

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Journal of Economic Behavior and Organization

journal homepage: www.elsevier.com/locate/jebo

On the feasibility of technosocialism

Peter J. Boettke^a, Rosolino A. Candela^{b,*}^a Department of Economics, George Mason University, Fairfax VA 22030, United States^b Mercatus Center, George Mason University, Fairfax, VA 22030, United States

ARTICLE INFO

Article history:

Received 19 May 2022

Revised 30 October 2022

Accepted 31 October 2022

JEL classifications:

B13

B25

D83

P51

Keywords:

Economic calculation

F.A. Hayek

Ludwig von Mises

Technosocialism

ABSTRACT

Technological advances associated with computing power and the prospect of artificial intelligence have renewed interest on the economic feasibility of socialism. The question of such feasibility turns on whether the problem of economic calculation has fundamentally changed. In spite of the prospect of what King and Petty (2021) refer to as “technosocialism,” we argue that technological advances in computation cannot replace the competitive discovery process that takes place within the context of the market. We do so by situating the case for technosocialism in the context of the socialist calculation debate. Understood in these terms, technosocialism represents a restatement of the case for market socialism, which incorrectly framed the “solution” to economic calculation under socialism as one of computing data, rather than the discovery of context-specific knowledge that only emerges through the exchange of property rights. Therefore, the arguments put forth by Ludwig von Mises and F.A. Hayek, and later Israel Kirzner and Don Lavoie, regarding the impossibility of economic calculation under socialism remains just as relevant today.

© 2022 Elsevier B.V. All rights reserved.

1. Introduction

Jack Ma, founder and chairman of Alibaba Group, declared in 2016 that:

Over the past 100 years, we have come to believe that the market economy is the best system, but in my opinion, there will be a significant change in the next three decades, and the planned economy will become increasingly big. Why? Because with access to all kinds of data, we may be able to find the invisible hand of the market.

The planned economy I am talking about is not the same as the one used by the Soviet Union or at the beginning of the founding of the People’s Republic of China. The biggest difference between the market economy and planned economy is that the former has the invisible hand of market forces. In the era of big data, the abilities of human beings in obtaining and processing data are greater than you can imagine.

With the help of artificial intelligence or multiple intelligence, our perception of the world will be elevated to a new level. As such, big data will make the market smarter and make it possible to plan and predict market forces so as to allow us to finally achieve a planned economy.¹

* Corresponding author.

E-mail address: rcandela@mercatus.gmu.edu (R.A. Candela).

¹ See “Can big data help to resurrect the planned economy?” *Global Times Published*, June 14, 2017: <https://www.globaltimes.cn/content/1051715.shtml>. See also Fernandez-Villaverde (2021).

He is not alone in this assessment. Books and articles have been published at an increasing pace extolling the virtues of technosocialism for the 21st century.² In their manifesto, *The Rise of Technosocialism* Brett King and Richard Petty define technosocialism not as a political movement, but as a “social outcome” (2021: 38) based on “long-term sustainability, equality and the advancement of humanity as a whole” (2021: 39). The means by which to achieve this outcome, according to King and Petty, is the advanced computational power of artificial intelligence: “With the emergence of Artificial Intelligence (AI) we are on the verge of perhaps solving the biggest mysteries of the universe, but AI will also allow us to automate society to provide untold abundance and prosperity” (2021: 15).

The aspiration is fueled by a critique of existing society as mired in inefficiency, instability and inequality that perpetuates the power of the privileged. The current system damages the planet and destroys the life chances of the dispossessed and disenfranchised. The Global Financial Crisis of 2008 exposed the fault lines of the modern capitalist economy, and COVID-19 has only exacerbated the problems of inefficiency, instability and inequality. Capitalism isn’t in crisis, the argument goes; it is the crisis. But technological advances in AI provide the solution to the ills that plague contemporary society throughout the world.

Sound utopian? Perhaps, but so have all socialist proposals throughout history, e.g., the Paris Commune to the Bolshevik Revolution. The historical problem is that reality fell far short of the promised utopia, and in fact produced hell on earth. Technosocialism, like the previous Marxist and non-Marxist versions of socialism, promises the transformation from the Kingdom of Necessity to the Kingdom of Freedom. No matter how much the current advocates insist that their project cannot be equated with the older project to transform society, they share this common element – the rationalization of production to such an extent that a burst of productivity will result in material abundance. In short, the economic problem of society will be solved.

However, we argue that the proposal provided by technosocialism is analogous to putting old wine into an irrelevant new bottle. What seems to be a novel proposal to deliver the age-old aspiration of socialism is not fundamentally different from the market-socialist model which had been proposed by Oskar Lange and Abba Lerner in the 1930s in response to Ludwig von Mises and F.A. Hayek, both of whom had argued that economic calculation under socialism was impossible. Lange would later propose the following in response to Mises and Hayek: “Let us put the simultaneous equations on an electronic computer and we shall obtain the solution in less than a second. The market process with its cumbersome *tâtonnements* appears old-fashioned. Indeed, it may be considered as a computing device of the pre-electronic age” (emphasis in original; 1967: 158).

The promise only works, however, if the technology is actually capable of rationalizing production as advertised. The organization of society through AI must, as was the case with proposals for comprehensive central planning or decentralized market-socialist planning before it, be able to achieve the goal of rationalization and thus eliminate the inefficiency, instability and inequality that is claimed to plague capitalism. Thus, the question remains fundamentally one that is subject to the economic analysis of the feasibility of the social system to achieve its stated ends via its chosen means, and not a dispute over the ends of technosocialism.³

Therefore, we propose to tackle this feasibility question by restricting our analysis only to means-ends assessment, and in particular, focus on the question of whether modern information technology can meet “knowledge problem” challenge that Mises, Hayek, Kirzner and Lavoie raised during the socialist calculation debate and after. As [Cockshott and Cottrell \(1993: 111\)](#) so clearly state: “The problem of information has a social as well as a technical aspect. We need the right hardware and software, but we also need the right measures and incentives, so that it will be in people’s interest to supply accurate information.” It is clear that effective comprehensive planning requires the transmission of vital information quickly and correctly. To most technosocialist enthusiasts, the market process with its price adjustments, its profit-and-loss accounting, and shifting pattern of resource ownership is merely an old-fashioned computing device of a pre-electronic age, as was argued by [Lange \(1967\)](#). However, Lange’s assessment, like that of technosocialism, is based on a fundamental misunderstanding of the economic problem of society as being of a computational nature rather than a “knowledge problem” that must be addressed and the nature of how the market process in fact does address the problem.

In [Section 2](#) we will revisit the classic argument against the feasibility of socialist planning, with an emphasis on the dynamic nature of the problem. [Section 3](#) will discuss the claim from Lange onward that modern developments in computer technology have rendered the older concerns about economic planning obsolete. [Section 4](#) attempts to provide a restatement of the Mises-Hayek-Kirzner-Lavoie position in light of the arguments for technosocialism. [Section 5](#) will conclude.

