ECONOMICS OF ARTIFICIAL INTELLIGENCE AND INNOVATION

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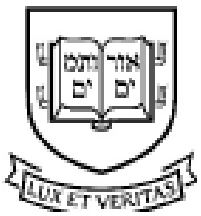

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ECONOMICS OF ARTIFICIAL INTELLIGENCE AND INNOVATION

Short title for running header: Economics of Artificial Intelligence

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Abstract: The author of this article describes the content of her course titled "Economics of Artificial Intelligence and Innovation." The course is offered by the Department of Economics of Yale University at a senior undergraduate level. The author also teaches this course at the MBA program of the Yale School of Management in another format.

Keywords: Artificial intelligence, innovation, Internet markets

JEL codes: A22, A23, L21, O31

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COURSE DESCRIPTION

Artificial Intelligence (AI) is transforming how almost every market works. Traditional strategies of product differentiation and transaction costs are no longer offering companies a lasting competitive advantage. Instead, the digital experience itself and the provision of highly tailored recommendations, prices, and discounts have emerged as a lucrative new avenue for companies to use to sell their products and services.

This course focuses on the effects of AI on markets from an industrial organization perspective. It examines the incentives faced by customers and retailers and analyzes how these agents interact in traditional stores, but also in new Internet marketplaces and platforms. It also discusses how AI has disrupted the structure of existing industries (e.g., music, TV, journalism) and how AI has affected the operation of the new Internet markets (e.g., platforms of accommodation and transportation).

The goal of this course is to familiarize students with fundamental economic theories of innovation and business strategies and equip them to understand how these theories are challenged in the digital environment. The students develop skills in modeling and economic analysis. They are also equipped to identify the market dynamics and trends and connect economic models to ongoing policy discussions about privacy, intellectual property (IP) rights protection, big tech and antitrust.

The topics are divided into two broad sections. First, we study how economic theories and business strategies are changing with the use of AI in retail. We analyze the economics of price discrimination (e.g., personalized pricing, dynamic pricing), bundling, searching cost, network effects, switching costs, product differentiation, price competition, etc. Second, we analyze economic models related to current policy debates. For example, we study the

economics of patents and copyrights, and then we discuss whether the existing IP system is appropriate to protect machine-created inventions, AI systems and the data that AI relies on to operate. We study the economics of prizes and analyze why targeted and blue-sky prizes are being used in promoting research in AI. We also examine whether mergers among high-tech giants are a threat to consumer welfare.

TOPICS

Topics that are covered in class include, but are not limited to, the following.

Price Discrimination

Price discrimination is a selling strategy that charges customers different prices for the same product or service. Price discrimination strategies refer to charging a different price to every consumer, charging a different price for different quantities consumed, or segmenting the market into consumer groups who have different demand curves. The retailer sets different prices for each segment. In this course, we study how the retailers can extract the "unexploited" consumer surplus and the deadweight loss, when each type of price discrimination can be implemented, how we set the optimal prices, and what the limitations are. Once we have a good understanding of the economics of all types of price discrimination, we study what we can achieve in the digital world.

Personalized Pricing. Perfect price discrimination or personalized pricing boils down to providing different prices to customers based on individual attributes. A key assumption is that the retailer knows each consumer's willingness to pay for any number of units. This assumption is exactly why the implementation of perfect price discrimination is impossible in real life. However, AI is a tool that can provide a reliable prediction of a customer's willingness to pay. Advanced AI algorithms can remember customers' likes and dislikes, their regular outgoings and

disposable income, their credit score, the value of their home, and digital footprints to decode their interests. They can analyze demographic data and social media impressions, and estimate the reservation price of individual shoppers. AI algorithms also process shoppers' emotional responses and behavior during previous shopping experiences and build customer profiles that allow for unprecedented customization. Retailers are using AI to hyperpersonalize prices, product recommendations and design promotions for a particular customer.

In traditional stores, retailers can use Beacons: small wireless devices that transmit a Bluetooth signal to a smartphone app. Beacons suggest offers and purchases based on a customer's exact location within a store. In digital stores, with AI, retailers can analyze the efficacies of multiple pricing models and arrive at the optimal price that each customer will see. Retailers who decide to set a uniform price can also implement personalized pricing by optimizing markdowns. As a result, the price after the discount that each customer pays can be different and based on the customer's shopping profile. Fairness and other ethical issues related to data collection methods and the transparency of the implementation of these business practices arise and ignite in-class discussions.

Market Segmentation and Dynamic Pricing. In class, we analyze economic models of dynamic pricing and market segmentation and examine how the use of new technologies enables retailers to develop more sophisticated ways to implement these business strategies. The *Wall Street Journal* (Mattioli 2012) has reported that the U.S. travel agency Orbitz was directing Mac users to more expensive options than Windows users. The *WSJ* (Valentino-DeVries,Singer-Vine, and Soltani 2012) has also reported that the office supplies firm Staples was charging consumers different prices based on their location. Consumers who were close to a competitor saw a lower price.

