Artificial Intelligence and Economic Calculation

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1 Introduction

In a day and age when socialism is ascendant in the United States and computer technology continually improves, it is reasonable to ask if economic planning is more viable than it once was. The classic arguments against central planning, put forward by Ludwig von Mises and F.A. Hayek are now decades old and do not account for the rapid and vast changes in technology. Since that time, a small amount of research has been done on the viability of socialism with modern advances in computing power. There are arguments for and against socialism guided by artificial intelligence (AI) and computer technology (see sections 2.1 and 3), but none of them takes a comprehensive view of the realistic capabilities and shortcomings of an AI-planned economy.

Our questions are succinct. First, we ask whether AI can plan an economy. We then ask if it can achieve results equivalent to or better than those of a free market. The first question asks whether AI is better than humans at planning, which may be the case but this is not certain. Central planning by humans has a deplorable track record and some of its inherent failings can be corrected by AI, but AI also introduces new problems. The second question asks if AI is better than a spontaneous market order, or unplanned economy. We show that it is not. Beyond falling short of the outcomes of the free market, AI introduces new public choice problems into an economy. Some of these are magnifications of earlier public choice problems from planned economies, but others are unique. With AI, socialism is more of a public choice issue than an economic calculation issue; it is still not a viable way to organize an economy. Notwithstanding the increased prominence of public choice problems that can bring down an AI-planned economy, there is a remaining calculation problem.

2 Economic Calculation: Price Signals or Knowledge Coordination

The economic calculation argument has become a widely accepted refutation of command planning. Ordinarily it would not need to be rehearsed, but an overview of its two predominant lines of reasoning is needed to show the relevance of AI for each. Like all arguments, the economic calculation argument rests on assumptions, and AI can refute some of these and also present new problems for economic planning.

The two broad divisions of economic planning are command planning and indicative planning. Economic planning most often connotes command planning, especially in the context of socialist economies in which the government makes resource use and allocation decisions. Indicative planning is more common and is practiced even in countries with capitalist-oriented systems. In an indicative planning system, to use Nove's description, the state uses "influence, subsidies, grants, and taxes, but does not compel" (Nove 1987).

2.1 Mises, Hayek, and the Refutation of Command Planning

Hayek (1945; [1960] 2011) advanced one line of reasoning opposing command planning that centered on the coordination of knowledge dispersed throughout the economy. He divided knowledge into "scientific knowledge" and "knowledge of the particular circumstances of time and place," later termed "tacit knowledge" by Polanyi (1966). This latter type of knowledge could not be obtained or coordinated by a central planning authority.

Hayek (1945) emphatically states that this knowledge "never exists in concentrated or integrated form but solely as the dispersed bits of incomplete and frequently contradictory knowledge which all the separate individuals possess." Historically, centrally planned systems have lacked both a means for planners to obtain all necessary information and capacity to analyze it. Obtaining this knowledge is still difficult in an age of digital connectivity, but it is far easier than it once was. Hayek hints that the problem of coordinating knowledge may be tractable and it has recently become much easier with advances in computing power. This point about computing power has been addressed by proponents of central planning, some of whom have developed models of a planned economy (Cockshott and Cottrell 1989; 1992; 1993). These models focus on employment and output but have little to say about maintaining incentives for compliance with the economic system's rules, incentives and goals for planners and the economy, or entrepreneurial innovation.

The other dominant line of reasoning opposing command planning was advanced by Mises ([1949] 2007) and centers on market exchange based on private property. Property rights make free human action possible. Market exchange produces price signals that cause resources to be allocated to their highest use. Price signals operate by quantifying production and consumption decisions in terms of costs. The best use of something is whatever the one who pays the most for it wishes to do, leaving ample room for entrepreneurship. In Mises's view, if there is no private property in productive resources, there will be no entrepreneurial innovation.

Hayek (1945) makes clear that planning happens throughout the economy, but effective and comprehensive government planning was, in his view, untenable. Firms are nodes of planning within a market. Firm managers, without knowing each small detail, make plans which can lead toward production and profit if they give employees the right incentives, even if employees have no "property" in the company. Large firms can succeed with considerable centralized direction if their employees have the right incentives.

