6

Financial Economics: What Kind of Science Is It?

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Financial economics has been steadily maturing as a subfield of economics for many decades now. Finance scholars have received some of the most prestigious research awards in economics, and the key finance journals belong to the most respected outlets in economics as a whole. Financial economics is also a research field that is—there can be no doubt—of enormous practical importance and consequence. Its models and theories inform actors on financial markets, in financial regulation, and in central banking.

The practical influence of financial economics is especially important in asset pricing. Asset pricing is a core component of financial economics and in many ways also one of its most popular and successful parts: it accounts for Nobel Prizes in economics, and its models and theories are important for many questions in micro- and macroeconomics. At the heart of asset pricing is the CAPM—the Capital Asset Pricing Model. Conceived by Treynor (1962), Sharpe (1964), Lintner (1965), and Mossin (1966), it is one of the major frameworks in financial economics for analysing investor behaviour under risk. The CAPM is also inextricably linked to important trends in financial markets. Consider the growing relevance of index funds and passive investment more generally, which by the end of 2020 accounted for $15tr in assets (Wigglesworth, 2021). The roots of this financial innovation can be traced directly the CAPM (Bernstein, 1993, ch. 12; Mehrling, 2005, ch. 4).

Despite the theoretical and practical importance of financial economics, there has not been a lot of specific and sustained engagement with its models and theories by philosophers of science. Indeed, the *Stanford Encyclopedia of Philosophy* entry on money and finance observes: 'only a few philosophers of science have considered finance specifically' (de Bruin et al., 2018). In similar vein, Vergara-Fernández and de Bruin (2021) characterize financial economics as 'terra incognita' for philosophers of science.[1]

[1] While the literature that examines financial economics is small, there are a number of significant contributions on which our chapter builds. First, there is a sizable literature in the sociology of science, especially with regard to the theme of "reflexivity" or "performativity" of financial models and theories

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In this chapter, we provide a roadmap for how philosophers of science can engage more with financial economics. We argue that financial economics is best characterized by its use of *models* and its *performative* nature. We show that the model-based and performative character of financial economics is: (1) visible in the history of its emergence and its current scientific practice; (2) central to the kind of insights it aims to generate; and (3) key to understand what kind of ethical values are at play. We do so by focusing on the CAPM. As a model that is both theoretically and practically important, it is a good starting point for asking how philosophers of science should go about assessing the epistemic performance of financial economics.

We proceed as follows. Section 1 tells an abridged story of the emergence of financial economics, outlining how it became its own branch of economics. Section 2 makes the case for characterizing financial economics particularly by its focus on the use of *models* and by its *performative* nature. To do so, we focus on asset pricing and analyse the kind of claims that are made in asset pricing research. Specifically, we analyse models that originate in the CAPM, the centre-stage model at the emergence of the field. With its multiple extensions, it continues to play an important role in financial economics as well as in industry practice. Section 3 comments on the significance of analysing the role of ethical values in financial economics. Section 4 concludes.

1. The Emergence of Financial Economics: From 'Old' to 'New' Finance Research

Financial economics is a branch of economics concerned with the allocation and redistribution of financial resources (capital).[2] The key feature of financial economics is its focus on financial assets that represent claims to future uncertain payoffs. In his Nobel lecture, Robert C. Merton (1997) described financial economics as 'the study of allocation and deployment of economic resources, both spatially and across time, in an uncertain environment' (p. 85).

(see MacKenzie, 2006a; Boldyrev and Svetlova, 2016; and a special issue in the *Journal of Economic Methodology* on reflexivity e.g. Davis, 2013; Hommes, 2013; Soros, 2013). Second, there are contributions from a philosophy of science perspective that are focused on models and theories in financial economics (e.g. Walter, 2000, 2016, 2021; Vuillemey, 2014; Mangee, 2015; Jovanovic, 2018; Svetlova, 2018; Delcey, 2019; Miotti, 2021; Vergara-Fernández and de Bruin, 2021) and reflections on highly specific questions (e.g. Brav et al., 2004; Greene, 2019; Boldyrev, 2021). Some attention is paid to models of finance, such as Black–Scholes or Modigliani–Miller (Hindriks, 2008, 2013; Pfleiderer, 2014; Brisset, 2018; Vergara-Fernández and de Bruin, 2021). There is recent interest in models of econophysics by some philosophers of science (e.g. Rickles, 2007; Jhun et al., 2018) as well as behavioural finance (e.g. Greene, 2019). Ippoliti (2021a, 2021b) reflects on the epistemology and ontology of finance and also touches on issues in the philosophy of science.