Dynamic pricing occurs when prices fluctuate over time. We all are familiar with Uber's "surge pricing": a rapid adjustment to the fares on Uber's platform in the attempt to match driver supply to rider demand at any given time. In mortar-and-brick stores, "smart" pricing strategies become possible with the use of electronic price tags that allow multiple price changes within a day, in contrast with the paper price tags that require an employee to update them manually. A prominent example is the Spar stores in the United Kingdom. *The Guardian* (Adams 2017) has stated that Spar stores implemented dynamic pricing in the food hall. A different price was set in the morning than at the end of the day when the customers were heading home right after work. The retailers reported that they experienced an increase in revenue and profit.

Personalized Product Bundling

When customers visit online and brick-and-mortar stores to buy products to complete a look or a project, they often leave without buying everything they need. Thus, promoting the right products at the right time would increase customer satisfaction and drive sales. AI is reframing how companies approach cross-selling. Using past customer behavioral data, availability and purchase data, or data on what is abandoned and viewed, AI can identify the best product combinations that can be bought together and promote specific bundles with significant discounts. Personalized product bundling has emerged as a lucrative business strategy. In this course, we analyze the methods of bundling and how we can implement them more efficiently by exploring AI's ability to identify each customer's buying patterns and needs.

Searching Cost

In Internet markets, competition is one click away. Artificial intelligence can classify millions of items from various brands and compare prices within seconds. In this course, we analyze models on searching costs. Some parameters on the models affect all consumers in the same way. These

parameters can capture changes that are associated with the switch from shopping in traditional stores to shopping online. But other parameters can be customer-specific.

We also analyze the economics of anticipatory shipping: a business strategy that can minimize searching costs. It can be implemented when an online marketplace can evaluate a customer's taste and ship them a product preemptively. By using this business model, a company can increase its profit for two reasons. First, it preempts the customers from buying those items from competitors. Second, they may be less inclined to return items that are in their possession. This demonstrates that by improving the accuracy of its prediction tool, a company can flip its shopping-then-shipping model to a shipping-then-shopping model.

IP Protection

We study the economics of patents, and once the students are familiar with the current system of IP protection, we discuss what transpires if an artificially intelligent system creates a new product. Should patent offices recognize this AI system as the inventor? Machine-learning algorithms can allow a computer to learn from data input, evolve, and make decisions independently. The first-ever patent applications related to inventions solely created by an AI system were filed in 2019. But, who should own the patent? The engineer who built the AI system? The AI system itself? The current patent laws only recognize "natural persons" or "individuals" as inventors.

Similar concerns arise for copyrights. AI systems can generate music or write local news articles. In 2016, a Japanese computer program wrote a short novel that reached the second round of a national literary prize. But, the U.S. Copyright office registers only "an original work of authorship, provided that the work was created by a human being." With the advancement of AI systems, new forms of IP protection are needed.

ASSIGNMENTS

Problem sets are assigned weekly. They are a critical component of this course because they help the students master the material and practice solving economic problems. The problem sets are designed to meet the mathematical skills of senior undergraduate students who are pursuing a major in economics. A course in introductory microeconomics and a course in mathematics at the level of multivariable calculus are prerequisites.

The students are asked to perform an industry analysis in order to identify the competitiveness of an industry as well as a firm's competitive advantage and potential profitability. An industry analysis also can specify the impact of AI on business operations and economic transactions. The industries under consideration include transportation (autonomous and electric cars), healthcare, pharmaceutical, finance and banking, online platforms, and entertainment. The students are asked to identify what the main industry trends are and discuss how different this analysis would be if it had been performed ten years ago.

CONCLUSION

The topics and format of this course allow the students to better understand the potential, but also the limitations, of the use of AI in business. In the end-of-the-semester survey, the students stated that this course "was not only insightful but also inspiring and interesting to learn about the different choices tech companies face for their pricing models and product development." Regarding the knowledge and skills the students developed by taking this course, they reported: "We developed the economics of the present and the future in a world where AI and consumer data can help determine individual consumer preferences in an accurate way"; "Learning to think critically about the economy and markets given the current (and potential future) impact of AI

was one of the biggest skills I picked up"; "Along the way, I sharpened my research, presentation, and math skills."

As economic activity is moving online, AI is becoming a core component of business software. The future of retail, healthcare, transportation, finance, entertainment, sports, and numerous other sectors relies on the advancement of AI. This course aims to examine the new business practices that are used in Internet markets and how the economic theories can be developed to model them.

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