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THE CAPM, APT, AND PAPM

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The Popularity Asset Pricing Model (PAPM) generalizes the Capital Asset Pricing Model (CAPM) with popularity as the basis for multiple priced characteristics. The CAPM along with the Arbitrage Pricing Theory (APT) are the dominant textbook asset pricing models. Both require restrictive and unrealistic assumptions. The former suffers empirical shortcomings, and the latter is largely unused. Fama and French (2007) identify "tastes" and "disagreement" as impacting asset prices. In the PAPM, investors have a variety of risk and non-risk preferences (tastes) and divergent beliefs about expected returns and risk (disagreement), in which aggregate tastes and disagreement impact equilibrium prices.

Pricing models are central to almost every aspect of finance. They are used in estimating expected returns, valuation, portfolio formation, and cost of capital analysis. Asset pricing models are theoretical, but the models themselves are of paramount importance to practitioners and the profession. Unfortunately, from a practitioner's perspective there has arguably been little progress over the last half a century. In this paper, we compare the CAPM (Capital Asset Pricing Model) and the APT (Arbitrage Pricing Theory) with a newer asset pricing model, the PAPM (Popularity Asset Pricing Model).

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While the CAPM of Lintner (1965) and Sharpe (1964) is literally the textbook asset pricing model of the last 50 years and a key element of every finance curriculum; numerous papers have been written on the CAPM's shortcomings (e.g., Basu, 1977; Banz, 1981; Fama and French, 1992, 1993). A key limitation of the CAPM is that only exposure to overall market risk is priced, while many recognize that asset pricing is multi-dimensional.

The multi-dimensional APT of Ross (1976), also featured in many textbooks, held great promise because it introduced a linear model of expected return with multiple risk factors. Although the *arbitrage framework* has been very useful in *derivative* pricing relative to an established price, arbitrage models do not forecast underlying or non-derivative prices.

The Popularity Asset Pricing Model (PAPM) is a general equilibrium model in which risk and non-risk dimensions of securities are priced, leading to asset prices that differ from those of the CAPM. The PAPM is a new multi-factor asset pricing model rooted in the idea of "popularity" with less restrictive assumptions than the CAPM and more realistic assumptions than the APT.

The main idea behind popularity is that if enough investors like or dislike a given characteristic, it will impact asset prices. More specifically, investments with liked characteristics are in high demand (popular) and thus more expensive, with lower expected returns. Conversely, investments with disliked characteristics are in low demand (unpopular) and thus less expensive, with higher expected returns. If aggregate tastes are changing, such as collective demand for investments with various environmental, social, and governance (ESG) characteristics, changes in aggregate tastes can cause investments with the liked/disliked characteristics to temporarily have worse/better returns during periods of changing tastes.

1 The Need for A Better Asset Pricing Model

1.1 Tastes, disagreement, and CAPM shortcomings

In an academic article that is not well-known among practitioners called "Disagreement, Tastes, and Asset Prices," Fama and French (2007) (hence forth "FF") identifies "disagreement" and "tastes" as two key ingredients missing from the CAPM that should impact asset prices.

Tastes refer to investor preferences beyond the single dimension of risk-tolerance. *Disagreement* refers to heterogeneous expectations. Lintner (1969) was the first to extend the CAPM to allow for *heterogeneous* expectations. Later, we demonstrate through applied examples based on FF, that in the PAPM, both tastes and disagreement, lead to *different* asset prices than the CAPM. When discussing those differences, we refer to difference emanating from disagreement as a form of *mispricing*. In Fama's Nobel lecture, Fama (2014, p. 1482), referring to tastes, Fama writes, "*This is a behavioral story, but it is not about irrational behavior. In economics, we take tastes as given, and make no judgements about them.*"

The PAPM model posits an equilibrium with both heterogeneous investor *preferences/tastes* for security characteristics and heterogeneous *expectations* or *opinions* about the cash flows or values that corporations supply. The equilibrium prices are formed from the aggregate weighted (by wealth and risk aversion) averages of investor tastes and disparate expectations.

1.2 APT and the quest for multiple factors

As early as the 1970s, it was understood that multiple factors are likely contribute to asset prices.

The APT is the most well-known of these multi-factor *asset pricing models*. The APT presupposes that the economy *supplies* returns in a multi-factor linear structure. Since these risk factors are systematic, they are not eliminated by arbitrage, and each factor is priced in an isolated long/short portfolio.

Separate from arbitrage-based approaches, but in pursuit of multiple *priced* factors, Eugene Fama and Ken French are well-known for the so-called "Fama–French factors" of high-minus-low (HML) or value/growth factor and small-minus-big (SMB) or size factor (Fama and French, 1992). FF (1992) proposed these as potential *pricing* factors, but practitioners have primarily used them as *attribution* factors to describe realized returns (see, Idzorek *et al.*, 2024).

From a practical perspective, a useful multi-factor asset pricing model is needed.

2 The PAPM: An Asset Pricing Model with Disagreement, Tastes, and Multiple Factors

The PAPM is related to a wide variety of prior research worth noting. The PAPM of Ibbotson *et al.* (2018), henceforth referred to as IIKX, assumes homogeneous expectations. Importantly, in this article we expand the PAPM to include heterogeneous expectations. The PAPM is inspired by the New Equilibrium Theory (NET) of Ibbotson *et al.* (1984). However, the PAPM expands beyond the classical preferences of NET (e.g. various dimensions of risk, liquidity, tax-efficiency) to include behavioral preferences (e.g. value, ESG, reputation, brand preference). Ibbotson and Idzorek (2014) and Idzorek and Ibbotson (2017) build upon and provide additional rationale for the New Equilibrium Theory by including tastes in the set of things that matter to investors. The PAPM formalizes the NET framework into an asset pricing model that allows for *any* type of systematic investor preference to be priced, whether risk or non-risk, rational or irrational, classical or behavioral.

