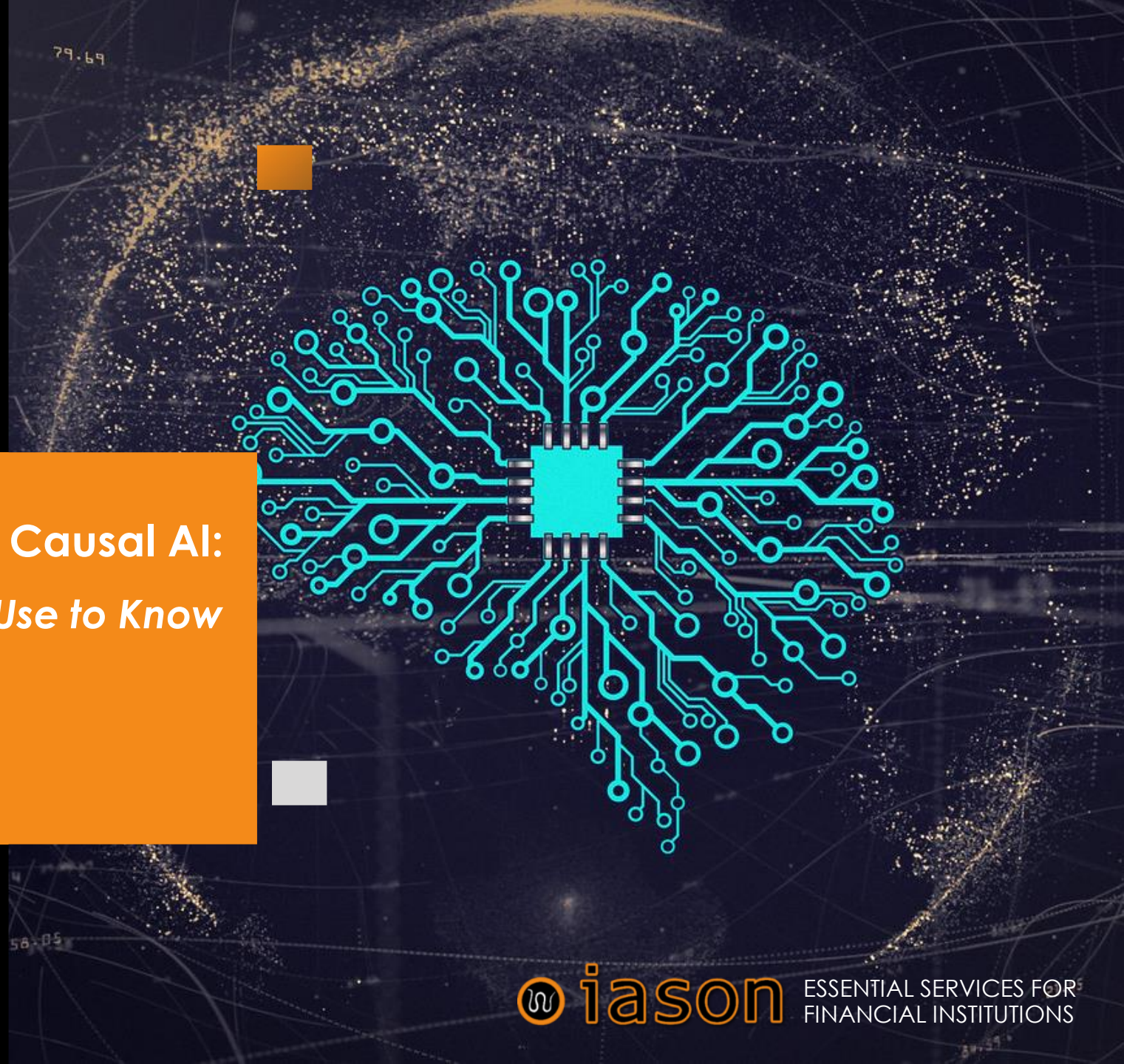
Just in Time

Causal AI:

Not the AI You Use to Know

Dec 2021



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Executive Summary

Despite the relevant adoption rate of ***Machine Learning*** (**ML**) in different aspects of our daily life, there are **areas** where **classical *Artificial Intelligence*** (**AI**) approaches demonstrated **flaws** or which require features that those have not.

In **Finance**, for example, there are **sectors** who **heavily leveraged** on **ML** techniques, but **others** who are **still in an early adoption stage** and the reasons are many.

