Exchange-traded Funds and Financial Stability

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Abstract

Exchange-traded Funds (ETFs) are easy to understand, cost-efficient ways of investing in asset markets that have become very popular for both institutional and retail investors. Investing in an index of assets via an ETF can generate quite complex and sometimes counterintuitive investment behaviors on the level of individual assets. These dynamics depend among others on the kind of market index, the shares of different types of traders in the market, price trends in individual stocks and the overall market, as well as situations of over- or undervaluation of individual stocks and the index. Based on a heterogeneous agent model we reproduce several stylized facts concerning ETFs. We find that the the availability of ETFs per se affects financial stability much less than the role of increased trading, for example, caused by lower assumed risk.

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Exchange-traded index funds; ETF; index fund; heterogeneous agent model; bubbles; financial stability; volatility

JEL codes

C63, G01, G10, G11

1 Introduction

Exchange-traded Funds (ETFs) are easy to understand, cost-efficient, and liquid investment vehicles that have become very popular for both institutional and retail investors (Gastineau, 2010; Oura et al., 2015; Wiandt and McClatchy, 2002). While the typical ETF tracks the performance of an underlying stock index, ETFs are also available for a wide variety of indices of other asset classes such as bonds and for a broad spectrum of alternative investment strategies. It therefore might not come as a surprise that ETFs have seen an extraordinary growth since their introduction in the mid-1990s with assets under management of around 3.4 trillion USD by mid-2016 (Kremer, 2016).

As ETFs have grown substantially in assets, diversity, and market significance in recent years, regulators and researchers in particular ask how these developments might affect financial stability and financial market governance (Fichtner et al., 2017; Ivanov and Lenkey, 2014; Ockenfels and Schmalz, 2016b). Still there is only limited analysis on how these ETFs' dramatic growth might affect the performance of asset markets.

However, in a first step ETFs can be seen as part of the general long-lasting trend in the asset management industry from active to passive investment and a lot can be learned by work trying to explain this trend and to explore the implications for market quality (see Ben-David et al., 2014, 2016, 2017). On the one hand the spread of passive investment is seen as evidence of improved market efficiency as arbitrage opportunities have disappeared (Stambaugh, 2014). Research on index-based investment strategies is also related to work on the role of institutional asset managers for financial asset prices. Cuoco and Kaniel (2011) find that conditional volatilities of an index stock and aggregate stock market decrease in the presence of benchmarking. On the other hand Baker and Wurgler (2011) points to a number of potential adverse effects associated with increased indexation. Indexing might create distortion in securities' valuations, such as inclusion and deletion effects (e.g., see Shleifer, 1986; Wurgler and Zhuravskaya, 2002; Kaul et al., 2000; Greenwood, 2005) comovement of the stock with the index (e.g., see Greenwood and Sosner, 2007; Basak and Pavlova, 2013, 2016; Da and Shive, 2016), and higher sensitivity to bubbles and subsequent crashes. In addition, problems for corporate governance might arise.

More specifically in the case of ETFs Ben-David et al. (2014) find that ETF ownership of stocks leads to higher volatility and turnover. In contrast, Ivanov and Lenkey (2014) find no empirical evidence for an increase in price volatility in the case of leveraged ETFs. ETFs are also likely to affect the process of price discovery in asset markets. Glosten et al. (2016) find that stocks incorporate information more quickly once they are in ETF portfolios. They argue that some of the increased comovement that was documented by other researchers can be explained by better incorporation of systematic information into stock prices. This evidence is consistent with the study of Da and Shive (2016) that documents an increased comovement in returns in the stocks that are part of an index. When investors trade on news related to the index, they trade the ETF more actively. The mechanical basket trading of the underlying securities tied to the ETF through arbitrage exhibits in higher return comovement and causes basket stocks to lose part of their idiosyncratic volatility. Therefore, individual stock response is expected to be less sensitive and less timely to idiosyncratic earnings news (see also Sullivan and Xiong, 2012; Israeli et al., 2017, for supporting evidence).

However, not all researchers agree that ETFs improve the informational efficiency of assets in ETF baskets pointing to among others to higher trading costs and lower analyst coverage (e.g., Israeli et al., 2017), slower price discovery (Bradley and Litan, 2011, 2010), the impact of retail investor sentiments (Da et al., 2015), and the increased attractiveness of ETFs for short-horizon noise traders with correlated demand across investment styles (Broman, 2016). In related research a number of studies analyze how ETFs may transmit noise to the underlying assets. ETFs have seen high turnover and are traded by traders who tend to make directional bets with short time horizon implying low informational efficiency, deterring long-term investors and exacerbating price drops in times of market turmoil (e.g. Stratmann and Welborn, 2012; Cella et al., 2013; Ben-David et al., 2014). Chinco and Fos (2016) analyze how the rebalancing needs of ETFs in case of price changes trigger large rebalancing cascades that exacerbate the original price shock.

In their broadly based analysis of the asset management industry Oura et al. (2015) identify risk-creating mechanisms even for seemingly simple financial products such as ETFs. They conclude that large ETFs do not necessarily contribute to systemic risk. Rather it is the investment focus that appears to be relatively more important.

To sum up, maybe, ETFs are assumed to be mainly used for long-ranged buy-and-hold investments. Actually, ETF shares are often actively traded and they are more traded than the underlying stocks (Shiller, 1980). This increased trading can be explained in different ways: ETFs are traded by big investors who trade more, ETFs are easy to trade, which causes the excess trading, or investors presume a lower risk when trading ETFs and, thus, trading more.

This study contributes to the literature on the role of ETFs for financial stability by systematically bringing together the specific relation between ETF and the underlying assets via the rebalancing effect and specific trading strategies ETFs are used for. The interaction between this rebalancing effect and the specific ETF trading strategies can imply very complex, seemingly counterintuitive trading strategies on the level of the individual stocks depending on

- the strategy of ETF investors, e.g., fundamentalist or chartist,
- the price dynamics of the individual stocks, i.e., increasing or decreasing,
- the prices of the individual stocks relative to their fundamental values, i.e., situation of over- or undervaluation,
- the type of underlying index, e.g., assets being weighted by price or market capitalization.

Take, e.g., a bull market in which stock A rises more slowly than the overall market (index). An index chartist pursuing a trend following strategy would invest in such situation, i.e., she would invest in all stocks in the index according to their relative weight. If the stocks in the index are price weighted as, e.g., in the Dow Jones Industrial Average, the relative weight of stock A in the index decreases as its price declines relative to the remaining asset prices in the index. The necessary rebalancing of the index implies that the index investor invests relatively less in stock A and can even disinvest from that stock, a behavior which is obviously opposite to her trading on the level of the overall index. As a consequence of these complex interactions seemingly destabilizing investment strategies such as trend following can have stabilizing effects on the level of the individual stock while a fundamentalist on the index level might induce instabilities on the level of individual stocks. Thus, depending on specific price developments, rebalancing effects can imply that, e.g., trend following index investors behave like fundamentalists for individual stocks.

To explicitly allow for different investment strategies and their interactions on the level of the index and individual stocks, we follow Challet et al. (2015) and Drescher and Herz (2012) and use a heterogeneous agent model (HAM) framework (Hommes, 2006) to analyze how the increasing use of ETFs and other index-orientated financial products alters the price dynamics of the underlying assets, possibly increasing risks for financial stability.

Our simulation results indicate that it is not so much the presence of ETF funds per se but rather the increased trading as well as the specific investment strategies that might be a cause of concern. Thus, we analyze:

- Increased comovement of stocks that are included in the index and the index

- Higher speed of inclusion of new information/price discovery in case of aggregate index shocks
- Slower speed of inclusion of new information/price discovery in case of idiosycratic shocks
- Possibly increased volatility in the index's underlying stocks
- Increased price reversals in the index's stocks
- The role of increased trading, which is very important for our results

Concerning financial stability, we find that ETFs might jeopardize financial stability by an increased trading volume and shifting indiosyncratic excess volatility all over the index. Especially when trend followers use ETFs high investments are spread over the index and, thus, financial stability is lowered. Fundamentalists that trade ETFs are not always able to balance this effects when prices strongly oscillate around their fundamentals.

In Section 2 we present some analytical findings on the effects of index based investment strategies and in Section 3 we discuss some counterintuitive price effects that can result from strategies of fundamentalists and chartists, in particular trend followers, based on index funds. Section 4 studies ETF specific effects in greater detail in an HAM based on Monte Carlo simulations. Section 5 concludes the paper.

2 Investment Strategies and Price Dynamics of Individual Assets and Indices

In the following, we analytically investigate the relation between the price dynamics of a stock index and its underlying individual stocks. We define as *index* both a publicly known set of assets that are considered to be representative for a market as well as the price of that index which is defined as the sum of the (weighted) prices of the index's assets. To simplify our analysis, we assume that the price of the index is available to all market participants at any time and at no costs.

For the case of an index in which stocks are price weighted, such as the Dow Jones Industrial Average and the Nikkei 225, the implicit net asset position $I_i^\ell(t)$ of an ETF trader ℓ in stock i at time t is given by

$$I_i^\ell(t) = I^\ell(t) \cdot \pi_i(t) \tag{1}$$

$$= I^\ell(t) \cdot \frac{p_i(t)}{p(t)}$$

where $I^\ell(t)$ denotes trader ℓ's net asset position in the ETF with price $p(t) = \sum_{j=1}^{N} p_j(t)$. With a market price $p_i(t)$, stock i's relative weight in the index is $\pi_i(t)$. Note that traders investing in ETFs are per se (a little bit) like chartists, especially like trend followers, since the ETF is investing more in rising stocks and disinvesting from falling ones.

Investments in an ETF imply trades in individual stocks according to two effects, namely the level of the net asset position $I^\ell(t)$ (*level* or *quantity effect*) and the stocks's relative weight $\pi_i(t)$ (*rebalancing*, *price*, or *composition effect*).[1] To better understand how trading in ETFs implies specific tradings in the index's underlying stocks, we focus on the level and the rebalancing effect of ETF investments for the underlying individual stocks as given in Equation (1). Given the previous net asset position, its current investment in the index, and the index's rebalancing dynamics, we can determine an ETF trader's investment in the individual stocks.

