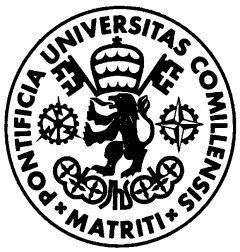

UNIVERSIDAD PONTIFICIA COMILLAS

ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA (ICAI)

OFFICIAL MASTER'S DEGREE IN THE ELECTRIC POWER INDUSTRY

Master's Thesis

Spanish Electricity Wholesale Market Analysis about the use of manipulation practice types listed by ACER in guidance 6th

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Master's Thesis Presentation Authorization

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Summary:

ACER published on July 2021 a 6th guidance on the application of the "Regulation on Wholesale Energy Market Integrity and Transparency" (REMIT) and listed 20 types of manipulation practices. These practices are more suitable to be present in the intraday continuous market. Indeed, the continuous market does not rest on a sealed-bid auction mechanism as the day-ahead market or the intraday market by auctions but on continuous trading. Because of this, there is a higher risk of market manipulation such as agents giving false or misleading signals or securing an artificial price.

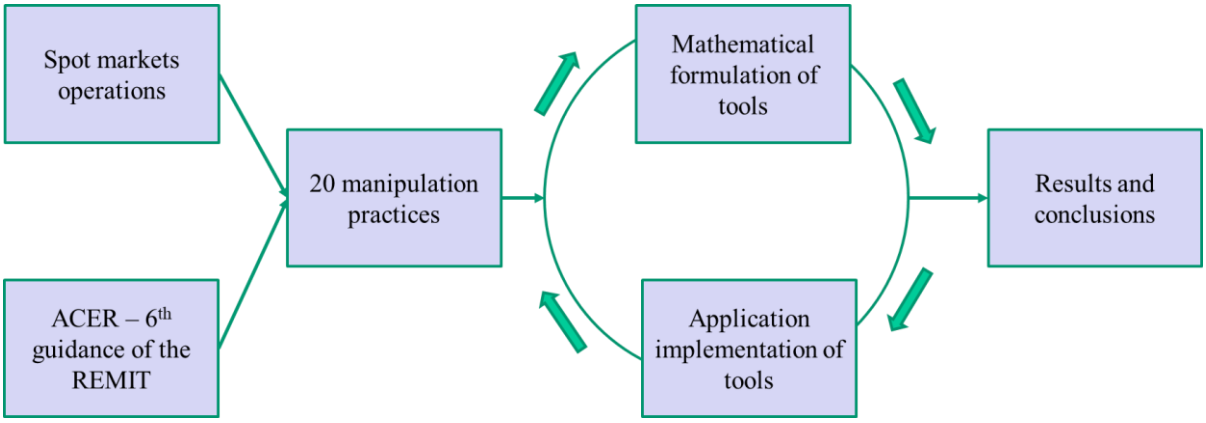
In this work, the 20 manipulation practices listed by ACER are explained and examples are provided. This analysis of the practices aims to establish what are the magnitudes of interest and how to monitor them. Then, this work develops means and tools to monitor these manipulations. These tools are monitoring indexes designed to detect strange behaviour and abnormal results in the continuous market. The tools developed are for example ratios of offers accepted for each agent based on quantity (MWh) or cardinal number of offers, net results of agents during a certain timeframe, activity of an agents on both sides of the orderbook (ask side and bid side) or comparison of offer's price to an expected interval.

Let's expose briefly the method used to develop the tools. First, a theoretical mathematical formulation is defined. Then the tool is implemented with SQL programming and applied on real market data. Two databases of market data are used, one week of offers and the same week of transactions in the continuous market. Finally, the post-treatment of the data and analysis of the results is done with Excel. The implementation with SQL and post-treatment with Excel led to modifications and improvements of the mathematical formulation part. In other words, the application part of the process allows me to develop an upgraded and more realistic theoretical part. This loop between theory and application was particularly fruitful. For the results obtained, each tool can identify certain abnormal results according to the thresholds sets and a dashboard with the different tools is provided.

It was necessary to keep a constant trade-off between tool sophistication and achievability because of the amount of data involved, the time constraint of the project and the programming skills required. Several approaches were possible for this complex problem, with for each tool many options and parameters. In order to keep a clear path through all these possibilities, the use of the method exposed (mathematical formulation, implementation and analysis) was essential.

For the future, two main routes are possible. On the one hand, it is possible to develop new tools and improve existing ones. On the other hand, it is possible to work on their combination and implement protocols with several tools to monitor each manipulation practice.

Methodology used:



Graph of the method used to carry out this master thesis

I allocated few weeks at the beginning of the project to learn the market mechanisms and improve my knowledge on spot markets operations and participated to a 2 weeks program of OMIE. In parallel, I studied and made a report of ACER publication in order to understand the scope of the REMIT and the recent updates.

These two prerequisites completed, I focused on the 20 manipulation practices listed by ACER in the 6th and new guidance of the REMIT. The objective was to understand them better, illustrate them and think about means to monitor them.

Then, the most interesting part and the core topic of this project: the development of tools to monitor these manipulation practices, with a loop between mathematical formulation of tools and implementation with SQL programming.

Finally, the analysis of the data extracted provides results and pave the way for the conclusions.

Foreword

I would like to thank different people thanks to whom this professional experience abroad has been possible and as enriching.

First of all, I would like to thank all the monitoring unit department of OMIE: Enrique, Juan, Julio and Sixto. They are passionate about their work and don't count their time to pass on their knowledge. More individually, I would like to thank Juan for its several explanations on the sector specificities, for its pedagogy, its confidence and understanding of the master's constraints. I would like to thanks Enrique for its day-to-day support. Throughout the internship, he helped me to structure my tasks, to choose some directions during the development part and to complete my work. I would also like to thanks Sixto and Julio for their precious help on SQL language. The four of them answered all my questions, doubts and explained me several mechanisms during the project.

I am grateful to have been able to participate to the 2 weeks OMIE formation at the end of February. I would also like to thank OMIE's operators and more generally OMIE's people for the friendly exchanges we had.

I would like to thank my friends Nuño Requejo and Joaquín Pérez with who I spent a great year in Spain. They facilitated my integration in Madrid, in the master of ICAI and in my internship.

I would like to thanks ICAI institution and the teachers of the Master of Electric Power Industry for the quality of the classes we received, which was useful for this work. Particularly, I would like to thank Luis Olmos, director of the master, for its support all the year-long and Javier García González for its time and precious advices during my research of internship and master thesis.

Finally, I would like to thank my home institution, Ecole Centrale de Nantes, and all the people in the international relations office who enabled me to establish a partnership with ICAI to carry out this Master's program and this master thesis work.

Index

Recommendation for readers

Of course, the best would be to go through the whole document. However, it is ninety pages long and readers may not have enough time to do so. In case of time constraint to browse this document, I recommend to read, by order of priority:

- Summary (page 3)
- Chapter 5: Conclusions
- Introduction of each chapter to understand the thread of the thesis
- Chapter 4, which includes the main developments and results, to gather what interests you the most

It will allow any reader to benefit from the document in an optimal way according to the time he has to read it.

Chapter 1: Introduction and state of the art

In this chapter the objective is first to contextualize the topic. Then, a state of the art on spot market operations in Spain and Europe is provided. Lastly, a synthetic summary of ACER guidance on the REMIT is exposed.

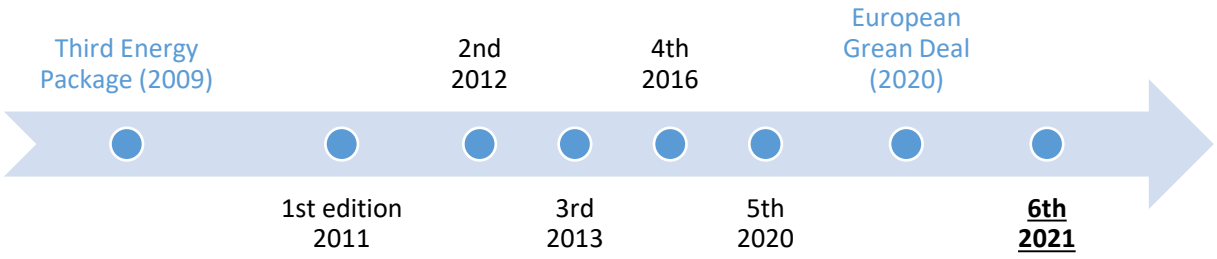
I. Introduction

Following the example of Chile who liberalised its electric power industry in the late 70s, European countries liberalised the European electricity sector in the late 90s and wholesale energy markets were introduced.

This liberalisation required a regulation to set rules and provide an efficient framework for all shareholders. It led to the apparition of system operators, market operators and regulators. Using the European terminology, we speak about System Operator or "SO", National Regulator Authority or "NRA" and Nominated Electricity Market Operator or "NEMO". NEMOs are the organizations mandated to run the day-ahead and intraday integrated electricity markets in the EU and responsible for monitoring the markets in order to make it works as well as possible.

The Third Energy Package adopted by the European Parliament in 2009 led among other things to the creation of "ACER" which stands for European Union Agency for Cooperation of Energy Regulators. ACER is responsible for monitoring the wholesale market and detect market abuse. One of ACER´s activity is the REMIT: Regulation on wholesale Energy Market Integrity and Transparency. It is a regulation at the European-scale of the sector-specific framework. Its objective is to prevent insider trading and market manipulation but also foster competition in the European wholesale energy markets. In the scope of the REMIT, ACER has to provide non-binding guidance to the NRAs in order to help their activity and foster their coordination.

<u>Different editions of the REMIT's Guidance:</u>



Timeline with the different editions of the Guidance of REMIT

In a nutshell, the European Green Deal set the objective for the old continent to be carbon neutral in 2050 and raise a plan of transformations with medium-term objectives to achieve it. It imposes a decarbonization of the EU's energy system with a high-level of renewable integration and system interconnexion without jeopardizing security of supply and affordability. In the 6th and last edition of the Guidance, there is an update of the expected market developments after the adoption of the European Green Deal and with the feedback of NRAs. ACER also makes in the 6th publication a full list of types of practices that can be labelled as market manipulation. These practices are more suitable to be present in the intraday continuous market. [1]

The purpose of this thesis is to study the use of market manipulation practices in the Iberian wholesale market of electricity. The first objective is to understand and describe each one of the 20 manipulation practices listed in ACER's publication. The second objective is to develop a mathematical formulation of the selected manipulation practices and then to set up tools to monitor these market manipulations. This last part requires the use and analysis of market data.

There are 3 spot markets: day-ahead, intraday by auctions and intraday continuous. The first 2 markets (day-ahead and intraday by auctions) rest on a *sealed-bid auction mechanism* (or "*blind auction*"). It is different in the continuous market: bids are visible and one agents' bid can influence another agents' behaviour. There is not only the two components of price and quantity but also a component of time (chronology). Much more offers are published than accepted. Many are cancelled or rejected and never lead to any transaction. In the context of manipulation practices in the continuous market, offers may not be published with the aim to be accepted but rather to send misleading signals and influence price formation. As the continuous intraday market is more likely to have manipulation practices, this work will mainly focus on this market.

The market data used corresponds to one week of offers and transactions in November 2021, in the continuous intraday market. To give order of magnitudes, we have around 266.000 offers and 61.000 transactions for this week.

ACER published the Guidance on REMIT 6th edition on the 22nd July 2021. The project rests on this recent update of the European Institution's document. As a consequence, it is a priority topic for the company.

OMIE is one of the neuralgic points of the Iberian Electric Power Industry. Coming from a French School of Engineering, to work in OMIE and make an analysis on the Spanish electricity market through the prism of a European Institution publication is enriching. It requires to develop strong knowledge on wholesale market operation but also data analysis skills.

II. State of the art: Spot market operation

In this part we present the different wholesale spot markets of electricity, their processes, imbrication and perspectives of evolution.

Day-ahead market

The day-ahead market is a market coupled with the rest of Europe. We speak about the Single Day-ahead Coupling (SDAC). The SDAC is under the Capacity Allocation and Congestion Management (CACM) EU target model. The idea is to build a single pan European cross zonal day-ahead electricity market. This European market includes 26 countries, 16 NEMOs and 34 TSOs. Thanks to this coupling, 98,6% of the EU consumption is coupled. [2]

This market is solved by Euphemia, a common algorithm which is coupling wholesale electricity markets from different regions and allocates scarce cross-border transmission capacity in the most efficient way in order to maximise the social welfare.

This functioning involves NEMOs and TSOs of the different countries.

Map of countries involved in SDAC

The offers are sent before 12:00 of the D-1. Then, it is solved by Euphemia in approximately 17 minutes. It is quite impressive considering the size and complexity of the optimization problem. The algorithm uses implicit allocation of interconnexion capacity for day-ahead while it is an explicit one for long-term products.

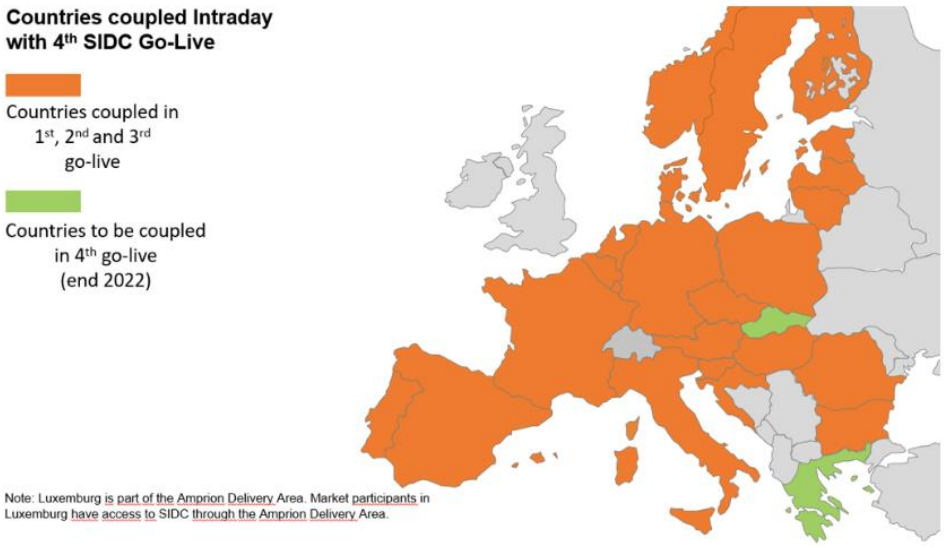
Intraday Market by auctions

This intraday market existed before the continuous market. It rests on 6 auctions with a sealed-bid mechanism and it is a regional market for the MIBEL ("*Mercado Iberico de la electricidad*") which includes Portugal and Spain.

A project in development aims at designing 3 European intraday auctions on a similar model than SDAC and with clearing by Euphemia. It would replace the 6 intraday auctions limited to Spain and Portugal. These auctions would be developed in complement of the intraday continuous market and would foster the coupling of European markets, with a more efficient use of the interconnexion capacities. A first version is planned for 2024. [3]

Intraday Continuous market

As it is done for the day-ahead with SDAC for the day-ahead market, a Single intraday coupling (SDIC) exists also for the continuous market. It is done with "XBID" which is the intraday continuous trading platform. Again, it involves TSOs and NEMOs and enables cross-border trading across Europe. SIDC is (like SDAC) part of the CACM (Capacity Allocation and Congestion Management), an EU Target model. This European Market includes 23 countries, 15 NEMOs and 31 TSOs. [4]

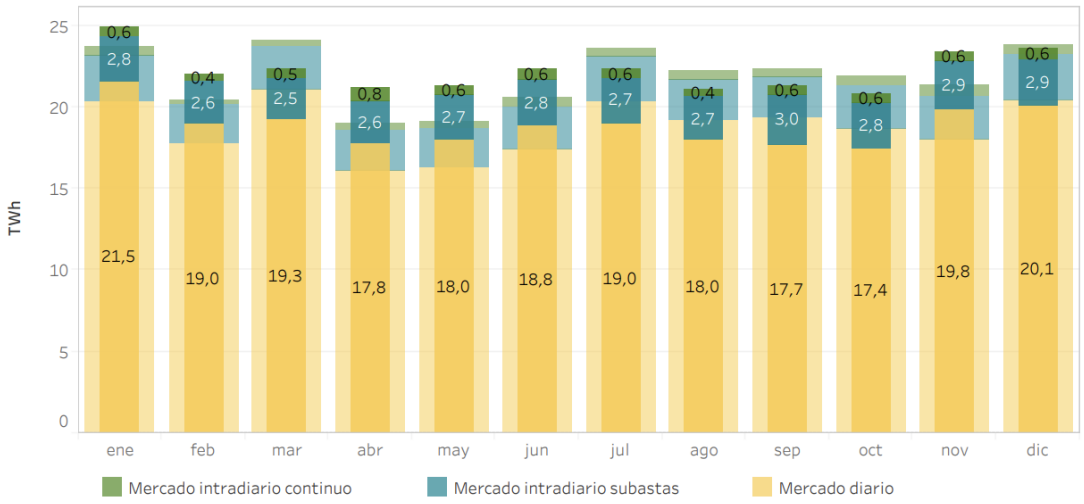


Map of countries involved in SIDC project

The continuous is present in the Iberian Peninsula since 2018. Before, the only intraday market was the auctions. The actual co-operation of two intraday markets necessitates a specific operation: when the clearing of an intraday auction is done, the continuous market is suspended, as explained in next paragraph on markets imbrication.

3 markets processes and imbrication: volumes, prices, and imbrication

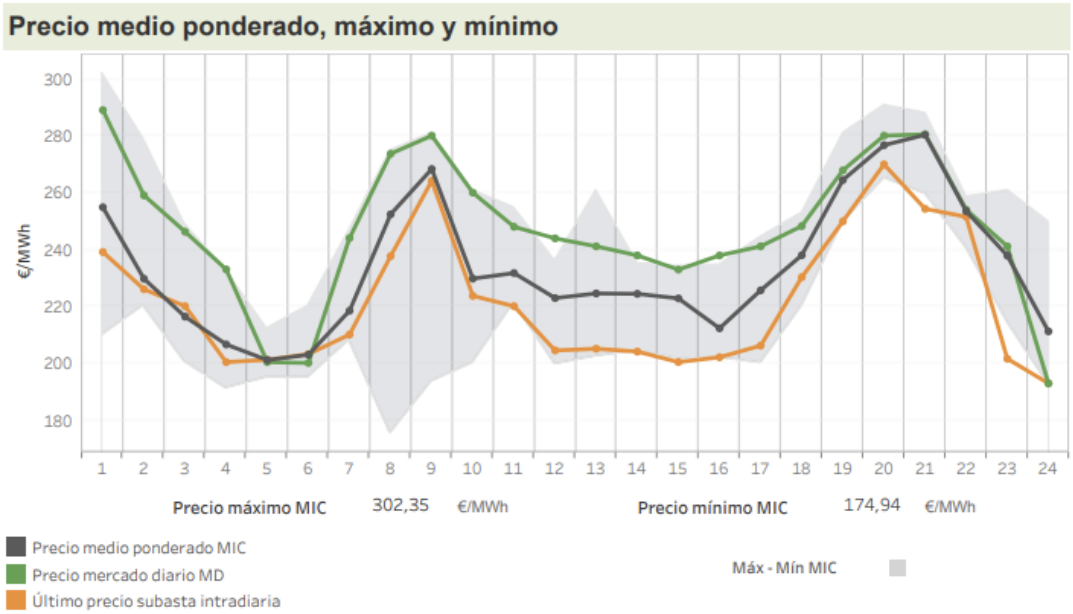
The day-ahead market is the most important market by far in terms of volume. Let's present a graph from OMIE annual report 2021 [5] to illustrate this:



Energy traded in the different spot markets in 2021 in the MIBEL – Source: OMIE [5]

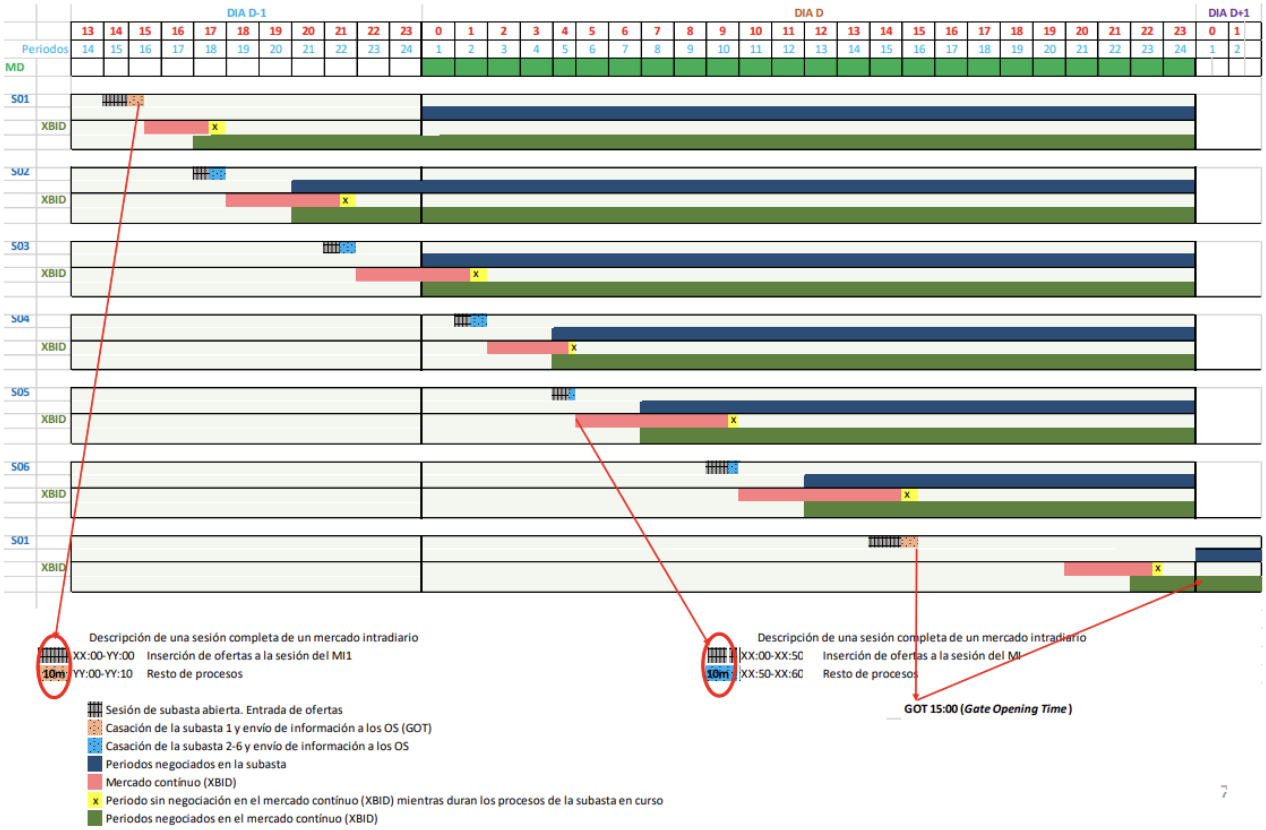
Definitely, the day-ahead is the main market where agents offer all their capacity and intraday markets are designed to be markets of adjustments because closer to the real time.

