

Analysis of the process of labour value creation in the digital economy from the perspective of Marxian political economy

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Abstract

Purpose – This study aims to analyze the value creation process of the digital economy.

Design/methodology/approach – Drawing on Karl Marx's theoretical analysis of labour value creation in the industrial economy, labour value creation in the digital economy can be divided into two aspects: value transfer from digital means of production and value creation by digital living labour.

Findings – In contrast to the process of labour value creation within the context of an industrial economy, the creation of value through digital labour entails the combination of digital labourers with digitalised means of production, unifying both the generation of new value by digital living labour and the transfer of value from the means of production.

Research limitations/implications – In the process of value transfer involving digital means of production within digital value creation, the substitution effect generated by data—as a pivotal means of production—significantly enhances labour collaboration and production efficiency. In the digital transformation of labour, which originates from the platformisation of labour organisation and the diversification of working modes, multiple forms of invisible surplus value are realised through digitalised division of labour and collaboration.

Originality/value – Karl Marx's incisive examination of the process of labour value creation in the industrial economy provides fundamental research methodologies and theoretical foundations for our examination of labour value creation in the digital economy. Digital labour has undergone profound transformations across multiple dimensions—such as the instruments of labour, the objects of labour, the modes of work, organisational structures, and the ultimate outcomes of production. These shifts are bound to impact the relations of production in the digital economy era, thereby necessitating theoretical interpretation and foundation within the framework of Marxist political economy.

Keywords Value creation, Digital labour, Digital means of production, Marxian political economy

Paper type Research article

1. Introduction

The digital economy, which utilises digital information and knowledge as production factors and relies on information networks as its carrier, has profoundly transformed the fundamental elements of productive forces. This transformation has led to the emergence of digitalised labourers and digitalised means of production. Consequently, it has shaped a new process of creating labour value in the digital sphere, while simultaneously driving changes in digitalised production relations and generating novel challenges in the realm of production relations. Karl Marx's incisive examination of the process of labour value creation in the industrial economy provides fundamental research methodologies and theoretical foundations for our examination



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of labour value creation in the digital economy. Applying his theory of the twofold character of labour, Marx dissected the general labour process of commodity production within a commodity economy, pointing out that value originates from abstract labour, whose essence is “a mere congelation of homogeneous human labour” (Marx, 2018, p. 51). On this foundation, he incorporated the means of production into his framework, offering an in-depth examination of the two aspects of labour-value creation in the era of large-scale machine industry under capitalism: the transfer of pre-existing value from the means of production and the creation of new value by living labour. Marx’s analysis further revealed phenomena at the level of production relations inherent in the labour-value creation process, such as the alienation of technology and the one-sidedness of labour. Moreover, he emphasised that the capitalist reproduction process not only generates commodities and surplus-value but also produces and reproduces the capital-relation itself.

In contrast to the process of labour value creation within the context of an industrial economy, the creation of value through digital labour entails the combination of digital labourers with digitalised means of production, unifying both the generation of new value by digital living labour and the transfer of value from the means of production. Also, digital labour has undergone profound transformations across multiple dimensions—such as the instruments of labour, the objects of labour, the modes of work, organisational structures, and the ultimate outcomes of production. These shifts are bound to impact the relations of production in the digital economy era, thereby necessitating theoretical interpretation and foundation within the framework of Marxist political economy.

2. Value transfer by digital means of production

Means of labour represent a key indicator that reflects the development of productive forces. Marx (2018, p. 210) observed, “It is not the articles made, but how they are made, and by what instruments, that enables us to distinguish different economic epochs.” In the digital economy, data presented in the form of bits can directly function as the subject of labour, and it can also act as a major component of the means of labour, such as software programmes and platform algorithms. Therefore, broadly speaking, data itself constitutes a critical means of production in the digital economy. It not only drives the digitalisation, intellectualisation, and virtualisation of other physical means of production but also substitutes traditional physical means of production during value transfer.

2.1 *Two forms of value of data as a critical digital means of production*

Marx analysed the transformation of value transfer processes from means of production resulting from the widespread application of science and technology in machinery during the era of industrial capitalism, providing a profound exposition of the historical development of capitalist productive forces. “In manufacture, the revolution in the mode of production begins with the labour-power, in modern industry it begins with the instruments of labour” (Marx, 2018, p. 427). Prior to the emergence of the large-scale machine industry under capitalism, value creation in the stage of simple cooperation was dominated by labour-power. The simple tools used by humans functioned as organic extensions of the body, while the labour process was orchestrated through collaborative human effort. The emergence of the division of labour merely advanced the labour process to the stage of manufacture, which remained predominantly reliant on human cooperation. During the phase of the large-scale machine industry, progress in science and technology transformed the tools of manufacture into extensive and intricate machine systems. Machinery, as a “productive force which has been produced” (Marx, 2009a, p. 280), supplanted the dominant role of human labour. By employing its characteristic machine-based means of production, large-scale industry incorporated immense natural forces and scientific knowledge into the production process, significantly enhancing labour productivity, which led to an increase in the relative portion of

value transferred, while reducing its absolute magnitude. The labour required to produce machinery is less than the labour it replaces, thereby lowering the cost of commodities. This exemplifies the unique advancement in productive forces resulting from large-scale machine production, where the most distinctive feature of the machine system is its contraction of the production sphere and living labour in spatial terms, while simultaneously expanding the scale of production and the scope of labour, thus maximising the “collective power” generated through cooperation.