² See, e.g., Philips and Rozworski’s *The People’s Republic of Walmart: How the World’s Biggest Corporations are Laying the Foundations for Socialism* (2019), or earlier works such as *Information Technology and Socialist Construction* by [Saros \(2014\)](#) and *Towards a New Socialism* by [Cockshott and Cottrell \(1993\)](#) which made the argument early on that modern computing technology would enable a post-Soviet socialism to be built on radical democracy and efficient comprehensive computerized economic planning.

³ For a recent consideration of these issues see Geoffrey Hodgson’s *Is Socialism Feasible?* (2019). Hodgson concludes that “Big Socialism”, by which he means the sort of comprehensive planning technosocialist envision is both economically unfeasible and inconsistent with democratic values. On the other hand, “Small Socialism” Hodgson believes can avoid many of these problems in cohesive communities. The question for Hodgson is in many ways how one can transition from these small and cohesive communities to the sort of large scale economy while grounded in liberal solidarity. For an overview of the classic socialist calculation debate in the 20th century see Don Lavoie’s *Rivalry and Central Planning* (1985) and the reference collection edited by Boettke, *Socialism and the Market: The Socialist Calculation Debate Revisited*, 9 volumes (2000).

2. Economic calculation as rivalrous discovery of contextual knowledge

It is in the context of Red Vienna and conscious efforts to implement socialism throughout Europe that Ludwig von Mises felt compelled to put pen to paper and author his essay “Die Wirtschaftsrechnung im sozialistischen Gemeinwesen”, translated as “Economic Calculation in the Socialist Commonwealth” in late 1919 and published in 1920. This article was directly motivated as a reply to the recent work of the Marxist economist Otto Neurath on the “natural economy” and the promise of socialism. Mises followed up his essay with a full-length book titled *Gemeinwirtschaft* (1922), later translated as *Socialism* (1936). Mises’s article was the first salvo in what has become known as the socialist calculation debate, and immediately generated a heated exchange of ideas in the German language journals and periodicals of the time, invoking responses not only by Oskar Lange and Abba Lerner, but also Jacob Marschak and most famously Karl Polanyi. But one can also see responses in the English language literature already in the 1920s by Taylor (1929) and Knight (1936). Mises’s *Gemeinwirtschaft* would have a major impact on both a young F. A. Hayek (and his contemporaries in Austria) and Lionel Robbins (and his contemporaries in England). Mises’s article would only be translated and published in English for the first time in a volume edited by Hayek (1935). In addition, Robbins since the mid-1920s was working with Mises to get his book translated and published in English as *Socialism*, which was accomplished in 1936⁴. Although the case for technosocialism is not written in the context of the socialist calculation debate, the challenge Mises put forth concerning socialism and systems of social cooperation would stimulate research over the next 100 years in a variety of directions theoretically and empirically.

Recently, Geoffrey Hodgson has returned to this debate, given the renewed interest in socialist ideas among students and members of the cultural and political elite. In *Is Socialism Feasible?* (2019), Hodgson tackles both what he calls “Big Socialism” and “Small Socialism” and the implications of the argument for the varieties of capitalism discussion and the future alternatives for a humane and just political economy. However, in *Wrong Turnings: How the Left Got Lost* (2018), Hodgson provides a warning of how that quest for a humane and just political economy can be derailed due to the populism and loose thinking about the organization of society, and a mix of innocence of what economic reasoning can provide and opportunism by strategic but bad faith actors. To counter the wrong turns, Hodgson argues the Left must embrace its roots in the Enlightenment values of liberty, equality and universal rights. In short, the answer to the wrong turns provides the path toward a more humane and just future. But to get on that path, one must first understand in detail why the socialist path does not provide that answer.

That being said, Hodgson does not endorse the path that Mises and Hayek suggested either. Despite the limits of knowledge and the complexity of the economic system that make socialist economic planning infeasible, Hodgson argues that there remains a critical role of the state and targeted interventions in creating a society based in liberal solidarity. “A better defense of markets and private property,” he writes, “would know better their limitations” (Hodgson 2018: 190). A market society is embedded, Hodgson argues, in a web of social relationships “that build trust and transcend the monetary calculus of cost and reward” (Hodgson 2018: 190). We must move beyond the myth of the universal market, and instead understand the broader social infrastructure that makes commercial society work for all rather than the privileged few. Yet, at the same time he deeply shares the concerns of the Left over the “extreme inequalities of income and wealth; poverty and destitution; low wages; appalling working conditions; the lack of access to good education; inadequate healthcare provision; discrimination by race, gender, sexuality or beliefs; the ravaging of the planet by uncaring corporations or governments; the threat of climate change; and illegal or unjustified wars” (Hodgson 2018: 192). Such concerns are not at all different from those held to motivate the case for technosocialism, which we will discuss in the next section. But Hodgson is concerned that those on the Left do not pay “enough attention to the politico-economic conditions that are necessary to sustain human rights and democracy” (Hodgson 2018: 192). Correcting that fundamental flaw would require that we recognize that “the theoretical critique of collectivist socialist planning by von Mises and Hayek is one of the most important intellectual achievements of the twentieth century” (Hodgson 2018: 183). The picture Hodgson is painting for the future humane and just political economy is one that accepts the Mises-Hayek critique, but embraces the normative concerns often identified with the Left.

Despite the narrative that has been constructed, mostly by hostile critics, Hodgson’s argument is not far off that of Mises, Hayek, or Robbins. They consistently opposed all systems of privilege, and fought throughout their respective careers against odious racial and nationalistic doctrines. Mises, for example, declared himself in the 1920s as a cosmopolitan liberal (Mises 1927 [2005]: 76–77), and maintained that position until his death in 1973. This essay is not the place to settle the interpretative score on the politics of Mises and Hayek. Rather, it clarifies precisely the *positive economics* of their argument against socialist economic planning and its implications for the *methodology* and *analytics* of economics before we contemplate the broader range *social philosophical* implications.

Mises understood he was not the first economist or social thinker to criticize socialism. Despite Mises’s already strong priors as a liberal, it is important to stress that he was even more committed, perhaps because of his own strong commitments, to the Max Weber strategy of *wertfrei*, or value freedom, to bringing dispassionate *scientific* analysis to heated public policy disputes, and in a way that could produce resolutions between the different parties to the dispute. Because moral disputes and condemnations tended to fail to produce any common ground, ends are treated as given, and never

⁴ Mises, L.v. 1936. *Socialism: An Economic and Sociological Analysis*. London: Jonathan Cape.

questioned, and only the efficacy of chosen means to achieve the given ends is the business of the social scientist. This was positive economics prior to positivistic philosophy of science.

