



Agent-Based Modelling for Commodity Market

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01

Introduction





Commodity Market

A commodity market is a physical or virtual marketplace for **buying, selling, and trading raw or primary products.**



Purpose of Our Project

Objective

The purpose to build this model is to better understand the dynamic commodity trading process, the interactions between multi agents and the environment and the evolution of liquidity in this environment based on different endogenous and exogenous variables of the model.

Focus

We will focus on crude oil as a commodity product in a single market.



Why Agent-Based Modelling?

Prices are the result of the interaction of market players

There are multiple types of market players interacting and influencing each other

The behaviour of market players is dynamic, adaptive and heterogeneous



The background features a complex network of white lines and dots on a blue gradient. The lines connect various points, creating a web-like structure that is denser on the left and right sides and sparser in the center. The dots are of varying sizes and are scattered throughout the network.

02

Literature Review

Commodity Market Analysis

Used to

1. Forecast price
1. Anticipate price change





Commodity Market Analysis

Focuses on supply and demand variables and their relationship to prices.

Fundamental Analysis

Use to analyse price change in short run. Analyse the historical price changes to identify patterns.

Technical Analysis



Shortage

The analysis is generic over a long period of time. The analysis is not good at predicting the price change in short-run.

Fundamental Analysis

Non-obvious or changing trend. Difficult decision making in choosing parameters.

Technical Analysis

Agent-Based Modelling



Logic-based

Able to perform prediction
both in short and long run

Able to test the impact level
of different parameters via
experiments





03

Problem Statement

How would the behaviour of different market players affect the price change in a commodity market over time?



04

Model



Continuous Double Auction Model

Agents act in the single commodity market, buying and selling, determining the futures price. In this model transactions are processed one at a time by a mechanism known as continuous double auction, **buyers and sellers place at any time their orders, specifying at what price they are willing to buy or sell.**



Exogenous variables

Production

labour patterns, development in the tools and technologies used

Economic & Political Environment

trade constraints, subsidies, taxes.

Natural Factors

climatic conditions, crop diseases, earthquakes

These factors will affect spot price and there is correlation between spot price and future price.





Agents



Agents

Hedgers

Hedgers are **commercial producers or consumers** of a traded commodity.
Hedgers are exposed to commodity price volatility in the spot market.
They use the futures market to offset (hedge) this risk.



Agents

Speculators

They may not have any exposure to the spot market. To them, commodity futures are an investment avenue, like the stock market.

They can either trade with other speculators or trade with market makers.

They have their own attributes such as buy, sell, get information, price, cash, options, bankruptcy.

If they are not bankrupt, they can choose buy, sell and get information as their action.

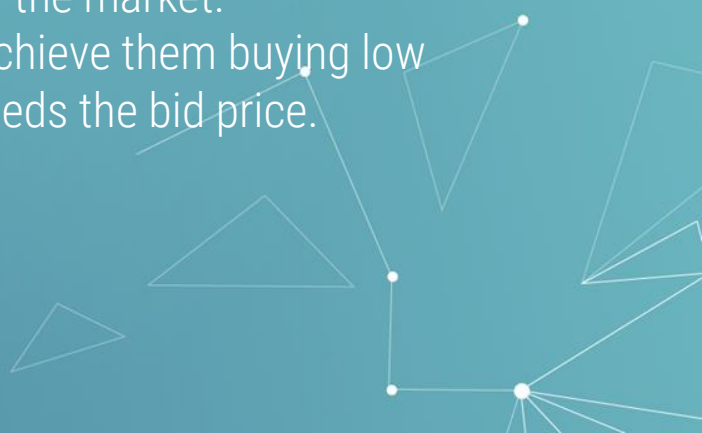


Agents

Marketmaker

It is a party that can buy or sell a large amount of asset at a publicly stated price in order to influence the liquidity of the market.

The market maker's goal is to earn profits and to achieve them buying low and selling high, so the ask price always exceeds the bid price.



