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Information in Financial Markets and Its Real Effects*

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Abstract

Financial markets have a central role in allocating resources in modern economies. One of the main functions of financial markets is the discovery of information. This information in turn helps guide decisions in the real side of the economy. The literature on the "feedback effect" of financial markets explores this channel. Empirical work tries to identify the informational feedback from markets to corporate decisions. Theoretical work explores implications that this feedback effect has for the equilibrium in financial markets and for economic efficiency. Current trends in information technology under the FinTech revolution change the nature of information processing in financial markets and so may change the nature of the feedback effect. In this article, I review the main themes of this developing literature and connect them to the current information revolution. I also discuss directions for future research.

* This article is based on my keynote speech at the European Finance Association Annual Meeting hosted by Bocconi University in 2021. Over the last few years, I have given keynote speeches and plenary sessions related to the same theme in: Finance Theory Group Summer School (2017), Hong Kong University of Science and Technology Finance Symposium (2017), Tsinghua University International Corporate Governance Conference (2018), Finance Forum in Madrid (2019), Swedish House of Finance Conference on Financial Markets and Corporate Decisions (2019), Cambridge Corporate Finance Theory Symposium (2019), University of Texas at Austin (2019), Financial Management Association Research Ideas Session (2019), INSEAD (2019), Santiago Finance Workshop (2019), Global Virtual Seminar Series on FinTech at Georgetown University (2020), Greater China Area Finance Conference (2020), Mid-Atlantic Research Conference in Finance at Villanova University (2021), Indian School of Business Summer Research Conference (2021), Conference on Financial Economics and Accounting at Indiana University (2021), Duke Accounting Theory Summer School (2022), and EIASM Workshop on Accounting and Economics in Erasmus University (2022). I thank the many participants in these events for numerous excellent comments and helpful discussions. I am also particularly grateful to the following people for reading a draft of this article and commenting on it: Simona Abis, Ralph Boleslavsky, Qi Chen, Olivier Dessaint, Espen Eckbo, Alex Edmans, Thierry Foucault, Laurent Fresard, Ray Gao, Alexander Guembel, Sudarshan Jayaraman, Wei Jiang, Xuewen Liu, Steven Chong Xiao, Xixi Xiao, Liyan Yang, Christina Zhu, Luo Zuo, and an anonymous referee. All remaining errors are mine.

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1. Introduction: The Feedback Effect from Financial Markets to the Real Economy

1.1 Information in Financial Markets

One of the basic premises in financial economics is that prices in financial markets are very informative about the fundamentals of the underlying assets. Prices aggregate information from many different individuals and institutions, who trade for profit motives, and so have a natural incentive to trade on informative signals. Through the trading process, market prices then aggregate and reflect the different signals, creating a powerful source of information, which is difficult to generate in other ways.

The idea that prices are a useful source of information goes far back in economics and is often associated with Hayek (1945). He referred to prices more generally, for example, those of goods and services. The powerful informational role prices play according to him is similar to that in financial markets, coming from the fact that they aggregate pieces of information from different market participants. This view of the powerful role of markets as information providers has led many economists since then to advocate for using prices as a primary source of information for important decisions. Such is the push for establishing prediction markets for important events (see Wolfers and Zitzewitz, 2004) and using the information they produce in advance.

While markets in general can be powerful in information provision, it is difficult to compete with financial markets in this respect. With the level of liquidity, the sophistication of participants, and the huge attention they are getting, financial markets are prime candidates to provide informative signals. Moreover, over the years, financial markets have become more liquid, market participants more sophisticated, and information around financial markets more widely available. A natural conjecture then is that market prices should have become even more informative. The analysis in Bai, Philippon, and Savov (2016) largely supports this conjecture, while Farboodi *et al.* (2022) conclude that this is the case only for a subset of the firms, namely the large growth firms. Thinking forward about the rise of financial technologies that make markets even more sophisticated and the sources of information available even richer than before, many wonder whether market signals will become even more powerful. In any case, an important question is what the implications of market information for the real economy are. This is where the feedback effect comes in.

1.2 Learning from Market Prices in the Real Economy

If prices are indeed such a powerful source of information, a simple extension of the argument would suggest that they should be an important guide for production and investment decisions, or resource allocation more broadly. The literature on the "feedback effect" of financial markets builds on this premise. The idea is that aggregating information from different parts of the market, financial asset prices can provide useful signals to decision makers in the real side of the economy. These decision makers will then use the price signal

when making decisions that affect the cash flows of the firms whose securities are traded in the market.

Who are the decision makers in the real side of the economy who learn from market prices? The literature has focused mostly on managers. Most of the empirical evidence, some of which will be reviewed in the next section, is about them. This is natural given that managers are the main decision makers shaping the future of the corporation and they are closely tuned to the market prices of their firms' stocks. When making big investment decisions, they are thus expected to take a look at what market prices say and incorporate this feedback into their decisions. However, the scope of the feedback effect is not limited to managers.

One prime example is regulators, who take actions that affect firms' values and are known to pay attention to market prices. Faure-Grimaud (2002) provides nice examples of the way UK regulators use market prices of regulated firms to change the level of regulation. In the context of bank supervision, this is explicitly acknowledged and encouraged by regulators. For example, Gary Stern, the former President of Minneapolis Fed provided the logic clearly in the following quote:

> Market data are generated by a very large number of participants. Market participants have their funds at risk of loss. A monetary incentive provides a perspective on risk taking that is difficult to replicate in a supervisory context. Unlike accounting-based measures, market data are generated on a nearly continuous basis and to a considerable extent anticipates future performance and conditions. Raw market prices are nearly free to supervisors. This characteristic seems particularly important given that supervisory resources are limited and are diminishing in comparison to the complexity of large banking organizations.[1]

Ben Bernanke, the former Chairman of the Federal Reserve System, also acknowledged clearly that market prices play an important informational role in policymaking:

> . . . policy makers watch financial markets carefully for another reason, which is that asset prices and yields are potentially valuable sources of timely information about economic and financial conditions. Because the future returns on most financial assets depend sensitively on economic conditions, asset prices—if determined in sufficiently liquid markets—should embody a great deal of investors' collective information and beliefs about the future course of the economy.[2]

Another example is creditors. When giving credit to firms, they use every piece of information available, and, for public firms, this includes the stock price. To begin with, credit rating agencies, whose ratings have a large effect on creditors' decisions, are known to pay attention to market prices of the firms' securities, even though they supplement them with their own information (Gredil, Kapadia, and Lee, 2022). The concern about creditors' reaction to stock prices has been key in imposing restrictions or bans on short selling across countries and episodes of market stress. For example, when imposing bans on short sales of stocks of financial institutions in the crisis of 2008, the U.S. Securities and Exchange Commission (SEC) explained

> Under normal market conditions, short selling contributes to price efficiency and adds liquidity to the markets. At present, it appears that unbridled short selling is contributing to the recent, sudden price declines in the securities of financial institutions unrelated to true price valuation.

1 https://www.minneapolisfed.org/article/2001/taking-market-data-seriously

2 http://federalreserve.gov/BOARDDOCS/SPEECTTES/2004/20040415/default.htm

> Financial institutions are particularly vulnerable to this crisis of confidence and panic selling because they depend on the confidence of their trading counterparties in the conduct of their core business.[3]

A common counterargument to the channel of learning from prices is that many decision makers who have significant impact on the value of the firm should have more information about the underlying fundamentals than the participants in the financial market. This is especially the case when thinking about managers, who have access to first-hand information that is difficult for others to obtain. However, while it is certainly true that the manager may be more informed than any other individual in the financial market, the power of the market is in aggregating pieces of information from many different traders. In addition, the market is powerful because market participants have information on different dimensions that can be relevant to firms' decisions. As long as there is some information that managers do not have—which surely must be the case—then they should rationally update based on market prices.

This also has implications for what kind of information managers will attempt to learn and when the feedback effect will be most relevant. Big investment decisions, such as an acquisition or entering a new geographical region, are based on speculations about future synergies, competition, and demand for the firms' products. While managers are well informed about assets in place, they need to base such decisions on speculative assumptions about these future developments. The same is true when the firm is contemplating entering new activities that are developed in the economy. One can think of the development of the Internet in the 1990s or activities related to financial technologies or sustainability today. Similarly, managers may be limited relative to outsiders in evaluating the implications of macroeconomic developments on their firms. Hutton, Lee, and Shu (2012), for example, find that analysts have an informational advantage over managers when it comes to the effect of the macro conditions on the firm. Overall, in all these cases, internal information is limited, and the firm can benefit from some outside perspective. This outside perspective is at times most accurately provided by the market.

Another counterargument is that prices are very noisy, or that it is difficult to interpret them because it is not known what kind of information they are conveying. While there is certainly noise in prices, the idea of the feedback effect is that, after taking the noise into account, prices are still informative. Rational economic agents will update, fully aware of the possibility of noise, and still find the price informative. In fact, as will be discussed in Section 2, the noise in prices adds interesting dimensions to the literature and helps in identifying the channel of active learning from the price. Similarly, as discussed in Section 3, there are interesting equilibrium implications coming from the fact that there are multiple dimensions of information potentially reflected in the price, and these also enrich the study of the feedback effect, and provide more directions for future research.