Much of the recent literature on tastes focuses on ESG as a consumption good. For example, Zerbib (2020) develops an asset pricing model that incorporates tastes for green stocks and an exclusionary preference regarding sin stocks. Barber *et al.* (2021) demonstrate that investors derive non-pecuniary utility from investing in impact-oriented venture capital funds and are willing to sacrifice substantial returns. Friedman and Heinle (2016) put forth a model that shows how investor tastes for corporate social responsibility impacts demand for shares. Cooper *et al.* (2016) present a multi-characteristic model of portfolio construction that is very similar to the PAPM, where the characteristics are various social impact metrics.

In the behavioral finance literature, the idea of popularity is most closely linked to affect (Zajonc, 1980). Shefrin and Statman (2000) introduce what they call "behavioral portfolio theory" to address the Friedman and Savage (1948) puzzle in which people who buy insurance policies often also buy lottery tickets. Behavioral finance drops the assumption of rationality.

The vast majority of these asset pricing models are consistent with the PAPM, in which the desired characteristics have high prices and lower expected returns. The PAPM would seem to provide an overarching rationale, "popularity," that helps to unite many of the numerous asset pricing models and studies under a generalized equilibrium model.

3 The Popularity Asset Pricing Model

We leave most of the details of the PAPM to the Appendix. Here, we discuss a key to understanding the PAPM; namely, the optimization problem that each investor solves. Equation (1) says the utility of investor i is expected excess return, plus a non-pecuniary benefit, minus a personalized penalty for risk.

$$\max_{\vec{\boldsymbol{x}}_i} \underbrace{U_i(\vec{\boldsymbol{x}}_i)}_{\substack{\text{Utility for} \\ \text{investor } i}} = \underbrace{\vec{\boldsymbol{\mu}}_i{}'\vec{\boldsymbol{x}}_i}_{\substack{\text{Expected} \\ \text{Return}}} + \underbrace{\vec{\boldsymbol{\phi}}_i{}'\boldsymbol{C}'\vec{\boldsymbol{x}}_i}_{\substack{\text{Nonpecuniary} \\ \text{Benefit}}} - \underbrace{\frac{\lambda_i}{2}\underbrace{\vec{\boldsymbol{x}}_i{}'\boldsymbol{\Psi}\vec{\boldsymbol{x}}_i}_{\text{Variance}}}_{\text{Penalty for Risk}} \tag{1}$$

where

n = the number of risky securities in the market
p = the number of non-pecuniary characteristics
$\vec{\boldsymbol{\mu}}_i$ = the n-element vector of expected security returns in excess of the risk-free rate, reflecting investor i's views (the source of disagreement)
$\boldsymbol{C}$ = $n \times p$ matrix of characteristic exposures of the securities

$\vec{\boldsymbol{\phi}}_i$ = p-element vector of investor i's attitudes (tastes) toward the characteristics (The elements can be positive, negative, or zero.)

$\boldsymbol{\Psi}$ = the $n \times n$ variance–covariance matrix of returns on the risky securities

$\vec{\boldsymbol{x}}_i$ = the n-element vector of investor i's allocations (portfolio weights) to the risky securities with the remainder going into a long/short position in the risk-free asset

λ_i = the risk aversion parameter of investor i

This is similar to the mean–variance optimization of Markowitz (1952, 1959, 1987) objective function, with investors differing in their estimates of expected excess returns (the source of disagreement), as in Lintner (1969). Equation (1) has one critical addition; namely, it includes a new term that captures the degree to which the investor derives utility or disutility from investments with characteristics that they like and investments with characteristics that they dislike—each investor's tastes. The specific values of phi ($\vec{\boldsymbol{\phi}}_i$) capture the degree to which investors like/dislike a given characteristic on a scale (e.g., love, like, neutral, dislike, hate) and matrix C identifies the exposures of the securities to the different characteristics. Equation (1) incorporates each investor's non-pecuniary tastes and pecuniary views serving as a clear recipe for personalized portfolio construction that in turn leads to equilibrium prices.

With each investor solving the problem in Equation (1) to arrive at their individual portfolio, we *aggregate* across all investors to arrive at the demand for each security. We then equate demand and supply and simultaneously solve for the equilibrium prices of all securities. In the Appendix, we show that in equilibrium, Equation (2) holds. The expected excess return on security j is the beta of the security to the market portfolio multiplied by the market premium (just as it is in the CAPM), plus a linear series of "popularity" premiums/discounts.

$$\underbrace{\mu_{Mj}}_{\substack{\text{Average PAPM}\\ \text{Expected Excess}\\ \text{Return for}\\ \text{security } j}} = \underbrace{\beta_j \mu_M}_{\substack{\text{CAPM Expected}\\ \text{Excess Return for}\\ \text{security } j}} + \underbrace{\textstyle\sum_{k=1}^{p} \delta_{jk} \pi_k}_{\substack{\text{Linear Popularity}\\ \text{Premiums /}\\ \text{Discounts}}} \tag{2}$$

where

μ_{Mj} = average PAPM equilibrium expected excess return on security j (market-weighted average of investors averaging out all disagreements)

β_j = beta of security j relative to the market portfolio

μ_M = expected market risk premium (above the risk-free rate)

δ_{jk} = exposure of security j to characteristic k

π_k = popularity premium of characteristic k (the aggregation of all investor tastes)

Note how the PAPM incorporates the two missing ingredients identified in FF—*tastes* and *disagreement*—and in the spirit of APT and the Fama–French factors, can have a *multiple linear factor structure*.

4 Contrasting the CAPM, APT, and PAPM

The CAPM and the PAPM are *equilibrium* asset pricing models, in which prices are determined in part by investor *preferences* or *demand* for various security characteristics. APT relies on an arbitrage argument.

The practical distinction between equilibrium and arbitrage models is in what the two approaches say about prices. Arbitrage models describe the relationships *between* security prices in a law-of-one-price world enforced through arbitrage, but arbitrage models do not explain how root prices are formed. In contrast, equilibrium models, such as the CAPM and PAPM, explain security prices in terms of both the characteristics of the securities and the preferences of investors. In the PAPM, aggregate investor preferences lead to endogenous popularity premiums, while APT factors are exogenous and APT risk premiums are not explicitly derived from investor preferences. The PAPM is the generalized asset pricing model that encompasses the CAPM as well as many of the new ESG-specific models, allowing for *any* number of asset characteristics and a wide range of investors with various tastes and expectations.

