Progress Past Rationality: An Application of Lakatosian Methodology to Traditional and Behavioral Finance Theory

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Abstract

There has been substantial debate about the question whether fluctuations of security prices reflect fundamental or psychological factors (Shiller 2003, 83). The efficient market hypothesis (EMH) of traditional finance assumes the competition of a sufficient number of rational agents to move security prices in accordance with fundamental factors (Fama [1965] 1995, 76). In contrast, behavioral finance theory asserts that trading activities of irrational investors cause prices to deviate from their intrinsic values (Barberis and Thaler [2003] 2005, 3). However, there is disagreement about the distinctness of the two theories, namely about differences in their axiomatic assumptions, supporting methodologies, and vitality. This research aims to contribute to a systematic assessment of these aspects by answering the question whether traditional and behavioral finance can be classified as distinctive research programs according to Lakatos' ([1969] 1978) methodology of scientific research programs (MSRP). I am going to apply the MSRP to both theories by conducting a review of theoretical and empirical literature to evaluate their hard cores, protective belts, and progressiveness.

The application provides support for my hypothesis that the differences between the theoretical elements of traditional and behavioral finance allows for their classification as two individual research programs. The strong core assumptions of traditional finance have not been met empirically since the 1990s, despite the repeated readjustment of auxiliary hypotheses and the introduction of more encompassing multifactor models. Accordingly, the EMH can be considered to be in a degenerating phase. During its short history, the broad core assumptions of behavioral finance remained unchanged. Its success lies in the accommodation of anomalies through the introduction of more flexible models to its protective belt. While this success warrants overall progressiveness, the variety of models lacks consistency. However, developments towards more precise and encompassing models may ensure the program's progressiveness in the future.

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List of Abbreviations

BHC	Behavioral finance hard core assumption
BNH	Behavioral finance negative heuristic
BPB	Behavioral finance protective belt hypothesis
BPH	Behavioral finance positive heuristic
CAPM	Capital asset pricing model
EMH	Efficient market hypothesis
MSRP	Methodology of scientific research programs
THC	Traditional finance hard core assumption
TNH	Traditional finance negative heuristic
TPB	Traditional finance protective belt hypothesis
TPH	Traditional finance positive heuristic

1. Introduction

In 1936 John Meynard Keynes observed that "[d]ay-to-day fluctuations in the profits of existing investments [...] tend to have an altogether excessive, and even an absurd, influence on the market" (Keynes 1936, 153). He explained the fluctuating valuations as "the outcome of the mass psychology of a large number of ignorant individuals" (Keynes 1936, 154). For the past three decades, the question whether such price fluctuations reflect fundamental or psychological factors has been at the center of the behavioral debate in finance (Shiller 2003, 83). Traditional finance theory revolves around the efficient market hypothesis (EMH). It describes a market in which a sufficient number of competing agents rationally base their decisions to buy and sell securities on the information available to them. The changes in supply and demand lead prices to reflect all available information and moves them closer to the securities' intrinsic values (Fama [1965] 1995, 76). Findings of anomalous price movements as well as insights from experimental psychology have challenged these assertions and led to the development of behavioral models. According to behavioral finance theory, trading activities of irrational investors are not fully offset by rational agents and therefore cause prices to systematically deviate from their intrinsic values (Barberis and Thaler [2003] 2005, 3).

Scholars disagree about what separates the two theories. For several authors, behavioral finance substantially breaks with its traditional counterpart. Shiller (2003, 83) characterizes behavioral finance as a vital research program that "stands in sharp contradiction to much of efficient markets theory". He also describes a methodological shift towards behavioral models (Shiller 2003, 90). Similarly, Thaler (2005, xi) stresses the constructiveness of behavioral finance theory and the independence of its research agenda. Dowling and Lucey (2016, 566) praise the research agenda's potential, but stress the need for more rigorous assumptions and models. For Brav, Heaton, and Rosenberg (2004, 404) the paradigmatic novelty of behavioral finance lies in its axiomatic assumptions, while for Park and Sohn (2013, 4) it lies in its innovative methodology. De Bondt et al. (2008, 11) and Shefrin (2009, 1) also consider the traditional paradigm to be on retreat. However, they predict the discipline's future in a combination of behavioral assumptions and traditional methodology.

Other authors contest that behavioral finance contributes novel assumptions or methodologies. Berg and Gigerenzer (2010, 133) criticize that behavioral theory only modifies parameters to fit outcome data and follows the same set of traditional axioms. While Frankfurter and McGoun (2000, 208) assert a lack of vitality to the traditional paradigm, they think behavioral research differs only slightly in its assumptions. Similarly, Frankfurter, McGoun, and Allen (2004, 455) as well as Cohen and Dickens (2002, 335) observe that alternative axi-

oms are available but not taken up by behavioral finance. Lo (2004, 19) as well as Hong and Stein (2007, 126) accept the novelty of behavioral axioms, but criticize the incoherence of its methodology.

This debate reveals disagreement about the differences between the axiomatic assumptions and supporting methodologies, as well as about the vitality of traditional and behavioral finance theory. However, none of the aforementioned studies evaluate potential differences in a methodologically coherent manner. A promising approach to address this research gap more systematically is Imre Lakatos' ([1969] 1978) methodology of scientific research programs (MSRP). As a theory of scientific rationality, it focuses on the identification and appraisal of a series of theories based on the nature of their theoretical core, auxiliary hypotheses, and overall progressiveness. This research is guided by the question whether traditional and behavioral finance can be classified as two individual research programs according to Lakatos' MSRP. My hypothesis is that the two theories differ in their core assumptions, auxiliary hypotheses, and overall progressiveness and can therefore be identified as distinctive series of theories.

To answer my research question, I am going to apply the MSRP to both traditional and behavioral finance theory. In conducting a literature review of comprehensive research and review articles by central actors of the two fields, I am going to identify the research programs' core theses and auxiliary hypotheses.[1] I am then going to consider the hypotheses' empirical implications and whether they are corroborated by the empirical literature to evaluate the programs' progressiveness.

While the MSRP provides criteria guiding the identification of relevant theoretical elements, the retrieval of these elements and the nature of the guiding criteria bare some limitations. Assumptions and hypotheses are not always stated explicitly, making the identification of shared elements an interpretive endeavor. Although reviewing empirical literature to evaluate the hypotheses' implications is less problematic, the multitude of studies in finance makes the risk of omission unavoidable. Another limitation is the generality of guiding criteria. Lakatos ([1969] 1978, 48) only describes the hard core as assumptions shared by a series of theories. The scope and level of generalization of the shared assumptions, however, can vary between the compared programs. Unlike traditional finance, the behavioral program, for example, does not assume a specific type of collective behavior and can accommodate a greater variety of models in its protective belt.

[1] For the traditional finance research program early defining actors were Paul Samuelson and Eugene Fama, for behavioral finance they were Hersh Shefrin and Richard Thaler.

Granted these limitations, the application of Lakatosian methodology unveils substantial differences in the core assumptions, auxiliary hypotheses, as well as in the progressiveness of the two theories. Accordingly, traditional and behavioral finance can be regarded as two distinctive research program. Despite the repeated adjustment of auxiliary hypotheses and the introduction of more encompassing multifactor models, the strong core assumptions of traditional finance have not been met empirically. The EMH can therefore be considered to be in a degenerating phase since the 1990s. The broad core assumptions of behavioral finance have remained unchanged throughout its short history. Its success lies in the accommodation of anomalies through the introduction of more flexible models to its protective belt. While this success warrants overall progressiveness, the variety of models lacks consistency. However, developments towards more precise and encompassing models may ensure the program's progressiveness in the future.

The paper is structured as follows: Section 2 lays out Lakatos' MSRP and its applicability to economic theories. Section 3 describes the historical development of traditional finance theory, the composition of the research program, as well as its progressiveness. Section 4 focuses on the historical development, program composition, and progressiveness of behavioral finance. Section 5 concludes the analysis by providing a summary and discussion of the findings.