Socialism, at the time of Mises's writing, had a very specific meaning and this must always be remembered in assessing the argumentative claims in the subsequent debate. Socialism, both theoretically and practically, meant "all the means of production are the property of the community" (Mises 1920 [1935]: 89). As Karl Marx and Friedrich Engels state in *The Communist Manifesto* (1848 [1998], p. 75), the abolition of private property in the means of production was the means by which "to wrest, by degrees, all capital from the bourgeoisie, to centralize all instruments of production in the hands of the state, i.e., of the proletariat organized as the ruling class; and to increase the total of productive forces as rapidly as possible." It is important to reiterate here that Mises did not claim that socialism was impossible, per se. Rather, Mises argued that *rational economic calculation under socialism was impossible*. Thus, Mises was not rejecting the aim of increasing economic productivity in a manner that would increase standards of living for the poorest and least advantaged in society. Rather, taking the ends of socialism as given, Mises was addressing the incoherence between the means and ends of socialism, instead of making a normative critique against the ends of socialism. As Mises states:

But that Socialism alone has the public welfare in view can at once be denied. Liberalism champions private property in the means of production because it expects a higher standard of living from such an economic organization, not because it wishes to help the owners. In the liberal economic system more would be produced than in the socialistic. The surplus would not benefit only the owners. According to Liberalism therefore, to combat the errors of Socialism is by no means the particular interest of the rich. It concerns even the poorest, who would be injured just as much by Socialism. Whether or not one accepts this, to impute a narrow class interest to Liberalism is erroneous. *The systems, in fact, differ not in their aims but in the means by which they wish to pursue them* (emphasis added, Mises 1922 [1981]: 46).

Central planning will be entrusted to make decisions concerning staffing, administrative tasks, and goals all with the explicit purpose of articulating and representing the general will of the community. In the socialist vision, consumption decisions are separated from production decisions. The consumption questions in terms of *who* and *what* is to be consumed is a question of socialist distribution. But the *how* question of production is the critical question for economic organization of the socialist society. The administrative body will have to determine the use of factors of production to produce the greatest yield and minimize waste in order to meet the goal of rationalizing production.

The critical lynchpin in Mises's argument was that the rationalization of production projects for direct use under a single central plan would be rendered senseless in the move to total socialization because without private property in the means of production, there would be no way for economic actors to engage in *rational economic calculation*. This is because outside the context of exchangeable private property rights, exchange ratios in the form of money prices cannot emerge to calculate the opportunity cost of capital goods in alternative consumer uses (Mises 1920 [1935]: 111). Therefore, without profit and loss signals to communicate whether or not capital goods have been directed toward value-creating consumer uses, economic actors will have no economically meaningful way to sort from the array of technologically feasible projects those which are economically viable. All systems of social cooperation must have some mechanism that enables the system itself to sort from imagined normatively desired states to feasible states, and furthermore from the feasible to the viable. Nirvana is not an option for humanity, so in contemporary philosophical parlance, ideal theorizing must be disciplined by social science so we get non-ideal theorizing as a guide to the "desirable". Marx was critical of utopian socialism, and so must we be today. And, certainly Mises was critical of it in his time. It is this very task that we must ultimately bring to the assessment of technosocialism.

The critique of rational economic calculation is not a moral critique of socialism. Mises, personally a staunch individualist, does not invoke the moral dispute between collectivist ethos and individualist ethos. That is not his ground of attack. Mises understood full well the incentive problems associated with collective property arrangements. This leads Mises to make his argument such that "even if we for the moment grant that these Utopian expectations can actually be realized, that each individual in a socialist society will exert himself with the same zeal as he does to-day in a society where he is subjected to the pressure of free competition, there still remains the problem of measuring the result of economic activity in a socialist commonwealth which does not permit of any economic calculation. *We cannot act economically if we are not in a position to understanding economizing.*" (emphasis added, 1920 [1935]: 120). But for the sake of argument, he was willing to grant the moral case for communal property and the assumption of benevolence to adjust to the requirements of socialism as a social necessity demands. Rather than question the motivations and incentives of central planners, Mises directed his attention at the knowledge problem they would inevitably face outside the institutional context of private property: "No individual could so discriminate between the infinite number of alternative methods of production that he could make direct judgments of their relative value without auxiliary calculations. *In societies based on the division of labor, the distribution of property rights effects a kind of mental division of labor, without which neither economy nor systematic production would be possible*" (emphasis added, Mises 1922 [1981]: 101). Indeed, the commercial society is predicated on private property rights to provide incentives to decision makers to husband resources efficiently, but it is the *contextual* knowledge embodied in relative prices, as well as profit and loss signals, that guide them in their efforts. Regardless of how well-motivated central planners may be, absent private property rights, decision makers are left without prices, and without prices, profit and loss statements are rendered economically meaningless. They would not *know* how best to utilize resources and how best to act to coordinate their activities with others so as to create the conditions of material abundance that classical socialism, market socialism and

technosocialism all promise. As would later be stressed in subsequent rounds of the debate, prices without property are the grand illusion.

In engaging in this comparative institutional exercise, Mises is forced to articulate the nature of the price system in more detail than had previously been developed. And this is vital for our exercise at challenging the contemporary proposals for technosocialism. As Hayek so eloquently put it: “When one reads Mises’ opponents, one gains the impression that they did not really see why such calculation was necessary” (1981: xxii). The definition of technosocialism refers to a social *outcome*, not to a process by which to discover how that outcome would unfold. Part of this is because of the continued preoccupation with assessing the market in terms of an ideal outcome rather than a process. Mises was clear both in 1920 and in 1922 that the “static state can dispense with economic calculation” (1920 [1935]: 109). The model of stationary economy is not the relevant depiction of the market economy according to Mises, despite however useful it may be for the economic theorist. In equilibrium, Mises argued, “there no longer exists a problem for economic calculation to solve. The essential function of economic calculation has *by hypothesis* already been performed” (emphasis in original; 1922 [1981]: 120). The market process ceases in equilibrium, the economic forces at work in the system have done their job and economic stasis has been achieved. All the factors of production have been deployed, under the given conditions, to optimally satisfy the demands of the consumers. That is the definition of a competitive equilibrium. This defining state of affairs, however, does not explain how economic forces *at work* bring it about. And that is the critical task Mises thought economic theorists must engage in if they hoped to understand the nature of the capitalist economy in contrast with the socialist economy. As Mises summed it up, “the problem of economic calculation is of economics dynamics: it is no problem of economic statics.” Instead, we must understand that the “problem of economic calculation is a problem which arises in an economy which is perpetually subject to change, an economy which every day is confronted with new problems which have to be solved” (1922 [1981]: 121).

We have belabored Mises’s rendering of the argument because the standard account of the debate, which fuels the confidence of technosocialists, be it Lange (1967), or the more contemporary renditions, has it that Hayek and Robbins concede to the critics that Mises’s calculation argument does not hold. Instead, they retreated to a computational argument that stresses the complexity of the planning task which renders it impractical, but not impossible. The answer then is that modern developments in computing have reduced that computational challenge to a solvable and exceedingly manageable issue. Perhaps in 1920, computers couldn’t comprehensively plan an economy, and perhaps even in the 1950s and 1960s, when Soviet cybernetic communism was being developed, the task remained too difficult. By the turn of the 21st century, however, surely the computational issue of socialist planning has become manageable. At least that would follow as a line of argument were the standard account correct that Hayek and Robbins had conceded Mises’s argument.