[2] Financial economics studies both capital and money markets.

The history of financial economics as a distinct branch of economics is recent. It starts around the mid-twentieth century, with the emergence of 'new' finance research.[3] 'New' finance research, as much of the rest of economics, starts with the setting of two of its most significant concerns,[4] *asset pricing* and *corporate finance*, on a model-based footing. Asset pricing and investment theory is concerned with the determinants of the value of financial assets and the financial decisions of investors. Corporate finance is concerned with the financial decisions within corporations, which are the main users of funds, and their impact on corporate valuations.

In contrast to 'new finance,' 'old finance' had mostly a descriptive character. The *Journal of Finance*, which appeared in 1945, published articles which mostly described Federal Reserve policy, taxation, corporate finance, insurance, accounting, and the impact of money on prices and business activity (Bernstein, 1993, ch. 2). There was also little interest in the stock market as an object of study. The market crash of 1929 and the Great Depression were only in the recent past. In the minds of academics, the stock market was almost comparable to gambling (Bernstein, 1993, ch. 2). Corporate finance, in turn, which was exemplified by Arthur Stone Dewing's handbook *The Financial Policy of Corporations* (1919), centre on the history of corporations, their relation to other financial institutions, particularly regarding their funding, and the effects of regulation on their rise and survival. According to a review of its fifth edition published in 1954, its two volumes constituted 'a short encyclopedia of the conception, birth, life and death of a corporation' (Forer, 1954, p. 889).

At least two important efforts by both individuals and institutions led to the transformation of 'old' finance research into 'new' model-based research in finance. The first set of efforts was aimed at bringing rigor to research in *asset pricing*. The second set of effort concerns *corporate finance*.

The first set of efforts, on *asset pricing*, advanced from within the Cowles Commission, particularly during the directorships of Jacob Marschak and Tjalling Koopmans in the late 1940s and early 1950s. The Cowles Commission aimed to establish a solid foundation for economics in which economic theory, mathematics, and statistics would come together (Dimand, 2019). The research at the Commission built on the theory of expected utility by Von Neumann and Morgenstern and focused on addressing uncertainty in decision-making

[3] "New finance" is an informal term to mark the watershed in the field, which historians have characterized as a "revolutionary idea" (Mehrling, 2005); the "origins of modern Wall Street" (Bernstein, 1993); and the emergence of the scientific community of financial economics (Jovanovic, 2008). With "old finance" (see further below) we refer to the period prior to this watershed.

[4] There are other subfields of finance research, such as personal and public finance. Notably *banking* is sometimes described as a separate subfield of finance research. Banking is concerned with the financial intermediaries including (trans)national and private banks, it studies their activities, related risks, and their impact on the economy. As such, it touches on both asset pricing and corporate finance.

(Herfeld, 2017). This development was also crucial for the models of financial decision-making.

In 1952, Harry Markowitz published 'Portfolio Selection' (Markowitz, 1952), the article that does for capital markets what the Cowles Commission project called for: to establish how rational agents, in this case investors, should make decisions in the face of uncertainties. In his article, Markowitz provided a decision rule for selecting investment portfolios. This decision rule, contrary to what was customary in the industry, established that investors should maximize expected return, instead of just return. This involved accounting for the risk involved in investing. To do this, Markowitz characterized expected return as mean and risk as variance, and offered a geometrical proof. It established that there was an efficient frontier of portfolios that either maximize return for a given level of risk or minimize risk for a given level of return. Investors should choose portfolios on the efficient frontier.

William Sharpe took Markowitz's decision rule as an input for his CAPM (Sharpe, 1964). The CAPM uses the portfolio choices of individual investors to represent investors' demands for financial assets. By aggregating the investor demands and equating them to asset supplies, equilibrium asset prices are determined. Although the CAPM has been shown unable to account for all the data well (Black et al., 1972; Banz, 1981; Fama and French, 1992, 1996) and has been called untestable (Roll, 1977), the ideas it espouses about the functioning of financial markets continue to play a crucial role in the analysis of these markets (see section 2). It is also used in analyses in corporate finance. For example, the CAPM expected returns are used to estimate firms' costs of capital (Graham and Harvey, 2001; Brounen et al., 2004).