The differences between Hayek's and Mises's arguments have been a point of contention, with some rejecting Hayek's argument (Salerno 1993; Hermann-Hoppe 1996). Yeager (1994) believed that prices facilitated calculation and, if this knowledge could be centralized, a planned economy would be possible. Salerno (1994) countered that the absence of private property in a planned economy prevents free human action, so any central allocation would not be the same as that produced by a free market. Salerno's view is pertinent in analyzing the role of computing power in a planned economy because it may solve the calculation problem yet not produce an outcome equivalent to that of the free market. AI is distinct from computing power. The question of whether entrepreneurship is possible in an AI-planned economy is one of the critical questions pertaining to the viability of an AI-planned economy.

Boettke and Subrick (2002) point out that AI can "replicate the mind as a 'thinking machine' and the interconnectedness of different parts of the brain, but at the cost of losing the human attributes of meaning and intentionality." They believe that AI systems differ fundamentally from human action because the human mind is not a syntactically-defined mechanical device, basing their argument on Searle's (1980) repudiation of the strong AI concept. This conclusion is premature, although it may be valid. Their work lacks a deep exposition of the potential of AI. Even if an AI-planned economy will ultimately fail (and we agree that it will), it may be for reasons other than those they articulate.

2.2 The Chinese Success Story: Challenges for Mises, Questions for Hayek

China's rapid economic development raises questions about the empirical validity of Mises's argument. Market reforms began shortly after Mao Zedong's death, but these did not include private property rights. Command planning has long characterized China's economy, but much of it has been at the local level with broad goals set centrally. Within these state goals, much private enterprise is allowed (Coase and Wang 2012).

Property rights in China are still weak despite improvement since Mao's time. State-owned enterprise account for much economic activity, but by no means all. The Communist Party of China operates party committees in nearly all organizations, including private businesses, to steer the direction of the economy and maintain its grip on power (Wu 2016). Price signals operate, but are manipulated by state planning, both command and indicative. Economic calculation and entrepreneurship take place, but incentives are skewed by state policy. Despite not allowing much private property in the western sense, China has experienced economic growth by letting many economic incentives function.

China's government effectively coordinates decentralized knowledge in its planned economy, something the Soviet Union could not do. Its strategy is to preserve incentives for production, but to direct it by manipulating signals and with some command planning. China has achieved rapid and sustained economic growth with this strategy.

Mises believed that a third system apart from capitalism and socialism would have limited private ownership, exchange, and prices, but no entrepreneurship because of state control (Mises [1949] 2007). China has avoided this pitfall by letting firms "grow out of the plan" and produce for a free market after satisfying state goals (Coase and Wang 2012). This policy gave incentives for efficiency and achieved state goals.

By attempting to replicate the incentives that property rights create, China has maintained considerable state planning while preserving incentives for efficient production and some entrepreneurship. This approach challenges Mises's argument about property by focusing on other ways of creating the needed incentives. These incentives, of course, lead to a different allocation than what would result without state planning.

Hayek's argument is still largely intact. Although China has much state planning, it is not done so in a way that causes problems Hayek outlines. There is much decentralization and, although the government does specify broad goals, there is considerable practical autonomy. China's model is no refutation of Hayek's argument. The remaining question for Hayek's argument is whether the outcome is better or worse than the free market or equivalent to it.

3 Machine Automated Economies

If a successful economic structure can emerge using hybrid incentives and partial information, an fully automated structure may have the capacity to replicate this same effect. Models of planned economies that rely on computers tend to emphasize computing power, not artificial intelligence (Cockshott and Cottrell 1989; 1992; 1993). They focus on programs to exploit computing power, but not on systems that can produce outcomes that rival those of spontaneous orders.

Turing (1950) conceptualized a test of the thinking capability of machines. The words "thinking" and "machine" are too broad to succinctly answer the question of whether machines can think. The test to answer the question, now known as the Turing test, is that a machine can be said to "think" if it can act in a way that is indistinguishable from a human. In other words, a machine passes the Turing test if, out of sight from a human, it can fool the human into thinking that it (the machine) is a human.

The Turing test is still widely used as a benchmark in the field of AI, but it is hard to quantify and is deficient in matters of planning an economy. No single person has planned or can plan an economy, as Mises and Hayek aptly argued. For purposes of economic planning, we reframe the Turing test as follows: An AI system can plan an economy if it can produce results indistinguishable from a human spontaneous order. Reducing this to a transaction-specific test, AI can plan an economy if the incentives it produces are indistinguishable from those produced by price signals. This means that economic incentives must exist for the individuals, groups, and firms that exist in an AI planned economy and some form of entrepreneurship and innovation must take place, whether human- or machine-led.