Proposition 1. The investment in stock i of an ETF trader ℓ with a net asset position I^ℓ in period t is given by

$$\Delta I_i^\ell(t) = \Delta I^\ell(t)\pi_i(t) + I^\ell(t-1)\Delta\pi_i(t) \tag{2}$$

Proof. It holds:

$$\begin{aligned}
\Delta I_i^\ell(t) &= I_i^\ell(t) - I_i^\ell(t-1) \\
&= I^\ell(t)\pi_i(t) - I^\ell(t-1)\pi_i(t-1) \\
&= I^\ell(t)\pi_i(t) - I^\ell(t-1)\pi_i(t) + I^\ell(t-1)\pi_i(t) - I^\ell(t-1)\pi_i(t-1) \\
&= \Delta I^\ell(t)\pi_i(t) + I^\ell(t-1)\Delta\pi_i(t)
\end{aligned}$$

□

To better understand how ETF trading affects the implicit trading of the underlying stocks and to motivate the subsequent Monte Carlo simulation analysis in Section 4, we analyze the quantity and price dimensions of the investment in the individual stocks in greater detail. First, the investment in an individual stock i depends on the investment

[1] A trader's gain is independent of trading in ETF shares or in the underlying stocks according to Equation (1), see Appendix A.1 for a proof.

in the index given the relative weight of the stock in the index, i.e., $\Delta I^{\ell}(t)\pi_i(t)$ (*level effect*). Secondly, the investment in individual stocks also depends on how the fund reallocates the overall investment in the index due to changes in the relative weight of the individual stocks, i.e., $\Delta\pi_i(t)$ (*rebalancing effect*). The level effect, i.e., the first summand of Equation (2), depends on the trader's strategy and her investment $\Delta I^{\ell}(t)$, whereas the rebalancing effect, the second summand, depends on the change of the relative price of the stock, i.e., on market dynamics that cannot directly be influenced by the trader. Thus, an ETF trader actively controls her investment only on the level of the index, and passively tolerates the implications for investments on the level of the individual assets. As the two effects can work in the same or in opposite directions, the net effect of index trading on indivdual stocks is a priori indeterminate and depends on the relative size of the level and the rebalancing effects. The interactions of these two effects can have complex and sometimes counterintuitive effects of ETF investments on the underlying stocks, as we illustrate further below.

3 Motivation for Counterintuitive Trading

We conduct some simple simulations to illustrate how investment strategies on the level of an index can imply quite different investment behavior on the level of the individual stocks of the index due to the rebalancing caused by changes in the relative price of the underlying stocks.

Obviously, the effects of ETFs on price and investment dynamics of individual stocks depend substantially on the investment strategies of the ETF traders. In the following, we compare investment decisions under specific price dynamics for different investment strategies.[2] In particular, we specify simple trading strategies for chartists, in particular trend followers, and fundamentalists while differentiating between traders who invest in individual stocks or ETF stock indices giving rise to four distinct types of traders, namely chartists in individual stocks (C) and in ETFs (E-C) as well as fundamentalistic investors in individual stocks (F) and ETFs (E-F).

To keep our analysis simple, we assume in this preliminary analysis that traders can only invest or disinvest a constant amount $\overline{\Delta I}$ per period and that price dynamics are given, i.e., traders are price takers and too small to affect market prices. Therefore, we denote chartists with constant investment with C_Δ and fundamentalists with constant investment with F_Δ. In our subsequent simulation analysis (see Section 4), we allow for

[2] In the case of the buy-and-hold trader, the most simple type of trader in our analysis, there is no difference between directly investing in the index's stocks and investing in an ETF, see Appendix A.1.

investments with varying size and allow traders to affect prices in the framework of an HAM (Hommes, 2006).

Chartists in individual stocks (C_Δ) invest the amount $\overline{\Delta I}$ according to

$$\Delta I_i^{C_\Delta}(t) = \begin{cases} +\overline{\Delta I}, & p_i(t) > p_i(t-1) \wedge t > 1, \\ -\overline{\Delta I}, & p_i(t) < p_i(t-1) \wedge t > 1, \\ 0, & p_i(t) = p_i(t-1) \vee t = 0, \end{cases}$$
$$= \overline{\Delta I} sgn(p_i(t) - p_i(t-1))\mathbb{I}_{t>0} \qquad \forall i \in \{1, \dots, N\}$$

while ETF chartists (E-C_Δ) invest according to

$$\Delta I^{E-C_\Delta}(t) = \begin{cases} +N\overline{\Delta I}, & p(t) > p(t-1) \wedge t > 1, \\ -N\overline{\Delta I}, & p(t) < p(t-1) \wedge t > 1, \\ 0, & p(t) = p(t-1) \vee t = 0, \end{cases}$$
$$= N\overline{\Delta I} sgn(p(t) - p(t-1))\mathbb{I}_{t>0}$$

with N being the number of stocks in the index. Note that the investment of an ETF chartist is diversified across the index according to Equation (1).

Analogously, fundamentalistic traders who invest in individual stocks (F_Δ) follow

$$\Delta I_i^{F_\Delta}(t) = \begin{cases} +\overline{\Delta I}, & p_i(t) < f_i(t+1), \\ -\overline{\Delta I}, & p_i(t) > f_i(t+1), \\ 0, & p_i(t) = f_i(t+1), \end{cases}$$
$$= \overline{\Delta I} sgn(f_i(t+1) - p_i(t)) \qquad \forall i \in \{1, \dots, N\},$$

while fundamentalistic ETF traders (E-F_Δ) invest according to

$$\Delta I^{E-F_\Delta}(t) = \begin{cases} +N\overline{\Delta I}, & p(t) < f(t+1), \\ -N\overline{\Delta I}, & p(t) > f(t+1), \\ 0, & p(t) = f(t+1), \end{cases}$$
$$= N\overline{\Delta I} sgn(f(t+1) - p(t))$$

for given expected fundamental values f_i for all stocks i and respective fundamental value of the index $f = \sum_{i=1}^{N} f_i$. The market environment is non-stochastic, i.e., there is

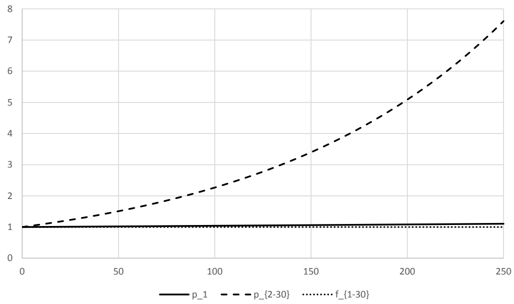

Figure 1: Price paths p_1 of stock 1 and p_{2-30} of stocks 2-30.

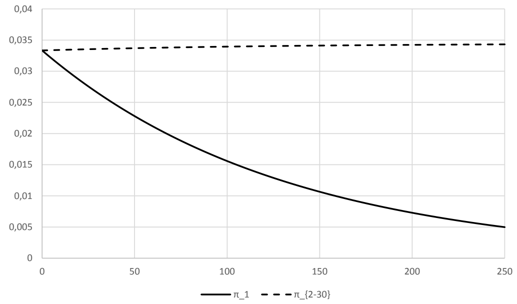

Figure 2: Change of the ratio π_1 and π_{2-30} of stock 1 and stocks 2-30, respectively.

no noise in the fundamentals.

In the subsequent scenario analysis, we assume an index with $N = 30$ stocks with starting price $p_{1-30}(0) = 1$ on time grid $\mathcal{T} = \{0, 1, \dots, T = 250\}$. The price of stock 1 follows $p_1(t+1) = p_1(t)e^{\frac{\mu_1}{250}}$ and the index develops according to $p(t+1) = p(t)e^{\frac{\mu}{250}}$ where $\mu_1 > -1$ and $\mu > -1$ are fixed and $p_i(t) = p_j(t)\ \forall t\ \forall i, j \in \{2, \dots, N\}$. The trends μ_1 and μ are chosen so that $p_i(t) > 0$ is fulfilled for all $t \in \mathcal{T}$ and all $i \in \{1, \dots, N\}$. Additionally, we set $0 < f_i \equiv \overline{f_1}$ as constant for all i and so $\overline{f} \equiv N\overline{f_1}$ is constant as well. (Dis)Investment per period is $\pm\overline{\Delta I} = \pm 1$. The parameters under investigation are μ_1, μ, and $\overline{f}$.

Given this simple framework, we identify different scenarios in which ETF investments have interesting, seemingly counterintuitive effects on the level of individual stocks due to the complex interactions of level and rebalancing effects.[3]

Scenario: modestly rising stock in a bull market We assume that the price of stock 1 rises with trend $\mu_1 = 0.1$, while the price of the index grows with trend $\mu = 2$, i.e., π_1, the relative price of stock 1, falls. All stocks are assumed to be overvalued relative to their fundamental values f_i that are set to unity, i.e., $p_i > f_i = 1$ and $p > f = 30$ holds $(t > 0)$. Figures 1 and 2 display these price dynamics that underlie the four investment strategies.

Given the price dynamics, how do the different traders allocate their funds? As the prices of all stocks rise, chartists that either invest in individual stocks (C_Δ) or the index (E-C_Δ) invest in their respective target asset. As the stocks and the index are overvalued, single stock (F_Δ) and index (E-F_Δ) orientated fundamentalists disinvest

[3]See Appendix A.3 for two additional scenarios in which ETF trading has counterintuitive effects on individual stocks.

from their respective target assets.

Stock 1 as well as the other stocks have increases in price and are above their respective fundamental values (see Figure 1). However, stock 1 differs from the other stocks as its relative price π_1 declines (see Figure 2). Chartists (C_Δ) invest in stock 1 as the absolute price of stock 1 rises, while fundamentalists (F_Δ) disinvest as the stock is overvalued (see Figure 3). These single stock strategies serve as benchmarks to demonstrate how "conventional" fundamentalists and chartists trade given constant investment per period ($|\Delta I^{C_\Delta}| \equiv |\Delta I^{F_\Delta}| \equiv \overline{\Delta I}$ being constant).

The strategies of ETF investors can have rather complex effects on the level of individual stocks. Given the assumption that the index is overvalued and its price rises (see Figure 4), ETF chartists invest, while ETF fundamentalists disinvest on average. This implies interesting trade dynamics on the level of stock 1 in the case of the two types of index investors. ETF chartists (E-C_Δ) implicitly invest less and less as the relative price of stock 1, π_1, and thus its relative weight in the index declines (see Figure 2), i.e., the level effect of E-C_Δ investment decreases as less money $\Delta I^{E-C_\Delta}\pi_i(t)$ is allocated to stock 1 (see Equation (2)). At the same time the rebalancing effect, the second part of Equation (2), calls for disinvesting from stock 1 to account for its reduced weight in net asset position I^{E-C_Δ}. Eventually, the rebalancing effect dominates the level effect and the ETF chartists disinvest from stock 1 (see Figure 3). In contrast, ETF fundamentalists (E-F_Δ) start off disinvesting from the overvalued index and thus disinvest from stock 1 at first. Over time they disinvest less and less of this stock (see Figure 3) as its relative price and thus its relative weight in the index decreases. While they disinvest from ETF shares due to the overvaluation of the index (level effect), they implicitly invest in stock 1 to assure the appropriate portfolio allocation (rebalancing effect). As the relative price of stock 1 continues to fall, the positive rebalancing effect eventually dominates the level effect and ETF fundamentalists become de facto net investors in an overvalued stock.

