# Cybersocialism and the Future of the Socialist Calculation Debate

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**Abstract:** In the long running debate about the desirability and feasibility of a planned socialist economy, Austrian economists proclaim victory. Drawing from Mises and Hayek, they stress that the problem of deciding the most economic methods for producing goods and services is not simply, as some early socialist responses suggested, a 'computational' one but is rather epistemological. Hence, they reject recent 'cybersocialist' claims that developments in computational technology offer potential for addressing the 'socialist calculation problem' famously formulated by Mises, long before the advent of computer technology. Yet this theoretical claim by Austrians hinges more than is recognised upon the capacity of rapidly evolving computational technologies and their potential applications. We highlight the need to re-appraise Austrian conclusions, attending closely to the distinction offered by Mises between supply and demand-side calculation. Recent cybersocialist proposals should be viewed as opening up several different avenues of research relating to different aspects of the long-running socialist calculation debate, including the inter-relationships between economic calculation, incentives and innovation.

**Keywords:** socialist calculation debate, cybersocialism, technosocialism, economic planning, economic calculation, Mises, Hayek

**JEL Classification:** B13, B14, B24, B25, B51, B53, D83, P21, P51

## I. INTRODUCTION

Debates about the feasibility of alternatives to capitalist market economies have a long history. Proposals for such alternatives, which typically

involve some form of non-market planning, remain a matter of ongoing debate (Piketty 2021; Varoufakis 2020). There are a range of motivations for such proposals, including inequality (Piketty 2014), environmental destruction (Kovel 2007) and the domination of workers (O'Shea 2019) under current economic systems. In debates about possible forms of post-capitalist society, some recent contributions stress the significance of developments in information technology (Cockshott and Cottrell 1993; Dapprich 2020; Phillips and Rozworski 2019; Saros 2014). These include proposals for 'technosocialism' or 'cybersocialism,' which argue that computer networks and increased computing power make economic planning a feasible and attractive alternative to markets.

Earlier debates about the feasibility of socialist planning started over a century ago, with the 'socialist calculation debate,' sparked by Ludwig von Mises' critique of socialist planning (Mises 1920, 1936). The contributions to the debate from Mises and his fellow Austrian economist Friedrich Hayek conceptualized the market process as an indispensable feature of modern, civilized economies. In light of the significance of these philosophical Austrian School arguments, present day Austrian theorists tend to conclude that Mises and Hayek decisively settled the debate, with some declaring victory for their side (Boettke and Leeson 2004, 2005; Horwitz 1996; Rothbard 1991). Notably strident is Boettke and Leeson's proclamation that Mises demonstrated that a "socialist *economy* is impossible" (Boettke and Leeson 2005, 157). Indeed, especially since the problems of Soviet planning became further apparent and the subsequent collapse of the Soviet Union, the idea of a non-market, planned economy has become widely viewed as unfeasible. An acceptance of the philosophical grounds for the indispensability of markets, as set out by the Austrians, is evident amongst authors with a range of views about the role of markets in society, not just advocates of the market-orientated liberalism of Mises and Hayek (such as Hodgson 2019; Knight and Johnson 2011).

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A range of contributions in a broadly socialist tradition have responded in different ways to the socialist calculation argument. Proposals for market socialism (Nove 1983; Roemer 1994), or the 'socialization of markets' (Elson 2000) have accepted that markets are, to a degree, indispensable allocative mechanisms. Others continue to propose entirely non-market forms of planning, including 'cybersocialist' proposals which seek to directly counter the Austrians' conceptual arguments (Cockshott and Cottrell 1993; Dapprich 2022). Contemporary scholars in the Austrian tradition suggest these contributions fail to engage with the calculation problem as conceptualized by Mises and Hayek, leading to a stalemate (Boettke and Candela 2023; Lambert and Fegley 2023). Huge, recent, and rapid advances in computational power, they argue, make no difference to the prospects for socialist calculation. By contrast, we challenge the conclusions that Austrians infer from their philosophical conceptualization of the market process. We argue that technological advances have important implications for the feasibility of socialist planning. Recent contributions, we suggest, show that the debate has already evolved in response to technological advances. Rather than having been conclusively settled by the Austrians, the debate needs to be viewed as open and ongoing, involving significant contingencies and scope for future research. Boettke and Candela (2023) challenge socialists to develop 'immanent' critiques showing the potential for socialist planning models to address the calculation problem in the conceptual terms set out by the Austrians. We highlight the potential for such an immanent critique, explaining how, in light of technological advancements, planning processes might be capable of fulfilling the same kind of epistemological functions that markets fulfil.