1.3 Implications of the Feedback Effect

Traditional theories on price formation in financial markets (Grossman and Stiglitz, 1980; Hellwig, 1980; Glosten and Milgrom, 1985; Kyle, 1985) treat the cash flows of the underlying asset as exogenous and unaffected by the financial market. These models provide powerful frameworks to understand how information is produced, processed, and

3 https://www.sec.gov/news/press/2008/2008-211.htm

aggregated in the financial market for a given realization of the firm's cash flows and future value. The limitation, however, is that the financial market in these models is essentially a side show: It reflects what is going on in the real economy but has no effect on it. The literature on the feedback effect builds on these frameworks but changes the paradigm to account for the real effect: Once decision makers in the real side of the economy learn from the market price and change their decisions based on it, the price plays an active role in affecting cash flows and valuations.

In an early review of the feedback-effect literature, Bond, Edmans, and Goldstein (2012) discuss how it profoundly impacts the theory of financial markets. They make two main points. First, thinking about the feedback effect challenges the traditional notion of efficiency used to analyze financial markets. Bond, Edmans, and Goldstein (2012) distinguish between two types of efficiency. Forecasting price efficiency (FPE) is the ability of the market to predict future cash flows. One way to think about it is as the correlation between prices and future cash flows. This is in many ways the usual way financial economists think about market efficiency. On the other hand, revelatory price efficiency (RPE) is the ability of the market to provide information to decision makers in the real side of the economy that improves the economic efficiency of their investment and production decisions. It has been referred to in the literature as real efficiency in short. While market efficiency is what is typically studied, real efficiency is arguably what is more relevant and important to understand. Interestingly, as the literature shows, these two measures of efficiency are sometimes in conflict with each other, implying that it is not always sufficient to focus on market efficiency and assume that it is correlated with the real economic efficiency.

Second, incorporating the feedback effect into models of financial markets can fundamentally change predictions on how prices are formed and help understanding some phenomena that otherwise seem puzzling. Once cash flows change as a result of learning from prices, the price formation process itself changes. Phenomena such as manipulation, limits to arbitrage, trading frenzies, and others then emerge in equilibrium, even if they do not arise in models without a feedback effect. Hence, modeling the feedback effect is not just a detail required to complete the model. Rather, it changes the fundamental insights from the model.

1.4 Layout of the Rest of the Article

The remainder of the article is organized as follows: In Section 2, I provide a short review of the empirical evidence for the feedback effect. I also highlight some of the challenges with the empirical analysis and how the different research streams are trying to overcome them. The empirical evidence focuses primarily on showing that the feedback effect is present and not on testing some of the subtle theoretical implications. Hence, discussions of insights from theory follow the empirical evidence and are featured in Section 3. In this section, I discuss the tension that models of the feedback effect expose between the different notions of efficiency and then describe how these models help us understand the origins of observed phenomena. In each case, the illustration is focused on a key example, based on a recent paper, or motivated by a recent real-world episode, yet trying to highlight the general themes. In Section 4, I provide some future perspectives linked to recent developments. Specifically, I consider how the recent revolution of information technologies is changing the information environment in financial markets and discuss possible implications through

the lens of the feedback-effect literature. Section 5 concludes with additional, more general, perspectives for future research.

2. Empirical Evidence about the Feedback Effect

2.1 Identifying Feedback: The Empirical Challenges

The empirical literature has focused mostly on the effect of market prices on managerial investment decisions, asking whether managers learn from the market. In many cases, such market feedback is expected to gradually affect long-run investment plans and so is not easily visible and requires careful analysis. However, one setting in which market feedback is easier to detect is an acquisition decision. Here, there is typically an announcement, then a market reaction, and then the firm may change its plans. This is why the setting of an acquisition is also one where anecdotes are easier to find. Before diving into the empirical literature, let us thus consider one recent anecdote to fix ideas of what market feedback may look like.

On February 4, 2020, The Wall Street Journal reported that Intercontinental Exchange (ICE), the owner of the New York Stock Exchange (NYSE) and other exchanges around the world made a takeover offer to acquire eBay, a pioneer in e-commerce who had been struggling to keep up with competitors.[4] This was confirmed later in the day. In public communication, the rationale for the deal was described as building on the similarities in businesses across the two firms, such as matching buyers and sellers or collecting and organizing data. However, for the investors of ICE, this came across as a bad idea, given that this acquisition would divert ICE's attention from its core business of running financial markets and selling financial data. Investors voted by selling their shares, sending ICE stock price down 7.5% on February 4 and another 3% down on February 6. With this harsh market feedback and additional conversations with investors, ICE decided later that day to cease the exploration of this strategic opportunity. The market rallied 3% in response to this announcement.[5]

This example demonstrates how the feedback from the market can cause managers to change the firm's investment plans. Even though managers are close to the deal and considered various aspects of it, such a deal is ultimately based on assumptions about synergies and what a reasonable price might be. These are issues on which investors in the market will have opinions and the aggregation of their insights can lead to a significant updating by the managers. This kind of dynamics is clearly on display with some acquisition decisions.

As the nature of anecdotes goes, however, one could suggest alternative mechanisms to be in play. For example, with the above episode, it could be that there was no actual learning, but rather managers just surrendered to market pressure. That is, maybe they knew all along that this was not a good acquisition, but wanted to pursue it for private benefits. Then, only the strong reaction from the market made it too costly to continue and so led them to abandon the acquisition. Hence, systematic studies are needed to see a broader pattern and link it more clearly to the informational channel.

4 https://www.wsj.com/articles/intercontinental-exchange-approaches-ebay-about-a-takeover-11580845016?mod=article_inline

5 https://www.wsj.com/articles/nyse-owner-abandons-potential-ebay-deal-11581025909

Luo (2005) provides a systematic study to document the managerial learning from the market on acquisition decisions. He shows that acquisitions are more likely to be canceled when prices react more negatively to their announcements, and that this is particularly so when there are reasons to believe that managers can benefit from learning. This is the case, for example, when the uncertainty is not about technology, since managers have a clear information advantage about technology but not necessarily on other aspects of the deal. Given their distinct nature, the dynamics around mergers and acquisitions continued to play a role in the development of the feedback-effect literature. Potential targets usually see a run-up in price prior to an announcement, and the question is what the parties infer from this and how it affects merger negotiations. Betton *et al.* (2014) provide an analysis on this, emphasizing learning about synergies and examining the implications for the eventual offer price.

The broader empirical literature has been looking beyond acquisitions, trying to see whether there is an active role of market prices in determining other corporate decisions, such as investments more generally. There is a significant empirical challenge in doing so. Market prices can be correlated with firms' investments for various reasons, most prominently because both are positively affected by firms' fundamentals, without a causal effect of prices on investments. The literature has used two main strategies to pin down the mechanism. One relies on analyzing the investment–price sensitivity and whether it is correlated with variables that indicate an active informational role. Another one relies on shocks to prices that affect them for non-fundamental reasons. Below, I will elaborate on each one of these branches of the literature. Then, I will briefly describe new work providing survey evidence for the effect of market prices on corporate decisions.

2.2 Price Informativeness and Investment Sensitivity to Stock Price

The first paper in this stream of work (Chen, Goldstein, and Jiang, 2007) analyzes the sensitivity of corporate investment to stock price. To test whether managers learn from the price, it asks how this sensitivity is related to measures of price informativeness. The idea is that if investments are more sensitive to prices when prices are more informative, then this indicates that the information in the price is used for the investment decisions. Two measures of price informativeness, which were common at the time, were used for the analysis: price non-synchronicity, going back to Roll (1988), and the probability of informed trading (PIN), going back to Easley, Hvidkjaer, and O'Hara (2002). The paper finds a positive relation between price informativeness and the sensitivity of corporate investment to stock price, consistent with the active learning story. In a follow-up paper, sharpening the methodology behind the investment–price sensitivity tests, Bakke and Whited (2010) provide evidence that bolster these results.

Still, another interpretation of the above results is that the information in the price was already known to managers without looking at the price, that is, a passive correlation channel, which is also consistent with a positive relation between the sensitivity of investment to stock price and price informativeness. Chen, Goldstein, and Jiang (2007) address this alternative by controlling for measures of managerial information that are based on insider trading and on the level of earning surprise. Since the results are not affected, the evidence supports the active learning channel more strongly. Later papers provide further tests to separate the active learning story from the passive correlation story, as described below.

One challenge in the above strategy is to find measures that truly capture price informativeness. Price informativeness is, after all, hard to define empirically, and different measures present tradeoffs in what they capture or do not capture. Instead of trying to measure price informativeness, several papers rely on market characteristics or shocks that are expected to affect the amount of private information impounded into the price. One example is Foucault and Frésard (2012) who analyze the effect of the stock being cross-listed on the investment–price sensitivity. The idea is that being listed in different markets will improve the informativeness of the price, and so this provides a natural setting for such exploration. Indeed, they find a positive relation between the cross-listed status and the investment–price sensitivity.