In term of price, the intraday markets prices are correlated to the day-ahead market results, with some volatility. The 3 markets follow the same price dynamic and the average prices' order of magnitude are similar as we can see in OMIE website [6]. To illustrate this, let's focus on one specific day:



Price comparison between the 3 markets – Date: 01/12/2021

The 3 markets coordinate operation is complex, and is well described in the following scheme:



Description of intraday market processes and imbrication in the MIBEL (source: OMIE)

The main ideas are the following. The day-ahead market is closed to bids (gate closure) at 12:00 of D-1. Then the intraday continuous market open at 15:00 of D-1 and energy can be traded until one hour before physical delivery. This hour of “free” time, called lead time, is used by the system operator to verify the market results feasibility ensure the system reliability with ancillary services and reserve markets.

The intraday auctions and the continuous are simultaneous, except during each clearing of the 6 intraday auctions. The continuous is then paused during the 10 minutes of the clearing. This interruption of the continuous is necessary. It prevents transactions from being carried out at the same time on the two intraday markets against the will of the agents or without considering the grid constraints and limits. Indeed, if an agent is offering 10 MWh in the continuous and try to sell its energy also in the intraday by auctions, the interruption of the continuous is required to avoid energy being sold twice at the same time. Moreover, the grid capacities and interconnexions is limited and so cannot be allocated on 2 markets at the same time if we want to ensure feasibility of the physical delivery of electricity.

Time granularity in markets: from 1-hour to 15- and 30-minutes market time unit

The market time unit is the period for which a market price is established. It is also defined as the temporal granularity of the market. To illustrate, an hourly product refers to 60 minutes of a physical electricity delivery. Only 1-hour products are currently traded in the Iberian Peninsula. Another in development consists in introducing products with a lower time granularity such as 15 minutes or 30 minutes ones. This project is developed in collaboration with System Operators (REE, REN) and NRAs (CNMC, ERSE). Based on the current plan, it should be implemented progressively in 2024 and 2025.

It is already implemented in other European spot markets managed by EPEX SPOT or Nord Pool: half-hourly products in the continuous market are used in the United Kingdom, Luxembourg France, Germany, and Switzerland. Quarter-hourly products in the continuous intraday market are used in Austria, Belgium, Germany, Hungary, Luxembourg, the Netherlands, Slovenia and Switzerland. [7]

Increasing the granularity of electricity markets would improve the flexibility in operations through price signals and eventually enable higher shares of renewables in the power system.

Gate closure and lead time

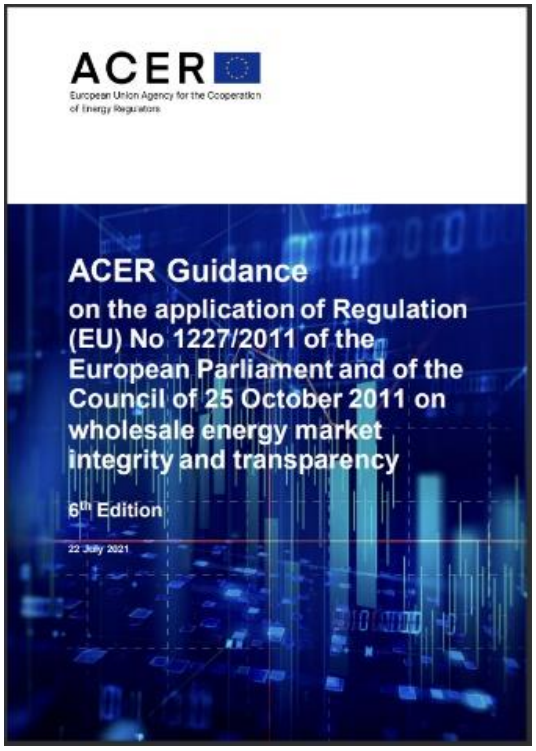
The gate closure is the moment up to which market agents can either submit bid or ask offers and modify them. The gate closure is the borderline between market and system operation. The lead time is the time span between trading gate closure and physical delivery. On the one hand, setting a gate closure closer to real time reduce the System Operator's time slot to activate reserves and solve imbalances but on the other hand, it helps market agents adjust their positions, with increased certainty about forecasted generation enabling them to minimise imbalances.

As explained before, in Spain, the energy can be traded in the intraday markets until one hour before the physical delivery. It is not the case in all European Countries: Nord Pool and EPEX (two NEMOs of Nordic countries and Central West Europe) use a shorter lead time. Nordic countries have flexible resources thanks to abundant hydro, facilitating this small lead time.

III. ACER 6th edition of REMIT guidance

Before getting in the heart of the matter with the analysis of the 20 manipulation practices, let's conclude this introductive and state-of-the-art chapter with a summary of *ACER Guidance on the application of the REMIT – 6th edition* in order to set the foundations of the study. [1]

This document was published by ACER on the 22nd of July 2021 and is 119 pages long. The following synthesis presents main definitions, issues and impacts of the guidance.



ACER Guidance on the application of the REMIT - 6th publication

Index of the document synthesis:

1) REMIT Scope

Contents: Definitions of Wholesale energy products, Wholesale energy market, geographical scope, market participant (legal and natural persons), interaction between REMIT and financial legislation.

Wholesale Energy Products (WEP): Contracts or derivatives concerning natural gas or electricity produced, supplied, traded or delivered in the EU. For example, gas delivered from a foreign country in the EU is under the European legislation.

What? Natural gas, Liquified Natural Gas, Electricity (Contracts or derivatives)

Example of contracts and derivatives: Capacity Remuneration Mechanisms, Power Purchase Agreement, Over-The-Counter contracts.

We do not consider CO2 emission allowances and green certificates as a WEP neither oil and coal.

Who? Producers, large consumers, sellers and buyers

We do not consider electricity and gas supply for final consumer with a consumption under 600 GWh per year as a « Wholesale » energy product. To compute the consumption and compare it to the threshold of 600GWh, we consider a consumption at full capacity during the all period.

Where? Products from the EU, imported in or exported from the EU

When? Any timeframe, intraday to long-term contracts.

Wholesale Energy Markets (WEM): Any market where Wholesale Energy Products previously defined are traded. It encompasses commodity markets and derivative markets because they deeply influence energy markets (and financial markets).

Many markets are encompassed: Balancing markets for the trading of electricity or natural gas, re-dispatching and countertrading mechanisms, intra-day or within-day markets, day-ahead or two-day-ahead, contract markets, physical markets, derivatives markets about production (including financial OTC markets), derivative markets about transportation, generation capacity market and capacity remuneration mechanisms, local flexibility markets…

Geographical scope of REMIT:

Defined by the concept of « Wholesale Energy Product », not by the geographical location of the legal or natural person trading. To illustrate, a foreign (non-EU) trader is under the REMIT scope when working with European WEP. He has to register to the competent NRA and report data to the Agency.

There are 4 criteria regarding the geographical scope of the REMIT:

1. Delivered in the EU (gas or electricity)
2. Produced, traded or delivered in the EU
3. Relating to transportation in the EU
4. Consumption in the EU: for large customers (>600GWh)

Legal and natural persons in REMIT scope:

All REMIT prohibitions and obligations apply to the same array of persons (market participants). There are 6 REMIT obligations and prohibitions:

1. Prohibition of insider trading
2. Obligation to publish inside information
3. Prohibition of market manipulation
4. Obligation to report REMIT data
5. Obligation to register
6. Obligation to notify and have arrangements in order to identify market abuse by persons professionally arranging transactions (PPAT)

Definition of “Market participant” or “MP”: Any person (including TSO) who enters into transactions in a wholesale energy market. They have to register to the competent NRA.

Some examples of MP: Energy trading companies, Producers of electricity or natural gas, shippers of natural gas, balance responsible entities, wholesale customers, final customers (with consumption > 600GWh), TSOs, DSOs, Storage System Operator (SSOs, for gas), LNG System Operator (LSOs, also gas), investment firms.

Interaction between REMIT and the Financial Legislation:

There is a distinction to make between a classic Wholesale Energy Product (WEP) (meaning it is not a financial instrument) and a WEP that is a financial instrument. In the latter case, the regulation is not anymore REMIT (operated by ACER) but the MAR (Market Abuse Regulation – operated by ESMA: European Securities and Market Authorities) and the NRA assessing the case should refer to the competent financial authority.

2) Application of the definition of « inside information »

Definitions of information, reasonable market participant, inside information, Trading plans and strategies.

Definition of « information »:

What do we consider here? Data that should be public (guidelines, network codes), data about capacity and use of facilities for production, storage, consumption or transmission (of electricity or gas), data about how works the markets and more generally any data or facts that a « reasonable market participant » would be likely to use to make is decision. Last criterion encompasses a large-spectrum of elements. Planned but also unplanned events or unavailabilities are concerned.

What is a « reasonable market participant »? We consider a broad range of market participant (beginner to professional) with different strategies (portfolio optimization, arbitrage, speculative). « Reasonable » is related to the use of cognitive elements (by opposition to instinct or mood). There is a test to determine if the market participant is considered reasonable or not.

Definition of « Inside Information »: a two-step approach

To qualify a specific fact an « *inside information »*, there are 2 steps:

3) Is there an item of information in the fact considered? (cf. previous definition of information)
4) If Q1 is proven correct, then there are 4 criteria to verify if it is an inside one:
    a. Is it precise? (Realistic prospect meaning it can happen)
    b. Not public? (Information asymmetries, not simultaneous information)
    c. Related to a WEP? (Directly or indirectly)
    d. Likely to affect prices? (“likely” means “if it could, even if it does not”)

The objective of the REMIT is to protect the integrity and transparency of wholesale energy markets and inside information creates asymmetries of information which jeopardize market participants’ confidence in them.

Trading plans and strategies

Market participant are responsible for transparency. However, trading plans and strategies of any market agent must not be considered as inside information by the NRA. “Trading plans and strategies” means methods of evaluation, market analysis, investments targets and trading decisions.

3) Application of the obligation to disclose « inside information »

Disclosure mechanisms, Inside information platform (IIP), minimum quality requirements, disclosure of inside information in a timely manner

The objective is to guarantee easy and equal access to all. There is a platform for this: Inside Information Platform (IIP). A unique platform allows centralized and standardized disclosures and so an easier access to information for market agents. IIP must be reliable, accessible, effective and handy for both historical and real time data. The platform is not managed by market agents but the latter are responsible for inside information disclosing.

The timing aspect is important here. It is not only about simultaneous, complete and effective public disclosure but also about the timing of it. Indeed, a market agent has to disclose inside information before trading WEP in the concerned wholesale market.

In very specific set of circumstances, a market agent may exceptionally decide to delay a disclosure. In this case, the market agent must not make trading decisions on this inside information and has to notify the NRA and the Agency. These specific circumstances could be linked with "critical infrastructure" or "maintenance of vital societal function, health, safety, security, economic or social well-being of people".

4) Prohibition of insider trading

Insider trading, simple signals and complex types of practices (front-running, double printing), exemptions and specific situations

Insider trading:

Insider trading is the use of an inside information for trading (or trying to trade), or the transmission of an inside information without following the procedure. It can be for one's own account or for the account of a third party, it can be directly or indirectly. NRAs have to evaluate each case in his context. We have 4 types of insider trading:

- Using inside information by trying to acquirer or dispose of WEP
- Using inside information acquiring or disposing of WEP
- Disclosing of inside information not following the procedure
- Recommending or inducing to acquire/dispose of WEP

Moreover, ACER recognizes freedom of press and freedom of expression but highlights the importance of accuracy and credibility of the information disseminated. About the 2nd point (disclosing of inside information), REMIT procedure is of course encouraging the market players to disclose inside information but it has to be done publicly and in an effective and timely manner.

Simple signals: Some indicators exist to detect insider trading. Possible signals can be for example relevant or sudden changes in the traded volume or prices or trading behaviour, suspect profit changes or the lack of compliance with other REMIT obligations on inside information.

Types of practice:

- **Front running or pre-positioning**. Example: PPAT that receives clients orders and take advantage of the information to immediately bid for himself). To detect it, we can analyse the time proximity, the nature of the order, the profit and the occurrence.

- **Double-printing**: several trades when only one is needed. Example: An intermediary (PPAT) gets an order from its client but instead of buying directly for the client in the market, he buys by himself in the market and then sell to his client to capture the price difference. It can be detected with trades of similar prices or quantity.

Scope of the provisions:

Some natural or legal persons are "**insiders**": by the nature of their activity, they possess inside information in relation to a WEP. Of course, these "insiders" are prohibited of insider trading. Here are some examples of insiders:

A. Members of an undertaking (Chief executive officer of an undertaking, TSO/DSO)
B. Persons with holdings in the capital of an undertaking (shareholders)
C. Persons with access to information through the exercise of their activities (PPATs, market participants)
D. Persons who acquired such information through criminal activity (IT hackers, market participant doing industrial espionage

Exemptions:

TSOs have to ensure the reliability, security and efficiency of the system they have to buy ancillary services while they can be considered as "insiders". Between every member state, different market models and TSOs frameworks exist and so it is the role of NRAs to apply the guideline according to their specific operating.

Other exemptions such as the following ones exist:

1- Transactions done in order to respect a contract previously set after an unplanned outage
2- Market participants acting under national emergency rules

5) Prohibitions of market manipulation and attempted market manipulation

Market manipulation or attempted market manipulation, indicators, simple signals and more complex practices, legal and natural persons, scope of the provision and exemptions

Market manipulation or attempted market manipulation:

The objective here is to give a guidance for NRAs about practices that could influence the market. If there is a likely effect or real effect, it is considered as market manipulation. If it is only an intention, it is considered as "attempted market manipulation". These practices can be "on-market" or "off-market" and on purpose or not by a market agent. As a consequence, REMIT does not necessitate the examination of the agent's state of mind to analyse a case of market manipulation.

ACER defines several practices, listed in 4 categories:

a. Giving false or misleading signals

On-market practice. Giving/likely to give/intend to give false or misleading signals can lead other agents to make wrong decisions, to mistrust market integrity. It can also diminish liquidity of the market and cloud price signals. The NRA has to identify orders at price level that are uneconomical or which do not reflect real buying or selling interest.

Example: high frequency trading (algorithms introducing and cancelling large number of orders, speculative trading).

What to analyse with orders likely to give false signals: circumstances, characteristics of the orders, size, price, timing and occurrence.

b. Securing an artificial price

On-market practice. Setting the price of a WEP at a certain level. Artificial means that the resulting price deviates (higher or lower) from the price that would have resulted in a competitive market between supply and demand.

Example: MP A has a long-term contract indexed on the market price with MP C. MP A agreed with MP B agreed on a transaction to increase the market price. By doing this, they increase the market price and so MP A's revenue from its long-term contract. This type of practice is only possible in the intraday market, not in the day-ahead because of the different operations between both markets.

c. Using fictitious devices/deception/contrivance

On-market practice. The use of a fictious device, deception or contrivance to make a transaction or an order which gives (or is likely to give/intend to give) false or misleading signals is considered as market manipulation.

d. Disseminating false or misleading information

Off-market practice. The dissemination of false or misleading information can be done by any mean (internet, rumours, media…).

Indicators of market manipulation and types of practice

Some signals can help the NRA to analyse market behaviour and identify manipulation practices. For example: are transactions leading to a significant change in price, what is the buying or selling position of the market agent, are transactions made in a short time span?

Some types of practice are listed in the REMIT. It is a non-exhaustive list which objective is to support NRAs in their task, giving them a starting point to work on.

Manipulation practices are not exposed here because each practice will be explained in detail next chapter.

Scope of the provision and exemptions

This part of the REMIT is of course addressed to market participant but not only. We can also consider legal or natural persons that manage physical assets, public authorities, PPAT… As long as dissemination of information can be considered as market manipulation, any legal or natural persons providing information should also be considered.

Algorithmic trading being more and more used, NRAs should also consider that the algorithms and its conception fall into the scope of REMIT.

Finally, the application of the REMIT is not challenging the European competition law, which remains and covers same breaches and other ones.

Market manipulations must be studied by the NRAs and some could be considered as “Accepted Market Practices” (AMPs) as it is done in financial markets under the MAR (Market Abuse Regulation). The agency provides a non-exhaustive list of factors that NRAs can take into consideration.

6) Registration of market participant

Market agent's registration process and NRAs role

Any person (legal or natural) which is a market participant has to register to the competent NRA. To do so, the market agent has to provide accurate data about him but also natural persons linked, ultimate controller, corporate structure and delegated parties. The Market agent is responsible for its data updating in any case of change.

Given that the process is a national one, the NRA must establish a registration system, transmit the information to the agency and guarantee the data accuracy. Then the agency provides a unique identifier (the ACER Code) to every market participant and establishes a European register that can be completed by the market agent. The agency is developing a European register supported by a Registration User Manual (RUM) that could be used directly by NRAs as the national register system.

A market agent could be present in more than one member state and would have then to register in the Member State where they have primary establishment. A foreign market participant can choose between the Member States where they are active in which Member State to establish.

7) Application of the obligations of PPATs

PPATs, notification of breaches, arrangements and procedures to identify breaches, organisational structure

PPATs stands for Persons Professionally Arranging Transactions. It means any natural or legal person arranging transactions as a normal and regular paid occupation. Arranging transactions means to enable or assist third parties in participating in the wholesale market, provide a facility to enter in transaction or more generally to play an intermediary role. By playing these roles of intermediates, they have exclusive knowledge on the market. Trading matching system (TMS) and organised market place (OMP) are considered PPATs.

Examples of selected entities: Energy exchanges, Broker platforms and brokers, cross-border capacity exchanges/platforms, Secondary capacity allocation platform, TSOs.

There is a distinction in REMIT between a PPAT and a market participant but one person can be a market participant in a transaction and a PPAT in another one. Moreover, some transactions can be done without PPAT or with several ones.

Notification of potential breaches

PPATs have a duty to notify potential breaches caused by suspect transactions with a Suspicious Transaction Report (STR) and should perform market surveillance routinely.

What to notify? Suspicious Transactions Report describes the type of market abuse, details of the notifying party, a description of the potential breach, reasons for suspecting a breach, identifications of persons involved and notified parties and further available information.

Whom to notify? NRAs concerned and eventually financial authorities if the WEP in question is also a financial product.

When to notify? The timeline is crucial to collect evidence and logically, PPATs should notify "Without further delay" any suspicious case. In concrete terms, the notification should not be more than 4 weeks later the occurrence. It seems sufficient to confirm consolidated reasons to notify and to produce a relevant STR.

How? The Agency has established a platform. NRAs can also establish their own one.

PPATs' Market surveillance of potential breaches

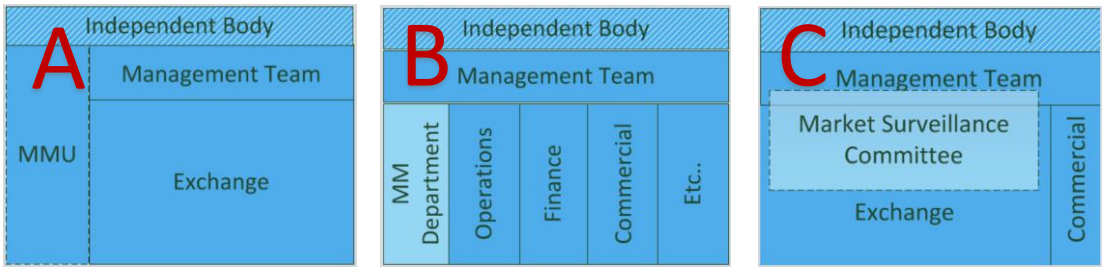
PPATs have to establish and maintain effective arrangements and procedures to identify breaches. NRAs should expect from PPATs a proactive approach in market surveillance rather than only the notification of breaches. A well-designed organisational arrangement must guarantee independency, integrity and efficiency in the market surveillance and avoid conflict of interests.

However, "PPATs" encompass a large-spectrum of agents with several sizes, characteristics and playing in different Wholesale Energy Markets. Each one has to use relevant organisational arrangements to fulfil market surveillance.

Example of corporate conflicts and conflicts of interests in the company: The market surveillance team member identifies and wants to report a breach but the management team doesn't want to for commercial reason.

In order to avoid this kind of situation, different governance structures are possible:

A. Market Monitoring Unit: the monitoring is separated from the PPAT activities and does not refer to the management team.
B. Market Monitoring Department: the market surveillance team operates as any other department and reports to the management team.
C. Market Monitoring Committee: this model consists in experts from different departments of the PPAT.



Whatever the governance structure is, a proper organisation of the market surveillance is needed to detect market abuse. Five dimensions are pivotal issues here:

1) Adequacy of resources (depending of the PPAT's size): human resource, data and analytical tools available
2) Human resources policy: independence and integrity of the team to avoid conflicts of interest at individual level
3) Dedicated market surveillance team: one team specifically assigned (Chinese wall)
4) Communication with other units
5) Confidentiality

PPAT's employees working outside the market surveillance team should be aware of their mission and furthermore they should be able to report them a potential breach. PPATs have to establish a monitoring strategy and to be able to defend it. The level of automation of the system generating alerts should be appropriate to its activity. They must also guarantee traceability because NRAs could request information related to market monitoring for a period of at least 5 years.

8) REMIT compliance and penalty regimes

Market participant should develop a compliance regime towards disclosure of inside information, obligations and prohibitions of REMIT thanks to compliance practices. NRAs should analyse PPATs' practices considering their size and trading capacity.