2. Methodology of Scientific Research Programs

Imre Lakatos (1922-1974) was a Hungarian philosopher of mathematics and science. He is most renowned for the methodology of scientific research programs, which he published during his time as Professor of Logic at the London School of Economics (Musgrave and Pigden 2016). In the following, I am going to explain the MSRP and discuss its applicability to economic theories.

2.1 Lakatos and Scientific Rationality

By reconciling Karl Popper's strict demarcation criterion of falsifiability with Thomas Kuhn's notion of paradigms, Lakatos derived a novel theory of scientific rationality (Currie and Worrall 1978, 6). His focus lies on the appraisal of research programs. A research program is a series of theories within an academic discipline that share the same core of assumptions (Lakatos [1969] 1978, 48). For Lakatos ([1969] 1978, 36), "naïve falsificationism", i.e. the presentation of corroborated counter-evidence, does not suffice to dismiss a theory as unscientific. Applying the criterion of falsifiability to an isolated theory would be too stringent, is not

practiced by scientific elites, and should therefore be avoided (Lakatos [1970] 1978, 125). Instead, Lakatos ([1970] 1978, 102) champions the normative MSRP that allows for a more realistic interpretation of the history of science, while simultaneously providing a rational explanation for the growth of knowledge. If one so reconstructs the history of a theory, the seemingly "irrational adherence to a 'refuted' or to an inconsistent theory […], may well be explained […] as rational defence of a promising research programme" (Lakatos [1970] 1978, 114). It is only when a better research program supersedes the other that counterevidence may be recognized as refuting the original theory (Lakatos [1969] 1978, 35). According to Lakatos ([1969] 1978, 69), the resulting transition from one research program to another, however, does not follow the successive periods of normal science described by Kuhn. Rather, he emphasizes that research programs coexist in a "long-extended theoretical and empirical rivalry" (Lakatos [1970] 1978, 118).

Each sequence of theories forming a research program is characterized by a common hard core of central assumptions and a protective belt of auxiliary hypotheses (Lakatos [1969] 1978, 48). The construction of these elements is informed by two methodological rules: the negative and the positive heuristic (Lakatos [1969] 1978, 47). The negative heuristic forbids the direct falsification of core assumptions. Therefore, a program's core may be devoid of empirical consequences and remains "relatively solid" throughout the sequence of theories (Lakatos [1968] 1978, 174). Accordingly, scientists faced with counterevidence need not immediately give up the central assumptions of a potentially promising program (Lakatos [1969] 1978, 48). Instead, it is the protective belt of auxiliary hypotheses which entails empirical predictions and is subject to testing (Lakatos [1969] 1978, 48). If falsified, these hypotheses "get adjusted and re-adjusted, or even completely replaced to defend the thus-hardened core" (Lakatos [1969] 1978, 48). The positive heuristic is a strategy for anticipating and digesting refutations, and guides the adjustment of the protective belt (Lakatos [1969] 1978, 50). To Lakatos ([1968] 1978, 174), this falsification-driven adjustment of hypotheses gives science its "scientific" character.

The deciding criterion between two competing research programs is their progressiveness. In the absence of competition, scientists may retain any program, solely by continuously readjusting its auxiliary hypotheses (Lakatos [1969] 1978, 42). However, if another research program is available, the nature of these readjustments, namely their progressiveness, determines which program should prevail (Lakatos [1969] 1978, 42). An adjusted theory is theoretically progressive (or constitutes a theoretically progressive problem shift) if it predicts a novel fact and thus has excess empirical content over its predecessor (Lakatos [1969] 1978, 34).

Lakatos ([1970] 1978, 184–92) originally defined a novel fact as previously unknown and unexpected, but later accepted Zahar's (1973, 103) amendment, by which a known fact counts as novel as long as no rival program was designated to predict it. If some of these newly predicted facts are subsequently confirmed by empirical observations, the adjusted theory is also empirically progressive (or constitutes an empirically progressive problem shift) (Lakatos [1969] 1978, 34). Overall progressiveness is achieved if the adjustments to a program are uniformly theoretically progressive and intermittently empirically progressive (Lakatos [1969] 1978, 49). If a research program fails to present at least partly corroborated novel empirical content, it is degenerating and potentially subject to "sophisticated falsification" by a more progressive rival (Lakatos [1969] 1978, 34–42).

2.2 Applicability

The MSRP has qualities that warrant its applicability to economic theories. Firstly, in accommodating both historiography and methodology, the MSRP provides a dynamic criterion of appraisal and has been applied successfully to several economic theories and subdisciplines (Blaug 1992, 31).[2] Where Popper's falsificationism dismisses most economic theories and Kuhn's methodology fails to appreciate their scientific rigor, Lakatos strikes a middle ground between over-stringentness and under-appreciation (Blaug [1975] 1976, 157). Secondly, De Marchi (1991, 3) argues that the dynamic criterion of appraising successive theory modifications overlaps significantly with economic methodology. Both the MSRP and Friedman's ([1953] 2007, 153) methodology of positive economics, for instance, emphasize the primary role of excess explanatory content. The *a priori* assumptions guiding this progress in economics behave analogously to a research program's hard core. The empirical economic models correspond to the protective belt, as both render unobservable variables measurable (De Marchi 1991, 3–8). The tolerance for anomalies in economics is accommodated by Lakatos' requirement for mere intermittent corroboration of novel predictions (De Marchi 1991, 3). Lastly, Lakatos succeeds in circumventing Duham's ([1906] 1991, 184) thesis, which forbids the simultaneous testing of multiple hypotheses often seen in economics. By focusing on the development of theories, the MSRP allows to evaluate economic theories jointly with their empirical models (Kim 1991, 128).

[2] Latsis (1976) as well as Blaug and De Marchi (1991) edited comprehensive summaries of Lakatosian applications to economics. Additional work includes applications to finance by Schmidt (1982), to general equilibrium analysis by Weintraub (1985), to dynamic-stochastic equilibrium theory by Heise (2014), and to behavioral economics by Dow (2014).

Nonetheless, the application of Lakatosian methodology to economic theories has been subject to several points of critique. Firstly, the MSRP has been criticized for not fitting all theories and disregarding institutional and historical contexts, since it prescribes a strict program composition (Leijonhufvud 1976, 69; Mäki 2008, 414). Secondly, Mäki (2008, 414) and Hausman (2007, 18) argue that the core of economic theories is not solid but often requires reformulation. Lastly, the most prominent criticism is directed at Lakatos' original requirement of predicting previously unknown facts, since most economic theories explain known phenomena (De Marchi 1991, 7; Hands 1985, 2; Leijonhufvud 1976, 76; Mäki 2008, 414). In a word of defense, however, Lakatos ([1970] 1978, 134) acknowledges that the normative reconstructions produced by the MSRP are often "caricatures of actual history". These reconstruction, however, allow the evaluation of competing theories. To account for contexts and theoretical elements that are disregarded by the MSRP, Lakatos ([1970] 1978, 102) requires its application to be supplemented by a description of historical developments. Moreover, Lakatos ([1969] 1978, 48) does not prescribe a solid core but one that "develops slowly, by a long, preliminary process of trial and error". Even the requirement of novel facts matches the notion of progress in economics if one regards Zahar's amendment (Mäki 2008, 421).

Thus, while Lakatos' methodology does not substitute historiography, it can serve as a means for rationally evaluating traditional and behavioral finance theory. In applying the MSRP, I am therefore going to briefly consider the theories' historical development, before analyzing the research program composition. By conducting a literature review of comprehensive research and review articles by central actors, I am going to identify the guiding core assumptions as well as relevant protective belt hypotheses. To evaluate the programs' progressiveness, I am then going to consider the hypotheses' empirical implications and whether these are corroborated by the empirical literature. The negative and the positive heuristic are deduced tentatively from the nature of core assumptions and auxiliary hypotheses. However, the heuristics are seldomly made explicit by authors and do not influence overall progressiveness (Hands [1993] 2007, 196; Leijonhufvud 1976, 70; Mäki 2008, 414). Therefore, they are not considered in the concluding comparison of the research programs.

