Andreas Krause

Trading with informed investors

Informed traders
○○○○○

Market efficiency
○○○○○○○

Market liquidity
○○○○○○○

Summary
○○○○

Outline

■ Informed traders

■ Market efficiency

■ Market liquidity

■ Summary

Outline

- Informed investors play a particularly important role to make market efficient. It is only through the trading decisions of such investors that prices are adjusted to reflect information, at least partially.
- We will now investigate how the information of informed investors is actually included into the price and then how much of their information will be included.

Outline

- We will first characterise the behaviour of informed traders and then look at the implications of their behaviour for market efficiency as well as the liquidity of a market.
- Liquidity here is to be understood as the impact a trade of an uninformed investor has on the price.

■ **Informed traders**

■ Market efficiency

■ Market liquidity

■ Summary

- We assume that informed investors are trading such as to maximize their expected profits. Their optimal behaviour will be determined first, before we can analyze the consequences of such behaviour for market prices in more detail.

Traders in the market

- A number of traders receive information about the future value of an asset
- Before the information is publicly revealed, they can make a several of trades
- Informed traders are choosing their trades as to maximize their total profits
- In addition, noise traders are trading for exogenous reasons without optimizing their behaviour

→ We will first determine what types of traders are active in the market and how they behave.
▶ Let us assume that some traders obtain information about the value of an asset and we assume that this information is perfect. We will vary how many traders are informed.
▶ After a while this information will be publicly revealed, but until this time investors can conduct trades. We will vary how many such trades can be made.
▶ Informed traders will seek to maximize their individual profits across all trades they can make.
▶ We also have traders that do not seek to maximize their profits; we assume they trade for exogenous reasons. They might be selling assets in order to meet a demand for liquidity or they might be buying asset to reduce their liquidity. Such trades are assumed to be random and on average the demand is zero, but will have a positive variance. Traders acting in this way are referred to as 'noise traders'. As noise traders do not trade as to maximize their profits, it is irrelevant whether they are informed or uninformed as they would not make use of any information; it is common to assume they are uninformed.
→ We will now analyse a market with just these two types of traders; informed traders with a perfect knowledge of the future value of the asset, and noise traders.

Informed traders
○○●○○

Market efficiency
○○○○○○○

Market liquidity
○○○○○○○

Summary
○○○○

Price determination

- The information is only known to informed investors, other investors can only observe orders that have been submitted
- Whether an order originates from an informed trader or noise trader is not known
- Prices are set such that it reflects the value based the information from the total demand over time demand of the informed traders and noise traders
- $P_t = \mathsf{E}\left[V | \sum_{\tau=1}^{N} Q_\tau + \sum_{\tau=1}^{M} U_\tau\right]$
- We assume prices are linear in the total demand
- $P_t = \mu_t + \lambda_t \left(\sum_{\tau=1}^{N} Q_\tau + \sum_{\tau=1}^{M} U_\tau\right)$
- A high value of λ_t implies that prices are reaction sensitively to any additional order submitted, which is referred as low liquidity

Price determination

→ We will first have to make additional assumption on how the market price at which trades can occur are determined.
▶
- We assume that there is an additional market participant that determines the price at which transactions occur. This market participant is assumed to the uninformed ; consequently, only the informed investors have access to information.
- All other investors, most importantly here the price setter, is uninformed, but as his information source knows the total amount of orders that have been submitted.

▶ It is only known that orders have been submitted, but not who submitted them, whether the order originated from a noise trader or an informed trader. In addition, the price setter can only observe the total orders submitted, thus no inferences can be made from observing a number of similar orders and attributing them to informed traders.

▶ We now set prices such that this price reflects the information available to the price setter. This information is the combined orders of all informed traders (Q_τ) and all noise traders (U_τ), across all time periods. A negative demand implies that a trader sells the asset and a positive demand that it is bought.

▶ The price set by the price setter will now be the expected value, given the information the price setter holds, which is the combined orders of all traders.

▶ We now make an additional assumption and assume that this price is linear in the total demand.