At around the same time, at the University of Chicago, Eugene Fama published his work on the Efficient Market Hypothesis (1965a, 1965b, 1970). The Efficient Market Hypothesis postulates that prices fully reflect all available information. It explained the randomness of the prices (Kendall and Hill, 1953) and the inability of financial analysts to forecast them (Cowles, 1933) in terms of competition between rational agents in markets where prices converge to fundamental values. Hence, the randomness of price variation is attributed to the random arrival of new information.[5] Consequently, the only source of returns in efficient markets is the compensation investors receive for bearing the risk (i.e. equilibrium expected returns). And so, investors are not able to earn extra returns by trading on new information, but only by subsuming higher risk on their investments. And yet, Fama's work, as much of the work at Chicago at the time, was empirical in nature,

[5] At the same time, in an independent contribution, Paul Samuelson has also linked the randomness of prices to the competitive markets (Samuelson, 1965). The two contributions: Fama's and Samuelson's differ, however, in their approach, in particular in the assumptions about the statistical model describing the price process (Delcey, 2019).

fuelled by the establishment of the Center for Research in Security Prices (CRSP) at the University of Chicago in 1960.[6] Fama did not take a stance on a particular theory of expected returns. William Sharpe's CAPM arrived just in time to fill that gap.

These first efforts to set finance research on a more scientific footing have led to a proliferation of model-based research in *asset pricing*. We now turn to the second set of efforts, which concerned *corporate finance*.

The second efforts, on *corporate finance*, came from scholars in finance at Carnegie Tech (later Carnegie Mellon). Like the economists at the Cowles Commission, they were equally interested in bringing rigor to their discipline. Towards the end of the 1940s there was dissatisfaction among some scholars about the business education in the United States. In the words of Herbert Simon, it was a 'wasteland of vocationalism that needed to be transformed into science-based professionalism, as medicine and engineering had been transformed a generation or two earlier' (Simon, 1996, p. 139). From this project emerged one of the most remarkable contributions to corporate finance: the Modigliani and Miller propositions, also known as the Modigliani and Miller theorem, or the principle of the irrelevance of capital structure (Modigliani and Miller, 1958).[7] The Modigliani and Miller theorem states the following. In equilibrium, the market value of a company is determined by the value of its future earnings discounted at the market rate that reflects the riskiness of those earnings. Crucially, the market value of a company is thus independent of how a company finances its operations—its capital structure. That is to say, the Modigliani and Miller theorem set firms' capital structure, an aspect that would traditionally be studied by corporate managers—and thus not economists—under the economics framework of studying markets in equilibrium.[8] (For a detailed review of the relevance of the Modigliani and Miller theorem, see Vergara-Fernández and de Bruin (2021).)

[6] Other important work in this empirical effort was that of Benjamin King, whose dissertation "The Latent Statistical Structure of Security Price Changes," was supervised by James Lorie, director of the CRSP (see Mehrling, 2005, ch. 3).

[7] On the basis of these propositions, Merton Miller was awarded the Nobel laureate in 1990, together with Markowitz and Sharpe. Modigliani was awarded the Nobel Prize in 1985, for his pioneering studies of saving and financial markets.

[8] In their article, Modigliani and Miller, under a set of stringent assumptions, demonstrated that the decisions of a firm about how to fund its activities, be it by issuing debt or equity, are irrelevant for the firm's market valuation. Contrary to what was thought at the time, that there had to be an optimal balance between debt and equity issuance for minimizing the cost of capital, the choice, in fact, has no effect on the market's valuation of the firm. There is much literature that discusses the contribution to corporate finance of the Modigliani and Miller propositions (e.g. Bhattacharya, 1988; Miller, 1988; Ross, 1988; Knoll, 2018). For our story, however, one is particularly relevant. It is that the financial structure of firms was treated in a way that aimed to solve the larger macroeconomic problem of firm investment decisions for economic fluctuations. This involved addressing the problem "from the macroeconomic perspective" (Miller, 1988, p. 101). In other words, a problem that was previously addressed as exclusive of the corporate manager—viewed from within the firm—was now treated from the larger perspective of capital markets in equilibrium.