An AI-planned economy could be thought of as "successful" if it mimics a spontaneous order. However, the counterfactual of a spontaneous order will not exist in a planned economy. Because a spontaneous order is based on voluntary exchange, one measure of success is if participants cooperate willingly and *perceive* no more coercion than in a market economy. All other measures of success or failure are subjective. If an AI system is effective enough to achieve its goals, then success is less a matter of computational success than a matter of setting goals, which is a political matter.

3.1 Coordination of Information

Rapidly obtaining information and analyzing it are major challenges for AI systems that could potentially plan an economy just as they were for central planners in earlier generations. AI has not eliminated this challenge, but has rather refined it. Data problems are now more technical and less theoretical, but they still pose major risks for an AI-planned economy.

Modern intelligence frameworks are designed to operate in belief space, or a set of possible worlds. This was in response to complications posed from applications in unstructured environments where algorithms could only obtain information from partially observable non-deterministic systems. This is especially true when algorithms respond to and make decisions involving human actors, a best judgment must be made not just on what information is presented, but on what the expected responses (non-deterministic) might be. AI systems must carefully weigh potential responses while constructing several worlds (belief space) that may cause those results to occur.

Another complexity now widely considered is that of state estimation, the best guess of the current reality. In the face of partial observation where parts of the system are not able to be assessed directly, understanding the true state of a system can require significant computational resources. This is a difficult problem in a non-probabilistic system and is certainly compounded in the face of probabilistic signal.

3.1.1 Potential Sources of Information

Any AI system for planning an economy will fail if it relies on raw data that has not passed through a robust ETL (extracting, transporting/transforming, and loading) process. Data must be properly collected and processed to represent the same information throughout the economy, minor discrepancies in data generation even in a small economy is difficult to correct once compiled. Collection of all relevant data is also important, a real-time transmission of transactions, factor use, production results, and use of time can be made readily available.

Computing power is readily available and many sources of information are linked to computers and are only protected from transmission by law. Many production processes are innately tied to real-time metrics and reporting software which have been further streamlined through the IoT infrastructure changes. Many individuals also carry smartphones that tracks device activity, location, communication, and information history. Obtaining a fairly clear picture of an individual is possible now and will likely become easier in the future. Many phones actively learn user preferences to streamline computational resource allocation to applications that are more used, these phones can immediately provide cleaned and processed data on a device user's preferences.

3.1.2 Calculation vs. Planning

Economic calculation and planning are similar, but distinct. Economic calculation is the process of comparing costs and benefits to reach a certain goal. Planning is making decisions based on calculation results. Calculation relies on data. Planning creates more data, which feeds calculation. Data problems can cascade through this feedback loop and could even corrupt deep learning algorithms, which are only as good as the data that train them.

3.1.3 Signals, Noise, and Inference

Clean and robust data are harder to obtain than complete data. Any large dataset is bound to have noise alongside signals. Major anomalies could be detected in real time, but the challenge of filtering and cleaning data still seems largely insurmountable.

Firm managers face the same problem within their firms, but their decisions have less impact than those of a central planner. Every signal obtained from data has a level of confidence based on the level of noise. Decisions made pursuant to signals in turn affect production or consumption of intermediate and final goods and the flow of more data into the AI system. A well-developed economy with many intermediate stages of production has many opportunities for errors in data gathering processes to cascade and magnify. An AI system may be able to detect if something is not right and prescribe a solution, but its success in so doing assumes that it actually knows what is going into a production process and what outputs are being produced. Without complete data, an AI system could incorrectly observe what is happening and draw erroneous inferences for other production processes.

3.2 Decision Making Algorithm

A general optimization or controls framework directs the efforts of the overall mission planning. In the case of an economic optimization problem, this mission objective is determined by the political entities who have charge over the economy.

This objective is translated into a cost, penalty, or reward function which guides the decisions towards the goals that the governing entity desires.

3.2.1 State Space

The state space representation describes the world of interest to the algorithm's objectives. This world will likely contain pertinent information on the state of consumer sentiment, consumption spending, industrial output, investment spending, firm holdings, supply chain health, and overall physical health of the populace. This is by no means an exhaustive list but serves to illustrate items that may be of importance to governing entities.