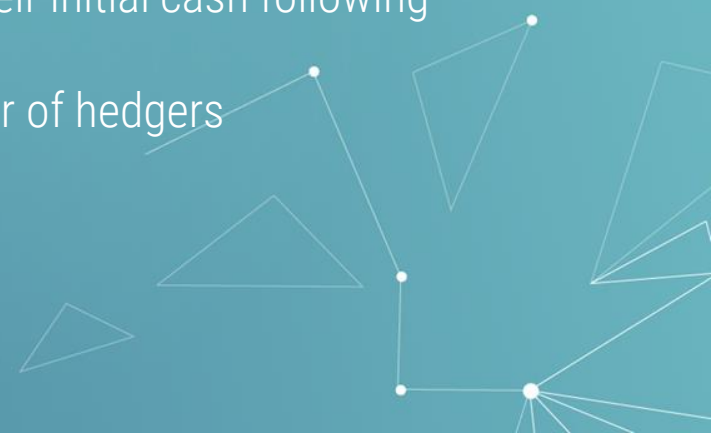


Functions



Functions

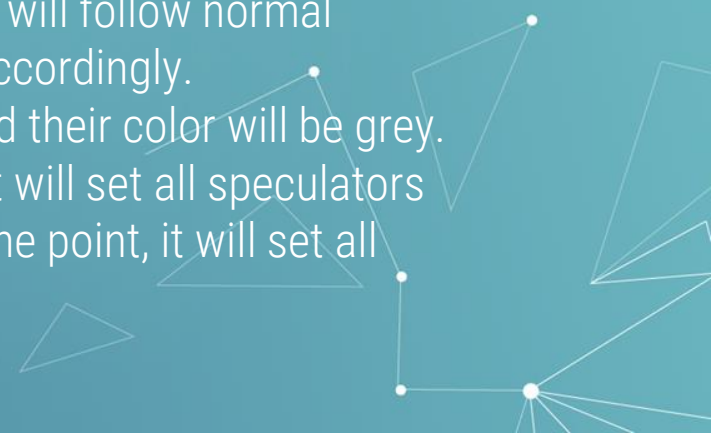
Setup

1. Set futures price based on spot price and exogenous variable
 2. Creates certain number of speculators and their initial cash following normal distribution
 3. Creates one market maker and certain number of hedgers
- 



Functions

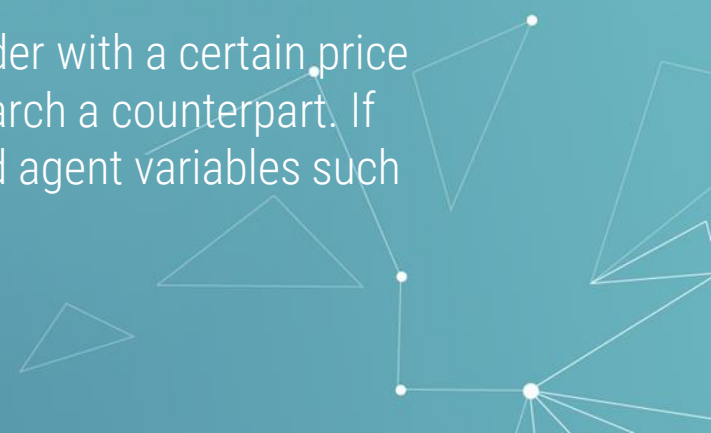
Initialization

1. Set market maker ask price equals future prices plus half of bid ask spread price and bid price equals future prices minus half of spread price
 2. If speculators not bankruptcy, it will set speculator participation rate of speculators buy and sell action equally, their price will follow normal distribution and their color will be red and green accordingly.
 3. Set the rest speculators get information action and their color will be grey.
 4. When futures price greater than upper line point, it will set all speculators sell action. When futures price less than bottom line point, it will set all speculators buy action.
- 