Compared to the physical means of production characteristic of the industrial economy, data, as the pivotal means of production in the digital era, exists in bit form. This development marks an unprecedented trend towards the digitisation and virtualisation of productive assets, giving rise to digitalised means of production, wherein data emerges as the most paradigmatic and crucial form. More specifically, in the production process, digital means of production encompass both physical digital means derived from the digital transformation of traditional physical means of production, and new types of non-physical digital means of production. Physical digital means of production primarily refer to digital technology applications and the tangible components that serve as data carriers. This includes not only land, machinery, factories, and consumable raw materials that have undergone intelligent and digital transformation, but also digitalised products of labour presented in physical forms, such as electronic hardware facilities. Non-physical digital means of production, on the other hand, mainly consist of data-based means of production represented by data flows. These are manifested in virtual forms, such as data code, graphics, text, audio, and video, making them the most typical and critical means of production in the digital economy era.

As a means of production, data manifests primarily in two forms during the production process: First, data in its natural form. First, data in its natural form. This refers to data generated through private social activities such as consumption or entertainment, which leaves natural digital footprints on the internet without traces of human labour processing. Such data is produced by self-sufficient labour not intended for exchange. Although it possesses use-value, it lacks exchange-value and value. Closer to natural raw materials among the means of production, it exhibits a zero-value characteristic. Second, data in its commodity form. This denotes natural-form data serving as the object of labour, processed by workers using digital technologies embedded in software and hardware carriers. It results from non-self-sufficient productive labour aimed at exchange and embodies undifferentiated human labour. As a means of production, such data also functions as a data commodity, possessing both value and use-value. The fundamental difference between the two lies in the fact that the so-called “prosumer labour,” “play labour,” and “audience labour” that produce nature-form data are not labour in the Marxian sense because they cannot create value, let alone produce commodities with two factors. They do not belong to digital labour. The labour that produces commodity-form data is labour that can create value and surplus-value, and it therefore falls into the category of digital labour.

2.2 Substitution effect of data as a means of production in the transfer of value

In the industrial economy, the development of machinery systems had a substantial impact on the process and outcomes of value transfer from means of production. Marx (2018, p. 239) noted, “In the labour-process the means of production transfer their value to the product only as far as along with their use-value they lose also their exchange-value. They give up to the product that value alone which they themselves lose as a means of production. The maximum loss of value that they can suffer in the process is plainly limited by the amount of the original value with which they came into the process.” In the process of value transfer, machinery enters the production process in its entirety, yet transfers its value only partially. Its use-value gradually diminishes as it contributes to the creation of new products, while its intrinsic value is transferred incrementally to new labour products through depreciation. Regarding the outcome of this transfer, machinery—as a distinctive instrument of labour in large-scale

industry—"instead of being cheapened, the product is made dearer in proportion to the value of the machine" (Marx, 2018, p. 444). Furthermore, "the extent to which this latter value makes the product dearer, depends in the first instance, upon the size of the product" (Marx, 2018, p. 446). Secondly, it also depends on the value of the machine itself. "The less labour it contains, the less value it imparts to the product. The less value it gives up, so much the more productive it is, and so much the more its services approximate to those of natural forces" (Marx, 2018, pp. 447–448). The use of machinery is constrained by the proportion between the amount of value it can transfer and the quantity of living labour it replaces. This principle is encapsulated in the formulation that "less labour must be expended in producing the machinery than is displaced by the employment of that machinery" (Marx, 2018, p. 451). Furthermore, a larger disparity between the value of the machine and the value of the labour-power it supplants implies that the machinery tends to displace a greater amount of human labour. Consequently, this leads to a reduction in the cost of commodities and a decrease in the wages of workers.

In the specific process of value transfer of digital means of production, data—as a non-physical digital means of production—brings about significant transformative changes to the value transfer process within the means of production by replacing certain traditional physical means of production. Moreover, this substitution effect also directly or indirectly affects labourers themselves. The substitution effect arising from data as a means of production during the labour process can be examined from the perspective of two forms of data.

First, in its natural form, data exists as a natural entity possessing no value and thus transfers no value to the product. When data in this form substitutes for the original physical means of production, the constant capital (C) in the formula $W = C + V + M$ can be decomposed into two components: the substitutable physical means of production (C_1), which can be substituted by data (C_d) as a means of production, and the non-substitutable physical means of production (C_2), i.e. $C = C_1 + C_2$. Given that C_1 is substituted by C_d , and that the value of C_d is zero, the value of C is determined completely by C_2 . Consequently, the objectified value in the post-substitution constant capital C is necessarily less than that in the original constant capital, resulting in a decrease in the total value transferred by the means of production.

Second, in its commodity form as a means of production, data is the data commodity processed through human labour, possessing value that can be measured by socially necessary labour time. Similarly, within the formula $W = C + V + M$, the value of data as a means of production (C_d) is not zero, and its substitution effect on physical means of production (C_1) can be expressed as $C_d - C_1$. There are two scenarios here. When $C_d > C_1$, $C_d - C_1 > 0$, indicating that the substitution effect of data as a means of production is positive. However, being virtual, data incurs no tangible wear and tear. Its involvement in the production process does not cause its use-value to disappear. Thus, its intrinsic value can be amortised infinitely, exhibiting the characteristic of diminishing marginal costs. Over time, the value of data as a means of production (C_d) will fall below that of physical means of production (C_1), reversing the substitution effect from positive to negative and reducing the total value transferred. In the second scenario, where C_d is less than C_1 from the outset, the substitution effect of data as a means of production is negative from the beginning. Moreover, as the marginal cost of data as a means of production diminishes, the total value transferred by the means of production will exhibit a marginal decrease.