Penalties applicable due to infringements of REMIT is a nation scale issue. Member States should have laid down the rules on penalty regime.

Chapter 2: Description of each manipulation practices and examples

Introduction

In this chapter we focus on the 20 manipulation practices listed by ACER in the 6th Guidance of the REMIT in the section "*Types of practice of (attempted) market manipulation through (attempting to give) giving false or misleading signals and/or securing the price at an artificial level*", pages 88 to 90. The objective of the chapter is to explain each manipulation and provide examples of infringement if there are some. These practices are quite briefly described in ACER´s document and we will do our best to clarify them.

a) Wash trade

Definition from REMIT: *entering into arrangements for the sale or purchase of a wholesale energy product where there is no change in beneficial interests or market risk, or where beneficial interest or market risk is transferred between parties who are acting in concert or collusion.*

In other words, a wash trade is when a single agent (or parties in concert or collusion) makes simultaneously a same or similar sell offer and buy offer. It is artificially increasing the volume exchanged and sends wrong signals because the price of the transaction can be quite different from the reference price. This manipulation is present only in the intraday continuous market.

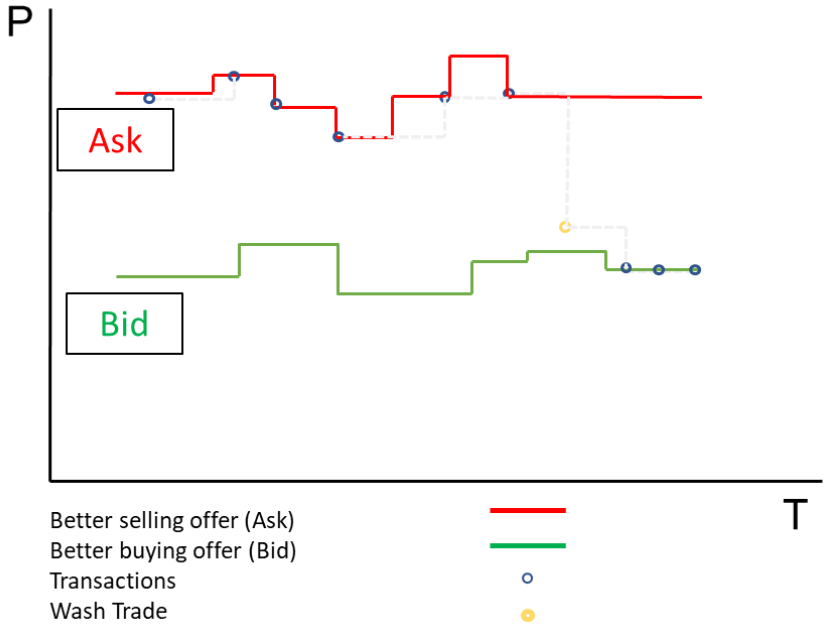


Illustration of wash trade

Transactions were initially made at the price of the better selling offer with attacks from the bid side, but then a wash trade is done at a price close to the better buying offer price. It sends a signal and influences next transactions' prices which are now made at the better buying offer price.

The case of a PPAT doing a transaction between two of its clients, one buyer and one seller, draws particular attention. The transaction price must be watched carefully with respect to the price gap between the ask and the bid best offers.

Why some agents could use it?

- To artificially increase the volume of sells (wrong signals for other participants)
- To create an illusion of liquidity and activity in the market
- To generate a commission to indirectly remunerate a broker (cf next manipulation practice: pre-arranged trading)

Wash trade is a common manipulation practice and ACER published a specific guidance note for this type of manipulation practice: *GUIDANCE NOTE 1/2017 - ON THE APPLICATION OF ARTICLE 5 OF REMIT ON THE PROHIBITION OF MARKET MANIPULATION WASH TRADES 1st Edition*.

Mathematical formulation and quantitative parameters: to monitor this type of transactions, the parameter must take into considerations volume of transactions. For example, in each session (hour) of the continuous intraday market, the volume traded is between 100 MWh and 1 GWh. An alarm can be set if a transaction is set at an unusual price for a certain volume. This volume can be indexed on the price gap between the reference and the transaction price.

b) Pre-arranged trading

Definition from REMIT: *entering into arrangements for the sale or purchase of a wholesale energy product where the transfer of beneficial interest or market risk is only between parties who are acting in concert or collusion.*

Pre-arranged trading when there is a previous agreement to the transaction between two market players. Pre-arranged trading can be linked with other manipulation practices. For example, a wash trade can be also a pre-arranged trading as explained in the Guidance on wash trade.

This practice is present in the continuous market but not in the day-ahead neither in the intraday by auctions because the market is closed with a clearing. This operation avoids some manipulations as this one because agents cannot realize transactions in concert or collusion.

To monitor this, we can use a "heat map" graphic with buyers and sellers on each axis. This is efficient to explicit which couple of agents enter a lot into transactions and could be in concert or collusion.

c) Phishing

Definition from REMIT: *executing orders to trade, or a series of orders to trade, in order to uncover orders of other participants, and then entering an order to trade to take advantage of the obtained information.*

This manipulation practice is a two-step process. Firstly, the agent executes small orders to uncover others' orders and obtain information and secondly, the agent enter an order taking advantage of it. This practice is present in the continuous market.

Price	T1	T2	T3	T4	T5
70	50	50	50	50	50
69	50	50	50	50	50
68		5!			
67		2!			
66		2!			
65	20	2! 20		18! 18	
64	10	10	10	10	40
63	40	40	40	40	40
62	50	50	50	50	50

Table illustration - Ask in Red, Bid in green, orders from MPA with a "!"

d) Layering

Definition from REMIT: *issuing multiple non-genuine orders to trade at different price levels (layers) on one side of the order book, in order to enter into one or multiple transactions on the other side of the order book.*

In other words, the idea is to make others agents believe an evolution of the market in a direction and then take advantage of it. To create this illusion of market evolution, an increase of offers on the demand side will lead to a price increase and an increase of offers on the seller side will lead to a price decrease. This practice is present in the continuous market.

Layering is a particular case of spoofing. The illusion of market evolution is created by publishing small offers at the better price (idea of superposition or stratification). They are not expected to be accepted but only to influence other bidder from the same side of the order book to outbid.

ACER published a specific guideline for this practice: *GUIDANCE NOTE 1/2019 - LAYERING AND SPOOFING*

	ORDER QUANTITY in MW in TIME SEQUENCE T1 to T7						
PRICE euro/MWh	T1	T2	T3	T4	T5	T6	T7
28	400	400					
27		200!	200!	200!	200!	200!	
26		100!	100!	100!	100!	100!	
25			400	400			
24				50!	50!	50!	
23				20!	20!	20!	
22					400	300! 400	100
21	100	100	100	100	100	100	100

Legend: Bid orders in green and underlined; Ask orders in red; Orders from MP A represented with a "!".

Table from the guidance - MP A wants to reduce the spread to buy to MP B and uses layering

Two examples of REMIT breaches and enforcement decisions on layering:

- NRA: CNMC (Spain) – Company: Rock Trade Center [8]
- NRA: CRE (France) – Company: VITOL [9]

e) Spoofing

Definition from REMIT: *issuing a single large or multiple non-genuine order at the same price level on one side of the order book, in order to enter into one or multiple transactions on the other side of the order book.*

As for layering, the idea is to make an illusion of a stronger will to buy or sell in one side of the order book to enter in transaction on the other side of the order book. Unlike layering, the apparently stronger will to buy on one side of the order book is created without bidding more competitive offers but simply by increasing the activity and posting similar offers, as it is done in the illustrative table below.

This practice is present in the continuous market.

ACER published a specific guideline for this practice: *GUIDANCE NOTE 1/2019 - LAYERING AND SPOOFING* [10]

Figure 2 – Chronological representation of the order book

	ORDER QUANTITY in MWh/h in TIME SEQUENCE T1 to T5				
PRICE euro/MWh	**T1**	**T2**	**T3**	**T4**	**T5**
27	50	50	50	50	50
26	50	50	50	50	50
25			**!50**	**!50** 50	
24					
23	50	50	50	50	50
22		**!200**	**!200**	**!200**	
21	50	50	50	50	50

Legend: Bid orders in green and underlined; Ask orders in red; Orders from MP A represented with a "!".

Table from the guidance - MP! wants to reduce the spread to sell to MP B and uses spoofing

f) Creating a floor or a ceiling in the price pattern

Definition from REMIT: *transactions or orders to trade carried out in such a way that obstacles are created to the wholesale energy products, with prices falling below or rising above a certain level, mainly in order to avoid negative consequences deriving from changes in the price.*

The concept is to block the price at an artificial level (down with a floor for a seller or high with a ceiling for a buyer). This do not allow the price formation and create a price distortion for the session concerned. The result is a non-competitive session. It requires a sufficient market power. A bid offer can create a floor (minimum price) while an ask offer can create a ceiling (maximum price).

It is more likely to be done in the intraday continuous market but could also be done in other markets. Let's use an example to explain it:

Illustration of creating a floor in the price pattern

An agent "i" from the bid side has a strong capacity to buy. He is bidding (Qi; Pi) which is the most competitive offer for a large quantity at the opening of the continuous market session. No transactions will be done at a lower price. Its bid creates a price floor at the opening of the continuous.

g) Painting the tape

Definition from REMIT: *other forms of entering orders to trade or engaging in a transaction or series of transactions which are shown on a public display facility to give the impression of activity or price movement in a wholesale energy product.*

Painting the tape means to give the impression of activity in the market by making transactions or publishing offers and canceling it. It can be linked with wash trades. One way to monitor this type of practice is to give attention to unexecuted trades and ratios of offers accepted, cancelled or rejected compared to the number of offers published. After this first-step analysis, the challenge for this practice monitoring is then to prove that there is no intention to trade. This practice is present in the continuous market.

h) Momentum ignition

Definition from REMIT: *entering orders to trade or a series of orders to trade, or executing transactions or series of transactions, likely to start or exacerbate a trend and to encourage other participants to accelerate or extend the trend in order to create an opportunity to close out or open a position at a favourable price.*

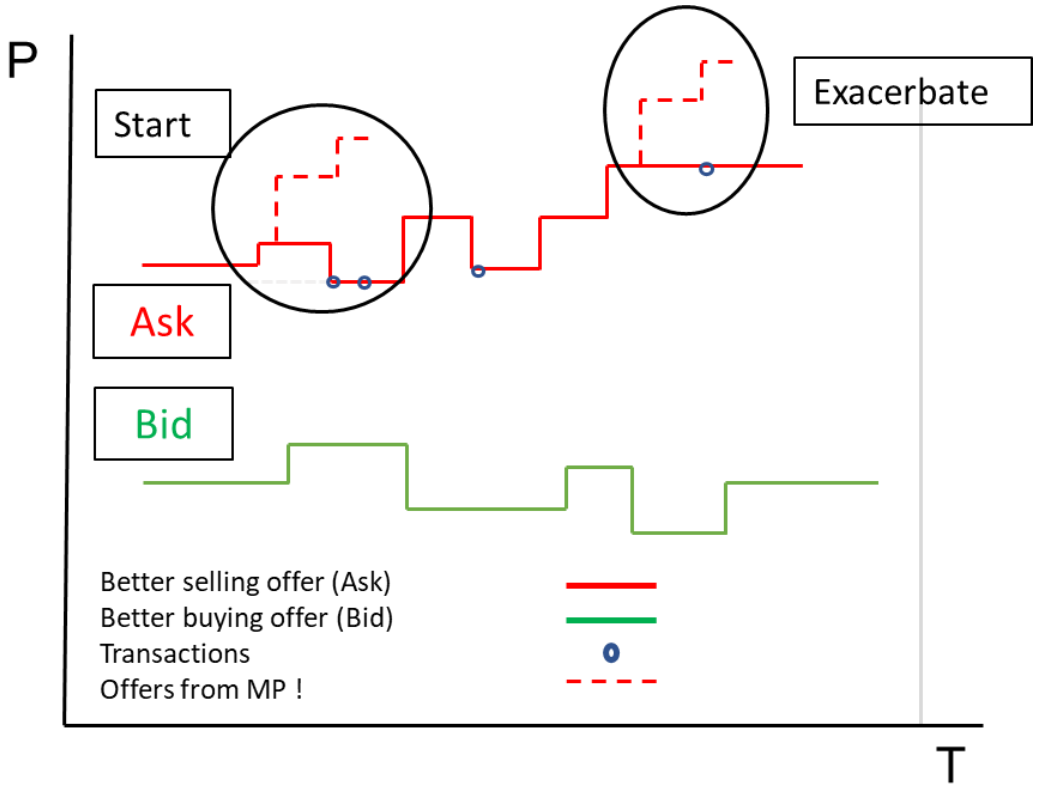


Illustration of Momentum ignition – An agent trying to start or exacerbate a trend

An agent is making offers in order to start or exacerbate a trend in the market. This practice is present in the continuous market. The use of layering practices can be perceived as a momentum ignition and agents with more market power (which do not always correspond to agents with more capacity) are more likely to use this practice.

In the analysis of this practice, simple tools like ratio may not be sufficient because it is necessary to understand first the initial state of the market (stationary or with an appearing trend) and then to consider the influence of one agent and its orders in the evolution of the market.

i) Quote stuffing

Definition from REMIT: *entering a large number of orders to trade and/or cancellations and/or updates to orders to trade so as to create uncertainty for other participants, slowing down their process, and/or to camouflage one's own strategy.*

The idea with this manipulation practice is to confuse the other agents and to put up a smokescreen on your strategy using a profusion of orders to trade. This practice is present in the continuous market.

For the mathematical formulation and monitoring, it requires to focus on the number and volume of offers accepted and erased with respect to the total capacity of the agent. It matters here to take into consideration the profile of the market player. A market player who has a large portfolio capacity and uses to achieve significant transactions is unlikely to offer a tremendous number of small offers, out of his usual range of offers.

j) Advancing the bid

Definition from REMIT: *entering orders to trade which increase the bid (or decrease the offer) for wholesale energy products, in order to increase (or decrease) its price.*

It consists in increasing the bid to increase the price or decrease the offer to decrease the price. This practice is present in the continuous market and can be linked with "h) momentum ignition".

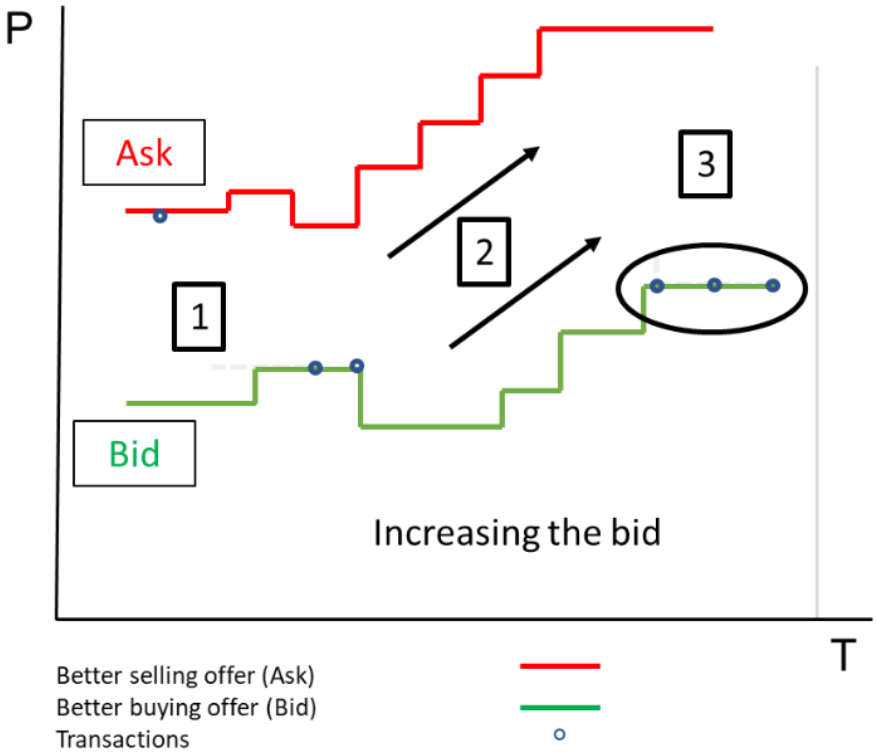


Illustration of increasing the bid with a simplistic representation

Three steps are needed to describe the manipulation presented in the example above.

- Step 1: market in its initial state
- Step 2: Increase of the better ask price, quickly followed by the bid side
- Step 3: transactions influenced and done at a higher price than in step1

To be effective, the manipulation of entering orders to increase the bid has to be follow by other agents to provoke an evolution of the best bid offer as represented in the illustration. If it is not followed by other agents, no evolution of better bid or ask will be observed. It is then more comparable to manipulation h) "Momentum ignition".

k) Smoking

Definition from REMIT: *posting orders to trade to attract other market participants employing traditional trading techniques ('slow traders') and then rapidly revising the orders onto less generous terms in the hopes of executing profitably against the incoming flow of 'slow trader' orders to trade.*

In other words, smoking is publishing some generous offers using "slow-trading" to attract "slow traders" and then rapidly revising the offers on less generous terms to take advantage of the new "slow traders". Temporality plays a key role here. This manipulation is present in the continuous market.

For the monitoring, it is necessary to detect change in the rhythm of offers.

A first alarm could be based on time distribution between two consecutive offers of a market player, with the objective to identify the combined use of "slow trading" and quick offers.

A second alarm must be related to the price difference between two consecutive offers with a first slow trading offer and a second quickly modified offer.

l) Erroneous orders

Definition from REMIT: *unintentionally placing orders or entering into transactions that send false or misleading signals regarding supply, demand or price of a wholesale energy product.*

This manipulation is not done on purpose by a market player but can have consequences by sending misleading signals and influence the price.

This practice is present in the continuous market where other agents can see in real time other offers' price and quantity (but not the associated market player). Erroneous orders may also exist in day-ahead and intraday by auctions markets. However, with such sealed-bid auctions, other agents cannot see other agents' offers so it is not influencing them neither sending misleading signals. Then, the clearing is rejecting offers out of the market and erroneous orders accepted would not have much consequences on the price formation thanks to the pay-as-clear approach.

To detect a mistake of a trader, it is necessary to analyse the order of magnitude of the offer and compare it with reference values (q, p) of the session to see if it is out of an expected range with the use of thresholds. Expected range for quantity seems more complex because the quantity you may have to adjust in the intraday market (adjustment market) can be low if you have almost nothing to adjust or high if you have a big damage.

m) Placing orders with no intention of executing them

Definition from REMIT: *issuing order(s) to trade, without an interest in their individual execution (the orders may be withdrawn before the execution or even executed), which are likely to give misleading signals as to the supply of or demand or price for wholesale energy products or likely to secure the price at an artificial level.*

This manipulation is present in the continuous market.

We have concrete examples of this manipulation with a sanction decision:

- Bnetz (German NRA), Company Optimax Energy GmbH [11]
- Bnetz (German NRA), Company Energi Danmark [11]

Both companies sold energy that was not available. These two cases highlight a specific situation with a high risk of manipulation: when the intraday market prices are especially high and are expected to be higher than balancing energy prices, agents are tempted to offer energy they don't have because they would sell this energy at a higher price than the cost they will have to pay after for balancing energy.

n) Marking the reference period

Definition from REMIT: *entering into orders to trade or executing transactions on a wholesale energy product at a reference time of the trading session (e.g. marking the closing, the opening, the settlement) in an effort to increase, decrease or maintain the reference price (e.g. closing price, opening price, settlement price) at a specific level. This practice may take place on any individual trading day, but also on specific dates such as future/option expiry dates or quarterly/annual portfolio or index reference/valuation points.*

Some products as long-term contracts are indexed on the spot market prices. For example, the indexation can be set on the ultimate transaction of one session because it is the closest to the real time and so the more precise, the one that reflects with the best accuracy the state of the market.

As a consequence, some market players may have an interest in making the ultimate transaction of the session to influence its price. It is called "marking the close". This will have an influence on their other products price because of the indexation. This practice is present in the continuous market. Two examples to illustrate this:

- CNMC – Rock trading World – Marking the close [8]
- Gas retailer in Lithuania: At the end of every period, the agent (a gas retailer) used to place bid offers (offers to buy) at a higher price than the reference price of the period (and a minimum volume). Their objective was to increase the period last transaction's price because they had retail contracts indexed on this price. The transaction was generous in term of price but done for a small quantity and didn't represent a heavy cost for the company. [12]

o) Distort costs associated with a commodity contract

Definition from REMIT: *entering into arrangements in order to distort costs associated with a wholesale energy product, such as storage or transportation, with the effect of fixing the settlement price of a financial instrument or a related wholesale energy product at an artificial level of price.*

The idea of this manipulation is to influence some costs composing the price of a product in order to influence it. In the case of gas, it can be done with transmission or storage for example. This manipulation is dealing with gas products more than with electricity products.

"Entering into arrangements" is not quantitatively easy to represent and may require to have access to communication data between agents.

p) Abusive squeeze (or "market cornering")

Definition from REMIT: *this involves one or more natural/legal persons with a significant influence over the supply, demand, or delivery mechanism for a wholesale energy product and/or the underlying product of a derivative contract exploiting this influence in a way that distorts, or is likely to distort, the price at which others have to deliver, take delivery or defer delivery of the product in order to satisfy their obligations. It should be noted that the proper interaction of supply and demand can, and often does, lead to market tightness, but this in itself is not market manipulation, nor does having a significant influence over the supply, demand, or delivery mechanisms for a wholesale energy product by itself constitute market manipulation.*

An agent who has sufficient market power (a lot of market shares for example) can exercise market cornering and distort costs. The issue here is not market power but the use of it. It is not always a matter of installed capacity and market shares. One unit with a small capacity can have market power because of its strategic position as "Peaker" or its ability to provide flexibility.

For example, if a hydro reservoir decided not to produce while the estimated water value is lower than the market price, it is provoking a price increase because the next unit in the merit order (a more expensive one) will be committed.

This manipulation practice can be present in all of the three markets: day-ahead, intraday by auctions and intraday continuous. It can be linked with withhold generation capacity.

To analyse market cornering, it is possible to use existing indexes such as the Herfindahl-Hirschman Index (HHI) which provides information on market tightness.

