Dynamics of Price Formation in Financial Markets

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Citation for published version (APA):

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The consensus on the price formation process in financial markets has changed fundamentally over the past two decades. In contrast to the neoclassical contention, we now believe that the structure within which trade takes place is of primary importance to the formation of prices and the final allocation of resources. Also, the informational efficiency of financial markets is understood to be of a more subtle and complex nature. The cornerstone of these changes is the paradox introduced by Grossman and Stiglitz [1980]. They demonstrated that prices should less than perfectly reveal information in order to reveal information at all. The result is that two components are necessary to facilitate trade: information and noise. Moreover, these two components are intrinsically related and interact through the formation of prices.

The importance of a proper understanding of the price-formation process should not be underestimated. It implies that one can impose a market structure and a regulatory mechanism that optimally contribute to the welfare of an economy. Its complexity, however, means that details of market characteristics need to be incorporated to arrive at models that accord well with reality. This is not a trivial task, especially given the involved nature of information aggregation and disclosure through prices that are derived from the rational updating of beliefs by investors.

A popular vehicle that accommodates the information feedback of prices to investors and vice versa is the so-called noisy rational expectations approach. We adopt this paradigm to focus on the dynamics of trade under asymmetric information. Our approach is unique in its consideration of price discovery in overlapping generations economies. This focus on models of re-trade is motivated by the observation that most financial assets have a lifetime that extends beyond the time horizon of the common investor. It implies that investors usually do not buy and subsequently hold the asset for an infinite amount of time, but rather trade and re-trade the asset, realizing capital gains. Consequently, agents face additional price-risk due to the necessity to liquidate their position at market prices, with the consequence that higher risk premia prevail. Moreover, there is no resolution of uncertainty, given that the asset’s true value continuously changes and is never revealed by the price system. Another salient feature of our study is its focus on the properties of steady state economies, which allows the
unconditional consideration of market statistics and optimal technical trading rules. It resolves
time-dependency problems present in liquidation models that occur due to the resolution of
uncertainty.

As stated, our approach derives from the noisy rational expectations paradigm. This concept
captures both the feedback of information through prices and the existence of distorting noise.
It has shown the dependency of market efficiency on the structure of the market, and the way
in which information asymmetries affect allocation decisions and risk premia. Its applications
have yielded many practical implications, in the form of new insights into insider regulations,
the characteristics of market clearing mechanisms, and alternative explanations for phenomena
reported by the empirical literature. In chapter 2 we present a survey that considers in detail the
main features of the noisy rational expectations approach. In particular, we discuss the recent
multi-period extensions. It provides a background against which our efforts in subsequent
chapters should be viewed.

In Chapter 3 a generic framework is presented that incorporates the features unique to our
approach. We derive the equilibrium conditions for a multi-asset multi-period noisy rational
expectations model where the assets traded are infinitely long lived. Investors have finite hori­
zons, and we allow its distribution to be heterogeneous. As such, the model reflects a market
in which assets are exchanged across generations of traders. The generality of the model is
emphasized by the fact that it incorporates both Admati's [1985] multi-asset model, and the
Grundy and McNichols[1989] multi-period model as special cases. Although the complexity
of the equilibrium conditions prohibits the explicit derivation of pricing coefficients, the equi­
librium has many intuitive features. For instance, it is shown that if agents foresee a future
liquidation of the assets, even this liquidation date is at a time infinitely far in the future,
their rationality makes prices unconditionally unbiased predictors of the fundamental value
of the asset. Moreover, it is shown that due to the re-trade effect, economies in which either
all investors are uninformed or all investors are informed, are equivalent regarding statistics
such as liquidity, volume and variance of price changes. The difference only enters in the
form of a lead-lag effect caused by the lagged information flow in the uninformed economy.
The main ambition of this chapter, however, is to contribute by extending the noisy rational
expectations to a multi-period, multi-asset, steady-state economy. Additionally, it provides a
generic basis for the models in the next two chapters.

In Chapter 4 we utilize this framework to consider the impact of insider trading on market
statistics. Usually, the impact of a presence of insiders has a dual character. On the one
hand, it increases the information content of prices with respect to fundamentals. On the
other hand, it introduces an adverse selection component in price formation that is to the
detriment of liquidity traders. If the asset is re-traded, however, investors do not care about fundamentals, but only about price realizations. Hence, the information content of price is valued according to its ability to predict future prices. If price conveys more information about fundamentals due to a larger presence of insiders, additionally its sensitivity to news increases. This in turn implies that, although inference of fundamentals may be more precise, future price risk may increase due to a high news sensitivity of future price realizations. This feature of re-trade models magnifies the role of information dispersion as opposed to the absolute degree of informativeness. The dominance of information friction allows us to disentangle the usual dual character of insider trading and focus on its adverse selection component. We show that volume, variance and market depth have an uni-modal dependency on the fraction of informed in the market. All are found extremal for a certain critical fraction of informed where information friction is highest. We relate our exogenous parameters to market development. It is shown that the critical fraction of informed is decreasing in the degree of development of a market. Interestingly, although higher developed markets are less sensitive to information friction when measured by the variance of price changes, this does not apply to the costs of liquidity. These are actually more sensitive to information dispersion than in less developed markets. The implication is, that insider regulations may yield more benefits in terms of cost reduction for liquidity traders in relatively well-developed markets.