The state estimation occurs based on data received and attempts to construct the actual state of the economy. Some of this can be directly assessed or evaluated. As an example of this, industrial output data can be directly collected and investment spending can be computed given spending figures. However, some items such as physical health of a populace, general happiness, and support of a regime needs to be approximated based on the collected data.

While these terms are harder to consider, it is important to note that they play a part in a decision-maker's considerations. A well defined state estimator for an economy must be able to predict the actual situation as best as possible in order to propagate expected changes moving forwards.

3.2.2 Control Space

The control space is defined as the space in which the controllable inputs are considered. These controllable parameters can be policy decisions, fiscal policy, monetary policy, or any other type of inducement an entity can exert on the economy. It is important to explicitly consider this space and understand how action in control space at time t_i impact the state space in $t_{i+1,..,i+n}$.

By considering the control space directly the sometimes intractable problem of solving a 2-point boundary value problem (where current state and desired states are connected by a series of control inputs) no longer must be considered. Rather, direct propagation by using search algorithms of a series of control states can directly return sets of feasible actions one can take to obtain the goal.

3.2.3 Modeling External Interactions

No economy exists in isolation. There are interactions with the world, which a national AI system cannot control. In optimizing its equations, the AI system must take into account its predictions what the world will do. Gathering information is an uncertain process in the domestic economy; it is even more so for foreign countries, even just major trading partners. This problem will not go away if all national economies are centrally planned with AI because the goals of the objective functions will vary by country.

3.2.4 Time Horizons

The goal of the AI system should determine its horizon. A focus on new inventions or research and development will be most effective with longer horizons. Perfect information is a long-run phenomenon, but optimization is for the short run. Imperfections will always exist, as explained in section 3.1. Many socialist countries have used 5-year plans, but other finite time horizons could be chosen. Infinite horizons are less realistic because the goals of an AI planning system will change in response to political pressures and always involve judgments about how rapidly to move toward achieving goals.

Optimizing equations is a matter of deciding what to do (adjusting control variables) to achieve an outcome during the time horizon. Actions can be updated more frequently with the horizon for each action resetting with each update.

3.2.5 Corrective Action

Central planning as it has existed in socialist countries during the twentieth century was characterized by inefficient use of resources and much waste. These spectacular failures obscure the fact that many resources are also wasted in markets. Around 40% of new consumer products fail in the marketplace (Castellion and Markham 2013; Crawford 1987). The failure rate for new startup companies is also quite high. According to the Bureau of Labor Statistics, between 600,000 and 700,000 new businesses are started in the United States in non-recession years. Of those founded in 2012, 79% survived their first year and 68.7% survived the second, but only 50.1% made it through five years and the survival rate continues to decline with age. This pattern of decline is stable going back to firms that started in the mid-1990s.[1] Entrepreneurs must make predictions and plan their operations accordingly and they often do not succeed. The reason markets have dramatically outperformed central planning is not because they have no waste (they do) but because waste and inefficiency are quickly corrected. The lack of profits causes unsuccessful enterprises to shut down. For any AI planning system to succeed, it must have a mechanism for detecting inefficiencies and correcting them.

To avoid these inefficiencies, both overproduction and underproduction must be penalized. Overproduction is the inefficiency discussed in the preceding paragraph, and can be prevented by a sufficiently long horizon. Underproduction is a problem that can be solved in part by permitting entrepreneurship, discussed below in section 3.4. Other aspects of underproduction, such as persistent shortages, are a simple part of the optimization problem.

Reliability of data is the critical problem for solving both underproduction and overproduction. The AI planning system must accurately determine the absolute value the difference between expected consumption (determined by the system's goals) and actual production for every sector and the rest of the world.

The same raw materials feed many different intermediate inputs which then compose a diverse array of final products, many of which came from the same raw materials. As a result, supply chains for many goods are interlinked at numerous stages of the production process; individual goods do not have isolated supply chains. As a result, each supply chain for each product or class of products has its own optimization problem that focuses on meeting the goal of the entire system. All of these supply chains must be simultaneously optimized. The AI planning system thus needs a higher order optimization that draws on these smaller optimizations after setting output targets.

