Trading with informed investors

Andreas Krause

Outline

- Informed traders
- Market efficiency
- Market liquidity
- Summary

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- 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
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- Market liquidity
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- 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

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→ 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.

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  - 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.
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- 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.
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- $P_t = \mathrm{E}\left[V \middle| \sum_{\tau=1}^{N} Q_\tau + \sum_{\tau=1}^{M} U_\tau\right]$

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Order determination for informed traders

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→ Informed traders will take into account how prices are determined and submit their orders accordingly such that their own profits are maximized.

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  - 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.
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→ We can now continue to determine the optimal demand.

Order determination for informed traders

- Profits from a trade arise from the difference between the asset value and the price paid
- $\Pi_t^i = (V - P_t)$

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- Profits from a trade arise from the difference between the asset value and the price paid, for each asset traded
- $\Pi_t^i = (V - P_t)\, Q_t^i$

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Solution of the model

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→ 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.

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

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

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

  $\mu_t = P_{t-1}$

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- 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.

Measuring market efficiency

Measuring market efficiency

→ 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.
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Measuring market efficiency

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Market efficiency

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.

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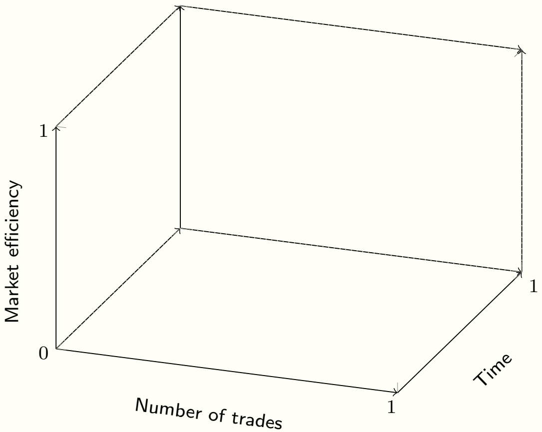
Market efficiency



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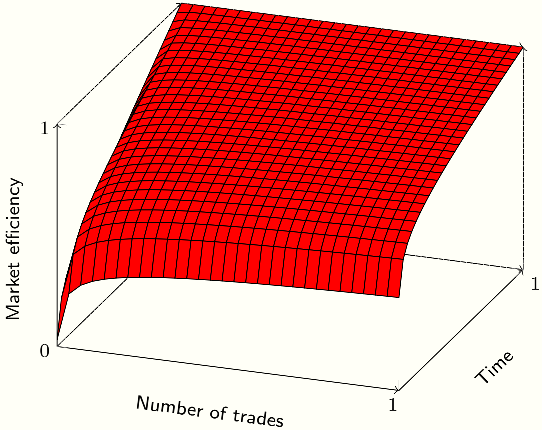

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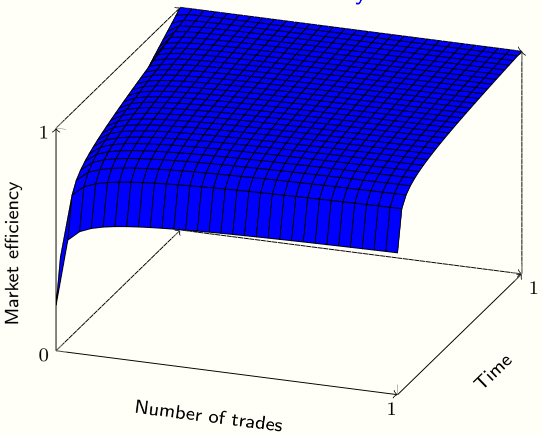

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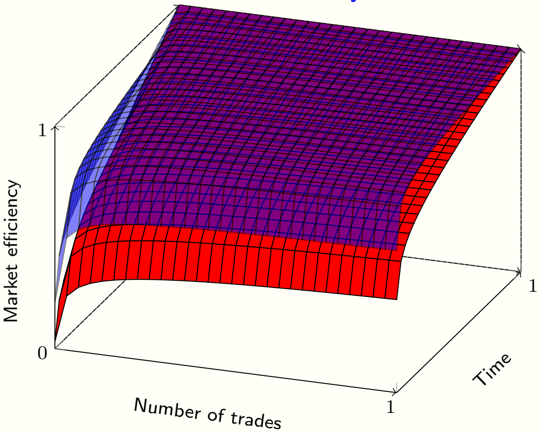

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Market efficiency develops over time

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→ We first look at how market efficiency changes over time and what the reason for this is.

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  - 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.
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  - 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.
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  - 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.
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  - 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.

Market efficiency develops over time

- Markets become efficient over time as information is incorporated into prices

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

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- 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

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  - 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.
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  - 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.
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  - 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.
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  - 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.

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

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More frequent trading increases market efficiency

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→ 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.
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  - 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.
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  - 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.

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- If informed investors can trade more frequently, the market will be more efficient more quickly

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→ The final observation we made was that with more informed traders, market efficiency increases.