Lastly, the substitution effect of data as a means of production will change the ratio between variable and constant capital. An increase in labour productivity requires that the increase in value transferred by constant capital be smaller than the living labour saved through the use of machinery, thereby driving a continuous rise in the organic composition of capital. However, in the digital economy, this trend is challenged by the transfer of value from data as a means of production. In the context of data as a means of production, both in its natural form and in its commodity form with an initially negative substitution effect, the magnitude of constant capital (C) is reduced from the outset. Provided that the input of variable capital remains unchanged, the organic composition of capital will inevitably decline; an expansion in the

labour-power mobilised by capital implies a decrease in labour productivity. In reality, however, the substitution effect associated with data as a means of production reduces the commodity price, and through the coordinated application of artificial intelligence, it displaces a greater number of workers. Thereby, it accelerates the reduction of variable capital inputs and ultimately raises the organic composition of capital. In the alternative scenario, where the substitution effect is initially positive—often associated with higher-value commodity-form data as means of production—the input of constant capital first increases and then gradually decreases. Correspondingly, the organic composition of capital also rises initially and subsequently declines. In the end, however, this mechanism still elevates the organic composition of capital by expelling surplus labour.

2.3 New characteristics of value transfer by digital means of production

First, value transfer from digital means of production essentially reflects the complementary, agglomerative, and shared nature of digital technologies in the production process, which significantly enhances labour cooperation and production efficiency. The high permeability of data as a factor of production across primary, secondary, and tertiary sectors, the natural monopoly of data and information, and the non-exclusivity of data resources determine that digital technologies possess the characteristics of technological complementarity, technological agglomeration, and technological sharing. All these characteristics contribute to further improving labour cooperation and production efficiency. Firstly, the extensive application of data as a means of production in various industrial sectors enables digital technologies to complement other productive and operational techniques, thereby optimising production cooperation across different technological sectors and improving operational efficiency (Tian and Li, 2022). Moreover, the scale effect of data as a means of production gives rise to data's natural monopoly feature, leading to a "winner-takes-all" scenario (Yi *et al.*, 2019). This also results in the agglomeration of technologies in monopolistic sectors, promoting the concentration of more homogeneous labour. Such a technology-agglomerated cooperation model can improve the efficiency of utilising the means of production. In addition, data, as a non-exclusive resource, enables technological sharing in the production process through data sharing, completely transcending the constraints of time and space in collaborative labour, thereby shortening production cycles and enhancing productivity. The very nature of digital means of production, coupled with improvements in collaborative modes underpinned by digital technology, enhances production efficiency, thereby intensifying the incentive to substitute physical means of production with digital ones. By reducing fixed capital depreciation and conserving circulating capital, data enhances the quality of factor inputs, improves allocation efficiency, and boosts productivity within the digital economy as a means of production (Jing and Sun, 2019).

Second, the monopoly over natural-form data as a means of production enables large digital platform organisations to obtain what Marx termed "false social value." In his analysis of differential rent, Marx introduced this concept to describe a scenario where landowners, by virtue of their monopoly over more fertile tracts of land, receive a monopoly price of production that exceeds the real value generated on that land. To a certain extent, data, as a means of production, shares similar natural properties with natural forces such as land or waterfalls. Large-scale platform organisations often act as monopolists possessing vast quantities of high-value-density data, whereas smaller platforms typically struggle to capture and retain data, frequently ending up with lower-value-density data. Regardless of their scale, platform organisations do not directly engage in productive labour themselves, yet they generate profits. Monopolistic platforms, in particular, surpass others in securing monopoly profits that exceed average market levels. In this sense, the profits, especially monopoly profits, accruing to platform organisations differ substantially from differential rent, whose profits appear to arise "like water without a source," and may thus be construed as an even "more false" form of social value. This intensified form of false social value does not

originate within the platform organisations themselves; instead, it is derived from productive sectors or gig workers that use the platform as an intermediary. Platforms seize profits created in other productive sectors through profit-sharing mechanisms. Within such organisations, data has completely supplanted physical means of production. By wielding monopolistic control over high-value-density data, platforms attract numerous individual labourers and firms. The higher the value density of the data a platform monopolises, the more productive labour it draws in, and the greater the amount of “false social value” it captures.

Third, the substitution effect of data as a means of production enables capital to establish expulsive, absorptive, and demand-driven control over labour, intensifying the subordination of labour to capital. In digitally transformed sectors such as intelligent manufacturing, the initial phase is characterised by the high value of data-related key production factors and outputs. The proliferation of digitalised and intelligent machinery reduces the demand for labour, leading to a slower increase in variable capital compared to constant capital. This dual domination by both machinery and data as means of production reinforces the crowding out of low- and medium-skilled workers, resulting in the expulsive domination by capital. Within the platform-based digital service economy, data can completely replace physical means of production, further consolidating expulsive domination—exemplified by app-based self-service systems displacing human labour. At the same time, the expansion of the labour force creates absorptive domination: platforms incorporate informal workers into a gig economy characterised by low entry barriers and high capacity for absorbing those displaced from intelligent manufacturing. Nonetheless, platforms reinforce this absorptive control through robust user retention strategies and extensive integration into social life. In technology-intensive industries, such as information and communication technology (ICT), where digital technology is a leading factor, the substitution effect of data as a means of production has a more direct impact on variable capital. On one hand, the substantial demand for highly skilled labour and the increasing complexity of work raise variable capital inputs, manifesting as a decline in the organic composition of capital. By offering higher wages, capital binds these workers in a relation of dependency, constituting demand-driven domination. On the other hand, the trend toward simplifying complex labour through technological iteration allows artificial intelligence to replace certain cognitive tasks, thereby reducing both the number of workers and the compensation allocated to variable capital. This becomes a new force driving down the organic composition of capital and shifting the form of control from demand-driven to expulsive domination.

3. Value creation by digital living labour

The impact of digital technologies and digital means of production on value creation by living labour is primarily realised through the transformation of traditional labour into digital labour. Defined within the digital techno-economic paradigm, digital labour constitutes a production process that utilises digitalised means of production to create exchangeable digital products and services, embodying the congelation of undifferentiated human labour. This process simultaneously encompasses both the formation and valorisation of value in digital outputs. Central to this transformation is the role of digital technologies in reshaping labour practices, which has given rise to digital platforms as novel organisational forms. The integration of digital labour with these platforms further engenders new configurations of digitalised labour relations.