This paper is structured as follows. Section 2 assesses the Austrian calculation argument as articulated by Mises and Hayek. Having an

epistemological thrust, their contributions are considered by contemporary Austrians to provide grounds for decisively refuting the feasibility of cybersocialist proposals. The next two sections assess these claims in detail, being organized in terms of a distinction, evident in Mises' work, between the 'supply' and 'demand' side of socialist planning. Section 3 focuses on the supply side problem which is the focus of Mises' initial calculation argument. Even assuming a benevolent socialist planning board can suitably define a 'target' set of final goods and services meeting the needs and preferences of citizens, the question of how to efficiently produce these, Mises argues, involves profound complexity. We review recent socialist responses to this 'supply side' problem and assess the potential for this problem to be overcome through computational techniques. Section 4 then turns to the demand side problem that arises once we drop this assumption of a 'given' target set of outputs. How might the target set of outputs for a non-market planned economy be established? We emphasize how this question is shaped by social and institutional contexts, while also considering some recent technologically orientated approaches. Section 5 concludes.

## II. THE AUSTRIAN SCHOOL AND THE CALCULATION ARGUMENT

Mises and Hayek are well-known for their 'classical liberal' proposals (Hayek 1960), which involve a strictly delimited role for the state, being primarily concerned with defining and maintaining private property rights. They were strongly opposed to socialism, and it is through their critique of socialist proposals that they developed their conceptualization of the market process. The Austrian case for markets tends to be associated with the rise of free-market ideology, often referred to as 'neoliberalism'. However, to understand the course of the calculation debate, there is an important need to distinguish the Austrian School from the work of Milton Friedman and mainstream Neoclassical economics that were also influential in pro-market thought (Lavoie 1985, Vaughn 1980). Whereas Neoclassical economists analyzed economic outcomes in relation to an optimal or 'ideal' standard of equilibrium, the Austrians stressed that institutional arrangements are inevitably imperfect. Drawing from the Austrian tradition, contemporary scholars including Peter Boettke and Mark Pennington (Boettke and Leeson 2004; Pennington 2017) highlight the need for analysis of institutional robustness, given the inevitable imperfections and uncertainties associated with human knowledge and motivation.

Mises' original articulation of the 'calculation argument' puts aside, for the sake of argument, questions of the motivations of socialist planners, assuming their benevolence. Instead, he emphasizes the fundamental complexities involved in economic decision-making in the absence of markets. This served as the basis for Hayek's epistemologically orientated critique of socialist planning (Boettke 1993, 52–53; Greenwood 2007b; Hodgson 1998; Horwitz 1998),[1] which concerns the indispensability of markets in facilitating 'knowledge discovery'. As Boettke and Candela (2023) put it, the prices that emerge through market processes encapsulate complex knowledge concerning demand and supply, thus serving as a guide to economic calculation and the discovery of new knowledge. In light of this inseparability, it will be suggested below, developments in computational techniques for calculation have implications for how far the knowledge argument can be addressed.

Mises' initial 'calculation' argument focuses upon the 'supply side' problems that planners would face. This is made evident by his assumption of planners having established a 'target' set of final goods that reflects the current needs and priorities of society (Mises 1920, 107). Even given these assumptions, he argues, socialist planners would face the profoundly complex problem of establishing *how* to produce the target set of final goods and services. This challenge, that Mises views as insurmountable, concerns how to choose specific combinations of factors of production (labor, natural resources, and capital goods) for producing the target set. In the absence of markets, Mises holds, planners would have no way of establishing which factor combinations, or production methods, should be used to make production as efficient as possible. Markets, Mises made clear, are not perfect (Greenwood 2006). However, he argued, they do have at least a tendency to promote the rational allocation of resources. Attempts to replace factor markets with non-market planning, he held, would lead to a huge fall in living standards for the population (Mises 1920, 130).

For Mises, this supply side problem alone is sufficient to render socialism unfeasible (Mises 1920, 90). He considers this supply side calculation problem to be logically separable from 'demand side' questions of

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[1] Some commentators have suggested that Hayek's contributions to the calculation debate offer a distinct argument from Mises' formulation of the calculation problem (for example, Salerno 1990). However, the essentially epistemological nature of the calculation problem formulated by both Mises and Hayek has since been widely emphasized, even though Hayek's work has a more explicit epistemological emphasis (Greenwood 2007b; Lavoie 1985; Yeagar 1996).

how to establish which goods and services to produce, given the needs and preferences of the population. However, as he makes clear, there must necessarily be an interrelationship between supply and demand side calculation. Factor valuations must reflect the prioritization, or 'demand,' for different final goods, regardless of the type of market or planning through which this demand is being established. For, even if a set of final goods targets are defined by socialist planners, these targets will affect relative factor values through a process referred to by Mises (1920, 90) as 'factor imputation' (see also Lavoie 1985, 51; Mises 1936, 117). For example, if the demand for domestic heating increases, this will, ceteris paribus, cause an increase in the relative value of factors involved in energy production.

