

From alienated instrument to revolutionary potential: a preliminary study of the early machine theory of Marx and Engels

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Abstract. The early machine theory of Marx and Engels re-examines the dialectical role of machinery in capitalist production, elucidates its revolutionary potential, and lays the theoretical groundwork for the systematization of Marx's later reflections on machinery. First, it reveals how machinery is transformed from a means of labor into an alienated instrument. Under the domination of capital's logic, machinery becomes a value-extracting apparatus that absorbs living labor; through the factory system, it restructures the spatiotemporal order of labor, reducing workers from subjects of labor to mere living components of the machine. Second, it analyzes the internal contradictions embedded in machinery. Although machinery, as the engine of productive-force revolutions, intensifies exploitation by raising the rate of relative surplus value, it simultaneously displaces living labor, thereby shrinking variable capital and lowering the rate of profit. At a deeper level, it exacerbates the antagonistic conflict between the socialization of production and private ownership, planting the seeds of a revolutionary self-negation. Finally, it explores the practical pathways through which machinery's revolutionary potential may be realized. Only by transforming ownership—turning machinery from capital's property into the common means of production of associated workers—can technological alienation be overcome and labor ultimately be elevated from a mere means of subsistence to “life's prime need.” The core concern of the early machine theory of Marx and Engels lies in exposing the logic of domination inherent in capitalist relations of production rather than critiquing machinery itself. This critical perspective is foundational for decoding the paradoxes of artificial intelligence in the digital-intelligent era.

Keywords: Marx, alienated instrument, system of machinery, logic of capital, revolutionary potential

1. Introduction

Since the Industrial Revolution, machinery has symbolized both humanity's liberation from natural constraints and the cold instrument of class oppression. The dual nature of machinery's application became the starting point of the early technological critique by Marx and Engels. Drawing on Marx's early works—*Economic and Philosophic Manuscripts of 1844* and *The Poverty of Philosophy*—as well as Engels's *Outlines of a Critique of Political Economy* and *The Condition of the Working Class in England*, this paper offers a preliminary exploration of the internal mechanism through which machinery shifts “from alienated instrument to revolutionary potential,” aiming to highlight the contemporary significance of Marx and Engels's early reflections on machines.

2. Machine alienation under capitalist relations of production

The transition from tool-based production to machine-based production intensified four dimensions of workers' alienation—from their labor products, their labor process, their species-being, and their social relations. Labor products thereby become an external, dominating force over the workers themselves, while workers are degraded into mere appendages of the machine. In this reversal, the fundamental relationship between humans and machines is overturned. Machinery functions not only as a gauge of labor development marking humanity's entry into the age of large-scale machine industry, but also as an indicator of the complex network of production relations in bourgeois society [1]. Naturally, the alienating effects of machinery do not arise from technology itself; they are the inevitable result of capitalist relations of production. Machines do not inherently oppress or dominate workers. Rather, capital transforms machinery into an instrument of exploitation, extending surplus labor time and intensifying labor in order to realize capital's self-expansion.

The formation of the early machine theory of Marx and Engels was heavily influenced by Engels, who focused primarily on the domination and oppression machines exerted on workers—an emphasis that would set the overall tone for their early reflections on machinery. Born into a bourgeois family, Engels became exposed early to issues surrounding machine production. In his early writings, he affirmed the historical role of machinery while sharply criticizing the unprecedented oppression it imposed on workers. In *Outlines of a Critique of Political Economy*, Engels observed: “The self-acting mule... by doubling the amount of machine labor and thereby reducing manual labor by one half, rendered half of the workers unemployed and lowered the wages of the other half. This invention broke the resistance of the workers against the factory owners and destroyed the last remnant of strength that labor had possessed in its unequal struggle with capital.” [2]85 The widespread use of machines appears, at first glance, to have liberated workers to some extent, but this is illusory. The rise in productivity brought by machinery does not reduce labor intensity; instead, it generates mass unemployment. The self-acting mule doubled labor efficiency and simultaneously halved the number of workers needed, leaving half the workforce unemployed. Moreover, the remaining half stayed only by accepting wage cuts imposed by capitalists; if they refused, unemployed workers would quickly take their place. The hardship of survival crushed workers’ resolve. Those dismissed were forced into new industries, and when these became saturated, new industries had to emerge. Throughout this process, capitalists grew ever stronger while workers’ power steadily diminished. Although machinery could reduce physical labor intensity, under capitalist relations it is alienated into an instrument used by capitalists to manipulate and discipline workers. Under capitalist private ownership, the human-machine relationship is severed from its original object-mediated character; combined with the factory system’s relentless extraction of surplus value, the relationship is pushed into an absolutely antagonistic condition. The two are thus plunged into a sharp state of alienated contradiction [3]. Engels not only analyzed how machines became alienated instruments that oppress workers, but also demonstrated that machinery functions in essence as a tool through which capitalists exploit labor.