Functions

Speculators trade

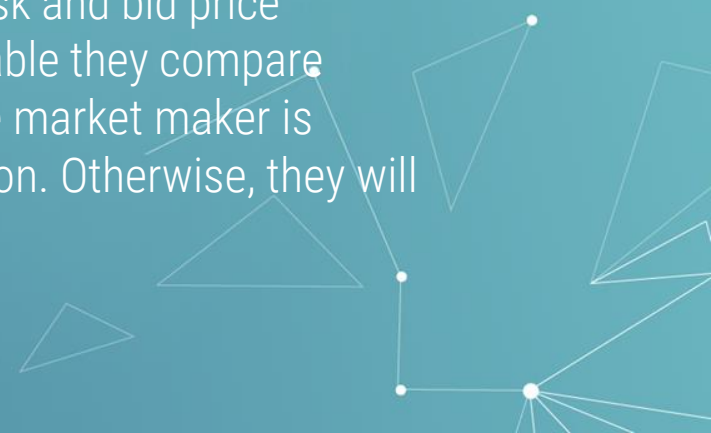
1. This function will ask speculators who are not getting information and bankrupt to trade with each other.
 2. When speculators enter the market, set an order with a certain price at which they are willing to trade, and they search a counterpart. If they can find it, they make the transaction and agent variables such as cash and options are updated.
- 



Functions

Speculators trade with marketmaker

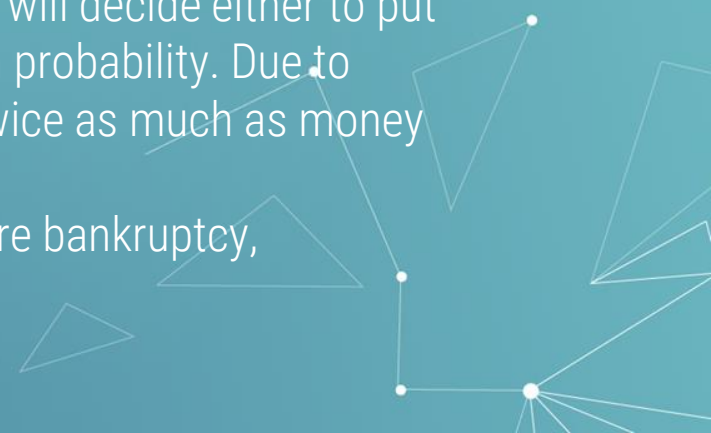
In this function speculator can trade both with the market maker and the other investors. Speculators when they are active, compare the price at which they are willing to deal with market maker ask and bid price according their position, then if the prices are suitable they compare market maker price with other traders prices, if the market maker is offering the best price they will make the transaction. Otherwise, they will trade with speculator who offers the best price.





Functions

Update speculators status


1. If speculator's cash is not enough to buy options, it will choose get information action.
 2. If speculators choose to get information, they will decide either to put in more money or take out money with certain probability. Due to disposition effect, the amount they put in is twice as much as money taken out.
 3. If speculators' cash is less than 0, it will declare bankruptcy, accordingly, its color will become black.
- 



Functions

Hedgers trade

Here, it simplifies Black Scholes model and Delta Hedging strategy. Instead, it use option ratio to calculate call option price and black Scholes call option price. Then it will calculate final offset for both options price and futures price.