Both the PAPM and the APT result in a linear structure of expected returns, in which there are likely multiple factors. However, the PAPM helps identify the factors in the linear structure, since it starts with some idea as to what sort of characteristics investors in aggregate like (liquidity, ESG, brands, etc.) or dislike (market risk, downside risk, negative asymmetry, etc.). As such, the PAPM is every bit as practical as the APT, perhaps more so. Importantly, unlike the APT factors, the PAPM characteristics do not have to be risk related, just *liked* or *disliked* by enough investors.

Table 1 summarizes key aspects of the CAPM, APT, and PAPM. The cells are color coded with green highlighting when the PAPM is similar to the other models and orange indicating where there are differences. In our view, the key assumptions of the PAPM are far more realistic than those of the CAPM and APT, and thus more practical. The APT *assumes* a linear structure, while the linear structure of the PAPM is not an

Table 1 Key theoretical differences between the CAPM, APT, and PAPM.

	CAPM	**APT**	**PAPM**
Model type	Equilibrium	Arbitrage	Equilibrium
Key assumptions	Perfect capital markets; homogeneous expectations; risk aversion	Multi-factor structure; complete markets (no arbitrage opportunities)	Tastes and diverse opinions
Multi-factor structure	No	Yes	Yes
Source of linearity	Pecuniary-only utility function	Linearity is assumed	Pecuniary and non-pecuniary utility function
Tastes	Single risk	Multi-risks	Multi-risks and non-risks
Driver of asset prices	Investor demand	Economy supply	Investor demand
Mispricing allowed	No	No	Yes, due to disagreement
Portfolio construction	Levered/unlevered market portfolio	Personalized	Personalized
Reasons for personalization	N/A	External to model	Diverse opinions and tastes

assumption, rather it *flows* from the underlying utility functions of the investors linking portfolio formation to asset prices. Arguably, practitioners will find most, if not all, of the key aspects of the PAPM more realistic than those of the CAPM and APT.

Practitioners know that the market is not perfectly efficient (even if the market is hard to beat). With the PAPM, both tastes and disagreement individually and collectively lead to asset prices that differ from what they would be if the CAPM held; thus, the market is *not* necessarily efficient. If the CAPM does not hold, portfolio construction is more complicated than simply levering/delivering the market portfolio. In fact, portfolio construction under the CAPM and PAPM are very different. Under the CAPM, all investors should divide their wealth between the market portfolio and cash (long or short). Hence, with the CAPM portfolio optimization is not needed. With the PAPM, portfolio optimization is how investors arrive at their personalized portfolios that reflect their tastes and expectations. Thus, the PAPM provides a theoretical justification and practical objective function for building personalized portfolios that align with what is often observed in practice.

5 Demonstrating the PAPM Based on Fama and French (2007)

We now demonstrate through an example based on FF, that in the PAPM, both tastes and disagreement lead to *different* asset prices than the CAPM.

With regard to tastes, FF postulates two groups of investors: those who have no tastes for assets as consumption goods, and those who do. Similarly, FF frames the discussion of disagreement around the assumption that there are two groups of investors: *informed* and *misinformed*.

FF provides *empirical* evidence that both tastes and disagreement impact asset prices, but in the absence of a formal model, they are unable to disentangle if the root cause of the impact stems from (a) tastes for investments as consumption goods (e.g., Daniel and Titman, 1997; Geczy *et al.*, 2005) or (b) disagreement. Armed with the PAPM, we can untangle the contribution of tastes and disagreement to pricing differences relative to the CAPM, and prove that both impact asset prices.

To illustrate the joint impact of tastes and disagreements, we consider a world with four investors with equal wealth and the same level of risk aversion and use the PAPM model that allows for *both* tastes and heterogeneous expectations put forth in the Appendix to solve for equilibrium asset prices. The four investors are:

Investor 1: Informed investor with *no* preferences/tastes

Investor 2: Informed investor with preferences/tastes

Investor 3: Misinformed investor with *no* preferences/tastes

Investor 4: Misinformed investor with preferences/tastes

We assume that the two investors with preferences/tastes (Investors 2 and 4) both prefer the characteristic(s) embodied by the riskier asset, so it is the popular asset. Next, we assume that the two misinformed investors (Investors 3 and 4) are overestimating the expected ending value (and therefore expected return) of the riskier popular asset and underestimating the expected ending value (and therefore expected return) of the less risky unpopular asset. Of course, under any permutation or expansion of this example (including more investors, more securities, more disagreement, a wide variety of numerous preferences/tastes, a range of wealth levels, and a range of risk aversion), the PAPM can be solved for equilibrium prices (and expected returns).

In this demonstration of the PAPM, the riskier asset has a higher price for two reasons: two of the investors (Investors 3 and 4) are overestimating its expected ending value (underestimating its expected return) and two of the investors (Investors 2 and 4) desire its characteristic(s). The less risky asset has a lower price (higher expected return) for the opposite reasons.

To illustrate the differences between the PAPM and the CAPM, we also solved for the equilibrium asset prices (and expected returns) under the CAPM (no tastes and no disagreement). In Figure 1, the risk and expected return plot point of the liked and overvalued riskier asset (red square) is 103 basis points lower than it would be under the CAPM (a pricing difference of 0.97%). Conversely, the plot point of the unliked and undervalued less risky asset (green square) is 97 basis points higher than it would be under the CAPM (a pricing difference of 0.94%).

Investor 1, the informed investor with no preferences/tastes, correctly identifies the true tangent portfolio (orange triangle) and levers it up based on their risk aversion preference (to the black diamond on the orange line). Investor 1 is the classical "homo economicus" and, in the PAPM, is expected to outperform both by better forecasting and taking advantage of the preferences/tastes of other investors.