This higher order optimization with subordinate optimization problems results in a large, simultaneous problem with many constraints. With enough computing power, it is tractable, but this assumes data are reliable. As more constraints are placed on an AI system, the options for controlling

[1] United States Bureau of Labor Statistics Table 7: Survival of Private Sector Establishments by Opening Year

it devolve to a binary choice, or bang-bang control, especially if the optimization problem is linear in the control variables. When this happens the options for controlling the system become more a matter of starting and stopping resource flows to specific uses, not of continuously varying the mandated prices.

3.2.6 AI and Governing Action

For every control variable, the AI system must have power to "turn the knobs" or somehow control it. This power is the coercive executive and legislative power of the state. The optimization problem dictates the optimal course of action with a given time horizon. If the AI system can use the entire control space, it can fully follow the recommendations of the optimization. If not, it is constrained. Constraining the control space may be reasonable to prevent more than small incremental changes from being made too rapidly. This would mean limiting the latitude that he algorithms have under specified circumstances.

The AI system necessarily predicts what the world will do and chooses actions for its own economy accordingly. The degree to which the predictions of the world can be trusted is the degree to which the AI system should have latitude. Recall from section 3.1 that coordinating information remains a severe pitfall for an AI-planned economy. The need to make decisions based on what predictions of what the world will do severely limit the reliability of an AI planning system, implying that its control space should be limited.

Limiting the control space may or may not be good for efficiency, but it is good for the "success" of the AI system as measured by the revised Turing test. The AI system will need some power to set prices and allocate resources, although these prices and allocations need not be uniform geographically or across industries. It will also need the power to form, merge, divide, and close businesses. From the perspective of the end-user consumer, this may be no different from a market, but not from the case for firms. If changes are made only incrementally, the perceived difference from the market may be minuscule. A limited control space does not imply a small role for the AI planning system. The economy could be comprehensively planned, but only small, limited changes are made in each period. Limiting the control space is an issue of avoiding potentially harmful major changes and instead moving more slowly. Information issues, especially relating to predicting the rest of the world, are the primary reason that an AI-planned economy cannot make rapid changes and, in this regard, may or may not outperform current bureaucratic structures in terms of speed of decision making, even if it is more efficient. An unlimited control space is more suitable when planning for a small-scale operation less susceptible to external forces, like an individual factory.

3.3 Objectives and Outcomes

Outcomes may be prescribed by a planner, learned through algorithms, or a combination. A spontaneous order maximizes utility and profits of all participants through voluntary exchange. Any planned system will have some broad prescribed goals. These could include GDP growth, income equality, full employment, more new inventions, environmental quality, export promotion, production of specific goods and services, regime stability, or any other goal. Political processes set these goals.

3.3.1 Hierarchy of Goals

In a spontaneous order, the economic system has no overarching goal. Firms have the goal of maximizing profit. Goals exist in a hierarchy; the profit goal is at the top, but there are related sub-goals, like recruiting top talent, investing in good equipment, producing at lower cost, and designing better products. An AI-planned system must have goals if the objective function is to be maximized by adjusting control variables.

An AI system can have a broad overarching goal and choose sub-goals to reach it, or it could have firm-level sub-goals and leave the top goal unspecified. The latter option will be closer to success in terms of the revised Turing test. Given that economic planning is always subject to political pressures, the former option seems more likely. There could still be a role for AI planning even if there are only firm-level goals, such as maximizing profits. Just as the AI planning system must have predictions for what the world will do, individual firms must make uncertain predictions about what other firms will do. Even without an overarching goal, an AI system could eliminate much of this uncertainty. Despite this potential, it seems more reasonable that a system as powerful as is needed to plan an economy would be subject to political pressures and have broad goals.

3.3.2 Planning Action and Deep Learning

Learned outcomes are an advantage of AI planning. Any action that an AI system recommends must eventually be carried out by real people. These “planners” who carry out the AI system’s recommendations will act in accordance with their own goals and incentives. As they tweak the prescribed actions, deep learning algorithms can perceive what they “really want” and update recommendations accordingly. AI systems may eventually prescribe less intuitive actions to meet these perceived unstated goals of planners. The ability of AI planning algorithms to produce productive and allocative efficiency and accomplish ostensible goals relies on the planners to trust and implement the recommendations in addition to all other pitfalls.