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  - 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.
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  - 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.
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  - 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.
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  - 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.

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- Informed traders obtain an informational advantage over noise traders

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- Submitting larger orders now implies that the observed demand is more likely to come from informed traders

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  - Thus more informed traders increases the competition between them, as it does in any oligopoly with more members.
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- 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.

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

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→ 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.
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The impact of noise trading and asymmetric information

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→ 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.
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    - 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.
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    - However, informed traders compensating for this by now submitting larger orders to increase their profits.
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- 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.
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    - As they submit larger orders, prices will adjust more and the variance reduce more as more information is revealed.
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- More noise trading allows informed traders to hide their orders better

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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

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

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Market liquidity

Market liquidity

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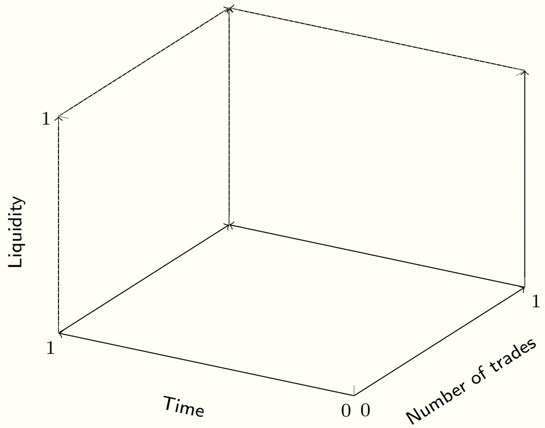

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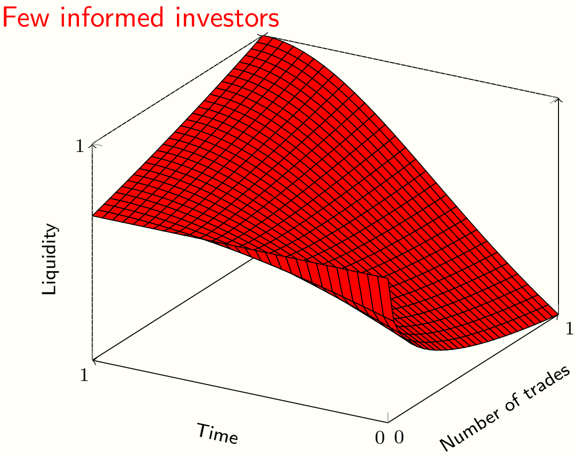

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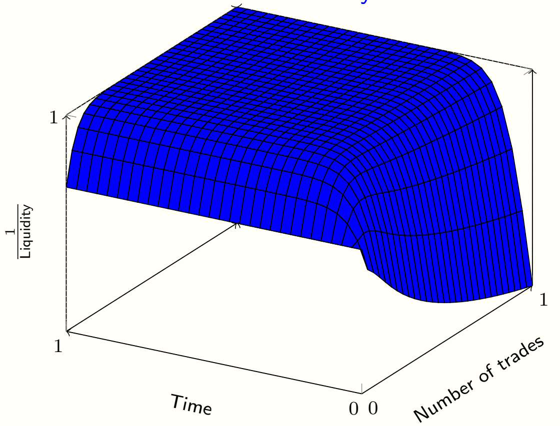

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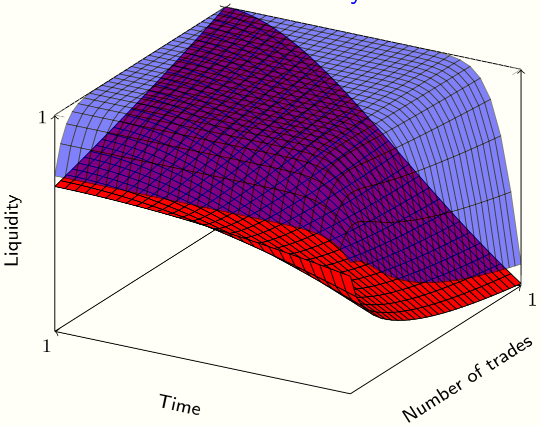
Few informed investors and many informed investors



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Markets become more liquid over time

Markets become more liquid over time

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

→ 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.

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The effect of the number of trades

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→ 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,
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- - As trading continues, information is accumulated in the price and the more frequent trading is, the more information will accumulate.
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→ We thus see that more frequent trading by informed investors initially reduces the liquidity of the market, but then over time it increases liquidity.

The effect of the number of trades

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

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.
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- Informed traders have more opportunities to obtain profits from trading

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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

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More informed traders increase liquidity

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→ 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.

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

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The impact of noise trading and asymmetric information

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- - 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.
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- 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.

Informational efficiency is not instant

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→ 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.

Informational efficiency is not instant

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

Informational efficiency is not instant

- → 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.

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- 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

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Liquidity increases over time after an information event

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- → 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.

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