3. Traditional Finance

The central concept of traditional finance theory is the efficient market hypothesis. This section details the application of Lakatos' theory to the EMH. This includes describing the historical development of the EMH, identifying its theoretical hard core, explaining the develop-

ment of its auxiliary hypotheses, and lastly assessing the progressiveness of these developments.

3.1 Historical Development

The EMH describes a market in which a sufficient number of competing agents rationally base their decisions to buy and sell securities on the information available to them. The changes in supply and demand lead prices to reflect all available information and moves them closer to the securities' intrinsic values. As a result, changes in individual security prices are random and cannot be predicted to gain excess profit (Fama [1965] 1995, 76). The EMH's foundation was laid by the literature on the random-walk character of changes in security prices, more specifically Bachelier's (1900) assertion that these changes are normally distributed. Mandelbrot (1963, 418; 1966, 243) refined this assertion by describing the price changes in terms of a stable Paretian distribution and later in terms of a fair-game martingale. The explanation of why price changes follow a martingale was first provided by Samuelson (1965). His axiomatic formulation of the EMH describes how a competitive market discounts information in prices (Samuelson 1965, 48).

Fama (1963) was the first to infer the dynamics of an efficient market empirically by testing Mandelbrot's assertions. He concludes that actual security prices are a good estimate of their intrinsic value (Fama 1963, 426). According to Fama (1965, 38), efficiency in real security markets is guaranteed by arbitrage, the offsetting mechanism by which rational investors exploit any profitable opportunity. What followed were several tests designed to measure the EMH's empirical consequences, namely relative price independence, the impossibility of excess investment returns, and the quick adjustment of prices to new information (Fama 1965; Fama et al. 1969; Fama and Blume 1966). At the height of the EMH, Fama (1970) presented extensive evidence in his landmark work "Efficient Capital Markets". Among the most promising tests were applications of Sharpe's (1964) and Lintner's (1965) capital asset pricing model (CAPM), which uses the characteristics of the portfolios of utility maximizing investors to derive the equilibrium relationship between risk and expected return (Fama 1971, 30). The explanatory power of the model is taken as evidence for market efficiency since it attributes variations in returns to a purely rational risk factor (Fama and MacBeth 1973, 634).

Throughout the 1980s, more sophisticated statistical tests increasingly discovered anomalous findings. Observations of short-term price underreaction, long-term overreaction, excessively volatile returns, and irrational seasonality in price movements indicated a higher predictability of returns than previously assumed (Fama 1991, 1582–87). In response, advo-

cates of the EMH pointed to event studies displaying efficient adjustments to information and argued that most anomalies are either produced by chance, lack profitable exploitability, or are offset by arbitrage (Fama 1991, 1577; Fama 1998, 284; Malkiel 2003, 72). However, perhaps the most important line of defense remains that anomalous findings are largely due to the empirical models used to test efficiency (Fama 1970, 413; 1991, 1576; 1998, 284). Several asset pricing models using multiple factors to rationally explain some of the anomalies have been introduced in addition to the Sharpe-Lintner CAPM.[3] Although unmitigated anomalies persist, Fama (1998, 284) maintains that "market efficiency can only be replaced by a better specific model of price formation".

3.2 Hard Core

Lakatos ([1969] 1978, 48) conceptualizes a theoretical core that, after preliminary adjustments, hardens over time and characterizes the research program. His definition fits the core assumptions of the EMH, which were adjusted in its early phase, hardened during its height in the 1970s, and were retained throughout the phase that followed. The hard core emerged slowly from the assertion of independence by Bachelier (1900) and Mandelbrot (1963). Samuelson (1965) embedded this assertion in the description of a competitive market. His additions included the assumption of rational agents acting on information, the discounting of this information in prices through competition, and of the impossibility of gaining excess returns from analyzing past prices (Samuelson 1965, 48). Fama (1963, 426) concluded from the random walk literature that prices reflect underlying economic conditions and thus added the hard core assumption of prices estimating the intrinsic value of securities. Accordingly, an early version of the evolving traditional hard core assumptions (THC) can be stated as:

THC1.1 Changes in successive individual security prices are independent.
THC1.2 Analysis of price sequences does not yield excess return.
THC1.3 Costs of information and transaction are zero.
THC1.4 Agents rationally base their action on information.
THC1.5 Prices fully reflect available information.
THC1.6 Prices estimate the intrinsic values of securities.

[3] See for example the two-factor model tested by Jensen, Black, and Scholes (1972), the three-factor model by Fama and French (1993), as well as the five-factor model by Fama and French (2016).

Important adjustments to the initial hard core assumptions undertaken by Fama in 1965 made the EMH applicable to actual markets. All previous theories required the implausible condition of zero costs for information and transactions to incentivize information gathering and to ensure perfect independence (Grossman and Stiglitz 1980, 401). Fama (1965, 35) relaxed the notion of independence to include dependencies that are not exploitable for profit. A second adjustment was accepting that some agents do not rationally base their actions on information but "may be primarily motivated by whim" (Fama 1965, 36). However, efficiency is ensured by arbitrage. Fama (1965, 38) asserts the existence of a sufficient number of rational investors offsetting profitable opportunities created by irrational agents. Thus, prices fully reflect information and are a good estimate of intrinsic values even in real markets (Fama 1965, 90). The evolved hard core can be stated as:

THC2.1	Dependencies of changes in successive individual security prices do not yield excess returns.
THC2.2	Some agents rationally base their action on information.
THC2.3	Rational agents offset effects that irrational agents have on prices.
THC2.4	Prices fully reflect available information.
THC2.5	Prices estimate the intrinsic values of securities.

During the 1970s, new ways of testing the EMH led to a hardening of the core. The adjustment of the tests enabled the hard core to be retained throughout the late phase of the EMH by shielding it from anomalous findings. Directing these findings directly at the hard core is prohibited by the research program's negative heuristic (TNH). For the EMH, it can be stated in prescriptions such as:

TNH1	Do not infer inefficiency from dependencies in price changes.
TNH2	Do not infer inefficiency from rational or irrational individual behavior.
TNH3	Do not question the offsetting effects of arbitrage.
TNH4	Do not question the rational composition of prices.

3.3 Protective Belt

Tests designed to observe consequences of core assumptions make empirical predictions and allow for the formulation of auxiliary hypotheses. These hypotheses make up the protective belt of a research program (Lakatos [1969] 1978, 48). Tests in the early phase of the EMH

were concerned with the assumption of independence (THC1.1). The random character of price changes was inferred from comparing them to a Gaussian (Bachelier 1900) or to a stable Paretian (Fama 1963; 1965; Mandelbrot 1963) probability distribution. Other procedures designed to assess the assumption of independence included tests of serial correlation, runs tests, and tests of Alexander's filter rules (Fama 1965). The auxiliary hypotheses making up the traditional protective belt (TPB) during the early phase of the EMH can thus be stated as:

TPB1.1 Price changes are independent if they follow a Gaussian or stable Paretian distribution.

TPB1.2 Price changes are independent if so implied by tests of serial correlation.

TPB1.3 Price changes are independent if so implied by runs tests.

TPB1.4 Price changes are independent if so implied by tests of mechanical trading rules.

The assumptions of the evolved hard core in the second phase of the EMH were given empirical content by new auxiliary hypotheses. The assumption that price dependencies in individual securities are not exploitable for excess returns (THC2.1) is analogous to the martingale property of security prices identified by Mandelbrot (1966). Like the previous assumption of independence, the martingale property was inferred from literature on the probability distribution of price changes (Fama et al. 1969; Fama 1970; Mandelbrot 1966), tests of serial correlation (Fama 1970, 393), and tests of Alexander's filter rules (Fama and Blume 1966; Fama 1970, 396). New performance tests directed at the assumption of unexploitable dependencies compared the return of investment funds to a simple buy and hold strategy (Fama 1970, 412). Other hypotheses in the protective belt were concerned with the assumption of prices fully reflecting available information (THC2.4). Multiple studies tested how quickly prices adapt to the information presented by events like stock splits (Fama et al. 1969), earnings announcements (Ball and Brown 1968), or secondary stock offerings (Scholes 1970). Another approach was to examine whether individuals possess private information not yet reflected in prices (Fama 1970, 412). A final class of auxiliary hypotheses infers the assumption that prices estimate the intrinsic values of securities (THC2.5) from the explanatory power of asset pricing models (Fama 1970, 403). Tested models included the Lintner-Scholes CAPM as well as two-factor models (Fama 1970, 403; Fama and MacBeth 1973). Accordingly, the protective belt during the second phase of the EMH consisted of the following auxiliary hypotheses:

TPB2.1 Prices follow a martingale with unexploitable dependencies if price changes approximate a Gaussian or stable Paretian distribution.