Functions

Update hedgers profit

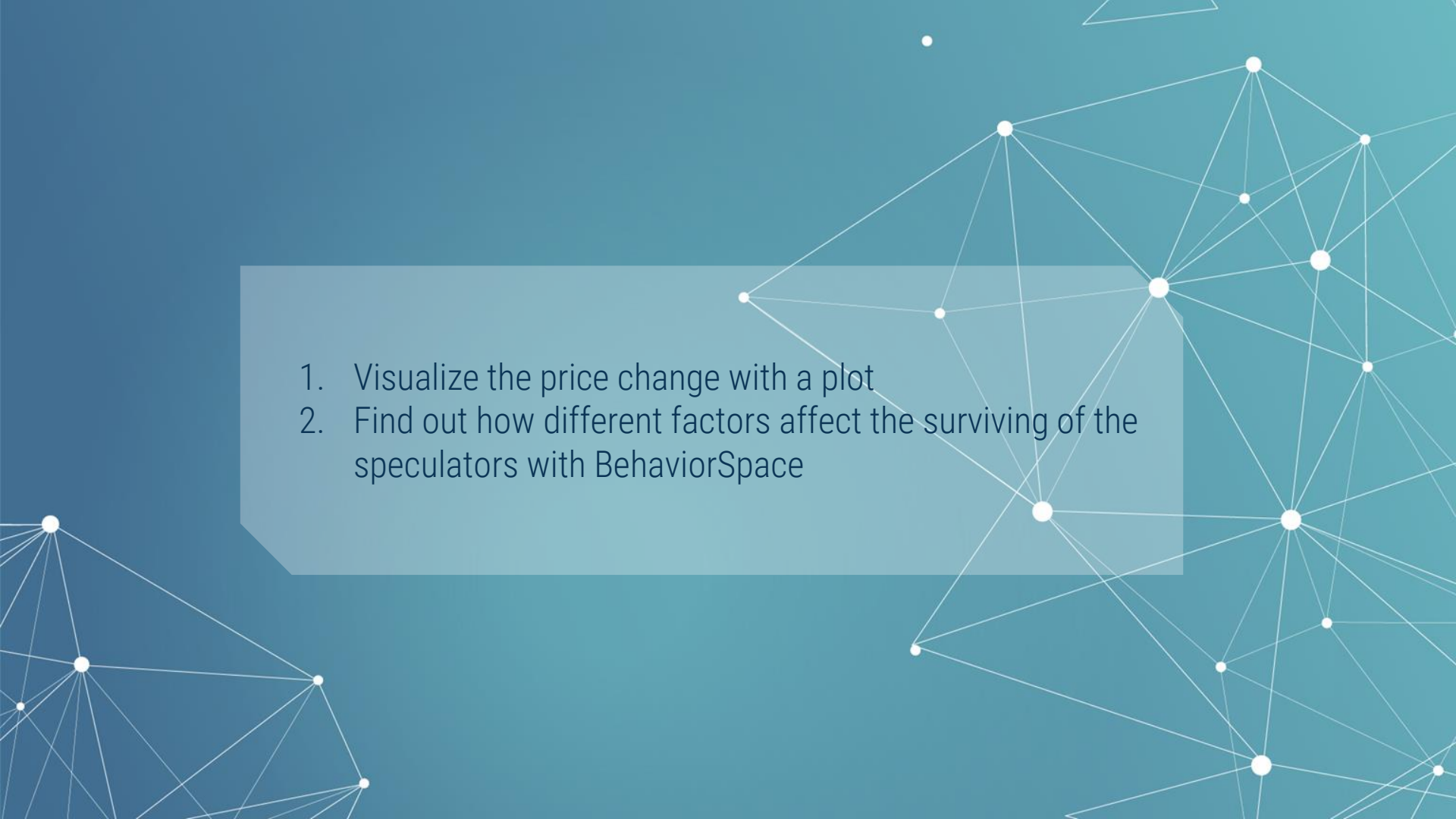
Plot profit changes for different hedgers