On the background, **regulators**, **supervisors** and **practitioners** are now posing **important questions** regarding ***trustworthiness***, ***explainability*** and ***fairness*** of ML algorithms and it is clear how, in this direction, an important step forward need to be done.

In this context, ***Causal AI*** is growing fast as a branch of AI which can help in **overcoming different barriers** and **constraints** classical approaches have.

This work aims at providing a brief introduction on what Causal AI is, how it differs from classical AI and which are the expected benefits from its adoption.

At a Glance

01

Background

Classical ML Fostered a Flourishing Adoption of AI in Many Real-world Applications

…But Complex and Dynamic Ecosystems Have Complex Requirements

…Which are Driving Regulators, Supervisors and Practitioner to Look for Other Options

Background 1/3

Classical ML Fostered a Flourishing Adoption of AI in Many Real-world Applications

Real world **applications of AI bloomed rapidly** in the last decade and the trend seems to confirm such a momentum going forward with **adoption rates growing in different sectors**.

Classical *Machine Learning*

By means of "Classical" Machine Learning (ML) we refer to models applied to (primarily) **Supervised** and **Unsupervised** Learning[1] and ranging in:

- Logistic Regression, Support Vector Machines, Decision Trees, Naïve Bayes, simple Neural Networks (e.g., MLP)
- Different Ensembles, as Random Forests, XGBoost, …
- Deep Learning models

Non-financial *applications*

- **Service operations**
- **Product and/or service development**
- **Marketing and sales**

Applications in ***Finance***

- **Trading**
- **Credit Lending**
- **Risk Management**

Main sectors of applications

Background 2/3

…But Complex and Dynamic Ecosystems Have Complex Requirements

To **proven successful**, especially when deployed in real world environments and used in production, ML models face **different challenges**:

- **Biases** are often **inherited** from the **data**
- **Models** can be good at predicting, but **not useful in critical decision making** (i.e., *what-if* unapplicable)
- **Explainability** can be a real **burden**

- **Most heavily used models** are **black-boxes**
- **Performance** are often **critical** for production deployment
- Different **controls** can be applied **only ex-post**

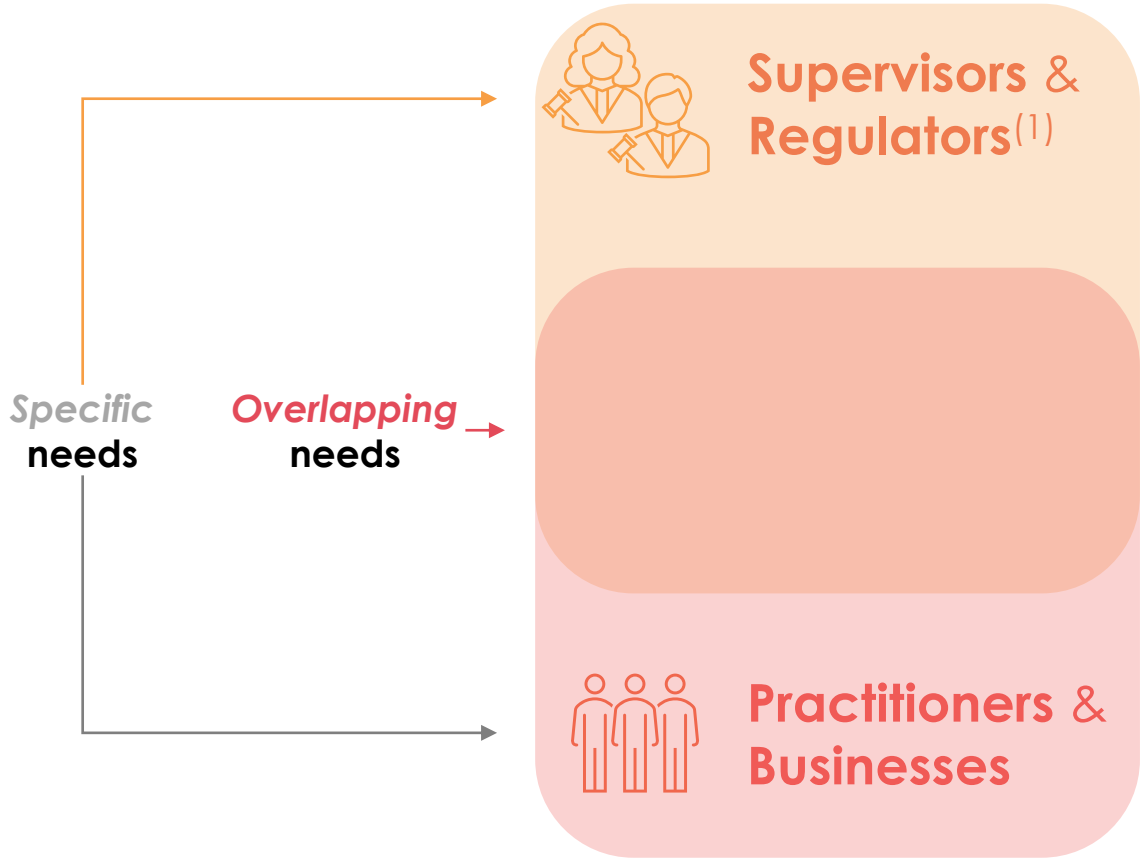
- **Changing dynamics**: most of the real-world use-cases need models who can **adapt rapidly to changing conditions** and **assumption** (e.g., financial applications)