The risk and expected return of the portfolios of Investors 2 and 3 are somewhat similar, but for different reasons.

Investor 2, the informed investor with preference/tastes, has the correct expected ending values for the two assets, but knowingly tilts their portfolio toward the overvalued asset that embodies the characteristic(s) they prefer. As an

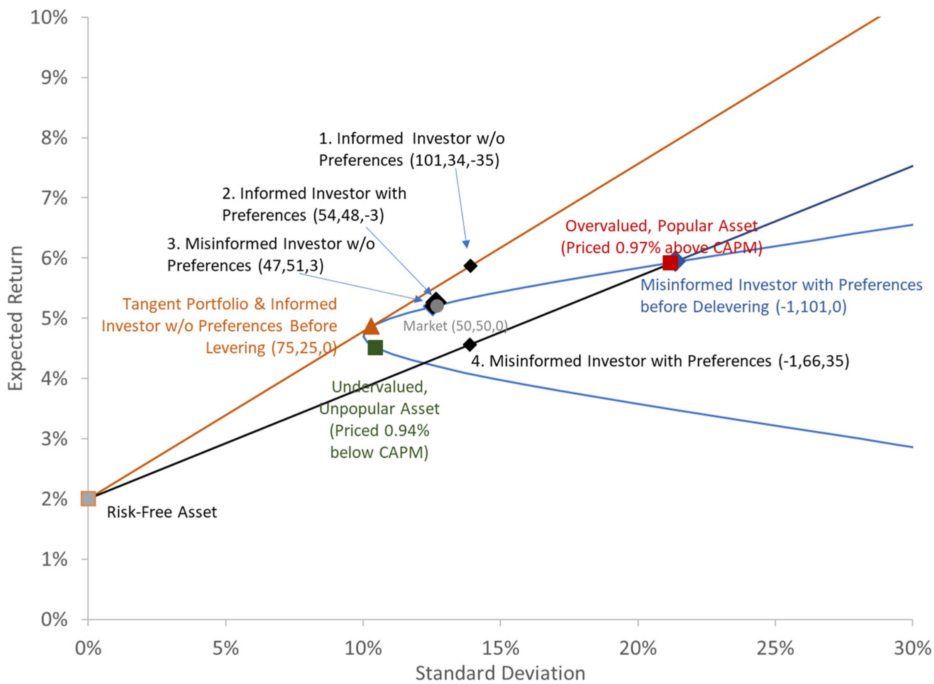

Figure 1 PAPM with preferences/tastes and *heterogeneous* expectations (disagreement).

*Parentheses identify percentage allocated to: unpopular asset, popular asset, risk-free rate.

example, one might think of Investor 2 as an *informed* ESG investor with an ESG mandate. As a result, the Sharpe Ratio (Sharpe, 1994) of their portfolio is somewhat lower than that of Investor 1.

Investor 3, the misinformed investor with no preferences/tastes, incorrectly assesses the expected ending values for the two assets. As a result, the actual (as opposed to perceived) Sharpe Ratio of their portfolio is also somewhat lower than that of Investor 1.

Investor 4, the misinformed investor with preferences/tastes, incorrectly assesses the expected ending values for the two assets, and also tilts their portfolio toward the asset with the characteristic(s) they prefer. Investor 4 might be thought of as a *misinformed*, ESG investor who selects their portfolio based on both their misinformation and on socially responsible characteristic(s). As a result, the actual Sharpe Ratio of their portfolio is the lowest of the four investors.

Table 2 compares the actual Sharpe Ratios, betas, and Jensen's alphas (Jensen, 1968) of the true tangent portfolio, the market portfolio, and the portfolios of the four investors. The market portfolio is the aggregate of the four investors' portfolios. With the exception of the tangent portfolio, in this illustration all the portfolios have a beta indistinguishable from 1 relative to the market portfolio. Investor 4, the misinformed investor with preferences/tastes, is expected to underperform. In this illustration, Investors 2 and 3, the informed investor with preferences/tastes and the misinformed investor with no preferences/tastes, arrive at actual Sharpe Ratios close to that of the market portfolio. The positive Jensen's alphas of the portfolios of the informed investors (1 and 2) are offset by the negative Jensen's alphas of the portfolios of the misinformed investors (3 and 4) and the Jensen's alpha of the market portfolio is zero. The differences in portfolios and their portfolio statistics are due to both disagreement and preferences/tastes. We did not include betas relative to the tangent portfolio in Table 2, but we could equivalently express expected returns relative to the tangent portfolio, in a manner similar to the CAPM.

By incorporating both tastes and disagreement, the PAPM subsumes a number of other asset pricing models as special cases, including the CAPM and many of the newer ESG asset pricing models. For example, Pedersen *et al.* (2020), which is frequently cited and could be viewed as a specific illustration of the PAPM, presents a model in which ESG is not only a consumption good, but also impacts investor expectations regarding the future payoffs of assets. Pedersen *et al.*'s (2020) model does *not* include an investor who is misinformed and has preferences/tastes (our Investor 4), and importantly, the PAPM allows for any number of tastes beyond those related to ESG.

Table 2 Actual Sharpe Ratios, betas, and Jensen's alphas of portfolios resulting from preferences/tastes and disagreement.

	Tangent portfolio	Market portfolio	Investor 1 (informed/ no tastes)	Investor 2 (informed/ with tastes)	Investor 3 (misinformed/ no tastes)	Investor 4 (misinformed/ with tastes)
Sharpe Ratio	0.278	0.254	0.278	0.257	0.250	0.184
Beta	0.74	1.00	1.00	1.00	1.00	1.00
Jensen's alpha	0.48%	0.00%	0.65%	0.05%	−0.05%	−0.65%

5.1 *APT, limits to leverage, and an informed pseudo-arbitrage*

If the APT holds, the potential impact of any tastes not related to undiversifiable systematic risk on expected returns should be arbitraged away. Again, APT assumes that the economy supplies multiple systematic sources of risk and return, and that these systematic risks cannot be removed by arbitrage. Critically, *any* other factors would not be priced since their impact would be removed by arbitrage.

