Prediction Machines: The Simple Economics of Artificial Intelligence
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Summary

1. Discussion of AI through an economic lens and its implications of business, strategy, and society as a whole.

Key Takeaways

Introduction: Machine Intelligence

1. AI does not actually bring intelligence, but rather prediction which is a component of intelligence and an input into decision making.
2. Economic frameworks and making decision under uncertainty provide good explanation for what comes next.
3. Prediction Machines are not a recipe for success as they still emphasize tradeoffs: more data means less privacy, more speed means less accuracy, and more autonomy means less control.

Cheap Changes Everything

1. When the price of something falls, we use more of it; the rise of the internet was a drop in the cost of **distribution, communication, and search**.
2. **Reframing a technological advance as a shift from expensive to cheap or from scarce to abundant is invaluable for thinking about how it will affect your business.**
3. Google made search cheap from an economist's perspective and companies that made money selling search through other means (i.e. Yellow Pages, travel agents, classifieds) found themselves in a competitive crisis and businesses that predicated on being found by others prospered.
4. Technological change makes things cheap that were once expensive.
5. Reducing something to pure cost terms has a way of cutting through the hype; **Does (x) make something cheap?**
6. Cheaper prediction will be more predictions; this is simple economics: when the cost of something falls, we do more of it.
    a. When things become cheap, it can enhance the value of other things that are complements to it. For example, just as a decrease in the price of coffee enhances the value of cream and sugar, so too for autonomous vehicles, a drop in the costs of prediction increases the value of sensors that capture data on the vehicle's surroundings.
    b. When prediction is cheap, there will be more prediction and complements to prediction.
7. Metaphor: AI uses data to improve its predictions akin to turning up the volume knob on a speaker dial, but instead of volume a predictions accuracy.
8. Amazon Thought Experiment: Amazon may find it more profitable to go from "shopping-then-shipping" to "shipping-then-shopping" before people request items and handle returns as needed; by launching sooner, the Amazon fly wheel can get ahead as better predictions will attract more shoppers and more shoppers will generate more data to train the AI, more data will lead to better predictions and so on, creating a virtuous cycle.
    a. AI subject to increasing returns and scale economies.
9. **Predictions facilitate decisions by reducing uncertainty while judgement assigns value**; judgment is the skill used to determine a payoff or utility. The most significant implication of prediction machines is they increase the value of judgement.

a. Will be used for traditional prediction tasks (i.e. inventory and demand forecasting) and new problems (i.e. navigation and translation) and drop in the cost of prediction will impact the value of other things, increasing the value of complements (data, judgment, and action) and diminishing the value of substitutes (human prediction).

Part One: Prediction

1. Prediction in the process of filling in missing information; it takes information you have (i.e. data) and uses it to generate information you don't have. Prediction can generate data about the present, past, and future.
2. **Important: the impact of small improvements in prediction accuracy can be deceptive.**
    a. **For example, an improvement from 85 – 90% may seem twice as large as an improvement from 98-99.9%, but if you invert the error rate the former declines by 1/3 and the latter declines by a factor of 20.**
3. Machine learning predictions may by wrong on average unlike regression but when they miss it isn't by much. This would be described as allowing a tradeoff in bias in exchange for reducing variance if it makes the prediction better.
    a. Statistics emphasized being correct on average but biases improve some predictions.
4. Data is a key complement to prediction and it becomes more valuable as prediction becomes cheaper. With AI, data plays three roles:
    a. Training data used to generate the algorithm initially and train it to predict in the wild.
    b. Input data which feeds the algorithm used to make a prediction.
    c. Feedback data is used to improve the algorithms performance with experience.
5. Trade-offs in data involve its cost: the benefit of acquiring more data versus its cost; but to generate more accurate predictions you need more data to study.
6. Economically, data may have increasing or decreasing returns to scale: as you get more data, each additional piece is less valuable but more data can help you make better predictions.
    a. There is a relationship between adding more data, enhancing prediction accuracy, and increasing value creation.
7. Machines still need to be complemented by humans because they can make naïve prediction: i.e. hotel example cited in the book. A machine could say raise price of a hotel room to generate more revenue but it could be the "off season" and a human would know this.
8. With more data, the better prediction machine will be in making the decision with humans making better decisions with thin data sets.
    a. Humans will likely provide the prediction by exception.
    b. Prediction machines scale so the unit cost per prediction will fall as the frequency increases.