▶ *Formula*
▶
- the coefficient λ_t has a significant interpretation; it shows how sensitive the price reacts to the demand of traders, whether informed or uninformed. The larger λ_t is, the more the price changes for a given order, even if this order is from a noise trader and thus conveys no information. If prices change a lot if an order is submitted, a high λ_t,
- this is referred to as a low liquidity; similarly a small λ_t implies that the market has a high liquidity as prices will react much less to any orders.

→ Having established how prices are determined, we can now continue to derive the optimal demand by informed investors. Note that noise traders were assumed to have random trading demand, so these will be not be optimised.

Informed traders
○○○●○

Market efficiency
○○○○○○○

Market liquidity
○○○○○○○

Summary
○○○○

Order determination for informed traders

- ▶ Profits from a trade arise from the difference between the asset value and the price paid, for each asset traded, plus any future profits the traders will receive

- ▶ $\Pi_t^i = (V - P_t) Q_t^i + \Pi_{t+1}^i$

- ▶ We assume that orders are linear in the value of the asset

- ▶ $Q_t^i = \alpha_t + \beta_t V$

- ▶ We assume that profits are quadratic in the difference between the value and price of the asset

- ▶ $\Pi_t^i = \delta_t + \gamma_t (V - P_t)^2$

- ▶ The total demand by informed traders is $Q_t = \sum_{i=1}^{N} Q_t^i$

→ Informed traders will take into account how prices are determined and submit their orders accordingly such that their own profits are maximized.
▶
  • If we assume that once the information is revealed the price will adjust to the true value, then the profits of the informed trader, knowing the true value, is the difference between this value and the price he pays or receives for the asset.
  • This profit will be generated for each asset that is traded.
  • This will give the profits for a single time period, the current time period; in addition the informed trader will be able to obtain profits from future profits. In each time period, the trader will seek to maximize its remaining profits. If we consider the last possible trade before the information is revealed, we will obviously have $\Pi_{t+1}^i = 0$.
▶ *Formula*
▶ We now make the assumption that the demand of informed traders is linear in the fundamental value (true value) of the asset.
▶ *Formula*.
▶ Furthermore, we assume that all profits from the current trade onwards are quadratic in the difference between the value of the asset and the current price. That profits are quadratic is a common result when determining the optimal demand and re-inserting this result back into the profit function; here it is used as an assumption to make the solution of the problem easier.
▶ *Formula*
▶ We also have that the total demand by informed traders is the aggregation of the demand for all informed traders.
→ We can now continue to determine the optimal demand.

Solution of the model

▶ Informed investors will maximize their profits by choosing an optimal order size for each time period until the information is revealed publicly

▶ Conducting this optimisation, we can determine the parameters as

▶ $\lambda_t = \frac{N\beta_t \sigma_{t-1}^2}{N^2\beta_t^2\sigma_{t-1}^2 + t\sigma_U^2}$

$\beta_t = \frac{1-2\gamma_t\lambda_t}{\lambda_t(1+N(1-\gamma_t\lambda_t))}$

$\mu_t = P_{t-1}$

$\alpha_t = -\beta_t P_{t-1}$

$\gamma_{t-1} = \frac{1-\gamma_t\lambda_t}{\lambda_t(1+N(1-2\gamma_t\lambda_t))^2}$

▶ $\sigma_t^2 = \text{Var}[V|P_t] = (1 - N\lambda_t\beta_t)\sigma_{t-1}^2$

▶ These parameters can only be solved numerically

Solution of the model

→ The solution to this model is not easy and straightforward, so we will not seek to show the intermediate steps but only show the results.

▶ For each trade, informed traders will seek to submit an order that is chosen such that it maximizes the profits for the remaining trades.

▶ The strategy in solving this maximization problem is to make use of the assumed linearity of the price determination and trade size; we can determine the relevant coefficients after conducting such a maximization.

· We obtain the parameters as detailed in the *formulae*.

▶ σ_t^2 represents the uncertainty of the value, given the that the price can be observed. As the price is set in response to the trade demand by informed traders and noise traders, it reflects all the available information the price setter has. Thus the price incorporates all publicly available information, revealed through the trade demand, and we can use the price as a proxy for this information. Knowing the price, which is observable, we can thus make inferences about the value of the asset, and the variance then represents the uncertainty about the value of the asset that is left when observing the price.