Related to that, Edmans, Jayaraman, and Schneemeier (2017) utilize changes in regulation around the world leading to greater enforcement of insider-trading laws. When such laws are enforced more strongly, insiders will trade less on their information, encouraging outsiders to trade more on their own information, and so bringing more of the information that is not known to managers into the price. This is expected to cause managers to rely more on the price in their investment decisions. Indeed, the paper finds that such enforcement changes make the sensitivity of investment to price stronger. This article improves the methodology, bringing it closer to causal identification, as it relies on a regulatory shock to generate the change in informativeness. More recently, Ye, Zheng, and Zhu (2022) build on a randomized controlled change in tick size as a shock to price informativeness. They show that a larger tick size reduces algorithmic trading and encourages fundamental information acquisition. This, in turn, leads to an increase in the sensitivity of investment to price.

An important branch of the literature explored learning from prices of peers. Foucault and Frésard (2014) provide the first analysis on this. When thinking about learning from prices, this is a very natural direction to explore. Managers are expected to utilize all sources of information available to them, and so will not look only at their own prices, but also at the prices of their peers. This setting also allows for richer empirical exploration focusing more clearly on the active learning channel. This is because, for example, if a firm's reliance on its peer stock price strengthens when its own price informativeness decreases, it would be difficult to attribute this to a passive correlation channel: Why would a firm's investment and its peer's price be more strongly related when its own stock price is less informative? In this spirit, the authors show that firms' investments are more sensitive to the peers' stock prices when those prices are more informative and when their own stock prices are less informative. They also show that the sensitivity of the firm's investment to its own prices decreases when the peers' prices are more informative. Overall, the tests provide strong support for the active learning channel as opposed to the passive correlation channel.

Another interesting direction in the literature is to explore firms' communications to the market. Such communications provide a sense of what firms know, and can help us see more clearly how firms update following the reaction they receive from the market. Zuo (2016) shows that firms revise their earnings forecasts in response to price movement after the original forecast, and they do so more when the price contains more information. Jayaraman and Wu (2020) show how firms utilize voluntary disclosure on capital expenditure as a tool to elicit information from the market. They show that firms adjust their capital expenditures based on the market reaction to the forecasts, and that they do so more strongly when it is more likely that the price contains new information.

With all the above progress, new directions are continuing to emerge. Banerjee *et al.* (2022) posit that the extent to which managers would be willing to learn from the price depends on the perceived informativeness of the price from their point of view. Then, if managers are overconfident, they will think there is less to learn, and follow the price less. Using proxies for overconfidence, they indeed confirm a weaker feedback effect for managers who are more overconfident. Gao and Xiao (2022) exploit the geographical dimension to proxy for the additional information that could come from the market to guide managers. If investors in the firm are more distant from the headquarters, then they can potentially bring new insights that managers do not have. They confirm in the data a stronger sensitivity of investment to price when investors are distant and live in areas that are relevant to the business of the firm. In the context of acquisitions, they further show that the acquirer's response to the market is stronger when the investors are far from the acquirer but close to the target.

2.3 The Effect of Non-fundamental Shocks to Market Prices

Another strategy in the literature to identify the active role of market prices is based on non-fundamental shocks to prices. Recall that the empirical challenge is that prices and corporate decisions are affected by the same fundamentals, and so it is difficult to tell whether prices have a causal effect on corporate decisions. However, when prices are affected by non-fundamental shocks, we have an opportunity to test whether prices in general play an active role in determining corporate decisions. This is because the non-fundamental shock should not have a direct effect on the corporate decision. One question here is whether this can still be linked to learning. After all, why would decision makers rationally follow non-fundamental information? The key is that decision makers cannot differentiate when the price is moving for fundamental reasons and when it is moving for non-fundamental reasons. They can be learning from the price, expecting that it is informative on average, but then sometimes end up inadvertently being affected by non-fundamental price changes.

Edmans, Goldstein, and Jiang (2012) developed such a measure of non-fundamental price change based on extreme mutual-fund outflows. Going back to Coval and Stafford (2007), such outflows are thought to generate fire-sale pressure, depressing prices for non-fundamental reasons. In Coval and Stafford (2007), however, the focus is on the stocks that fund managers sell. This creates the concern that the selling decision is itself based on weak fundamentals. To overcome this problem, Edmans, Goldstein, and Jiang (2012) do not consider which stocks were actually sold. Rather, their measure is based on hypothetical selling based on the ex ante holdings of the mutual funds. That is, in response to outflow pressure, funds are assumed to sell stocks proportionally to the level of holding. Another concern is that the outflows from investors might be driven by bad fundamentals. However, the flows are at the fund level, and so they are not directly driven by the fundamentals of individual stocks. To make sure that there are no correlated fundamental shocks affecting all the holdings of the fund, the measure excludes funds that focus on specific sectors. After establishing the measure, the paper uses it to demonstrate a real effect of prices on an important corporate event. Specifically, it is shown that large negative non-fundamental price shocks make the firm more likely to become a takeover target.

Dessaint *et al.* (2019) have used this measure to analyze the effect of prices on corporate investments. Moreover, they use peer firms to focus more directly on managerial learning. They point out that if firms' investments are affected by this measure of pressure on their

own price, then one could argue that the effect is not due to learning, but rather due to a direct effect of the change in price, for example, the firm finds it more difficult to raise capital when its price declines. This is why they look at how firms' investments are affected by non-fundamental changes to the prices of their peers. They find that firms decrease their investments in response to a negative non-fundamental price shock to peers' stock prices. Since there is no direct reason for managers to be affected by peers' prices, they conclude that the effect must be informational. Managers end up extracting the wrong information from prices, given that prices are overall informative, but sometimes contain noise. Hence, noise in the market affects real outcomes through learning.

A recent paper by Wardlaw (2020) challenges the measure of mispricing based on mutual fund outflows. The heart of the critique is that the outflows from mutual funds are normalized by total volume, which brings the price itself into the measure. This normalization has an economic rationale, as Wardlaw (2020) acknowledges. It helps capture the extent to which outflows can impact prices given the level of market depth. However, it might also inadvertently lead the measure to capture more than just the exogenous price pressure. With this in mind, recent papers, using this measure of mispricing, avoided this normalization. They find that this does not materially change the results on mispricing and real effects. See, for example, Jayaraman and Wu (2020), Dessaint *et al.* (2021), Banerjee *et al.* (2022), and Gredil, Kapadia, and Lee (2022).[6]

Another recent paper by Tubaldi (2021) follows up on this research with a more direct approach to identify non-fundamental mutual-fund outflows and their real effects. He shows that liquidity needs driven by hurricanes cause significant outflows by affected investors from mutual funds and lead to fire sales of the stocks that the mutual funds hold. These fire sales generate price drops for affected stocks of 7%, which revert within 10 months. Tracking the effect on the real economy, he shows that affected firms reduce their investments by 4%. Hence, he concludes that when an undeniably exogenous source of liquidity shock drives the mispricing, the conclusions of the above literature remain intact. Yan (2021) adopts another strategy. She shows that private firms in the UK adjust their investment based on price changes of public firms in the same industry. Following the approach of identifying a learning channel through the effect of noise in price, she shows that this effect holds when the price change is driven by public firms' unrelated minor segments. Another aspect of her work is that she utilizes both indicators of noisy price movements and measures of overall price informativeness, combining the two streams of the literature discussed in this subsection and the previous one. Other papers in this literature, for example, Zuo (2016), have also followed this path. There is probably room to do more to combine the streams of research in the future, for example, by asking whether non-fundamental shocks have a bigger impact when the price is overall more informative.

The idea that noise becomes a prominent factor in price and that it ends up affecting the underlying fundamentals of firms is often featured among practitioners. The most vocal advocator of this idea over the years is perhaps George Soros. Here is a quote from him following the financial crisis of 2008, which provides a good summary of his thesis of financial markets and the real economy

6 A working paper version of Edmans, Goldstein, and Jiang (2012) prior to its publication is also based on the alternative measure without the normalization and is thus not affected by the issue identified by Wardlaw (2020). The results are also not materially different. See https://www.fmg.ac.uk/sites/default/files/2020-08/takeover-activity.pdf.

> We must understand financial markets through a new paradigm which recognizes that they always provide a biased view of the future, and that the distortion of prices in financial markets may affect the underlying reality that those prices are supposed to reflect. (I call this feedback mechanism reflexivity . . .)[7]

While the view I emphasize here of how noise in the financial markets affects the real economy builds on the learning channel, there is another branch of the finance literature that features another channel for the real effect of mispricing. This literature is summarized well in Baker (2009). In his framework, market prices move for non-fundamental reasons. Such mispricing then persists due to limits to arbitrage, for example, because of the limited capacity of financial intermediaries. Firm managers in this framework know the fundamentals better than the market, and know that there is mispricing in the market. They then take advantage of it, for example, by issuing stocks when the market overvalues their shares. Since cash is flowing into the firm, the argument is that mispricing ends up affecting the real economy.

There are two important distinctions between the learning channel and the channel in Baker (2009). First, the channel in Baker (2009) only applies to primary financial markets, not to secondary financial markets. Primary financial markets are characterized by new capital issuance and secondary financial markets are characterized by trading of stocks without active flow of capital. Importantly, most trading in financial markets happens in secondary markets after capital issuance has already happened, and so understanding the real effects of secondary financial markets is important. Second, even in primary financial markets, the channel in Baker (2009) can be used to explain capital issuance, but not so easily to explain the important real variables such as investment, employment, and production. This is because managers, who know that their stock is overvalued, have no reason to make real investment or expand their business. They would be better off just issuing the shares and accumulating the cash. Since the real effect of financial markets is mostly about variables such as investment, employment, and production, this distinction is critical.

