anomaly (Banz, 1981); HML captures the **book-to-market** (BM, value-growth) anomaly (Rosenberg, Reid, and Lanstein, 1985)
- This multifactor model can be seen as the academic foundation for **factor investing**: all factors are traded ⇒ enables to conduct performance evaluation (see below)

- The FF3 model explains well the average returns on portfolios sorted on both size (market capitalization) and BM

- However, this represents nearly a **tautological exercise**: it just informs us that the relationship between average stock returns and BM is approximately **monotonic**—stocks in the second decile of BM behave closer to stocks in the first decile (extreme value stocks) relative to stocks in the upper deciles (growth stocks)

- A model with traded factors (empirical model) is only useful to the extent that it helps explaining anomalies that are not mechanically related (by construction) to its factors

- A good example is the 4-factor model of **Hou, Xue, and Zhang** (2015, HXZ4),

$$E(R_i^e) = \beta_i E(R_m - R_f) + a_i E(ME) + b_i E(ROE) + c_i E(IA),$$

  which does a relatively good job in explaining the **momentum** (broadly defined) anomaly

- Such pricing performance comes from their **profitability (high-minus-low ROE) factor** $\Rightarrow$ these two anomalies (momentum and net profitability) are connected (something that is not obvious a priori)

- Fama and French (2015, 2016, FF5) proposed the following 5-factor extension of their 3-factor model:

$$E(R_i^e) = \beta_i E(R_m - R_f) + s_i E(SMB) + h_i E(HML) + r_i E(RMW) + c_i E(CMA)$$

  - CMA (conservative-minus-aggressive) represents an **investment factor** (quite similar to the IA factor in HXZ4)
  - RMW (robust-minus-weak) represents an **operating profitability factor**
  - The differences between ROE and RMW explain the **differences in the empirical performance among the HXZ4 and FF5 models** (e.g., Cooper and Maio, 2019a, 2019b; Hou, Mo, Xue, and Zhang, 2019, 2020)
- However, FF5 is not able to explain **momentum-based anomalies** (just like FF3)
- In response to that failure, Fama and French (2018, FF6) add the momentum factor (UMD, up-minus-down) of Carhart (1997):

$$E(R_i^e) = \beta_i E(R_m - R_f) + s_i E(SMB) + h_i E(HML) + r_i E(RMW) + c_i E(CMA) + u_i E(UM$$

- Barillas and Shanken (2018) propose a 6-factor model, which **combines** some of the factors in **FF6** and **HXZ4**:

  $E(R_i^e) = \beta_i E(R_m - R_f) + s_i E(SMB) + h_i E(HML) + r_i E(ROE) + c_i E(IA) + u_i E(UMD)$

- Hou, Mo, Xue, and Zhang (2019, 2010, HMXZ5) add an **expected growth factor** (EG) to HXZ4:

$$E(R_i^e) = \beta_i E(R_m - R_f) + a_i E(ME) + b_i E(ROE) + c_i E(IA) + d_i E(EG)$$

- We have also seen the emergence of **other** empirical multifactor models: Novy-Marx (2013); Asness and Frazzini (2013); Stambaugh and Yuan (2017); Daniel, Hirshleifer, and Sun (2020); Asness, Frazzini, and Pedersen (2019)

- Similarly to the factors in HMXZ5 and FF6, the factors in those models are **traded**: excess returns on portfolios associated with different anomalies (i.e., other stock characteristics correlated with average stock returns)

- The hurdle in the empirical asset pricing literature has increased substantially in recent years: A newly proposed asset pricing model should explain risk premia in a broad cross-section of **all** equity portfolios (associated with a large number of CAPM anomalies)
- This is especially relevant in the case of empirical models, which have a weaker theoretical background
- Hou, Xue, and Zhang (2015) test their model on 35 anomalies
- Hou, Mo, Xue, and Zhang (2020) employ 150 anomalies to test their 5-factor model
- Cooper, Ma, Maio, and Philip (2020) conduct a horse race of several multifactor models in terms of pricing jointly 42 anomalies

- In principle, the traded multifactor models can be rationalized as empirical applications of the Arbitrage Pricing Theory (**APT**) of Ross (1976)
- Under the APT framework, factors that do a good job in summarizing the common time-series variation in **realized excess returns** of a large number of portfolios $\Rightarrow$ candidate risk factors to explain the risk premia (**expected returns**) associated with those same portfolios: **Statistical factors are pricing risk factors**
- However, Cooper, Ma, Maio, and Philip (2020) show that most empirical multifactor models are **not good empirical proxies for the APT**: These models underperform by a large degree a **benchmark statistical model** designed (by construction) to price a cross-section associated with 42 anomalies
- HMXZ5 is the sole model that is not dominated (in statistical terms) by the benchmark statistical model