▶ The parameters as shown above depend on each other and as they are non-linear, we cannot obtain an analytical solution, but have to resort to numerical procedures to obtain actual values.

→ We are not so much interested in the trading demand of informed investors, but our focus will be in the first instance on implications for the efficiency of markets, and in a second step, the liquidity of the market.

Informed traders
○○○○○

Market efficiency
●○○○○○○

Market liquidity
○○○○○○○

Summary
○○○○

Informed traders

Market efficiency

Market liquidity

Summary

- We will first seek to investigate how well prices reflect the available information that informed investors have. We will interpret the degree to which their information is included into the price as the market efficiency.

Informed traders
○○○○○

Market efficiency
○●○○○○○

Market liquidity
○○○○○○○

Summary
○○○○

Measuring market efficiency

- ▶ Of interest is the variance of the value, given the price
- ▶ $\sigma_t^2 = \text{Var}\left[V|P_t\right] = (1 - N\lambda_t\beta_t)\,\sigma_{t-1}^2$
- ▶ This reflects the uncertainty an uninformed trader has about the value of the asset when observing the price
- ▶ σ_0^2 is the uncertainty without any price information
- ▶ We can interpret $1 - \frac{\sigma_t^2}{\sigma_0^2}$ as a measure of market efficiency
- ▶ If the variance on observing the price does not reduce, $\sigma_t^2 = \sigma_0^2$, the market is inefficient
- ▶ If the variance on observing the price is zero, $\sigma_t^2 = 0$, the market is perfectly efficient

→ Before analysing the efficiency of the market, we need to develop a measure of market efficiency.
▶ We will be using the degree of uncertainty left after observing the price as our measure of market efficiency. Thus we will look at the variance of the true value of the asset, given the price observed, as derived above.
▶ *Formula*
▶ • This conditional variance represents the uncertainty an uninformed trader would have about the true value of the asset,
  • after having observed the current price.
▶ We know the unconditional variance of the true value of the asset, that is the variance an investor would have if he had no information whatsoever.
▶ The smaller the conditional variance is, the less uncertainty remains for uninformed traders observing only the price and hence the market become more efficient. If the variance is zero, $\sigma_t^2 = 0$, then the market is fully efficient as the uninformed trader knows the true value with certainty (there is no variance) and if $\sigma_t^2 = \sigma_0^2$, then he obtains no benefits from observing the price, as his uncertainty is not reduced, implying that the market is very inefficient. To determine the degree of market efficiency we use the *formula*, which represents how much the uncertainty is reduced when observing the price and thus acts as out measure of market efficiency.
▶ If the variance is not reduced, the measure takes a value of 0 and the market is fully inefficient.
▶ If the variance is nil, the measure takes a value of 1 and the market is fully efficient.
→ We can now use this measure and analyse how market efficiency is evolving in different parameter constellations.

Informed traders
○○○○○

Market efficiency
○○●○○○○

Market liquidity
○○○○○○○

Summary
○○○○

Market efficiency

Few informed investors and many informed investors
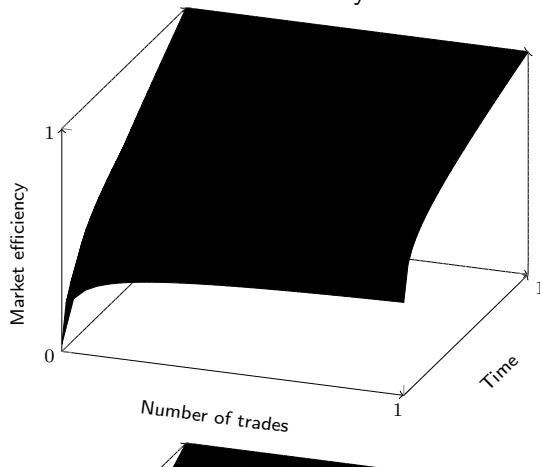
Market efficiency

→ We now determine the market efficiency for some parameter constellations by solving for the parameters of our model numerically and graphically exploring the results.