Stemming from Friedman (1953), Fama (1965), and others, many believe that the actions of informed investors eventually eliminate the mispricing caused by misinformed investors.[1] In this section, we introduce a 5th investor into our example of a PAPM equilibrium. One might think of this 5th investor as an informed pseudo-arbitrager with no preferences/tastes, who, although not truly risk-neutral, is much less risk averse than the other four investors, and as such, counteracts mispricing. We can think of each investor as representing a category of investors.

From an efficient market hypothesis' (EMH) perspective, there should be no arbitrage opportunities or mispricing. However, from an equilibrium perspective, risk-averse informed investors do not fully offset the price effects of the misinformed (and presumably those with tastes) as demonstrated in Figure 1. Here, our goal is to further demonstrate the limited impact of an arbitrage-like investor on asset prices and corresponding price difference *relative to the CAPM* within the PAPM context.

Building on the four-investor example, we reduce the amount of wealth controlled by the original four investors from 25% each to 24% each, so that a 5th investor, a pseudo-arbitrager, controls 4% of wealth. The first row of Table 3 presents the base case depicted in Figure 1 prior to the introduction of the 5th investor. Notice within Figure 1 the asset that is overpriced by 0.970% and the asset that is underpriced by 0.945% (relative to the CAPM price). We continue to assume that the original four investors all have risk aversion coefficients of 2.0, and then we vary the risk aversion coefficient of the 5th investor using values of 2.0, 0.5, 0.1, 0.01, and 0.001, respectively. The ensuing rows of Table 3 identify the degree to which the two assets are priced differently from the CAPM under the five risk aversion scenarios.

The introduction of Investor 5 decreases the amount of price differences relative to the CAPM, moving from nearly 1% to 1/100 of 1%. Under each scenario in sequence, Investor 5 uses more

Table 3 Price difference relative to CAPM under varying risk aversion levels for Investor 5.

Risk aversion of Investor 5	Price difference relative to CAPM of overpriced/ liked asset	Price difference relative to CAPM of underpriced/ disliked asset	Investor 5: allocation to overpriced/ liked asset	Investor 5: allocation to underpriced/ disliked asset	Investor 5: allocation to risk-free asset
No Investor 5	0.970%	−0.945%	N/A	N/A	N/A
2.0	0.931%	−0.907%	34.35%	99.32%	−33.67%
0.5	0.828%	−0.809%	122.48%	355.27%	−377.75%
0.1	0.522%	−0.514%	387.92%	1,135.61%	−1,423.53%
0.01	0.101%	−0.101%	756.90%	2,245.27%	−2,902.17%
0.001	0.011%	−0.011%	836.43%	2,488.43%	−3,224.86%

and more leverage investing in a tangent portfolio that strongly favors the lower valued asset, whose large demand for the lower valued asset decreases the amount of price differences relative to the CAPM. As can be seen in Table 3, it takes an unrealistic amount of leverage and willingness to take risk for an arbitrager to significantly remove the impact of tastes and disagreement mispricing from the market.

While our PAPM model is very different from the model of Shleifer and Vishny (1997), this example demonstrates that arbitragers could potentially eliminate the price impact of tastes and mispricing from disagreement, but that is highly unlikely to occur because real-world investors are risk averse and are constrained in the amounts of leverage they can take and would take, given that such a trade would not be a riskless arbitrage.

Continuing with this example, we solve the PAPM for a full spectrum of risk aversion coefficients for Investor 5. As the risk aversion coefficient of Investor 5 approaches zero, the amount of leverage used by Investor 5 increases dramatically, and the amount of mispricing relative to the CAPM asymptotically approaches zero. As such, in the presence of a truly risk-neutral arbitrager, neither disagreement nor preferences/tastes would lead to pricing differences from the CAPM. Consistent with the PAPM and a world in which markets are not perfectly efficient, neither the price impact of tastes nor mispricing is likely to be eliminated, because there is no risk-free arbitrage here. Instead, Investor 5 is likely to have some aversion to risk and extreme leverage, so there are *limits to leverage*. This is illustrated graphically in Figure 2. The red line in Figure 2 correspond to the overvalued/liked asset (red square in Figure 1)

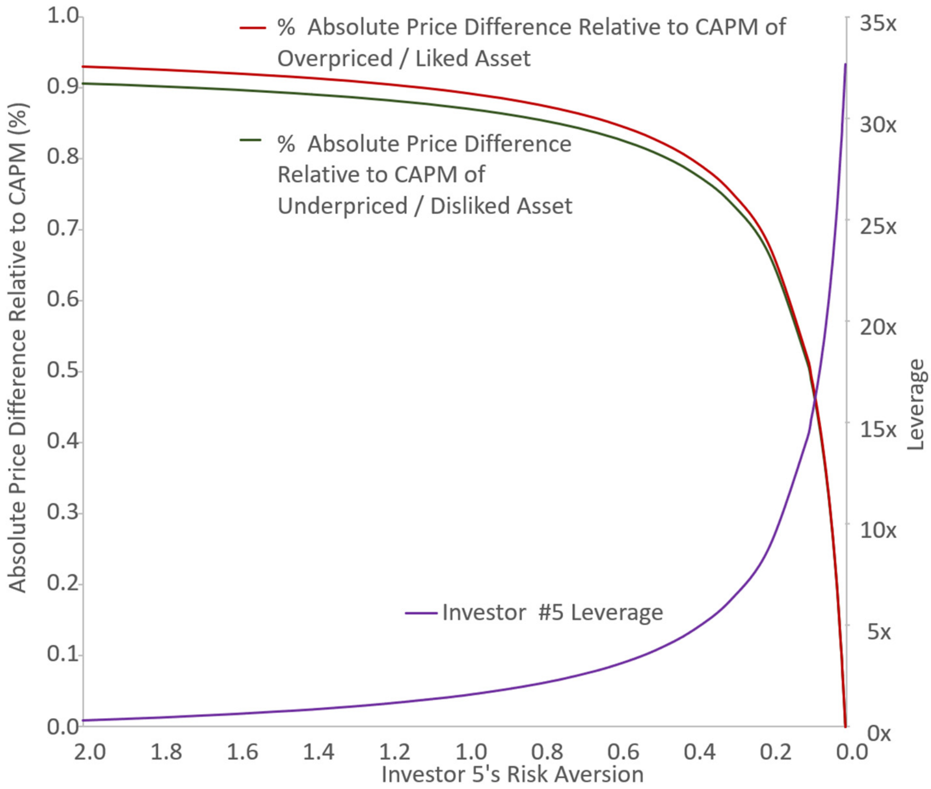

Figure 2 CAPM versus PAPM price differences for different risk aversion levels of Investor 5 (pseudo-arbitrager).