Multifactor Models: Fundamental/Macro Factors

- All empirical models contain the standard market factor despite the failure of the CAPM in explaining the market anomalies

- The job of the market factor is to act as a "**level**" factor: to explain the average risk premium in the cross-section

- Since all empirical multifactor models contain the market factor plus other equity factors, they are candidates to being empirical applications of the Intertemporal CAPM (**ICAPM**) from Merton (1973):

$$E(R_i^e) = \beta_{i,M}\lambda_M + \beta_{i,z}\lambda_z$$

- Under the ICAPM, the non-market factors (z) are called "**hedging** factors"—innovations in **state variable**s that predict changes in the investment opportunity set

- In practical terms, this means variables that help to forecast the excess market return and/or aggregate stock volatility

- ICAPM **risk story**: Stocks that are more correlated (higher betas) with positive shocks in future investment opportunities (as measured by some factor z) $\Rightarrow$ underperform in bad times (times of declining expectations of future aggregate investment conditions) $\Rightarrow$ are riskier and offer higher risk premiums (in comparison to stocks that are uncorrelated or less correlated with future investment conditions)

- Fama (1991) labels the ICAPM as a "**fishing license**" for empirical multifactor models

- Maio and Santa-Clara (2012) postulate simple **sign restrictions** on the risk prices of the hedging factors in order to achieve consistency with the ICAPM

- They find that most multifactor models proposed in the literature do not satisfy those sign restrictions $\Rightarrow$ **not consistent with the ICAPM**

- However, Cooper and Maio (2019a) show that both **HXZ4 and FF5** are (to a large degree) **consistent** with the ICAPM framework

- Nonetheless, the empirical factor models cannot represent the ultimate explanation of a given risk premium; these models represent **relative asset pricing**: explaining one equity risk premium (anomaly) by a collection of other equity risk premiums (factors)
- In most cases, we do not know why the factor risk premium exists in the first place (**absolute asset pricing**)
- Both CAPM/ICAPM refer to absolute asset pricing while APT refers to relative asset pricing ⇒ **the ICAPM is more demanding** and imposes more structure (assumptions) than the APT
- Ideally, at least some of the major sources of systematic risk (factors) must originate from **outside the equity market**
- The traditional 3 major classes of fundamental asset pricing models are the Lucas–Breeden Consumption-CAPM (**CCAPM**), the **ICAPM**, and the **Conditional CAPM**

- In the CCAPM, the only risk factor is the **growth in aggregate consumption** (non-durable goods plus services):

$$E(R_i^e) = \beta_i \lambda_C,$$

where λ_C is the risk price for the consumption factor

- In the case of CCAPM (and other fundamental models), the factor is not traded $\Rightarrow$ the risk price estimates are obtained by running a cross-sectional regression (of average excess return onto betas)

- Under the Consumption-CAPM, the definition of "**bad times**" are periods with low (negative) growth in aggregate consumption

- CCAPM **risk story**: stocks that are more correlated with aggregate consumption tend to underperform in bad times (times in which aggregate consumption is declining) $\Rightarrow$ these stocks are riskier and offer higher risk premiums (compared to stocks that are less correlated or uncorrelated with the consumption factor)

- Empirically, the CCAPM performs poorly due to the small correlations between stock returns and aggregate consumption

- Multifactor extensions of the CCAPM: Other macro factors in addition to aggregate consumption

- Yogo (2006) proposes the following 3-factor macro model,

$$E(R_i^e) = \beta_{i,M}\lambda_M + \beta_{i,C}\lambda_C + \beta_{i,D}\lambda_D,$$

  in which λ_M, λ_C, and λ_D denote the risk prices associated with the excess market return, non-durable consumption growth, and durable consumption growth, respectively

- The superior empirical performance of the model (relative to CCAPM) is mainly driven by the presence of the **durable-consumption factor**

- The traditional hedging factors in the ICAPM are innovations in state variables that forecast the excess market return

- Typically, these factors are not traded (not excess stock returns)

- The most popular predictors of the aggregate equity premium are the **dividend yield** (DY), **term spread** ($TERM$), **default spread** (DEF), and **T-bill rate** (RF) (Fama and French, 1988, 1989)

- Empirically, the ICAPM has had some success in explaining several CAPM anomalies (e.g., value-growth)