The question Modigliani and Miller addressed is perfectly complementary to the question addressed by the CAPM. Whereas Modigliani and Miller solve the problem of the corporate manager by claiming that all that matters for the firm valuation is market valuation—not its capital structure—the CAPM claims that all that investors care about is the undiversifiable risk (market risk) and not the individual risk of corporations. The two models solve the same problem. One does it for the corporate manager and the other for the investor. More generally, both models highlight the transformation from descriptive, vocationalist 'old' finance research to model-based 'new' finance research.

In the following section, we focus on the CAPM—as it is still the central modelling framework for asset prices. Studying it will allow us to get a more specific insight into the kind of claims financial economics makes today.

2. Financial Economics as a Model-Based and Performative Science

We now turn to the topic of assessing the epistemic performance of financial economics. We continue with a narrowed focus on asset pricing and use the CAPM as the main example.

First, what is the content of the claims made in asset pricing research, and which strategies are employed to make them?

The methodology of financial economics is similar to other areas in economics; it is also a model-based science. The models, while often partial rather than general equilibrium models, are based on the prevailing paradigm of neoclassical economics.[9] The story of asset pricing models and the CAPM in particular shows how much financial economics is driven by models. Indeed, the very fact that asset pricing has developed by considering a multitude of variants and extensions of the CAPM highlights this fact. Here, we comment on some peculiarities of the ecology of models that have developed from the original CAPM.

Claims made on the basis of the CAPM centre on its core idea: an equilibrium in which the mean-variance efficiency of the market portfolio is derived from aggregate investor demand. As such, the CAPM offers insights into the determinants of the returns of assets, and can explain differences in asset returns in terms of their relation to market risk in equilibrium. To do so, the CAPM makes a series of assumptions that describe (i) investors' preferences, (ii) the investment universe

[9] In parallel to many other subfields in economics, where the models and insights of behavioural economics play an increasingly important role, there is also an emerging literature on behavioural finance (for an overview, see e.g. Hirshleifer, 2015).

based on the mean-variance portfolio choice, (iii) the availability of the risk-free rate for borrowing and lending, and the (iv) homogeneity of investors' expectations (i.e. all investors agree on expected values, variances, and correlations of assets).

Specifically, the CAPM assumes that all investors have the same information about the investment universe, face the same risk-free rate, and follow Markowitz's mean-variance portfolio rule. Under these assumptions, the optimal portfolio of all investors should consist of the risk-free asset and the single mean-variance portfolio of all risky assets. The portfolio of risky assets is chosen such that it offers maximum return above the risk-free asset per unit of risk.[10] Investors' portfolios, thus, differ only in the proportion of wealth allocated to risk-free versus risky assets, but the relative proportions of risky assets are identical across the investors. Because the market portfolio is the sum of all the risky assets held in the economy by all investors, it is thus the sum of identical mean-variance portfolios of risky assets that each investor holds. Hence, the market portfolio is mean-variance efficient. Consequently, there is a linear relation between the asset's expected return and its quantity of market risk. The quantity of the market risk is measured with the so-called market (or CAPM) beta (β), which captures how much the returns on a given asset co-move with the market.[11] According to the CAPM, the riskier the asset is—i.e. an asset with higher market risk—the higher the expected return investors will demand to hold that asset. So, an asset that has a high market beta is a very risky asset. Holding this asset will pay off well when the market is doing well, and badly when the market is doing poorly. Therefore, there would be little demand for this asset. In equilibrium, such an asset would have to offer high expected returns to convince investors to hold it.

The four contributions that make up the original CAPM have been extended in various ways. The CAPM extensions comprise both theoretical and empirical models. They vary in the way they extend the CAPM: some models vary only some parameters and assumptions, while others depart more fundamentally and add components, as we show below.

What can be said about the strategies employed in asset pricing? First, asset pricing is model based. Second, the centre stage example of the CAPM shows that there is a model with a main core, extended in various ways, and subjected to empirical tests. Let us now delve a bit deeper into the CAPM extensions and empirical tests.

[10] It is also referred to as the portfolio that maximizes Sharpe ratio in the economy or the optimal tangency portfolio.

[11] Fama (1968) provides the well-known beta-form of the CAPM:

$$E[R_{i,t+1} - R_{f,t+1}] = \beta E[R_{m,t+1} - R_{f,t+1}], \quad (1)$$

where $R_{i,t+1}$ is the return on asset i, $R_{f,t+1}$ is the risk-free rate, $R_{m,t+1}$ is the return on the market, and $\beta = \frac{Cov[R_{i,t+1}, R_{m,t+1}]}{Var[R_{m,t+1}]}$.