But as Hayek argues forcefully in his 1982 essay “Two Pages of Fiction” no concession was in fact ever made. And Hayek stressed Mises’s point in the context of challenging the common assumption of “given data”, which is an “irresistible attraction to mathematical economists” for the simple reason of tractability (1982: 135). The knowledge necessary for capitalist entrepreneurs to decide the best courses of action emerges only through their active participation in the market process. Absent that market process, which by definition even market socialism would entail, and “[t]his knowledge would not be available to anyone in a socialist economy where prices are not provided by the market” (Hayek 1982: 137).

It is neither the dispersed nature of knowledge, nor even the different judgments of different entrepreneurs, that is the critical factor in the Mises-Hayek argument. It is that the knowledge utilized in the market process is *contextual* and fleeting. As Steven Phelan elaborates on this point: “As such, a machine makes a poor entrepreneur because it does not care about the significance of one economic judgment over another” (2020: 74) in the way in which a residual claimant would. “In every AI task to date, the importance of one outcome over another is pre-specified by a human. Humans tell the AI what to care about. We *care* about winning a chess game, we *care* about making a profit, we *care* about not hitting a pedestrian with a vehicle. The AI, on the other hand, places no inherent value on one sequence of moves (or one combination of resources) over another” (emphasis original; Phelan 2020: 74). The subjective judgements of the exchange value of goods and services are translated into publicly information embodied in market prices only in the context of exchangeable private property rights, from which exchange ratios (i.e. market prices) emerge, and emerges only within that context, and therefore does not exist outside of that context. It is not that the knowledge is difficult to compute; it is knowledge tied up with questions of incompleteness and undecidability.

3. Computation of data or discovery of contextual knowledge?

That the central direction of an economic system, as opposed to the management of a firm, factory or farm, presents a computational problem, has long been understood. Adam Smith argued that the market system accomplishes, in coordinating the vast division of labor, what far exceeds our human abilities to compute. As Smith discusses the division of labor in the first chapters of *The Wealth of Nations*, he illustrates his point about the complex set of exchange relationship that are required to produce even the most ordinary of goods with the common woolen coat on the back of the day laborer. In concluding his example, Smith impresses upon his readers that “the number of people whose industry a part, though but a small part, has been employed in procuring him this accommodation, *exceeds all computation*” (1776 [1981]: 22, emphasis added). In the very next chapter of *The Wealth of Nations* Smith argues that we cannot rely on benevolence to secure the goods and services required for our daily survival, but must offer favorable terms of trade with our fellow human beings. And, to emphasize the point, Smith states: “In civilized society he stands at all times in need of the cooperation and as-

sistance of great multitudes, while his whole life is scarce sufficient to gain the friendship of a few persons” (1776 [1981]: 26). We must, Smith states, appeal to self-love of our trading partners to secure what we demand from the butcher, the baker and the brewer. Commercial society based on private property and freedom of exchange enables individuals to pursue productive specialization and realize peaceful social cooperation.

Computation and incentives are thus themes that can be found in the economics literature from the classics to the contemporaries. The earlier neoclassical writers Vilfredo Pareto and Enrico Barone both stressed these points. It is worth quoting them both at length because what they actually said, versus how others interpreted what they said, will become relevant in Section 4. Pareto in his *Manual of Political Economy* (emphasis in original; 1927 [1971]: 233–234) states:

It may be mentioned here that this determination has by no means the purpose to arrive at a numerical calculation of prices. Let us make the most favourable assumption for such a calculation, let us assume that we have triumphed over all the difficulties of finding the data of the problem and that we know the *ophelimites* of all the different commodities for each individual, and all the conditions of production of all the commodities, etc. This is already an absurd hypothesis to make. Yet it is not sufficient to make the solution of the problem possible. We have seen that in the case of 100 persons and 700 commodities there will be 70,699 conditions (actually a great number of circumstances which we have so far neglected will further increase that number); we shall thereafter have to solve a system of 70,699 equations. This exceeds practically the power of algebraic analysis, and this is even more true if one contemplates the fabulous number of equations which one obtains for a population of forty million and several thousand commodities. In this case the roles would be changed: it would not be mathematics which would assist political economy, but political economy would assist mathematics. In other words, if one really could know all these equations, the only means to solve them which is available to human powers is to observe the practical solutions given by the market.

And, Barone (1908 [1935]: 287–288) while admitting that if all the data was given and collected “it would be possible by a paper calculation to find a series of equivalents, which would satisfy the equations expressing the physical necessities of production and the equalization of costs of production and the equivalents, which become the *prices*.” In the next paragraph, however, Barone explicitly states: “But it is frankly *inconceivable* that the *economic* determination of the technical coefficients can be made” through this mathematical procedure (emphasis in original; 1908 [1935]: 287). The only method by which the system transforms the technologically possible into the *economically viable* is through the experimentation of the market process itself, without which the Ministry of Production would be lost in its effort to coordinate economic activity in an *economically efficient* manner.

This last point, which is basically shared by both Pareto and Barone, is not how they were subsequently read by scholars such as Abram Bergson and Paul Samuelson. The literature confused an insistence on the formal similarity in the economic efficiency of resource allocation and the required optimality conditions in socialism and capitalism with an argument that both could achieve such conditions. As Hayek could later stress: “The fact is that it has never been denied by anybody, except socialists, that these formal principles *ought* to apply to a socialist society, and the question raised by Professor Mises and others was not whether they ought to apply but whether they could in practice be applied in the absence of a market” (emphasis in original; 1940: 127).

The consequences of the wrong interpretation of this debate are detailed in Lavoie (1985a), but also discussed in Vaughn (1980), Kirzner (1988) and Caldwell (1997). It is worth quoting here at length this point as stated by Lavoie (1985b: 57), who summarizes the crux of the matter:

Whether applied to comprehensive or noncomprehensive planning, the knowledge problem argument crucially depends on the view that knowledge is not the same as data, that is, given pieces of explicit information. If this conception of knowledge is valid, then what really is at stake in the knowledge problem goes far beyond the issue of merely gaining access to scattered bits of explicit information, and implies that the whole standard approach to economic planning has been based on a misconception of the real problem to be solved.

Many of these same issues are still on the table, even in the contemporary debate over technosocialism. For example, King and Petty (2021: 286) state that if “data is the new oil, then edge computing, AI, and blockchain are the refineries and pipes of that oil.” The point here is that the economic calculation problem continues to get translated into a computational problem, which pushes the limits of algebraic capabilities circa 1900–1920, but developments in mathematical economics, econometrics, and linear programming tackle this computational issue. And, any remaining issues are addressed by advances in computer science, including quantum computing and AI. The economists associated with the Cowles Commission were some of the major developers of these approaches to economic planning and economic control. From Planometrics to Input-Output to Cybernetics to Computopia⁵, the basic presentation of the fundamental puzzle picked up from the standard interpretation of the debate and the Pareto and Barone position as computational. Hurwicz (1973), for example, argued that the chief point of the debate was the feasibility of the socialist solution when faced with the complexity of the number of variables and equations ranging in hundreds of thousands that must be continuously made. And, Hayek’s dispersed knowl-

⁵ Computopia is the idea that the planning board can now completely abolish the market in the means of production and replace with a centralized computer system which solves a giant maximization problem.

edge problem is translated as a distributed knowledge problem – bits and pieces of *known* information are scattered and must be collected by the planning authorities. Both the tasks of collection and computation may have presented a problem earlier, but today with high-speed electronic computers and networked computers the older argument is obsolete. The computer can calculate quickly once the data is entered into the program. The key issue for Hurwicz and subsequent generations of mechanism design theorists, from Eric Maskin and Roger Myerson, to Alvin Roth, Jan Tirole, John Roberts and Paul Milgrom (all Nobel Prize winners) was how to ensure the system was aligned so that information could be processed quickly and accurately. Once the informational requirements are met, the computations, though complex, are somewhat routine. The puzzle is ensuring accurate information transmission, and the system design must wrestle with strategic issues as well as processing issues to assure efficient administration of economic life (see [Hurwicz 1969, 1973](#)).