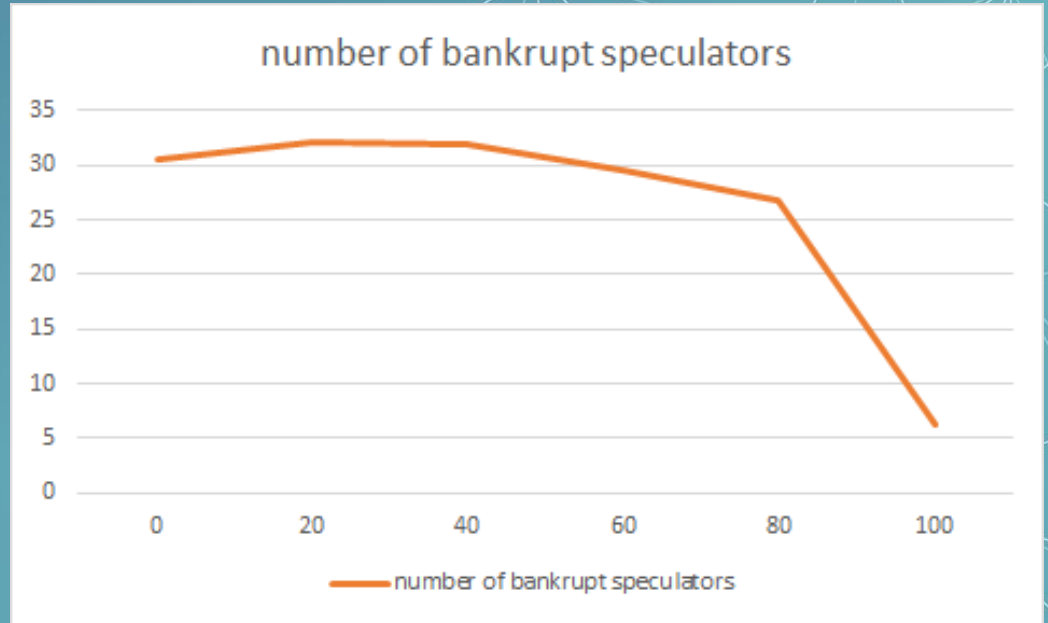
05

Result Analysis

- 
1. Visualize the price change with a plot
 2. Find out how different factors affect the surviving of the speculators with BehaviorSpace

Speculator participation rate

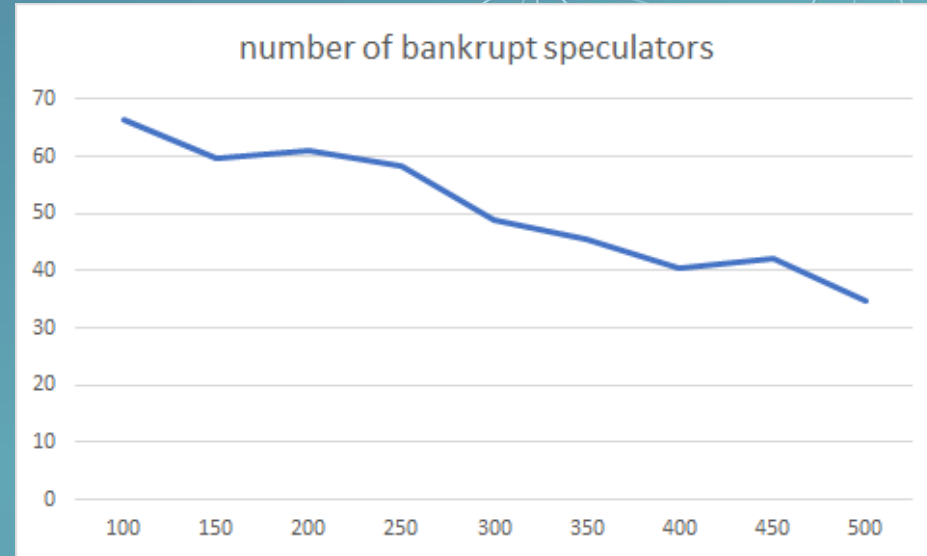
speculator participation rate	number of bankrupt speculators
0	30.6
20	32.15
40	31.85
60	29.6
80	26.85
100	6.3



Number of bankrupt speculators decreases when speculator participation rate increases

speculator mean cash	number of bankrupt speculators
100	66.6
150	59.8
200	61
250	58.2
300	49
350	45.4
400	40.4
450	42.2
500	34.8