Influenced by Engels and others, Marx turned to political economy in 1844 and compiled the famous *Economic and Philosophic Manuscripts of 1844*. There, Marx employed the theory of labor alienation to analyze and critique the negative consequences of machinery’s capitalist application. Marx noted: “The transition from complex manual labor to the next stage requires that this labor be broken down into a number of simple operations. Initially, only a portion of these monotonously repeated operations is taken over by the machine, while another portion is performed by the worker. As both the nature of the matter and unified experience show, such uninterrupted, monotonous activity is equally harmful to the mind and to the body.” [1] 126 The high intensity and mind-numbing monotony of such labor caused workers to “flee from work as they would from the plague” [1]. 159 Yet the ambitions of capitalists extended far beyond this. To further reduce labor costs, they increasingly employed women and children, which sharply raised mortality rates within factories. Marx thus further analyzed the “complete domination of dead matter over human beings” [1]. 152 He argued that it is not actual, physical machines that dominate people, but machines that have become alienated—machines appropriated by capital. Capitalists are the masters of all machinery; thus, machines become powerful weapons with which they exploit and oppress workers. Marx wrote: “The capitalist can most easily and most cheaply appropriate the labor-power of the lower classes, even of children, in order to use up this labor-power in place of mechanical means; and it is precisely this state of affairs that hinders the rapid progress of machinery.” [1] 126 Marx insightfully recognized that the root of machinery’s domination over human beings lies in its capitalist mode of application. Machine domination is, in essence, the domination of workers by capitalists. Machinery could, through continuous innovation, reduce the amount of monotonous labor required of workers; yet capitalists prefer employing child labor rather than bearing the costs of technological development. The mechanism of capital accumulation and the advance of machinery are inherently contradictory. Although capital seems to favor constant technological innovation to expand production, such innovation—once it reaches a certain threshold—encounters resistance from the capitalist himself. Whether capital chooses to update machinery depends solely on whether doing so can yield excess monopoly profits from technological advantages.

3. The dialectical tension between technological innovation and social transformation

The productive revolution brought about by machinery contains within itself the potential for social transformation. By integrating labor tools into a systematic whole and mobilizing natural forces, machinery represents a revolutionary power through which human beings transcend the inherent limits of manual labor and significantly enhance the efficiency of material production. Marx provided a comprehensive account of the developmental stages of machinery: “simple tools; the accumulation of tools; composite tools; composite tools set in motion by human beings alone, and then by natural forces; machines; a system of machines driven by a single motor; a system of machines driven by an automatic engine.” [1] 626 Yet under capitalist relations of production, machinery is systematically distorted into an instrument for intensifying exploitation. Capitalists use machines to raise labor productivity, thereby shortening necessary labor time and extracting greater amounts of relative surplus value. At the same time, however, they extend absolute labor time and heighten labor intensity, further reducing workers to appendages of the machine. Once introduced into production as means of labor, machines replace workers as the dominant agents of the labor process [4]. The logic of technology—aimed at increasing efficiency—is thus alienated by the logic of capital into a means of oppressive domination. Machinery, which contains the possibility of becoming a liberating force, is transformed

into an alienated device that consolidates capitalist domination. Ultimately, the productive revolution set in motion by machinery will inevitably outgrow the narrow confines of capitalist relations of production. Marx observed: “Every major advance in machinery intensifies the division of labor, and every intensification of the division of labor likewise leads to new mechanical inventions.” [1] 627 The application of machinery creates new forms of division of labor, while these new divisions require production on an ever-larger scale. When the socialization of production surpasses the structural limits of capitalism, the conditions for social revolution will mature.