HHI index (Herfindahl-Hirschman):

$$HHI = 10.000 * \sum_i s_i^2 \qquad With\ s_i: market\ shares\ of\ company\ i$$

$$HHI < 1000 : enough\ competition \qquad HHI > 1800 : lack\ of\ competition$$

q) Cross-product manipulation

Definition from REMIT: *undertaking trading or entering orders to trade on one wholesale energy product (including entering indications of interest) with a view to improperly influence the price of another (usually related) product. An example might be trading in the underlying wholesale energy product to distort the price of the derivative contract, or trading on the day-ahead/intraday market to influence the balancing market. Another example might be entering into arrangements in order to distort costs associated with a wholesale energy product, such as the transportation cost, with the effect of fixing the price of a wholesale energy product at an abnormal or artificial level.*

The idea is to make transactions on one product in order to influence transactions related to another product. It rests on the complementarity of different products, links or indexations. It may for example rest on links between long-term contracts and spot markets. It can also be linked with "marking the period" and we can evoke the previous example of a Lithuanian gas retailer who used to mark the close.

r) Cross-venue manipulation

Definition from REMIT: *undertaking trading or entering orders to trade through one PPAT or bilaterally (including entering indications of interest) with a view to improperly influence the price of the same wholesale energy product in another PPAT or on another bilateral contract.*

The difference with the previous manipulation (Cross-product manipulation) is that the transactions here are made on one product in order to influence other transactions of the same product.

s) Transmission capacity hoarding

Definition from REMIT: *this practice involves (i) the acquisition of all or part of the available transmission capacity (ii) without using it or without using it effectively.*

To explain this practice, it is necessary to give some complementary definitions on transfer capacity and interconnexion capacity allocation.

ATC and NTC definitions:

Net Transfer Capacity (NTC) is the maximum transfer capacity from a system A to a system B. To compute NTC, the TSO first computes the Total Transfer Capacity (TTC) with considering thermal limits, voltage limits and stability limits and secondly subtracts Transmission Reliability Margin (TRM) due to uncertainties.

So, we have: NTC = TTC - TRM

Available Transfer Capacity (ATC) is the transfer capacity remaining between two systems above already committed utilisation of the interconnexion. To compute, ATC is the NTC minus the Notified Transmission Flow (NTF) which is the already occupied part of NTC by the already accepted contracts at the studied time frame. So, we have ATC = NTC – NTF

As a consequence, we can have ATC (A to B) > NTC (A to B) if NTF (A to B) is negative, meaning that B is currently importing to A.

Explanation and interpretation:

ACER published a specific guideline for this practice: GUIDANCE NOTE 1/2018 - TRANSMISSION CAPACITY HOARDING [13]

This manipulation is when a market player buys the available transmission capacity between two zones but doesn't take advantage of the interconnexion. The consequence is a decoupling of the two zones and the appearance of a price spread (market splitting). This practice jeopardizes the use of interconnexion and following economically efficient outcomes. Then, some market players can take advantage of the decoupling and the social welfare is impacted.

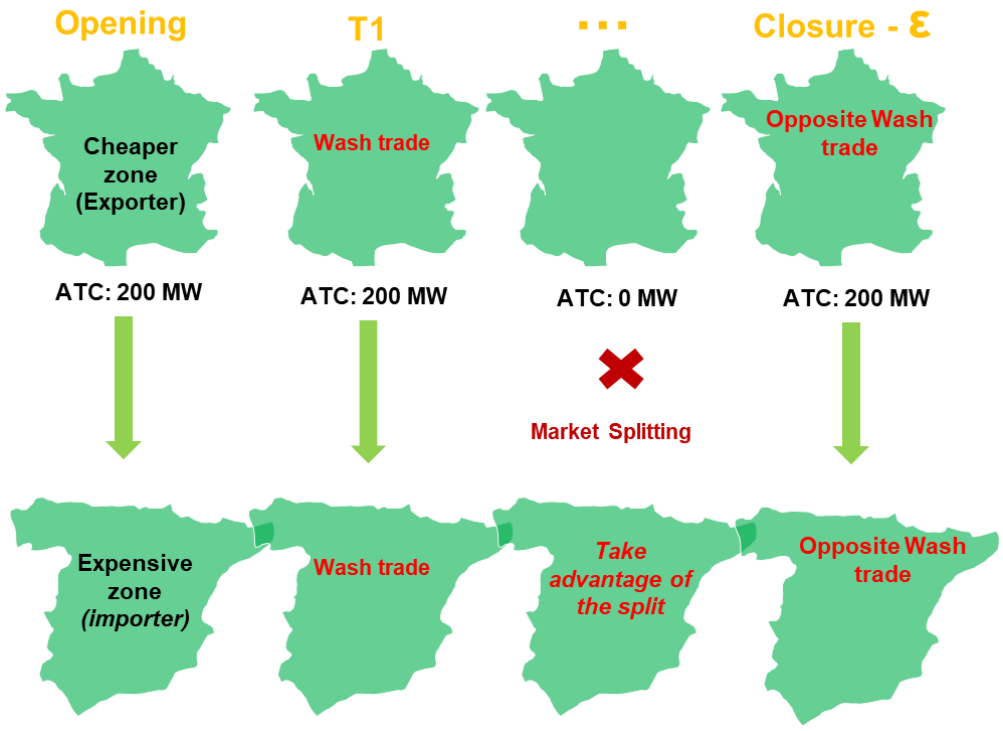
Implicit and explicit capacity allocation:

Here it matters to differentiate **implicit** and **explicit** capacity allocation: With the implicit capacity allocation, when the agent buys contracts for electricity supply between two bidding zones, it implicitly contains the ATC needed to deliver the electricity from a

bidding zone to the other. Energy and transfer capacity are bought simultaneously. With the explicit capacity allocation, ATC and energy are unbundled and bought separately.

How to do manipulations in each case?

With the implicit capacity allocation, the manipulation can be done in the continuous market. It is first a wash trade selling from A to B and hoard the ATC(A→B) and later (at the end of the trading session) the opposite wash trade from B to A to annihilate the transaction. The time span between the two wash trades is fundamental, it stops other agents from using the interconnexion until the end of the session. This manipulation is possible in the continuous market which works with implicit capacity allocations.



Transmission capacity hoarding in continuous market with two wash trades

With the explicit capacity allocation, it is the same concept but instead of doing wash trades of {energy supply + correspondent transfer capacity} it only contains {transfer capacity}. Once again, the time span between both transactions is crucial to measure the impact on other market players.

A concrete example of this manipulation:

- Energi Danmark: With 2 wash trades, one at the opening of a session and one at the end, affected the efficient use of the transmission capacity by other agents [14]

t) Capacity withholding and electricity generation capacity withholding

Definition from REMIT: *when a market participant with the relative ability to influence the price or the interplay of supply and demand of a wholesale energy product, decides, without justification, not to offer or to economically withhold the available production, storage or transportation capacity on the market. This includes the undue limiting of infrastructure or transmission capacities, resulting in prices that likely do not reflect the fair and competitive interplay of supply and demand.*

In particular, electricity generation capacity withholding refers to the practice of keeping available generation capacity from being competitively offered on the wholesale electricity market, even though offering it competitively would lead to profitable transactions at the prevailing market prices.

This manipulation can be present in the 3 markets. In the day-ahead market you have the obligation to offer all your available capacity.

Capacity withholding with transmission: a system operator could have an interest in reducing the interconnexion capacity in order to create a market splitting and generate congestion rents.

Electricity generation capacity withholding: An agent with a large panel of units may have an interest to not bid one of his units in order to increase the marginal price and so increase the revenues of his other units committed.

Capacity withholding can be of two types: physical capacity withholding which means not offering the capacity available at any price or economic capacity withholding which means offering the capacity at prices that do not reflect the marginal cost or opportunity cost.

Chapter 3: Mathematical formulation of tools to monitor manipulation practices

Introduction

In this part we focus on the monitoring of the manipulation practices previously described. Six of them will not be analysed: we decided to focus on the other 14 whose analysis was more accessible and more linked with the continuous market. The six are *b) pre-arranged trading, l) Erroneous orders, n) Marking the reference period, o) distort costs associated with a commodity contract, q) Cross-product manipulation and r) cross-venue manipulation*. For the fourteen other manipulation, we present and describe tools that can be implemented. Then we identify the more relevant tools and develop them in priority. The analysis mainly focuses on the continuous market because manipulation practices are mostly present on this market.

Manipulations listed by ACER are a description of types of practice. Thanks to the work done chapter 2 where we try to understand each manipulation and the reasoning of the new guidance of the REMIT, we identify what are the key parameters to monitor. In this chapter, we establish a mathematical formulation of tools to monitor these parameters. It is a theoretical definition of monitoring indexes and tools to monitor strange behaviours and abnormal results.

When dealing with monitoring these practices, the process is to develop and use tools more than to focus on each manipulation one by one. In few words, the approach will be more tool-based than practice-based.

In the first part « Definition of tools », the aim is to create a « library » of tools, instruments and criterions. Then, the second part illustrates the method of picking up tools from the library to combine them and build protocols to monitor market data. A graphical synthesis of different tools combination is presented. It highlights which tools are mostly used and must be developed in priority. It is a transition from this theoretical chapter to chapter 4, which is an application on tools implementation and data analysis.

Table of contents of chapter 3:

I. Definition of the tools

List of tools:

- Ratios: Ratios on cardinal number (#) of offers accepted, Ratios on weighted-average quantity (q) of offers accepted, Ratios on cardinal number (#) of offers partially accepted and then cancelled by user, ratios on the opening or closing of the session
- Net results, Net results comparing the opening and closing of the session
- Activity on both side: simple Boolean and Boolean on minimum percentage and minimum number of offers on both sides
- Price level with respect to reference prices: comparison to a weighted-average, comparison to an interval around the weighted-average price, agents´ statistics on their offers price level, price distribution, price comparison to the Bid/Ask spread
- Economic impact: impact of an offer or transaction, impact on the net results
- Chronology: Graphical evolution of transaction prices with chronology, time span between transactions on both sides
- Indexes to measure market tightness (ex-ante approach)

Ratios

In the continuous market many offers are published but then many outcomes are possible. The offer can be matched (which means accepted) completely, partially or not at all, it can be cancelled by the user or even partially matched and then cancelled. Ratios of offers accepted, cancelled, or partially accepted are indicators on every agent's behaviour and a tool to look for manipulation practices.

Different parameters are possible to build these ratios. They can be based on cardinal number of offers or weighted-average quantity. In the latter case, small quantity offers are less considered thanks to the weighted-average method. The ratios can be based on different time scales: one single session or several ones, day by day or even for the entire week. We can compute them considering each agent one by one or all agents. It is also possible to enter more in detail and consider offer units instead of agents. With offer unit approach, the analysis can be more sophisticated by discriminating the results according to the type of technology.

These ratios depend on agents' trading method and the state of the market on a specific situation. It is useful to establish ratios of reference in order to put in perspective ratios values. To do so, it is necessary to define benchmark period.

It is also relevant to study these ratios on a specific window of the session such as the opening or the closing of the session because it is more likely to be manipulated. Indeed, an agent may want to send misleading price signals at the opening of continuous trading to immediately alter the price formation for the whole session and profit from this distortion, or at the closing to take advantage of an indexation of long-term contracts on the last transaction made on intraday markets for example. In concrete terms, it is possible to analyse the first X minutes and/or last X minutes.

Ratios on cardinal number (#) of offers accepted

Ratio of offers accepted on a cardinal number basis (#) for a Market Player "i" during session u

$$R_{a,\#}(MP_i\ , u) = \frac{\#accepted}{\#total}$$

$\#accepted$: number of offers from agent i during session u that enter into transaction (partially or completely)

$\#total$: total number of offers of the agent i during session u

Variant: It could also be done on another time frame (several sessions, one day, one week) or considering another "candidate" (all agents or on the contrary one offer unit of one agent). The following examples illustrate this:

- $R_{a,\#}(MP^*\ , u9\ to\ u12) = \frac{\#accepted}{\#total}$: ratio for all agents during session 9 to session 12
- $R_{a,\#}\big(SU_j, MP_i\ , day\ x\big) = \frac{\#accepted}{\#total}$: ratio for one offer unit j of a market player i during all the day x

Ratios on weighted-average quantity (q) of offers accepted

Ratios of offers accepted on a weighted-average quantity basis (q) for a market player i (MPi) during session u (all market players).

$$R_{a,q}(MP_i, u) = \frac{Q\ accepted}{Q\ total}$$

$Q\ accepted$: quantity matched from "agent i" ´s offers during session u. It can be with partial match or total match.

$Q\ total$: total quantity offered by agent i during session u

Ratios on cardinal number (#) of offers partially accepted and then cancelled by user

Ratio of offers accepted and then cancelled by user on a cardinal number basis (#) for a Market Player i (MPi) during session u

$$R_{a,\#}(MP_i\ , u) = \frac{\#accepted\ then\ cancelled}{\#total}$$

$\#accepted\ then\ cancelled$: number of offers from agent i during session u that enter into transaction partially and are then cancelled by the market player himself.

$\#total$: total number of offers of the agent i during session u

This tool is quite specific. If the ratio is high, it means that this behaviour is quite used and it must trigger our attention.

An extra-tool: Ratios on the opening or closing of the session

We keep looking at the offers results but focusing on a specific moment of the session (opening or closing). As it is done before, ratios can be based on cardinal numerous of offers or quantity-weighted.

Let's take two examples:

1) *Ratio of offers accepted on a weighted-average quantity basis (q) for a session u and market player "i", focusing on the last hour (noted "-3600" in the ratio indices).*

$$R_{a,q,-3600}(MP_i\ , u) = \frac{Q\ accepted}{Q\ total}$$

This ratio could be used to analyse the behaviour of an agent in the "money time" (last moments before the closing), to see if he is strongly releasing all the trades he did during the session, potentially after giving misleading information or having used transfer capacity hoarding.

2) *Ratio of offers cancelled on a cardinal number basis (#) for a session u and market player "i", focusing on the first hour (noted "+3600" in the ratio indices).*

$$R_{can,\#,+3600}(MP_i\ , u) = \frac{\#cancelled}{\#total}$$

This ratio could be used to detect agents trying to give the impression of activity using the manipulation "painting the tape" (manipulation g). Next step would be to study chronology and more especially time span between offers publications and cancellations but also offers prices with respect to price references.

Net results:

This tool aims at computing for an agent i during session u the energy bought, sold, the money spent and earned, the net assessment for energy and money. It allows to see each agent strategy, if they are mostly bidding to sell energy as a generator, trading in both sides of the orderbook or mostly buying.

Let:

$Q_{sell}(j,i,u)$: $Quantity\ accepted\ of\ sell\ offer$ "j" $ofMarket\ Player$ "i" $during\ session$ "u"

$P_{sell}(j,i,u)$: $Price\ of\ accepted\ sell\ offer$ "j" $ofMarket\ Player$ "i" $during\ session$ "u"

$Q_{buy}(j,i,u)$: $Quantity\ accepted\ of\ sell\ offer$ "j" $ofMarket\ Player$ "i" $during\ session$ "u"

$P_{buy}(j,i,u)$: $Price\ of\ accepted\ buy\ offer$ "j" $ofMarket\ Player$ "i" $during\ session$ "u"

Then:

Energy sold (MWh, negative): $E_{Sold}\ (MPi, Session\ u) = \sum_j Q_{sell}\ (j,i,u)$

Energy bought (MWh, positive): $E_{Bought}\ (MPi, Session\ u) = \sum_j Q_{buy}\ (j,i,u)$

Income of energy sold (€, positive):

$$F_{Sold}\ (MPi, Session\ u) = \sum_j Q_{sell}\ (j,i,u) * P_{sell}\ (j,i,u)$$

Income of energy bought (€, negative):

$$F_{bought}\ (MPi, Session\ u) = \sum_j Q_{buy}\ (j,i,u) * P_{buy}\ (j,i,u)$$

Then, we can compute the trading behaviour (Buyer/Trader (net null)/Seller) and the weighted-average price of buy and sell offer:

Trading behaviour: $\mathrm{TB} = \frac{Net\ energy}{Absolute\ energy} = \frac{E_{Sold} + E_{Bought}}{|E_{Sold}| + |E_{Bought}|}$

Weighted-average price of buy offer

$$P_{WAVG-buy}(u) = \frac{\sum_j P(j) * Q(j)}{\sum_j Q\ (j)} \quad with\ j : only\ buy\ offer$$

Net results comparing the opening and closing of the session:

This tool is inspired by the previous one, but instead of computing E_{Sold}, E_{Bought}, F_{Sold} and F_{bought} on the whole session, we compute it at the beginning and closing of the session (for example first and last hour) and then compare the results to detect if there is an opposite behaviour in these two strategic moments.

We define two parameters A and B to see if there is an abnormal quantity of trades realised at the opening and closing of the session (parameter A) and if we observe a balance or a correlation between trades realised at the opening and closing of the session (parameter B).

Definition of A and B, considering first and last hour (+3600, -3600 seconds):

$$\begin{cases} A_{+3600,-3600}(i,u) = \left|E_{bought,opening} - E_{sold,opening}\right| + \left|E_{bought,closing} - E_{sold,closing}\right| \\ B_{+3600,-3600}(i,u) = E_{bought,opening} - E_{sold,opening} + E_{bought,closing} - E_{sold,closing} \end{cases}$$

Parameter A must be compared to a reference value"$A_{threshold}$". This value could be defined by as average value of others market players during the same session or average value of the market player in question during the whole session.

Similarly, parameter B must be compared to a reference value"$B_{treshold}$" which can be defined in several ways.

Then if we have:

$$\begin{cases} A_{+3600,-3600}(i,u) \geq A_{threshold} \\ \quad and \\ B_{+3600,-3600}(i,u) \leq B_{threshold} \end{cases}$$

It means than MP_i is entering into transactions for a large amount at the opening and closing of the session but using an opposite behaviour at each moment meaning that the overall assessment on quantity traded is low or null. It could correspond to a manipulation of the market such as sending misleading signals to other market players or transfer capacity hoarding.

Offers or transactions on both side:

Here we analyse the number of offers or transactions done by an agent on both sides of the order book. Playing on both sides can be done by an agent to influence one side of the order book in order to attack from the other side.

Simple Boolean

Firstly, we can define a Boolean variable "X" taking as input parameter a session u and an agent MPi and telling if yes or no the agent is doing offers (or transactions) on both sides:

$$Definitions: \begin{cases} Boolean\ variable : X \\ Input\ parameter - Session : u \\ Input\ parameter - Market\ Player : i \end{cases}$$

Is MPi doing offers on both side of the order book during a session "u" ?

$$Results : \begin{cases} TRUE \Leftrightarrow X\ (u, MPi) = 1 \\ OR \\ FALSE \Leftrightarrow X\ (u, MPi) = 0 \end{cases}$$

Nevertheless, it can be understandable that an agent is offering (or entering into transaction) on both side of the order book in one session of the continuous market. For example, a wind producer is adjusting his position from the day-ahead market in the intraday markets thanks to new forecasts and may have to make both sell and buy offers during the session.

Furthermore, it is important to clarify that trading (buying and selling energy) is not manipulation. It is possible and legal to make offers and transactions on both sides of the orderbook and to benefit from it. What is regulated and monitored is sending misleading signals to other agents and securing an artificial price.

As a consequence, the tool "transaction on both sides" is a first step and must then be linked with other tools as "chronology" or "equations on the opening and closing of the session".

Boolean on minimum percentage and minimum number of offers on both sides

With a similar approach, we can design a more sophisticated tool with two Boolean variables on a minimum number and a minimum percentage of offers (or transactions) on both sides.

The combination of this two Booleans allows to detect agents having a significant part of their activity on both sides and at the same time doing a significant number of transactions.

- Minimum percentage of offers on both sides

$$Definition: \begin{cases} Boolean\ variable: X_{0,33} \\ Treshhold: 33\%\ on\ each\ side \\ Input\ parameter - Session: u \\ Input\ parameter - Market\ Player: i \end{cases}$$

Is MPi doing more than 33% of his offers on each side of the order book during a session "u" ?

$$Results: \begin{cases} TRUE \Leftrightarrow X_{0.33}\ (i,u) = 1 \\ OR \\ FALSE \Leftrightarrow X_{0.33}\ (i,u) = 0 \end{cases}$$

The threshold is an adjustment parameter and can be changed. The value selected (33%) is arbitrarily chosen but it is a good order of magnitude to estimate if there is activity on both sides from the agent.

- Minimum number of offers on both sides

$$Definition: \begin{cases} Boolean\ variable: X_n \\ Treshhold: n\ transactions \\ Input\ parameter - Session: u \\ Input\ parameter - Market\ Player: i \end{cases}$$

Is MPi doing more than n offers on both side of the order book during a session "u" ?

$$Results: \begin{cases} TRUE \Leftrightarrow X_n\ (i,u) = 1 \\ OR \\ FALSE \Leftrightarrow X_n\ (i,u) = 0 \end{cases}$$

- Threshold improvement

The threshold on “n” transactions is an adjustment parameter. If we want to make it adaptative to the session we consider, we could define:

$$n_X = X\%\ of\ the\ total\ number\ of\ offers\ by\ all\ agents\ during\ session\ i$$

The threshold is now different for each session according to the trading activity, and the new adjustment parameter is X. When facing a such amount of data, it is efficient to build adaptative tools. There is a tremendous number of possibilities to build each tool. The tool may or may not work depending on the threshold definition. Because they play a key role, a specific study can be necessary to design them well.

Reference price:

The idea is to compare an offer price with respect to reference prices of the session such as average price of the session or distribution of the session prices. A key choice is to take into consideration chronology or not. Chronology increases a lot complexity. In a first step, tools can be defined without chronology and only taken into considerations to go deeper. Let’s give some “reference price” tools:

Comparison to the weighted-average:

For an offer (or transaction j), we compare its price to the weighted-average price of the session and compute the price difference. Boolean detects if it is upper or lower than an interval around the weighted-average price or not.