- Petkova (2006) proposes the following 5-factor ICAPM:

$$E(R_i^e) = \beta_{i,M}\lambda_M + \beta_{i,TERM}\lambda_{TERM} + \beta_{i,DEF}\lambda_{DEF} + \beta_{i,DY}\lambda_{DY} + \beta_{i,RF}\lambda_{RF}$$

  in which the hedging factors are the innovations in $TERM$, DEF, DY, and RF

- The innovations are obtained from a vector autoregression (VAR) model

- Campbell and Vuolteenaho (2004) and Maio (2013) estimate different versions of the Campbell (1993)'s variant of the ICAPM: The (composite) factors represent linear functions of the VAR innovations in the state variables

- Often, the factor risk prices in fundamental models are connected to structural parameters (e.g., risk aversion coefficient) $\Rightarrow$ constraint in both the sign and magnitudes of the risk price estimates
- In empirical models, there is no connection between the factor risk price estimates and structural parameters
- The main advantage of fundamental models (macro/ICAPM) is to provide an economic foundation (other than the law of one price, as in the APT) for the risk premium associated with a given anomaly

- The pattern in **factor loadings** associated with a given group of portfolios (anomaly) puts an additional **constraint** in the factor model: Does such cross-sectional pattern in factor loadings make sense?
- For example, Maio and Santa-Clara (2017) shows that several value-growth and investment anomalies can be explained by an interest-rate factor in a two-factor ICAPM
- Value and low-investment stocks are more negatively correlated with short-term interest rates (in comparison to growth and high-investment stocks, respectively): the former type of equities are near financial distress after a sequence of negative shocks to their cash-flows $\Rightarrow$ more sensitive to rises in short-term interest rates, which increase their financial costs (Fama and French, 1992; Bernanke and Gertler, 1989, 1990)
- Because the interest-rate factor has a negative price of risk $\Rightarrow$ value and low-investment stocks offer higher risk premia (expected returns) than growth and high-investment stocks, respectively

Implications for Factor Investing

- A disadvantage of fundamental multifactor models is that these cannot be used for performance evaluation: (some of) the factors are not traded
- For this reason, **factor investing** focuses on **empirical factor models**: all factors are traded (excess stock returns)
- Traded (also labelled as dynamic) factors represent long-short or zero-cost portfolios: taking long position in securities with similar characteristics (e.g., value stocks), which tend to comove with each other, and offsetting short positions in securities with the opposite characteristics (e.g., growth stocks)
- The factors are **dynamic** because they need to be rebalanced: the stock characteristics change over time

- Consider the case of the FF3 model
- The average return on Fund i is equal to the average return on the **replicating** (or **benchmark**) portfolio plus the average **active** return (α_i):

$$E(R_i) - R_f = \alpha_i + \beta_i E(R_m - R_f) + s_i E(SMB) + h_i E(HML) \Leftrightarrow$$
$$E(R_i) = \alpha_i + \beta_i E(R_m) + (1 - \beta_i) R_f + s_i E(SMB) + h_i E(HML) \Leftrightarrow$$
$$E(R_i) = \alpha_i + E(R_b)$$

- The **alpha** (α_i) is the "risk-adjusted return" or active return of the fund: Unique average return generated by the manager in excess of what could be done mechanically through passive exposures to the factors (average return on the benchmark portfolio, $E(R_b)$)

- The composition of the benchmark portfolio is as follows:
  - β_i on the stock market portfolio
  - $1 - \beta_i$ on the risk-free asset (T-bill)
  - s_i on a portfolio of small caps
  - $-s_i$ on a portfolio of large caps
  - h_i on a portfolio of value stocks
  - $-h_i$ on a portfolio of growth stocks
- The benchmark portfolio is indeed a portfolio, as the weights sum up to 1:

$$\beta_i + 1 - \beta_i + s_i - s_i + h_i - h_i = 1$$

- Dynamic factors assume the investor (owner of funds) can short: If not, the factors (in the benchmark portfolio) should represent long-only equity portfolio (e.g., a diversified portfolio of value stocks) in excess of the risk-free rate

- **Duality** between asset pricing and factor investing:
  - In asset pricing, the factor loadings represent the measure of systematic risk associated with each factor
  - In factor investing, the factor loadings represent the weights (for each factor) in the benchmark portfolio
  - In asset pricing, the objective is to obtain low alphas (pricing errors)
  - In factor investing, the objective is to obtain large alphas (high active performance)
- The reward of the portfolio manager (active management fee) is based exclusively on the alpha, not R_b $\Rightarrow$ possible **moral hazard** in the form of taking excessive risks (large factor exposures)
- To minimize this problem, the investor (owner of funds) might **specify ex-ante**, not only the factors, but also the corresponding **weights** in the benchmark portfolio

- The return on the **benchmark portfolio** represents the return that the investor would obtain by investing on its own on the desired factors: The benchmark model should be **specific** to each investor (owner of funds)