The central contradiction of machinery in the production of surplus value is rooted in the internal negativity embedded within the dynamic changes in the organic composition of capital. Although machinery does not create value, it is the principal weapon for producing relative surplus value. By drastically increasing productivity and shortening necessary labor time, machinery continuously raises the rate of surplus value. Yet this advance harbors a fatal contradiction: machinery displaces workers and reduces variable capital (v). Even if the rate of surplus value (m') rises, the total mass of surplus value (m) may decline. To offset this loss, capitalists further extend the working day and suppress wages, intensifying class antagonisms. The root of this contradiction lies in the rising organic composition of capital (the increasing c/v ratio). As machinery—embodying constant capital (c)—crowds out variable capital (v), it lays the groundwork for declining profit rates and cyclical crises. Precisely because of this antagonistic contradiction, machinery transforms from a tool of capital accumulation into a mechanism that undermines the very foundation of the capitalist system. As the material bearer of constant capital, machinery can reduce the value of labor-power and significantly raise the rate of surplus value. Yet at the same time it shrinks the scale of variable capital by excluding living labor. This dual movement triggers a systemic tendency for the rate of profit to fall, since the rising share of constant capital erodes the very source of surplus value—living labor. At a deeper level, machinery propels a degree of socialized production fundamentally incompatible with capitalist private property. It objectively demands cooperation and planning on a social scale, yet its results are privately appropriated by individual capitalists. This contradiction reflects the clash between the development of productive forces and the capitalist relations of production. It is precisely this antagonistic tension that enables the capitalist application of machinery to build the material foundation for a higher social form, while simultaneously nurturing the revolutionary forces that will overturn its own conditions of existence.

The revolutionary potential inherent in the machinery system ultimately lies in its reorganization of the social form of labor, providing the historical preconditions for overcoming alienation and realizing human emancipation. Large-scale machine industry forcibly integrates dispersed individual workers into a highly coordinated proletariat. This new form of socialized labor objectively trains the organizational discipline of the working class and lays the material foundation for the emergence of class consciousness. Engels made explicit the view that machine production gave rise to the proletariat. In *The Condition of England in the Eighteenth Century*, he wrote: “The most important result produced in eighteenth-century England... was the emergence of the proletariat through the industrial revolution.” [1] 87 Under the impact of machinery, the social gap between rich and poor widened, and former intermediate strata gradually fused and polarized into two opposing classes: the proletariat and the bourgeoisie. More importantly, rising labor productivity made possible by machinery compresses socially necessary labor time and expands free disposable time, creating the material conditions for the free and all-round development of individuals. Yet capitalist relations suffocate this potential, transforming what could have been liberating free time into the threat of unemployment and the misery of a relatively surplus population. In practice, the labor time of workers under the machine system has not been shortened; rather, it has become even longer than that of so-called “barbarian” societies or eras of simple, primitive tools. Because this potential is completely confined within capitalist relations, workers’ free time is transformed into surplus labor time and becomes the very space from which capital extracts additional surplus value.

Marx emphasized that modern science and the automated machinery it produces are always “variables”—in constant revolutionary movement [5]. Only through revolution—through transforming the means of production into the common property of associated workers—can human beings cease to be appendages of the machine and become its masters. Only then can labor be elevated from a mere means of survival to “life’s prime want,” completing the dialectical transition from alienation to liberation and achieving humanity’s historic leap from the “realm of necessity” to the “realm of freedom.”

4. The revolutionary potential of machines and its conditions for realization

The capitalist application of machinery fundamentally suppresses its revolutionary potential; therefore, unleashing the productive capacities of machines requires freeing them from the constraints of capitalist relations of production. In the *Economic and Philosophic Manuscripts* of 1844, Marx noted: “Even under the most favorable conditions for the worker, his ultimate fate is overwork and premature death, becoming a machine, a slave of capital.” [1] 121 Large-scale machine production, which ought to serve as a lever for freeing humanity from the compulsion of necessary labor, instead reduces workers to slaves of capital. Even so, machinery does shorten socially necessary labor time by replacing human labor with natural forces, thereby creating the material preconditions for the “realm of freedom.” This emancipatory potential should have been translated into temporal and spatial conditions for the free development of all members of society. Yet capitalist relations of production completely distort this logic: capital alienates machines into instruments of value expansion. Through the machinery system, capital deliberately

produces a relative surplus population. The industrial reserve army generated by machines' displacement of living labor transforms free time into a source of unemployment anxiety, forcing workers to submit to harsher exploitation in order to survive. Capital further converts leisure—originally belonging to the sphere of free development—into a domain of commodity consumption, turning human emancipation into market dependence. Under the factory regime dominated by capital, the high-speed operation of machines compels workers to strain their bodies to match mechanical rhythms, generating a paradox in which labor time is shortened while suffering multiplies. The root of this distortion lies in the domination of living labor by dead labor: machines, the crystallization of past labor that should serve human liberation, are endowed by capital with the authority to oppress. Marx did not simply carry forward the early modern conception of machinery; instead, he exposed the illusory nature of both “machine omnipotence” and “machine-based emancipation.” [6] Only by breaking the privatized enclosure of technological ownership and transforming machines from the “machines of masters” into the “machines of a free association of producers” can free time truly become the sphere for the development of creative activities such as art and science.