Through this initial supply side focus, Mises emphasizes the indispensability of the factor prices generated by markets, that capture the relative levels of demand and supply for factor inputs in terms of a single unit of measurement. As Mises makes clear, factor values so defined are not reducible to any single physical unit of measurement. This had been the assumption of socialists such as August Bebel ([1879] 1910) and Karl Kautsky (1925) with their proposals for measuring the value of factors in terms of labor time. This approach, Mises argued, overlooked the scarcity of other inputs into the production process, such as scarce natural resources. The epistemological function of market prices is made evident by Mises when he refers to them as "aids to the mind" (Mises 1920, 102), allowing producers to compare the costs of alternative production methods in terms of multiple criteria. In the absence of these factor prices generated by markets, producers would have no guide as to the most efficient uses of factors for producing goods and services.

As Hayek's contributions make especially clear, these 'aids to the mind' serve as a guide for the discovery of new knowledge concerning both production and distribution. On the production side, this is the discovery of knowledge about more efficient means of producing goods, given current supply levels of factors of production, through processes of innovation. Such innovation means that production functions are subject to continual change, with new factor combinations yielding improved levels of productivity. Such processes of knowledge discovery are also apparent in final goods markets. While Hayek does not emphasize the point in his early writings, his later work makes clear that markets similarly capture the vital locally situated knowledge and preferences of

consumers, which emerge and dynamically evolve through the process of exchange.[2]

As contemporary Austrians have stressed, the initial responses of socialists to Mises did not sufficiently engage with the Austrian conceptualization of the market process evident in his calculation argument. It is important to note the nature of these misunderstandings, for recent Austrian contributions suggest that these have been repeated by cybersocialist proposals (Boettke and Candela 2023). These responses from socialist economists such as Oscar Lange (1936) and Henry Dickinson (1939) were inspired by Enrico Barone's formal demonstration that, in a non-market planned economy, socialist planners could, in principle, calculate an efficient plan for producing a given set of target goods (Barone [1908] 1935). Their proposals for non-market planning had a supply side focus. Indeed, both authors envisaged a role for markets in the allocation of consumer goods and labor. Being based upon formal neoclassical models that had gained recent prominence within economics, Barone's model assumed a given set of production functions and factor input constraints. Given these assumptions, he formally defined an efficient allocation of factors of production, from which an equilibrium set of factor prices could be inferred. With reference to this mathematical demonstration, Lange and Dickinson proposed a process through which a socialist planning board could set 'shadow prices' for factors of production. For Dickinson this would be achieved through mathematical calculation, whereas for Lange this would be carried out through an ongoing process of 'trial and error' price adjustments. Their contemporaries, for example Dobb (1937, 274) and Dahl and Lindblom (1963, 211) who understood Mises to have denied the logical, a priori possibility of socialism (Bergson 1948, 445–46; Rothbard 1991, 53–54) heralded these contributions to have successfully refuted Mises' calculation argument. However, from an Austrian perspective such proposals begged the question at issue.

Hayek very explicitly challenges the Barone-inspired models on epistemological grounds. He points to their assumption that anyone could have complete knowledge, not only of the ends of the many individuals across society but also the most efficient possible means of attaining those ends (Hayek 1945; cf. Vaughn 1980; Murrell 1983). More specifically, as Hayek subsequently stresses, the Barone model assumed a given

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[2] For example, Hayek (1978) discusses the epistemological functions of markets in general and it is clear that he views consumer as well as production goods markets as responsive to context-dependent knowledge and preferences of market actors.

set of efficient production functions. Hayek and subsequent commentators stressed that the fundamental epistemological problem facing socialist planners was that they could not obtain such knowledge of efficient production functions in the absence of factor markets.