TPB2.2 Prices follow a martingale with unexploitable dependencies if tests show little predictable autocorrelation.

TPB2.3 Prices follow a martingale with unexploitable dependencies if so implied by tests of mechanical trading rules.

TPB2.4 Prices follow a martingale with unexploitable dependencies if the tested performance of funds does not exceed the market line.

TPB2.5 Prices fully reflect available information if they quickly react to firm specific events.

TPB2.6 Prices fully reflect available information if individuals do not possess private information not reflected in prices.

TPB2.7 Prices estimate the intrinsic values of securities if returns are captured by one or two-factor asset pricing models.

In the EMH's third phase, greater availability of data and computational power opened up further possibilities for testing the empirical implications. The martingale property of security prices (THC2.1) was assessed with more sophisticated tests of autocorrelation (Fama 1991, 1581–82). Other ways of testing the martingale property were the identification of forecast variables or seasonal price movements (Fama 1991, 1583). Once again, the impossibility to profit from dependencies was tested with performance tests (Fama 1991, 1606). Tests on whether prices reflect available information (THC2.4) also remained unchanged, including studies of firm specific events and examinations of private information (Fama 1991, 1600–1605). The assumption of prices reflecting intrinsic values (THC2.5) was assessed with volatility tests and new multifactor asset pricing models (Fama 1991, 1586–97). Therefore, the adjusted protective belt can be stated as:

TPB3.1 Prices follow a martingale with unexploitable dependencies if tests show little predictable autocorrelation.

TPB3.2 Prices follow a martingale with unexploitable dependencies if returns cannot be forecasted with specific variables.

TPB3.3 Prices follow a martingale with unexploitable dependencies if their movements do not follow seasonal patterns.

TPB3.4 Prices follow a martingale with unexploitable dependencies if the tested performance of funds does not exceed the market line.

TPB3.5 Prices fully reflect available information if they quickly react to firm specific events.

TPB3.6 Prices fully reflect available information if individuals do not possess private information not reflected in prices.

TPB3.7 Prices estimate the intrinsic values of securities if they do not display excess volatility.

TPB3.8 Prices estimate the intrinsic values of securities if returns are captured by multifactor asset pricing models.

According to Lakatos ([1969] 1978, 50), adjustments to the protective belt are guided by a positive heuristic which prescribes the path research should pursue. Judging by the nature of auxiliary hypotheses, the positive heuristic of the EMH (TPH) consists of statements such as:

TPH1 Construct statistical tests.

TPH2 Test the predictability of prices and returns.

TPH3 Test the possibility to achieve excess returns.

TPH4 Observe correlations between information and prices.

TPH5 Construct models that assume rationality.

3.4 Progressiveness

A research program is progressive if all adjustments to its protective belt constitute theoretically progressive problem shifts and if some of these adjustments also constitute empirically progressive problem shifts (Lakatos [1969] 1978, 49). The auxiliary hypotheses which formed during the early phase of the EMH were directed at testable consequences of price independence, which no research program before had been concerned with (Fama 1963, 420). This excess empirical content is consistent with theoretical progressiveness. The hypothesis asserting that prices approximate a Gaussian or stable Paretian distribution (TPB1.1) found initial empirical support (Fama 1963; 1965; Kendall 1953; Mandelbrot 1963; Moore 1962). Tests of serial correlation (TPB1.2), runs tests (TPB1.3), and tests of Alexander's filter rules (TPB1.4) uncovered small but statistically significant dependencies (Fama 1970, 84). However, because the novel facts predicted by the auxiliary hypotheses were corroborated in part, the adjust-

ments to the protective belt were empirically progressive. Therefore, the EMH can be considered overall progressive in its initial phase.

In the second phase of the EMH, adjustments made to its protective belt relaxed the notion of independence and added hypotheses about prices reflecting information and intrinsic values. While some hypotheses included tests used during the initial phase of the EMH (TPB2.1, TPB2.2, TPB2.3), they implied results consistent with the novel prediction of an unexploitable martingale. All other hypotheses were directed at hitherto untested empirical facts. Thus, the adjustments constitute theoretically progressive problem shifts. The martingale property hypotheses (TPB2.1, TPB2.2, TPB2.3, TPB2.4) were all corroborated (Fama 1970; Fama and Blume 1966; Mandelbrot 1966). Hypotheses about the reflection of information were partly corroborated. Event studies showed the quick adjustment of prices (TPB2.5) (Ball and Brown 1968; Fama et al. 1969; Scholes 1970). However, some individuals were shown to have exclusive access to profitable information (TPB2.6) (Niederhoffer and Osborne 1966). Lastly, the explanatory power of asset pricing models supported the hypothesis that prices estimate intrinsic values (TPB2.7) (Fama 1970; Fama and MacBeth 1973). The intermittent empirical progressiveness of the theoretically progressive problem shifts results in an overall progressive second phase of the EMH.

The adjustments to auxiliary hypotheses in the third phase of the EMH introduced new procedures to test whether prices follow martingale movements and estimate intrinsic values. Tests were either directed at novel phenomena (TPB3.2, TPB3.3, TPB3.7) or, as in the case of multifactor asset pricing models, predicted known anomalies to be a result of newly considered factors, such as firm size or book-to-market ratio (TPB3.8). Therefore, all adjusted hypotheses made novel empirical predictions and are consistent with theoretical progressiveness. The old hypothesis that price movements show little predictable autocorrelation (TPB3.1) was rejected by several studies reporting short-term positive autocorrelation (Jegadeesh and Titman 1993; Lo and MacKinlay 1988) and long-term negative autocorrelation (De Bondt and Thaler 1985; 1987; Fama and French 1988b). Other studies identified potentially exploitable forecast variables (TPB3.2) (Campbell and Shiller 1988; Fama and French 1988a; 1992; Shiller, Fischer, and Friedman 1984). Similarly, findings of seasonal movements in prices suggested the existence of exploitable patterns (TPB3.3) (Ariel 1987; 1990; Cross 1973; French 1980; Gibbons and Hess 1981; Harris 1986; Keim 1983; Thaler 1987).

Yet, the old hypothesis that price dependencies are unexploitable as long as investment funds do not outperform the market (TPB3.4) found further empirical support (Elton et al. 1993; Malkiel 2005). Additionally, the old hypothesis that prices reflect information since

they quickly react to firm specific events (TPB3.5) was corroborated by a large number of short-term studies (Fama 1991, 1602). Long-term event studies have, however, contested this hypothesis (Lakonishok and Vermaelen 1990; Loughran and Ritter 1995). Moreover, there is substantial evidence against the hypothesis that there are no informational advantages since prices already reflect all information (TPB3.6) (Ippolito 1989; Liu, Smith, and Syed 1990; Lloyd-Davies and Canes 1978). Finally, neither studies on price volatility (TPB3.7) nor multi-factor asset pricing models (TPB3.8) succeeded in providing evidence that prices estimate intrinsic values. Instead, research uncovered excess volatility (Shiller 1979; 1981; 1988) and multifactor models failed to capture substantive anomalies (Fama and French 1996; 2016). In conclusion, all auxiliary hypotheses were theoretically progressive. However, none of the hypotheses introduced since the second phase of the EMH have been corroborated and thus do not constitute empirically progressive problem shifts. Therefore, the EMH did not meet the necessary criterion for overall progressiveness in its third phase and can be considered degenerating.[4]

Degenerating problem shifts of course do not justify the rejection of the research program. Anomalous findings of volatility and lacking explanatory power of asset pricing models, for example, are not taken to imply the irrational composition of prices (NH4) (Fama 1991, 1610). Future adjustments to the core may lead the way towards a new progressive phase. Whether it is worthwhile clinging to the research program until then depends on the availability of a more progressive alternative.