3.4 Entrepreneurship and Anomaly Detection

An AI planning system must have some means of anomaly detection and correction to ensure compliance with the plan. If the control space is sufficiently large and the hierarchy of goals is complete, there is no room for entrepreneurship. Entrepreneurs successfully do what nobody else has successfully done. When an attempt to do so is made, a well-designed AI planning system will detect the anomaly and, with support from government officials, put a stop to it. If officials choose not to act, the AI system may recognize the value of that entrepreneurial activity and cause it to expand, but will not be friendly to future entrepreneurial anomalies. Mises ([1949] 2007) opposed mixed economic systems that controlled some but not all economic activity, believing that they would inevitably degenerate into comprehensive planning. His fear did not come true in western economies, but it looks more plausible with AI planning because of the necessary completeness of the planning system.

There are three dominant strands of economic thought on entrepreneurship. Schumpeter (1943) coined the term "creative destruction" in which entrepreneurs are a disequilibrating force that introduce new innovations and displace existing businesses. Kirzner ([1973] 2013) took the opposite view that entrepreneurship is equilibrating and is only possible because existing disequilibrium leaves untaken profit opportunities, which alert entrepreneurs seize. Entrepreneurs thus perceive a disequilibrium and profitably correct it. Lachmann (1956, 1963) put forward another idea that entrepreneurs combine and recombine inputs looking for success. Unlike Schumpeter and Kirzner, Lachmann leaves room for research and development to be considered entrepreneurship.

There is a superficial role for AI in entrepreneurship in Kirzner's or Lachmann's mold. AI systems can plan new combinations of inputs and make predictions of what will work. They can also see where profit opportunities might exist. The "disequilibrium" that an AI system can perceive and correct, however, is just a deviation from realizing the programmed goals. Whether AI can produce new products or just make incremental efficiency improvements is uncertain, but if it is programmed to develop new products, then this "entrepreneurship" is not really entrepreneurship; it is AI-augmented product development that develops goals from the system's economic data.

Schumpeterian entrepreneurship is even more distant from the realm of AI. There are ways an AI system could encourage creative destruction, but all of these surrender some of the AI planning system's control. Much as China permitted businesses to "grow out of the plan," individuals could be permitted to start businesses and sell goods and services. This necessitates leaving some small-scale economic activity unplanned and would allow for the entrepreneurship envisioned by Schumpeter, Kirzner, and Lachmann. Even if AI does not dictate some small-scale activity and permits entrepreneurial startups. As a firm expands, it would invariably come under the control of the AI system, potentially cutting off follow-up work by the successful entrepreneur.

4 Economic Planning Implications of Artificial Intelligence

To say that there are public choice problems with an AI-planned economy because of the incentives of planners is an oversimplification. The nature of these problems is more nuanced. Moreover, there are issues of unintended consequences and manipulation of the flow of information that an AI system needs to plan an economy, and there is a remaining economic calculation issue.

4.1 Decision Makers and the Scope of Collective Decision Making

The scope of collective decision making expands dramatically in any planned economy. Power gets concentrated in the hands of planners. An AI system does not solve this because goals must still be set by planners. As the control space expands, the power of planners expands, magnifying the incentive problems.

Firm managers have little power because many decisions are predetermined by central planners. To the extent that they have autonomy, their choices are constrained by controlled input prices. Traditional roles such as negotiating pay rates with employees or labor unions or dealing with pressure groups that are unhappy with the firm's ethical or environmental practices become matters for planners. Labor unions, nonprofit organizations, and political pressure groups, which already undertake political activity, will inevitably become exclusively political organizations.

4.1.1 Locus of Power

In any planned economy, government officials take on more power as market participants lose some. This is true in an AI-planned economy, but with the caveat that programmers also assume considerable power. The public choice problems that can plague an AI-planned economy are not just a matter of perverse incentives for increasingly powerful elected officials. Institutional arrangements governing the AI system determine power structures. Programmers will face different individual and collective incentives depending on these arrangements, which should be at the forefront of any discussion of how to implement an AI-planned economy.

In an AI-planned economic system, the locus of power shifts from elected officials to programmers. Elected officials may make decisions and bear responsibility, but programmers implement the decisions. Any decision made pursuant to deep learning within the AI-system is still overseen by programmers, not elected officials. The Wilsonian paradigm of an expert-led economy is an inevitable result of AI planning, but the "experts" are AI programmers, not economists or scientists. Overseers (elected officials) can rely only on programmers' explanations. They bear accountability but may lack control. Not only does the scope of collective action increase, but the locus of power shifts, along with the public choice problems.