As Mises put it, "the problem of economic calculation is of economic dynamics: it is no problem of economic statics" (Mises 1936, 139). Hayek was especially explicit in stressing that markets are a highly distributed and dynamic process, capturing and generating the shifting knowledge and preferences of the many locally situated individuals across society (Lavoie 1985). As Hodgson (1998, 441) puts it, socialist proposals overlook the question of "how knowledge is acquired and communicated". Hayek highlights the broad range of context dependent knowledge and expertise, shaped by "circumstances of time and place" through which individuals and firms address economic decisions (Hayek 1945, 80). The exercise and development of such knowledge involves responses to the prices generated by the market process. Hence, processes of knowledge discovery and price formation are inextricably connected. This Austrian position, stressing the epistemological functions of markets, came to be considered unrefuted and has become the prominent, central line of argument in more recent Austrian-inspired contributions to the calculation debate (Boettke 2000; Horwitz 1998; Lavoie 1985).

Economic 'knowledge' yielded by the market process, as Boettke and Candela (2023) suggest following Hayek (1945), can be distinguished from 'information' that can be explicitly formulated independently of the market process. On this conceptualization, economic 'knowledge' of efficient production functions is continually generated and dynamically changes through market processes of economic calculation and discovery (Boettke and Candela 2023). This knowledge, which is integral to processes of choosing production methods as Hayek highlights, is often 'tacit', meaning that it cannot be explicitly articulated or pre-specified. The exercise of such tacit knowledge relates to specific spheres of production, involving economic actors taking locally situated 'on the spot' decisions. Hayek gives the examples of a shipper making locally situated, spontaneous decisions about how to transport products, or the trader earning a living by capitalizing upon local differences in commodity prices, continually responding to changing circumstances (Hayek 1945, 80). Austrian scholars have subsequently stressed that this 'knowledge discovery' argument decisively demonstrates the unfeasibility of socialist planning (Boettke and Candela 2023; Lavoie 1985, 57). The next two sections assess this claim.

This assessment requires careful attention to Mises' distinction between the supply and demand side of the challenges that socialist planners would face. This distinction is also evident in a range of proposals for non-market planning. For example, numerous advocates of non-market planning have proposed institutional arrangements that still include features very similar to markets for consumption goods to capture knowledge about consumers' preferences. Examples of this range from the early models of Lange and Dickinson, through to more recent proposals for cybersocialism. These proposals envisage the role of markets differently with respect to the demand and supply side challenges respectively. Hence the distinction is used to organize our discussion in Sections 3 and 4 below. We assess the implications of the Austrian contributions for the feasibility of both supply side and demand side forms of economic calculation. The approach we adopt also shares the emphasis of recent Austrian-influenced scholarship on the contingencies that affect institutional robustness. The effectiveness of planning for addressing problems of socialist calculation, we argue, involves more contingencies than is acknowledged by Mises and Hayek's formulation of the calculation argument.

## III. SUPPLY SIDE CALCULATION

Since the 1930s calculation debate, researchers on both sides have exhibited different understandings of the supply side problem for socialism, as defined by Mises. As discussed above, the proposals of Mises and Hayek's socialist contemporaries, such as Lange and Dickinson, treated the problem as a computational one. However, Lange (1936, 56–57) in particular did discuss the need for a practical method for carrying out the computation. This is evident in Lange's comment in 1967 about the potential offered by computers, describing markets as "a computing device of the pre-electronic age" (Lange 1967, 158). For the Austrians, such a suggestion that computational techniques for supply-side planning could substitute for the market overlook markets' fundamental, epistemological functions. Before further assessing this objection there is a need to set out how socialist proposals have been further developed since the 1930s Dickinson-Lange models.

The Lange-Dickinson approach can be viewed as having been continued by Leonid Kantorovich (1960, 1965) who devised planning techniques for the Soviet Planning Board. Kantorovich developed and applied linear programming, a mathematical technique for solving constrained

optimization problems. He was concerned with essentially the same optimization problem as Lange and Dickinson, that is to say calculating the factor input requirements for efficiently producing a target set of final goods, given a set of factor input constraints. Like Lange and Dickinson, Kantorovich assumed a given set of production technologies, proposing that a set of shadow prices, which he referred to as *objectively determined valuations* (Kantorovich 1965), could be inferred from the efficient plan that was calculated. In the context of linear programming, shadow prices are the change in the value of the optimized objective function with an incremental change in one of the constraints. These shadow prices can be used to determine the opportunity cost of producing an item.