In Chapter 5, we consider how market statistics are affected by market growth if agents have the possibility to acquire private information at a certain cost. Many models that study how information friction affects financial markets assume agents are endowed with an information advantage. If the informativeness of agents is determined endogenously, however, equilibrium depends on the comparative advantage of better information. Indeed, agents need to be able to offset the cost of information acquisition. The impact of such endogenous dependency of the economy is profound. When we endogenize the information acquisition efforts of agents, market depth is seen to decrease with increased competition on financial markets. This contrasts the usual relation that market growth leads to an increase in market depth. Hence, this result only holds ceteris paribus. The reason is that an increase in competition decreases the relative advantage of informed investors, which can only be compensated if risk premia are increased and consequently market depth is decreased. This implies that the increase in trader activity that is observed in many financial markets over the past years, may not have as desirable effects as are implied intuitively. Such increase in competition may in fact come to the detriment of liquidity investors. The lesson learned is that the endogenous determination of information acquisition efforts may be crucial for a good understanding of market dependencies. We also consider how the length of the time horizons of investors
impacts a financial market. A unique feature of the model is the explicit consideration of a heterogeneous distribution of time horizons across investors. It is shown that increasing their time horizon generally leads to an increase in trading aggressiveness. The possibility of intermediate trade allows for dynamic diversification over time, giving investors the opportunity to trade more aggressively in the early stages of their trading career.

Crucial to the mechanics of the rational expectations approach is the market clearing condition. It reflects how we envision the type of competition on financial markets. Instead of competing for the total excess supply, investors compete for a portion of the supply of an asset. The supply itself, as well as the stochastic variations in supply, is by definition perfectly inelastic. The implication is that investors can earn a return for holding the asset that more than compensates the risk they incur. Moreover, this excess utility is a convex function of the riskiness of the asset. This has two practical implications that are supported by empirical studies. First, markets will be more volatile, and second, risk will be priced disproportionately. Moreover, the fact that noise and the anticipated existence of noise is priced, implies that even agents that do not invest in information acquisition can benefit from participating in trading. In combination with the noisiness of information disclosure through prices, it immediately follows that technical analysis is both necessary and profitable, and in fact is a natural component of a rational equilibrium in financial markets.

In Chapter 6, we consider the topic of technical analysis in detail. We propose a stationary noisy rational expectations economy in which the aggregation of noise and information in prices motivates the presence of pure technical analysts. Closed form solutions for a generic class of economies are derived. We allow liquidity supply to follow any type of AR(n) process. In the process, we argued how a presence of technical analysts may increase risk premia and decrease market depth. Moreover, we showed that if agents believe that the asset is ultimately liquidated at its true value, prices are an unbiased estimate of the fundamental value. We also demonstrate that, contrary to what one may expect, an increase in the fraction of technical analysts leads to an increase in the significance of correlation patterns. Additionally, we show that if agents believe that the asset is ultimately liquidated at its true value, prices are an unbiased estimate of the fundamental value. In an application of our framework, we study how both persistence of liquidity supply and correlation between liquidity shocks impact the trading behavior of technical analysts and the time series properties of returns. It is shown that when liquidity supply is highly persistent and shocks to liquidity are correlated, (i) uninformed agents apply a trend-following exponential moving average rule; (ii) short-term autocorrelations are positive; and (iii) long-term autocorrelations are negative. These results
are partially confirmed by empirical studies, though this type of research is not conclusive on this point. The reason that technical analysis has added value ultimately stems from the absence of Bertrand competition. Many discussions on the functioning of financial markets implicitly assume that the competitive character of markets results in perfect price competition. Though agents may act as price takers, it is questionable whether this is indeed the case. If agents are risk averse, the only situation in which perfect price competition occurs is when the aggregate supply that has to be absorbed by the market is infinitesimally small compared to the market as a whole.

In Chapter 7, we explore a special case of the model derived in Chapter 6. We consider how the presence of technical analysts impacts the utilities of investors and market statistics. It is shown that though technical analysts are contrarians, they do not have a smoothing effect on price evolution. Instead, their presence leads to an increase in price volatility and a decrease in market depth. Both groups of agents benefit, however, when the fraction of technical analysts is as large as possible, this to the detriment of the liquidity investors who pay a high risk premium. It is also shown that the market may fail if the fraction of technical analysts is too large. This type of market breakdown is quite unique. It is the informed traders that refuse to trade in a too uninformed market, instead of the opposite type of market breakdown investigated by, for instance, Bhattacharya and Spiegel[1991]. This implies that financial markets should impose trading costs in order to induce agents to collect information, and make pure technical analysis unprofitable.