3.1 Platformisation of digital labour and diversification of labour practices

In its early stages, capitalist labour processes began with cooperation—the foundational form of the capitalist mode of production—which, through division-based collaboration, shaped the distinctive labour methods of large-scale industry and established a corresponding organisational system. During the phase of simple cooperation, labourers engaged in

elementary collective activities under capitalist direction, either participating in the same or interconnected labour processes, thereby replacing individual labour with combined labour. The development of manufacturing introduced division of labour into production, simultaneously fragmenting labour into more isolated and one-sided tasks while integrating previously separate handicrafts into a unified “productive mechanism whose parts are human beings” (Marx, 2018, p. 392). This led to the detailed character of labour, where workers became increasingly “deformed,” and “the labourer is brought face to face with the intellectual potencies of the material process of production, as the property of another, and as a ruling power” (Marx, 2009b, p. 418).

In the era of large-scale machine industry, the subjective division and synthesis of labour were replaced by the objective breakdown and organic recombination of production processes by machinery. Labourers were assimilated into the machine system as “conscious linkages” of an automaton composed of mechanical and intellectual organs (Marx, 2012, p. 773). Labour processes grew more simplified and isolated, exacerbating the separation between manual and mental labour. The factory—a distinctively capitalist form of labour organisation—consolidated substantive control over labour processes by leveraging the tendency of large-scale industry to “render science an independent productive capacity divorced from labour and subservient to capital” (Marx, 2009b, p. 418). The alienation of the labour process manifested under the factory system, where machinery and its scientific applications technically reinforced the real subsumption of labour under capital. Throughout the value creation process, machinery, its products, and the science it embodied “confront the worker as powers of capital” and “function solely as instruments of labour exploitation” (Marx, 2009c, p. 395).

In the era of the digital economy, the digital transformation of the means of production has further driven the digital evolution of labour-power as a factor of production, establishing digital labour as a vital source of value creation in the digital economy. The digital labour process, which takes place on digital platforms, has expanded the organisational forms of production and the modes of working. In terms of labour organisation, new forms of labour organisation (digital platforms) have emerged, following the growth of virtualised means of production and electronic labour instruments into the online virtual sphere. Characteristics of the internet, such as openness, decentralisation, and interactivity, have contributed to a trend towards the socialisation of digital labour originating from the internet (Weng *et al.*, 2022). Platform organisations provide the arena for this socialised digital labour, giving rise to “online factories,” which encompass both platform technicians and managerial staff—who maintain formal, direct employment relationships with the platform, albeit concealed behind its technological form—as well as those who access and are compatible with the platform, such as application providers and live streamers (Zhao *et al.*, 2022). The latter group establishes informal employment relationships with platforms through arrangements, including the gig economy, outsourcing, and virtual participation.

In terms of modes of working, data factors and digital technologies dominate the digital labour process. The deepening application of digital technologies—such as 5G, cloud computing, blockchain, and artificial intelligence—has more clearly delineated distinct digital modes of working. The first category constitutes a purer form of mental labour, referred to as technical digital labour, which is primarily engaged in work related to data analysis and the research and development of digital technologies—examples include big data engineers and blockchain technicians. The second category, termed general digital labour, primarily involves affective labour and manual labour. Affective labour typically includes roles such as internet marketing specialists and live streamers. Relying on network carriers and data flow transmission, and contingent on the development of digital technologies, these roles provide “affective labour” that goes beyond traditional mental and manual labour. This involves producing and manipulating emotions through the mediation of knowledge, information, communication, and relational responsiveness (Peng and Meng, 2022), thereby creating “affective value”. Digital manual labour, meanwhile, remains embedded in traditional physical production but utilises digitalised intelligent labour tools. For both modes of working,

3.2 Multiple forms of invisible surplus-value creation by digital living labour

In his discussion on machinery and large-scale industry, Marx (2018, p. 453) stated, “The revolution in the instruments of labour, and this revolution attains its most highly developed form in the organised system of machinery in a factory. Before we inquire how human material is incorporated with this objective organism, let us consider some general effects of this revolution on the labourer himself.” The purpose of using machinery was to increase labour productivity, primarily by altering the subjective conditions of labour, such as extending the working day, intensifying labour, and simplifying labour tasks. The transformation of labour cooperation and division of labour by machinery was a key factor driving the changes in the subjective conditions of labour.

The moral depreciation inherent in machinery improvements necessitates a continual reduction in the labour-time required for its reproduction. This imperative becomes particularly acute in the early phases of machine deployment, incentivising capitalists to prolong the working day to accelerate the amortisation of machinery costs. Collective labour within the machine system constitutes not only cooperation subsumed under capital but also large-scale coordination dictated by the operational logic of machinery itself. The continuous operation of machinery significantly facilitates the extension of cooperative labour time. As machinery becomes more advanced, its heightened efficiency demands an overall acceleration of cooperative labour, intensifying the pace of work. The reduction in the number of workers resulting from mechanisation amplifies the pressure to extract greater absolute labour from a smaller workforce. Moreover, the increasing complexity of machinery systems leads to a finer division of labour, expanding the number of detail workers engaged in fragmented, repetitive tasks. This process gradually eliminates intellectual elements from work activities, depleting workers’ individual productive capacities. As Marx (2009d, p. 348) noted, machinery “reduces all labour capacities to simple labour capacities and all labour to simple labour, whereby the total amount of labour capacities is depreciated.”