More recent 'cybersocialist' proposals also approach planning as a computational problem, building upon Kantorovich's work. Of particular significance here are the contributions of Paul Cockshott (2019) whose work demonstrates the applicability of optimal planning algorithms to supply side calculation. He offers insights into how this might not be as computationally complex as one would expect. Klee and Minty (1970) had shown that, in worst case scenarios, the simplex algorithm for solving linear programming problems runs in exponential time, meaning that the time needed to solve the problems scales exponentially with the number of variables. Still, such worst-case scenarios rarely occur and for most practical applications the simplex algorithm can be run in polynomial time and is thus tractable. Cockshott (2019) and Dapprich (2020) both found that the time needed to solve planning problems using the simplex method roughly scales with $n^3$. Cockshott (2019) also tested his own harmony algorithm and suggests that it scales with $n\log(n)$, hence is even faster. While plans have so far only been calculated for test economies with few variables, the author projected that a modern supercomputer could calculate a plan covering five successive planning years for an economy disaggregated to 200 million products in 22 minutes (Cockshott 2019, 314). Cockshott and Cottrell's model evaluates factors of production in terms of Marxist labor values. By contrast, Dapprich's model, like that of Kantorovich, is based upon shadow prices (Dapprich 2022). Dapprich's approach recognizes that shadow prices are a better measure of opportunity cost because they consider constraints, such as limited supplies of natural resources, that cannot be reduced to labor time.

Just as Hayek had argued that Lange and Dickinson's proposals assumed that an efficient set of production functions was known to planners, contemporary Austrian scholars argue that recent cybersocialist

proposals are based on the same flawed assumption (Boettke and Candela 2023; Lambert and Fegley 2023). Hence, Boettke and Candela describe technosocialist proposals as "putting an old wine into an irrelevant new bottle" (Boettke and Candela 2023, 45). The essence of the calculation problem, they contend, concerns "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" (Boettke and Candela 2023, 52; cf. Lambert et al. 2023, 302). Insofar as cybersocialist models presume an efficient set of production methods to be known, they are thus begging the question. The model proposed by Cockshott and Cottrell is indeed sometimes understood to assume a set of production technologies as given (Greenwood 2007b, 431). However, as Dapprich (2022) shows, optimal planning techniques can also start off with a diverse set of technologically feasible production methods. The optimal plan will in the end specify a combination of those production techniques that is economically efficient. Hence, rather than presuming knowledge of efficient production technologies, that knowledge is generated through mathematical optimization. Optimal planning thus does exactly the kind of sorting from technologically feasible to economically viable that Boettke and Candela (2023, 52) demand. Of course, there could be significant limits to the set of technologies specified within such a model. But the technique set out by Dapprich is potentially applicable to a very large set. Furthermore, with the Austrians' emphasis on processes of innovation that generate new technologies, there is more to their argument than this framing of the calculation problem indicates. The question of the potential for incorporating such innovation processes into planning models is discussed further below.

The planning model outlined by Dapprich cannot by itself fully address the Austrian calculation argument. A key limitation is that planning is limited to a relatively abstract level, specifying total outputs and factor inputs at sector level. Location-specific, firm-level plans, of the kind Hayek highlights as necessary, are not provided. Optimizing plans at this level of detail would significantly increase the computational complexity, so might prove difficult even with computationally efficient algorithms and modern computing power. However, optimization techniques for addressing such highly complex problems are continually advancing. Distributed optimization techniques, often based on the use of deep neural networks and evolutionary techniques, have matured and been proven in a range of applications involving highly complex problem-solving. These

include supply chain management, aircraft design, transport system simulations and high-performance visual object recognition systems of the kind used in autonomous vehicles, as well as the 'large language models' used in applications such as ChatGPT (Cui et al. 2018; D'Acierno, Gallo, and Montella 2010; Thomas et al. 2013; Vogels, Karimireddy, and Jaggi 2020). While it remains to be seen whether these techniques are appropriate for the problem of socialist planning, optimization technology is rapidly evolving.

As Austrian scholars point out (Boettke and Candela 2023), the key question for the socialist calculation problem is how production functions and the plan they are used to calculate might be adjusted to changing conditions. Supply side examples of such changing circumstances include shifts in levels of factor supplies and availability affected by a range of variables, from weather conditions to public health, from migration patterns to ecosystem change. At the same time the set of technologically feasible production technologies is constantly progressing. There is potential though for a cybersocialist approach to be used to adjust the plan in the face of such changing conditions. If, as Cockshott (2019, 13) suggests, the time it takes to calculate a new plan is in the order of 22 minutes, this could in principle be done regularly, for example on a daily basis, should conditions change so quickly.[3] The viability of this approach would of course depend on a number of contingent factors such as computational speed and the process through which multiple possible production functions are identified, developed and added to the model.