The first public choice problem is the hierarchy of goals. Goals can be set democratically or in other ways, but they are implemented through objective functions and constraints on those functions. There is a vast technical component to goal setting. Constraints must be adequately programmed with thresholds of acceptability for certain activities and must permit decisions only in some cases. Even if the hierarchy of goals is complete, which is difficult enough, programming the hierarchy in a way that reflects the political decision is not trivial. This creates a public choice for programmers who will inevitably have discretion in writing economic planning algorithms.

The next public choice problem is collective action among AI programmers. They may or may not exist in one geographical location depending on institutional arrangements, and horizontal and vertical communications among them may be extensive or nonexistent. There will invariably be many programmers, each with different responsibilities because of the number of optimizations that need to be done and the data collection apparatuses that need continual evaluation and refinement. The outcomes of an AI-planned economy will depend on the institutional arrangements that govern programmers as they will on the individual incentives of programmers and the ability of the AI system to achieve its goals.

Another public choice problem arises with those who can influence the collecting and reporting of information to the AI system. These persons have power distinct from programmers and elected officials. Such persons could be those with control over computer network systems that oversee surveillance apparatuses and parse information for the AI system or they could be those who can successfully feed misinformation into the system. Abuses if this source of power will be difficult to detect because an AI planning system must take the information it receives as given.

4.1.2 Creating Faulty Information

Incentives exist to manipulate the AI planning system at every stage where decisions are made. If there are a large number of simultaneous optimizations subordinate to the highest, then incentive problems exist at all of these lower levels. This is an unavoidable problem because of the need to simultaneously optimize each supply chain.

Operations managers, local officials, and AI programmers for subordinate optimizations presumably have their own goals and objectives. They may attempt to manipulate the flow of information to the AI system as a way of diverting resources where they want them. These incentives can take many forms. The most obvious is if managers are rewarded for certain performance measures, like quantity of output. Even if this is not the case, they may want to maintain excessive employment to curry favor locally.

The ways of manipulating the flow of information or creating faulty information to induce the AI system to take desired actions depend on the means of collecting information and the type of information collected. It is not hard to imagine attempts, though, as shown by motorists using mannequins to drive in high-occupancy vehicle lanes without carrying a passenger.

As the economy is planned more centrally, opportunities for free enterprise diminish unless they are in accordance with the AI plan. The only way to seek economic gain is by manipulating the flow of information to suit one's aims. Such behavior should be expected, and will be a serious problem for an AI-planned economy, which will already suffer from data reliability issues. Entrepreneurs, who need freedom from planning if they are succeed, are those who should be most expected to attempt to manipulate the flow of information to the AI system.

4.2 Remaining Calculation Problem

The problems already mentioned are public choice problems and technical difficulties that persist in spite of AI and computing power. The potential of AI to plan an economy seriously undermines the economic calculation arguments of Hayek and Mises, but it does not refute the fact that central planning suffers from calculation problems. The calculation issues when AI is planned by an economy are of a different sort, but they still exist.

Even if information can be gathered and organized flawlessly, AI cannot determine the highest and best use of resources. The market solves this problem by allocating resources to those who value them most highly (at market prices which reflect scarcity), and these people collectively determine the direction of the economy. An AI-planned economy operates differently because it directly plans how resources should be used and sets prices accordingly or coercively allocates them. Under AI planning, there may be little waste and goals will be achieved, but the absence of market prices makes it impossible to know what the highest and best use of resources is. If the AI system operates in an indicative planning framework that manipulates prices for products (or even specific uses or users of products) as opposed to coercively allocating resources, resources are allocated not to those who value them most highly and can make the best use of them, but to those who will use them for state aims. Setting the goals is a public choice problem, but the problem of calculating the highest and best use of resources remains. Prices and "markets" become subordinate to planned goals, whereas in an unplanned economy prices and markets determine which goals get accomplished.

If the hierarchy of goals is not defined completely, the results of economic calculation when done by an AI system can have unintended consequences, even if information is complete and accurate.

This is especially problematic if the control space is large.