Taken together and somewhat counterintuitively, ETF chartists end up disinvest from a rising stock, while ETF fundamentalists invest in an overvalued stock. From the perspective of financial stability, ETF chartists tend to stabilize, while ETF fundamentalists tend to destabilize this specific stock price development. Ultimately, the complex trade dynamics are driven by the different investment strategies of the two types of traders and the complex interactions between the market price dynamics of individual stocks and the index, the relative market to fundamental price of individual stocks and index, as well as the initial positive or negative net asset position of the investors. Appendix A.2 analyzes in greater detail how these interrelations work to (de)stabilize stock prices. Obviously, these counterintuitive effects only hold for the "outlier" stock 1, while for

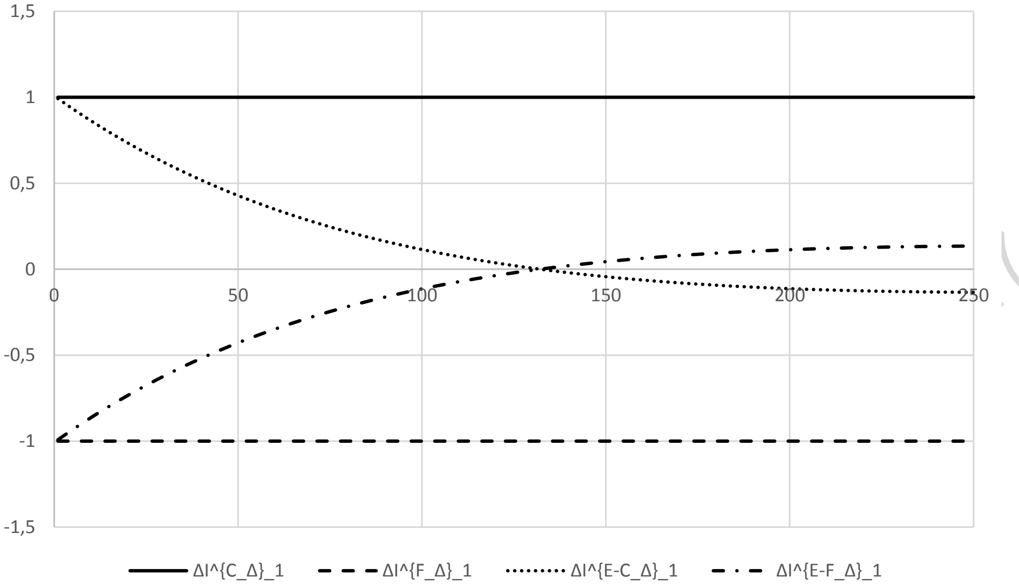

Figure 3: Investment ΔI_1^ℓ in stock 1 if the stock price rises more slowly than index price.

stocks 2-30 the effects of chartists and fundamentalists are as conventionally expected (see Figure 5).[4]

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[4] Appendix A.3 contains two more examples, namely *scenario 2: a rising stock in a bear market* and *scenario 3: falling stock in a bull market with the index crossing its fundamental value from below.* Also in these cases, we can see the counterintuitive behavior of ETF traders.

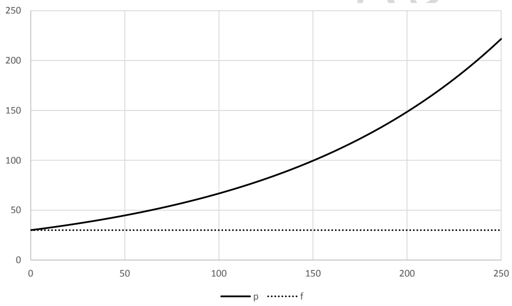

Figure 4: Price path p of the index.

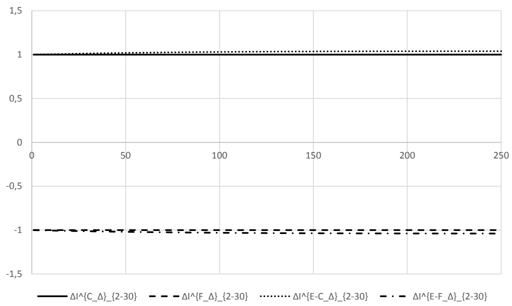

Figure 5: Investment ΔI_{2-30}^ℓ in stocks 2-30.

4 Exchange-traded Funds and Market Dynamics in a Heterogeneous Agent Model

Based on the insights developed in Sections 2 and 3 on the role of ETF traders for financial (in)stability, we analyze in a dynamic HAM how the interactions of different types of (ETF) traders affect asset price dynamics and financial market stability. Heterogeneous trader, which act from an objective point of view somehow irrational, are widely used for analyzing market efficiency and stability (Shleifer, 2000). For heterogeneous strategies see Hommes (2006) (and more empirically also Menkhoff and Schmidt (2005)).

4.1 Price Model and Trader Types

We base our analysis on a market maker HAM of the type analyzed by Challet et al. (2015); Drescher and Herz (2012). Also Beja and Goldman (1980); Franke and Westerhoff (2012); Westerhoff (2012) use a similar kind of market maker model. Thereby, a market maker can be seen as a further type of trader whose investment is a residual of the other traders' (excess) demands.

In this framework, agents decide on selling and buying assets with the market maker clearing the market and adjusting prices according to the timeline depicted in Figure 6. In every time period $t \in \{0, \ldots, T-1\}$, agents of type ℓ determine their demand (actually this is an excess demand function) $D_i^\ell(t)$ based on the market price of their target asset $p_i(t)$, the market price of the index $p(t)$, and their expectations of the fundamental values $\mathbb{E}_t[f_i(t+1)]$ and $\mathbb{E}_t[f(t+1)]$.[5]

The market maker aggregates asset demand und adjusts the asset price according to the pricing rule

$$p_i(t+1) = p_i(t) \exp\left(\sum_\ell D_i^\ell(t)/M\right)$$

with $M > 0$ as an overall scaling factor for trading volume and market power. As in the discussion of Section 3, we distinguish between four types of traders depending whether they invest in a single stock or an ETF index and whether they are fundamentalists or chartists. In contrast to the above analysis in which traders could only invest or disinvest a fixed volume of assets, we generalize the investment behavior so that traders can also decide on the volume of their (dis)investment. The single stock traders invest in all assets available on the market separately whereas the ETF traders invest in one

[5] For HAMs in the context of bubble analysis cf. Baumann et al. (2017); De Long et al. (1990).

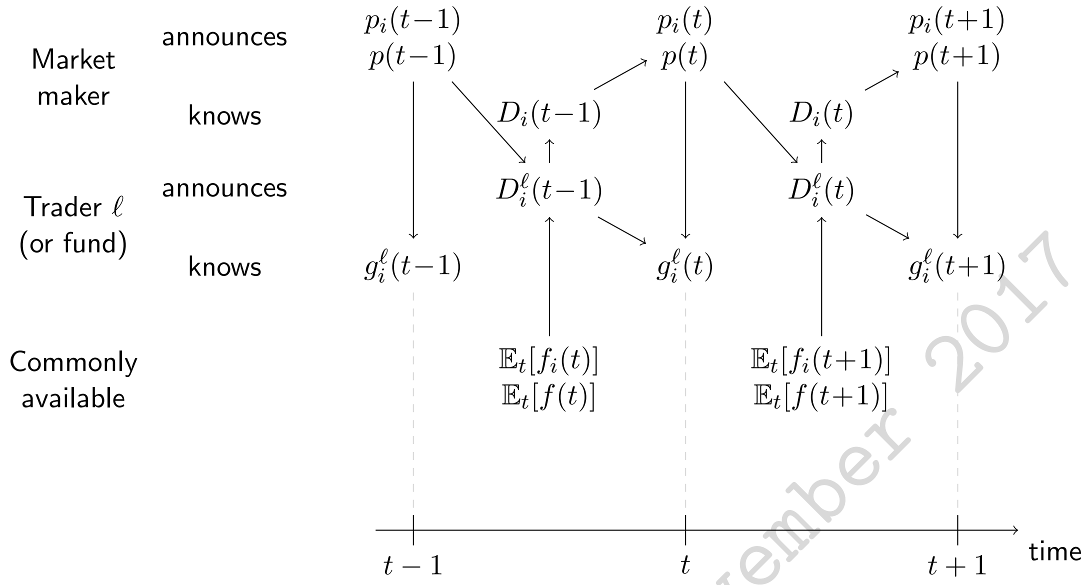

Figure 6: Timeline of actions and distribution of information for stock i.

index reproducing these assets. We regard on the following specific trading strategies:[6]

Chartists (C) in individual stocks follow the trading rule

$$D_i^C(t) = (1-Q) \cdot K_C \cdot \left(\frac{p_i(t)}{p_i(t-1)} - 1 \right), \ t > 0$$

with feedback parameter $K_C > 0$. The parameter K_E, which is the same for all ETF traders, denotes the increased trading, e.g., caused by lower assumed index risk. The overall gain of trader ℓ from asset i is given through $g_i^\ell(t) = \sum_{\tau=0}^{t-1} D_i^\ell(\tau) \cdot \frac{p_i(t)-p_i(\tau)}{p_i(\tau)}$.

Parameter Q specifies the fraction of ETF traders to single stock traders: If $Q = 1$ there are only ETF traders, if $Q = 0$ there are only single stock traders, if $Q = 0.5$ the relative weight of single stock and ETF traders is fifty-fifty. Later on, we vary this parameter for analyzing the effects of ETFs.

A chartist as defined above is investing in all N assets separately. The investment in asset i for $t > 0$ depends on the returns from the very same asset i, meaning that the single asset trader treats all assets (the investments) separately. However, their overall investment might also become negative, for example due to a large price decrease.

[6] See, e.g., Timmer (2016) for the mapping of financial institutions and trading stategies.

Fundamentalists (F) in individual stocks follow the investment rule

$$D_i^F(t) = (1-Q) \cdot K_F \cdot \ln\left(\frac{\mathbb{E}_t[f_i(t+1)]}{p_i(t)}\right)$$

as similarly stated by Drescher and Herz (2012). Note that the fundamental value of asset i, f_i, is assumed to be noisy with all traders holding the same expectation $\mathbb{E}[f_i]$. The single asset fundamentalist invests in all N single assets separately.