and the green line in Figure 2 corresponds to the undervalue/disliked asset (green square in Figure 1). The left axis shows the absolute price difference between the CAPM price and the PAPM price for the two assets in the example for different levels of Investor 5 leverage (in purple and corresponding to the right axis).

Figure 2 also illustrates how difficult it would be to arbitrage pricing factors, as in the APT (assuming the pricing factors were known). In the real world, investors do not agree on the pricing factors nor how to estimate them. While it may be relatively easy to arbitrage prices that are direct derivatives of one another, as in option-pricing models, from a practical perspective it is nearly impossible to arbitrage asset prices involving unknown APT-like factors. Even if one knew the factors, one would not know how the price of each asset embeds exposure to the factors, nor the factor payoffs.

6 Practical Implications

Asset pricing models are used in many contexts including portfolio construction, cost of capital estimation, as a discount rate in valuation, and as a way to identify mispriced securities. In these contexts, the PAPM has a number of practical benefits for practitioners.

The PAPM rests on assumptions that are realistic: prices are based on investor tastes and expectations. With the PAPM, investors now have a pricing model that aligns with the way they actually think about investments. Investors do not have to rely on the CAPM, in which only one dimension of risk is priced, and everyone is assumed to have the same market expectations. Nor do they have to rely on the APT, which assumes an unspecified set of priced multiple linear risk factors, with arbitrage removing all other factors.

In the PAPM, as we discussed with Equation (1), investors construct personal portfolios that reflect their individual tastes and expectations. This differs from the CAPM, in which everyone has identical expectations, invests in the market portfolio, and then either levers or delevers the market portfolio. This also differs from the world assumed by the APT, a world in which investors only need to consider a small set of risk factors in constructing their personal portfolios, so long as they eliminate unsystematic risk through diversification. In the PAPM, investors maximize their utility by creating an optimized personal portfolio reflecting their expectations as well as the degree to which they like/dislike different security characteristics. A more detailed presentation of the formal process of constructing personalized portfolios based on the PAPM objective function that is a direct extension of the Markowitz portfolio selection (with taxes, trading costs, etc.) is found in Idzorek and Kaplan (2022, 2024) and Idzorek (2023). Even though many practitioners will never use optimization, the PAPM provides a rationale for the various ways that personalized portfolios are constructed based on the investors' return expectations (disagreement) and non-pecuniary preferences (tastes) to arrive at utility maximizing portfolios that tilt toward/away from the characteristics they like/dislike.

The PAPM provides a rich and practical structure for thinking about capital markets, asset prices, and the drivers of expected returns. As documented in IIKX, there is a popularity-based explanation for the vast majority of realized premiums and discounts in which exposure to liked characteristics have historically underperformed and exposure to disliked characteristics have historically outperformed.

Equation (2) presents a linear formula for expected excess return. Given that it may be difficult to arrive at the various popularity premiums of Equation (2), per Equation (3) we propose the various taste premiums be expressed in a high-minus-low format as a generalization of the Fama–French 3-factor model. In this context, market exposure and exposures to non-pecuniary characteristics can be measured as coefficients in the following time-series regression equation:

$$R_{jt} - R_{Ft} = \beta_j(R_{Mt} - R_{Ft}) + \sum_{k=1}^{p} \gamma_{jk}(R_{kt}^H - R_{kt}^L) + \varepsilon_t \quad (3)$$

where:

R_{jt} = security j's return for month t
R_{Ft} = risk-free return for month t
β_j = security j's market beta
R_{Mt} = market return for month t
γ_{jk} = security j's regression coefficient for characteristic k
R_{kt}^H = return on a portfolio of securities with high exposure to characteristic k
R_{kt}^L = return on a portfolio of securities with low exposure to characteristic k
ε_t = security j's residual return for month t (expected value is not zero with mispricing, showing up as a constant alpha in a regression)

Based on Equation (3), we have the following equation for expected excess return:

$$\mu_{Mj} = \beta_j \mu_M + \sum_{k=1}^{p} \gamma_{jk} \Pi_k \quad (4)$$

Where Π_k is the taste premium for characteristic k, expressed in the familiar Fama–French high-minus-low format.[2] These high-minus-low taste premiums can potentially be measured over long historical time periods, since we usually consider the taste premiums to be relatively stable over time, with the estimation error decreasing with the square root of time.

We expect that this linear structure with factor loadings and premiums is familiar to most readers of this article. It may look similar to the APT, but with the PAPM, the premiums can be associated with risk and *non-risk* characteristics, and the tastes that are priced are limited to the set of tastes that are systematically liked/disliked in aggregate across all investors and reflected in their personalized portfolios. In the equilibrium solution to the model, the investors are weighted in aggregate by their wealth, but inversely weighted by their risk aversion. Similar to Lintner (1969), in the equilibrium solution, investors opinions are also weighted by risk aversion and wealth.

As discussed in the Appendix, in the PAPM, prices reflect the aggregation of both tastes and expectations. The potential mispricing stemming from disagreement in the PAPM presents a rationale for active management. Those who are more informed can expect to earn a positive alpha over and above the market wide premiums associated with aggregate tastes. We illustrated this in Figure 1 and Table 2. In contrast, those who are less informed (and know it) should seek to hold passive portfolios, with little trading, but still reflecting their tastes.