Thus, it makes perfect sense that Lange's 1967 reply would be that “[w]ere I to rewrite my essay today my task would be much simpler. My answer to Hayek and Robbins would be: so what's the trouble?” (1967: 158). Mathematical programming, Lange argued, is the essential instrument for optimal long-term economic planning of society. This argument has inspired others, such as [Saros \(2014\)](#) to argue that Mises's argument is historically limited. Such information problems plague both socialist and market regimes, but if the objective conditions are satisfied, modern technology has placed within the realm of the possible the socialist promise if the proletariat decides to choose to put those forces to use in a conscious effort to revolutionize the social forces of production ([Saros 2014: 248](#)). And in [Morozov \(2019\)](#), though he is more subtle than most in his understanding of the historical debate and its challenge for the contemporary discussions, he nevertheless concludes that digital innovations enable the introduction of social change to bring about a more just and humane social order.

Philips and Rozworski's *The People's Republic of Walmart* (2019), while a polemical work rather than a scholarly one, pushes these arguments in rather intriguing directions for the debate. They argue that the existence of central planning is all around us, in modern large corporations, in central bankers, and in modern finance with mutual funds. All these examples, they argue, prove that the old critique of economic planning is flawed and fundamentally so because modern computer technology, which enables Walmart (or Amazon for that matter) to administer its economic affairs at a scale on par with countries the size of Switzerland or Sweden. Walmart's success demonstrates that the technological conditions are such that planning is possible. The problem is these giant corporations and the entire institutional infrastructure is designed for profit, not people and the planet. But modern technology means the required information can be collected and processed accurately and quickly. Centralized economic planning of an economy, they conclude, is easier and more accurate than ever before. Earlier efforts at realizing socialism in practice failed, either because the lack of technological capabilities or non-democratic forces that blocked the transmission of vital information (Soviet Union), or external interference which overturned the revolution (Chile). But if we can, through democratic awareness, turn this technology away from being a tool for profits, but instead focus on urgent social needs of people, then the computing power utilized by Walmart and Amazon, etc., could achieve progressive goals. A communal democratic society will finally emerge and fulfill the promise that socialist intellectuals have dreamed of since 1848.

The arguments that have been developed from sophisticated scientists to ideologically pundits have a common theme. First, conflate the calculation argument with a computation argument. Second, conflate the logical demonstration of the formal similarity of optimality conditions for capitalism and socialism, with a demonstration that both capitalism and socialism can achieve those optimality conditions. Third, interpret the Mises-Hayek argument concerning the role of prices in the competitive system as an earlier version of the neoclassical model of general competitive equilibrium and the informational assumptions required for achievement of the optimal allocation of resources. Fourth, interpret the demonstration of market failures such as monopoly, externalities, asymmetric information, and aggregate demand failure as evidence that markets cannot achieve competitive equilibrium, but that an appropriate mechanism design for socialism could achieve the efficient allocation of resources. Fifth, that while the computational task years ago may have stretched credulity, modern advances in computing and in particular AI have made that argument obsolete. Assume the data is given, and all else follows. Socialist planning can harness modern technology, and realize a true democratic society. As [Cockshott and Cottrell \(1993: 198\)](#) concluded: “With socialism gone, what hope is there left for the dispossessed but fascism and nationalism? Nothing, unless it is a socialism that is more radical, more democratic and more egalitarian than any which went before, that is founded on clear economic and moral principles and that does not surrender its integrity to the demoralizing myths of the market.”

4. Technosocialism: computation without discovery

Don Lavoie, in an essay titled “Computation, Incentives and Discovery” (1990), attempts to clarify why even the most sophisticated advances in computer technology do not address the Mises-Hayek-Kirzner objections to socialist economic planning. It is the last word in his title that is the key – *discovery* – and all that it entails for how the price system works in a market economy that is still missing from the arguments. In [Section 2](#), we stressed that Mises made clear from his first essay in the debate that if one assumes perfect knowledge and static conditions, then the problem of economic calculation is solved by hypothesis. Economic calculation is a tool that enables actors to steer a course in a turbulent sea of economic uncertainty, of ceaseless change, of ignorance of the environment, and of alluring hopes and haunting fears. Once all those are assumed away, then the functional significance of economic calculation disappears. But so would opportunities for mutual gain, entrepreneurial innovations, and discovery of new opportunities. In other words, if you assume away change, you assume away the possibility of economic growth and progress. Equilibrium means precisely that: equilibrium. No change,

no dynamics, no adaptation, no adjustments. Just static optimality in the use of given technology, given tastes and given resource endowments. And we should add that methodologically, the technique of simultaneous equation solving by AI is an intellectual impediment to understanding the *process* by which the solution is ever found.⁶ This last point is illustrated by King and Petty in their proposal for technosocialism. Recall that in their definition, technosocialism would utilize AI as the means by which to automate production and deliver the technological capability to supersede capitalist production. They argue the following (emphasis added; King and Petty 2021: 288):

The move to digital-first industries and replacement of large portions of human labor by algorithms is changing our understanding of supply and demand, and how productivity should be measured. The 21st century economy will mostly comprise intangible goods and services – at least in terms of value and spend. If demand increases, then supply could be simply processing cycles in a Gigafactory – managed by humans, but no longer dependent on human labor for productivity gains.

The relevance of our earlier discussion on the socialist calculation debate is that the implementation of technosocialism parallels the market socialist model proposed by Oskar Lange and Abba Lerner in the 1930s. However, rather than being directed by a central planning board of human beings, it would be directed by an algorithm, not unlike Lange's later proposal for computers as an "instrument of economic accounting" (1967: 159). Economists from the US and the UK, such as Taylor (1929), Knight (1936), Dickinson (1933), Lange (1936, 1937) and Lerner (1934, 1935, 1936) began developing an argument that used modern neoclassical economics to ensure the efficiency of socialist economic planning. Using neoclassical reasoning, Oskar Lange was able to formulate his critique of Mises.