Analogously, *ETF chartists* (E-C) and *ETF fundamentalists* (E-F) invest according to

$$D^{E-C}(t) = NQ \cdot K_C \cdot K_E \cdot \left(\frac{p(t)}{p(t-1)} - 1\right),$$

respectively

$$D^{E-F}(t) = NQ \cdot K_F \cdot K_E \cdot \ln\left(\frac{\mathbb{E}_t[f(t+1)]}{p(t)}\right).$$

Investments into ETFs are allocated to the individual stocks with respect to Equation (2). For an ETF trader ℓ the demand function for the single assets is by proxy given through:

$$D_i^\ell(t) = D^\ell(t)\pi_i(t)$$

Although it seems to be quiet obvious that $D_i^\ell(t) = D^\ell(t)\pi_i(t)$ implies $I_i^\ell(t) = I^\ell(t)\pi_i(t)$, an proof by induction is provided in Appendix A.1, Proposition 4. For simplification issues, we assume that the F and E-F traders are very well informed in the sense that they exactly know $f_i(t+1)$ resp. $f(t+1)$. This simplification does not have substantial influence on the results because in high volatility phases or in a bubble case the distance between the price and its fundamental value becomes considerably large while the distance between a subjective expectation of the fundamental value and its realization is (in probability) bounded. Thus, this simplification has no influence on identifying financial instabilities.

4.2 Stylized Facts and Parameter Choices

In our simulation analysis we consider a market with $N = 10$ stocks on a time grid $\mathcal{T} = \{0, 1, \ldots, T\}$ with $T = 250$. Each stock p_i has a fundamental value f_i, $i = 1, \ldots, N$, i.e., we have ten paths of fundamental values in one market scenario. In particular, a market scenario is defined by the specific paths of these ten fundamental values. Each of these fundamental value paths f_i follows a geometric Brownian motion with trend $\mu = 3\%/T$ and volatility $\sigma = 4\%$. We will vary parameters, especially Q, and thereby get a lot of price developments for every market scenario. In this way, we analyze the influence of the parameters, because the underlying fundamentals are always the same. For each parameter constellation a Monte Carlo analysis over $mc = 50$ market developments is done.

The starting points of both fundamental values and stock prices are set to $f_i(0) \equiv p_i(0) \equiv 1$, the scaling parameter is set to $M = 50$. Indeed, the parameters M, K_C, and K_F itself are not important, the fractions $\frac{K_C}{M}$ and $\frac{K_F}{M}$ are. A greater M lessens the influence of traders.

In a market setting with fundamentalists only, i.e., with $K_C = 0$, with no ETF traders, $Q = 0$, and with parameter so that $K_F = M$, the price processes would follow geometric Brownian motions. Furthermore, we set $K_C = 9$, $K_F = 6$, and $K_E = 5$. These parameters are found via trial and error as well as grid searches in order to reproduce the stylized facts for ETFs found in the literature as empirical results. When disturbing the model parameters we can observe which stylized facts are robust to the disturbance and which ones are sensitive. We will find that the stylized facts the literature is not that clear about, even qualitatively, are that ones we identify as sensitive.

For our simulation we draw 50 market developments, i.e., 500 fundamental value paths (50 for each of the ten single assets). For each of these market developments we simulate the corresponding price paths for all Q between 0% and 75% on a discrete grid with a step width of $0,025$. For $Q > 75\%$ the trading behavior becomes nearly independent of the underlying fundamental values, which leads to unreasonable behavior on the level of single stocks. In this analysis we are mainly interested in the bubble rate, the mean volatility of the single stocks, the rate of price reversals for single stocks, and the comovement of the single stocks to the index. Additionally, we calculate the distance of the stock prices to their fundamentals, the distance of the index to its fundamental, the volatility of the index, and the rate of price reversals of the index. Volatility is measured as the averaged standard deviation of the log-returns, price reversals are the fractions of time points when the last real price movement was up and now is down or vice versa, comovement is measured as the averaged correlation of the stocks to its index, and the distances of the price paths to the fundamental values are the sums of the squared differences (SSDs) of the respective time series. To avoid distortions in the volatility and SSD graphs caused by bubbles, we replace the corresponding NA value, if possible, by the last available value of this market development. This leads to graphs still edgy but no longer spiky. A bubble is defined if the index's price exceeds two times its fundamental value. Note that $T < \infty$ is crucial for our simulations, since if the probability for a bubble is positive and we would have no termination time, the probability that all market developments would eventually crash would go to one.

In Figure 7 we observe an increasing amount of bubbles with an increasing share of ETF traders Q. However, not until a share of about 40% of ETF traders, bubbles start to occur. This may correlate with the relationship shown in Figure 8, where we plot the volatility against Q. At the beginning, the volatility is slightly decreasing up to about $Q = 0.2$, then it is strongly increasing in Q. At some point, the volatility seems to be high enough to possibly cause bubbles. In this case, volatility is the averaged historical volatility of the single assets as calculated from the single asset developments. Figure 9 shows the volatility of the index against Q. Here, we cannot see the early decrease of the volatility as it is the case for the single assets. Thus, with respect to the volatility evolution of the index, it holds that the more ETF traders are on the market, the more volatile is the index.

Figure 10 displays the distance between the assets and their fundamental values as the sums of squared differences (SSDs) over $\mathcal{T}$. In the plot, we see the SSD averaged over the ten single assets. For the very first part of the graph, i.e., up to $Q < 0.1$, the SSD is very slightly decreasing. Afterwards, it is strongly increasing in Q. Regarding the SSD of the index, Figure 11, i.e., the sum of squared differences between the index and its fundamental value, we see that it is decreasing up to a share of ETF traders between 30% and 40%. Only afterwards it is increasing. In this plot, we can distinguish between two overlaying effects: On the one hand, the SSD is decreasing for the index, as there are more ETF traders on the market that trade according to the index development, not according to the developments of the single assets. That means, the more index trader are on the market, the "better" the index development is, at least up to a certain share of index traders. Namely on the other hand, the bubble rate increases with an increasing share of ETF traders. Thus, starting at about the ETF-trader share where the first bubbles occur, the SSD also increases again. For about $Q = 30\%$, the SSD of the index is lowest.

Figures 12 and 13 show how the fraction of price reversals change with Q for the single assets or for the index, respective. Price reversals of x mean that in $x \cdot 100\%$ of the time points the price changes its direction and in $(1 - x) \cdot 100\%$ the price keeps going in the direction of the period before. Please note that a price reversal number deviating from 0.5 does not mean that there is an arbitrage possibility because there is no information on the height given. We can see that the price reversals go up in Q for the single assets (in average) and in the index it goes down. This is quiet intuitive because more and more traders regard to the index and not to the single assets. In Figure 14 we can see that the comovement of the stocks with the index rises with Q.

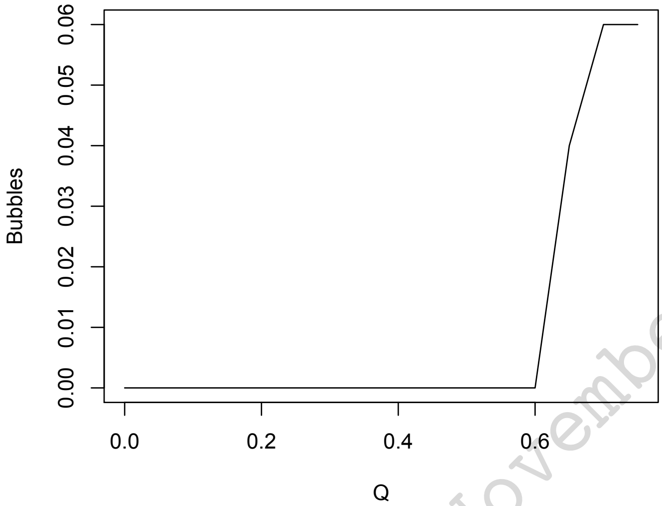

Figure 7: Bubble rate against Q.

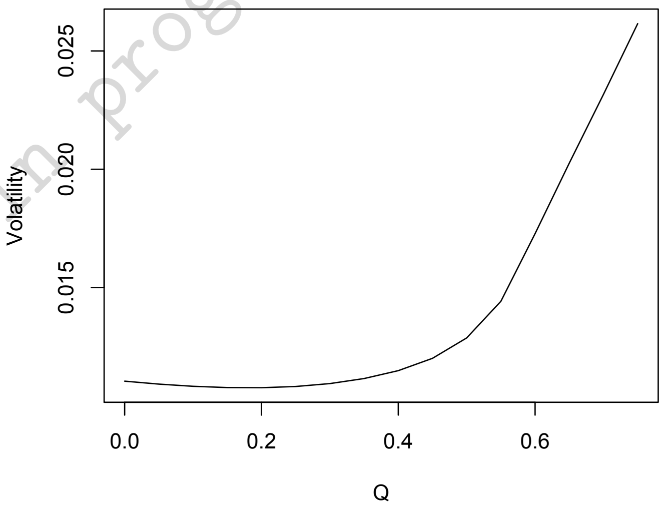

Figure 8: Volatility of the single assets againts Q.

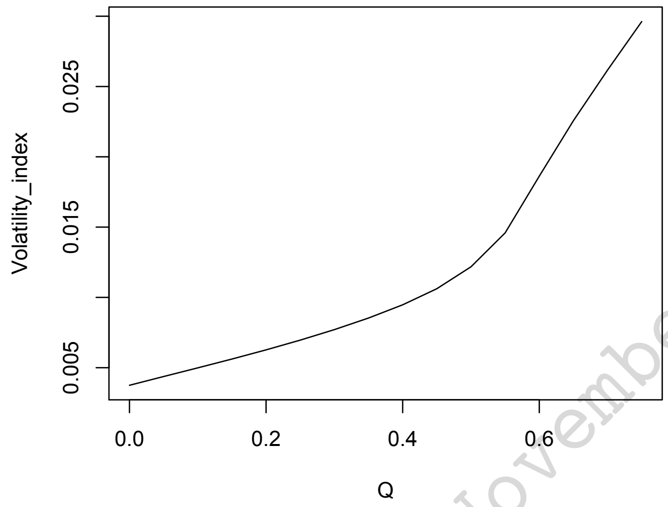

Figure 9: Volatility of the index against Q.

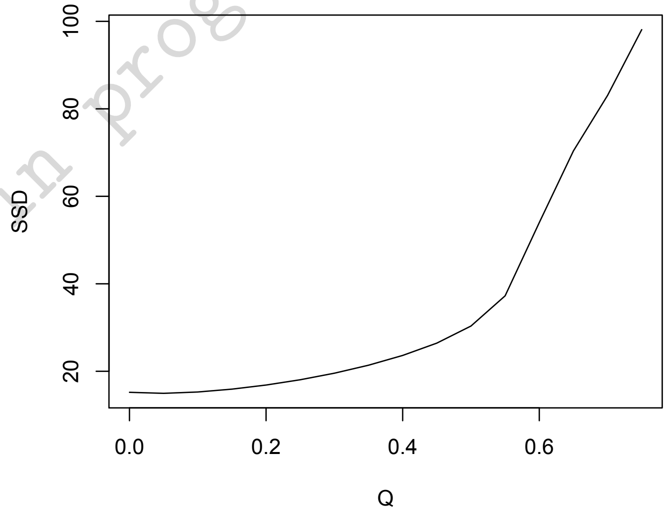

Figure 10: Average distance between single asset prices and fundamental values.