We illustrated in Figure 2 and Table 3 that a well-informed investor with no non-pecuniary preferences and a very low level of risk aversion would need to take on extreme levels of leverage to drive asset prices to CAPM prices. The PAPM with disagreement allows for mispricing and provides a path as to how to identify undervalued securities that are overlooked (unpopular), or overvalued securities that are too popular.

Thus, in the PAPM, with its realistic assumptions, investors construct personalized portfolios, factor premiums are based on risk and non-risk security characteristics, and there can be mispricing that can be exploited in active management. Table 4 summarizes the practical implications

Table 4 Practical implications of the CAPM, APT, PAPM of IIKX, and PAPM.

Asset pricing model	Major assumptions	Personalized portfolios	Expected return model	Residual risk
CAPM[a]	Risk aversion	Risk aversion	Security market beta × market risk premium	Not priced; explains security specific realized returns
APT[a]	Multi-factor linear risk structure	Individual risk preferences	Multiple risk loadings × *risk* premiums	Not priced; explains security specific realized returns
PAPM of IIKX[a]	Tastes (likes/dislikes)	Individual tastes	Multiple loadings × risk and *non-risk* premiums	Not priced; explains security specific realized returns
PAPM	Tastes (likes/dislikes) and diverse return expectations (disagreement)	Individual tastes and return expectations	Multiple loadings × risk and *non-risk* premiums	Disagreement leads to mispriced securities.

[a]Assumes homogeneous expectations (no disagreement).

of the CAPM, the APT, the PAPM of IIKX (no disagreement), and the full PAPM (with disagreement).

7 Conclusions

The CAPM and the APT of the 1960s and 1970s are the dominate textbook asset pricing models influencing how practitioners think about asset prices and portfolio formation. The CAPM is an *equilibrium* model that prices assets via expected returns, assuming *homogeneous* expectations and risk aversion as the sole preference. Both practitioners and academics are troubled by a variety of asset pricing anomalies relative to the CAPM and the restrictive assumptions that investors do not have preferences beyond risk aversion and that all investors share the same expectations. The APT posits a linear multi-factor structure of returns, priced through arbitrage. Yet, it does not provide a theory as to what are the factors or what is the factor structure, since the linearity is assumed.

Fama and French (2007) identify "tastes" and "disagreement" as two ingredients that impact asset prices that are missing from the CAPM, but stopped short of developing an asset pricing model that incorporates either. The PAPM achieves this as a generalized equilibrium model with less restrictive assumptions than the CAPM, expanding the CAPM to allow for any number of risk and non-risk preferences regarding any number of security characteristics, with diverse investor expectations. Important insights and conclusions include:

- In the CAPM, there is only one "taste" and that is a single dimension of risk aversion. The CAPM assumes homogeneous expectations, so there is no "disagreement."
- Both the APT and the PAPM have a linear structure, but in the APT an unknown factor structure is supplied by the economy, whereas in the PAPM the structure arises out of the investor demand for security characteristics, which need not be risk based.
- The PAPM of IIKX is a model which prices "tastes," but assumes homogeneous expectations/no disagreement. Characteristics that are

nearly universally liked are in high demand (popular) and thus are expensive, leading to lower expected returns; while conversely, characteristics that are nearly universally disliked are in low demand (unpopular) and thus are inexpensive, leading to higher expected returns.

- The PAPM with "disagreement" leads to mispricing, inefficient markets, and the potential for active management.
- The CAPM, as well as a number of new ESG equilibrium asset pricing models, are special cases of the PAPM, which allows for any number of tastes for any number of characteristics and disagreement.

The PAPM leads to powerful conclusions and important real-world implications for practitioners. By allowing for a variety of investor preferences/tastes and incorporating diverse opinions, the PAPM takes two major steps toward a more realistic asset pricing model, with a theoretically driven multi-factor linear structure. The PAPM helps practitioners to better value assets, estimate cost of capital, and form personalized portfolios.

Appendix Formal Presentation of the PAPM with Heterogeneous Expectations

We develop the PAPM as an extension and generalization of the CAPM that specifically addresses the two unrealistic assumptions of no disagreement and no tastes. For a formal presentation of the CAPM, and the PAPM with *homogeneous* expectations, please see Appendices B and C of IIKX. Here we focus only on the new contribution of this article, the extension of the PAPM to also include heterogeneous expectations.

Investor i's problem is:

$$\max_{\vec{\boldsymbol{x}}_i} U_i(\vec{\boldsymbol{x}}_i) = \vec{\boldsymbol{\mu}}_i'\vec{\boldsymbol{x}}_i + \vec{\boldsymbol{\phi}}_i'\boldsymbol{C}'\vec{\boldsymbol{x}}_i - \frac{\lambda_i}{2}\vec{\boldsymbol{x}}_i'\boldsymbol{\Psi}\vec{\boldsymbol{x}}_i \tag{A.1}$$

Where

n = the number of risky securities in the market

$\vec{\boldsymbol{x}}_i$ = the n-element vector of investor i's allocations (portfolio weights) to the risky securities with the remainder going into a long/short position in the risk-free asset

$\vec{\boldsymbol{\mu}}_i$ = the n-element vector of expected security returns in excess of the risk-free rate, reflecting investor i's views

p = the number of popularity characteristics

$\boldsymbol{C}$ = $n \times p$ matrix of characteristic exposures of the securities

$\vec{\boldsymbol{\phi}}_i$ = p-element vector of investor i's attitudes toward the characteristics (The elements can be positive, negative, or zero.)

$\boldsymbol{\Psi}$ = the $n \times n$ variance–covariance matrix of returns on the risky securities

λ_i = the risk aversion parameter of investor i

This is similar to the Markowitz mean–variance problem, although Equation (A.1) contains an additional term (middle term on the right-hand side) that captures popularity characteristics and investor i's additional preferences serving as a clear recipe for personalized portfolio construction based on unique forecasts and preferences. This is similar to the utility functions of Baker *et al.* (2020) and Cooper *et al.* (2016). Investor *preferences* for different characteristics can be driven by expectations around popularity premiums.