- **Data scarcity**: models can need huge amount of data
- **Data overreaching** and **quality**: datasets often do not contain truly different information, but rather spurious correlations
- **Data preprocessing**, with huge effort and costs

Background 3/3

…Which are Driving Regulators, Supervisors and Practitioner to Look for Other Options

Especially in the financial system, where markets and their participants are tight with **complex dynamics** which can **change dramatically and with very short to no-notice**, some AI approaches can be at least suboptimal, if not practical at all.



- **Key people** & **Management** with adequate **skills**
- Appropriate **compliance**
- Appropriate **model & data governance**
- **Security**
- **Ethics** and **no Bias**
- **Explainability**
- Usefulness in **decision-making** process
- **Human-AI interaction**
- **Cost efficiency**
- Appropriate **ROI**
- **Performance**
- Model **scalability**

(1) More on regulatory and supervisory expectations for the financial sector can be found in the literature

02

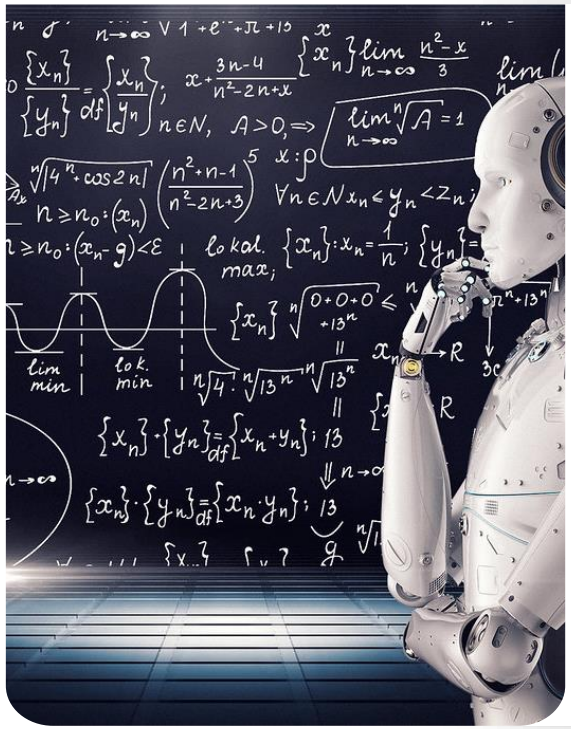
What is Causal AI

In a Nutshell: The Intersection Between Causal Inference and AI

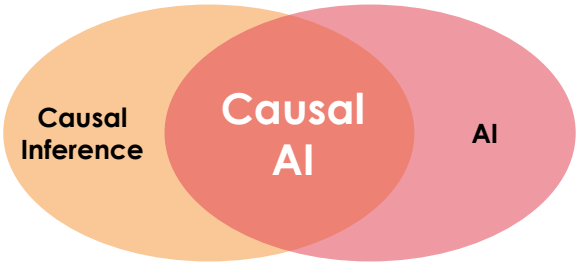
What is Causal AI?