2.4 Survey Evidence

Given the challenges in identifying the feedback effect in market data, it is useful to consider a direct approach and ask corporate managers themselves whether they care about stock prices, and if so, then why. Goldstein, Liu, and Yang (2022) study the results of such a survey in China. The survey was conducted in 2019 in collaboration with the China Securities Regulatory Commission, which is China's counterpart of the U.S. SEC, and included all 3,628 firms listed on the Shanghai and Shenzhen stock exchanges. The response rate was close to 100% (3,626 firms responded), providing a wide range of responses and also avoiding the sampling bias problem which is common to other surveys. China's financial markets are also a good place to study the feedback effect, given that their information efficiency has increased substantially in recent years, as documented by Carpenter, Lu, and Whitelaw (2021).

The responses provide strong support to the idea that stock prices play an important role in firms' operations, and highlight two main channels through which this happens; one of them is the informational channel. Specifically, in response to the question whether and how they pay attention to the stock market, and given a few options of what they might

7 https://www.wsj.com/articles/SB123785310594719693

care about, 91.6% of the firms reported that they care about their own stock price. Firms in this group were then given a few non-exclusive options as to why they care about their stock prices. The most common reason, chosen by 75.2% of the firms, points to an informational channel, as the firms say that the stock price contains information that is new for investment decisions. The second most common channel, chosen by 66.1% of the firms, points to a financing channel, where firms are saying that the stock price would impact refinancing (SEO/bond issuance/bank loan). This channel can also be related to the informational channel in a case where the decision makers are creditors, but it can also reflect the primary-market channel mentioned above.

The article then goes on to analyze firms' responses and how they relate to their characteristics and actions. This serves to validate the results of the survey, in showing that the responses are consistent with firms' actions, but also to gain some additional insights as to which firms care about the market for what reasons. One interesting analysis, for example, is related to firms' choices to suspend the trading of their stocks. The availability of this option to firms is unique to China. It turns out that those firms, who say that they learn from the information in the price, are less likely to suspend their trading. This is consistent with the idea that they think the information in the price is valuable and hence they do not want to suppress it. On the other hand, those firms, who say that they care about the price because of the financing channel, are more likely to suspend trading when faced with large price drops. This is consistent with the idea that the first-order consideration for these firms is to prevent the price from falling further, as this will hurt their financing conditions.

3. Models of Feedback Effect and Their Implications

3.1 Financial Markets with Feedback: A New Paradigm

The theory of security prices says that the price of a security should be equal to the present value of future cash flows generated by the security. In the case of a stock, this would be the present value of future cash flows produced to the equity holders. In models of information and trading in financial markets, such as Grossman and Stiglitz (1980), Hellwig (1980), Kyle (1985), and Glosten and Milgrom (1985), there is asymmetric or heterogeneous information about these future cash flows. Speculators produce information about them and trade, and then through the trading process the price aggregates the information, with noise, providing a signal about expected future cash flows.

What is unique to models of the feedback effect is that decision makers in the real side, who affect the future cash flows of the firm, learn from the price and adjust their behavior based on the information from the price. A manager may update following a negative price reaction and cancel a planned acquisition. A creditor may decide to reduce the amount of capital provided to the firm if the price of its stock suggests that its fundamentals are not as strong. A bank supervisor can learn from the price that the bank is facing difficulties and then take a corrective action aiming to stabilize the situation. A board of directors can update based on the price that the CEO is not doing a good job and replace the CEO. In all these cases, the information from the price ends up affecting future cash flows. It is important to note that there are also situations where the information in the price affects future cash flows because decision makers, mostly managers, care about the price directly, as it affects their compensation or because they exhibit short-termism. The earlier review paper by Bond, Edmans, and Goldstein (2012) provided more discussion on this alternative channel.

That the information from the price affects future cash flows is a new feature relative to traditional models of trading and information in financial markets. In the traditional models, the price only reflects expected future cash flows, and so the market is effectively a side show. Under the feedback paradigm, it is not a side show, since what happens in the market can affect decisions in the real side that affect future cash flows. Early models that incorporated a feedback channel include Fishman and Hagerty (1989), Leland (1992), Dow and Gorton (1997), and Subrahmanyam and Titman (1999).

More recent models developed unique insights that come from the feedback effect. As described in Bond, Edmans, and Goldstein (2012), these insights follow two themes. First, because the market affects corporate decisions and cash flows, real efficiency can be naturally analyzed and compared with market efficiency. Moreover, it is often shown that the two are in conflict with each other. Second, because the actions of speculators in the market spill over to the real economy and alter the ultimate valuation of the firm, speculators' expected payoffs also change. This affects their incentives in trading and information production and generates new implications for financial-market equilibrium. Below, I will illustrate these two types of insights.

On a more technical note, the second theme above generates a feedback loop between the financial market and the real economy. Speculators' actions affect firms' cash flows through the information conveyed in the price. Expected cash flows, in turn, affect speculators' expected payoffs, and so alter their equilibrium actions. This loop, where the market affects and reflects the real economy, challenges traditional solution methods. Hence, feedback-effect models often rely on specifications that are different from the usual ones in traditional models of trading and information in financial markets.

3.2 Market Efficiency versus Real Efficiency

Market efficiency is a central object of interest in the study of financial markets. The market is considered to be more efficient when it provides more accurate information about the future cash flows generated by the traded securities. Market efficiency is typically measured based on the correlation between prices and future cash flows, or as the inverse of the variance of future cash flows conditional on market prices (see, e.g., Goldstein and Yang, 2017). A high level of market efficiency is thought to indicate that the market is working efficiently to aggregate and process information, and so does a good job in predicting future realizations.

The focus on market efficiency seems natural to many financial economists, but less so to people outside financial economics. As a justification for the interest in market efficiency, financial economists tend to bring up the positive implications of an efficient market for the real economy. For example, Fama and Miller (1972) wrote that an efficient market

> has a very desirable feature. In particular, at any point in time market prices of securities provide accurate signals for resource allocation. That is, firms can make production-investment decisions . . .

This notion that Fama and Miller (1972) highlight is a notion of allocative efficiency or real efficiency, that is, the extent to which firms can use the information in prices for their investment and production decisions. The implicit assumption made by Fama and Miller (1972), which is reflected more broadly in financial-economics thinking, is that market efficiency is a good proxy for real efficiency, and this is why we should focus on market efficiency.

Models of the feedback effect, by incorporating the feedback from prices to corporate decisions and cash flows, are well positioned to investigate whether market efficiency and real efficiency are indeed aligned. If they were aligned, then incorporating the feedback effect into models of financial markets would be redundant as far as obtaining implications for real efficiency is concerned. The literature, by and large, demonstrated the opposite: that the two notions of efficiency are not aligned and so that incorporating the feedback effect is necessary for studying real efficiency.

These analyses go back at least to Dow and Gorton (1997). They highlight an equilibrium where speculators do not produce information since they think the firm will not invest, and the firm indeed does not invest since there is no information in the market. This equilibrium features a high level of market efficiency, since prices reflect future cash flows well in the absence of new investment. However, it has a low level of real efficiency, since the market does not provide the information to allow the firm an efficient process for investment decisions. Bond, Edmans, and Goldstein (2012) provide more discussion with additional examples. They define market efficiency as FPE and real efficiency as RPE, and discuss cases where the market can forecast future cash flows but not reveal useful information for decisions leading to these cash flows. Their examples of the failure of RPE revolve around situations where the fact that the market reflects and affects expected future decisions prevents it from providing the information for making these decisions more efficient, such as in Bond, Goldstein, and Prescott (2010) and Bond and Goldstein (2015).

More recently, a stark difference between market efficiency and real efficiency has come out of models that consider multiple dimensions of information. This is an important direction to explore, given the tension that firms' cash flows and investment decisions are affected by different dimensions of uncertainty, but the price of the firm's stock is limited in what it can convey. Goldstein and Yang (2019) consider two dimensions of information. On one, firm managers have a clear informational advantage, but on the other one, they can benefit significantly from market information. For example, one can think of the first dimension as the technology of the firm, on which the managers have a lot of inside information, and the other as the demand for the firms' products, which is more speculative such that the wisdom of the crowd can provide important insights. Alternatively, the first dimension can represent firms' assets in place, on which managers are well informed, but the other can represent growth opportunities, which are speculative and may require an outside perspective.

To illustrate the conflict between market efficiency and real efficiency arising in such an environment, consider two cases. In one case, the information known to managers is also strongly reflected in stock prices. In the other case, the information that is not known to managers is the one reflected more strongly in stock prices. In the first case, market efficiency will be high: markets and managers are informed about the same thing and markets can predict managerial decisions and firm cash flows quite well. However, real efficiency will be low in this case, given that the market does not provide any new information to managers and so does not do anything to improve the efficiency of the firm's decisions. In the second case, the opposite will be true. Because managers and markets are informed about different things, market efficiency is not guaranteed to be high. Yet, real efficiency is higher because the market provides the information that managers need to know for their investment decisions to be more efficient.