This leads us to a further question, the vital significance of which is highlighted by Austrian theory (Kirzner 1978), concerning the kind of processes that might facilitate the definition and development of new production methods through innovation in the kind of planned economy envisaged by cybersocialists. Ever since Mises' 1920 article, Austrian contributions have emphasized that non-market planning will inevitably lack any means of guiding the development of new productive methods towards more efficient means of meeting demands for final goods. Market prices play an important epistemological role in the innovation process, as they communicate the cost of various production factors. Entrepreneurs can use price signals as guidance when exploring new and more profitable opportunities to deploy these factors. However, in Austrian

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[3] Greenwood (2007a) also suggests the use of distributed optimization techniques to dynamically address problems of supply-side calculation through a 'virtual factor market.'

terms, shadow prices of the kind yielded by the Dapprich model could, analogously to market prices, communicate information about the cost of various factors, serving as 'aids to the mind' for exploring and developing new, more efficient production techniques. The epistemological functions shadow prices might fulfil include enabling producers to exercise their tacit knowledge and expertise (Greenwood 2007b, 429–30), responding to sectoral and locally situated contexts, in the same way as do economic actors in a market economy. This addresses the epistemological dimension of the calculation argument, for shadow prices can be used to communicate important information about the costs of various goods incurred within different scales and sectors of the economy. This could allow locally situated actors to make use of their specific knowledge of time and place while still considering the wider economic context, such as scarcities and alternative uses for various factors. The possibility of shadow prices fulfilling such a role in a socialist economy is simply not considered by Austrian contributions.

Such a computational approach to planning leaves open the question of the incentives and motivations that might drive locally situated actors to make good use of the information communicated through shadow prices in a non-market system. As computational tools become increasingly able to replace the epistemological functions of the market, we believe that such questions of incentive and motivation will play an increasingly important role in the calculation debate. The proposals for cybersocialism from Cockshott and Dapprich do not directly address the question of the institutional and social processes through which a non-market planning system could foster the kind of non-market processes of innovation discussed above. Wenzel and Phelan (2023) stress that in a private property system, property owners bear the costs, risks, and potential profits of innovation. This encourages investment in promising innovation, but also an appropriate degree of care and deliberate deployment of capital. Incentives could not involve an ownership stake in a socialist enterprise, for such enterprises would be collectively owned. But other material incentives, such as additional access to consumption goods, could still play a role in incentivizing innovation and effective management. The debate might also increasingly focus on whether alternative social norms and practices, the significance of which some socialists have always stressed, could, in combination with the epistemological aids of shadow prices, serve as an adequate substitute for markets.

In summary, this assessment of the debate about supply-side calculation provides significant cause for questioning whether this part of the debate has been settled in the way Austrians suggest. Computational technology, far from being irrelevant to the debate, can address the epistemological aspects of the supply-side calculation problem in three important ways. Firstly, despite the contrary claims of several contemporary Austrian scholars, computational optimization can be used to filter from a set of technologically feasible production techniques those that are economically viable. Secondly, as computational methods and capacities develop, this increases the speed at which these optimizations can be carried out. This is significant, because computational time limits how often production plans can be adjusted to the changing economic conditions, as Austrian scholars frequently highlight. Thirdly, the shadow prices which can be derived from computational optimization encapsulate and communicate important information about wider economic conditions such as scarcity and factor demand. In principle, this could allow local actors to make use of their knowledge of local circumstances when exploring potential innovations, while still considering the wider opportunity costs of various production factors. Hence, the question of the feasibility of socialist calculation hinges far more than Austrians acknowledge upon contingencies about the capacities of computational technologies. Austrian critiques of cybersocialist approaches to supply side calculation do have significant force and have not been fully addressed by cybersocialist proposals. Nonetheless, recent cybersocialist contributions offer scope for questioning Boettke and Leeson's defense of the Austrian case that socialist economic calculation is impossible on epistemological grounds alone. This points to the need for further research exploring the institutional contexts needed for supply side calculation. This 'state of the debate' regarding supply side calculation also provides an important context for assessing the 'demand side' debate, as further set out below.

## IV. THE DEMAND SIDE QUESTION

As explained above, Mises originally formulated the socialist calculation problem as an essentially supply-side one. For, his argument started from the assumption that a benevolent socialist planning board has established a target set of final goods that reflects the priorities of society. Mises understood socialism as essentially a system where production is planned without markets for factors of production (Steele 1992, 4). This definition

of socialism left open important questions about the 'demand side' problem, including the question of the role and scope of final goods markets. As both Mises and Hayek stressed during the years that followed Mises' initial 1920 article, the profound complexities involved in non-market planning become greatly exacerbated once this demand side problem is considered. Here again, addressing this question involves a significant epistemological challenge, given the highly complex, context dependent and pluralistic character of the needs and preferences of individuals across society.