The intellectualisation of machinery systems and innovations in digital technology have further reconfigured labour coordination and division, enabling digital living labour to generate multiple forms of invisible surplus value. Firstly, the widespread adoption of digital office software and social communication platforms has created an online labour field, wherein data-mediated interaction and feedback render data elements indispensable to value creation. The immediacy and shareability of data transmitted through digital networks further erode the boundaries between working hours and leisure time. Equipped with electronic devices as instruments of labour, workers engage in ubiquitous, flexible coordination—effectively allowing fragmented labour to encroach upon leisure time. This imperceptible extension of working hours constitutes a fragmented mode of surplus-value production, generating the first form of invisible surplus-value (M_1). Beyond the surplus-value (M) produced during formal working days, workers unwittingly contribute an additional, invisible surplus-value increment (M_1) during their leisure hours. While the value composition of labour-products ostensibly remains $W = C + V + M$, it ought more accurately to be expressed as $W = C + V + M + M_1$, where M_1 denotes the obscured and often unobservable first form of invisible surplus-value. The magnitude of M_1 correlates positively with the degree of blurring between work and leisure. In highly flexible digital work environments—such as remote or home-based work—data often functions independently of other means of labour, becoming the primary instrument in the labour process. Under these conditions, the encroachment of work into leisure time faces fewer physical and temporal constraints, thereby amplifying the invisible surplus-value M_1 extracted from digital workers.

Secondly, with the pervasive integration of online platforms into daily life, the demand for affective labour, which primarily produces informational and cultural content, has

significantly expanded. This necessitates that workers provide additional, often invisible and difficult-to-quantify, affective labour beyond mere physical and intellectual effort, thereby generating a second, latent form of affective surplus value. Affective labour delivers services through emotional management and regulation, imbuing the value-creation process with social attributes via text, images, and videos. It is manifested entirely through various data streams and is frequently characterised by unstable and informal employment relationships rooted in digital networks. Notably, a substantial proportion of this affective labour is provided by the vast user base of the platforms themselves. Consequently, the production of its surplus value becomes intrinsically linked to the different value forms of data. On the one hand, concerning labour that produces commodity-form data—such as in the flexible production in smart manufacturing and digital services with distinct social attributes—the labourers are subordinate to certain employment relationships. Their labour value creation inherently comprises variable capital (V) and surplus value (M). However, as their labour process is augmented by affective labour, the surplus value portion can be expressed as $M = M_1 + M_2$, where M_2 represents the second, latent “affective surplus value” generated by the workers through affective labour. Although the labour process creating this surplus value is not directly observable, it is often measured via the online evaluations of buyers/clients. This metric, however, is inherently susceptible to subjectivity and can become a tool for platform control over workers. On the other hand, in the case of labour producing natural-form data, once this data is utilised for profit generation, it necessarily embodies the labour of the data producers, i.e. the platform users. The users’ initially self-sufficient labour is thereby transformed into non-self-sufficient labour. Crucially, this transformation does not incorporate the value of the labour-power that produced the data but only encompasses the value of the labour performed by the technical staff responsible for data collection, processing, and refinement. Thus, more surplus value is effectively produced without a corresponding increase in variable capital investment. The “raw material” for this surplus product often encapsulates specific emotions and value orientations of the data producers (users), thereby also constituting a form of latent affective surplus value. Consequently, this surplus value can similarly be expressed as $M = M_1 + M_2$.

Moreover, the versatility and rapid iteration of digital technologies accelerate the simplification of complex digital labour. Through the “learning-by-doing” mechanism in complex labour, surplus-value attains a self-multiplication effect, thereby creating a third layer of implicit, self-multiplied surplus-value. Compared to complex labour in the industrial economy, complex labour in the digital economy emerges from the intellectualisation of both the subjects and means of labour. This intellectual transformation is a process of accumulating knowledge and information, resulting in a qualitative change. Consequently, digital labourers engaged in complex labour exhibit stronger digital and knowledge-intensive characteristics. Their work incorporates more technology and demonstrates higher complexity (Zhou and Han, 2023). This more complex digital labour also exhibits a stronger value reduction effect. However, this relatively stronger reduction effect does not stem entirely from increased labour complexity. As social productive forces develop, the prevalence of complex labour production increases, ultimately reducing complex labour to the level of general social labour. The more significant reduction effect of digital complex labour originates from the networked nature of “learning-by-doing.” The proliferation of the internet has disrupted traditional models of small-scale labour skill accumulation, enhancing knowledge sharing. Particularly due to the replicability and zero marginal cost of data, the cost of acquiring and updating labour skills through online learning is reduced while efficiency improves, allowing the scope of labour skill accumulation to expand infinitely.

Training costs that employers should ordinarily bear are transferred to labourers through online “learning-by-doing,” manifesting as voluntary overtime or self-directed learning during leisure hours. This networked “learning-by-doing” approach has become widespread due to the rapid iteration of intelligent machines and digital technologies, coupled with intense competition among labourers. The “tendency towards self-exploitation” in skill updating

intensifies among labourers, and the saved training costs are converted, on a larger scale, into the self-multiplication of surplus-value achieved by labourers through “learning-by-doing.” Assume the reduction coefficient of complex labour is h , meaning one unit of complex labour can be reduced to h times simple labour. Under the “learning-by-doing” effect, assuming the capitalist’s advanced wages remain unchanged, and no additional training costs are incurred, the capitalist can still obtain the labour productivity of certain advanced labour. That is, the “learning-by-doing” effect h enhances the labour reduction effect, transforming it into $h + h'$ times simple labour. The excess represents the surplus-value generated through self-multiplication by labourers via “learning-by-doing.” This constitutes the third layer of invisible surplus value, M3, which cannot be directly observed or measured in the labour process. Thus, the distinction between complex and simple labour lies in the magnitude of the self-multiplication effect of surplus-value produced through “learning-by-doing” in complex labour. A larger self-multiplication effect implies a continuously declining threshold of labour skills, whereas a smaller effect indicates that labourers are struggling to update their skills through “learning-by-doing”—leading to a higher skill threshold.