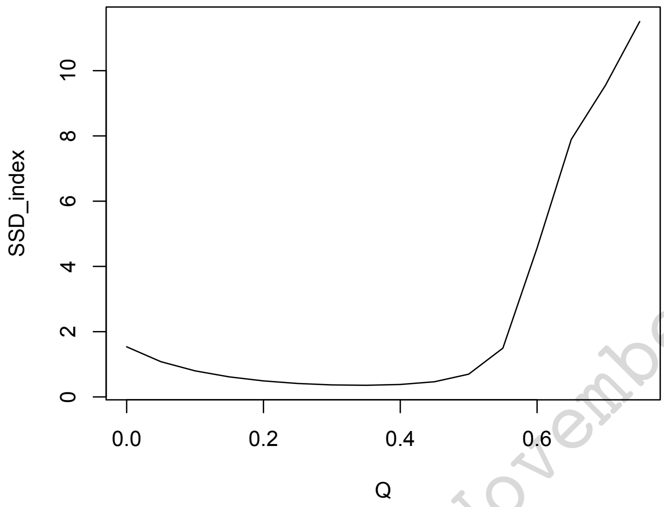

Figure 11: Distance between index and its fundamental value.

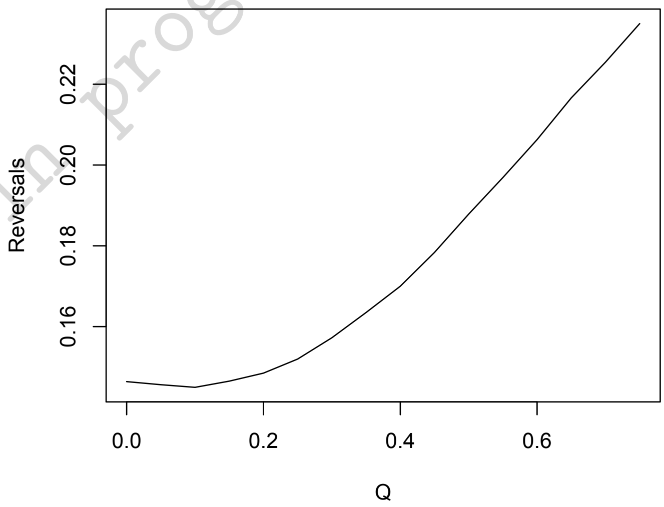

Figure 12: Price reversals against Q..

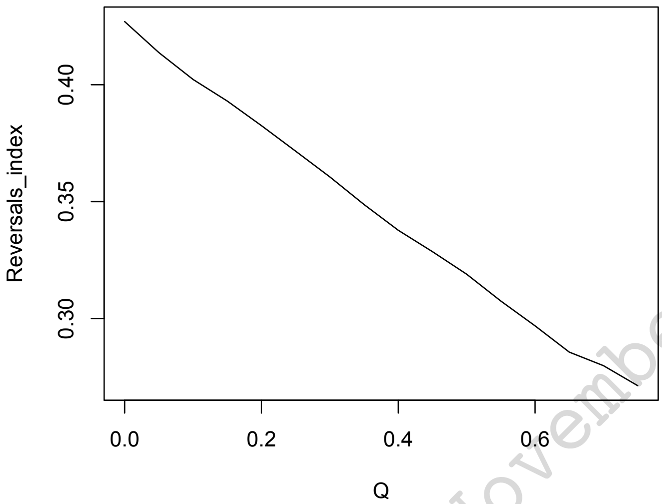

Figure 13: Price reversals of the index against Q..

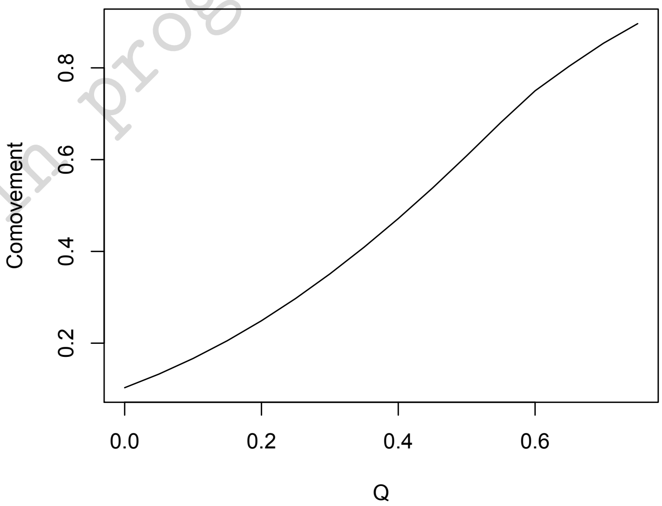

Figure 14: Comovement of the stocks and the index against Q..

4.3 Idiosyncratic vs. Aggregate Index Shocks

In this section we analyze how the number of ETF traders changes the speed of price discovery when there are shocks. We distinguish between idiosyncratic shocks and aggregate index shocks, i.e., in the first scenario we assume one asset to deviate from its fundamental while all other $(N-1)$ assets are perfectly priced and in the second scenario we assume all assets to deviate evenly from their fundamentals. In both cases, the fundamental value of all assets is set to 1 *const*. An idiosyncratic shock in asset 1 is given through $p_1(0) = 1.5$ and $p_k(0) = 1$ for $k = 2, \ldots, N$ (Figure 15). An aggregate index shock is given via $p_i(0) = 1.05$ for all $i = 1, \ldots, N$ (Figure 16). In both cases the index deviates 5% from its fundamental value ($N = 10$). To measure the speed of pricing new information we choose the SSD. In the corresponding figures we can see the SSD of stock 1, the SSD of stocks 2-N, and the SSD of the index as a function of Q, respectively.

In Figure 15 we see the higher Q is the higher SSD is, i.e., the longer it takes until the information is reflected in the price. Clearly, the SSD for stocks 2-N rises as well, since these stocks are without ETF traders not affected by an idiosyncratic shock in stock 1. Contrary to that, the SSD of the index decreases with Q, i.e., in the middle over all stocks in the index the ETF traders increase the speed the information is reflected in the price.

An aggregate index shock is shown in Figure 16. Clearly, the behavior of stock 1 equals the behavior of all other stocks. We see that all stocks as well as the index reflect new information faster in their prices when Q is increased.

5 Conclusion

Exchange-traded Funds are easy to understand, cost-efficient ways of investing in stock market indices that have become very popular for both retail and institutional investors. The discussion of the wider repercussions of ETFs on the stability of the financial system have just begun and typically focus on the rapid growth of these financial products and in particular on the relative size of ETF index investors in stock markets. In our study we focus on the investment strategies underlying the use of ETFs. We show that it is not only the size of ETFs that is relevant (cf. Appendix A.1), but additionally how these financial instruments are used in portfolio allocation, i.e., which strategy is used when trading with them.

Under the complex interactions caused by index investments on the price dynamics

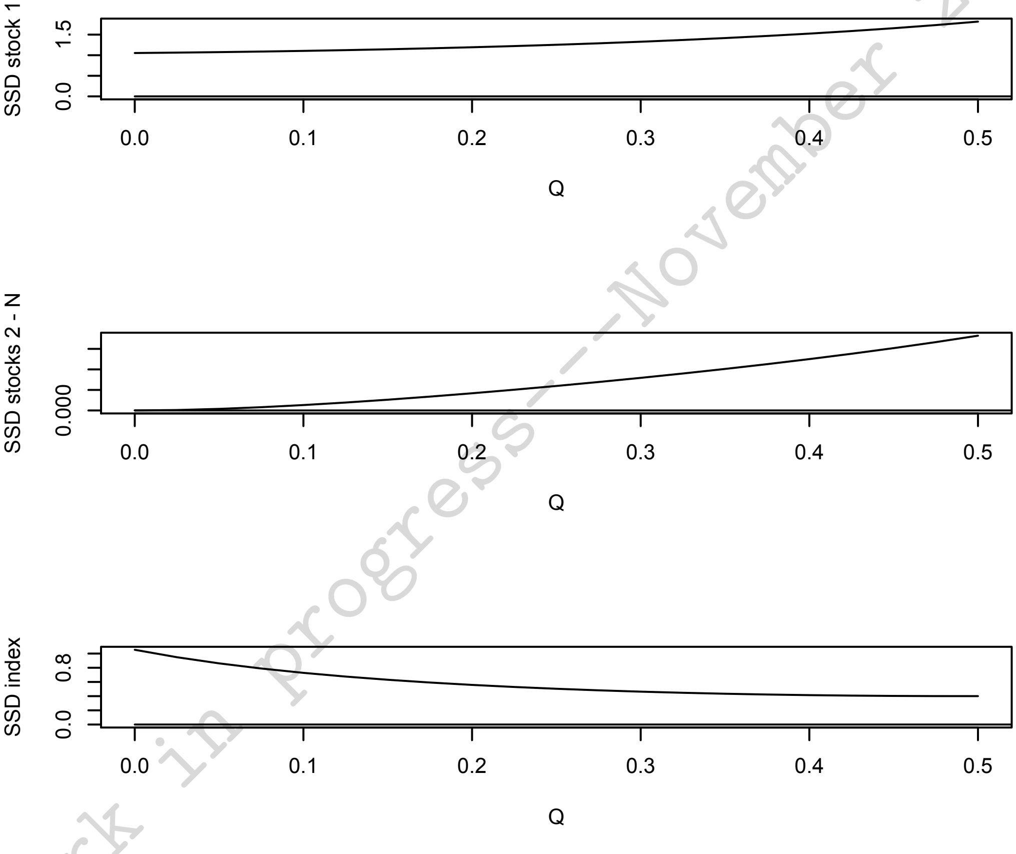

Figure 15: Idiosyncratic shock.