The claims made on the basis of the CAPM and its extensions centre on explaining the determinants of asset prices, notably with relation to market risk and other aspects, which depend on the specific extension of the CAPM used. In that sense, there is a broad similarity in terms of the content of the claims they make: they are aimed at explaining the determinants of asset prices. At least that much can be said about the original CAPM and its theoretical extensions.

However, even among the theoretical extensions of the CAPM we can further identify notable differences in the content of the claims made. For example, the original CAPM identifies a single determinant of asset prices, namely assets' market risk. The intertemporal extension by Merton (1973) allow for other determinants of stock prices (that are different from market risk). The Consumption CAPM of Breeden (1979) also aims at explaining the determinant of asset prices and points towards consumption risk rather than the market risk.

There are also empirical extensions of the CAPM that seem to be less geared towards explanatory import and more closely related to improving on the predictive power of the original CAPM. Fama and French (1992, 1996) introduced the three-factor model where next to the market factor of the CAPM they added size and book-to-market factors. The three-factor model is an empirical extension to the CAPM, because the additional two factors are not a result of a theoretical extension of the CAPM (i.e. relaxation of the CAPM assumptions), but are motivated by the observed differences between the CAPM predictions and the observed cross-section of stock market returns (the so-called CAPM anomalies, as mentioned in section 1 (Black et al., 1972; Banz, 1981)). The main goal of this model is to summarize the differences in return across assets, rather than providing the determinants of their prices.

While such characterizations can be made, at least provisionally, our main contention is that it is difficult to make more precise the content of the claims and their differences between the different CAPM-related models (for a more detailed analysis of this point, see Vergara-Fernández et al. (2023a)). Our brief review suggests that the persistent proliferation of slightly varied empirical and theoretical extensions of the CAPM has resulted in a scientific practice that is complex. As such, model-based asset pricing is fertile ground for the exploration of model-based inquiry more generally in practice-oriented philosophy of science, not only regarding financial economics, but also other disciplines such as biology.

Second, what is the practical import of the claims typically made in asset pricing?

Let us now move from analysing the *content* of the claims that are made in CAPM-based asset pricing to their *practical import*. Here, it is striking that—despite the differences between the various CAPM extensions—the close interrelation with financial practice is a common theme. We briefly highlight two aspects of these interrelations. First, there is overwhelming evidence that the

CAPM plays a central role in financial practice. Graham and Harvey (2001) show that the CAPM is the most popular method for estimating cost of capital (i.e. 73.5% of CFO use CAPM). Brounen et al. (2004) claim that CAPM is consistently more popular among large firms in estimating the cost of capital (45% in Europe and 73% in the US). Similar evidence exists for firms in the UK (McLaney et al., 2004), the Netherlands and China (Hermes and Yao, 2007), Australia (Truong and Peat, 2008), and Iceland (Khalfan and Sturluson, 2018). Berk and van Binsbergen (2016, 2017) show that the CAPM is the closest approximation to the model that mutual fund investors use to make their capital allocation decisions. Blocher and Molyboga (2017) show that the CAPM best models sophisticated investors' preferences and that this model dominates all other known multifactor models. This evidence suggests that—despite the complex picture of CAPM extensions, and despite the empirical failures of CAPM—the CAPM plays a significant role in financial practice. What precisely such surveys show remains unclear, though: the CAPM might be used as one of many tools, as a baseline model, or as one ingredient in a complex decision calculus.

A second aspect of the practical import of the CAPM we have already mentioned in the introduction to this chapter. One of the biggest trends on financial markets in the past decades is the advent of 'passive investment'. In contrast to active investment, there is no discretionary strategy by an investment manager in passive investment. Passive funds simply follow a predetermined rule, which can generally be carried out by computers. They invest in publicly listed stocks or bonds that are liquid, or easy to buy and sell. The most popular are 'index' funds that track benchmark stock and bond indices (e.g. S&P 500). Passive investing is cheaper: there are no expensive portfolio managers. As such, it has 'democratized investment' by opening up the possibility for institutional investors to market investment opportunities to individual households. As mentioned in the introduction to this chapter, index funds accounted for $15tr in assets at the end of the year 2020 (Wigglesworth, 2021), and the roots of this financial innovation can be traced to the theories of financial markets proposed in the 1960s and 1970s (Bernstein, 1993, ch. 12; Mehrling, 2005, ch. 4).