A focus on automation and productive efficiency could lead to unemployment and adverse societal outcomes (Acemoglu and Restrepo 2020). If GDP growth is the goal, a system may produce ever-increasing amounts of healthcare products and services that have only a marginal effect on health outcomes. Conversely, if trimming excessive health spending is a goal, an AI system could stop treating the elderly or chronically sick. A focus on automation could lead to unemployment and adverse societal outcomes, indicating that there is a need for a focus on more than just productive efficiency. Even relying only on firm-level goals of maximizing profit, there must still be a hierarchy of sub-goals to determine the choice when similar options exist.

Goals may need to be hierarchically defined to an exceedingly precise level to deal with knife-edge cases. Consider the dilemma of choosing to provide cancer drugs worth hundreds of thousands of dollars that will extend the life of a near-death patient by two or three months. A goal that preserves life or maximizes economic output will produce a rule that allocates drugs to the patient, even if it diverts resources away from others who could use them. A goal of maximizing marginal health improvements for the resources used would produce a rule that focuses on treating patients with better prognoses. Goals will need to be defined in ways that set cutoff rules for certain uses of resources. Some of these could be set through deep learning, especially for situations that occur rarely or may not be perceived ahead of time.

An AI system can perform calculations with complete information, but the objective function that it maximizes must be complete. Achieving the necessary level of completeness involves a calculation decision by government officials or programmers who may do it directly or design deep learning algorithms to do it. In any case, defining the hierarchy of goals remains a severe problem of economic calculation that AI cannot solve because planning always subordinates resource use to the goals, rather than choosing among goals based on price signals.

Calculation problems become public choice problems when goals are defined more completely. Defining goals completely, however, just changes the calculation decisions from being made in the moment to being made in advance. The public choice problems exist in the goal-setting process, blurring the line between calculation and public choice. Resource use and pricing decisions are always made pursuant to chosen goals, converting calculation into a matter of finding the most efficient way to satisfy predetermined objectives.

5 Conclusion

Computers have revolutionized the economy in ways that were unimaginable even just a decade ago. Artificial intelligence has made impressive strides. Given the power of machines to "think" and make reliable decisions, it is reasonable to reopen the economic calculation argument. This argument, advanced by Hayek and Mises, has been a mainstay of the economic refutation of socialism. Although portions of Mises's argument leave little room for an AI-planned economy, Hayek believes that can potentially be solved with sufficient computing power.

The ability of AI to obtain and coordinate reliable information is still lacking to the point that planning a small economy is an insurmountable task. This is especially so when there is international trade, because AI must correctly model the rest of the world as well as the national economy. Processing data is no trivial task, even with sufficient computing power, largely because noise can obscure signals as it is amplified through a series of cascading decisions. State-of-the-art AI algorithms offer little hope of surmounting these challenges.

The problematic issue is not speed of calculations or the inability to parse vast quantities of data; the issue is that analyses and results are not reliable enough. Human economic calculation fails in part because of inability to gather and analyze sufficient information. AI-driven economic calculation fails because of the information itself. Beyond information, the ability to set goals completely enough to avoid unintended consequences is nearly impossible. Moreover, the goal-setting process is not transparent, so planners and programmers are somewhat disconnected as programmers must take planners' ideas and write them into objective functions and constraints. Finally, entrepreneurship can only exist in its fullest sense outside of state planning. Entrepreneurship is the driving force of economic growth and development, and an AI-planned economy will likely stifle it.

Socialism has always had a public choice problem because leaders were less accountable to the people and they wielded greater power than under pluralistic, free market systems. Comprehensive economic planning requires substantial coercive power and the ability to quickly make and execute decisions. This is incompatible with democratic governance and constitutional constraints. If an AI-planned economy existed, public choice problems will be magnified even if calculation problems are mitigated. Public officials, economic planners, and AI programmers will have incentives to maximize their own well-being through AI-prescribed actions. Given that planned economies have central goals, unlike spontaneous market orders, there will inevitably be conflict over these goals and public choice problems in the nontransparent process of setting them.

AI can play a wonderful role in firms, personal computing, data analysis, research and development processes, scientific research projects, and many other things. It lacks the ability, however, to plan an economy in a way that can be expected to produce outcomes that rival those of the free market. For this reason, even though the economic calculation arguments of Hayek and Mises may be undercut by advances in AI and computing power, socialism is still not a viable economic system.

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