Part Two: Decision Making

1. Prediction is not a decision: making a decision requires applying judgement to a prediction and then acting. This distinction did not matter before AI.
    a. Other components include judgement, action, outcome, and the three types of data.
2. Breaking a decision into its key elements: prediction, judgement, data, and action. Prediction value by humans will decline but the other elements will have enhanced value.
3. Judgment: the process of determining the reward to a particular action in a particular environment; determining the relative reward and penalties of pursuing an action.
4. As predictions become commoditized, the value of complements and the human skills associated with data collection, judgement and actions will become more valuable.
5. Uncertainty increases the cost of judging the payoffs for a given decision.
6. Consumer data is valuable as it gives prediction machines data about preferences.

7. Machines are bad for predictions of rare events.
8. Better prediction identifies more "ifs" expanding its capabilities by creating more "thens" and could undermine airport lounges as they are imperfect solutions to uncertainty.
    a. These are examples of satisficing in the absence of good prediction.
9. Enhanced prediction allows decision makers to handle more "ifs" and "thens" to lead to better outcomes.
10. Full automation only makes sense depending on the relative returns to the machines doing other elements.
11. The tasks most likely to be automated are those for which full automation delivers the highest returns. These include tasks that:
    a. Other elements are already automated except for prediction.
    b. The returns to speed of action in response to prediction are high (i.e. driverless cars).
    c. Returns to reduced waiting time for predictions are high (i.e. space exploration).

Part Three: Tools

1. When computers were integrated into companies, the best way to see how to integrate them was to state the Company's objective and then examine their work flow and identify which tasks were needed to achieve the objective and how a computer could be (or not be) used in said task.
2. Goldman Sachs CFO said IPO has 146 distinct tasks that are begging to be automated.
3. AI can change work flows in two ways: they can render tasks obsolete and remove them from work flows or add new tasks.
4. Large corporations are comprised of work flows that turn inputs into outputs; work flows are made up of tasks.
    a. In deciding how to implement AI, companies will break workflows into tasks and estimate the ROI for building / buying AI for each tasks and rank order them in terms of ROI and then go down the list and implement.
5. A job is a collection of tasks and some may be automated and new tasks may be created.
6. The implementation of AI generates four implications for jobs:
    a. Augment jobs.
    b. Contract jobs.
    c. Lead to reconstitution of jobs with some tasks added and some taken away.
    d. May shift emphasis on the specific skills required for a particular job.
7. AI may change the relative returns of skills for doing a certain type of job.

Part Four: Strategy

1. **"Shopping then shipping" continued**: physical stores actually function as a hedge for demand by pooling a group of customers and reduce uncertainty; moving to a shipping then shopping model requires individual household demand data to overcome the competitive advantage of physical stores and prediction machines may be able to tip that balance. Benefits of increased sales would need to outweigh the cost of returns.
2. Large corporations have large profit margins and can afford to experiment with AI as they operate at scale.
3. Prediction and judgement are complements so when prediction increases the value of judgement rises.
4. **Strategy is about capturing value and who will capture the value that better prediction creates?**
5. Like oil, data has different grades: training data is used to build a prediction machine; input data is used to power it to produce predictions; feedback data is used to improve it.

a. Only input and feedback are needed for future use and training may not be useful anymore once it's up and running.

6. AI can lead to strategic change if three factors are present:
   a. There is a core trade-off in the business model (i.e. shop-then-ship versus ship-then-shop).
   b. The trade off is influenced by uncertainty (higher sales versus returns).
   c. An AI tool that reduces uncertainty tips the scales of the trade-off.

