Remarks in support of European Parliament's AIDA webinar with the European University Institute (EUI) on state of play on AI research

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Thank you for this kind invitation. I am an economist at the Department of Economic of the European University Institute. I am specialized in Industrial Organization, in Competition Policy and Antitrust. I also work on financial markets and banks, and on technology and applications of Artificial Intelligence (AI) in markets. Relatedly, with my colleagues Nicolas Petit and Giovanni Sartor, I codirect the European University Institute's Interdisciplinary Research Cluster Technological Change and Society.

The world of AI is vast, and it is one of the most fascinating frontiers of research in Economics. I would like to give you a snapshot of what I am doing on this as an economist and what I think are some of the most relevant developments of AI for economies and markets.

Let me start stating upfront that what I am interested in is the fact that AI can bring enormous efficiency gains to our economies that can then translate into wealth and well-being for all of us. You may know that economics is named the dismal science, because we study how to allocate resources that are always scarce (otherwise we would not have an economic problem). AI can help us in greatly improving this difficult allocation.

This said, I am convinced that we need to learn to cohabitate in economies and markets that are populated by AI and humans.

I will base my presentation on two key ideas, which are in fact the drivers of my research: interactions and learning.

In markets we are never alone. We continuously interact with someone else: between consumers and firms, workers and firms, between firms as competitors, across countries, etc. Incidentally, this need of interaction in economic activities is probably the main reason for our economies suffering so much with the Covid restrictions, which are unfortunate but necessary.

Interactions with AI in markets is a profound novelty in the economic scene, with many important questions. What happens to these economic interactions when some of the subjects delegate their decisions to AI algorithms? Or, how do algorithms perform when interacting, with other algorithms

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and/or with humans in markets? These interactions already take place in financial markets or in retail mass markets, where the prices of products are set by algorithms, and where we get product recommendations.

I come now to the second key ingredient: learning. In my view, the most significant novelty of the new version of AI we are seeing these days is the ability to learn. And to learn autonomously. Probably the most spectacular of this learning process is with the Reinforcement Learning (RL) class of algorithms, on which I am actively working. These are AI/machine learning (ML) algorithms that are designed to explore the environment, obtaining a feedback and consequently adapting to it. The rules of behavior are not encoded as in Expert Systems, they are instead autonomously learned by the algorithm that autonomously explores. Exploration is here balanced with exploitation, that is, responding to the objective the algorithm is given.

What is phenomenal of these RL algorithms is that this learning can take place in self-learning mode: that is, simply with algorithms interacting among each other. For example, the famous AlphaGo program was trained in self-learning: interacting with a clone, it has learned somethings that have not been seen before on Earth, new strategies to play the game of Go and Chess.

You see here my two key ingredients, interactions and learning, at play together. I personally think it is mind-blowing to realize that self-learning algorithms may come up with some behavior that is totally new, some strategies that humans have not yet used.

Let me summarize: we already have AI algorithms that interact in markets and that autonomously learn to behave in ways that we had not seen so far. Is this good or is this bad?

To give an example about how to answer this question, I would like to dig a bit on my own research, with a recent article that gives the title of my presentation today, *Protecting consumers from higher prices due to AI* (Calvano, Calzolari, Denicolò, Harrington, & Pastorello, 2020).

The premise of the article is, as said before, that AI used for pricing commodities can be extremely effective and will help a lot with the efficient allocation of scarce resources in markets. We therefore welcome AI pricing algorithms as a remarkable development of AI in markets. At the same time, we want to know in advance if and how things can go wrong when populating markets with autonomous AI pricing algorithms.

As economist we have tools to study interactions in markets, for example Game Theory, and can apply them to see if AI pricing algorithms are capable of coordinating. Coordination in environments with interactions is very important and learning to coordinate is difficult. Think about learning to drive a car. What is most difficult here is learning how to interact with other people on the street (their different attitudes, level of attention, etc.) A branch at the frontier of computer science is precisely studying how AI can learn to interact and cooperate (multi-agent environment). Incidentally, this may have several interesting applications, for example, in cooperation for the use of natural resources.

This cooperation is good but can also go wrong on some dimension. We discovered that self-learning pricing algorithms can learn to behave in markets in ways that are very difficult for humans. When studying the efficient properties of AI-powered algorithmic pricing, we discovered an unexpected phenomenon. AI algorithms that were supposed to compete in markets, for example stealing each other consumers by means of discounts, instead autonomously learned to charge high prices. This is not a novelty per se, as collusion between human managers is a common phenomenon, and one of the *raison d'être* of antitrust is precisely fighting collusion.

What is remarkable is that 1) AI algorithms learned to collude autonomously, that is they autonomously learned to cooperate among each other to obtain the maximal objective they were programmed for, which is profitability; 2) and they did so without communication and in a very deep and sophisticated way that is very difficult to achieve, if not impossible, for humans. In fact, we discovered that the type of collusion learned by the algorithms was based on implicit promises that could be paraphrased in this way: "I sell my product at high price if you do so, but if you offer a discount to the consumer I will also offer a discount and we will all end up with miserable and low profits, so do not do it and just sell at a high price". Algorithms were able to obtain all this without communications, something that humans are almost incapable of doing.

This discovery has several implications. Since we do want AI algorithms in our markets, we need to understand how to avoid they end up wrong, which in this case means colluding to the detriment of consumers, and just deliver instead their good, which is increased efficiency. To this end we need to work on several dimensions. In particular, I think we need strong collaborations between computer scientists and social scientists (for example in explainable AI, the so called "XAI").

Finally, another topic I am investigating and that could be of interest to the members of the AIDA Committee is that of Recommender systems (RS). These are algorithms designed to offer personalized recommendations to individuals when confronting a possibly very large set of choices. We already live immersed in RS, as they help us choose among millions of products to buy, stocks to invest, songs to listen, movies to watch, news to read, etc. For all these choices, we have platforms that offer us recommendations that greatly simplify our choices. These algorithms, in their most advanced versions, rely on AI tools and are becoming more and more effective in their recommendations. As an economist I am interested in understanding how they work and how they interact with market outcomes.

RS are changing the market landscape, as a product that gets recommended gains a lot of visibility. This outcome is very good because it addresses the problem of consumers who may have no clue about the available options. At the same time, those products that are not recommended may disappear form the market, which is something that may happen in any case, by the way. But we need to better understand how RS in the end work, and we need to have a sense of their role, effectiveness, and impact on markets.

Let me thank you for your kind attention.

References

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