Given the apparent significance of rapid technological progress for addressing supply side calculation, the 'demand side' challenge for socialist proposals would seem to take on ever greater significance in debates about the overall feasibility and desirability of socialism. It is interesting to note that some recent Austrian authors' articulations of the calculation problem give greater prominence to the demand side question than does Mises' original 1920 article. For example, the thrust of the critique of Dapprich and Cockshott by Lambert and Fegley is to emphasize that socialist proposals for selecting technically feasible production methods would not adequately reflect consumer valuations of the final goods produced (Lambert et al. 2023). Likewise, Boettke and Candela comment that "what remains unresolved in Dapprich and Cockshott's model is the question of how consumer preferences become discovered under dynamic conditions" (Lambert et al. 2023, 303).

Reflections by socialists and their critics about the feasibility of addressing the 'demand side' problem for socialism will perhaps inevitably reflect contrasting normative views about the appropriate weight to place upon individual choice, or 'consumer sovereignty,' and the appropriate responses to the inequalities that can arise in economies where goods and services are distributed through labor and consumer goods markets. The problem can be formulated in different ways. Arguments in an Austrian vein stress the potentially infinite range of individual demands for consumer goods, as in Robert Murphy's contribution (Murphy 2006). Murphy concludes that the problem of demand side calculation is 'hyper-computational,' hence insoluble. He proposes that, in attempting to formulate the 'target set' of final goods, the planners would not only have to consider already invented products, but also an uncountably infinite number of potential future products, including vacations to Mars which are not offered at this time. It might indeed be true that computation with that many variables would be practically unfeasible, even if not theoretically

impossible, as Murphy suggests. However, the demand side question does not necessarily have to be formulated in this way. As Cottrell et al. (2009) point out, a decentralized market system could not consider an infinite number of products either. There is a finite number of entrepreneurs who each could only consider a finite number of potential product innovations. Similarly, a socialist society might limit their consideration to products which are likely to be feasible, say, in the next couple of years, which could serve as a reasonable basis for planning.[4]

The number of possible final products that it would be necessary for socialist planners to consider is also shaped by the wider institutional context and political processes through which output targets are established. Detailed consideration of such political processes within a post-capitalist society is beyond the scope of this paper. However, we can note that socialist proposals generally emphasize the importance of public goods and the range of products that might not be for individual consumption. Hence, they tend to envisage the scope of final goods markets as being more limited than in market-based capitalist economies. In this context, there are a range of institutional processes through which the objectives of planned non-market economies might incorporate a democratic sensitivity to the variety of individual needs and preferences of the population (Greenwood 2008).

Nonetheless, socialists often allow a role for some form of market for individual consumption goods. Dickinson (1939), for example, viewed them as necessary for ensuring efficient distribution. Where such final goods markets are envisaged, a further question concerns how purchasing power within this market would be allocated to individuals across society. The various responses from socialists to this question reflect contrasting views about distributive justice and how to most effectively address the nature of the motivational challenges that socialist systems face. Cybersocialists have also adopted mechanisms that closely resemble consumer goods markets into their systems (Cockshott and Cottrell 1993; Dapprich 2022, 2023). Dapprich (2023) proposes the use of non-circulating tokens as an alternative to money to distribute consumer goods.

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[4] The answer Murphy gives has much more to do with the Austrian theory of innovation than the computational complexity of planning. According to Murphy, if planners were to limit the considered potential products, they would inhibit innovation. Innovation would be limited to what the planners (rather than individual entrepreneurs) can imagine. However, there is no reason engineers might not work on innovative products that have not yet been considered by planners. Planners might precisely begin to consider them because of recent breakthroughs in production methods.

Unlike the labor vouchers proposed by previous generations of socialists, the token prices of goods would continuously be adjusted through trial-and-error to approximate market clearing rates. The trial-and-error process consists of continuously adjusting prices up and down based on an observed mismatch between supply and demand. As subjective consumer preferences evolve over time, this will become apparent in the demand for various products, which will ultimately be reflected in prices. Contrary to the claim of Boettke and Candela, cybersocialist models thus already contain a mechanism for capturing dispersed consumer preferences, thereby directly addressing the epistemological challenge on the demand side.