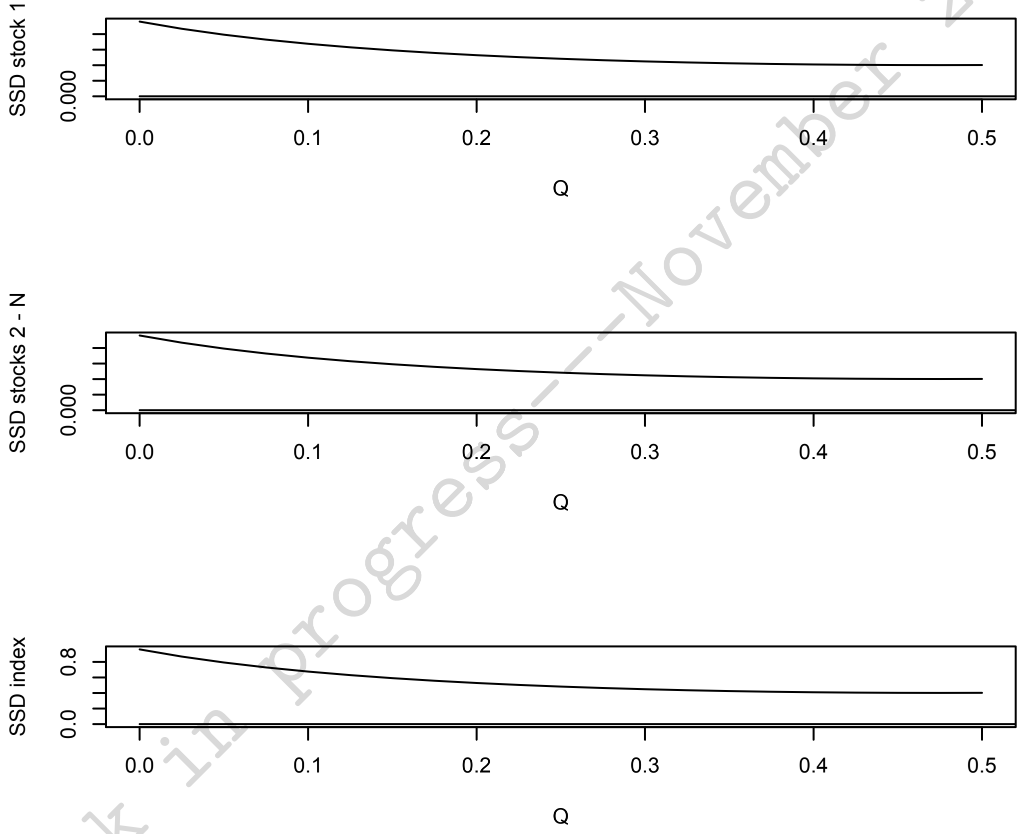

Figure 16: Aggregate index shock.

of individual stocks, we find that the usual assessment that fundamentalists tend to stabilize, while chartists tend to destabilize price dynamics does not hold in this context. In our analysis we see that the bubble rate, the speed of price adjustment to new information as well as the single stocks' volatility and their price reversals are sensitve to K_E, i.e., to increased trading, which seems to be much more important as the availability of ETFs itself. In our simulations we could reproduce the stylized facts known for ETFs in the literature and additionally show that the bubble rate increases with the share of ETF traders—but even this phenomenon is driven by the increased trading.

An important lesson to be drawn from this analysis suggests a refocussing of financial market regulation. New financial products such as ETFs are not (de)stabilizing per se and regulation should not (only) concentrate on their sheer size and speed of spreading. Rather it is the specific use of these products that is of interest and should be at the focus of financial market regulators, an idea also suggested from the perspective of market governance by Ockenfels and Schmalz (2016a).

One last thing we learn from our investigation is that products seeming harmless at a first glance like ETFs may have substantial influence on the market. Such new products should therefore be scrutinized closely in particular with respect to alternative market situations and trading strategies.

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List of Abbreviations and Symbols

abbreviations:

C, C_Δ	chartist/trend follower
d	destabilizing effect
E	ETF; Exchange-traded Fund
E-C, E-C_Δ	ETF chartist/ETF trend follower
E-F, E-F_Δ	ETF fundamentalist
E-H	ETF buy-and-hold trader
EK	excess kurtosis
ETF	Exchange-traded Fund
F, F_Δ	fundamentalist
H	buy-and-hold trader
HAM	heterogeneous agent model
s	stabilizing effect
sd	standard deviation
?	unknown (de)stabilizing effect

parameters and variables:

D, D^ℓ	demand function of the index (of trader ℓ)
D_i, D_i^ℓ	demand function of asset i (of trader ℓ)
f	fundamental value of the index
f_i	fundamental value of asset i
I, I^ℓ	net asset position of the index (of trader ℓ)
I_i, I_i^ℓ	net asset position of asset i (of trader ℓ)
K_C	feedback parameter of chartists
K_F	feedback parameter of fundamentalists
K_E	increased trading parameter for ETF traders
N	number of assets in the index
M	scaling factor for trading volume and market power
μ	trend
p	price of the index
p_i	price of asset i
Q	share of ETF traders
roi	return on investment
σ	volatility
t	time
T	termination time
$\mathcal{T}$	time grid

operators:

$\Delta\alpha(t) := \alpha(t) - \alpha(t-1)$

A Appendix

This is the Appendix to the paper "Exchange-traded Funds and Financial Stability" by Michael Heinrich Baumann, Michaela Baumann, and Bernhard Herz, University of Bayreuth, Germany, November 2017. Here, we provide some basic analytic results, robustness checks, as well as a few more examples, simulations, and insights.

A.1 Further Basic Analytical Results

In this section, before analyzing the buy-and-hold trader as a very straightforward kind of trader, we show that a trader's outcome does not depend on whether she is investing in ETF shares or whether the trader is investing directly in the underlying stocks according to Equation (1). Although it can be expected that investing in an index or directly in stocks does not make any difference, in real-world markets it can be observed that index funds are more volatile than the underlying assets, i.e., that people are more often shifting their index investments than their direct asset investments (Shiller, 1980). More precisely, we show that if a trader is investing directly in assets with the same weighting as these assets have in the index, then her total gain is the same as she would have invested the same sum in the index. With

$$\Delta g_i^\ell(t) = I_i^\ell(t-1) \cdot \frac{\Delta p_i(t)}{p_i(t-1)}$$

as the period gain of trader ℓ at time t from stock i when investing $I_i^\ell(t-1)$ at time $t-1$ in stock i we propose the following proposition.

Proposition 2. The total profit up to period t

$$g^\ell(t) = \sum_{\tau=1}^{t} \sum_{i=1}^{N} I_i^\ell(\tau-1) \cdot \frac{p_i(\tau) - p_i(\tau-1)}{p_i(\tau-1)}$$

of investing in all stocks $(1, \ldots, N)$ of trader ℓ selecting her portfolio according to Equation (1) only depends on her cumulated investment I^ℓ over all stocks and on the index's return on investment. In particular, for the period gain $\Delta g^\ell(t) = g^\ell(t) - g^\ell(t-1)$ it holds

$$\Delta g^\ell(t) = I^\ell(t-1) \cdot \frac{p(t) - p(t-1)}{p(t-1)}$$

which adds up to a total gain of

$$g^{\ell}(t) = \sum_{\tau=1}^{t} I^{\ell}(\tau-1) \cdot \frac{p(\tau)-p(\tau-1)}{p(\tau-1)}.$$

Proof. Exploiting Equation (1) leads to:

$$\begin{aligned}
\Delta g^{\ell}(t) &= \sum_{i=1}^{N} I^{\ell}(t-1) \cdot \frac{p_i(t-1)}{p(t-1)} \cdot \frac{p_i(t)-p_i(t-1)}{p_i(t-1)} \\
&= \sum_{i=1}^{N} I^{\ell}(t-1) \cdot \frac{p_i(t)-p_i(t-1)}{p(t-1)} \\
&= I^{\ell}(t-1) \cdot \frac{p(t)-p(t-1)}{p(t-1)}
\end{aligned}$$

Adding up over the time periods leads to the specified total gain formula which is independent of the single asset investments. □

Next, we will see that for a buy-and-hold trader there is no difference between directly investing in the index's stocks $1, \ldots, N$ or investing in an ETF, i.e., her investment decisions are the same in both cases. The proposed property seems to be obvious (by heuristics). If the reader is in doubt of this property, because ETF buy-and-hold traders indirectly reallocate there investment due to the rebalancing effect, we give a formal proof. A buy-and-hold trader (H) as well as an ETF buy-and-hold trader (E-H) buys a specific amount of assets at a certain point of time and keeps these assets irrespective of their price development. Specifically, the net asset position of an ETF buy-and-hold trader is given by

$$\begin{aligned}
I^{E-H}(t) &= I^{E-H}(0) + g^{E-H}(t) \\
&= I^{E-H}(t-1) + I^{E-H}(t-1) \cdot \frac{p(t)-p(t-1)}{p(t-1)} \qquad (3) \\
&= I^{E-H}(t-1) \cdot \frac{p(t)}{p(t-1)}
\end{aligned}$$

since $g^{E-H}(t)$ is exactly her shares' increase in value. For a "normal" buy-and-hold trader directly investing in stock i, it holds

$$I_i^H(t) = I_i^H(0) + g_i^H(t)$$

$$= I_i^H(t-1) + I_i^H(t-1) \cdot \frac{p_i(t) - p_i(t-1)}{p_i(t-1)}$$
$$= I_i^H(t-1) \cdot \frac{p_i(t)}{p_i(t-1)}$$

where $g_i(t)$ denotes the cumulated gain of stock i up to time t.

Proposition 3. The investment decision for stock i is the same for buy-and-hold traders directly investing in the index's stocks and for buy-and-hold traders investing in the ETF.

Proof. We use mathematical induction for proving Proposition 3 and show

$$I_i^H(t-1) = I_i^{E-H}(t-1) \Rightarrow \Delta I_i^H(t) = \Delta I_i^{E-H}(t).$$

We define $roi(t) := \frac{p(t)-p(t-1)}{p(t-1)}$ and $roi_i(t) := \frac{p_i(t)-p_i(t-1)}{p_i(t-1)}$. Note that for buy-and-hold traders the investment equals the period gain, i.e., the change of total gain $\Delta g_i^H(t)$, as they do not change the invested amount subsequently. With Equation (2) the investment in an individual stock is given by

$$\begin{aligned}
\Delta I_i^{E-H}(t) &= \Delta I^{E-H}(t)\pi_i(t) + I^{E-H}(t-1)\Delta\pi_i(t) \\
&= \left(I^{E-H}(t) - I^{E-H}(t-1)\right)\frac{p_i(t)}{p(t)} + I^{E-H}(t-1)\left(\pi_i(t) - \pi_i(t-1)\right) \\
&\overset{(3)}{=} I^{E-H}(t-1)roi(t) \cdot \frac{p_i(t)}{p(t)} + I^{E-H}(t-1)\left(\frac{p_i(t)}{p(t)} - \frac{p_i(t-1)}{p(t-1)}\right) \\
&= I^{E-H}(t-1)\left(\frac{p(t)}{p(t-1)} \cdot \frac{p_i(t)}{p(t)} - \frac{p_i(t)}{p(t)} + \frac{p_i(t)}{p(t)} - \frac{p_i(t-1)}{p(t-1)}\right) \\
&= I^{E-H}(t-1)\left(\frac{p_i(t)}{p(t-1)} - \frac{p_i(t-1)}{p(t-1)}\right) \\
&= \frac{I_i^{E-H}(t-1)}{\pi_i(t-1)} \cdot \frac{p_i(t) - p_i(t-1)}{p(t-1)} \\
&= I_i^{E-H}(t-1) \cdot \frac{p(t-1)}{p_i(t-1)} \cdot \frac{p_i(t) - p_i(t-1)}{p(t-1)} \\
&= I_i^{E-H}(t-1)roi_i(t) \\
&= \Delta I_i^H(t).
\end{aligned}$$

□

This equation shows that the buy-and-hold trader is of no interest for us in the analyses of this paper as mentioned although the E-H trader consistently reallocates her investment because of $\Delta\pi_i$ in Equation (2). But this reallocation resp. the E-H trader has the same effects on the market as the "normal" buy-and-hold trader has.