In deploying the formal similarity argument,⁷ Lange provided the following blueprint for all that followed as we have seen. First, allow a market for consumer goods and labor allocation. Second, put the productive sector into state hands but provide strict production guidelines to firms. Namely, inform managers that they must price their output equal to marginal costs, and produce that level of output that minimizes average costs. Adjustments can be made on a trial and error basis, using inventory as the signal. The production guidelines will ensure that the full opportunity cost of production will be taken into account and that all least-cost technologies will be employed. In short, these production guidelines will ensure that productive efficiency is achieved even in a setting of state ownership of the means of production (Lange 1936). By doing so, such managers would grope toward the conditions of perfectly competitive equilibrium through "trial and error," or what Lange referred to as a series of *tâtonnements* (Lange 1936, p. 59), a process which he regarded as analogous to that which takes place under capitalism. During this *tâtonnement* process, the Central Planning Board would mimic the function of a "Walrasian auctioneer" in its role of sorting goods and services to their most valued uses to eliminate shortages and surpluses in the market. The implementation of market socialism, according to Lange and Lerner, would outperform capitalism by eliminating inefficiencies associated with market failures, such as monopoly power and business cycles. For King and Petty's model of technosocialism, AI becomes the counterpart of the Walrasian auctioneer. Where King and Petty also parallel Lange is that socialism would actually outperform capitalism by purging society of monopoly and business cycles that plague real-world capitalism. Moreover, since the means of production would rest in the hands of authorities, market socialism would also be able to pursue egalitarian distributions in a manner unobtainable with private ownership.

It may indeed be the case, whether we are talking about market socialism or technosocialism, that technological advances in computation have been able to process existing data *quickly*, but this is distinct from a problem of *correctly* discovering the relevant knowledge about consumer demands, which fundamentally guides production (Lavoie 1985b: 56-57). Such knowledge does not exist outside the context of rivalrous competition between producers for inputs, rivalrous competition between consumers for outputs, and active buying *and* abstaining from buying by consumers for output (Lavoie 1985b: 56-57). As Don Lavoie puts it, "economic rivalry among competitors in the market generates knowledge that no rival on his own could have possessed in the absence of that rivalry" (Lavoie 1985a: 26). The social outcome of technosocialism therefore requires that AI has information that only emerges as context-specific knowledge from entrepreneurs competing as residual claimants for private property rights in the means of production and being subjected to market feedback from consumers in the form of profit and losses. Therefore, technosocialism cannot replace the competitive discovery process that takes place *only* within the context of the market, one in which residual claimants are the locus of decision-making, responsible not only for their correct decision-making communicated in the form of monetary profits, but more importantly their errors communicated as losses. It is particularly residual claimancy over losses that creates the context for learning and error-detection that is crucial to the discovery procedure of the market process, and cannot be replaced through advanced computational technology. King and Petty go further to raise many important questions that go straight to the heart of the problem of economic calculation under socialism, but are unable to address how to solve the problem of economic calcu-

⁶ As Lavoie (1986: 4) argues the technique focuses on a "pre-coordination of plans before launching any projects, whereas in the real world plans are post-coordinated by the calculation of profit-and-loss during and after the implementation of production projects." To put a fine point on this, pre-reconciliation of plans means that the function performed by economic calculation in coordinating plans is unnecessary, so is it really any wonder that even to this day that economists working with this technique have failed to see the importance of Mises's challenge?

⁷ There are many extreme ironies in this entire chapter of the history of economic thought. The formal similarity argument was laid out clearly by Frederick Wieser in the late 19th century, (Wieser 1891) and as Hayek stressed, Mises (and other critics of socialism) never said that these formal principles shouldn't be met. In fact, they argued that they should. The question was whether they *could* be satisfied in the absence of a private property market economy with its relative prices and profit-and-loss accounting.

lation. Continuing from their earlier discussion of how production would be managed by AI under technosocialism, they go further to ask the following questions:

How do we measure productivity when the input is, say, medical treatment that extends the working life of a person? Is it the value of a longer career? How do we separate the medical treatment that enables a longer working life from other changing variables such as work, relationships, our environment, or not abusing alcohol? This is difficult to do, and questions like these have led researchers to consider what role social factors and cultural context might play in improving productivity. Productivity itself may need to be redefined (King and Petty 2021: 288).

However, to suggest that changing the definition of productivity away from an economically relevant meaning will address the problem only assumes away the nature of economic calculation, which is not to solve a technological problem of allocating given means to a single end, but the discovery of the means available to satisfy an undefined set of ends.

As Hayek pointed out in his critique of Lange and others, the assumption of “given data” was precisely a problem of “assuming away” the very problem that had to be addressed for scientific progress on the issue to be made. Hayek was in many ways blindsided by the socialist calculation debate in the 1930s and 1940s. Lavoie (1986: 2) has stressed that this debate, what he labels “the most important theoretical controversy in the field of comparative economics”, led Hayek to articulate what Mises had left implicit, namely the way the competitive market process works to discover, utilize and disseminate *context-specific* knowledge in society. There can be no doubt, Lavoie argues, that “the Mises-Hayek position benefited enormously by being forced to confront the Langean variant of market-socialist models” (1986: 2). The problem is that the modern advocates of technosocialism despite claiming to have learned from this debate, including Lavoie’s own restatements, still make impermissible assumptions about economic knowledge. They conflate technological knowledge with economic knowledge; they conflate information with knowledge; and they assume the articulability of economic knowledge. The technosocialists, just like the earlier market socialists, in their own way assume they have the requisite data to plan the economy. It might be difficult to collect, they might have to ensure truthful communication rather than strategic, and they of course must compute what they have, but the “data” is still given.

As Lavoie (1986: 8) puts it, “these procedures are only valid for rather specialized models under very stringent assumptions.” One of the most serious problems confronting the market socialist response to Hayek, was that Hayek’s argument regarding relevant economic knowledge is inarticulate in nature. Economic actors know more than they can ever explicitly communicate to one another. It is this use of inarticulate knowledge within the market process that Hayek (1945) was attempting to capture in his emphasis on knowledge of time and place, and knowledge which by its nature cannot be treated as statistics. If Hayek’s argument holds, then the market socialist models from Lange to Hurwicz cannot in principle be implemented. It is not a matter of technological developments in computing power because that isn’t the knowledge problem that Hayek identified.

What is the most efficient way to pursue any production project must be discovered anew each day, Hayek (1940: 139) argued, and if not discovered by the current sitting entrepreneur, it will be by an alert competitor. The market is a social learning process. As Lavoie (1986: 12) argued the knowledge economic actors discover, utilize and disseminate “is fundamentally premised on our being embedded in a social process about the working of which we have only the crudest conception.” The communicative function of the market process is not as described in the neoclassical perfect competition model where definitive information on what techniques are optimal is supplied, “but rather continuously redraws the boundaries of what is economically feasible, within which boundaries economic decision-making take place by incremental adjustments to established habits. Production methods are not so much known as simply practiced, revised and occasionally abandoned in a continuously changing flux of competitive activity” (Lavoie 1986: 13).