Speculator mean cash

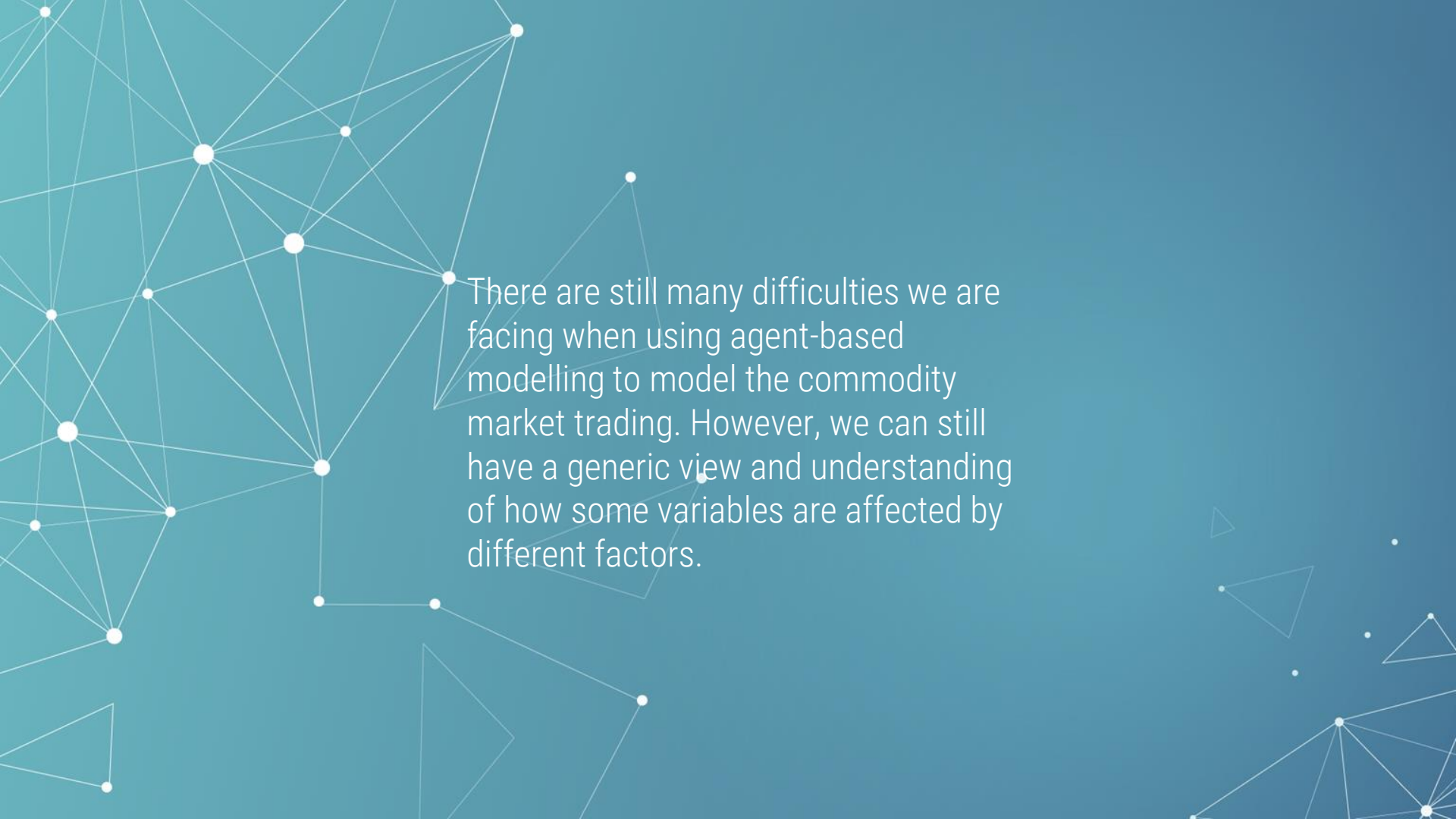


Number of bankrupt speculators decreases when speculator mean cash increases



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Conclusion



There are still many difficulties we are facing when using agent-based modelling to model the commodity market trading. However, we can still have a generic view and understanding of how some variables are affected by different factors.



THANKS

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RESOURCES

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