▶ We will look at how the market efficiency evolves over time. We had assumed that before the information is revealed, informed traders can make a number of traders and we will see how market efficiency evolves over time as such trades are conducted. We will also look at the impact the number of trades have until the true value is revealed; this might be interpreted as either the frequency of trading increasing or the time until information is revealed increasing.

▶ We firstly consider the case where the number of informed traders is very small. We clearly see two developments; firstly, market efficiency increases over time and, secondly, market efficiency increases the more trades informed traders can make.

▶ If we increase the number of informed traders, the same picture emerges, but the market efficiency is generally higher.

→ We will now provide detailed rationales for these results.

Informed traders
○○○○○

Market efficiency
○○○○●○○

Market liquidity
○○○○○○○

Summary
○○○○

Market efficiency develops over time

▶ Markets become efficient over time as information is incorporated into prices with each trade informed traders conduct

▶ Informed investors trade strategically and hide their trades among the random trades of noise traders

▶ Uninformed market participants do not know whether the demand is from noise traders or informed traders

▶ The larger the demand, the less likely it is from noise traders, and hence the more the price would be adjusted

▶ This reduces the profits of informed traders and they will submit smaller orders

→ We first look at how market efficiency changes over time and what the reason for this is.
►
- We see that over time market efficiency increases, thus more and more information is included into the price.
- This increase in information revealed through the price increases with each trade, and not because time has passed.

►
- Informed investors seek to maximize their profits, thus they will submit orders strategically to achieve this aim.
- What they seek to do is hide their trades in the trades of noise traders, who have random trading demand.

► Even when observing the demand of traders, it is not known how much of that demand is from informed traders and how much is from noise traders; financial markets are anonymous.
►
- If the demand is large, it is unlikely to be the result of noise traders as for any random variable large realisations are unlikely.
- This increases the likelihood of such a demand originating from informed traders, suggesting that the value is higher (lower) than the current price for buy (sell) orders. This will lead to the price setter to increase (decrease) the price more than if the demand was smaller.

►
- As the price is adjusted more with large orders, the profits of informed traders reduce.
- Thus they will submit smaller orders to avoid moving markets too much. Of course over time the small orders by informed traders add up and each order submitted reveals some information, but most importantly, it does not reveal all information and also the last trade will not fully reveal the information.

→ We therefore observe that over time more and more information is revealed and the market slowly becomes efficient.

Informed traders
○○○○○

Market efficiency
○○○○●○○

Market liquidity
○○○○○○○

Summary
○○○○

More frequent trading increases market efficiency

- ▶ If informed investors can trade more frequently, the market will be more efficient more quickly
- ▶ With more frequent trades, there is more information available at any time and the market incorporates this information more quickly into the price
- ▶ Informed traders will spread their trades over time optimally, but at any given point of time will trade more

More frequent trading increases market efficiency

→ We will now look at the impact the frequency of trading by informed investors has on market efficiency.

▶ We have also noted that that more often informed traders are able to trade before the information is revealed, the more efficient the market is at any point in time.

▶
- If trades happen more frequently, at any point in time (except the first trade), there is more information available as more orders have been submitted.
- With more information available from more frequent trades, the price will be come more efficient.

▶
- Trades will be spread optimally over time and informed traders will for each trade submit orders such that the remaining profits are maximized.
- Given that they have more trading opportunities, they do not need to make as much profits from each trade and will therefore submit larger orders, causing a larger price adjustment and thereby revealing more information to be incorporated into the price.

→ Thus, if informed traders have more opportunities to trade before their information becomes publicly known, the efficiency of markets will increase.