3.3 New characteristics of value creation by digital living labour

First, the process of value creation by digital living labour reflects the replacement of human mental faculties by machine intelligence, deepening both the domination of humans by machines and human dependence on artificial intelligence (AI). In the industrial economy, industrial machinery typically replaced simple human labour with natural or mechanical forces. In the digital economy, intelligent and digital machines, supported by deep learning and self-evolving systems, develop neural networks that simulate the way the human brain learns and analyse to interpret data, images, and texts. The adoption of intelligent machines supports the replacement of manual labour and human intelligence, which is a critical pathway for digital technologies to transform into “digital intelligence” and significantly enhance labour productivity. The displacement of labour by machinery has extended beyond simple labour to complex labour, with labourers across different skill levels facing the impact of intellectualisation. In the field of simple labour, such as the production end of intelligent manufacturing, intelligent applications in production equipment and assembly lines facilitate more seamless machine-to-machine collaboration, where machine-to-machine collaboration replaces repetitive, simple human cooperation. Such transformation further strengthens the displacement of human labour by machinery and amplifies the cost-reducing and efficiency-enhancing outcomes of the digital economy. In leading and cutting-edge digital technology-enabled industries, the deep learning of machines can reduce the demand for high-skilled labourers by offsetting the rise in costs of variable capital caused by increased labour complexity. While machines replace humans, they also reshape production cooperation relations, making human collaboration with intelligent machines increasingly prevalent and efficient. In the field of complex labour, human physical dependence on machines is manifested as their dependence on “machine intelligence.”

Second, the process of value creation by digital labour supports the digitalisation of the individual, which in turn exacerbates the distortion of human-machine relations caused by technological alienation. In general, digital technologies have greater potential than any previous scientific applications to reduce labour intensity, shorten working days, and promote the free and all-around development of individuals. However, the technological proliferation and diffusion of the digital economy drive labourers to develop stronger dependence on production tools and means of production, turning labourers into “digitalised beings” and intensifying technological alienation. In fact, this process also reinforces the real subsumption of labour under capital. On the one hand, digital technologies reduce humans to executors of commands, severing interpersonal connections. Labour time and fields are clearly segmented, with individuals becoming isolated, whose behavioural signals are received by systems to generate feedback. On the other hand, the digitalisation of the individual is also observable in

the expansion of labour into virtual spheres, making labour dependent on platforms. The “algorithmic dilemma” represents a distinct feature of technological alienation in the digital service industries. Such digitalisation of individuals is inevitable: the more intelligent machines and algorithms become, the more simplified labour becomes; the stronger people’s dependence on them grows, and the more labour takes place in the virtual spheres. The control of technological alienation over labourers increases labour intensity, shortens the necessary labour time, and increases surplus value, demonstrating the dominance of intelligent machines. The deep integration of machinery and technology, in turn, deepens capital’s possession of labour-power, as evidenced by the unavoidable prolongation of the working day and intensification of labour due to machinery. The result is that products become cheaper, aggregate social wealth increases, but the situation of low- and medium-skilled labourers engaged in simple labour production remains unchanged.

Third, digital labour can produce multiple forms of invisible surplus value, which is underpinned by the subjective will to power of digital capital, derived from the neutrality of digital technologies. The process and outcome of value creation by digital labour is the product of a superimposition of capital logic upon technology logic: capital logic gives technology logic personalised characteristics, giving rise to the distinctive will to power of digital capital. Science and technology are, in essence, independent objects and means for advancing productive forces. In contrast, digital technologies—an inevitable product of new productive forces in the digital economy—are subordinated to the logic of digital capital due to algorithmic settings and absolute data quantification. Through the sensuous process of human digital labour, the logic of digital capital undisguisedly highlights its objective of capital accumulation, thereby more comprehensively manifesting the will to power of digital capital. Driven by the will to power of digital capital, what digital technologies control has been elevated from physical strength to human emotions. Consequently, the will to power of digital capital achieves a comprehensive mapping onto humans and its all-round possession of labour-power from the inside out. In addition to labourers’ physical strength, a deeper level of their emotions falls under the control of digital technologies, thereby leading to the will to power of capital embedded into humans’ deep consciousness. Furthermore, the will to power of digital capital also transforms digital technologies into a subjective instrument serving the valorisation of capital, securing its dominance through the monopolisation of the power to exploit digital labourers. A unique advantage of valorisation of digital capital lies in the qualitative leap in productive forces enabled by digital technologies. Under the control of capital, the introduction of digital technologies imposes an additional, more concealed task of value creation on the digital labour process, with the speed of capital valorisation increasing exponentially. Consequently, digital technologies have thus been reduced to an agent acting on the will to power of digital capital.

4. Reproduction of labour value creation in the digital economy

“Whatever the form of the process of production in a society, it must be a continuous process . . . When viewed, therefore, as a connected whole, and as flowing on with incessant renewal, every social process of production is, at the same time, a process of reproduction” (Marx, 2018, p. 653). In the digital economy, the process of labour value creation is simultaneously its production process; the continuous process of value creation by digital labour is its process of social reproduction. This process encompasses the reproduction of digital means of production, the reproduction of digital labour-power, and the reproduction of digitalised production relations.