The emergence of financial economics shows deep and complex interrelations with financial practice. This 'reflexivity' or 'performativity' of financial economics has been analysed with tools from sociology of science already. Notably, MacKenzie (2006a, 2006b) and MacKenzie et al. (2007) have investigated how Black-Scholes modelled option pricing. While this is a significant contribution, the challenge for the philosopher of science is to ascertain what the performative aspect of financial economics has to do with the epistemic performance of this scientific field: is it (partly) constitutive of it, independent of it—or even detrimental to it in some sense? It is in this sense that observing 'performativity' forms a question and not an answer. For a more detailed elaboration of this point, see Vergara-Fernández et al. (2023b).

To sum up: the scientific practice of the CAPM and its extensions is complex, and analysing the content of the claims made is an intriguing task for philosophers of science. Moreover, the CAPM and its extensions are generally important for practice and also 'performative'. In particular the performative aspect of financial economics presents a pervasive challenge for the philosopher of science who is interested in analysing the content as well as the epistemic and non-epistemic import of the claims made in this field.

Third, what are the main problems related to obtaining adequate evidence for the claims made in the asset pricing literature?

As we have seen before, the empirical record of the CAPM is mixed: various empirical extensions of the CAPM have been proposed in order to deal with the CAPM anomalies (Black et al., 1972; Banz, 1981; Fama and French, 1992, 1996), that is, the observed differences between the CAPM predictions and the observed cross-section of stock market returns. But what are the main elements and problems in the empirical work in asset pricing in the first place?

In a seminal contribution Roll (1977) asserted that the CAPM is testable in principle, but that no correct test has been provided in the literature. Moreover, he claims that 'there is practically no possibility that such test can be accomplished in the future' Roll (1977, p. 129f.). The problem arises because the implication of the CAPM that betas are linearly related to expected returns is not an independent proposition. The only testable implication of the CAPM is that the market is mean-variance efficient. Betas will be linearly related to expected returns if and only if the market is mean-variance efficient. Moreover, the market portfolio, being the sum of all the risky assets held in the economy by all investors, is not observable. In any sample, there are always a number of mean-variance efficient portfolios. There will be a linear relationship between the betas of these portfolios and the expected returns. So, the relation between beta and expected return will be satisfied exactly irrespective of whether the true market portfolio is efficient or not. Therefore, at least in principle, the CAPM is not testable unless the true market portfolio is observed.

Now, problems of indirect observation, proxies, and auxiliary assumptions are familiar problems in all the empirical sciences, and the fundamental challenges described here are a classic case of theory being underdetermined by the evidence. And so, the question arises how the CAPM literature deals with these challenges. Simply put, they use a proxy to capture the true unobserved market portfolio. This is a sound empirical strategy, but still defeasible in two ways (Roll, 1977). First, the proxy might be mean-variance efficient when the true market is not. Or the chosen proxy might be inefficient, again implying nothing about the efficiency of the true market portfolio. Second, all the proxies will be highly correlated and correlated with the true market portfolio, which makes it seem that the exact

composition is not important whereas two proxies (one efficient the other not) will lead to the opposite conclusions.

Asset pricing scholars debate the prospects for progress in empirical testing in the face of these challenges. Consider that the three-factor model of Fama and French (1992, 1996) mentioned earlier became a new state of the art model and started a large (perhaps even the biggest) literature on more so-called 'factor models' in finance: Harvey et al. (2016) document 315 such factors and characteristics, and Harvey and Liu (2019) document more than 400 of them. The question thus arises whether this 'factor zoo' can be tamed (Feng et al., 2020). Cochrane (2008, 242f.) is pessimistic that the strategy pursued by factor models will be fruitful: 'The only content to empirical work in asset pricing is what constraints the author put on his fishing expedition to avoid rediscovering Roll's theorem. The instability of many 'anomalies' and the ever-changing nature of factor models that 'explain' them (Schwert, 2003) lends some credence to this worry'. This debate about the empirical research strategies in asset pricing presents a further angle from which to formulate interesting questions from the philosophy of science. For instance, are spurious findings in asset pricing an indication of a replication crisis, or could they also partially reflect changing causal relations? More generally, what kind of accomplishments can reasonably be expected from a branch of scientific inquiry that researches a phenomenon that changes and fluctuates as much as financial markets do?