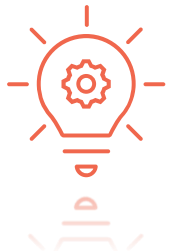
In a Nutshell: The Intersection Between Causal Inference and AI

In the context provided, **academia** and **companies** in different sectors started to **focus on different AI approaches** which can be beneficial or even overcome some of the pitfalls classical ML models have; **Causal AI** is one of these …



Causal AI refers to the **intersection** between **Causal Inference** and **AI**, where the former is the study of how actions, interventions, or treatments affect outcomes of interest.





Differently from **classical AI models** which are mostly ***correlation-based***(1), **Causal AI** models are meant to **learn the probabilistic dynamics** underneath the data and which drive the **cause-effect** relation between inputs and the target variable(s).

(1) Models learn the correlation (which can be spurious) structure, linear and not-linear, in the from historical data provided in the dataset

03

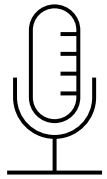
How is it Different from Classical AI?

The Clue

Causal AI Differs from Classical AI in Many Key Aspects

How is it Different from Classical AI? 1/3

The Clue



From "*Towards Causal Representation Learning*" *(cfr. [1])*

*"**Machine learning** often **disregards information** that animals use heavily: interventions in the world, domain shifts, temporal structure — by and large, we consider these factors a nuisance and try to engineer them away.*

*In accordance with this, **the majority of current successes of machine learning boil down to large scale pattern recognition** on suitably collected independent and identically distributed (i.i.d.) data"*

Classical AI and ML have been designed for objective more commonly related to pattern recognition or optimal policies identification under "fixed" regimes, but **struggle when asked to identify cause-effect relations among data**.

How Is It Different from Classical AI? 2/3

Causal AI Differs from Classical AI in Many Key Aspects 1/2

Classical AI		Causal AI
▪ The model **learns** the (historical and sometimes spurious) **correlation** present in the dataset	**Data vs Model driven**	▪ Rather than the correlation among data, the model tries to **learn the *cause-effect* relation** between inputs and target variable(s)
▪ The input-output dynamic is fixed given the data provided; in this sense the **model hardly adapts**	**Adapts to world changes?**	▪ Learning the casual dependencies, the **model adapts to real-world dynamics**
▪ Many of the classical models (especially Deep Learning ones) are **mainly black-boxes**: the model behaviour can be explained only ex-post	**Black or Glass box?**	▪ Models are **explainable by construction**: the causal dependencies graph allows to assess what's going on
▪ **Biases** and **ethics flaws** present in the data are **inherited by the models**; tricky *ex-ante* and *ex-post* procedures must then be put in place to prevent unfairness	**Fair?**	▪ The algorithm's assumptions and the inference the model performs can be more **easily assessed**, hence can **help preventing biases by design**

How Is It Different from Classical AI? 3/3

Causal AI Differs from Classical AI in Many Key Aspects 2/2

Classical AI

Causal AI

Classical AI		Causal AI
▪ The models learn only from the data provided and building *ad-hoc* "alternative" datasets for ***what-if*** **scenarios can require a lot of effort**, if been not even possible	**What-if …**	▪ By the so-called ***counterfactuals***, Causal AI models can allow **assessing and analysing scenarios never happened yet**, helping to: ▪ **Study what could have happened** ▪ **Take decision** based on **hypothetical future scenarios**
▪ **Encode practitioners' know-how** and expertise can be **cumbersome**	**Human *know-how***	▪ By intervening in the model graph, the **model designer can encode SME(1) key insights**
▪ Especially **Deep Learning** models require **huge amount of data**	**Data need**	▪ Data need **can be less demanding**

(1) Subject Matter Expert

04

Key Takeaways

Expected Benefits from the Adoption of Causal AI

Key Takeaways

Expected Benefits from the Adoption of Causal AI

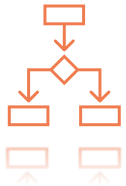
In the **past few yeas** there have been a **lot of increasing hype**(1) towards **Causal AI**, with an **increasing research** dedicated from both **academia** and **BigTech** companies.

If this trend keeps its momentum we can expect that, starting from the financial sector, the **next generation of AI models** can be **more resilient and robust**, with benefits along at least **4 main dimensions**:

+ Fair

+ Reliable

+ Responsive & Adaptable



Help the decision-making process

(1) For example, x8 is the increase of papers presented at NeurIPS from 2017
(2) Amazon, Google and Microsoft, for example, are actively working on these new technology

Sources and Literature

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Company Profile

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Antonio Menegon

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