4.1 Traffic-expanding and data-upgrading reproduction of digital means of production

“All other circumstances remaining the same, the only mode by which it can reproduce its wealth, and maintain it at one level, is by replacing the means of production—i.e. the

instruments of labour, the raw material, and the auxiliary substances consumed in the course of the year—by an equal quantity of the same kind of articles” (Marx, 2018, p. 653). In the traditional reproduction of means of production, the production process could only be sustained if the input of means of production remained at the same level as before or increased. With enhanced productive forces and technological progress, improvements in instruments of labour made it possible to reproduce means of production merely by adding more auxiliary substances that are consumed by the instruments of labour in one go. This was particularly evident in the industrial economy, where accumulation on an expanded scale based on the conservation of instruments of labour significantly promoted the development of productive forces. Compared with the reproduction of traditional means of production, the reproduction of digitalised means of production, on the one hand, saves far more on additional input in reproduction than ever before; on the other hand, it further achieves the “annihilation of space by time” amid reproduction on an expanded scale. That is, the virtual nature of reproduction breaks through the spatial constraints of material exchange, enabling capital to fulfil its purpose of expanding the spatial market by reducing the time required for the transfer of commodities. These two effects are mainly accomplished through the traffic-expanding reproduction and data-upgrading reproduction of data, a key means of production:

Data comes from human social activities and production processes. Similarly, the production and reproduction of data as a means of production comes from human activities and labour. Depending on the forms of data, the reproduction of data as a means of production can be categorised into two types: traffic-expanding reproduction of natural-form data and data-upgrading reproduction of commodity-form data. In the former case, natural-form data generated by private social activities manifests Metcalfe’s Law in the development of network technology more prominently than commodity-form data. Metcalfe’s Law means that the more internet users there are, the more interconnected network nodes there will be; and the value of a network is proportional to the square of its scale. Therefore, this gives rise to a mode of reproduction that focuses on expanding user traffic. Platforms continue to attract more new and potential users through advertising, rebates, and other means to expand data streams. They also reproduce more data in its natural form. The more “data footprints” internet users leave, the higher the value of traffic monetisation; the advantage in total data volume is transformed into a production advantage through unlimited aggregation. In the latter case, the collection and analysis of huge volumes of data form the foundation for iteration in digital technologies. The shortened innovation cycles of digital technologies further enhance data integration, effective information extraction, and data processing for upgrading, resulting in the production of more data with higher value density or higher unit value. First of all, this data-upgrading reproduction is built on a large-scale collection of raw data. In other words, building upon traffic-expanding reproduction of data, the larger the volume of data, the more sufficient the effective information that can be extracted, and the smoother the data-upgrading reproduction will become. Moreover, digital technologies serve as an essential external requirement for data-upgrading reproduction. This is evident in the big data capture capabilities and analysis speed, where the applicability of data as a means of production is enhanced through rapid data screening and matching, coupled with constructing more sophisticated data hierarchies. These two types of data reproduction as a means of production, on the one hand, amplify the substitution effect of data as a means of production, thereby saving production costs to a greater extent. On the other hand, they further expand the boundaries of production, achieve seamless integration between the production process and the reproduction process, and significantly shorten the entire production and reproduction process.

The reproduction of data as a means of production accelerates the reproduction of digitalised means of production and the overall production process. It expedites the accumulation of total social capital, represented by capital of digital platforms, through the concentration of data capital. Consequently, it further reinforces digital relations of production. The accumulation of data itself as a means of production continues to strengthen the algorithmic power of digital platform capital, driving the relations of

production into a new stage of data monopoly capitalism (Huang, 2020). By virtue of its monopoly over data, this platform capital attracts more users to reproduce larger volumes of data. The greater the data volume, the greater the discourse power this platform capital obtains to establish algorithmic rules. With continuous reproduction of voluminous data, data capital achieves rapid valorisation, and platform capital progressively evolves into data monopoly capitalism. On the one hand, platform capital utilises data-upgrading reproduction to develop algorithmic logic with more concealed capitalist exploitation and stronger exploitation capacity. Platform capital thus establishes stronger dominance over the users and labourers on its platforms, internalising the conflict between labour and capital into competition among labourers through seemingly more rational and moderate mechanisms. On the other hand, platform capital, particularly large platform capital, engages in traffic-expanding reproduction in a “snowballing” manner, monopolising data markets to control smaller platforms. Digital oligarchs, in forms such as digital e-commerce oligarchs, digital entertainment oligarchs, and digital financial oligarchs, are disrupting the operating rules of the market economy.

4.2 Extensive and intensive reproduction on an expanded scale of digital labour-power

In his analysis of simple reproduction under capitalism, Marx identified two dimensions of labour-power reproduction: reproduction of labour-power and reproduction of labour skills. On the one hand, for labourers, by the consumption of the means of subsistence, “the muscles, nerves, bones, and brains of existing labourers are reproduced, and new labourers are begotten” (Marx, 2018, p. 660). On the other hand, “the reproduction of the working class carries with it the accumulation of skill, that is handed down from one generation to another” (Marx, 2018, p. 662). The reproduction of the labour value creation process in the digital economy, on the one hand, generates an even stronger demand than ever for digital complex labour, namely, digital technology talents. On the other hand, through the use of digitalised means of production, it deskills the labour force displaced by intelligent machines, thereby transforming them into a reserve army of labour engaged in simple labour in the digital service industry. Hence, the reproduction of digital labour-power creates extensive reproduction on an expanded scale in terms of quantity, while the reproduction of its skills creates intensive reproduction on an expanded scale in terms of quality. This further shortens the iteration and innovation cycle of digital technologies, accelerating the accumulation of social wealth.