3. Ethical Values in Financial Economics

We now turn from the epistemic assessment of financial economics to the role of non-epistemic values. To what extent does financial economics take into account and discuss ethical, political, and social values?

First, it is interesting to ask which role the so-called 'value-free ideal' might play for financial economics. Here, we think that the existing literature in the philosophy and methodology of economics has much to offer in order to reflect about some issues related to this question. To what extent is or can a part of financial economics be value-free? We think it is fruitful to analyse this question from the point of view of the longstanding fact–value debate regarding economics (e.g. Mongin, 2006; Putnam and Walsh, 2012; Su and Colander, 2013; Małecka, 2021).

Second, a specific value topic of recently emerging relevance in the literature in financial economics is *sustainability*. Contributions related to sustainability are scattered across different topics that include, among others, the analysis of (i) Corporate Social Responsibility (CSR) policies of firms, (ii) Socially Responsible Investments (SRI), sometimes also called ethical or sustainable investments, (iii) Environmental, Social and Governance factors (ESG) and their relation to risk and performance, and (iv) climate finance.

In the asset pricing literature, Heinkel et al. (2001) were the first one to propose an equilibrium model with 'green' investors. Later, Bauer et al. (2005) and Renneboog et al. (2008) found no significant difference between risk-adjusted returns of sustainable and conventional mutual funds, while Geczy et al. (2005) report a worse performance of the portfolio of SRI funds compared to the unconstrained portfolio of all the funds. Statman and Glushkov (2009) compare the performance of firms with high and low ESG scores and find that investing in companies with high ESG scores can have a positive impact on portfolio value provided that investors do not shun stocks of companies associated with the so-called sin industries (i.e. tobacco, alcohol, gambling, firearms, military, and nuclear operations). More recently, Pedersen et al. (2021) attempt to solve the problem of incorporating costs and benefits of ESG into investors' portfolio choice.

Regarding climate finance, Beatty and Shimshack (2010) examine the impact of climate-related ratings of firms on their stock returns, Balvers et al. (2017) examine the impact of temperature shocks on firms cost of equity, and Bernstein et al. (2019) examine how housing markets price long-run risk related to sea level rise.

The results across these different studies are pointing in multiple directions. In general, the literature on all the aforementioned aspects of sustainability in financial economics (i-iv) has only been emerging recently, and there is no clear trend yet as to which kinds of claims about sustainability and its relation to performance and risk can be made.

The topic of sustainability also poses a deeper methodological question to financial economics: is it enough to estimate the impact of sustainability-related aspects on risk and performance? Or does financial economics itself need to change? Schoenmaker (2017, p. 8) answers the latter question in the affirmative and calls for a more fundamental methodological shift in the outlook of financial economics: 'Traditional finance focuses on financial return and regards the financial sector as separate from the society of which it is part and the environment in which it is embedded. By contrast, sustainable finance considers financial, social, and environmental returns in combination'. Critically examining these new developments, their methodological implications, and the role of ethical values in financial economics more generally presents a further opportunity for philosophy of science research into financial economics.

4. Conclusions

This concludes our threefold analysis of financial economics from a philosophy of science perspective. To summarize: First, we provided what we take to be a faithful description of how financial economics matured as a research field.

Second, we investigated how asset pricing establishes its claims. The model-based and performative character of asset pricing as depicted here by focusing on

the CAPM and its extensions paints a complex and intriguing picture. We have shown that there is a multitude of models in CAPM, which are at the same time closely related as well as slightly different from each other. Due to this, the content of the claims they make are difficult to analyse conclusively. What is more, the CAPM enjoys both enduring popularity in financial practice, and many claim that it has even played an important role in shaping financial reality through facilitating the growing importance of passive investment. In addition, there are some concrete debates about how to resolve the evidential challenges in asset pricing, as well as principled doubts about the eventual success of any such strategy.

Third, we emphasized that analysing the role of ethical values—and sustainability in particular—is another important, and potentially fruitful topic for the philosophy of science of financial economics.

In general, we think that the degree of complexity of the scientific practice that emerges from our analysis may be a reason for why analysis of financial economics has so far mainly proceeded by investigating single models, or not taken up as enthusiastically as other economic subfields by general philosophers of economics. It is our hope that some of the issues we outline in this chapter can be taken up in the emerging field of the philosophy of science of financial economics.

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