- **Unsophisticated investor** that wants to invest in a well diversified equity portfolio that does not deviate a lot from the market portfolio ⇒ the appropriate benchmark portfolio should be the **market portfolio** (combined with the risk-free asset)

- **Sophisticated investor** that wants to exploit the **value-growth**, **investment**, and **profitability** groups of anomalies; the investor can short on its own ⇒ the appropriate benchmark portfolio should correspond to either **FF5 or HXZ4**

- **Another sophisticated investor** that wants to exploit the **value-growth**, **investment**, **profitability**, and **momentum** groups of anomalies; the investor can also short ⇒ the indicated benchmark portfolio should correspond to either **FF6** or **HXZ4**

- In principle, **more factors** in the benchmark portfolio $\Rightarrow$ harder job of the portfolio manager in terms of generating significant positive alpha: Over a long period of time, it should be substantially easier to generate positive alpha against the market model than against the HXZ4 model

- **Tension** between the investor (owner of funds) and the portfolio manager in the definition of the benchmark portfolio

- Even if two investors want to have exposure to the same factors, the **portfolio weights can differ**: One investor might want to have a larger exposure to momentum risk premium, whereas the other investor might want to be more exposed to the value-growth or investment risk premia

- Therefore, factor investing (when properly implemented) is more about "**tailor-made**" investment products than about "**commoditized**" investment products

- Factor investing is more appropriate for **sophisticated (can short), long-horizon, and large (wealthier) investors** in comparison to unsophisticated, short-horizon, and small investors

- The **average investor** in the stock market holds the **market portfolio** (market capitalization weights) $\Rightarrow$ does not practice dynamic factor investing!

- Factor investing is similar in spirit to **selling insurance**

- One group of investors (**less risk averse who sell insurance**) are happy to have a larger exposure to riskier stocks (e.g., value stocks) in their portfolio, which is financed by a lower exposure to less risky stocks (e.g., growth stocks) $\Rightarrow$ In the long run, these investors collect a positive risk premium (insurance premium) associated with the higher risk exposure of their portfolio

- Another group of investors (**more risk averse who buy insurance**) want to have a lower exposure to riskier stocks (e.g., value stocks) in their portfolio, which is offset by a higher exposure to less risky stocks (e.g., growth stocks) $\Rightarrow$ In the long run, these investors are willing to accept a negative risk premium as a result of the lower (hedged) risk exposure of their portfolio

- The staring point for both groups of investors is the market portfolio (combined with the risk-free asset):
  - The first group will **overweight** (underweight) **value** (growth) stocks in their desired portfolio (positive loading on the HML factor)
  - The second group will **overweight** (underweight) **growth** (value) stocks in their desired portfolio (negative loading on the HML factor)
- Each investor chooses the risks (factors) he/she wants to take (**positive exposure**) and the risks (factors) that he/she wants to hedge (**negative exposure**)
- If the investor does not want to invest in a given anomaly (e.g., momentum) $\Rightarrow$ his/her benchmark portfolio will have a zero exposure to UMD (winner and loser stocks are held at market weights)
- Factor investing represents a **transfer of risks** from more risk-averse and short-horizon investors to less risk-averse and long-horizon investors

- Factor risk premiums do not come for free: episodic large negative returns
- The long-run positive expected return (risk premium) on a given factor represents a compensation for negative realized returns over some periods—the "bad times" according to the factor
- Consider the case of the price **momentum** anomaly (captured by UMD)
  - UMD has an average monthly return of 0.70% (8.40% per year!) over the 1973–2013 period
  - However, there are substantial episodic losses: The **maximum drawdown** (MDD, maximum cumulative loss) is -57.61%
  - The betting-against-beta factor (BAB, low-risk anomaly) from Frazzini and Pedersen (2014) produces an average monthly return of 0.88% (10.56% per year!) and a MDD of -52.03% over the same period
  - How many investors are willing to accept those losses (in more than half of their portfolio value)? Probably, not the majority of the investors in the stock market

- This finding has implications for the candidate theories explaining asset (factor) risk premia
- **Behavioral theories**: high expected returns result from investors' under- or over-reaction to news and/or the inefficient updating of beliefs; behavioral biases persist because there are **barriers to the entry of capital** (which prevent arbitrage opportunities, associated with psychological biases, to be eliminated)
- In particular, the finding above precludes behavioral theories from representing a consistent explanation of factor risk premia: **market imperfections and frictions** are difficult to sustain in the **long-run**!
- The **rational paradigm** in Finance (risk-return tradeoff) seems like a more plausible explanation!

- Looking forward to your **questions and comments**!

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