Economic calculation, once more, is not about computational complexity, but about sorting from the numerous technologically feasible ways to pursue a variety of production plans to find those subset of production plans which are *economically* viable. By “reducing to a manageable size the mind-boggling variety of conceivable methods of production, the price system performs an indispensable service” (Lavoie 1986: 13). Hayek and Lavoie would try to focus economists’ attention on competition as a discovery procedure. “From the point of view that I am calling the discovery approach,” Lavoie (1990: 77) argued, “the cognitive function of markets is not exhausted by its calculative and motivational aspects. The problem is a matter neither of mathematics nor of psychology. What the computation and incentive approaches have in common is their focus on the point of view of the single mind, what might be called a monological as opposed to a dialogical approach.” The knowledge assumption consistent with the discovery point of view is that the actors that populate the economy under investigation will know aspects of the system which the theorist will never be able to know. The discovery approach, Lavoie stresses, sees the market as intrinsically a social process that depends on the give-and-take of competitive activity, and the knowledge that is discovered, utilized, and disseminated emerges only within that process itself. Absent that process and that knowledge, it is not just difficult to gather and compute. Rather, *it simply does not exist* outside that context of a set of institutions, namely property, contract and consent. Thus, at the end of the debate we are back to Mises’s fundamental point – without private property in the means of production, there will be market for the means of production, and without a market in the means of production there will be no relative prices established for the means of production, and without relative prices reflecting relative scarcities, there can be no rational economic calculation of the alternative consumer uses of scarce means of production. Mises’s argument still holds 100 years after it was first penned, and after all the technological developments we have seen. Technosocialism might compute, but it cannot calculate in an economically relevant and meaningful way.

Mises in *Liberalism* (1927 [2005]) argued that forgoing the intellectual division of labor in society was the decisive objection of socialism. Hayek discussed how the division of knowledge in society represented the insurmountable problem that socialist planning would confront. And Lavoie stressed the socially embedded and emergent nature of the knowledge that reflects the cognitive function of the market. In *F. A. Hayek: Economic, Political Economy and Social Philosophy*, Boettke (2018) argues that this research program can best be described as epistemic institutionalism. And, thus in assessing economics systems the criteria deployed is how alternative institutional arrangements impact learning by economic actors. The subjectivity of values and costs, uncertainty and ignorance, and constantly shifting tastes and technology all must be taken into account when discussing the social learning in a modern economy. In the social psychology literature there is an interesting distinction between “wicked” and “kind” learning environments (see Hogarth et al. 2015). For our purposes in addressing technosocialism and the role of AI, we can state that “kind” learning environments are those with fixed algorithms – say as in a game of chess – and “wicked” learning environments are those that are open-ended. Computers can master “kind” learning environments, but they are at a loss in “wicked” learning environments. Computers can play chess, but they are not very good at playing soccer. “Wicked” environments require constant adaptation and adjustments to change, and thus the cognitive role of the economic system is that “aids to the human mind” must emerge to guide future action (prices), to lure actors to pursue possibilities (profits), and discipline decision makers to rethink their previous wishful conjectures (losses). The nimble entrepreneur is not only different from the bumbling bureaucrat, but from AI machine learning under conditions of a “kind” learning environment. Modern economies are not analogous to games of chess. As Dryfus (1972) long ago challenged the optimistic predictions of Herbert Simon and others made about the future of AI. Morozov (2019), for example, argues that computers can provide real time access to local data, and make decisions that are as good, if not better, than their human counterparts. But can they in “wicked” learning environments? Again, just compare a computer playing chess and the most advanced robots in the world playing soccer – Kasparov faces a challenge, Ronaldo does not. The real time adaptations and adjustments, let alone the creativity and cleverness that Ronaldo must exhibit in competitive play is a radically different task than recognizing patterns and processing a complicated yet finite set of strategic moves.

Ostrom (1990: 214) provided a warning to social scientists of the trap this outside-in perspective holds to practitioners. As she put it: “The typical assumptions of complete information, independent action, perfect symmetry of interests, no human error, no norms of reciprocity, zero monitoring and enforcement costs, and no capacity to transform the situation itself will lead to highly particularized models, not universal theories.” She continues, “[t]he intellectual trap in relying entirely on models to provide the foundation for policy analysis is that scholars then presume that they are omniscient observers able to comprehend the essentials of how complex, dynamic systems work by creating stylized descriptions of some aspects of those systems. *With the false confidence of presumed omniscience, scholars feel perfectly comfortable in addressing proposals to governments that are conceived in their models as omniscient powers able to rectify the imperfections that exist in all field settings*” (emphasis added; 1990: 215). Social science that is practiced under this false confidence sees the world through the government’s eyes, and not through the ideas of democratic citizenry capable of self-governance. It is a tool for *governing over*, not a tool for *governing with*, and that view distorts important economic, political and social issues, including any renewed proposals for socialism in whatever guise.

5. Conclusion

Entrepreneurs are entirely dependent on the context-specific knowledge of the market process, embodied in profit and loss signals, to guide them in their decision-making. In spite of this fact, some entrepreneurs, as evidenced by Jack Ma, are captured by the allure that technological advances can replace the competitive discovery procedure of the rivalrous market process. However, as Fernández-Villaverde (2021) has argued, the “increasing sophistication and competence of machine learning in these fields has given public policy analysts misguided confidence in the ability of machine learning-aided economic policy to substitute for human decisions. The truth is, these new methods repeat the errors of previous attempts to automate and centralize economies. Although machine learning demonstrates an impressive capacity to solve complex analytical problems, it only finds associations rather than meaningful causal relationships, and it is unable to overcome fundamental information incentive problems that the free market adequately solves. In other words, in spite of Mr. Ma’s optimism, artificial intelligence will simply never be smart enough to replace the free market.”

Thus, the knowledge problem that Mises, Hayek, Kirzner, and Lavoie identified is not solvable through advances in AI and modern computing. The knowledge of the market is not dispersed as bits and pieces throughout the economy that must be collected and computed to guarantee the efficient allocation of resources. Rather, the “intellectual division of labor” and the “division of knowledge” in society is contextual, embedded only within a division of exchangeable private property rights. Such knowledge of time and place, where entrepreneurs reside and in the socially embedded processes of exchange and production activity, only emerges within the competitive give-and-take of the market, and outside of that context the required knowledge does not exist.

Prices guide, profits lure and losses discipline, and in this constant process of adaptation and adjustment wealth is created as individuals pursue productive specialization and realize peaceful social cooperation through mutually beneficial exchange. As we stated in the beginning of the paper, the normative goals of technosocialism must be left unexamined in this treatment, while the positive economic analysis of technosocialism must be the focus of our attention. That exploration demonstrates that the promise of a new era of computer technology does not rise to the challenge that Mises, Hayek,

Kirzner, and Lavoie put forth. Technosocialism, just as the older version of market socialism, turns out to be unfeasible in principle, not just in practice. And it cannot, as a result, achieve its normative goals.

Declaration of Competing Interest

We have no interests to declare that conflict with the submission of our article.

Acknowledgments

We would first like to thank Bruce Caldwell, Steven Phelan, Nikolai Wenzel and the participants of the “Modern Computing and Economic Calculation Online Papers Workshop” sponsored by the Institute of Humane Studies on February 19th & 26th, 2022. The comments and feedback offered during the workshop greatly improved previous drafts of this paper. We also grateful to Pablo Prieto for his thoughtful and insight comments. In addition, we gratefully acknowledge Tegan Truitt for his research assistance on an earlier draft of this paper. Any remaining errors are entirely our own.