Goldstein and Yang (2019) develop this environment to analyze implications for optimal disclosure policies. They show that it is always optimal to have more precise disclosure

on dimensions, for which the managers (or other decision makers in the real economy) have a clear informational advantage over the market. When such information is disclosed, market speculators will not focus their trading on such information, but rather on the dimension that managers wish to learn more about. This will allow the market to improve the efficiency of real investment. On the other hand, when information is disclosed on things that managers wish to learn more about, it might backfire by crowding out speculators' trading on this information. This might reduce the ability of the market to improve the efficiency of real investment. Such damaging crowding out in the face of real effects was analyzed also by Gao and Liang (2013). Jayaraman and Wu (2019) provide empirical evidence using mandatory segment reporting in the USA. The analysis in Goldstein and Yang (2019) brings in the different dimensions of information and highlights that some disclosures might be good whereas others might be bad. Following empirical research such as that conducted by Jayaraman and Wu (2019), it would thus be interesting to explore in the data when crowding in dominates crowding out and vice versa.

One implication of the result in Goldstein and Yang (2019) is that accounting disclosure should tend toward being backward looking rather than forward looking. This means that accounting disclosure should focus on the value of assets in place or the realizations of past earnings rather than providing guidance on the value of growth opportunities or expectations for future earnings. This is because the managers of the firm are much more informed about past realizations than outsiders, whereas the integrated view from outsiders can be more precise than mangers' forecasts when it comes to future prospects. As such, managers can benefit from market information on this dimension. Accounting rules indeed tend to emphasize the backward-looking information over the forward-looking one, but the issue of what is the optimal system is often debated. The model provides rationale for the way the system currently works. It should be noted that in a model where managers do not learn from the price, but just try to maximize it, for example, because of short termism, the fact that they only disclose tangible information might cause them to neglect the intangible dimensions of firm value, which is bad for real efficiency. This is shown by Edmans, Heinle, and Huang (2016).

The above discussion reflects a broader connection between the feedback effect and the optimal design of disclosure systems, which is a core focus of the accounting literature. Basically, when designing systems of information disclosure, managers and regulators should keep in mind what the design will do to the incentives of outsiders to produce information and trade on information, and how this will affect the information available to the firm. Goldstein and Yang (2017) elaborate on this interaction more in their survey of the literature on information disclosure in financial markets. Recently, Chen *et al.* (2021) show how the feedback effect can rationalize another basic feature of accounting systems: more timely disclosure of bad news than good news. This arises in their model due to the fact that in feedback models (Edmans, Goldstein, and Jiang, 2015; Boleslavsky, Kelly, and Taylor, 2017) speculators have a stronger incentive to trade on positive news than on negative news.

Finally, when thinking about market efficiency and real efficiency, it is not always clear what managers and markets will be informed about. Allowing both market participants and managers to choose the dimension of information to focus on, the question is whether we expect them to specialize in different dimensions in equilibrium, as desirable for real efficiency, or not. In a recent paper, Goldstein, Schneemeier, and Yang (2022) analyze this question. They show that, other things equal, managers always have an incentive to

produce information that is not produced by the market. This is because the managers are interested in maximizing firm value, and from that point of view, acquiring information that is not otherwise available is beneficial. However, speculators in the market are motivated by their own profits, implying that they want to produce the information that will exhibit the strongest correlation with future cash flows. This sometimes gives them incentive to produce the information that managers already have, as this is the information to which future cash flows are most sensitive to. In equilibrium, which effect dominates depends on whether the ex ante net present value of the firm's investment is positive or negative. This will also determine whether firms and markets end up producing the same information, giving rise to market efficiency at the expense of real efficiency, or whether they specialize in different dimensions, giving rise to real efficiency at the expense of market efficiency.

3.3 New Implications for Financial-Market Equilibrium

Speculators in the financial market choose their trading positions or information production to maximize their expected utilities from trading, taking into account the expected profits and risks. When information in the price affects corporate decisions and cash flows, the underlying value of the securities changes, and so do the expected payoffs for speculators. This alters their optimal trading and information-production behavior in equilibrium. Hence, the feedback effect from prices to the real economy has the potential to change the equilibrium in the financial market in fundamental ways. The literature has shown that this then gives rise to market phenomena, which are observed in practice, and that would not have occurred without the feedback effect.

Models of information and trading in financial markets can be classified into two categories. In one, going back to Kyle (1985), speculators are strategic and take into account their effect on market prices when they trade. In the other, going back to Grossman and Stiglitz (1980) and Hellwig (1980), speculators are not strategic and take the price as given. The feedback effect changes equilibrium outcomes in the financial market under both types of models. In a setting with strategic players, speculators will now take into account not only their effect on the price but also their effect on the firm's decisions and cash flows. In such a setting, Goldstein and Guembel (2008) have shown how the feedback effect can give rise to price manipulation, where an uninformed speculator will short sell the stock, making a profit by depressing its underlying value. Edmans, Goldstein, and Jiang (2015) and Boleslavsky, Kelly, and Taylor (2017) have shown how the feedback effect generates asymmetric trading, where speculators trade more aggressively on good news than on bad news. Khanna and Sonti (2004) and Khanna and Mathews (2012) have analyzed the incentives of a trader with an inventory in the stock to push prices up in order to increase firm value. Interestingly, all these examples highlight how the presence of feedback leads to phenomena that reduce the ability of the market to convey the information, and so the feedback backfires to some extent. This is related to problems with real efficiency discussed above.

In a setting with price-taking traders, the presence of a feedback effect still alters trading motives and so equilibrium outcomes. Even though speculators take the price as given, the collective action across speculators changes the price, which affects the cash flows from the security, and the expectation of this changes the optimal action of speculators in equilibrium. One such example is the paper on trading frenzies by Goldstein, Ozdenoren, and Yuan (2013), giving rise to a phenomenon that recently received renewed attention following some major events in financial markets. I will now describe the mechanism in this

model and its relation to recent events in more detail. Other models of trading frenzies with a feedback effect, focused more exclusively on short selling, are offered by Brunnermeier and Oehmke (2014) and Liu (2015).

What is a trading frenzy? While different people may have different definitions, Goldstein, Ozdenoren, and Yuan (2013) refer to a situation, where speculators in financial markets rush to trade in the same direction, and, by doing that, might exert a large pressure on prices. This seems to capture many episodes in history. Most prominently, there is often a concern about a coordinated short-selling attack on a stock, a so-called bear raid, that leads to a spiral, where stock prices and firm fundamentals push each other down and end up deteriorating substantially. The quote from the SEC in Section 1.2 reflects exactly this concern, which led them to impose short-sale bans on financial institutions during the financial crisis. Other episodes feature frenzied buying, such as in the dot-com bubble. In early 2021, cases of this nature were in the headlines, as so-called meme stocks, like GameStop and AMC, experienced coordinated buying from investors, leading their prices to skyrocket.

Why are trading frenzies so puzzling? At its core, a trading frenzy is a situation where strategic complementarities are the dominant force in the interaction among speculators, that is, where each one of them wants to act like the others. While strategic complementarities are well expected in some economic contexts, such as bank runs, they are more surprising in the context of financial markets. This is because the price mechanism in financial markets naturally leads to the opposite force, that of strategic substitutes, whereby speculators want to trade differently from each other. Specifically, as a result of the price mechanism, when many people buy (or sell) the stock, they push the price up (or down), increasing the motivation of others to sell (or buy). Goldstein, Ozdenoren, and Yuan (2013) study a model of a financial market with the typical price-mechanism-generated strategic substitutes and add a feedback effect from the price to firms' cash flows. The feedback effect originates from capital providers basing their decisions on how much capital to provide to the firm on the realization of its stock price. They show that this feedback effect generates strategic complementarities among speculators: a deterioration (or increase) in price hurts (or helps) the firm's ability to raise capital and decreases (or increases) its real value, making it worthwhile for speculators to sell (or buy) when others are selling (or buying).

To see how the model works, consider a firm that raises financing from creditors, in order to make an investment. The creditors' decisions on how much capital to provide to the firm depend on their assessment of the profitability of the investment, which affects their expected return. The stock of the firm is traded in the market, and its price, determined through the trading of speculators, reveals information that is valuable to the creditors in their decision. Each trader in the financial market has access to two pieces of information about the investment profitability: One is a private signal and one is a signal that is correlated across the speculators (conditional on the realization of the profitability). They choose the weights they put on their signals in trading, and the price aggregates the information, with noise, accordingly.

If strategic complementarities are the dominant force across speculators, then they want to put more weight on their correlated information, making them trade like each other, which potentially leads to a frenzy. On the other hand, when strategic substitutes dominate, they want to put more weight on their private information, pushing away from a frenzy. The feedback from the price to the creditors' decision on capital provision is the source of complementarities and frenzies, as explained above. These complementarities act against

the traditional substitutabilities generated by the price mechanism, also explained above. When the complementarities dominate, we see a tendency for speculators to coordinate on the correlated information, and this may resemble a trading frenzy.

The mechanism described here is related to the frenzies we saw in early 2021 with stocks like AMC and GameStop. Of course, it would be difficult to attribute these events completely to rational forces, but two important aspects of the model may have strengthened them. First, the way that coordination manifests itself in trading on common or correlated signals relates to how traders behind these frenzies coordinated through the Reddit forum WallStreetBets. Indeed, Goldstein, Ozdenoren, and Yuan (2013) predict that trading frenzies will become more likely with such Internet forums becoming more prevalent

> A large volume of activity in such [internet] forums could suggest that speculators have more common information than private information and so trading frenzies become more likely to occur.