Informed traders
○○○○○

Market efficiency
○○○○○●○

Market liquidity
○○○○○○○

Summary
○○○○

More informed traders increases market efficiency

▶ Informed traders obtain an informational advantage over noise traders and will exploit this advantage like an oligopoly

▶ The more informed traders are in the market, the more they will compete with each other

▶ This competition leads to traders submitting larger orders to obtain more profits now, given that other traders can reduce future profits by submitting larger order now

▶ Submitting larger orders now implies that the observed demand is more likely to come from informed traders, revealing information and adjusting the price more

▶ This also reduces future profits as the price adjusts more

▶ The increased competition between more informed traders increases demand and markets become more efficient

▶ If competition was perfect, markets would be instantly efficient

More informed traders increases market efficiency

→ The final observation we made was that with more informed traders, market efficiency increases.
▶
   - Informed traders have an informational advantage over noise traders which they will seek to exploit. We can interpret this as informed traders having market power to extract surplus from the uninformed noise traders.
   - We can then interpret that market power to be exploited in an oligopoly as there will only be a finite number of informed traders.
▶ As in an oligopoly, the more informed traders there are, the more they will compete with each other and the surplus they are able to extract from noise traders will reduce.
▶
   - The consequence is that traders are submitting larger orders to obtain more profits while their informational advantage is still high (not much information has been revealed to uninformed traders).
   - This is the consequence of other informed traders being able to extract larger profits by submitting a larger order than their competitors and moving the price only marginally, thus their profits do not reduce much per unit of assets, but are more than compensated for by the larger order size. Other informed traders will see their profits diminished as prices adjust more and will react by increasing their orders in turn to compensate for this effect, leading to a vicious cycle of increasing order sizes and more information being revealed.
▶
   - As the order sizes of informed traders are larger, the observed demand is more likely the result of informed traders than an unusually large realisation of demand by npise traders.
   - Thus more information is revealed
   - and as a consequence the price setter adjusts the price more.
▶ As prices have adjusted more, future profits will also have been reduced, which will limit the incentives to increase order sizes too much for informed traders.
▶
   - Thus more informed traders increases the competition between them, as it does in any oligopoly with more members.
   - The consequence is that markets are more efficient.
▶ In the extreme case that competition was perfect, the number of informed traders becoming infinite, we can show that markets would become instantly efficient.
→ We have thus seen that in the realistic case of a small number of informed traders, markets are not instantly efficient, but increasing efficiency over time. This outcome is the consequence of informed traders exploiting their informational advantage optimally.

Informed traders
ooooo

Market efficiency
ooooooo●

Market liquidity
ooooooo

Summary
oooo

The impact of noise trading and asymmetric information

▶ The amount of noise trading and asymmetric information does not affect market efficiency

▶ More noise trading allows informed traders to hide their orders better and the market should be come less efficient as less information is revealed

▶ Informed traders compensate for this by submitting larger orders, offsetting the effect of more noise traders

▶ Markets with higher asymmetric information, a higher initial variance of the value, will see larger trades by informed investors

▶ This implies that prices will adjust more, giving rise to the same market efficiency

The impact of noise trading and asymmetric information

→ We will now briefly discuss two parameters in our model that have not yet been considered, the amount of noise trading and the degree of asymmetric information between informed and uninformed traders.

▶ We can show that both variables do not affect market efficiency.

▶
- If the amount of noise trading increases, that is the variance of noise trading is higher, informed traders can hide their larger order better as they could easily be the result of the now more volatile noise trading.
- This would then mean that less information is revealed and hence the market is less efficient.

▶
- However, informed traders compensating for this by now submitting larger orders to increase their profits.
- This offsets the effect higher noise trading has exactly.

▶ We have higher asymmetric information between informed and uninformed traders if the uncertainty of the uninformed is higher, thus the variance of the true value of the asset is increased. This larger informational advantage of informed traders will see them submit larger orders.

▶
- As they submit larger orders, prices will adjust more and the variance reduce more as more information is revealed.
- However, as the starting point is a higher level of uncertainty of the true value of the asset, our measure of market efficiency is unaffected.

→ We thus have established that markets are never fully efficient, but will increase efficiency slowly over time.

Informed traders

Market efficiency

Market liquidity

Summary

- We can now investigate another parameter of interest, the liquidity of the market. Liquidity is defined as the impact an order has on the market price, thus by how much the price moves of an order to a single unit of the asset is submitted.