At the end of this section we will show that $D_i^\ell(t) = D^\ell(t)\pi_i(t) \Rightarrow I_i^\ell(t) = I^\ell(t)\pi_i(t)$ by induction. Note that it is an important assumption that all buy and sell orders in the markets are always fulfilled.

Proposition 4. With $I_{(i)}^\ell(t) = I_{(i)}^\ell(t-1) \cdot \frac{p_{(i)}(t)}{p_{(i)}(t-1)} + D_{(i)}^\ell(t)$ it holds

$$D_i^\ell(t) = D^\ell(t)\pi_i(t) \Rightarrow I_i^\ell(t) = I^\ell(t)\pi_i(t).$$

Proof. Fot $t = 0$ it holds $I_i^\ell(0) = D_i^\ell(0) = D^\ell(0)\pi_i(0) = I^\ell(0)\pi_i(0)$. If the proposition is true for $t-1$ we conduct:

$$\begin{aligned}
I_i^\ell(t) &= D_i^\ell(t) + I_i^\ell(t-1) \cdot \frac{p_i(t)}{p_i(t-1)} \\
&= D_i^\ell(t) + I^\ell(t-1)\pi_i(t-1) \cdot \frac{p_i(t)}{p_i(t-1)} \\
&= D^\ell(t)\pi_i(t) + I^\ell(t-1)\pi_i(t-1) \cdot \frac{p_i(t)}{p_i(t-1)} \\
&= D^\ell(t)\pi_i(t) + I^\ell(t-1)\pi_i(t-1) \cdot \frac{p(t-1)}{p(t)} \cdot \frac{p(t)}{p(t-1)} \cdot \frac{p_i(t)}{p_i(t-1)} \\
&= \frac{p_i(t)}{p_(t)} \left(D^\ell(t) + I^\ell(t-1) \cdot \frac{p(t)}{p(t-1)} \right) \\
&= I^\ell(t)\pi_i(t)
\end{aligned}$$

□

That means, the ETF can fulfill the indexing by simply buying or selling an equal quantity of the stocks in the index.

A.2 (De)Stabilizing Effects of ETF traders

In this section, we examine and summarize the (de)stabilizing effects of ETF trading for ETF fundamentalists (Table 1) and ETF chartists (Table 2) on one single asset i. Altogether, we identified two influencing characteristics on the development of asset i for the E-F$_\Delta$ and two slightly different characteristics for the E-C$_\Delta$ derived from Equation (2) and two trader independent characteristics.

The influencing characteristics of the E-F$_\Delta$ are her previous net asset position and her decision about investing or disinvesting depending on the ratio of (expected) fundamental value and price.

- In the past, the index has rather been under-/overvalued, leading to a positive net asset position ($I^{E-F_\Delta}(t-1) > 0$) of the E-F$_\Delta$ or to a negative one ($I^{E-F_\Delta}(t-1) < 0$).
- The index is now undervalued ($\frac{f(t+1)}{p(t)} > 1$) or overvalued ($\frac{f(t+1)}{p(t)} < 1$).

The influencing characteristics of the E-C$_\Delta$ are her previous net asset position and her decision about investing or disinvesting depending on the observed rising or falling price.

- In the past, the index has rather been increasing/decreasing, leading to a positive net asset position ($I^{E-C_\Delta}(t-1) > 0$) of the E-C$_\Delta$ or to a negative one ($I^{E-C_\Delta}(t-1) < 0$).
- The price of the index is now increasing ($\frac{p(t)}{p(t-1)} > 1$) or decreasing ($\frac{p(t)}{p(t-1)} < 1$).

Independent of the two ETF trader types, the change of the relative weight of asset i in the index is of importance (also taken from Equation (2)) as well as the price p_i of asset i compared to its fundamental value f_i, which is exactly the basis for calling a certain investment stabilizing or destabilizing:

- The relative share of asset i in the index can be either increasing ($\Delta\pi_i(t) > 0$) or decreasing ($\Delta\pi_i(t) < 0$).
- The i^{th} asset is now undervalued ($\frac{f_i(t+1)}{p_i(t)} > 1$) or overvalued ($\frac{f_i(t+1)}{p_i(t)} < 1$). This parameter is needed for determining the stabilizing or destabilizing effect of the respective trader.

Combining these effects, we determine the sign of the investment decision for the i^{th} asset. We characterize an investment as destabilizing (d) if traders disinvest in an undervalued asset or invest in an overvalued one. An investment is considered as stabilizing (s), if traders invest in an undervalued asset or disinvest in an overvalued one. In the cells marked with a questionmark (?), the direction of the investment cannot be determined in general without knowing the particular values. This is the case when one summand is positive and the other one is negative in Equation (2). Consider, for example, the cell of the first row and the first column of Table 1. According to Equation (2), a positive net asset position together with a rising ratio of asset i (i.e., $I^{E-F_\Delta}(t-1)\Delta\pi_i(t) > 0$) plus an undervalued index price resulting in a positive investment (i.e., $\Delta I^{E-F_\Delta}(t)\pi_i(t) > 0$ where $\pi_i(t) > 0$ for all t) leads to a positive investment in asset i (i.e., $\Delta I_i^{E-F_\Delta}(t) > 0$).

Effects of E-F$_\Delta$		$\frac{f_i(t+1)}{p_i(t)} > 1$		$\frac{f_i(t+1)}{p_i(t)} < 1$	
		$\Delta\pi_i(t) > 0$	$\Delta\pi_i(t) < 0$	$\Delta\pi_i(t) > 0$	$\Delta\pi_i(t) < 0$
$I^{E-F_\Delta}(t-1) > 0$	$\frac{f(t+1)}{p(t)} > 1$	s	?	d	?
	$\frac{f(t+1)}{p(t)} < 1$	?	d	?	s
$I^{E-F_\Delta}(t-1) < 0$	$\frac{f(t+1)}{p(t)} > 1$	?	s	?	d
	$\frac{f(t+1)}{p(t)} < 1$	d	?	s	?

Table 1: Price dynamics imposed by past net asset position, over-/undervaluated index, over-/undervaluated asset, and increasing/decreasing relative share of the asset in the index leading to (de)stabilizing effects of ETF fundamentalists.

Effects of E-C$_\Delta$		$\frac{f_i(t+1)}{p_i(t)} > 1$		$\frac{f_i(t+1)}{p_i(t)} < 1$	
		$\Delta\pi_i(t) > 0$	$\Delta\pi_i(t) < 0$	$\Delta\pi_i(t) > 0$	$\Delta\pi_i(t) < 0$
$I^{E-C_\Delta}(t-1) > 0$	$\frac{p(t)}{p(t-1)} > 1$	s	?	d	?
	$\frac{p(t)}{p(t-1)} < 1$	?	d	?	s
$I^{E-C_\Delta}(t-1) < 0$	$\frac{p(t)}{p(t-1)} > 1$	?	s	?	d
	$\frac{p(t)}{p(t-1)} < 1$	d	?	s	?

Table 2: Price dynamics imposed by past net asset position, increasing/decreasing index price, over-/undervaluated asset, and increasing/decreasing relative share of the asset in the index leading to (de)stabilizing effects of ETF chartists.

Together with the condition of undervaluation of asset i ($\frac{f_i(t+1)}{p_i(t)} > 1$), the ETF fundamentalist's effect on asset i is stabilizing. In contrast, if asset i is overvalued (first row, third column of Table 1), her effect on asset i is destabilizing. Note that the 16 cases in the two tables are not the same for E-F$_\Delta$ and E-C$_\Delta$. For ETF fundamentalists, the ratio between fundamental value of tomorrow and price of today is important whereas for ETF chartists the ratio of today's price and yesterday's price is of interest. For better clarity we only consider the relevant market characteristics for the different trader types and also skipped the equality cases (= 0 or = 1).

A.3 Further Market Scenario Examples

In the following, we show two further example developments for specific market situations (scenarios 2 and 3) with T_Δ, F_Δ, E-T_Δ, and E-F_Δ. The traders as well as the background are the same as in Section 3.

Scenario 2: rising stock in a bear market In the second case, we assume that the absolute price of stock 1 rises with trend $\mu_1 = 0.1$ while the absolute price of the index falls with trend $\mu = -0.1$. As a consequence the relative price of stock 1 increases. Stock 1 is assumed to be overvalued, the index to be undervalued ($t > 0$). The fundamental values of the stocks are again set to $f_i \equiv 1$. Since stock 1 is overvalued and its price increases (see Figure 17), fundamentalists (F_Δ) disinvest from and chartists (C_Δ) invest in this stock. Since the index is undervalued and its price falls (see Figure 20), ETF fundamentalists invest on average, while ETF chartists disinvest overall.

Figure 19 depicts the investment of the four types of traders in stock 1. ETF chartists (E-C_Δ) implicitly disinvest more and more of stock 1 as its relative price π_1 and thus its relative weight in the index rises (see Figure 18). The level effect of the ETF chartist (E-C_Δ) causes a disinvestment in stock i which is even amplified through a high ratio of stock 1 in the index. The rebalancing effect through an increase of $\Delta\pi_1$ cannot compensate this. In contrast, ETF fundamentalists (E-F_Δ) invest more in stock 1 as its relative price (weight) increases. While they invest in stock 1 as part of investing in the ETF due to the undervaluation of the index (level effect), they overproportionally invest in stock 1 due to its high ratio in the index, which is even increasing (rebalancing effect). The investment in the other assets (Figure 21) does not show significant changes over time. Again we find the counterintuitive effects that implicitly ETF fundamentalists invest in an overvalued stock thereby destabilizing the market, while ETF chartists disinvest from a rising stock with a stabilizing effect on the market.

Scenario 3: falling stock in a bull market with the index crossing its fundamental value from below For the third scenario, we assume a bull market in which a specific stock falls. The index's price starts below its fundamental value and is undervalued at first, but later due to trend $\mu = 2$ surpasses its fundamental value. Stock 1 is undervalued and its price falls against the general market trend with rate $\mu_1 = -0.5$ (see Figures 22 and 25). For expositional reasons, the fundamental value of the index is set to $f \equiv 30 \cdot 1.3$, i.e., the fundamental values of the individual stocks are set to $f_i \equiv 1.3$.