4. Behavioral Finance

The research program of behavioral finance developed from the anomalous findings in the EMH's late phase and insights from experimental psychology. Analogously to the application to traditional finance, I am going to apply Lakatosian methodology by following the same four steps as in the previous section.

4.1 Historical Development

According to behavioral finance theory, trading activities of irrational investors are not fully counterbalanced by rational agents and therefore cause prices to deviate from their intrinsic values (Barberis and Thaler [2003] 2005, 3). The groundwork for this theory was provided by cognitive psychology. In a number of experiments, Kahneman and Tversky (1979, 263) found

[4] For an overview of the development of traditional hard core assumptions, protective belt hypotheses, as well as their empirical corroboration, see Table A1 in Appendix A.

people to systematically violate the predictions of traditional utility maximization models and hence rejected it as a descriptive model of decision making. By generalizing specific psychological principles and biases, new models were created (Kahneman 2003, 1449). Prospect theory, for example, translates attitudes towards gains and losses into a value function which is concave for gains and convex for losses (Kahneman and Tversky 1979, 274). The theory of self-control models individuals as consisting of a selfish doer and a farsighted planner with distinct utility functions (Thaler and Shefrin 1981, 395).

Finance researchers struggling to explain price movements within the traditional framework resorted to such generalizations and captured price anomalies with new irrational investor models. This approach was pioneered by four authors: Shefrin and Statman (1984) explained investors' preference for cash dividends with self-control and prospect theory. De Bondt and Thaler (1985) explained the long-term reversals of returns with investor overreaction. Besides these static models of irrational behavior, research on the limits to arbitrage took a central role. Russell and Thaler (1985, 1078) were first to note that the necessary conditions for offsetting irrational price deviations are rarely met in reality. Moreover, effective arbitrage is prevented by the risk posed by unpredictable noise trader activities (DeLong et al. 1990a), the possibility of rational feedback trading (DeLong et al. 1990b), and the difficulty of countering extreme deviations (Shleifer and Vishny 1997). Together with advances in experimental psychology, the discovery of limits to arbitrage promoted further behavioral models directed at phenomena like the mispricing of closed-end funds (Lee, Shleifer, and Thaler 1991) and the equity premium (Benartzi and Thaler 1995).

With increasing research efforts, more sophisticated models emerged around the turn of the century.[5] Asset pricing models based on more realistic preferences capture excess volatility (Barberis, Huang, and Santos 2001, 2). Dynamic models reconcile short-term positive autocorrelation with long-term reversals. Investors may wrongly interpret public information or rely too heavily on positive private information, thus pushing prices above their intrinsic values until an eventual reversal (Barberis, Shleifer, and Vishny 1998, 310; Daniel, Hirshleifer, and Subrahmanyam 1998, 1842). Other dynamic models ascribe the price movements to the interaction of heterogeneous agents (Barberis et al. 2015, 2; Hong and Stein 1999, 2146). This multitude of behavioral explanations for price formation sometimes lacks consistency and has been subject to critique (De Bondt et al. 2008, 9). However, Thaler (2005, xvii) holds

[5] For more comprehensive lists of behavioral models see Hirshleifer (2001) and Barberis and Thaler ([2003] 2005).

that with growing behavioral insights models are becoming both more consistent and accurate.

4.2 Hard Core

The hard core consists of assumptions which are shared by all theories in the sequence constituting a research program (Lakatos [1969] 1978, 48). Despite the short history of behavioral finance, its core assumptions have formed quickly and subsequently hardened. Kahneman and Tversky's (1979) critique of expected utility theory provides the first assumption in postulating that people systematically deviate from rationality in a generalizable manner. Shefrin and Statman (1984) assumed that these generalizations were applicable to financial markets. They focus on the interaction between rational and systematically irrational financial agents that leads prices to diverge from intrinsic values (Shefrin and Statman 1984, 278). The discrepancy between prices and intrinsic values also relies on the assertion of limited arbitrage introduced by Russell and Thaler (1985). Thus, the hard core assumptions (BHC) in the early phase of behavioral finance can be stated as:

BHC1	Some financial agents systematically deviate from rational behavior.
BHC2	Arbitrage offsetting the effects that irrational agents have on prices is limited.
BHC3	Prices do not fully reflect available information.
BHC4	Prices deviate from the intrinsic values of securities.

Throughout the evolution of the research program, these broad assumptions have been retained and restated by central actors.[6] All changes made since the onset of behavioral finance concerned the tests and models of its protective belt and the specific biases used in their construction. Judging from the development of assumptions, the prescriptions of the negative heuristic (BNH), which forbid the alteration of hard core elements, can be summarized as:

BNH1	Do not explain all price volatility rationally.
BNH2	Do not question the generalizability of behavioral patterns.
BNH3	Do not question the existence of limits to arbitrage.

[6] The first review was provided by De Bondt and Thaler (1995). Later reviews include Thaler (1999), Shleifer (2000), Hirshleifer (2001), Barberis and Thaler ([2003] 2005), De Bondt (2008), De Bondt et al. (2008), and Barberis et al. (2015).

4.3 Protective Belt

As with traditional finance theory, the assumptions of the behavioral core are made testable through models and tests. Their empirical implications are the basis for the auxiliary hypotheses of the protective belt (Lakatos [1969] 1978, 48). While psychological experiments play an important role in deriving the program's behavioral assumptions, they themselves are not informed by behavioral finance theory. Therefore, experiments must not be viewed as tests themselves, but as an informational source for the models of the protective belt (Smith, McCabe, and Rassenti 1991, 198). The generalizations of cognitive biases in Kahneman and Tversky's (1979) prospect theory and Thaler and Shefrin's (1981) theory of self-control, while not specific to finance, are a preliminary step in this direction.

The first phase of behavioral finance saw the construction of static models which apply such generalizations to specific anomalies like the preference for cash dividends (Shefrin and Statman 1984), the long-term reversal of returns (De Bondt and Thaler 1985), the disposition to sell winners (Shefrin and Statman 1985), the underpricing of closed-end mutual funds (Lee, Shleifer, and Thaler 1991), and the equity premium (Benartzi and Thaler 1995). Models like these enabled researchers to test whether the assumption of irrationality holds in the context of financial markets (BHC1). The deviation of prices from intrinsic values (BHC4) is inferred directly from the existence of anomalies that are not explained by rational asset pricing models (De Bondt and Thaler 1987, 558). Noise trader interaction models test the same assumption, but explicitly consider the existence of some irrational agents (Campbell and Kyle 1993; Shefrin and Statman 1994). Similar models were also used to identify potential limits to arbitrage (BHC2) (DeLong et al. 1990a; 1990b; Russell and Thaler 1985). In their first review article, De Bondt and Thaler (1995, 392–94) furthermore refer to studies of individual investor behavior (BHC1) as well as to the success of investment strategies which exploit cognitive biases (BHC1). Combined, the empirical implications of these models give rise to the auxiliary hypotheses of the protective belt of behavioral finance (PBH) in its first phase:

- BPB1.1 Agents systematically deviate from rational behavior if static belief-based models capture specific anomalies.
- BPB1.2 Agents systematically deviate from rational behavior if so implied by tests of individual investor behavior.
- BPB1.3 Agents systematically deviate from rational behavior if belief-based contrary investment strategies yield excess returns.
- BPB1.4 Arbitrage is limited if so implied by noise trader interaction models.

BPB1.5 Prices deviate from intrinsic values if returns are captured by noise trader interaction models.

BPB1.6 Prices deviate from intrinsic values if returns are not captured by rational asset pricing models.