Measuring liquidity

- A noise trader submitting an order will affect the price as it is not known whether he is informed or not

- The amount by which prices move when uninformed traders submit orders is referred as market liquidity

- This market liquidity was captures by the parameter $\lambda_t = \frac{N\beta_t\sigma_{t-1}^2}{N^2\beta_t^2\sigma_{t-1}^2+t\sigma_U^2}$

- It measures how much the price changes per unit of demand by traders

Measuring liquidity

→ We will first determine how we measure market liquidity.

▶ We are here concerned about the impact the order of an uninformed trader has on market prices. However, such an order would not contain any information and should therefore not move market prices; however, as it is not known whether the order has been submitted by an informed or uninformed trader, the price might still move.

▶ If no price movement was observed, we say that the market is liquid and the more the price moves, the more illiquid the market is said to be.

▶ Looking at our model, the marginal impact of the order on the price was given by λ_t, reproduced here.

▶ This λ_t, due to the linear structure of price formation, determined how much the price would be adjusted in response to trading demand. A high value corresponds to low liquidity while a low value corresponds to high liquidity

→ We will now investigate how the liquidity of the market changes.

Informed traders
○○○○○

Market efficiency
○○○○○○○

Market liquidity
○○○●○○○○

Summary
○○○○

Market liquidity

Few informed investors and many informed investors

Market liquidity
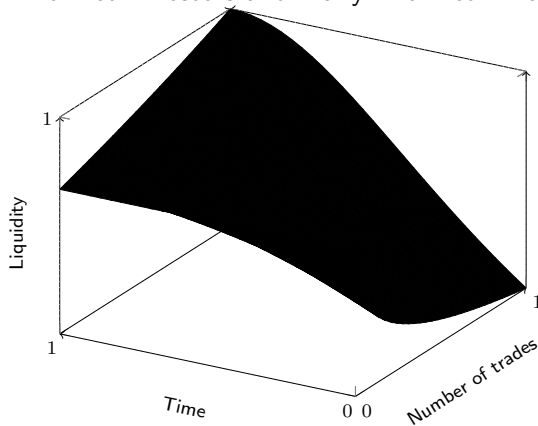
$\rightarrow$ We now determine the liquidity for some parameter constellations by solving for the parameters of our model numerically and graphically exploring the results.

$\blacktriangleright$ We will look at how liquidity evolves over time; note that here we use $\frac{1}{\text{Liquidity}}$ and thus a higher value corresponds to a less liquid market. We had assumed that before the information is revealed, informed traders can make a number of traders and we will see how market efficiency evolves over time as such trades are conducted. We will also look at the impact the number of trades have until the true value is revealed; this might be interpreted as either the frequency of trading increasing or the time until information is revealed increasing.

$\blacktriangleright$ We firstly consider the case where the number of informed traders is very small. We see that liquidity increases over time while the impact of the number of trades informed traders can conduct reduces liquidity in the early stages, but then increases liquidity in the later stages.

$\blacktriangleright$ If we increase the number of informed investors, we see that the market becomes less liquid and stays less liquid until the last few trades of the informed traders. The impact of the number of trades in market liquidity is similar to the case with few informed traders, but the differences are much less pronounced.

$\rightarrow$ We will now provide detailed rationales for these results.

Copyright © by Andreas Krause

Informed traders
○○○○○

Market efficiency
○○○○○○○

Market liquidity
○○○●○○○

Summary
○○○○

Markets become more liquid over time

- Market liquidity increases over time as λ_t reduces
- Potential losses from trading with informed traders are selling undervalued assets or purchasing overvalued assets
- With more information being available and the market becoming more efficient, this risk reduces
- Uninformed investors will adjust their expected value of the asset less, and hence the price adjusts less, as they must get closer to the value of the asset
- With prices adjusting less to demand, the market becomes more liquid

$\rightarrow$ The first observation is that the market becomes more liquid over time.

▶ We see that market liquidity increases, λ_t reduces as more and more trades are conducted by informed traders.

▶
- The losses to uninformed traders are that they might sell an asset to an informed trader at a price below its true value.
- Alternatively, they might purchase an asset at a price above its true value.

▶ As markets become more efficient, more information is available to uninformed traders through observing the price, hence the informational advantage of informed traders is reduced, reducing the risk of making such losses.