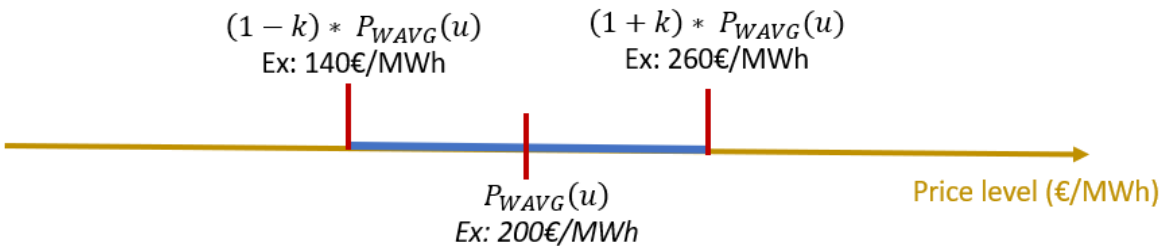
Weighted-average price of a session u: $P_{WAVG}(u) = \frac{\sum_j P(j) * Q(j)}{\sum_j Q(j)}$

with $P(j)$, $Q(j)$ price and quantities of a session´s offers

Price difference: $\Delta P(j) = P(j) - P_{WAVG}(u)$

Price level with respect to an interval around the weighted-average price:

The idea here is to check if yes or no the price offered is in or out an interval previously defined. The interval is centred on the weighted average price of the session. The upper and lower limits are defined with parameter k, as shown in the following diagram:



Note: the threshold k is an adjustment parameter.

Two Booleans on an interval around the weighted-average price:

$$Let: \begin{cases} Boolean\ variables: X_{upper}; X_{lower} \\ Treshhold: k \\ Input\ parameter - Session: u \\ Input\ parameter - offer: j \end{cases}$$

$$Then: \begin{cases} P(j) > (1+k) * P_{WAVG}(u) \Leftrightarrow X_{upper}\ (j,u) = 1 \\ P(j) < (1+k) * P_{WAVG}(u) \Leftrightarrow X_{upper}\ (j,u) = 0 \\ AND \\ P(j) < (1-k) * P_{WAVG}(u) \Leftrightarrow X_{lower}\ (j,u) = 1 \\ P(j) > (1-k) * P_{WAVG}(u) \Leftrightarrow X_{lower}\ (j,u) = 0 \end{cases}$$

Agents´ statistics on their offers price level

Using the previous tool, the objective is to compute each agent´ statistics. We focus on a period of time and answer the question: how frequently does an agent bid above or under a certain threshold chosen by user. We can focus on one week or on any other timeframe. We have for a transaction j during session u, the Boolean previously defined: $X_{upper}\ (j,u) = 1$

Ratio for an agent i during a timeframe u:

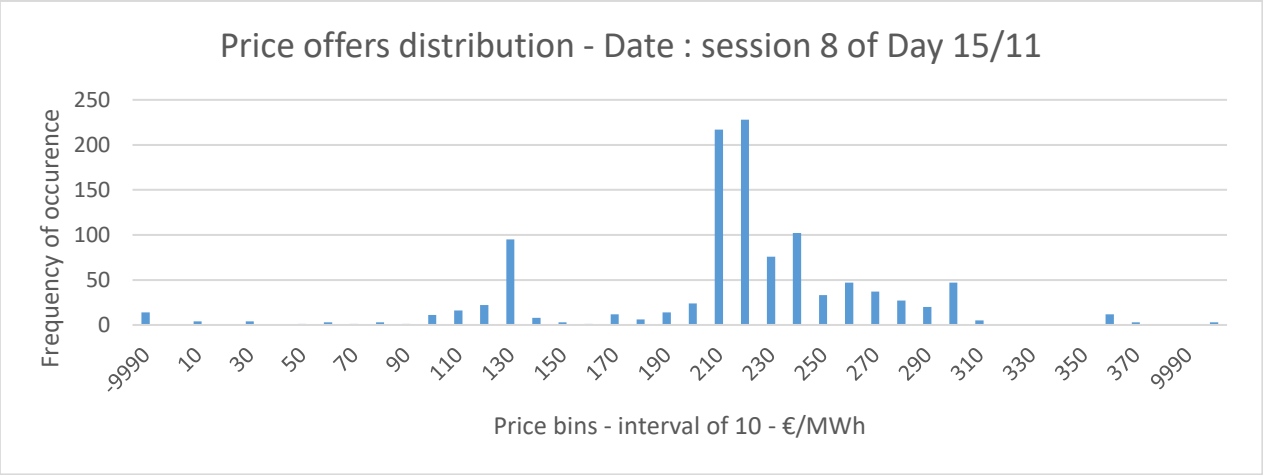
$$R_{upper}(i\ ,u) = \frac{\sum_j X_{upper(j,u)}}{\#total\_agent} \qquad R_{lower}(i\ ,u) = \frac{\sum_j X_{upper(j,u)}}{\#total\_agent}$$

$\sum_j X_{upper(j,u)}$: We sum the Booleans previously defined to obtain the total number of offers above the threshold

$\#total\_agent$: Total number of offers of the agent i during the time span selected

Price distribution

In order to have graphical description of the price distribution during a certain session, it is possible to set price intervals and to represent the frequency of occurrence of prices in each price interval. In the following graph, the price interval (price bin) is set at 10€/MWh.



Note: The bin "-9990" includes all the negative price offers.

To go further, it is possible to automatize it with a macro on excel. It can also be improved with vertical markers for first quartile Q1, median Q2, third quartile Q3, for 10% cheapest or the 90% cheapest. It can be done on other timeframe and for offers as well as for transactions.

Price Comparison to the Bid/Ask spread

The bid/ask spread (or price gap) is the price difference between the best ask offer and the best bid offer at a specific moment. This tool is more complex to implement because it requires chronology to evaluate the price level of the offer with respect to the bid/ask spread at the moment of the publication. It brings an additional level of complexity but it is relevant to be in the market agent´s shoe. The latter makes his decisions from ex-ante information available to him. Indeed, it is necessary to keep in mind that with an ex-poste monitoring, we have access to more information than the agent at the moment of his bid.

Using both price references and chronology, we can define a Boolean variable which describes if an offer is in the price gap or not:

$$G(j) : boolean\ variable\ associated\ to\ an\ offer\ or\ a\ transaction\ j$$

$$Results : \begin{cases} j\ is\ in\ the\ price\ gap\ \Leftrightarrow G(j) = TRUE \\ OR \\ j\ is\ out\ of\ the\ price\ gap\ \Leftrightarrow G(j) = FALSE \end{cases}$$

Impact:

Impact of an offer or transaction

The impact is defined by the product price per quantity. Both values must be considered to assess one transaction or offer's impact. Each analysis must be done keeping in mind the impact. Another criterion to establish the impact is linked with the price level with respect to the price gap. Is it in the price gap, close from it or completely out of the market?

The impact is also established by the consequences following the transactions: is it leading to a change on the price gap and if the transactions' prices are "moved" from the ask side to the bid side (or the other way around) (such as in the example exposed in "wash trade"). Indexes on the impact can also be computed based on a price gap with respect to an average value on the session, or with respect to last transaction price:

$$Imp_0(i) = P_i * Q$$

$$Imp_{AVG} = \Delta P * Q\ with\ \Delta P = (P_i - P_{session\ average})$$

$$Imp_{ultimate} = \Delta P * Q\ with\ \Delta P = (P_i - P_{ultimate\ transaction})$$

Impact on the net results:

Another index can be set to compute each agent earnings on a timeframe (few minutes, one session, several sessions or one day). The idea is to do the sums to establish the net energy bought/sold and the money earned/spent. Of course, collecting profits is not a manipulation but an agent earning much more than all other agents during a timeframe (or the other way around, losing a lot of money) can be an alarm to detect a suspicious behaviour and monitor it. For an agent "i" during session "u" (or any other timeframe) doing transactions "j", we define:

$$Net\ Energy = \sum_{j} Q_{bought}(i,u,j) - Q_{Sold}(i,u,j)$$

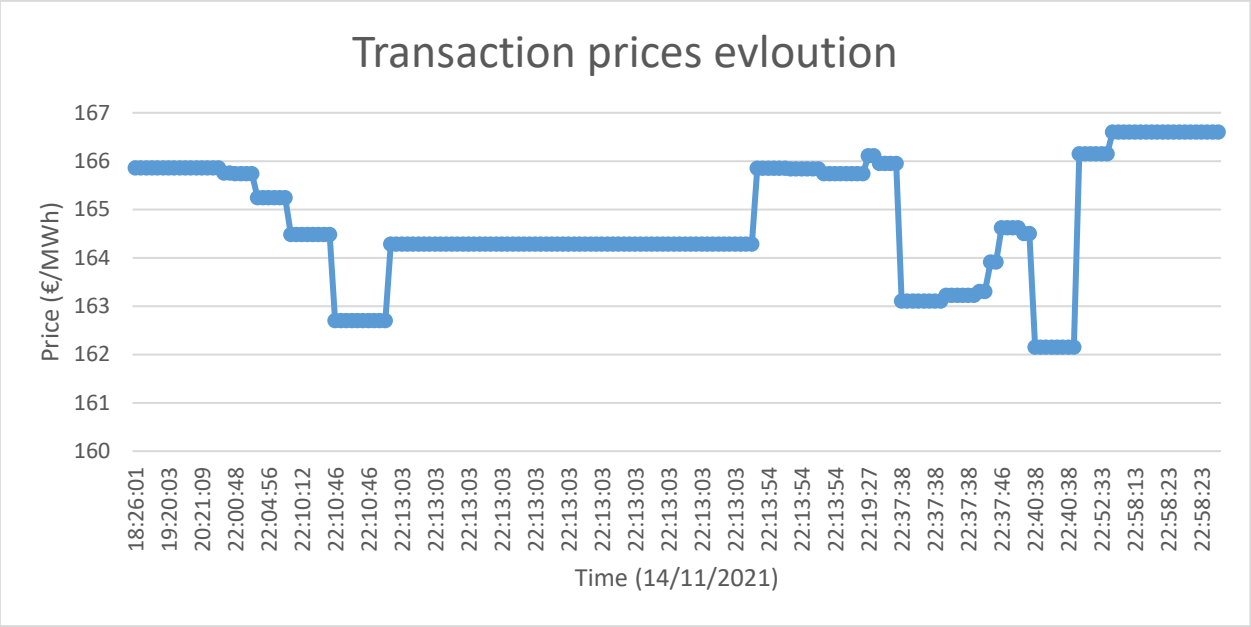
$$Net\ Results = \sum_{j} Q_{sold}(i,u,j) * P_{sold}(i,u,j) - Q_{sold}(i,u,j) * P_{bought}(i,u,j)_{bought}$$

Chronology:

The continuous market is a real time process and chronology plays a key role. According to the manipulation studied or the tools to which it is combined, the "chronology" tool can be used in several ways.

Graphical evolution of transaction prices with chronology

A visual representation of transaction prices is a first tool to monitor price evolution. It allows to see and monitor the transaction prices evolution.



Chronological representation of transactions done for period 1 of 15/11/2021

Time span between transactions on both sides

As discussed in section on “transaction on both side”, the analysis of chronology and especially the time span between two transactions is useful as a second step alarm to detect market manipulations such as phishing, layering, spoofing or smoking.

Indeed, it is interesting for these manipulations to set an alarm based on the time span between transactions on both sides of the order book as follows:

$$t_{n,A}: date\ of\ agent\ A\ transaction\ "n"\ on\ the\ \ side\ of\ the\ orderbook$$

$$t_{n-1,A}: date\ of\ agent\ A\ previous\ transaction\ on\ the\ other\ side\ of\ the\ orderbook$$

$$T_{both\ side}: Threshold\ for\ transactions\ on\ both\ side\ of\ the\ order\ book$$

$$If\ \Delta t = t_{n,A} - \ t_{n-1,A} <\ \ T_{both\ side}\ Then\ Alarm\ activated$$

Indexes to measure market tightness: ex-ante approach

On a short-term basis, it is tricky to monitor abusive squeeze and market cornering. However, it is possible to use existing indexes to analyse market cornering on a medium-term and long-term basis:

- HHI index (Herfindahl-Hirschman) which provides information on market tightness

$$HHI = 10.000 * \sum_i s_i^2 \qquad With\ s_i: market\ shares\ of\ company\ i$$

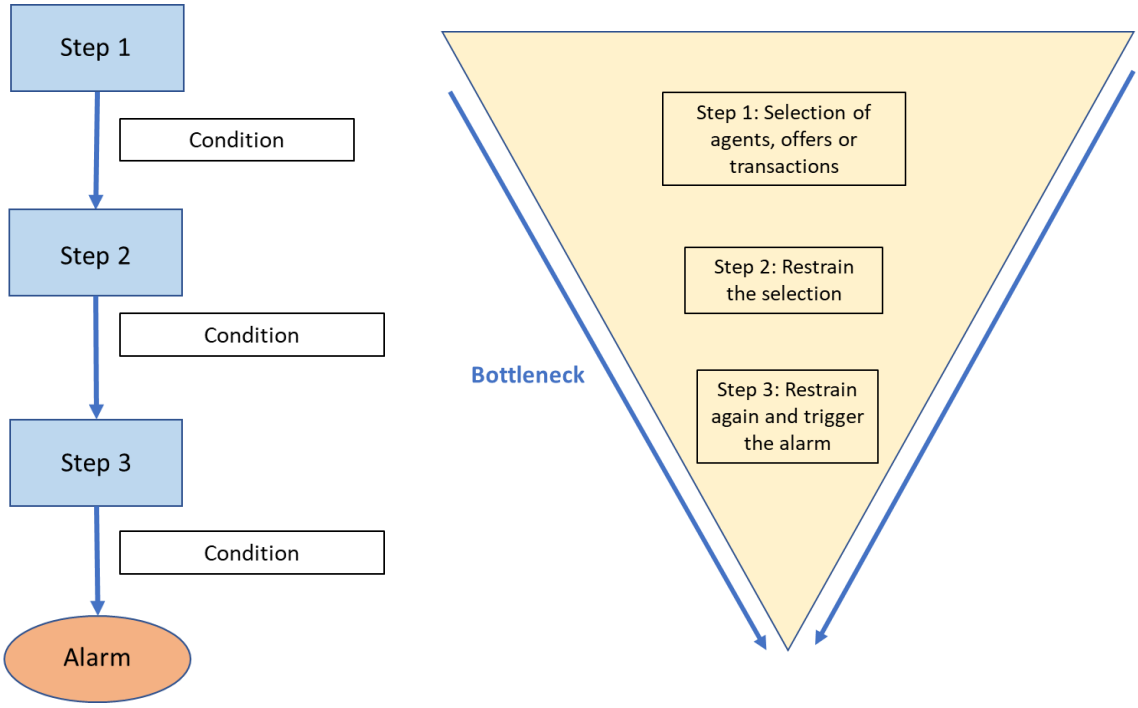
$$HHI < 1000 : enough\ competition \qquad HHI > 1800 : lack\ of\ competition$$

- Residual Supply indicator

Indexes on market tightness such as HHI are not so relevant because subject to interpretation. To illustrate this, some renewable projects are developed jointly by several companies in joint venture or subsidiaries of companies associated. In a such configuration, computing market shares of each agent can lead to different results according to the accounting method [15]. Moreover, some calculations consider installed capacity while other focuses on energy produced. Be that as it may, the electricity sector use to be described as a quite tight market.

II. Protocols by tool combination

Conceptual idea:



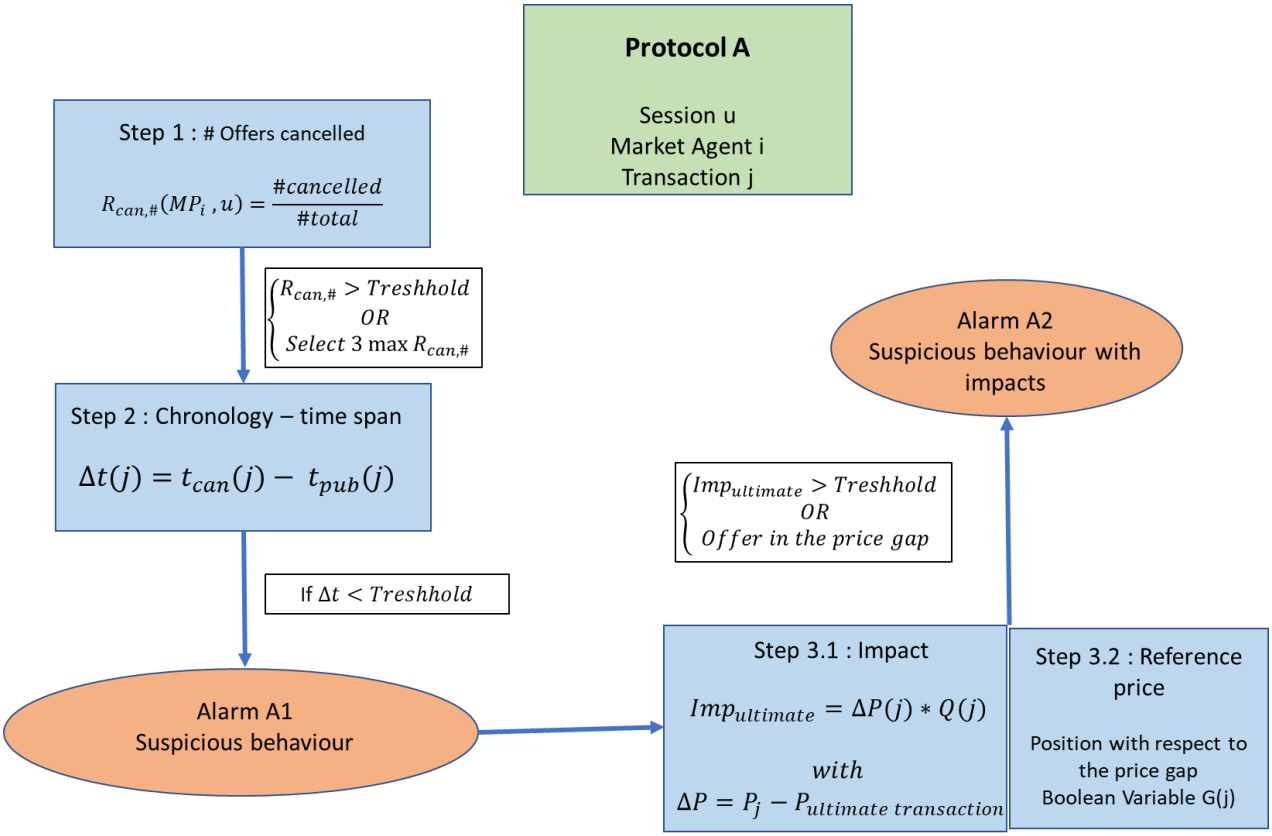
As explained in the introduction, the tools previously defined can be associated to create combination of tools and so a protocol to monitor manipulation practices. We use a tool at each step and a condition on each tool to select some agents, offers or transaction. The combination of tools creates a bottleneck. Indeed, as we go along the protocol, it should return less and less selected cases which verify all the conditions.

After defining the combinations of tools properly, the ultimate goal is to apply them on real data. It will bring improvements of the tools and adjustments of thresholds in the conditions. To build the protocols, the method used is to ask the question “For each manipulation, what are the most relevant tools?”. We can then identify the principal steps of a protocol and build it. Of course, it is always possible to build a more sophisticated protocol which is composed of an additional step or an extra-tool. But the objective here is to illustrate this approach with 3 feasible protocols.

For each manipulation, which are the most relevant tools to use?

Practice id	Name of the practice	Market concerned (DAM/continuous/auctions/...)	Main tools for monitoring
a	Wash trade	Continuous	Reference price Ratios on # and Q Impact
c	Phishing	Continuous	Transactions on both side Ratios on # and Q Chronology
d	Layering	Continuous	Transactions on both side Ratios on # and Q Chronology
e	Spoofing	Continuous	Transactions on both side Ratios on # and Q Chronology
f	Creating a floor or a ceiling in the price pattern	Intraday markets Continuous and auctions	Analysis on quantities Reference prices Impact
g	Painting the tape	Continuous	Ratios on # Reference prices
h	Momentum ignition	Continuous	Reference price Chronology
i	Quote stuffing	Continuous	Ratios on # Reference prices
j	Advancing the bid	Continuous	Reference price Chronology
k	Smoking	Continuous	Offers Chronology Reference price
m	Placing orders with no intention of executing them	Continuous	Ratios on # Reference price
p	Abusive squeeze (or "market cornering")	3 markets	Index to measure market tightness
s	Transmission capacity hoarding	Continuous	Specific monitoring (Protocol C)
t	Capacity withholding	3 markets	Reference price Additional data

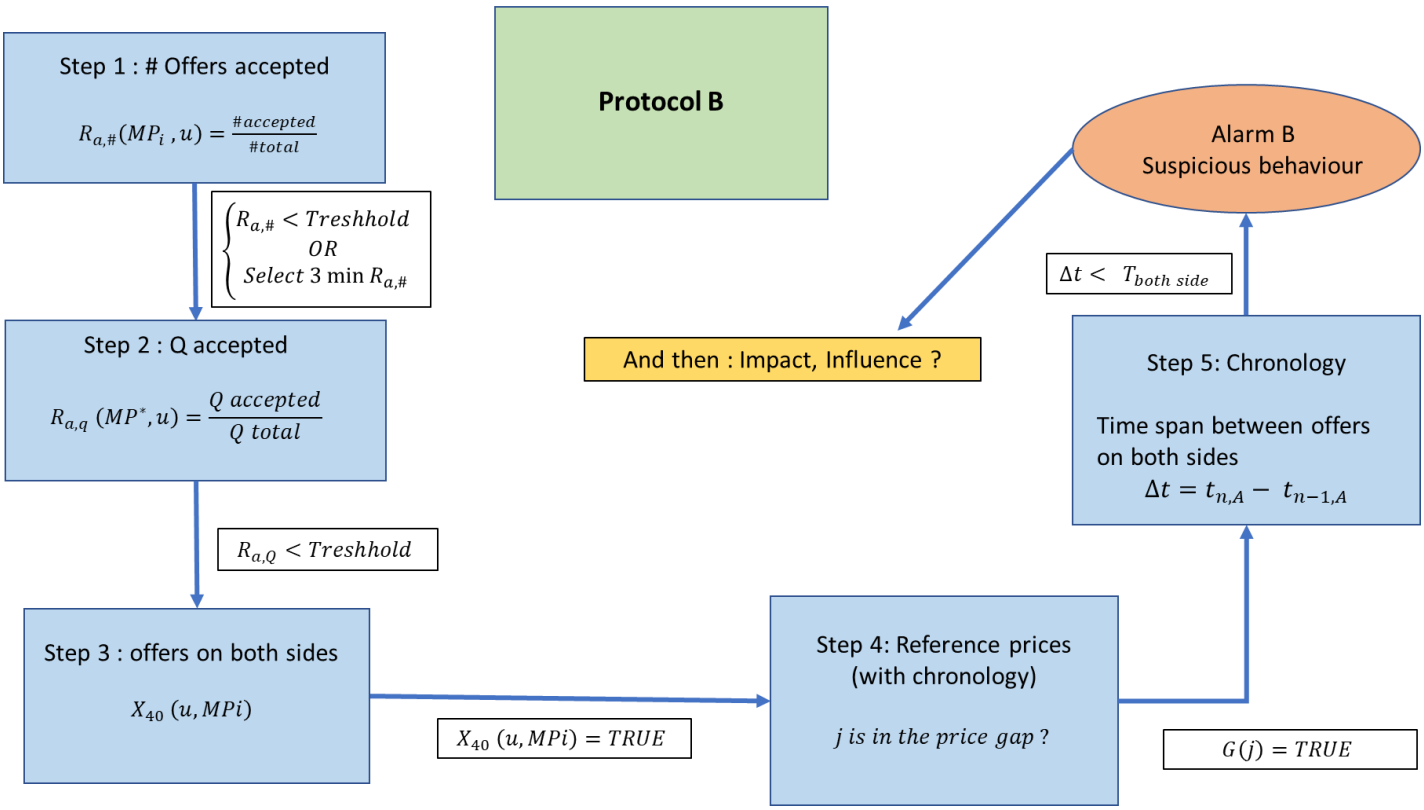
Protocol A



Step 1 is focused on each agent ratio of offers cancelled. Then two conditions are possible to pass to step 2. We can either select all agents having a ratio above a certain threshold or select the 3 worst ratios. In the case of threshold, the latter must be defined with an empirical approach. At the end of Step 1, we selected some agents. Step 2 will analyse specifically the offers of the agents previously selected using the tools on chronology and time span between publication and cancellation. If the timespan is shorter than a certain timespan, Alarm A1 is activated. This alarm could correspond to manipulation like placing orders with no intention of executing them, or quote stuffing, or smoking. The investigation should go further. At this stage of the process, we selected some agents (step 1) and their offers quickly cancelled (step 2). We analyse in step 3 two aspects in parallel: the economic impact (with respect to the ultimate transaction price) and the price level of these specific offers (in the price gap or not). Both tools of step 3 are more complex because they consider real time prices of the session. This third step and alarm A2 allows to evaluate if the offers selected are sending misleading signals or not.