The emergence of more sophisticated models marks the beginning of the second phase of the behavioral finance research program. Arguably the biggest development were dynamic belief-based models, which capture both short-term momentum and long-term reversals in price movements, thereby making a stronger case for the irrationality of financial agents (BHC1) (Thaler 1999, 15). The first models of this kind explained price movements with biases in the processing of information (Barberis, Shleifer, and Vishny 1998; Daniel, Hirshleifer, and Subrahmanyam 1998; Hong and Stein 1999). The behavioral asset pricing model by Shefrin (2008; 2009) simply adds a sentiment component to the traditional models' stochastic discount factor. Other models describe biased extrapolation or learning processes (Barberis et al. 2015; Gervais and Odean 2001). A different class of tests models alternative preferences for investors to account for anomalies (BHC1) (Hirshleifer 2001, 1570). Anomalies may be caused, for instance, by loss averse agents with narrow decision frames (Barberis and Huang 2001; 2008; Barberis, Huang, and Santos 2001). In addition to pricing models, researchers have used event studies to observe whether specific information is priced correctly (Barberis and Thaler [2003] 2005, 37–38). Any reaction to events with no fundamental implications is taken as evidence for limited arbitrage (BHC2), the mispricing of information (BHC3), and the deviation of prices from intrinsic values (BHC4) (Barberis and Thaler [2003] 2005, 8). Moreover, work on most auxiliary hypotheses of the early phase continued to grow. Thus, the protective belt of the second phase becomes:

BPB2.1 Agents systematically deviate from rational behavior if static belief-based models capture specific anomalies.

BPB2.2 Agents systematically deviate from rational behavior if dynamic belief-based models capture price movements.

BPB2.3 Agents systematically deviate from rational behavior if preference-based models capture price movements.

BPB2.4 Agents systematically deviate from rational behavior if so implied by tests of individual investor behavior.

BPB2.5 Arbitrage is limited if so implied by noise trader interaction models.

BPB2.6 Arbitrage is limited if event studies imply the persistent mispricing of stock.

BPB2.7 Prices do not fully reflect available information if event studies imply the persistent mispricing of stock.

BPB2.8 Prices deviate from intrinsic values if returns are not captured by rational asset pricing models.

BPB2.9 Prices deviate from intrinsic values if returns are captured by noise trader interaction models.

BPB2.10 Prices deviate from intrinsic values if event studies imply the persistent mispricing of stock.

Judging by the nature and development of empirical tests, the positive heuristic (BPH), which guides the articulation of auxiliary hypotheses, consists of prescriptions such as:

BPH1 Construct statistical tests.

BPH2 Construct models that do not assume collective rationality.

BPH3 Construct models informed by biases identified by experimental psychology.

BPH4 Construct models that consider the decision process of investors.

BPH5 Conduct tests to explain phenomena unexplained by rational models.

BPH6 Observe the behavior of individual investors.

BPH7 Observe discrepancies between prices and information.

4.4 Progressiveness

A necessary condition for the progressiveness of the behavioral finance research program is that all auxiliary hypotheses hold empirical implications that no other program was designated to predict (Zahar 1973, 103). The hypotheses introduced in the first phase of behavioral finance almost exclusively (BPB1.1, BPB1.2, BPB1.3, BPB1.4, BPB1.5) provide new empirical explanations and therefore predict novel facts. The reliance on traditional pricing models (BPB1.6) is likewise directed at a novel fact since their traditional prediction was not the identification of anomalies. Therefore, the hypotheses' empirical implications warrant theoretical progressiveness. If some of these implications are at least partly corroborated, the program is overall progressive (Lakatos [1969] 1978, 49). Static models aimed at explaining particular anomalies with investor irrationality (BPB1.1) often rely on empirical phenomena to begin with. Thus, Shefrin and Statman (1984; 1985), De Bondt and Thaler (1985), Lee,

Shleifer, and Thaler (1991), as well as Benartzi and Thaler (1995) all conclude that the data mostly matches their models' predictions. The hypothesis of irrational financial agents was also corroborated by studies on the behavior of individual investors (BPB1.2). Researchers found that investors overreact (De Bondt and Thaler 1990), disagree about the interpretation of identical information (Harris and Raviv 1993), and gamble more after experiencing gains (Thaler and Johnson 1990). Furthermore, belief-based contrarian investment strategies (BPB1.3) were found to yield excess returns (Chopra, Lakonishok, and Ritter 1992; De Bondt and Thaler 1987). The hypothesis that arbitrage is limited if interaction models match price movements (BPB1.4) was supported by Russell and Thaler (1985) as well as DeLong et al. (1990a), whose findings were consistent with known anomalies. Other interaction models likewise succeeded in capturing some return patterns. This was taken as evidence for deviations from intrinsic values (BPB1.5) (Campbell and Kyle 1993; Shefrin and Statman 1994). More evidence for such deviations came from the lacking explanatory power of traditional asset pricing models (BPB1.6) documented in works by Shiller (1981) as well as De Bondt and Thaler (1985). The extensive empirical support for the auxiliary hypotheses makes the research program progressive in its early phase.

The adjustments made to the protective belt during the second phase of behavioral finance either introduced new tests with empirical implications (BPB2.2, BPB2.3) or directed known tests like event studies at new phenomena (BPB2.6, BPB2.7, BPB2.10). Accordingly, all additions constitute theoretically progressive problem shifts. While static belief-based explanations of specific anomalies are seldomly scrutinized, new tests of similar bias models have yielded ambiguous results (BPB2.1) (Chan, Frankel, and Kothari 2004). Moreover, new dynamic models are often better supported as they succeed in explaining a greater range of anomalies (BPB2.2). Dynamic belief-based models (Barberis, Shleifer, and Vishny 1998; Daniel, Hirshleifer, and Subrahmanyam 1998; Hong and Stein 1999) capture both momentum and price reversals, behavioral asset pricing models (Shefrin 2008; 2009) capture volatility, and learning models (Barberis et al. 2015; Gervais and Odean 2001) additionally capture trading volume and expected profits. Furthermore, new preference-based models successfully predicted the high mean, excess volatility, and predictability of returns (BPB2.3) (Barberis and Huang 2001; 2008; Barberis, Huang, and Santos 2001). The growing literature on investor sentiment uncovered patterns like naïve or insufficient diversification (Benartzi and Thaler 2001; French and Poterba 1991) and excessive trading (Barber and Odean 2000), thus providing more empirical evidence for the irrationality of financial agents (BPB2.4). New noise

trader models present further support for the limits of arbitrage and the mispricing of stock (BPB2.5, BPB2.9) (Shleifer and Vishny 1997).

The findings of event studies reporting the persistent mispricing of twin shares (Froot and Dabora 1999) and index inclusions (Harris and Gurel 1986; Shleifer 1986) provide evidence for both limited arbitrage (BPB2.6) as well as deviations from intrinsic values (BPB2.10). Furthermore, predictable price movements after earnings announcements (Chan, Jegadeesh, and Lakonishok 1996), dividend initiations (Michaely, Thaler, and Womack 1995), stock repurchases (Andrade, Mitchell, and Stafford 2001), and new issues of stock (Loughran and Ritter 1995) empirically back the hypotheses that prices do not reflect all available information (BPB2.7). Lastly, the persistent failure of new rational asset pricing models to capture substantive anomalies corroborates the disparity between prices and intrinsic values (BPB2.8) (Fama and French 1996; 2016). Taken together, the intermittent empirical support for all auxiliary hypotheses warrants empirical progressiveness and accomplishes the overall progressiveness of behavioral finance during its second phase.[7] Of course, the generality of hypotheses and the flexibility of behavioral modelling ease the attainability of intermittent support. As with the EMH, more refined and consistent testing may lead to different conclusions about the program's progressiveness in the future.

5. Discussion and Conclusion

Traditional and behavioral finance disagree on the causes of fluctuations in security prices. While the traditional EMH asserts that fundamental factors cause the fluctuations, behavioral finance theory points to psychological factors (Barberis and Thaler [2003] 2005, 3; Fama [1965] 1995, 76). There is disagreement about the differences between the axiomatic assumptions and supporting methodologies, as well as about the vitality of the two theories. To contribute to a systematic assessment of these aspects, this research has been guided by the question whether traditional and behavioral finance can be classified as two individual research programs according to Lakatos' MSRP. In this section, I am going to conclude the analysis by summarizing the findings, answering my research question, and providing an outlook.