Fully resolving the demand side calculation problem requires a mechanism which ensures that the consumer valuations captured by token prices will also be reflected in production targets. For this purpose, Cockshott and Cottrell (1993) proposed a double control loop through which the plan target is continually adapted to consumer demand. In the first control loop, the token prices of final goods are continuously adjusted to approximate the market clearing rates at which demand matches supply as described above. Should demand for a good exceed its supply, its price must be increased. Should demand be below supply, the price must be reduced. In the next step, the approximated market clearing rates of each item are compared to the cost of producing it. Cockshott and Cottrell (1993) use labor values as a measure of cost, while Dapprich (2022) uses shadow prices instead. If the relative price of an item, for example an apple, is above the relative cost of producing it, then the plan target entry for the item will be increased. If it is below cost, then the plan target entry will be decreased. This is meant to ensure that consumer preferences, as indicated by price signals, are reflected in the proportions of produced goods. The double control loop is also a way of dealing with the dynamic nature of consumer preferences emphasized by Austrian theory. As preferences change, so will prices and thus ultimately production targets.

A problem for such proposed control feedback loops is that recent consumer demand is assumed to be indicative of demand in the near future. Targets for future production are adapted based on recently observed consumer demand. So, while this model does not ignore change, it still assumes that demand in the near future will be close to current demand. Dapprich and Cockshott (2023) and Grünberg (2023) suggest that better results can be achieved by anticipating future demand through forecasting techniques. One method that might be used for this is

machine learning. Machine learning algorithms use past data to make predictions about future observations. By analyzing past consumption patterns the algorithm might in principle be able to make improved predictions about what consumers will demand in the future. It is important to emphasize that neither markets, not feedback control loops, nor machine learning will be able to perfectly predict future consumer demand due to the significant uncertainties involved. However, cybersocialists can argue that feedback control loops and forecasting techniques might serve as a way of adjusting production in the right direction, while being reflective of expressed consumer preferences, much in the same way as the market mechanism in Austrian theory. The knowledge generated about consumer demand could also inform processes of innovation of the kind discussed in Section 3 above.

The different possible ways of framing and addressing demand side calculation serve to highlight that, like the supply side problem, the demand problem is ripe for further research. The calculation debate itself can be viewed as having shifted to a stronger focus on demand-side questions, perhaps indicating Austrian theorists' realization that a purely supply-side focus is insufficient to challenge the feasibility of socialism. The discussion above shows significant potential for responding to the Austrian conceptualization of these questions on their own terms, developing alternative means of fulfilling the epistemological functions that the Austrians hold can only be fulfilled by market prices.

## V. CONCLUSION: THE 'PRESENT STATE' OF THE DEBATE AND ITS FUTURE TRAJECTORY

The calculation debate is treated by Austrian-influenced scholars as having been firmly settled in favor of their view that a planned economy in the absence of markets is not feasible. According to the Austrian position, recent proposals for cybersocialism overlook the fundamentally epistemological problems faced by non-market planning, however far computational techniques and technology might advance. The need highlighted by the Austrians for mechanisms to guide economic decision-making in the face of complex inter-relationships and trade-offs is a vital one. However, rapidly advancing computational methods can be used to generate shadow prices that offer significant potential for fulfilling the epistemological functions of encapsulating and enabling the discovery of knowledge. This potential can be understood in terms analogous to

Austrian market process theory, suggesting the possibility of an *immanent critique* of the Austrian case against socialism.

Mises' initial articulation of the calculation problem had a supply side focus. However, as computational capacity for addressing supply side calculation can be expected to continually advance, the debate about the feasibility of socialism might shift to become more concerned with demand side questions. Indeed, while recent Austrian scholarship has highlighted the fundamental importance of epistemological problems for non-market planning, advances in computational capacity might lead to a shift of attention back to the questions of motivation and incentives that were secondary in Mises' original calculation argument. Rather than seeking to fundamentally challenge the heterodox foundation of Austrian political economy in philosophical terms, we suggest that our position is actually more in keeping with these foundations than that of Boettke and Leeson who suggest that Mises has successfully demonstrated the impossibility of socialism on a priori grounds. Recent Austrian-informed scholarship emphasizes the contingencies involved in analyzing institutional robustness and the importance of the institutional and social contexts within which economic decision-making takes place (Aligica, Boettke, and Tarko 2019, Pennington 2013). There is an important need for future research further exploring the calculation problem in a way that exhibits these hallmarks of Austrian scholarship.

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