▶
- As a consequence, the uninformed price setter will adjust their expectation on the asset value less over time for any observed trading demand as he knows that informed traders have less of an informational advantage.
- This implies that the price will be adjusted less in response to trading demand.
- This is the consequence of the price getting closer and closer to the true value of the asset through the accumulated information.

▶ As prices adjust less in response to the observed trading demand, the value of λ_t must decrease and hence liquidity increase.

$\rightarrow$ Therefore, as the market becomes more efficient, it also becomes more liquid as adverse selection between informed and uninformed traders reduces. This is because the lower adverse selection makes price adjustments smaller due to informed investors not being able to make as much profits from their informational advantage and price setters knowing that informed traders are trading less, suggesting that more trading is from noise traders, which conveys no information.

Informed traders
○○○○○

Market efficiency
○○○○○○○

Market liquidity
○○○○●○○

Summary
○○○○

The effect of the number of trades

▶ If informed traders can trade more frequently, this will initially reduce the liquidity of the market

▶ Informed traders have more opportunities to obtain profits from trading and will trade less aggressively

▶ This makes the market less efficient and the higher asymmetric information will reduce the liquidity of the market

▶ Over time, more frequent trades accumulate more information, market efficiency increases and liquidity improves the more trades are conducted

The effect of the number of trades

→ We will now look at the impact the frequency of trading by informed investors has on market liquidity.

▶ In the first instance, informed traders being able to trade more frequently will reduce the liquidity of the market.

▶
- This is because informed traders will have more opportunities to make profits from trading,
- This means informed traders will submit smaller orders to make smaller profits, but more frequently. Order sizes are often referred to as the aggressiveness of informed traders.

▶
- We have seen that this makes the market less efficient,
- implying that the informational asymmetry remains higher. This will reduce the liquidity of the market as detailed above.

▶
- As trading continues, information is accumulated in the price and the more frequent trading is, the more information will accumulate.
- This will increase market efficiency as outlined before
- and hence by the same arguments as above, liquidity increases.

→ We thus see that more frequent trading by informed investors initially reduces the liquidity of the market, but then over time it increases liquidity.

Informed traders
○○○○○

Market efficiency
○○○○○○○

Market liquidity
○○○○○●○

Summary
○○○○

More informed traders increase liquidity

▶ More competition between informed traders increases informed trading and reduces liquidity

▶ With information being revealed quickly through competition, asymmetric information reduces quickly as well

▶ This allows liquidity to increase much faster than with fewer informed traders

→ The final observation we made was that with more informed traders, liquidity decreases.

► As we have seen before, more competition between informed traders increases their trading and hence more information is being revealed. This also implies that prices will have to adjust more to take into account the information that has been revealed through trading. Thus the liquidity of the market will be low.

► As information is revealed, as there are not much more trading opportunities left, informed trading will reduce and thus the amount of information that is revealed be lower, making price adjustments smaller and thus increase liquidity quickly.

► This leads to a much faster and sudden increase of liquidity than with fewer informed traders.

→ We thus see that with more informed traders, the liquidity of markets is lower due to the increased aggressiveness of informed traders.

Informed traders
○○○○○

Market efficiency
○○○○○○○

Market liquidity
○○○○○○●

Summary
○○○○

The impact of noise trading and asymmetric information

▶ Markets with more noise trading are more liquid as informed traders are less dominating the market

▶ Even though they submit larger orders in consequence, this does not fully compensate for this effect

▶ Markets with higher asymmetric information, a higher initial variance of the value, will be less liquid

▶ The informational advantage of informed traders is higher and they will submit larger orders

▶ With more informed trading, the likelihood of demand coming from them is increased and prices adjust more

$\rightarrow$ We will now briefly discuss two parameters in our model that have not yet been considered, the amount of noise trading and the degree of asymmetric information between informed and uninformed traders.

►
- We can show that markets with more noise traders are more liquid.
- The reason is that noise traders are making a larger fraction of the orders and thus the information content of the order flow is reduced. This implies that the price setter will change the price less and liquidity will improve.

► We have argued above that informed investors will submit larger order to compensate for this effect, but while this perfectly compensates the effect on information efficiency, it will not fully offset the impact on market liquidity.