From the first-order condition, we have:

$$\vec{\boldsymbol{\mu}}_i = \lambda_i\boldsymbol{\Psi}\vec{\boldsymbol{x}}_i - \boldsymbol{C}\vec{\boldsymbol{\phi}}_i \tag{A.2}$$

The solution is:

$$\vec{\boldsymbol{x}}_i = \frac{1}{\lambda_i}\boldsymbol{\Psi}^{-1}(\vec{\boldsymbol{\mu}}_i + \boldsymbol{C}\vec{\boldsymbol{\phi}}_i) \tag{A.3}$$

Aggregating Equation (A.3) across investors, we have the security weights of the market portfolio:

$$\vec{\boldsymbol{x}}_M = \frac{1}{\lambda_M}\boldsymbol{\Psi}^{-1}(\vec{\boldsymbol{\mu}}_M + \boldsymbol{C}\vec{\boldsymbol{\pi}}) \tag{A.4}$$

Letting

m = the number of investors
w_i = the fraction of wealth held by investor i; $\sum_{i=1}^{m} w_i = 1$

Then, λ_M, $\vec{\boldsymbol{\mu}}_M$, $\vec{\boldsymbol{x}}_M$, and $\vec{\boldsymbol{\pi}}$ are:

$$\lambda_M = \frac{1}{\sum_{i=1}^{m} \frac{w_i}{\lambda_i}} \tag{A.5}$$

$$\vec{\boldsymbol{\mu}}_M = \lambda_M \sum_{i=1}^{m} \frac{w_i}{\lambda_i}\vec{\boldsymbol{\mu}}_i \tag{A.6}$$

$$\vec{\boldsymbol{x}}_M = \sum_{i=1}^{m} w_i \vec{\boldsymbol{x}}_i \tag{A.7}$$

$$\vec{\boldsymbol{\pi}} = \lambda_M \sum_{i=1}^{m} \frac{w_i}{\lambda_i}\vec{\boldsymbol{\phi}}_i \tag{A.8}$$

$\vec{\boldsymbol{\pi}}$ is the p-element vector of aggregate wealth and risk aversion-weighted investor preferences for different characteristics, and for reasons that will become apparent below, we call $\vec{\boldsymbol{\pi}}$ the vector *of popularity premiums*. Combining the matrix of security characteristics with the vector of popularity premiums, $\boldsymbol{C}\vec{\boldsymbol{\pi}}$ leads to an n-element vector of popularity-based adjustments that augment the market expected returns and impact the market portfolio.

From Equations (A.3) and (A.4), we derive an equation for the portfolio decision of each investor, relative to the market portfolio:

$$\vec{\boldsymbol{x}}_i = \frac{\lambda_M}{\lambda_i}\vec{\boldsymbol{x}}_M + \frac{1}{\lambda_i}\boldsymbol{\Psi}^{-1}[(\vec{\boldsymbol{\mu}}_i - \vec{\boldsymbol{\mu}}_M) + \boldsymbol{C}(\vec{\boldsymbol{\phi}}_i - \vec{\boldsymbol{\pi}})] \tag{A.9}$$

Hence, both differences in expected returns from market averages and differences in popularity preferences from market averages impact individual portfolio construction.

Solving Equation (A.4) for $\vec{\boldsymbol{\mu}}_M$ yields:

$$\vec{\boldsymbol{\mu}}_M = \lambda_M \boldsymbol{\Psi}\vec{\boldsymbol{x}}_M - \boldsymbol{C}\vec{\boldsymbol{\pi}} \tag{A.10}$$

Multiplying Equation (A.10) through by $\vec{\boldsymbol{x}}'_M$ yields:

$$\mu_M = \lambda_M \sigma_M^2 - \vec{\boldsymbol{c}}'_M \vec{\boldsymbol{\pi}} \tag{A.11}$$

where $\vec{\boldsymbol{c}}_M = \boldsymbol{C}'\vec{\boldsymbol{x}}_M$, which is the vector of security characteristic exposures of the market portfolio.

From Equation (A.11), it follows that:

$$\lambda_M = \frac{\vec{\boldsymbol{\mu}}_M + \vec{\boldsymbol{c}}'_M\vec{\boldsymbol{\pi}}}{\sigma_M^2} \tag{A.12}$$

Substituting the right-hand side of equation (A.12) for λ_M in equation (A.10) and rearranging terms yields the generalization of the CAPM equation for market average expected excess returns:

$$\vec{\boldsymbol{\mu}}_M = \vec{\boldsymbol{\beta}}\mu_M + (\vec{\boldsymbol{\beta}}\vec{\boldsymbol{c}}'_M - \boldsymbol{C})\vec{\boldsymbol{\pi}} \tag{A.13}$$

In Equation (A.13), the first term on the right-hand side is the same as the right-hand side of the CAPM. The second term represents the impact of popularity preferences on security expected returns. Superficially, this equation looks like a multifactor asset pricing model, but with the important difference that it has popularity premiums rather than risk premiums. For an individual security j, let

$$\delta_{jk} = \beta_j c_{Mj} - C_{jk} \tag{A.14}$$

so we can write:

$$\mu_{Mj} = \beta_j \mu_M + \sum_{k=1}^{p} \delta_{jk}\pi_k \tag{A.15}$$

We call δ_{jk} security j's *popularity loading* on characteristic k. It is positive if security j's exposure to characteristic k is less than that of the beta-adjusted market portfolio and negative if the reverse is true. In this way, the popularity loading of a security is positive for a given characteristic if the security is unpopular with respect to the characteristic and negative if it is popular.

Endnotes

[1] According to Friedman (1953, p. 175), "People who argue that speculation is destabilizing seldom realize that this is largely equivalent to saying that speculators lose money, since speculation can be destabilizing in general only if speculators sell when the currency (or commodity) is low in price and buy when it is high."

[2] Here we denote the premiums associated with the regression model with uppercase Π to distinguish them from the premiums that follow directly from the PAPM which we denote by lowercase π in Equation (2).

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