Second, and more important for the focus on the feedback effect, we indeed saw that firms benefiting from the meme-stock phenomenon were able to use the increase in stock prices to raise more capital at attractive terms, and this helped improve their fundamentals, in turn providing some reinforcement to the increase in their stock price. AMC is perhaps the most notable example of this.[8] It raised capital at attractive prices following the spike in its stock price, and was able to use this capital to avoid the likely fate of bankruptcy. Even a more stable firm, American Airlines, was able to benefit from this phenomenon at the time, raising capital to improve its financial position. GameStop, which was in many ways the posterchild of the meme-stock phenomenon more broadly, did not do that at first, but did join later on and used the stock price increase to improve its financial resilience. Whether the feedback was a primary-market channel, a learning-by-capital-providers channel, or a combination of both, the main takeaway from these episodes in connection to the model is how the feedback from the market to the firm itself can help support a trading frenzy.

More broadly, thinking about the meme-stock episode through the lens of feedback effects suggests that regulators should look into the real effect and not just at what happens in the financial market itself. The public discussion around this episode was in many ways focused on the instability of stock prices and the fact that some traders lost money. Yet, the implications for capital allocation in the real economy are likely more consequential: The fate of firms changed drastically because of what happened in the financial market. The article provides an analysis of the implications of trading frenzies for real efficiency and shows that they are not one-sided. But, overall, policymakers may want to think more about possible distortions to investments and the allocation of capital in the real economy, and not just about who wins and who loses in the financial market.

4. Fintech, Information, and the Feedback Effect

4.1 New Information Technologies

New technologies shaping the finance world are receiving a lot of attention in research and practice under the broad title of FinTech. In 2016, the *Review of Financial Studies* launched

8 https://www.wsj.com/articles/how-reddit-renegades-helped-theater-giant-amc-avoid-a-tragic-ending-11614358803

the FinTech initiative, culminating in a special issue in 2019. Introducing the special issue, Goldstein, Jiang, and Karolyi (2019) review the emerging research themes under this broad umbrella, based on submissions to the FinTech initiative and the published papers. There are several important themes behind the FinTech agenda, such as blockchain and decentralization. One major theme that is strongly related to the topic of this article is the emergence of new information technologies and their impact on financial services and markets.

There are two important innovations related to information technology that are reshaping the trading environment in the financial market and will have important impact on it for years to come. First, with developments in big data and machine learning, available information can be processed and analyzed more quickly and efficiently, potentially providing market participants with new insights for trading strategies, but also having impact on who is ultimately making trading decisions in the market (in particular, humans vs. machines). Second, technology is making new sources of information available to market participants. For example, market participants can now have access to real-time information about things like consumer transactions or satellite images, which enable them to update frequently about the evolving fundamentals of firms traded in the financial market.

In the spirit of the feedback-effect literature discussed in this article, evaluating the impact of information technologies requires scholars to pay attention not just to the effects in the financial market but also to the implications for the real economy. This is a major direction for research in future years. While it seems natural to assume that the effect would be positive, as the availability of data and efficient ways to process it can enable more informed decisions in the real side of the economy, some theory and emerging evidence suggest that more caution is required and the effects might be more nuanced. This is consistent with some of the ideas discussed above related to the complexities of the feedback effect.

On the theory side, Dugast and Foucault (2018) develop a model where the availability of quick imprecise information might crowd out the processing of slower and more precise information. They argue that this is what some of the information technologies might cause, and identify when, in equilibrium, the overall effect of the availability of new data sources is expected to be negative, so that new technologies imply a reduction in the quality of market information. They capture an important tension in modern financial markets: providing faster and faster information will have limited benefits beyond some point and might even cause damage. Their analysis is confined to the financial market, but thinking about the real economy, the crowding out effect mentioned in the previous section suggests that even if market information improves as a result of the technology, this might not be the right kind of information for guiding managerial decisions. For example, as in Goldstein and Yang (2019), following the introduction of new sources of information, market participants may focus on processing more information that managers already know, and this might hurt the efficiency of investment decisions.

4.2 Insights from Past Changes in Information Technology

While the effects of current information technologies on financial markets and the real economy are still being determined, and will likely be the subject of research for years to come, important insights can be obtained from looking into past changes in information technologies. One such event is the roll-out of the Electronic Data Gathering, Analysis, and Retrieval (EDGAR) information system by the SEC in the 1990s. This was a major episode that fundamentally upended the availability and processing of information in financial

markets. Before EDGAR, firms' financial statements and disclosures were available in hard-copy only and could be obtained in particular locations. This made it very difficult for many market participants to obtain and use this information for market analysis and trading decisions. EDGAR is an online system, and so made this information much more widely available. If current information technologies revolve around new sources of information and new methods to analyze it, EDGAR was about greater dissemination of existing information. For empirical analysis, the way that the roll-out of EDGAR was conducted makes it an attractive episode to explore the effects of changes in information technologies. This is because the implementation was staggered and based on exogenous criteria determined by the SEC.

Gao and Huang (2020) provide an interesting analysis of this episode and conclude that the introduction of EDGAR led to an improvement in market information. Based on their tests, EDGAR led to an increase in the incentives of retail investors to produce information, and this, among other things, led to improvement in the efficiency of market prices. Thinking about the real effects, however, Bird *et al.* (2021) show that the sensitivity of firm investment to their price has decreased as a result of the introduction of EGDAR. They interpret this to suggest that managers find less information in the price to be useful, indicating a negative real effect on the efficiency of investments.

Goldstein, Yang, and Zuo (2022) provide an analysis that suggests that the real effects are more complicated. While the sensitivity of investment to price decreased, the overall investment levels for firms affected by EDGAR increased. Hence, the wider availability of information seems to have reduced frictions among investors, making the access of firms to capital easier. This is a beneficial effect of the wider availability of information. They further show that this positive effect is concentrated among value firms and that the negative effect of reduced sensitivity of investment to price is concentrated among growth firms. Overall, value firms are those for which assets in place are more important. For these firms, the information through EDGAR had an important role in removing information asymmetries among investors, making the access to capital easier and less costly. The crowding out of new information to firms' managers is more important among growth firms that need to rely on markets to bring forward-looking assessments that are important to guide their investment decisions.

4.3 Emerging Evidence from New Technologies

With the progress in methods to process information, building on machine learning and artificial intelligence (AI), an important trend in financial markets in recent years has been the change in the type of market participants. In particular, there is increased reliance on machines in the trading environment. Machines can process the information and execute the trades based on models and algorithms. When the underlying tools are getting more sophisticated, they can potentially do a better job incorporating information into prices. The implications of this trend, however, are far from clear. Are machines replacing humans in the trading process, or can both play a prominent role? Are machines superior as far as the informational capacity and output go, or are there tradeoffs between the two? These are questions that are starting to be addressed by financial-markets researchers using theory and new data. The picture that emerges is mixed, but points to limitations in machine-based trading when it comes to the informational content in prices. Questions about the implications for the real economy are at even earlier stages of being explored.

Weller (2018) highlights this tension in an empirical paper that focuses on the case of algorithmic trading. Algorithmic trading is traditionally thought to make the incorporation of information in prices more efficient. However, Weller (2018) shows empirically that, while algorithmic trading indeed facilitates the ability of prices to reflect existing information, it also discourages the production of new information by market participants. This is reflected in the fact that less information is showing up in prices in the period leading up to corporate disclosure. The paper thus concludes that algorithmic trading may reduce overall price informativeness.

Another perspective on the limitations of machine-based trading is provided by Abis (2022). She inspects the behavior of active mutual funds that rely on computer models and fixed rules and compares it to that of active mutual funds that seem to rely more on human judgment. She finds that the former type of funds can keep track of more stocks and of stocks for which more information is available. On the other hand, she finds that these funds are less flexible, and are not as good at identifying changes in the business cycle, which leads to lower performance in recessions. This is a different tradeoff than the one in Weller (2018), but both suggest clear limitations in relying only on machines.

With such tradeoffs in mind, Cao *et al.* (2021) ask what optimal information processing might look like. They show than an AI analyst can beat most human analysts in forecasting, but fails to incorporate some subtle pieces of information. Hence, they portray the integration of machine and human skills as the most powerful arrangement for data analysis. Abis and Veldkamp (2022) conduct a structural estimation of knowledge production in the financial industry. They put the change associated with big data at the same level as the change that happened in the industrial revolution. They show that the labor share of income is decreasing, yet more workers are needed overall. A big shift happens within the labor force, as the fraction of financial analysts, whose expertise is in big data and AI, is increasing relative to those working with old technologies.

While all these papers provide results on changes in information in the financial market, the next step is to consider the implications for the real economy. Do firms care that machines are replacing humans in processing information in the financial market? Cao *et al.* (2022) look at one particular corporate action, namely disclosure, and analyze how it is affected by the rise of the machines in the financial market. They show that firms are adjusting the content of their disclosures when they know that their audience has more machines. Specifically, firms make their disclosures more suitable to processing by machines and avoid words that might be perceived as negative by computational algorithms. More research is needed to understand the implications for other corporate decisions, such as investments, which have been the focus of the feedback-effect literature.