► If the asymmetric information between informed and uninformed traders increases, that is the variance of the true value for uninformed traders increases, the markets will be less liquid.

►
- In this case the informed traders have a larger informational advantage compared to uninformed market participants.
- As argued before, they will seek to exploit their larger informational advantage by submitting larger orders.

►
- These larger orders imply that the order balance is more likely driven by informed traders rather than noise traders.
- Therefore the price setter will adjust the price more in response to orders, reducing the liquidity of the market.

$\rightarrow$ We thus see that more noise trading increases the liquidity of markets, while larger informational advantages of informed traders reduces market liquidity.

Informed traders
ooooo

Market efficiency
ooooooo

Market liquidity
ooooooo

Summary
●ooo

Informed traders

Market efficiency

Market liquidity

Summary

- We can now summarize the key results we have obtained from this model and look at some implications.

Informed traders
ooooo

Market efficiency
ooooooo

Market liquidity
ooooooo

Summary
oooooo

Informational efficiency is not instant

▶ Markets become efficient over time as information is included in the price trade-by-trade

▶ The more informed traders are present and the more they can trade, the more efficient markets are

▶ Informationally efficient markets are not possible instantly as informed investors will seek to exploit their informational advantage over time

→ We have seen that markets are not becoming efficient instantly but becoming more and more efficient over time.
▶ Every trade by informed traders reveals some information which is then included into the price, improving the efficiency of markets over time.
▶ Having more informed investors competing for profits, will increase the amount of information that is revealed, as will be the case if trades are conducted more frequently and hence more opportunities to reveal information are given. Thus the efficiency of markets will increase in those cases.
▶ We have seen that informed investors exploiting their informational advantage optimally will not reveal all information instantly, but the markets will become efficient over time only.
→ We can therefore conclude that informational efficiency cannot be instant and informed investors can generate profits, that might well allow then to recover the costs of obtaining this information in the first place. And rather than having a situation in which no information is acquired, the slow inclusion of information into the price, allows markets to become efficient eventually, even if the process might be slow. With frequent trading, and information often not being too long-lived, the delay in achieving a high degree of market efficiency should be low.

Informed traders
○○○○○

Market efficiency
○○○○○○○

Market liquidity
○○○○○○○

Summary
○○●○

Liquidity increases over time after an information event

▶ The liquidity of a market can be used as a measure of the degree of informational asymmetry in the market

▶ If prices react sensitively to orders, the liquidity is low and the market believes that informational asymmetry is high

▶ As information is included into the price over time, the liquidity of markets improves

▶ Uninformed investors not wanting to adversely affect the price by their orders, might want to wait until market efficiency has improved before submitting any order

→ We have also seen that like efficiency, the liquidity of markets increase over time as information is included into the price.

▶ We can interpret the liquidity of a market as a measure of the informational asymmetry in the market. The lower the liquidity, the higher the informational advantage of informed investors.

▶ If prices are adjusted significantly in reaction to an order being submitted, thus liquidity being low, this indicates that there is a large degree of asymmetric information between informed and uninformed traders.

▶ As markets become efficient and informed traders submit smaller orders, reducing the risk of losses when trading with informed traders, the liquidity improves as prices are adjusted less due to the reduced presence of informed traders.

▶ In the model were only informed traders and noise traders, that is traders that trade for exogenous reasons and do not seek to maximise their profits. If we have uninformed traders that are not required to trade, they might find it beneficial to wait to submit an order until the adverse selection has reduced sufficiently and the losses they are making from trading will be low as the market is quite efficient. That way uninformed traders reduce the costs of trading.

→ We have seen that information is included into prices gradually and markets become efficient over time. While market efficiency is difficult to determine empirically as the required data (uncertainty of uninformed traders and the uncertainty from observing the price) are not directly observable, we can estimate the degree of informational asymmetry by determining the liquidity of the market. Looking at order sizes and price movements should allow us to determine the value for λ_t.

Andreas Krause
Department of Economics
University of Bath
Claverton Down
Bath BA2 7AY
United Kingdom

E-mail: `mnsak@bath.ac.uk`