References

- Barone, E., Hayek, F.A., 1908 [1935]. The ministry of production in the collectivist state. In: *Collectivist Economic Planning: Critical Studies on the Possibilities of Socialism*. George Routledge & Sons, London, pp. 245–290.
- Boettke, P.J., 2018. F. A. Hayek: Economics, Political Economy and Social Philosophy. Palgrave Macmillan, New York.
- Caldwell, B., 1997. Hayek and socialism. *J. Econ. Lit.* 35, 1856–1890.
- Cockshott, W.P., Cottrell, C., 1993. *Towards a New Socialism*. Spokesman, Nottingham.
- Dickinson, H.D., 1933. Price formation in a socialist community. *Econ. J.* 43, 237–250.
- Dryfus, H., 1972. *What Computers Can't Do*. MIT Press, New York.
- Fernández-Villaverde, J., 2021. Artificial intelligence can't solve the knowledge problem. *Public Discourse J. Witherspoon Inst.* July 29. <https://www.thepublicdiscourse.com/2021/07/76963/#:~:text=The%20only%20reliable%20method%20we,its%20outcomes%20are%20often%20unsatisfactory.>
- Hayek (Ed.), F.A., 1935. *Collectivist Economic Planning: Critical Studies on the Possibilities of Socialism*. George Routledge & Sons, London.
- Hayek, F.A., 1940. Socialist calculation: the competitive solution. *Economica* 7, 125–149.
- Hayek, F.A., 1945. The use of knowledge in society. *Am. Econ. Rev.* 35, 519–530.
- Hayek, F.A., 1981. Foreword. In: *Mises, L.v., Socialism: An economic and sociological analysis*. Liberty Fund, Indianapolis, pp. xix–xxiv.
- Hayek, F.A., 1982. Two pages of fiction. *Econ. Aff.* 2, 135–142.
- Hodgson, G.M., 2018. *Wrong Turnings: How the Left Got Lost*. University of Chicago Press, Chicago.
- Hodgson, G.M., 2019. *Is Socialism Feasible?: Towards an Alternative Future*. Edward Elgar, Northampton.
- Hogarth, R.M., Lejarraga, T., Soyer, E., 2015. The two settings of kind and wicked learning environments. *Curr. Dir. Psychol. Sci.* 24, 379–385.
- Hurwicz, L., 1969. On the concept and possibility of informational decentralization. *Am. Econ. Rev.* 59, 513–524.
- Hurwicz, L., 1973. The design of mechanisms for resource allocation. *Am. Econ. Rev.* 73, 1–30.
- King, B., Petty, R., 2021. *The Rise of Technosocialism: How Inequality, AI and Climate will Usher in a New World*. Marshall Cavendish International, Ryebrook.
- Kirzner, I.M., 1988. The economic calculation debate: Lessons for Austrians. *Rev. Aust. Econ.* 2, 1–18.
- Knight, F.H., 1936. The place of marginal economics in a collectivist system. *Am. Econ. Rev.* 26, 255–266.
- Lange, O., 1936. On the economic theory of socialism: part one. *Rev. Econ. Stud.* 4, 53–71.
- Lange, O., 1937. On the economic theory of socialism: Part two. *Rev. Econ. Stud.* 4, 123–142.
- Lange, O., Feinstein, C.H., 1967. The computer and the market. In: *Feinstein, C.H. (Ed.), Socialism, Capitalism and Economic Growth: Essays Presented to Maurice Dobb*. Cambridge University Press, New York, pp. 158–161.
- Lavoie, D., 1985a. *Rivalry and Central Planning: The Socialist Calculation Debate Reconsidered*. Cambridge University Press, New York.
- Lavoie, D., 1985b. *National Economic Planning: What is Left?*. New York: Cambridge University Press, Cambridge: Ballinger.
- Lavoie, D., 1986. The market as a procedure for discovery and conveyance of inarticulate knowledge. *Comp. Econ. Stud.* 28, 1–19.
- Lavoie, D., 1990. Computation, incentives, and discovery: The cognitive function of markets in market socialism. *Ann. Am. Acad. Political Soc. Sci.* 507, 72–79.
- Lerner, A.P., 1934. Economic theory and socialist economy. *Rev. Econ. Stud.* 2, 51–61.
- Lerner, A.P., 1935. Economic theory and socialist economy: a rejoinder. *Rev. Econ. Stud.* 2, 152–154.
- Lerner, A.P., 1936. A note on socialist economics. *Rev. Econ. Stud.* 4, 72–76.
- Marx, L., Engels, F., 1848 [1998]. *The Communist Manifesto*. Penquin Books, New York.
- Mises, L.V., 1920. Die Wirtschaftsrechnung im sozialistischen Gemeinwesen. *Arch. fur Sozialwiss. Sozialpolitik* 47, 86–121.
- Mises, L.V., 1920 [1935]. Economic calculation in the socialist commonwealth. In: *Hayek, F.A. (Ed.), Collectivist Economic Planning: Critical Studies on the Possibilities of Socialism*. George Routledge & Sons, London, pp. 87–130.
- Mises, L.V., 1922. *Gemeinwirtschaft*. Gustav Fischer, Jena.
- Mises, L.V., 1936. *Socialism: An Economic and Sociological Analysis*. Jonathan Cape, London.
- Mises, L.V., 1922 [1981]. *Socialism: An Economic and Sociological Analysis*. Liberty Fund, Indianapolis.
- Mises, L.V., 1927 [2005]. *Liberalism: The Classical Tradition*. Liberty Fund, Indianapolis.
- Morozov, E., 2019. Digital socialism? *New Left Rev.* 116. [https://newleftreview.org/issues/ii116/articles/evgeny-morozov-digital-socialism.](https://newleftreview.org/issues/ii116/articles/evgeny-morozov-digital-socialism)
- Ostrom, E., 1990. *Governing the Commons*. Cambridge University Press, New York.
- Pareto, V., 1927 [1971]. *Manual of Political Economy*. Augustus M. Kelley, New York.
- Phelan, S., 2020. Can entrepreneurship be learned by intelligent machines? *Rev. de Inst. Ideas y Merc.* 69, 57–86.
- Phillips, L., Rozworski, M., 2019. *The People's Republic of Walmart: How the World's Biggest Corporations are Laying the Foundation for Socialism*. Verso, New York.
- Saros, D.E., 2014. *Information Technology and Socialist Construction: The End of Capital and the Transition to Socialism*. Routledge, New York.
- Smith, A., 1776 [1981]. *An Inquiry into the Nature and Causes of the Wealth of Nations*. Liberty Fund, Indianapolis.
- Taylor, F.M., 1929. The guidance of production in a socialist state. *Am. Econ. Rev.* 19, 1–8.
- Vaughn, K.I., 1980. Economic calculation under socialism: the Austrian contribution. *Econ. Inq.* 18, 535–554.