Machinery also stimulates the awakening of class consciousness. The compulsory cooperation found in machine factories presents a dual character in the early machine theories of Marx and Engels: it is at once a site where alienation deepens and a crucible in which revolutionary subjects are forged. On the one hand, the factory system degrades workers into “conscious appendages” of machines; the assembly line fragments the integrity of labor and strips individuals of the creative dimension of their species-being. On the other hand, this oppressive integration unexpectedly gives rise to a new class—the proletariat. Marx and Engels observed that machine production inflicts physical torment while simultaneously cultivating the revolutionary aptitudes of the working class. For them, the proletariat is the unity of the greatest victim of alienation and the only agent capable of overcoming it. The capitalist use of machinery expands the proletariat, and the broadening of social interaction creates conditions for the international unity of workers. Lukács later deepened this insight in *History and Class Consciousness*: once workers recognize themselves as the bearers of the loss of totality, they may advance from economic struggle to political revolution. It is crucial to note that the early machine theories of Marx and Engels already transcend technological determinism. Machinery does not automatically produce revolutionary consciousness; it must be activated through class struggle, transforming the class “in itself” into a class “for itself.”

The fundamental path to overcoming machine alienation lies in reconstructing the social form of technology through a revolution in property relations. To reform machinery itself without overturning the property relations that sustain it is merely to replace one set of chains with another. The communist redemption of machinery requires a threefold transformation. First, ownership must be transformed: machines must be converted from alienated property standing in opposition to living labor into the common means of production of associated workers. This is not the state monopolization found in the Soviet model but a genuinely socialized ownership in which all workers collectively possess the means of production, ensuring that technological applications serve the needs of the “free association of producers” rather than those of capital accumulation. Second, the logic of capital must be overturned. The application of machinery should shift from extracting surplus value to promoting each individual's free and comprehensive development—for example, deploying automation to eliminate dangerous forms of work rather than merely to increase profits. Third, technological knowledge must be democratized. The capitalist monopoly over scientific knowledge must be broken so that workers can rise from mere mechanical operators to technical understanders and participants in innovation. It is noteworthy that the early writings of Marx and Engels already contain the seeds of “technological democratization,” implicitly embedded within their critique of capitalist political economy. These ideas later laid the groundwork for the development of Marx's mature machine theory. As the objectification of human essential powers, technology should serve the overall needs of the social community rather than the monopolistic interests of private capital. This embryonic vision of “technological democratization” is neither technological determinism nor reformism; it presupposes a revolutionary transformation of property relations and a reconstruction of social relations.

In essence, the liberating power of machinery arises not from technological progress itself but from humanity's collective control over relations of production. Whatever “intentions” capital may appear to possess, it generates disposable time as a driving force of historical development; but once it becomes an obstacle to that development, it is destined to vanish. Only when the proletariat, through revolutionary practice, transforms the factory from a “fortress of capital” into a “laboratory of liberation” can machinery truly return to its nature as humanity's inorganic body and achieve a dialectical reconciliation between technology and human essence within the “free association of producers.”

5. Conclusion

Marx and Engels had already begun, in their early writings, to address the problem of the capitalist application of machinery. They observed how capital alienates machines into disciplinary devices that regulate and control workers: through factory discipline and the cult of efficiency, workers' bodies are subordinated to mechanical rhythms and their minds to the fetishism of commodities. This thoroughly overturns the subject-object relation in which humans should guide technology. Thus, Marx's theoretical task was to undertake a dual critique—philosophical and economic—so as to grasp the essence of modern conceptions of machinery while simultaneously transcending the capitalist machine perspective through a critique of modern

capital [7]. Through his dialectical analysis of the capitalist use of machines, Marx recognized that although machinery integrates tools into mechanical systems, unleashes the powers of nature, and advances productivity, the resulting changes in capital's organic composition introduce systemic contradictions within capitalism: the shrinking of variable capital, declining profit rates, and recurring economic crises. At a deeper level, the socialization of production fostered by machinery stands in fundamental contradiction to capitalist private property. It is precisely this contradiction that transforms machines from instruments of capital accumulation into revolutionary forces capable of undermining the capitalist system itself. The revolutionary potential contained in machinery constitutes a driving force for profound social transformation. From the machines of the Industrial Revolution to today's artificial intelligence, the trend toward technological automation could have created ever more free time. Yet under the logic of capital, this potential has instead been alienated into a tool for value expansion. Marx and Engels placed their hope for unlocking the liberatory potential of machines in the revolutionary action of the proletariat and in the abolition of private property, so that working people may truly become "masters of the machine," and the abundant wealth generated by machine production may genuinely be shared by all.

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