5.1 Summary of Findings

Following the MSRP, traditional finance can be considered a degenerating research program with specific hard core assumptions and auxiliary hypotheses. Its hard core underwent ad-

[7] For an overview of the development of behavioral hard core assumptions, protective belt hypotheses, as well as their empirical corroboration see Table A2 in Appendix B.

justments in its early phase until the mid-1960s. The core assumptions hardened during its height in the 1970s and were subsequently retained. Important assumptions include the unexploitable character of price dependencies, the existence of some rational agents and their offsetting effect on irrational price deviations, as well as prices reflecting available information and estimating intrinsic values. Auxiliary hypotheses of the protective belt hold empirical implications by defining the methodology to test core assumptions. Hypotheses of the early phase built on tests of distribution, autocorrelation, as well as on runs and filter tests. During the second phase, new tests on performance and private information, event studies, and asset pricing were introduced. Advances during the third phase saw tests for forecast variables, seasonal patterns, volatility, and new multifactor asset pricing models. All adjustments to the protective belt entailed the prediction of novel empirical facts. Together with the intermittent corroboration of these predictions during the first and second phase of traditional finance, this warranted overall progressiveness. The novel predictions made during the third phase, however, have not been corroborated and hence do not meet the criterion of empirical progressiveness. Therefore, the EMH can be considered a degenerating research program since the 1990s.

Analogously, behavioral finance has been identified as a progressive research program with distinct core assumptions and auxiliary hypotheses. Since the beginning of behavioral finance in the 1980s, its hard core formed quickly and hardened through the introduction of further auxiliary hypotheses since the mid-1990s. Central assumptions are the systematic deviation from rational behavior by some agents, the limited effect of offsetting arbitrage, and therefore, prices not reflecting information and deviating from intrinsic values. The auxiliary hypotheses of the behavioral research program grew from the anomalies identified by rational asset pricing models. Other methods used to test the behavioral assumptions included static belief-based models aimed at specific anomalies, tests of individual investor behavior, tests of belief-based investment strategies, as well as noise trader interaction models aimed at capturing the deviations from intrinsic values and the limits of arbitrage. Further hypotheses introduced during the second phase of behavioral finance built on dynamic belief-based or preference-based models as well as on event studies that tested the limits of arbitrage, the incorporation of information, and the deviation from intrinsic values. The auxiliary hypotheses of behavioral finance predict empirical phenomena not anticipated by the traditional program. These predictions found intermittent corroboration in the program's first phase, when static models captured most anomalies they were directed at. More encompassing models in the second phase increased the corroborated empirical content by explaining a wider range of

anomalies. Accordingly, the behavioral research program has been overall progressive since its commencement.

5.2 Conclusion

The findings support the hypothesis that traditional and behavioral finance have undergone divergent trajectories in terms of core assumptions, auxiliary hypotheses, and overall progressiveness and can therefore be identified as distinctive series of theories. There are substantial differences in the hard core assumptions of the two research programs. Traditional finance relies on the assumption of rationality, which leads to the discounting information in prices either directly through competition or through the ordering effects of arbitrage. Consequently, prices are assumed to estimate the intrinsic values of securities. Behavioral finance breaks with these assumptions by assuming the existence of systematic deviations from rationality joint with limits to arbitrage offsetting such deviations. Therefore, prices are assumed to systematically deviate from intrinsic values.

The requirement of different empirical tests for these distinct assumptions results in largely diverging methodologies. Since both traditional and behavioral finance aim to explain the movement and composition of security prices, their methodological frameworks overlap in the use of models and tests like event studies, asset pricing models, and tests of trading rules. However, behavioral finance differs from traditional methodology in three ways. Firstly, while relying on similar statistic modelling, the incorporated factors are informed by experimental psychology, not fundamentals. Secondly, the assumption of limited arbitrage paved the way for new interaction and dynamic models. Lastly, tests of individual investor behavior allow for a more precise identification of decision patterns in the context of financial markets.

The nature of the distinct core assumptions and protective belt hypotheses leads to differences in the vitality of the two research programs. Despite the repeated readjustment of auxiliary hypotheses and the introduction of more encompassing multifactor models, the strong core assumptions of traditional finance have not been met empirically. Therefore, the traditional finance research program currently lacks vitality and is degenerating. During its short history, the core assumptions of behavioral finance remained unchanged. The success of its behavioral models demonstrates the research programs vitality and warrants progressiveness. In conclusion, the identifiability of distinct core theses, supporting methodologies, and levels of vitality allow for the classification of traditional and behavioral finance as two individual research programs according to Lakatos' MSRP.

5.3 Outlook

The previous evaluation of traditional and behavioral finance holds implications for their progressive potential, developments within the finance discipline, as well as for future research. Although the EMH has provided many new insights, the relevance of non-fundamental factors for price formation appears likely. Therefore, the regaining of progressiveness through future adjustments guided by rational assumptions is improbable, albeit not impossible. The greater empirical success of behavioral finance, on the other hand, has been blamed on ad hoc data fitting (De Bondt et al. 2008, 9). Despite the construction of more encompassing models, the variety of tests in the protective belt lacks consistency. However, future adjustments to the belt may reveal which type of model fits best to describe price forming mechanisms more precisely. While more and more precise model may falsify existing hypotheses, an increase in corroborated empirical predictions would, nevertheless, ensure continuous progressiveness.

These differences in the progressive potential may influence the direction of the finance discipline. Following Lakatos' ([1969] 1978) theory of scientific rationality, researchers will abandon a degenerating research program if a more progressive alternative is available to them. The progressiveness of the behavioral finance program and the increasing body of behavioral finance research supports this hypothesis. Yet, at what point finance researchers will definitively abandon the degenerating traditional program is not clear. The persistent application of some traditional models, as well as the immunity of traditional assumptions to falsification contradict a clear Kuhnian or Popperian shift away from traditional finance theory. However, as long as behavioral finance holds the upper hand of progressiveness in this enduring battle of research programs, the increase in behavioral finance research is likely to continue.

As the competition of theories in debate about the determinants of security prices endures, there are various avenues for further research. One path to pursue is the evaluation of future developments in the protective belts of both theories. New models of individual decision making in the context of financial markets could make the auxiliary hypotheses of behavioral finance more consistent. Likewise, the identification of underlying business conditions as a rational explanation for price movements may revitalize the traditional research program. Another path for research to follow is the analysis of specific methodologies found in the protective belts of both programs. The development of rational and behavioral multifactor models, for instance, may be considered a research program of its own, possibly rivaled by methods like the interaction models championed by Hong and Stein (2007, 110). Finally, as researchers urge policy makers to take a more behavioral perspective, it will be interesting to

observe the political implications of a shift towards the behavioral finance research program (De Bondt et al. 2008, 11).