7. Prediction machines will increase the value of complements such as judgement, actions and data and better "judges" will rise in the corporate ladder.
8. Specific examples of strategy changes: Airlines and automakers.
   a. Airlines: contracting more with their partners.
      i. Lower cost versus control is a core trade-off
      ii. This tradeoff is mediated by uncertainty; the returns to control increase with the level of uncertainty.
         1. Airlines manage this by optimizing the boundaries of their own activities end and those of their partners begin.
      iii. If a prediction machine could reduce the uncertainty, they could contract more to their partners.
      iv. AI might enable machines to operate in more complex environments expanding the numbers of reliable ifs and reducing the need for capital equipment by making contacts with suppliers more specific and generating predictions.
   b. Automakers: face the choice of outsourcing or making the parts themselves to reap improvements over time as they control innovation life cycle of the product.
      i. Prediction machines that reduce uncertainty about customer needs could change this strategy.
      ii. Trade-off between short-term and long-term performance and routine versus non-routine events is resolved by a key organization choice: how much to rely on external suppliers.
   c. Predicting consumer satisfaction would enable automakers more confident in designing products up front leading to high satisfaction and minimal need for adjustments.
9. Issue with advertising: you pay per impression but small subset are customers so your willingness to pay for each impression will be relatively low.
10. Predictions and data are complements; AI useless without data to feed it.
11. **A key strategic choice is determining where your business ends and another begins; that is, deciding on the boundary of your firm (i.e. airline partnerships, outsourcing auto part manufacturing) and uncertainty influences this choice but AI can reduce uncertainty and possibly change this.**
12. **By reducing uncertainty, prediction machines increase the ability to write contracts and increase incentive for companies to contract out both capital equipment and labor focused on data, prediction, and action.**
13. AI relies on correlation so you can fall into traps. For example, if you want to know if advertising is effective you need to see whether ads lead to sales but this is hard because you'd need to know what happens to sales if you ran no ads and that is not always available.
14. Homogenous populations in Ecology show that if you optimize for the individual it multiplies the likelihood of system-wide failure. This means you should allow for some level of diversity in your prediction machines.
   a. A trade-off between individual and system-level outcomes.

Part Five: Society

1. Humans and AI likely to work together with AI doing predictions and humans doing the judgement.
2. This could cause incomes to go down and income accruing to the owners of AI.
3. **There are large scale economies inherent in AI: more customers lead to more data, more data to better predictions, and better predictions leads to more customers.**
    a. **Very easy to fall behind and prone to tip to a "winner takes all /most" scenario.**
4. Technological advances will make us better off and increase productivity but the question is distribution.
    a. AI make increase competition among existing humans for what tasks are left and income will flip more toward capital (owners of AI) than people.
    b. AI tools may only enhance productivity of skilled workers.
5. **AI has scale economies and increasing returns: better prediction accuracy leads to more users, more users generate more data, and more data leads to better prediction accuracy.**
6. Trade-off between performance and privacy and this will come to a head.

What I got out of it

1. AI will make predictions cheaper and more abundant; this will make complements to prediction more valuable such as data, judgement, action, and outcomes. This will also make human prediction obsolete.
    a. Humans will likely help with naïve prediction and predictions by exception.
    b. <u>Economic Mental Model</u>: when looking for something valuable, <u>think in complements</u> to see where the value lies when something gets cheap!
2. Predictions reduce uncertainty while judgement assigns value.
3. AI is subject to increasing returns to scale and data to both increasing / decreasing returns to accumulating more data.
    a. <u>More customers lead to more data, more data to better predictions, and better predictions to more customers.</u>
4. Inversion: decreases in error rates (15-10%) only decreases by 1/3 but to go from (2%-0.1%) is an improvement by a factor of 20!
5. Three types of data are needed for AI: training, input, and feedback data and there are tradeoffs in data acquisition; data comes in different grades just like oil.
6. Better prediction allows more "ifs" and "thens" which will have significant business implications.
    a. Will help in business contracts and determine the asset intensity of a business in the future.
    b. AI will affect the "boundaries" of firms due cheaper prediction and the reduction of uncertainty.
7. AI can change works flows by rendering some obsolete, but also can create new ones.
8. <u>Ecology tie in</u>: allow for some diversity in your prediction machine to reduce likelihood of system wide failure.