Alarm A1 may be the warning for manipulations such as quote stuffing, painting the tape. Alarm A2 may detect wash trades, advancing the bid or placing order with no intention of executing them. A similar approach could be used not on agents but on “offer unit”. One agent has a portfolio of offer units.

Protocol B



Description:

Step 1 is focused on each agent´s ratio of offers cancelled. Just as protocol A, then two conditions are possible to pass to step 2. We can either select all agents having a ratio above a certain threshold or select the 3 (or X) worst ratios. At the end of step 1, we selected some agents and we can then analyse their ratios on energy (not anymore a cardinal number of offers but quantity in MWh). With a similar condition on a threshold, we go to step 3: here a Boolean variable is telling if the selected agents are making more than 40 (or X) offers on both sides of the order book for a session u. Then we focus on the offers´ price of the agents selected in the three first steps. We can see with a Boolean G if it is in the price gap (Bid/Ask spread) or not. Lastly, we focus in step 5 on the time span between two offers on both sides selected in step 4 (which means that they are in the price gap).

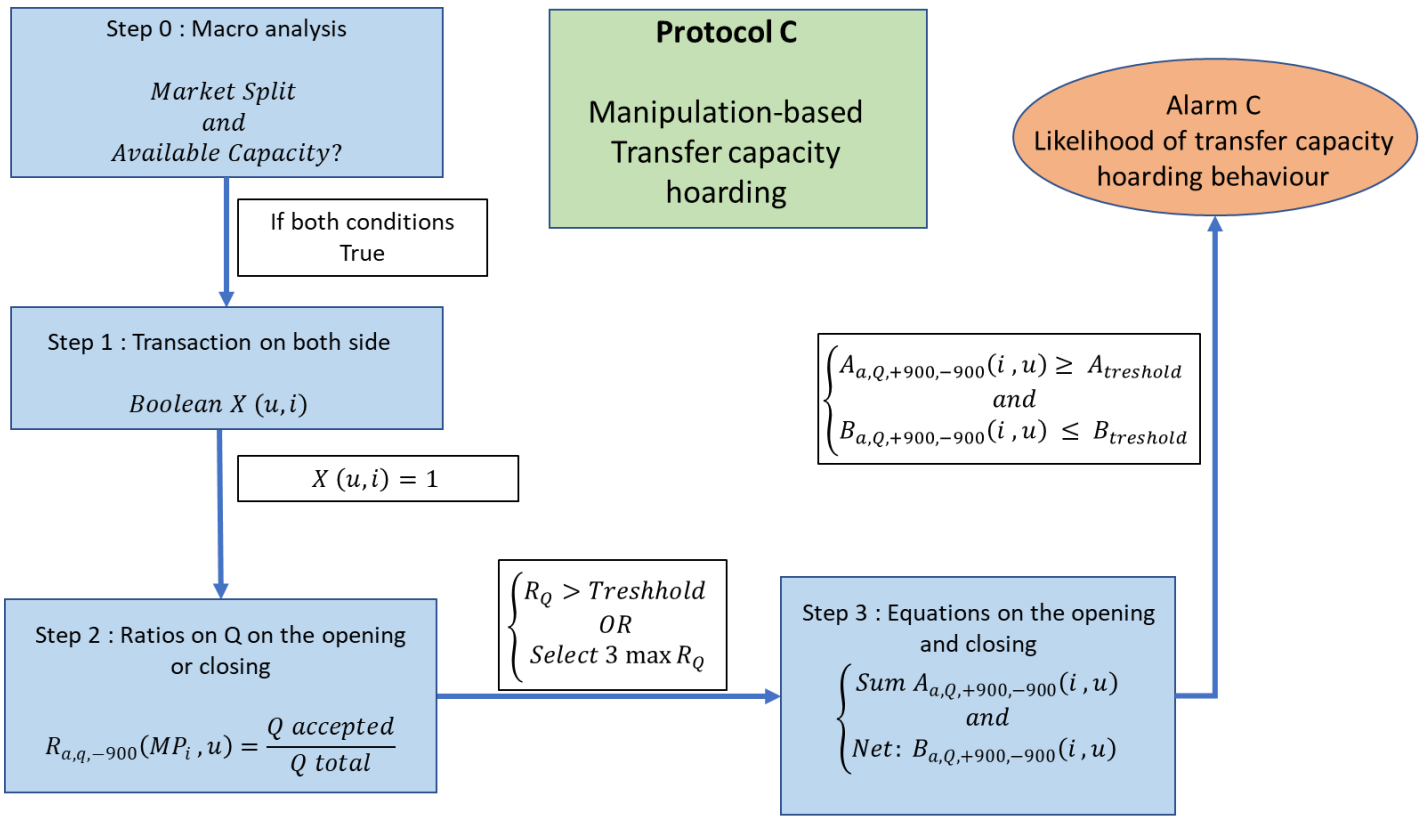
Then, we trigger the alarm B because we have agents with especially high ratios of offers accepted (cardinal number and quantity) making several offers on both sides which are in the Bid/Ask Spread and done in a short time.

It is a protocol to monitor manipulation practices such as phishing, layering and spoofing.

Protocol C: One exception of manipulation-based approach: Transfer capacity hoarding

This manipulation is a particular case for which a manipulation-based approach seems more appropriate than a tool-based approach. It means that we directly monitor this specific manipulation with tools instead of using one tool or a combination of tools to detect any market manipulation (which corresponds to a tool-based approach).

As a reminder, this manipulation can only be present in the intraday continuous market because it is an iterative process. It could not be present in a sealed-bid auction system. It is possible to monitor this manipulation with two approaches: we can use a macro-based analysis (large-scale approach) or an agent-based approach. Both approaches are complementary and the macro approach is a first step, the trigger of the agent-based one. This analysis not only requires market data but also data from the TSOs on the ATC for each session.

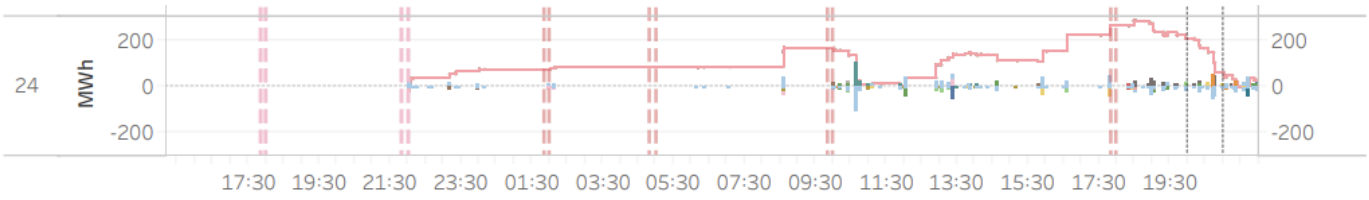


Description:

- Step 0: ex-post and macro-based analysis

For a specific session u, the question is: “Is there a market splitting between two zones and at the same time ATC > 0 from expensive area to cheap area?” If both conditions are TRUE, then there is something to analyse here. It can be also a tentative of manipulation with no visible effects at the end of the session. To visually monitor it, it is fruitful to analyse the evolution of the interconnexion capacity during time by drawing:

$$ATC = f(t)\ during\ session\ u$$



Evolution of the available interconnexion capacity – Spain <-> France – Session 24 of 01/12/2021

In the graph above, we can see the evolution of the available capacity between Spain and France during the session of continuous trading. It is an internal tool developed by the department.

- Then: agent-based analysis

We know that there is an issue on session u and will now focus on agents. Step 1 selects agents doing transactions on both side of the orderbook during session u. Of course, it is expected to return a lot of agents but it will become more refined with next steps.

Then step 2 analyses the quantity ratios at the opening and closing of the session for selected agents. We can fix a threshold or select the 3 worst ratios to pass to next step. Lastly in step 3, we analyse the equations on the opening AND closing with parameter A (sum of beginning and closing) and B (subtraction to obtain net results).

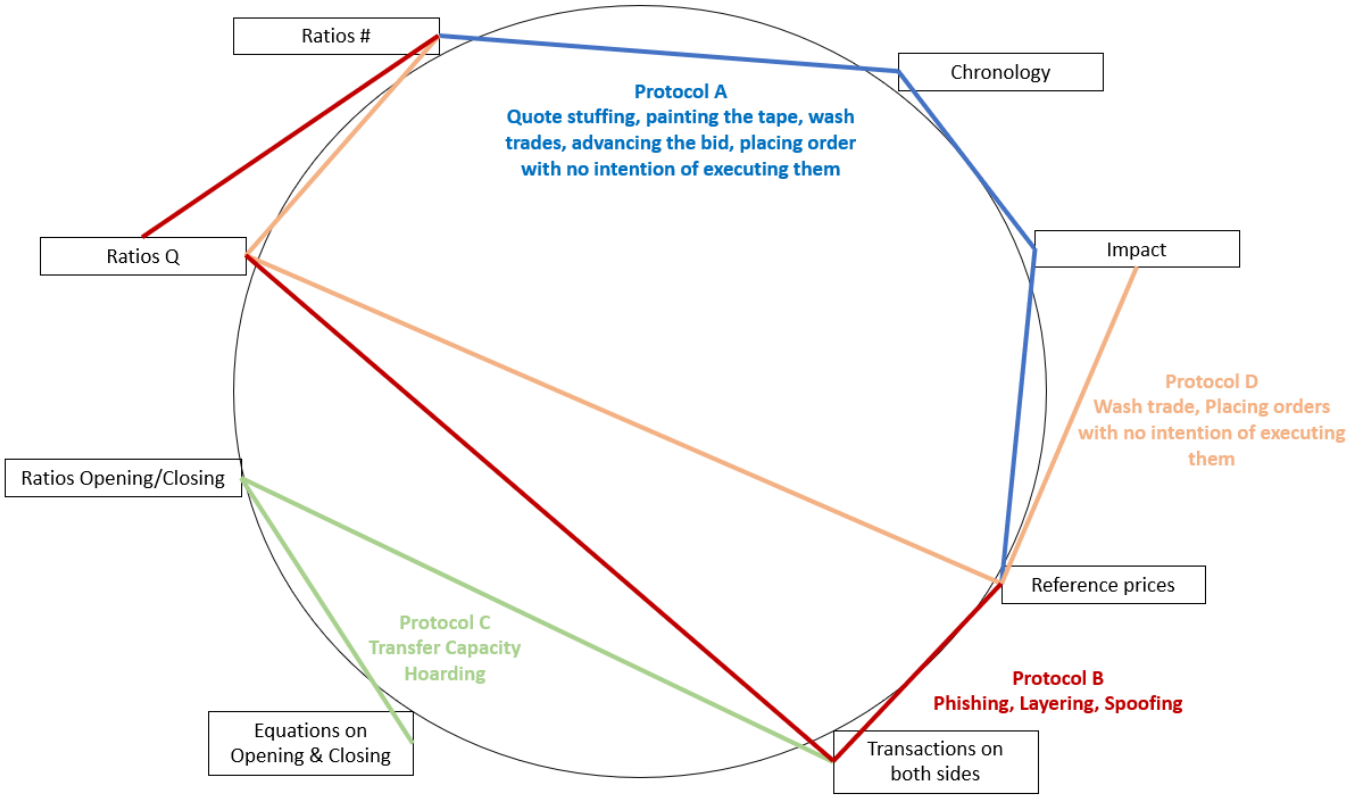
We can then activate an alarm “C” which corresponds to a likelihood of transfer capacity hoarding behaviour. The investigation can go further then with the detailed analysis of all transactions of the agent “i” during session “u”.

Protocol D

"Wash trade" and "placing order with no intention of executing them" are quite frequent manipulations. Let's develop in a nutshell a protocol in four steps to monitor it. The first two steps can be inspired from the protocol B on "Phishing", "Layering" and "Spoofing" manipulation. We use first the tool Ratios # on the cardinal number of offers and then Ratio Q based on the offer's quantity. Then the protocol focuses on the price reference to restrict the selection to offers with abnormal price level. Lastly, the tool "impact" allows to see the consequences of the behaviour selected through the process.

Synthesis diagram

To cloture this chapter, a synthesis diagram allows to see which tools are used in the 3 protocols exposed and so must be developed in priority in the next chapter.



Chapter 4: Tools implementation and results obtained from Data Analysis

Introduction:

This chapter is a concrete application of the previous theoretical part. The tools are translated from the previous mathematical formulation to SQL programming. The SQL requests are then applied on real market data. Finally, the post-treatment and analysis of the data extracted is done with Excel.

The tools developed are written with SQL language on Access software of Microsoft. To achieve this implementation part, it is necessary to keep in mind efficiency for two reasons. Considering my initial level on data analysis and my skills on SQL, but also regarding the time I had for this project, it was not possible to implement all tools and it was necessary to look for efficiency in order to obtain convincing results. Considering also the complexity of the problem, it was worthy to develop working tools following a global logic rather than few complex one. The objective was to implement tools that could later be automatized and applied on such amounts of data every week.

All the tools presented in the mathematical formulation part have not been developed, some of them have been modified because of technical constraints. For example, the tools on chronology bring the problem to another level of complexity. Some other tools were improved thanks to this application part. Indeed, the concrete application with real study of data brings new elements, allows to take some distance with the theorical part.

Method applied:

The method was to rest on the mathematical formulation previously defined and implement it on the database with SQL requests. The results obtained are then exported to Excel for the analysis. On Excel, thresholds are set to detect some abnormal results. For each tool, similar requests have been implemented to obtain results on different timeframe: for each session, on a daily-basis and on the whole week. The threshold then used on Excel for the post-processing analysis must be different for each of the three timeframes: Sessions/Day/Week. Indeed, when we consider several sessions, there is a smoothing effect. So, the threshold must be more restrictive when we consider a larger timeframe. Agents are anonymized in the results presented. For each tool, the mathematical definition is further developed in Chapter 3. In this chapter, there is simply a recall of the key elements.

I. Data base

For this application chapter, a real data base was necessary. I used two data bases of real market data from the continuous market: one database of offers and one of transactions. The project mostly focused on the first table on offers, but most tools developped are applicable on both tables.

Let's present both tables structure:

- First table: Database "Ofertas"

Offers from the intraday continous market for the contracts between 15/11/2021 and 22/11/2021. There are 265 846 offers from 75 agents. Let's present in a nutshell the different columns of the data base:

ID	CDERROR	FECHA	HORA	CDOFERTA	CDXBID	CDAGENTE	CDUNIOFE
1	ORDER_CANCELLED_BY_XBID	15/11/2021	1	23936908	1331297141	EGED	ACC1EBR
2	ORDER_CANCELLED_BY_XBID	15/11/2021	1	23936860	1331296961	EGED	ACC2EBR
3	ORDER_CANCELLED_BY_XBID	15/11/2021	1	23936874	1331296975	EGED	ACC2EBR
4	ORDER_CANCELLED_BY_XBID	15/11/2021	1	23937704	1331334647	GNCO	BES4

FEALTA	INESTOFE	FEANULA	INTIPOFE	INSUSOFE	PRECIO	CANTIDAD	CANTREST
14/11/2021 22:07	V	14/11/2021 23:00	V	S	303,75	17	17
14/11/2021 22:07	V	14/11/2021 23:00	V	S	303,75	6	6
14/11/2021 22:07	V	14/11/2021 23:00	V	S	303,85	21	21
14/11/2021 22:24	V	14/11/2021 23:00	V	S	205,11	16,6	16,6

CANTREST	EJECUCION	CANTOCUL	CANTTOTAL	CONDBASKE	REVISION	PRCORIG	DELTAPRECI	REVISIONNO
17		5	22	None	2	303,75	0,05	00:00
6		18	24	None	2	303,75	0,05	00:00
21		3	24	None	2	303,85	0,05	00:00
16,6				None	2	205,11		00:00

Screenshot of the 25 columns and 4 first lines of the database "ofertas"

As we can see in the screenshot above, there are 25 columns to describe each offer. Let's describe in a nutshell the content of each column. Some columns have not been used and are unuseful for the project. The most important one for this project (and the tools developped later) are in bold letters.

1) ID: is a primary key added by access. This primary key is efficient in SQL project to identify with an unique code each element of the data base.
2) **CDERROR: if an offer is rejected, this column exposes the reason. For example, an offer can be rejected by XBID or cancelled by user. It is empty if it is not rejected.**
3) **FECHA: date of the session targeted by the offer**

4) **HORA: hour of the session targeted by the offer**
5) CDOFERTA: ID of the offer in OMIE's orderbook
6) CDXBID: ID of the offer in XBID platform
7) **CDAGENTE: ID of the agent publishing the offer**
8) CDUNIOFE: ID of the unit publishing the offer (one agent has a portfolio of units)
9) FEALTA: Hour of the offer publication
10) INESTOFE: State of the offer (Valida, Inactiva, No valida)
11) FEANULA: date and hour of cancellation if the offer didn't enter into transaction
12) **INTIPOFE: 2 possibilities, Sell or Buy ("V" or "C" for "Venta" or "Compra"**
13) INSUSOFE: if the offer is modified
14) **PRECIO: price of the offer**
15) **CANTIDAD: quantity of the offer**
16) **CANTREST: remaining quantity after it has been partially accepted**
17) EJECUCION: Complex conditions (Empty if none or Fill or Kill "FOK" or Immediate or Cancel "IOC"). We have 2 cases of FOK conditions and 130 cases of IOC condition in this database corresponding to 1 week of offers. This column will not be used for the project.
18) CANTOCUL: for Iceberg offers, the hidden quantity. This column will not be used for the project.
19) CANTOTAL: for Iceberg offers, the sum of the quantity offered plus the hidden quantity. This column will not be used for the project.
20) CONDBASKET: Basket conditions, this column will not be used for the project.
21) REVISION: offers modification
22) PRICORIG: initial price
23) DELTAPRECIO: price difference after revision
24) REVISIONNOTIME: timespan of the revision

- Second table: Transactions between 15/11/2021 and 22/11/2021

Transactions from the intraday continous market for the contracts between 15/11/2021 and 22/11/2021. The database contains 122 740 lines but it is necessary to keep in mind that one transaction lead to two lines (one for the Ask and one for the Bid). As a consequence, here we have 61 470 transactions.

An other particularity of the table: there are 75 agents like for the offers database, plus an extra one “NULL” (empty cell) for foreign agents, meaning agents out of the iberian peninsula. Indeed, OMIE do not have access to the name of these agents. Let’s present in a nutshell the different columns of the data base:

CDTRANS	FETRANS	HOTRANS	CDCONT	FEPERIODO	NUPERIODO
1230957 28	14/11/2021	30/12/1899 22:58:23	246900	15/11/2021	1
123095728	14/11/2021	30/12/1899 22:58:23	246900	15/11/2021	1
123095727	14/11/2021	30/12/1899 22:58:23	246900	15/11/2021	1

CDAGENTE	CDUNIOFE	TIPOTRANS	CANTIDAD	PRECIO	CDOFERTA
HISPE	HISVD18	Ask	1,8	166,6	23938136
		Bid	1,8	166,6	
		Bid	1,9	166,6	

Screenshot of the 12 columns and 3 first lines of the database “Transacciones”

1) CDTRANS: ID of the transactions in the orderbook. We can see that the first two lines corresponds to the same transaction. One on the Ask side and one on the Bid side.
2) FETRANS: date of the transaction
3) HOTRANS: Hour of the transaction
4) CDCONT: the contract for which the transaction has been done. A contract means a session (one hour of one specific day).
5) FEPERIODO: Date of the contract
6) NUPERIODO: Period number of the contract. It means hour of delivery defined by the contract.
7) CDAGENTE: ID of the agent entering into transaction. Empty if it is a foreign one, as we can see in the second and third line.
8) CDUNIOFE: ID of the offer unit. One agent can have several offer units (unit portfolio).
9) TIPOTRANS: Type of transaction. Two possibilities: Ask or Bid. Each transactions lead to ttwo lines in the order book, one for the ask side and one for the bid side.
10) CANTIDAD: Quantity of the transaction
11) PRECIO: Price of the transaction
12) CDOFERTA: ID of the offer that was available before the transaction in the continuous market. Initially, the offer could be either on the bid side or on the ask side. As a consequence, this column has half of empty cells and half of cells with ID of offers that were available in the market.