As has been discussed above, the calculus of ETF and single stock chartists and fundamentalists is straightforward. In the case of index investors, ETF chartists invest,

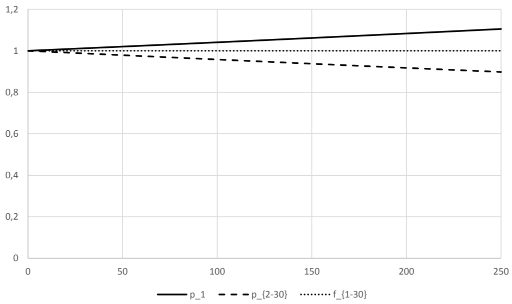

Figure 17: Price paths p_1 of stock 1 and p_{2-30} of stocks 2-30 in scenario 2.

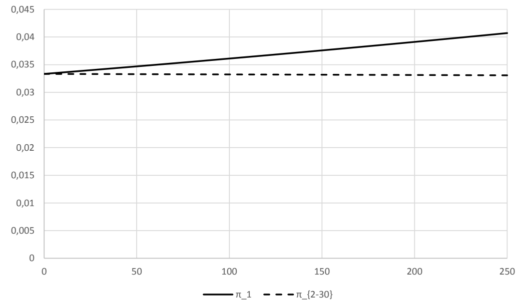

Figure 18: Change of the ratio π_1 and π_{2-30} of stock 1 and stocks 2-30, resp., in scenario 2.

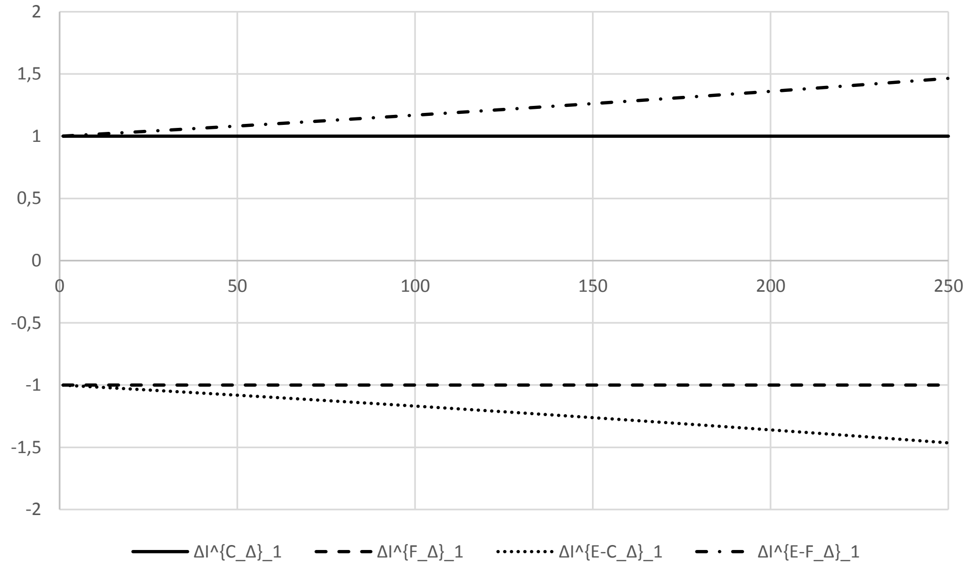

Figure 19: Investment ΔI_1^ℓ in stock 1 if this stock is rising when the index falls (scenario 2).

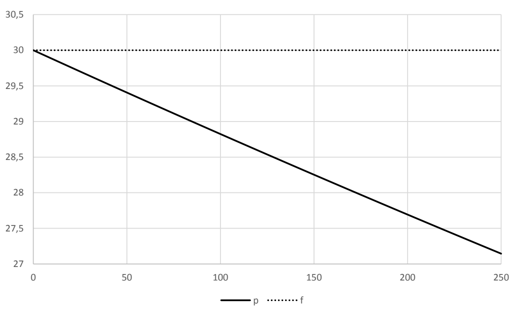

Figure 20: Price path p of the index in scenario 2.

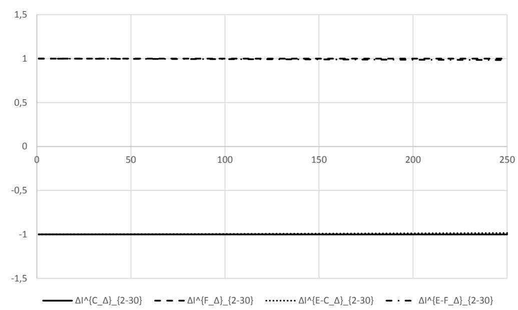

Figure 21: Investment ΔI_{2-30}^ℓ in stocks 2-30 in scenario 2.

while ETF fundamentalists first invest in the undervalued index and later disinvest from the overvalued index ETF. In case of stock 1 fundamentalists invest as the stock is undervalued while chartists disinvest (see Figure 24).

Again, we analyze how the investment decisions of ETF investors affect stock 1 and how this compares to the behavior of investors that only target stock 1. ETF chartists (E-C_Δ) invest overall due to the index's rising price. On the level of stock 1 they implicitly invest less and less as its relative price π_1 and thus its relative weight in the index declines (see Figure 23). The level effect of E-C_Δ investment decreases as less of the newly invested money ΔI^{E-C_Δ} is allocated to stock 1, and due to rebalancing, E-C_Δ investors disinvest from stock 1 to account for the reduced weight of stock 1 in their overall portfolio I^{E-C_Δ}.

ETF fundamentalists (E-F_Δ) pursue similar investments as long as stock 1 is undervalued (see Figure 24). Once the index's price surpasses its fundamental value they switch to disinvesting from the index and implicitly stock 1 due to the overvaluation of the index (see Figure 25). Due to the need to rebalance their portfolio because of the falling relative weight of stock 1, they implicitly invest in stock 1 to assure the correct portfolio allocation. As the relative price of stock 1 continues to fall the positive rebalancing effect eventually dominates the level effect. In the mean time ETF fundamentalists have disinvested from an undervalued stock. The ETF fundamentalist's investment behavior in stock 1 suddenly changes although neither the trend nor the fundamental value of stock 1 changes. Concerning stocks 2-30 (Figure 26), we see that both the fundamentalist and the ETF fundamentalist suddenly disinvenst when they get overvalued (Figure 22). This behavior is just as expected.

To sum up, ETF chartists invest for some time in a falling stock, while ETF fundamentalists disinvest from an undervalued stock. Also in this case ETF chartists tend to stabilize, while ETF fundamentalists tend to destabilize stock price developments. This behavior is somewhat counterintuitive.

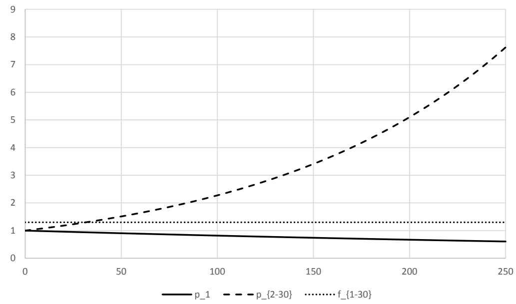

Figure 22: Price paths p_1 of stock 1 and p_{2-30} of stocks 2-30 in scenario 3.

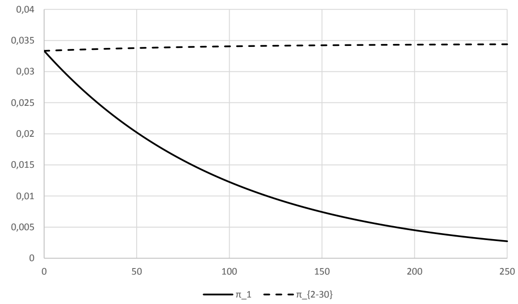

Figure 23: Change of the ratio π_1 and π_{2-30} of stock 1 and stocks 2-30, resp., in scenario 3.

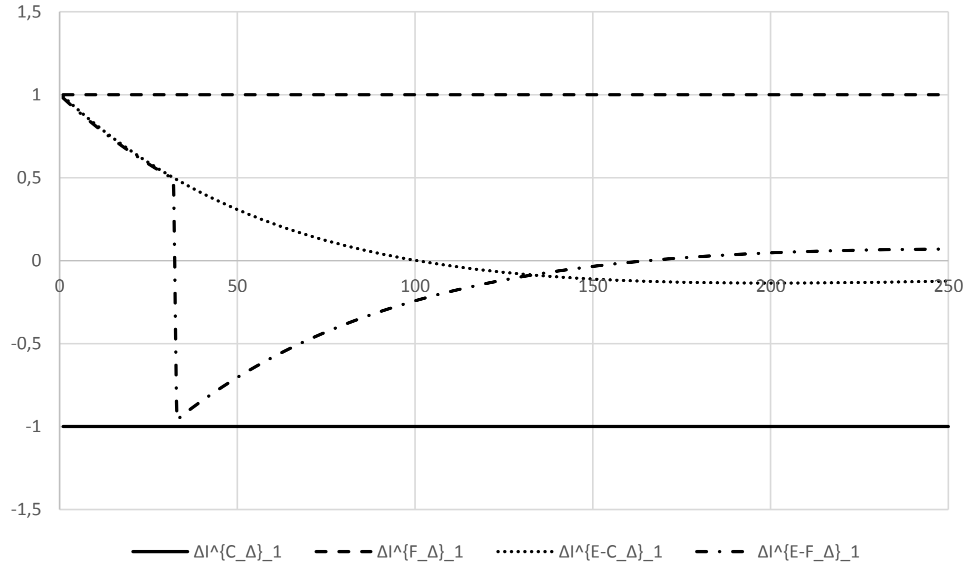

Figure 24: Investment ΔI_1^ℓ in stock 1 if this stock is falling when the index rises and crosses its fundamental value from below (scenario 3).

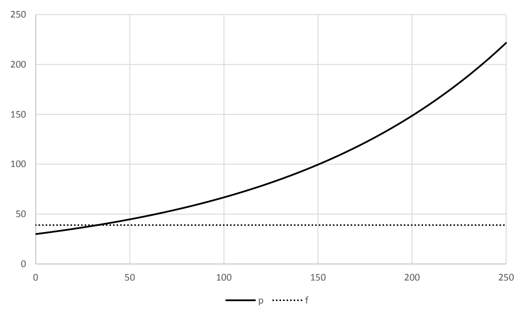

Figure 25: Price path p of the index in scenario 3.

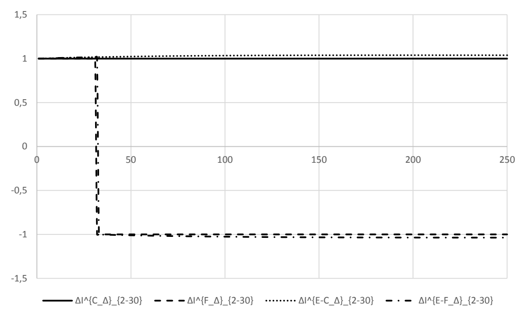

Figure 26: Investment ΔI_{2-30}^ℓ in stocks 2-30 in scenario 3.