While the rise of the machines, strengthened by machine learning and AI, is one important aspect of new information technologies, another important aspect is the proliferation of new sources of information, sometimes referred to as "alternative data." Multiple start-ups have started collecting data on things like point-of-sale transactions and satellite images in recent years following technological advances that made them easier to produce. Alternative data can also be about online activities, capturing social media or web traffic. Such sources of information offer very rich and diverse perspectives about firm performance and enable market participants to substantially improve their understanding of its business. Understanding the implications for overall market information and the spillover to the real economy is thus of utmost importance and research is starting to emerge along these lines.

Zhu (2019) provides an initial attempt to address these questions. She obtains data from two alternative data providers and compares the firms that they cover with firms, which are otherwise similar, but are not covered. Using a difference-in-difference analysis, she demonstrates an increase in price informativeness for firms after they started being covered by these data sources. Managers of these firms engage in less insider trading after this coverage starts, suggesting that they cannot exploit their informational advantage as much. Most importantly, for the real economy, she shows that alternative data availability increases the efficiency of corporate investment decisions. She interprets this as evidence that the market can discipline managers more effectively when it has access to such granular data.

Dessaint, Foucault, and Frésard (2022) provide a more mixed message about the effects of alternative data sources. Their evidence points to a crowding-out effect, albeit for a different type of data and with a different audience. Specifically, they analyze the effect of social media data on analysts' forecasts. Consistent with the idea that such alternative data are most effective for short-term developments, they show that the informativeness of short-term forecasts increases, but at the same time, they show that the informativeness of long-term forecasts deteriorates. They posit that due to the decrease in costs of producing short-term information after exposure to alternative data, analysts shift attention to short-term at the expense of long-term information. The result is the crowding-out effect which is quite damaging to the overall quality of information available to market participants.

Thinking about the implications for the real economy is of course a natural next step when evaluating this crowding-out result. Another important issue to consider when thinking about the real effect of new sources of information is the extent to which these sources of information are directly available to managers or not. In other words, what do information technologies do to the information gap between the manager and the market on different dimensions that are relevant to the manager's decisions? In the EDGAR example above, the information technology brought information, which was known to the manager, to the market. But this may not be the case for all new information technologies. I return to this in the next section as one direction for future research.

5. Summary and Perspectives for Future Research

5.1 Summary

The literature on information in financial markets and the feedback effect it has on decisions in the real economy is motivated by two premises. First, market prices play an important role in aggregating and reflecting information. Second, this information can contribute to the efficiency of decisions made by different economic agents in the real economy. Anecdotal evidence and direct quotes from relevant parties support these premises, as discussed in Section 1. Motivated by these, a growing empirical literature, discussed in Section 2, traces such feedback effects in large-scale empirical analyses. At the same time, a growing theoretical literature studies the implications that this feedback effect has for the economic efficiency and for the equilibrium in financial markets. These issues are discussed in Section 3. A major direction for future research involves the ongoing developments in information technology and their possible interactions with the feedback effect. Section 4 reviews some of the growing trends and how they relate to the themes from the prior sections. As I discuss there, many questions are open for exploration. In conclusion of this article, I now provide some additional perspectives for future research on the feedback effect and how it can be connected to other areas of research in finance and economics.

5.2 Perspectives for Future Research

5.2.a. *New empirical approaches*

Identifying an informational feedback effect from financial markets to corporate decisions is challenging. As discussed in Section 2, given the ways that market prices and corporate decisions are interlinked, identifying such a feedback effect often builds on proxies for price informativeness or non-fundamental shocks to prices. These are both difficult concepts to capture in the data. Overall, the accumulation of empirical evidence points in the direction of a feedback effect. But given the complexity of the problem and incompleteness of the empirical proxies, there is room for more work.

One dimension, on which interesting progress is currently being made, is the definition and measurement of price informativeness. There are new approaches emerging, such as in Bai, Philippon, and Savov (2016); Dávila and Parlatore (2022); Farboodi *et al.* (2022); and Kacperczyk, Nosal, and Sundaresan (2022). While these approaches are being explored in different directions, such as in connection to the value of information, there is room to link them more strongly to the feedback effect from financial markets to the real economy. In addition, these measures of price informativeness are often linked to FPE and not to RPE. Finding a proxy for the latter in the data would be a great step forward in this literature.

Another dimension is with the identification of shocks to the market environment that alter the information content or the potential for mispricing. A couple of papers along these lines (Edmans, Jayaraman, and Schneemeier, 2017; Ye, Zheng, and Zhu, 2022) were reviewed in Section 2. The current revolution in information technologies opens new possibilities for such shocks, and analysis can be conducted along the lines of that with a past shock to information technology—the introduction of the EDGAR system in the USA—which was reviewed in Section 4. Other shocks or experiments to the market environment have been utilized in the literature for related purposes, such as the regulatory experiment (regulation SHO) to relax short selling constraints (Grullon, Michenaud, and Weston, 2015) and brokerage closures leading to decline in analyst coverage (Kelly and Ljungqvist, 2012). They are starting to be used for the purpose of identifying a causal effect of information in financial markets on corporate outcomes; see Lin, Liu, and Sun (2019) and Bennett, Stulz, and Wang (2020). As before, the extent to which these shocks affect FPE versus RPE is also important to consider.

Finally, given that models of feedback effect generate unique predictions for financial-market equilibrium (see Section 3.3), another path for empirical exploration is to design tests tailored specifically for such predictions. This has not been done much in the empirical literature thus far, as its focus was mostly on identifying the feedback effect itself, but less on its unique implications for market equilibrium.

5.2.b. *Different types of information*

Empirical evidence on the feedback effect, as discussed in Section 2, is mostly about managers learning from market prices. The presumption behind some of the theories discussed in Section 3 is that managers may want to learn about some dimensions in particular. For example, they want to learn more about growth opportunities than assets in place. They also want to learn more about the demand for the firms' products than about the technological viability of their new projects. These conjectures are based on natural reasoning regarding what managers may be most informed about and where they can gain more from market

perspective. Some of these conjectures are also used in the empirical research, described throughout this article, to test for the presence of feedback or understand its implications.

An interesting direction for the literature going forward is to provide more direct evidence about what managers actually learn. Are they indeed learning about the demand for their products and the prospects of their growth options? Or maybe there are other dimensions, which have not been considered in the literature, that managers think they can learn more about from market information? For example, learning about the macro economy and its effect on the firm is another possible channel, given that managers have limited information about this dimension and aggregation from the market can be particularly useful for it. Moreover, there are situations, where learning may be particularly prevalent. Mergers and acquisitions, discussed here before, represent one such situation, given its discrete nature, the availability of immediate well-defined feedback, and the fact that managers may have a hard time assessing some aspects such as future synergies. Other situations, such as when firms enter into a new activity or geographical region, surely also provide a fertile ground for learning. Overall, designing empirical tests to identify when managers learn or what they learn will be very helpful to get a deeper understanding of the feedback effect.

5.2.c. *Broadening the scope of the feedback effect*

The scope of the feedback effect seems larger than what the literature has explored thus far. While many economic agents—managers, regulators, creditors, customers, and employees—can benefit from information in the price, the empirical literature has focused mostly on managers. There are strong indications, as reviewed in Section 1, that regulators and creditors attempt to learn from market prices, but there is room for empirical research that focuses on them. Thinking about customers and employees also seems particularly fruitful. They are the focus of the model of Subrahmanyam and Titman (2001), but have not received attention in the empirical literature. Exploring how they are impacted by market prices when thinking about where to work or what to consume is an interesting path for future research. Newly available data sources on the behavior of customers and employees can open the door to such research. Related to that, Liang, Williams, and Xiao (2021) provide interesting evidence that suppliers learn from customers' stock prices, helping to mitigate frictions in the supply chain. Specifically, they show that suppliers increase R&D and investment in customer-related patents following a positive reaction from the market to the announcement of the customer on a new product.

In addition, while the feedback literature has mostly focused on stocks as the financial assets from which decision makers learn, other financial securities and derivatives such as bonds, options, and commodity futures can also serve that purpose. With the growing prominence of such securities and derivatives, this direction seems increasingly relevant. One path that started to be explored in recent years involves commodity futures. With the recent rise of commodity futures financialization, whereby financial traders with no direct exposure to the commodities trade them, new interest emerged on the information contained in futures prices and its impact on the real economy. See, for example, Sockin and Xiong (2015); Brogaard, Ringgenberg, and Sovich (2019); and Goldstein and Yang (2022). In addition, recent empirical evidence (Blanco and Wehrheim, 2017; Chen, Ng, and Yang, 2021) points to the importance of learning from option prices.

5.2.d. *Market innovations and their real effect*

Financial markets are constantly evolving with different types of institutions, securities, derivatives, and technologies coming into prominence. Evaluating the effects of these innovations requires us to consider the feedback effect from the market to the real economy. Such is the case for new information technologies which I reviewed in more detail in Section 4. Such is also the case for the financialization of commodities futures markets which I mentioned above. We can investigate such developments to understand the feedback effect better, and we need to think about the feedback effect to understand their effects more generally. This applies to many other market innovations, which happened in recent years and will continue to happen in the future, and calls for more research into them.