II. Tools implementation and results

Tool 1 & 2: Ratios on cardinal number (#) of offers accepted & ratios on weighted-average quantity (q) of offers accepted

Definitions: $R_{a,\#}(MP_i, u) = \frac{\#accepted}{\#total}$ $R_{a,q}(MP_i, u) = \frac{Q\ accepted}{Q\ total}$

SQL Request:

```
SELECT a.FECHA, a.HORA, a.CDAGENTE,
       COUNT(*) AS total,
       SUM(IIf(CANTIDAD<>CANTREST,1,0)) AS casadas,
       Round(casadas/total,3) AS ratio_casasdas
FROM ofertas_modificado_05 AS a
GROUP BY a.FECHA, a.HORA, a.CDAGENTE;
```

```
SELECT a.FECHA, a.HORA, a.CDAGENTE,
SUM(CANTIDAD) AS total,
SUM(IIf(CANTIDAD<>CANTREST,CANTIDAD-CANTREST,0)) AS casadas,
Round(casadas/total,3) AS ratio_Q_casasdas

FROM ofertas_modificado_05 AS a
GROUP BY a.FECHA, a.HORA, a.CDAGENTE;
```

SQL request -Tool 1 (above) & 2 (under)- Timeframe: one session

Explanations:

As explain in chapter 3, the first request (tool 1) returns by agent the total number of offers published by the agent during the timeframe considered, the number of offers accepted (partially or completely) and the ratio ("*ratio_casadas*").

The second tool is quite similar to the first one, the only difference is that it does not consider only if yes or no offers lead to a transaction but it also considers the quantity accepted. Then, thresholds are defined to detect abnormal ratios.

Timescale	Lower limit (Red)	Upper limit (Green)
Week	0,05	0,9
Day	0,01	0,95
Session	0,005	0,99

Table of the thresholds used for tool 1 and tool 2

Post-treatment with Excel:

To illustrate the results obtained from these two tools, the table of results obtained on a daily basis was the most demonstrative. Indeed, with a timeframe of one session, we have 168 columns (24 sessions per 7 days), 76 lines (one for each agents) and the results are unreadable without Excel.

Agents are order by decreasing average ratio (average on the whole week). The thresholds previously defined allows to identify abnormal ratios. "NULL" cell means that any offer has been published. To illustrate, here are the results obtained for tool 2 (ratio on Quantity), on a daily basis:

Agents	15/11/2021	16/11/2021	17/11/2021	18/11/2021	19/11/2021	20/11/2021	21/11/2021
[redacted]	NULL	NULL	NULL	NULL	NULL	0,001	NULL
	0,004	0,002	0,003	0,008	0,005	0,004	0,004
	0,119	0,006	0,002	0,013	0	NULL	0
	0	0,012	0,268	0,001	0	0,002	0,004
	0,046	0,04	0,035	0,048	0,065	0,057	0,062
	…						
[redacted]	0,493	0,847	0,66	0,933	0,575	0,825	0,717
	1	1	0,8	0,954	0,858	1	1
	NULL	NULL	NULL	1	NULL	NULL	NULL
Total	**0,335**	**0,367**	**0,430**	**0,366**	**0,390**	**0,308**	**0,476**

Results:

Results obtained with tool 1 and 2 are closed, but the cross-analysis permit to differentiate agents bidding few offers of large volumes from agents bidding large amount of offers with low quantities. Two agents are remarkable and identified as having especially low ratios. By sessions, we observe a lot of "NULL", or ratios equal to 0 or 1 because of the low volumes of offers published by agents during one session. Tools 1 & 2 are more relevant on a daily-basis or on the whole week to identify agent's behavioural pattern. For monitoring activities, these two tools could be used weekly to compute agents' ratios on a daily-basis and on the whole week in order to identify abnormal figures.

Alternatives and improvements:

Thresholds are adjustment variables. Here, there are empirically defined. To go further, it would be interesting to design adaptative thresholds indexed on the statistics from the session considered. This remark is of course transposable to next tools' thresholds. The same tools could be used with offer units instead of agents. To go further, it could also be possible to set different thresholds according to the type of unit considered (thermal units/hydro/Wind/Solar). This approach is not possible with an agent-based approach because agents have unit portfolio with several technologies.

Tool 3: Ratios on cardinal number (#) of offers partially accepted and then cancelled by user

Definition: $$R_{a,\#}(MP_i, u) = \frac{\#accepted\ then\ cancelled}{\#total}$$

SQL Request:

```
SELECT a.FECHA, a.HORA, a.CDAGENTE,
Count(*) AS total,
Sum(IIf(CANTIDAD<>CANTREST And CDERROR="ORDER_CANCELLED_BY_USER",1,0)) AS casan_canceladas,
Round(casan_canceladas/total,3) AS ratio_casadas_canceladas
FROM ofertas_modificado_05 AS a
GROUP BY a.FECHA, a.HORA, a.CDAGENTE;
```

SQL request -Tool 3 - Timeframe: one session

Explanations:

With this request, we identify offers that are partially accepted and then cancelled by the agent. A ratio by agents is obtained for 3 different timeframes (session/day/week). This tool aims at identifying agents sending misleading signals. Here are the thresholds used to detect abnormal ratios:

Timescale	Upper limit (red)
Week	0,15
Day	0,2
Session	0,25

Table of the thresholds used for tool 3

Post-treatment with Excel:

As for the first two tools, the table of results obtained on a daily basis is the most demonstrative. Agents are ordered by decreasing average ratio (average on the whole week). The thresholds previously defined allows to identify abnormal ratios. “NULL” cell means that any offer has been published. To illustrate, here are the results obtained for tool 3 (offers accepted and then cancelled), on a daily basis:

Agent	15/11/2021	16/11/2021	17/11/2021	18/11/2021	19/11/2021	20/11/2021	21/11/2021	Total
[redacted]	0,136	NULL	NULL	NULL	NULL	NULL	0,25	0,193
	0,227	0,25	0,185	0,184	0,286	0,136	0,071	0,191
	0	0,25	NULL	NULL	NULL	NULL	NULL	0,125
[redacted]	0,007	0	0	0	0	NULL	0	0,001
	0	0	0	0	0	0	0	0,000
Total	**0,021**	**0,029**	**0,017**	**0,017**	**0,026**	**0,026**	**0,026**	**0,023**

Results and alternatives:

The first line corresponds to an agent who has a ratio above the threshold only one day over the whole week. Five other days are NULL meaning that he doesn't publish offers. The low activity of the agent justifies its position: a high ratio for one single day has weight on the whole week and its position. However, the second line identifies an agent using this practice of cancellation after transaction every day, including 3 days above the threshold. This case is remarkable.

As explained for tool 1 & 2, the request could be based on offer units instead of agents.

Tool 4: Net results

The aim of this tool is to answer the question: What is the energy traded and the benefits of each agents, on different timeframes?

Definitions:

For an agent during a certain timeframe:

Energy sold (MWh): $E_{Sold}\,(MPi, Session\ u) = \sum_j Q_{sell}\,(j,i,u)$

Energy bought (MWh): $E_{Bought}\,(MPi, Session\ u) = \sum_j Q_{buy}\,(j,i,u)$

Income of energy sold (€): $F_{Sold}\,(MPi, Session\ u) = \sum_j Q_{sell}\,(j,i,u) * P_{sell}\,(j,i,u)$

Income of energy bought (€):

$$F_{bought}\,(MPi, Session\ u) = \sum_j Q_{buy}\,(j,i,u) * P_{buy}\,(j,i,u)$$

Weighted-average selling price:

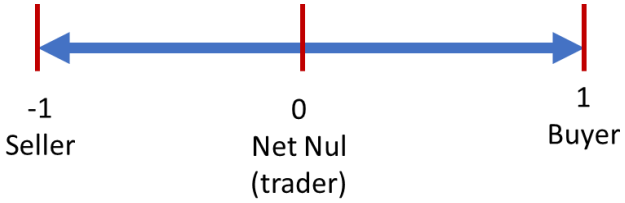
$$P_{Sell-WAVG}\,(MPi, Session\ u) = \frac{\sum_j Q_{sell}\,(j,i,u) * P_{sell}\,(j,i,u)}{\sum_j Q_{sell}\,(j,i,u)}$$

Weighted-average buying price:

$$P_{buy-WAVG}\,(MPi, Session\ u) = \frac{\sum_j Q_{buy}\,(j,i,u) * P_{buy}\,(j,i,u)}{\sum_j Q_{buy}\,(j,i,u)}$$

Trading Behaviour: a simple index to measure if the agent is mostly selling, buying, or trading with a net balance of zero (or close to zero).

$$Trading\ Behaviour = \frac{Net\ energy}{Absolute\ energy} = \frac{E_{Sold} + E_{Bought}}{|E_{Sold}| + |E_{Bought}|}$$



SQL Request:

```
SELECT FECHA, HORA, CDAGENTE,

ROUND(SUM(IIf(CANTIDAD<>CANTREST And INTIPOFE="V",-(CANTIDAD-CANTREST),0)),3) AS venta_energia,
Round(SUM(IIf(CANTIDAD<>CANTREST And INTIPOFE="C",CANTIDAD-CANTREST,0)),3) AS compra_energia,
ROUND(SUM(IIf(CANTIDAD<>CANTREST And INTIPOFE="V",(CANTIDAD-CANTREST)*PRECIO,0)),1) AS venta_ingresos,
ROUND(SUM(IIf(CANTIDAD<>CANTREST And INTIPOFE="C",-(CANTIDAD-CANTREST)*PRECIO,0)),1) AS compra_ingresos,

Round(
    sum(IIf(CANTIDAD<>CANTREST And INTIPOFE="V",(CANTIDAD-CANTREST)*PRECIO,0))/
    sum(IIf(CANTIDAD<>CANTREST And INTIPOFE="V",(CANTIDAD-CANTREST),0)))
    AS price_V_avg,
Round(
    sum(IIf(CANTIDAD<>CANTREST And INTIPOFE="C",(CANTIDAD-CANTREST)*PRECIO,0))/
    sum(IIf(CANTIDAD<>CANTREST And INTIPOFE="C",(CANTIDAD-CANTREST),0)))
    AS price_C_avg,

compra_energia + venta_energia AS Net_Energy,
Round(Abs(venta_energia)+Abs(compra_energia),3) AS abs_sum_energia,
Round(compra_ingresos+venta_ingresos,3) AS Net_ingresos

FROM ofertas_modificado_05
GROUP BY FECHA, HORA, CDAGENTE;

```

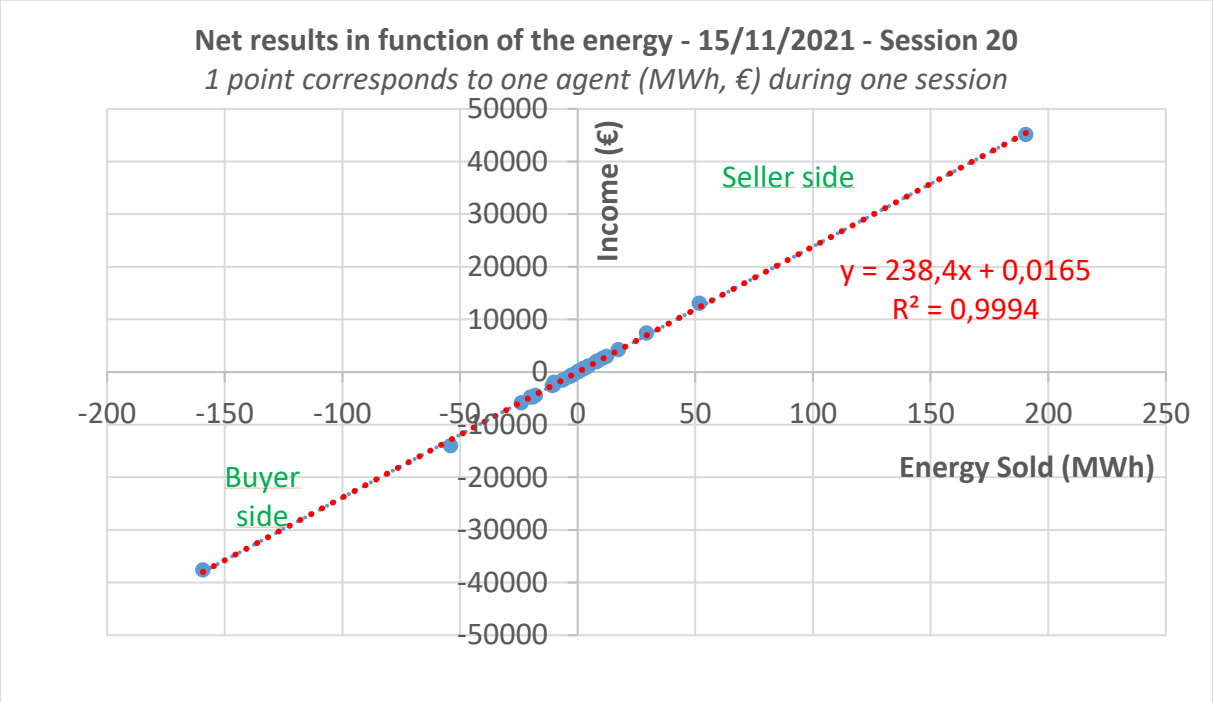
Explanations:

Again, there is one request for each timeframe (Session/day/week). By agent, the request returns the energy bought, sold, the net energy and the absolute energy traded. It computes the average selling price, average buying price and the financial results coming out of these trades.

Post-treatment with Excel and results:

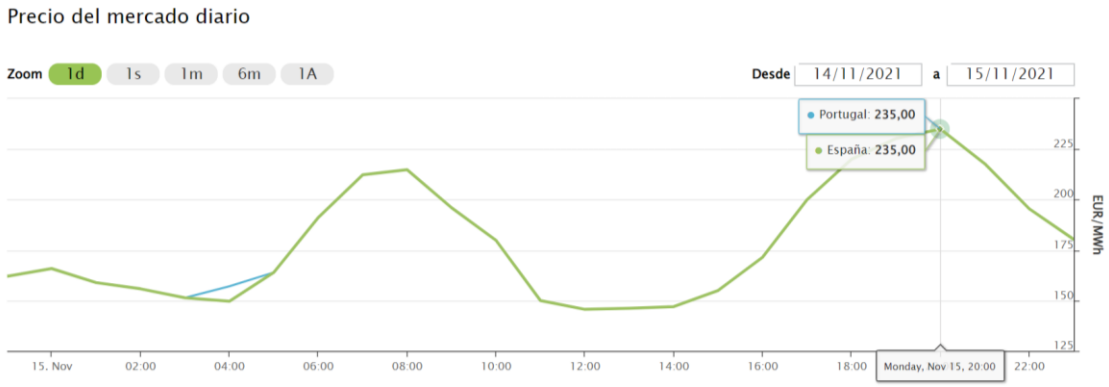
The analysis of this tool is divided in two parts. A first analysis consists in drawing the following graph $\text{Net incomes} = \text{f}\,(net\ energy)$. In a second phase, we focus on two indicators: the trading behavior and the delta price between the average selling price and average buying price.

- Graph: Net incomes $= \mathrm{f}\,(net\ energy)$



We notice that all points (MWh, €) follow a linear regression. The correlation is very good with $R^2 = 0{,}9994$. The order of magnitude of the slope is also coherent with a value of 238,4 €/MWh. To go further with this approach, it is possible to focus on the distance between one point and the linear regression (red straight line) to evaluate agents who are highly-performing or on the opposite who are counter-performing.

Remark: the slope obtained gives indication on the average price of the session in the intraday continuous market. The value obtained (238,4€/MWh) is coherent with the day-ahead price (235 €/MWh) for the same session, as we can see in the figure below. Here we see the correlation between the day-ahead market and the continuous market.



Day-ahead price on 15/11/2021 at 20:00 of 235€/MWh (source: OMIE)

- Trading behaviour and delta price between buy offer and sell offer

FECHA	CDAGENTE	…	price_V_avg	price_C_avg	**Trading behaviour**	**Abs Delta(V-C)**
15/11/2021	[redacted]		168	NULL	-1,000	only one side
15/11/2021			NULL	233	1,000	only one side
15/11/2021			174	226	-0,616	52

Tool 4 part 2 - Extract from the excel table – Timeframe: 1 day

This tool has been developed on a session basis, on a daily basis and on the whole week. Here, we have an extract from the daily analysis. To describe it, one line of the table gives for a certain day and a certain agent, the average price of sell offers and the average price of purchasing offer, the trading behaviour (-1 if only seller, +1 if only buyer, 0 if net result is null) and the absolute difference between buy and sell offer average price. By looking at this synthesis table, we have a good overview of the agent behaviour in the market.

The timeframe considered has to be chosen carefully, knowing what it entails. Indeed, a timeframe of one week give a good global overview on an agent activity. However, to consider one entire week has a drawback. We have to keep in mind that an agent can be short at the beginning of the week and long at the end depending of external parameters (meteo, wind, temperature). It will result on weird results on the whole week while its behaviour rational and justified on a daily basis. Similarly, when we consider one entire day, an agent can be short on some sessions of the day and long on others of the same day because of unplanned events.

As a consequence, it is important to keep in mind when we chose the timeframe of the analysis that choosing a timeframe including several sessions (for example one day or the whole week) can give a smoothing effect and a loss of information. I believe that this tool is especially efficient to detect abnormal net results for a timeframe of one session.

<u>Alternatives</u>

As well as for other tools, a same analysis could be done for transactions instead of offers. It could also be done for offer unit instead of agents.

Tool 4 Variant: Net results comparing opening and closing

Using the previous tool on net results, the aim of this tool is to answer the question: is there an opposite behaviour between the net results obtained at the beginning and closing of a session?

Definitions: (from chapter 3)

$$\begin{cases} Sum\ opening\ closing: \\ A_{+3600,-3600}(i,u) = \left|E_{bought,opening} - E_{sold,opening}\right| + \left|E_{bought,closing} - E_{sold,closing}\right| \\ \\ Net\ opening\ and\ closing: \\ B_{+3600,-3600}(i,u) = E_{bought,opening} - E_{sold,opening} + E_{bought,closing} - E_{sold,closing} \end{cases}$$

Then, we analyse if:

$$\begin{cases} A_{+3600,-3600}(i,u) \geq A_{threshold} \\ and \\ B_{+3600,-3600}(i,u) \leq B_{threshold} \end{cases}$$

SQL Request:

To create this request, it was necessary to use two tables: the initial table of offers presented before and an additional table of data that I created. This table gives the opening and closing hours of the 168 sessions of the week considered.

Then, the SQL request focuses on a session and an agent, and extract the offers made at the opening (first hour) and at the closing (last hour) using the two tables' data.

- New database: Table of opening and closing hours

Tabla_Apertura_Cierra				
ID	**Fecha**	**Producto**	**Apertura**	**Cierra**
1	15/11/2021	1	14/11/2021 15:00:00	14/11/2021 23:00:00
2	15/11/2021	2	14/11/2021 15:00:00	15/11/2021 0:00:00
3	15/11/2021	3	14/11/2021 15:00:00	15/11/2021 1:00:00
4	15/11/2021	4	14/11/2021 15:00:00	15/11/2021 2:00:00
5	15/11/2021	5	14/11/2021 15:00:00	15/11/2021 3:00:00
…				
165	21/11/2021	21	20/11/2021 15:00:00	21/11/2021 19:00:00
166	21/11/2021	22	20/11/2021 15:00:00	21/11/2021 20:00:00
167	21/11/2021	23	20/11/2021 15:00:00	21/11/2021 21:00:00
168	21/11/2021	24	20/11/2021 15:00:00	21/11/2021 22:00:00

To explain how this table works, let's take an example with the line 165. "ID" is an identifier (primary key), it corresponds to the contract 21 (physical delivery of electricity between 20:00 and 21:00) of the day 21/11/2021. The opening date and hour to trade for this product is 20/11/2021 15:00:00 and the closing date and hour to trade for this product is 20/11/2021 19:00:00 (one hour before physical delivery).

- SQL request based on the two table “offers” and “opening and closing hours”

```sql
SELECT *
FROM (
    SELECT a.FECHA, a.HORA, a.CDAGENTE,

    Round(SUM(IIf(INTIPOFE="C" And a.FEALTA<b.apertura+1/24,CANTIDAD-CANTREST,0)),3) AS compra_inicial,
    Round(SUM(IIf(INTIPOFE="V" And a.FEALTA<b.apertura+1/24,-(CANTIDAD-CANTREST),0)),3) AS venta_inicial,
    Round(compra_inicial+venta_inicial,3) AS net_inicial,
    Round(abs(compra_inicial)+abs(venta_inicial),3) AS abs_sum_inicial,
    Round(abs(abs_sum_inicial)-abs(net_inicial),3) AS threshold_inicial,

    Round(SUM(IIf(INTIPOFE="C" And a.FEALTA>b.cierra-1/24,CANTIDAD-CANTREST,0)),3) AS compra_final,
    Round(SUM(IIf(INTIPOFE="V" And a.FEALTA>b.cierra-1/24,-(CANTIDAD-CANTREST),0)),3) AS venta_final,
    Round(compra_final+venta_final,3) AS net_final, Round(abs(compra_final)+abs(venta_final),3) AS abs_sum_final,
    Round(abs(abs_sum_final)-abs(net_final),3) AS threshold_final,

    Round(compra_inicial+venta_inicial+compra_final+venta_final,3) AS B_net_total,
    Round(abs(compra_inicial+venta_inicial)+abs(compra_final+venta_final),3) AS A_abs_total,
    Round(A_abs_total-abs(B_net_total),3) AS Threshold_total

    FROM ofertas_modificado_05 AS a, Tabla_Apertura_Cierra AS b
    WHERE a.FECHA=b.fecha and a.HORA=b.producto
    GROUP BY a.FECHA, a.HORA, a.CDAGENTE, a.FEALTA)  AS [%$##@_Alias]


ORDER BY threshold_total DESC;
```

Results and alternatives:

This tool does not return any relevant case of opposite behaviour at the opening and closing of a session. It is quite normal that we don't obtain this type of behaviour every week. To go further, this tool could be applied on other weeks. It could also be used differently: the timespan parameter (here, 1 hour) that we define as the “opening period” and “closing period” could be change.