The reproduction of digital labour-power is based on the consumption of means of subsistence; “the labour-time requisite for the production of labour-power reduces itself to that necessary for the production of those means of subsistence; in other words, the value of labour-power is the value of the means of subsistence necessary for the maintenance of the labourer” (Marx, 2018, p. 199). With the improvement of production efficiency brought about by the large-scale introduction of intelligent machines and data as a means of production, the material replacement of means of subsistence for labour-power reproduction has relatively decreased. “Machinery produces relative surplus-value; not only by directly depreciating the value of labour power, and by indirectly cheapening the same through cheapening the commodities that enter into its reproduction . . . by raising the social value of the article produced above its individual value, and thus enabling the capitalist to replace the value of a day’s labour-power by a smaller portion of the value of the day’s product” (Marx, 2018, pp. 467–468). The reduced cost of reproducing labour-power creates the possibility for the quantitative extensive expanded reproduction of digital labour, and such reproduction occurs more frequently in the field of simple digital labour—particularly in digital service industries with lower skill requirements, larger industry capacity, and higher traffic demand. Existing studies indicate that the development of the digital economy will not displace employment in the service sector; instead, it tends to exert a compensating effect and a job creation effect, thereby boosting employment in the service sector (Zhou *et al.*, 2023). This transition is not fuelled by emerging labour-power out of thin air, but by the impetus of general-purpose technologies on the transformation of the employment structure—specifically, accelerating the shift in

employment structure from manufacturing to the service sector (Chen and Su, 2021), driven by the migration of displaced labour-power and industrial reserve army from manufacturing to the service sector. The reproduction of skills by digital labour, by contrast, occurs primarily in complex labour, that is, intensive reproduction on an expanded scale within leading digital industries or core digital technology-enabled sectors.

Compared with the technical reproduction of skills among traditional labour-power, the cultivation of digital technology talents, on the one hand, is also achieved through enhancing educational attainment and specialised technical training within enterprises. On the other hand, the technical reproduction of skills among digital workers is also realised through online self-learning, which is in fact a new form of “learning-by-doing” in the digital economy era. Due to the interaction between data science and digital technologies, digital technologies—driven by intellectual capacity—tend to iterate at an accelerated pace. Digital workers, especially those with digital technical expertise, will thus face greater pressure regarding the reproduction of their labour skills, which also reinforces the tendency of devaluation in the value of labour power itself under capital’s domination. Therefore, workers must continually develop higher-level digital skills through more convenient digital forms of “learning-by-doing.”

The extensive and intensive expanded reproduction of digital labour-power further reproduces capitalist digitalised relations of production through the process of labour’s value creation. The extensive expanded reproduction of digital labour power embodies the stronger domination of platform organisations over low- and medium-skilled workers in the digital era. Given the high proportion and greater purity of data as means of production used in digital platforms, the iteration and innovation of digital technologies are most intuitively manifested within digital platform organisations. The more people rely on the production convenience brought by platform organisations, the more labour becomes relatively simplified. On the one hand, workers are cast aside by intelligent machines; on the other hand, they have to bow to the capital logic of digital platforms. Hence, the extensive expanded reproduction of labour power becomes an inevitable choice: more workers in informal employment relationships are forced into potential exploitative relations. Even though the extension of the digital economy into the field of non-material production provides flexible employment opportunities for a large number of precarious workers, this only makes more workers subordinate to such hidden and involuntary digital production relations. Moreover, as digital technologies evolve, the influence of these invisible and involuntary digital production relations grows ever stronger.

By contrast, the intensive expanded reproduction of digital labour power transforms the external “exploitation by others” of the industrial economy era into internal “self-exploitation,” concealing the intense purpose of capital accumulation within the internal employment competition among workers. As a result, the contradiction between capital and labour is, to a certain extent, manifested through the intensification of internal conflicts among workers. Particularly, in each round of digital technology transformation, workers will be eliminated when their reproduction of digital skills fails to meet the needs of capital expansion. This elimination mechanism intensifies internal competition among workers and continuously drives the recurrence and reinforcement of “self-exploitative” labour relations under the logic of capital.

5. Conclusion

The process of digital labour value creation has not only forged an engine driving the development of productive forces but also spearheaded the transformation of digitalised relations of production. Meanwhile, the new characteristics of the digitalised mode of production have given rise to new issues in the operation of the digital economy that urgently require resolution and improvement.

First, digital platforms are key carriers for the creation of digital labour value and the expansion of digital capital. However, their dynamic competition, cross-sector operations,

network effects, and oligopolistic competition have exacerbated monopolistic problems in the platform economy, infringing upon the rights and interests of consumers and workers. For instance, platform capital—leveraging its strong capacity to aggregate and radiate production and consumption, its immense network effects, and its monopolistic power—routinely resorts to unfair competition and monopolistic practices using data and algorithms to secure excess profits. This leads to the alienation of algorithmic power, as algorithmic entities in the market abuse their algorithmic advantages and manipulate algorithmic power, thereby violating the legitimate rights and interests of consumers and platform workers. Such practices give rise to security issues, including price discrimination through big data, excessive data extraction, and leaks of platform users' private information.

Second, digital capital gains control over data, information, and technologies through mergers and acquisitions, forming a monopoly over digital means of production. This has intensified the dependence of means of production on digital capital, hindering the development of small and medium-sized platform enterprises and undermining full market competition and the fair distribution of social wealth.

Third, the dependence of digital labour on capital has heightened employment instability and income polarisation. For example, the gig economy, born from reliance on platform capital, reduces workers to one-off workers or workers without employment who provide their own tools and bear their own responsibilities. Workers are compelled to follow the logic of digital capital and are trapped in algorithmic dilemmas set by platforms. Even in high-level digital technology roles, “involution” in work has emerged as workers strive to maintain high wages, resulting in invisible infringement on their rights and interests.

These practical issues urgently demand more appropriate solutions. To promote the healthy development of the digital economy, continuous efforts are needed to improve platform regulation, refine data rights confirmation, enhance data transaction rules and data market norms, and promptly keep pace with labour protection laws and regulations for platform employment, establishing and improving social security for platform workers.

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