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Table A1. Traditional Finance Research Program Development

Phase		Hard Core		Protective Belt	Corroboration	Progress
Phase 1 (mid-1960s)	THC1.1	Changes in successive individual security prices are independent	TPB1.1	Price changes are independent if they follow a Gaussian or stable Paretian distribution	· Yes (Fama 1963; 1965; Kendall 1953; Mandelbrot 1963; Moore 1962)	Yes
	THC1.2	Analysis of price sequences does not yield excess return	TPB1.2	Price changes are independent if so implied by tests of serial correlation	· Intermittent (Fama 1970, 84)	
	THC1.3	Costs of information and transaction are zero	TPB1.3	Price changes are independent if so implied by runs tests	· Intermittent (Fama 1970, 84)	
	THC1.4	Agents rationally base their action on information	TPB1.4	Price changes are independent if so implied by tests of mechanical trading rules	· Intermittent (Fama 1970, 84)	
	THC1.5	Prices fully reflect available information				
	THC1.6	Prices estimate the intrinsic values of securities				
Phase 2 (mid 1960s - 80s)	*THC2.1*	*Dependencies of changes in successive individual security prices do not yield excess returns*	*TPB2.1*	*Prices follow a martingale with unexploitable dependencies if price changes approximate a Gaussian or stable Paretian distribution*	· Yes (Fama 1970; Fama and Blume 1966; Mandelbrot 1966)	Yes
	THC2.2	*Some agents rationally base their action on information*	*TPB2.2*	*Prices follow a martingale with unexploitable dependencies if tests show little predictable autocorrelation*	· Yes (Fama 1970; Fama and Blume 1966; Mandelbrot 1966)	
	THC2.3	*Rational agents offset effects that irrational agents have on prices*	*TPB2.3*	*Prices follow a martingale with unexploitable dependencies if so implied by tests of mechanical trading rules*	· Yes (Fama 1970; Fama and Blume 1966; Mandelbrot 1966)	
	THC2.4	Prices fully reflect available information	*TPB2.4*	*Prices follow a martingale with unexploitable dependencies if the tested performance of funds does not exceed the market line*	· Yes (Fama 1970; Fama and Blume 1966; Mandelbrot 1966)	
	THC2.5	Prices estimate the intrinsic values of securities	*TPB2.5*	*Prices fully reflect available information if they quickly react to firm specific events*	· Yes (Ball and Brown 1968; Fama et al. 1969; Scholes 1970)	
			TPB2.6	*Prices fully reflect available information if individuals do not possess private information not reflected in prices*	· No (Niederhoffer and Osborne 1966)	
			TPB2.7	*Prices estimate the intrinsic values of securities if returns are captured by one or two-factor asset pricing models*	· Yes (Fama 1970; Fama and MacBeth 1973)	
Phase 3 (since 1990s)	THC2.1	Dependencies of changes in successive individual security prices do not yield excess returns	TPB3.1	Prices follow a martingale with unexploitable dependencies if tests show little predictable autocorrelation	· No (De Bondt and Thaler 1985; 1987; Fama and French 1988b; Jegadeesh and Titman 1993; Lo and MacKinlay 1988)	No
	THC2.2	Some agents rationally base their action on information	*TPB3.2*	*Prices follow a martingale with unexploitable dependencies if returns cannot be forecasted with specific variables*	· No (Campbell and Shiller 1988; Fama and French 1988a; 1992; Shiller, Fischer, and Friedman 1984)	
	THC2.3	Rational agents offset effects that irrational agents have on prices	*TPB3.3*	*Prices follow a martingale with unexploitable dependencies if their movements do not follow seasonal patterns*	· No (Ariel 1987; 1990; Cross 1973; French 1980; Gibbons and Hess 1981; Harris 1986; Keim 1983; Thaler 1987)	
	THC2.4	Prices fully reflect available information	TPB3.4	Prices follow a martingale with unexploitable dependencies if the tested performance of funds does not exceed the market line	· Yes (Elton et al. 1993; Malkiel 2005)	
	THC2.5	Prices estimate the intrinsic values of securities	TPB3.5	Prices fully reflect available information if they quickly react to firm specific events	· Intermittent (Fama 1991, 1602; Lakonishok and Vermaelen 1990; Loughran and Ritter 1995)	
			TPB3.6	Prices fully reflect available information if individuals do not possess private information not reflected in prices	· No (Ippolito 1989; Liu, Smith, and Syed 1990; Lloyd-Davies and Canes 1978)	
			TPB3.7	*Prices estimate the intrinsic values of securities if they do not display excess volatility*	· No (Shiller 1979; 1981; 1988)	
			TPB3.8	*Prices estimate the intrinsic values of securities if returns are captured by multifactor asset pricing models*	· No (Fama and French 1996; 2016)	

Note: The program underwent three phases. Its hard core assumptions (THC) adjusted in its early phase and were retained from phase 2 onwards. The auxiliary hypotheses of the protective belt (TPB) make these assumptions testable. If adjustments to the belt make new empirical predictions, of which some are corroborated, the program is considered progressive. Adjusted assumptions and hypotheses are in italics. Empirical literature considered is in parentheses.

Table A2. Behavioral Finance Research Program Development

Phase		Hard Core		Protective Belt	Corroboration	Progress
Phase 1 (mid-1980s - 90s)	BHC1	Some financial agents systematically deviate from rational behavior	BPB1.1	Agents systematically deviate from rational behavior if static belief-based models capture specific anomalies	· Yes (Shefrin and Statman 1984; 1985; De Bondt and Thaler 1985; Lee, Shleifer, and Thaler 1991; Benartzi and Thaler 1995)	Yes
	BHC2	Arbitrage offsetting the effects that irrational agents have on prices is limited	BPB1.2	Agents systematically deviate from rational behavior if so implied by tests of individual investor behavior	· Yes (De Bondt and Thaler 1990; Thaler and Johnson 1990)	
	BHC3	Prices do not fully reflect available information	BPB1.3	Agents systematically deviate from rational behavior if belief-based contrary investment strategies yield excess returns	· Yes (Chopra, Lakonishok, and Ritter 1992; De Bondt and Thaler 1987)	
	BHC4	Prices deviate from the intrinsic values of securities	BPB1.4	Arbitrage is limited if so implied by noise trader interaction models	· Yes (Russell and Thaler 1985; DeLong et al. 1990a)	
			BPB1.5	Prices deviate from intrinsic values if returns are captured by noise trader interaction models	· Yes (Campbell and Kyle 1993; Shefrin and Statman 1994)	
			BPB1.6	Prices deviate from intrinsic values if returns are not captured by rational asset pricing models	· Yes (Shiller 1981; De Bondt and Thaler 1985)	
Phase 2 (since late 1990s)	BHC1	Some financial agents systematically deviate from rational behavior	BPB2.1	Agents systematically deviate from rational behavior if static belief-based models capture specific anomalies	· Intermittent (Chan, Frankel, and Kothari 2004)	Yes
	BHC2	Arbitrage offsetting the effects that irrational agents have on prices is limited	*BPB2.2*	*Agents systematically deviate from rational behavior if dynamic belief-based models capture price movements*	· Yes (Barberis, Shleifer, and Vishny 1998; Barberis et al. 2015; Daniel, Hirshleifer, and Subrahmanyam 1998; Gervais and Odean 2001; Hong and Stein 1999; Shefrin 2008; 2009)	
	BHC3	Prices do not fully reflect available information	*BPB2.3*	*Agents systematically deviate from rational behavior if preference-based models capture price movements*	· Yes (Barberis and Huang 2001; 2008; Barberis, Huang, and Santos 2001)	
	BHC4	Prices deviate from the intrinsic values of securities	BPB2.4	Agents systematically deviate from rational behavior if so implied by tests of individual investor behavior	· Yes (Benartzi and Thaler 2001; Barber and Odean 2000; French and Poterba 1991)	
			BPB2.5	Arbitrage is limited if so implied by noise trader interaction models	· Yes (Shleifer and Vishny 1997)	
			BPB2.6	*Arbitrage is limited if event studies imply the persistent mispricing of stock*	· Yes (Harris and Gurel 1986; Shleifer 1986)	
			BPB2.7	*Prices do not fully reflect available information if event studies imply the persistent mispricing of stock*	· Yes (Andrade, Mitchell, and Stafford 2001; Chan, Jegadeesh, and Lakonishok 1996; Loughran and Ritter 1995; Michaely, Thaler, and Womack 1995)	
			BPB2.8	Prices deviate from intrinsic values if returns are not captured by rational asset pricing models	· Yes (Fama and French 1996; 2016)	
			BPB2.9	Prices deviate from intrinsic values if returns are captured by noise trader interaction models	· Yes (Shleifer and Vishny 1997)	
			BPB2.10	*Prices deviate from intrinsic values if event studies imply the persistent mispricing of stock*	· Yes (Harris and Gurel 1986; Shleifer 1986)	

Note: The behavioral program underwent two phases. Its hard core assumptions (BHC) formed early and were subsequently retained. The protective belt hypotheses (BPB) make these assumptions testable. If adjustments to the belt make new empirical predictions, some of which are corroborated, the program is considered progressive. Adjusted assumptions and hypotheses are in italics. Empirical literature considered is in parentheses.