Tool 5: Activity on both sides

The aim of this tool is to answer the question: is there a meaningful activity on both sides of the order book (sell and buy)?

By "meaningful" activity, two aspects are implied: there is a threshold in terms of number of offers on both sides and another threshold in terms of percentage of offers on both sides.

Definition:

- Minimum number of offers on both sides

$$Definition: \begin{cases} Boolean\ variable: X_n \\ Treshhold: n\ transactions \\ Input\ parameter - Session: u \\ Input\ parameter - Market\ Player: i \end{cases}$$

Is MPi doing more than n offers on both side of the order book during a session "u" ?

$$Results: TRUE \Leftrightarrow X_n(i,u) = 1\ OR\ FALSE \Leftrightarrow X_n(i,u) = 0$$

Note: in practice, we used $n = 5$ for the application hereinafter

- Minimum percentage of offers on both sides

$$Definition: \begin{cases} Boolean\ variable: X_{0,33} \\ Treshhold: 33\%\ on\ each\ side \\ Input\ parameter - Session: u \\ Input\ parameter - Market\ Player: i \end{cases}$$

Is MPi doing more than 33% of his offers on each side of the order book during a session "u" ?

$$Results: \begin{cases} TRUE \Leftrightarrow X_{0.33}(i,u) = 1\ OR\ FALSE \Leftrightarrow X_{0.33}(i,u) = 0 \end{cases}$$

SQL Request:

```
SELECT
ofertas_modificado_05.FECHA,
ofertas_modificado_05.HORA,
ofertas_modificado_05.CDAGENTE,

Count(*) AS total_offers,

Sum(Switch(INTIPOFE="V",1,INTIPOFE<>"V",0)) AS venta,
Sum(Switch(INTIPOFE="C",1,INTIPOFE<>"C",0)) AS compra,

IIf(venta>5 And compra>5,1,0) AS threshold,
IIf((venta>total_offers/3) And (compra>total_offers/3),1,0) AS ratio_33percent

FROM ofertas_modificado_05, (
    SELECT ofertas_modificado_05.FECHA, ofertas_modificado_05.HORA,
    count(*) AS total_session

    FROM ofertas_modificado_05
    GROUP BY ofertas_modificado_05.FECHA, ofertas_modificado_05.HORA)  AS b

WHERE ofertas_modificado_05.FECHA = b.FECHA and ofertas_modificado_05.HORA=b.HORA

GROUP BY ofertas_modificado_05.FECHA, ofertas_modificado_05.HORA, ofertas_modificado_05.CDAGENTE;
```

For each session, we compute how many offers are made by each agent and verify the two thresholds (Boolean conditions) on cardinal number and percentage.

```
SELECT FECHA, HORA, CDAGENTE

FROM (
    SELECT ofertas_modificado_05.FECHA, ofertas_modificado_05.HORA, ofertas_modificado_05.CDAGENTE,
    Count(*) AS total_offers,

    Sum(Switch(INTIPOFE="V",1,INTIPOFE<>"V",0)) AS venta,
    Sum(Switch(INTIPOFE="C",1,INTIPOFE<>"C",0)) AS compra,

    IIf(venta>40 And compra>40,1,0) AS threshold,
    IIf((venta>total_offers/3) And (compra>total_offers/3),1,0) AS ratio_33percent

    FROM ofertas_modificado_05
    GROUP BY ofertas_modificado_05.FECHA, ofertas_modificado_05.HORA, ofertas_modificado_05.CDAGENTE)  AS T_request
WHERE threshold = 1 and ratio_33percent = 1

GROUP BY FECHA, HORA, CDAGENTE;
```

Then, another quite similar request returns data of sessions where both conditions on percentage and cardinal number of offers on both sides are verified.

Results:

Date	15/11/2021					16/11/2021		…
Contract	1			24		1		…
CDAGENTE	Threshold_%	Threshold_#		Threshold_%	Threshold_#	Threshold_%	Threshold_#	
[redacted]	1	1		0	1	1	1	
	1	1		1	1	0	1	
…			…					…
[redacted]	1	0		1	1	1	1	
	NULL	NULL		1	1	0	0	
	NULL	NULL		1	1	NULL	NULL	

Tool 5 - Extract from the excel table: Thresholds on activity on both sides - for each session and each agent

Thanks to the SQL requests, we obtain for all sessions of the week the Boolean on each condition (percentage and cardinal number). From this table, statistics for each agent on one specific day or on the whole week are computed. “NULL” means that there is no offer submitted by the agent during the session. Let’s analyse the results by agent on the whole week:

CDAGENTE	Numbers of sessions
[redacted]	94
	78
	38
	34
	25
	24
	18
	6
	4
Total	**321**

Tool 5 – Results analysis – Timeframe: the whole week – number of occurrences by agents

This table presents in decreasing order the number of sessions by agents for which both conditions on percentage and number of offers on both sides are verified.

To illustrate, let’s develop the first line: the agent X (anonymised) uses this behaviour of significant activity on both sides (in terms of percentage and cardinal number of offer) for 94 sessions out of the 168 sessions of the whole week.

Moreover, we can notice that only 9 agents out of the 75 agents bidding during this week use this behaviour for one session or more.

Let's analyse the results by sessions and day, independently of the agents:

Session / Date	15/11	16/11	17/11	18/11	19/11	20/11	21/11	Total by session
3				1		1		2
4						1		1
5	1			1	1	2	2	7
6	3	1	1			1	3	9
7		1	1		1	1	1	5
8	2	1	1	1	1		2	8
9	2	2	3		2	1	2	12
10	3	1	3	3	2	1	3	16
11	2	3	3	2	1	1	3	15
12	2	3	2	2	1	1	5	16
13	3	2	2	1	3	1	6	18
14	3	3	3	1	2	2	5	19
15	1	3	2	2	2	1	4	15
16	3	2	2	3	4	3	5	22
17	2	4	4	3	3	2	5	23
18	4	4	4	3	2	1	4	22
19	3	3	4	3	3	2	3	21
20	3	2	3	2	3	3	2	18
21	3	2	4	1	2	1	3	16
22	3	3	2	2	4	1	4	19
23	1	3	2	1	3	2	6	18
24	2	3	4	2	2	1	5	19
Total by day	46	46	50	34	42	30	73	321

Tool 5 – Timeframe: the whole week – number of occurrences by session and day

This table presents for each session of the week the number of agents using a significant activity on both sides. Again, in term of percentage and cardinal number of offers on both sides are considered. For example, the 18/11/2021 during session 6, any agent is using this behaviour while during session 16 of the same day, three agents are detected.

We notice a higher use of this behaviour between 9 am and 12 pm and only few cases during the first sessions of each day. Logically, the total number obtained for the whole week is the same than in the previous table based on agents. We obtain 321 cases where one specific agent during one specific session is using this behaviour.

Alternatives and improvements:

The request has also been developed for the “transactions” database instead of the “offers” database. To go further, this analysis could be based on offer units instead of agents.

In addition, thresholds used for this analysis are a cardinal number of 5 and a ratio of 33% for the two conditions on activity on both sides presented before. These thresholds are adjustment parameter and can be modified to detect less cases but more relevant ones. To sophisticate more, it is possible to use an adaptative threshold as explained in chapter 3 (tools definition). Indeed, instead of using a fixed threshold chosen up stream or ex ante as it is done here, the threshold could be defined as a percentage of the total number of offers during a specific session:

$$n_X = X\%\ of\ the\ total\ number\ of\ offers\ by\ all\ agents\ during\ session\ i$$

Thus, the thresholds would be indexed to the market situation at the time of the trades.

Tool 6: Price reference and weighted average comparison

The aim of this tool is to answer the question: How often does an agent bids out of an interval of price around the weighted-average (WAVG) price of the session?

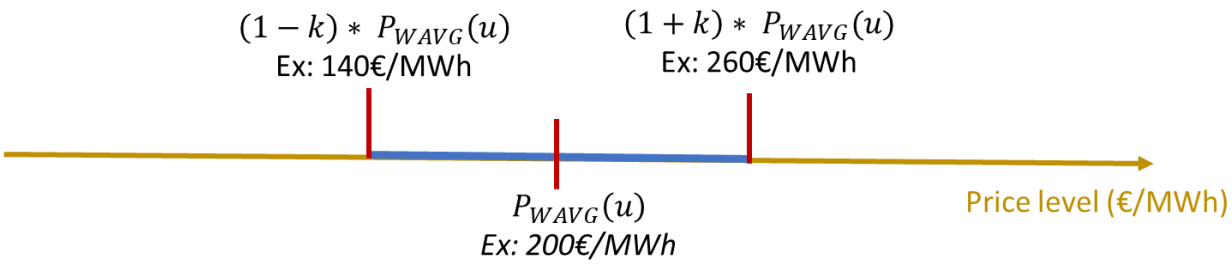
Definition (chapter 3):

We compute first the weighted-average price of a session u:

$$P_{WAVG}(u) = \frac{\sum_j P(j) * Q(j)}{\sum_j Q(j)}$$

Then, user choose a parameter k to define the interval around the weighted-average price. Let's illustrate with an example:

We consider a WAVG price of 200€/MWh for the session studied and the user chooses k=0,3 for his analysis so the interval is [140; 260].



Tool 6: Example - construction of an interval around the WAVG price

By using Booleans, a first SQL request detects for each offer the delta with respect to the WAVG price and if the price is inside or outside of the interval. In this latter case, whether the price is below the lower limit or above the upper limit.

FECHA	HORA	CDAGENTE	CDOFERTA	PRECIO	weigthed_av	Delta_Precio	upper_limit	lower_limit
15/11/2021	1	CENTE	23932823	152,85	219,05	66,2	0	1
15/11/2021	1	CENTE	23932826	167,85	219,05	51,2	0	0
15/11/2021	1	CENTE	23932828	174,85	219,05	44,2	0	0

Data extracted from the first request – only 3 offers out of 265.845 for the whole week

In a second phase, the analysis focuses on each agent's ratios on different timeframes. In concrete terms, we use a second SQL request to compute these ratios. Let X a Boolean for each offer "j", the ratios for an agent "i" during a timeframe "u" are:

$$R_{upper}(i,u) = \frac{\sum_j X_{upper(j,u)}}{\#total\_agent} \qquad R_{lower}(i,u) = \frac{\sum_j X_{lower(j,u)}}{\#total\_agent}$$

SQL Request:

- First SQL request on each offer

```
PARAMETERS [threshold_factor] IEEESingle;

SELECT ofertas_modificado_05.FECHA, ofertas_modificado_05.HORA,
ofertas_modificado_05.CDAGENTE, ofertas_modificado_05.CDOFERTA,
ofertas_modificado_05.PRECIO, table2.weigthed_average,
Round(Abs(PRECIO-weigthed_average),3) AS Delta_Precio,
IIf(PRECIO>(1+[threshold_factor])*weigthed_average,1,0) AS upper_limit,
IIf(PRECIO<(1-[threshold_factor])*weigthed_average,1,0) AS lower_limit

FROM ofertas_modificado_05, (

    SELECT ofertas_modificado_05.FECHA, ofertas_modificado_05.HORA,
    Round(sum(Abs(PRECIO*Cantidad))/sum(cantidad),2) AS weigthed_average
    FROM ofertas_modificado_05
    GROUP BY ofertas_modificado_05.FECHA, ofertas_modificado_05.HORA)  AS table2

WHERE (((ofertas_modificado_05.FECHA)=table2.FECHA) And ((ofertas_modificado_05.HORA)=table2.HORA))
ORDER BY ofertas_modificado_05.FECHA, ofertas_modificado_05.HORA, ofertas_modificado_05.CDAGENTE;
```

Tool 6 - Price WAVG comparison for each offer

- Second SQL request on each agent ratio

```
PARAMETERS [threshold_factor] IEEESingle;

SELECT CDAGENTE, COUNT (*) AS total_agent,
round(SUM(IIf(upper_limit,1,0))/total_agent,3) AS upper_ratio,
round(SUM(IIf(lower_limit,1,0))/total_agent,3) AS lower_ratio

FROM (
    SELECT ofertas_modificado_05.FECHA,
    ofertas_modificado_05.HORA, ofertas_modificado_05.CDAGENTE,
    ofertas_modificado_05.CDOFERTA, ofertas_modificado_05.PRECIO,
    table2.weigthed_average,
    Round(Abs(PRECIO-weigthed_average),3) AS Delta_Precio,
    IIf(PRECIO>(1+[threshold_factor])*weigthed_average,1,0) AS upper_limit,
    IIf(PRECIO<(1-[threshold_factor])*weigthed_average,1,0) AS lower_limit

    FROM ofertas_modificado_05, (
        SELECT ofertas_modificado_05.FECHA, ofertas_modificado_05.HORA,
        Round(sum(Abs(PRECIO*Cantidad))/sum(cantidad),2) AS weigthed_average
        FROM ofertas_modificado_05 GROUP BY ofertas_modificado_05.FECHA,
        ofertas_modificado_05.HORA)  AS table2

        WHERE (((ofertas_modificado_05.FECHA)=table2.FECHA) And
        ((ofertas_modificado_05.HORA)=table2.HORA))
        ORDER BY ofertas_modificado_05.FECHA,
        ofertas_modificado_05.HORA, ofertas_modificado_05.CDAGENTE)  AS [%$##@_Alias]

GROUP BY CDAGENTE;
```

Tool 6 - Price WAVG comparison - Agents Ratio

Results:

Results exposed are obtained with parameter k=0,3.

The results presented are each agents ratio for the whole week. We consider the total number of offers of the agent during the week, the percentage of offers above the upper limit and under the lower limit. The last column presents the sum of both ratios and the table is presented in decreasing order of this measure.

A threshold (figures in red) is set when a ratio is above 0,5. To explain it for the last column, an activation of the threshold means that more than 50% of the agent's offers are out of their price interval.

Agent	Total number of offers	Upper Ratio	Lower Ratio	Sum upper & Lower ratios
[redacted]	1	0	1	1
	25	0	0,96	0,96
	2575	0,122	0,593	0,715
	20874	0,151	0,414	0,565
	36273	0,007	0,534	0,541
	16	0	0,5	0,5
	14	0	0,429	0,429
…	…			
[redacted]	788	0	0,013	0,013
	8	0	0	0
	74	0	0	0
Total	**265845**	**0,16122667**	**0,01970667**	**0,18093333**

Tool 6 - Price comparison - Agents Ratio – Timeframe: one week

From a general point of view on the whole table, we observe higher value for the lower ratio than for the upper ratio. More specifically, we observe in the first line an agent who has a surprising ratio of 1. This is explained by the total number of offers he did during the timeframe. He only did one offer so this ratio is not relevant. However, the agents in line 4 and 5 for example are much more interesting. We have agents publishing a lot of offers with a high ratio (>0,5) out of the price interval.

Alternatives and improvements:

The tool has also been implemented on the transaction database. Some alternatives are possible here:

- The parameter k=0,3 is an adjustment parameter and can be changed
- Agents statistics are computed for the whole week here but it can be done on other timeframes

As for other previous tools, the ratios could be computed for offer units instead of agents. With a such approach considering offer unit, it would be possible to differentiate the thresholds on ratio according to the technology which would be interesting because the trading strategy may not be the same according to the technology.

To further develop this tool, it would be interesting to apply the same method by separating offers to buy from offers to sell in order to obtain distinct results and compare them.

To take a step back on this tool, its construction is cleverer (and more complex) than previous ones because it is quite adaptative. Indeed, each offer is compared to a reference price of the session concerned. And only then, agent's statistics are computed. It gives more sophisticated results and reflect with more precision agent's tendency to be out of the market or not because for each offer we consider the state of the market at the moment of the offer. It is appropriate in the current market context, facing a significant volatility during some sessions of the continuous market.

Here we find the idea of a constant compromise between tools that are sufficiently complex to be relevant but that remain both operational and functional and above all achievable in view of the time constraints and the level of programming required. The next step in terms of complexity and sophistication would be to consider chronology.

III. Synthesis of results obtained

Dashboard of tools

Protocols and tools combination presented in chapter 3 are not implemented in this thesis because it would be a project on its own requiring programming skill and more time. Nevertheless, I wanted to implement a synthesis of the six tools developed to take a step back. The aim is to have a global vision thanks to an exhaustive dashboard. Let's present a capture of the dashboard:

	1) ratio casadas # thershold: In red: ratio < 0,05 In green: ratio > 0,9	2) ratio casadas Q thershold (same as 1)	3) Ratio casadas canceladas threshold In red: ratio > 0,1 In green: ratio < 0,01	4) Net results Threshold Trading Behaviour: [-0,1 ; 0,1]				5) Activity on both sides Thresholds : > 1 session	6) Price interval Threshold: >0,5 of offers out of the interval			
AGENT	Moyenne de ratio_casasdas	Moyenne de ratio_Q_casasdas	Moyenne de ratio_casadas_canceladas	price_V_avg	price_C_avg	trading behaviour	Abs Delta(V-C)	# sessions	total_agents	Sum Up&Lo	Upper Ratio	Lower Ratio
[redacted]	0,475	0,536	0,03	194	216	0,754501613	22	0	1084	0,131	0,006	0,125
	0,07	0,004	0,002	209	205	0,248268514	4	0	5519	0,293	0,019	0,274
	0,665	0,574	0,091		250	1	only one side	0	176	0,028	0	0,028
	0,008	0,004	0,003	212	230	-0,259702627	18	25	36273	0,541	0,007	0,534
	0,14	0,068	0	209	247	-0,168	38	0	264	0,03	0	0,03
	0,163	0,165	0		219	1	only one side	0	246	0,15	0,016	0,134
	0,17	0,194	0,004	200	248	-0,084142395	48	0	833	0,094	0,02	0,074
	0,349	0,333	0,009	180	259	-0,292728828	79	0	789	0,238	0,034	0,204
	1	1	0		230	1	only one side	0	1	1	0	1
	0,436	0,479	0,074	237	229	-0,588755304	8	0	204	0,118	0,049	0,069
	0,556	0,718	0		262	1	only one side	0	9	0	0	0
	0,145	0,159	0,01	221	274	-0,687374749	53	0	788	0,013	0	0,013
	0,082	0,047	0,017	218	225	0,044087247	7	94	20868	0,19	0,017	0,173
	0,179	0,069	0,004	210	229	-0,554229794	19	4	10758	0,268	0,024	0,244
	0,375	0,261	0,078	212	213	0,039048293	1	0	1551	0,148	0,004	0,144
	0,968	0,999	0	218	242	0,458356315	24	0	31	0,259	0,065	0,194
	1	1	0	196	259	0,246963563	63	0	29	0,206	0,034	0,172
	0,043	0,031	0,001	195	204	-0,696629213	9	0	859	0,09	0	0,09

Dashboard – A synthesis with the six tools – Timeframe: the whole week

The table presented is for the timeframe on the whole week. As for the tools, agents are anonymised. The dashboard encompasses the 6 tools (ratios and monitoring indexes). Thanks to the thresholds and visual alarm set for each tool, it offers a global vision and allows to visualize quickly agent's behaviour in the continuous market on the timeframe considered. We can detect if several "warning light" are switched on for one single agent and if that is the case, analyse its statistics.

Chapter 5: Conclusions

Global overview: methodology used, difficulties, main findings and future developments

In this master thesis work, it was expected to analyse ACER last revision of the Guidance of REMIT and especially the list of types of practices that can be labelled as market manipulation. The purpose of this project was also to analyse different agents' behaviour, to detect the use of each practice in the past and the creation of a method with a mathematical formulation to detect the use of them.

I made a description of the manipulation practices and then developed a mathematical formulation of tools to monitor agents' behaviour. Then, I implemented several tools and spent time on data analysis. The initial objective is achieved as long as working tools and relevant results from market data analysis are provided. This conclusive chapter provides an assessment on the methodology used, the difficulties encountered, the main findings and possible future developments.

Monitoring the continuous market is a wide and complex issue. Many approaches are possible. For each tool developed, several options were possible. Because of this, it was vital to use a clear methodology, especially in the development part. It was fruitful to set first a mathematical formulation of the tools, then to implement it with SQL and finally to analyse market data. Indeed, when we only speak about mathematical formulation and theorical protocols for monitoring, it is possible to design very sophisticated schemes. On the other hand, implementation on real data and concrete application is definitely another topic. I am convinced that it was fruitful to reach this application part. It offers a step back from the theoretical work and allows to improve it by ensuring that it can be applied on concrete cases.

This application part and development period was a continuous trade-off to obtain relevant and working tools. I had to balance the tool sophistication to keep their implementation achievable with respect to the programming skills required and the time constraint of the project.

Of course, the final result is far to be perfect and could be improved. The dashboard presented in chapter 4 part 3 paves the way for future developments. Some elements are not implemented in this project but presented theoretically in chapter 3. It is possible to identify two mains routes for future research:

First, each tool can be upgraded individually and new ones should be developed. The existing tools can be improved with a deeper analysis on the thresholds and adjustment variables. As explained previously in the "variations and improvements" part of each tool (chapter 4), thresholds have a key role to play in this monitoring analysis. In this work, they are defined empirically but could be the subject of a specific study to build

more adaptative thresholds. New tools must also be implemented. Chronology is for instance a crucial parameter of continuous trading. Some tools linked with chronology are presented in the mathematical formulation but not implemented because of the complexity of programming it and the time constraint of this project. To take this project further, these tools should be implemented.

Second, and certainly the most promising part, the combination of tools and automatization of protocols can make the difference to monitor the manipulation practices. On the one hand, combination of tools would allow to build robust protocols to monitor each manipulation. On the other hand, the automatization would allow to apply this monitoring process every week, not only on one week as it is done in this thesis. It is necessary in view of the amount of data from the markets.

To bring this thesis to its close, this kind of work on market monitoring never ends completely. The current energy crisis forced Spain and Portugal to set a new market mechanism called “The Iberian Exception”. Soon, the Iberian spot markets will integrate 30-minutes and 15-minutes products which requires new monitoring tools. Continuous improvement is needed as long as wholesale markets and their regulation evolve.

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