A case in point is the rise of exchange-traded funds (ETFs). They have been growing extremely fast in recent years and so has the academic research about them. A lot of the research is focused on what they do to the prices of the underlying securities, how they differ from mutual funds, and the tradeoffs they present to investors in terms of risks and returns. Given the theme of this article, it is important to ask what they imply for the real economy, and in particular through the feedback effect. Such analysis was recently conducted in a paper by Antoniou *et al.* (2022). They show that higher ownership by ETFs is associated with a stronger sensitivity of investment to price and that inclusion of stocks in an ETF leads to an increase in their investment-to-price sensitivity. They conclude that ETFs lead to a greater flow of information and an improved real efficiency.

5.2.e. *Market efficiency, real efficiency, and beyond*

A key insight from the feedback-effect literature is the distinction between market efficiency and real efficiency, as discussed in Section 3.2. The former—also referred to as FPE by Bond, Edmans, and Goldstein (2012)—captures the ability of market prices to forecast future cash flows. The latter—also referred to as RPE—captures the ability of market prices to reveal information that improves the efficiency of corporate decisions. Understanding the cases where the two diverge is important for future research, such as when evaluating the effect of new information technologies (see Section 4).

Importantly, in some cases, the information in prices has direct implications that go beyond market efficiency and real efficiency. If the traded security is used for hedging purposes by some market participants, then there will be additional welfare implications from the information revealed in prices because of what it does to the hedging opportunities. An early analysis of such complex interactions appears in Dow and Rahi (2003). A couple of recent papers explore related effects in feedback models that are motivated by recent market developments. In Goldstein and Yang (2022), commodities futures are traded for hedging and speculation. They study the effect of the recent financialization of futures markets. In their model, even if the financialization of futures markets leads to more information in prices and as a result an improvement in the efficiency of production decisions, commodity producers might be worse off overall because of the reduction in hedging opportunities. Hence, financialization will mean different things to producers who use the market to hedge versus those who just learn from the market. This suggests that some caution is required in interpreting empirical results such as those in Brogaard, Ringgenberg, and Sovich (2019).

Banerjee, Breon-Drish, and Smith (2022) expose the tension between investment efficiency and welfare in another context of rising importance. In their model, managers decide

on real investment in "green" projects and use information in the price to guide their decisions. At the same time, the stock is used by some investors as a hedge against climate risk. Even though feedback from the market increases the efficiency of the investment, it might hurt the welfare of financial investors in the way it changes the exposure of the firm's cash flows to climate risk and alters hedging opportunities. Such interactions, where prices play different roles, emerge in other settings as well, and generate more opportunities for research.

5.2.f. *Financial markets and corporate finance*

To a large extent, financial economics is traditionally known for separate research tracks. Research on corporate finance deals with firms raising capital, investing, and producing. Research on financial markets focuses on traders trading securities and prices being formed. One of the appeals of the feedback-effect literature is in combining the two. Information in the trading process guides firms' decisions and a feedback loop is formed between the two. This is discussed in Section 3. However, while feedback-effect models bring the two together, many of them abstract from key frictions studied in corporate finance, where managers have agency problems vis-à-vis shareholders and/or debtholders. Instead, they focus on the subtleties in the financial market and their interaction with decision making in the real economy.

Early literature (e.g., Holmstrom and Tirole, 1993; Edmans, 2009) studies managerial incentives provided by stock prices. In such papers, information in prices affects the decisions of managers indirectly through incentives and not through learning. An interesting question is how learning from prices interacts with agency problems. A few recent papers take on this issue. Davis and Gondhi (2022) show that learning from the market reduces the severity of risk-shifting problems but increases the severity of debt-overhang problems. This is because the former (or latter) exhibit stronger (or weaker) sensitivity of cash flows to information, incentivizing market traders to produce more (or less) information and increasing (or decreasing) the overall efficiency of the investment. The role of risk shifting will be particularly important in a setting where bank supervisors are trying to learn from the stock price of the bank, a point made by Ding, Guembel, and Ozanne (2022) in a model of optimal stress test design.

In Banerjee, Davis, and Gondhi (2022), the incentive provision and feedback roles of prices are found to be in tension. The key is that the price is affected by two dimensions of information. When it is more informative about new investment opportunities, it is also more volatile and less effective for incentive provision. The presence of two dimensions of information sets their conclusions apart from those of Lin, Liu, and Sun (2019). Overall, given the depth of the literature on frictions and conflicts in corporate finance, there is ample room for more explorations on the interactions with the feedback effect.

Another direction of research with rich corporate-finance implications is to consider how firms may change some of their basic strategies in order to increase the extent to which market prices will reveal to them the information that they need, that is, in order to improve the RPE. Section 3.2, for example, described the way firms may change their disclosure policies in order to get the market to provide more of the information that they do not have. This logic extends to other important corporate decisions, such as the decision to go public or capital structure policy. In a recent paper, Foucault and Frésard (2019) provide a theory and empirical evidence that firms choose to reduce differentiation from their peers in the product market due to an informational motive. This is because conformity allows

them to learn from their peers' prices. This effect is particularly strong for private firms, for whom learning from peers' prices is more important. Exploring other corporate choices with the informational motive in mind is an interesting direction for research.

5.2.g. ***Implications for the macroeconomy***

The feedback loop between financial markets and the real economy has the potential to generate aggregate implications for the macroeconomy. Dow, Goldstein, and Guembel (2017) show in a model how the feedback effect can amplify shocks to the business cycle. The idea is that speculators in financial markets have a stronger incentive to produce information about potential investments when these investments are more likely to be undertaken. This is because cash flows will only be sensitive to this information when investments are undertaken. Given that investments are more likely to be undertaken in good times and that information from the market improves the efficiency of the investment decisions, amplification of underlying shocks arises. Moreover, this amplification can be particularly strong in some cases because of strategic complementarities in information production that emerge in this framework. In modeling the information production and linking it to the business cycle, the paper provides a channel to endogenize shocks to total factor productivity (TFP), which are often taken as exogenous in macroeconomic models.

Benhabib, Liu, and Wang (2019) develop a macroeconomic framework where information flows both from the market to the real economy and from the real economy to the market. Strategic complementarities emerge in their model between the two, such that the economy can end up in an equilibrium with low information and low productivity or with high information and high productivity. Moreover, information is more likely to be produced when the size of the investment is expected to be bigger. Thus, their framework leads to amplification, but also to self-fulfilling uncertainty traps. Benhabib, Liu, and Wang (2016) study how sentiment shocks in the financial market can give rise to self-fulfilling business cycles due to informational feedback, in a mechanism similar to the trading frenzies discussed in Section 3.3.

Given that macroeconomic models are usually dynamic, a challenge in this line of research is often to embed the informational channel into a full-fledged dynamic model. Benhabib, Liu, and Wang (2019, 2016) make progress in this direction, and so do Goldstein and Yang (2022) in their model of commodity futures markets. These papers use the models for a calibration exercise, which maps the insights from an information-based feedback model into dynamic evolution of market variables. Developing more dynamic frameworks of the feedback models and quantifying the channels is another important direction for research.

David, Hopenhayn, and Venkateswaran (2016) provide an interesting attempt along these lines to quantify the different channels of information. Based on a calibration exercise, they suggest that learning from the market does not contribute much to the efficiency of resource allocation. This might suggest that the macroeconomic effects would not be quantitatively important. However, their analysis does not account for some of the richer implications of the feedback effect, such as the complementarities highlighted here, and so the full implications of learning from the market are difficult to capture in their framework. In addition, direct empirical evidence does point to a causal effect of market information on the productivity of firms. This is established in the recent paper by Bennett, Stulz, and Wang (2020), using measures of price informativeness, firms' TFP, and several exogenous events. Xiao (2020) provides related evidence. Hence, more research is warranted.

5.2.h. *Other sources of information*

A long-standing question is whether alternative sources of information can replace the information from the market. This is an even more pertinent question in light of some of the theoretical research on the feedback effect, highlighting how it gives rise to phenomena characterized by limited flow of information (see Section 3). A recent theory paper by Boleslavsky, Hennessy, and Kelly (2022) shows that even with the limitations of information transmission from the market, the firm cannot do better in equilibrium by hiring an expert. The argument relies on off-equilibrium incentives, whereby if the firm is looking for experts, the experts will have an incentive to act like they do not have the information and make a larger profit in the market. Hence, relying on the market ends up being the viable strategy for the firm.

More broadly, with the proliferation of new sources of information, as discussed in Section 4, we should wonder to what extent those sources of information will be transmitted to decision makers through the market price or, alternatively, they could be accessed directly. This is one of the key questions perhaps going forward in light of the revolution of information technology. Are market prices still going to be important when so much information is available out there? Cookson, Niessner, and Schiller (2022) show that negative tone in social media following a merger announcement is associated with a higher probability of merger cancelation later. They show that this effect goes beyond the market reaction. Hence, they suggest that managers learn from social media directly. This is an intriguing possibility for the feedback effect going forward. More research is needed to understand the nature of different information sources. Some information sources, such as social media, can perhaps be transmitted directly to managers, but other sources may be more difficult to interpret, and so decision makers will still benefit from relying on the market's processing of them. Similarly, we need to understand the incentives of people creating the information in the first place, and whether some of the traditional advantages for market information, which were highlighted throughout this article, are still prominent in this new information age.

Data Availability

No new data were generated or analyzed in support of this research.

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