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The General Artificial Intellect

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Scholarly Abstract

In passages of Marx's *Grundrisse* known as the *Fragment on Machines*, Marx suggested that advanced capitalist development leads to the production of autonomous machines that replace labour-power in the direct production process. Autonomist Marxist interpretations of this text have emphasized that the proliferation of immaterial labour is the historical condition that is leading to a crisis in the measure of value based on labour-time and that will lead to a future communist mode of production. Further, Mario Tronti posited that as capitalist development unfolds, it subsumes both the state and society, a concept known as the 'social factory thesis'. This integrated article analyzes Marx and autonomist Marxist perspectives in relation to the advanced development of information technology. The approach contributes to the field of library and information science (LIS) by introducing Marx's materialist conception of history to the study of social consciousness, information and information technology and materialist conceptions of information. The thesis statement posits that the total replacement of labour-power with machine-power leads to the development of what I refer to as the *autonomous mode of production* while network information technologies have become capital and the bourgeois state's means of subsuming and producing 'the social factory'. Case studies of Industry 4.0, Uber and smart cities support the thesis statement. The conclusion examines the social and political implications of capitalist development of the autonomous mode of production and capitalist and bourgeois state control of network information technology, offering instead the alternative path of communisation.

Lay Abstract

In passages of Marx's *Grundrisse* known as the *Fragment on Machines,* Marx outlined a future in which the capitalist mode of production develops to a point where autonomous machines replace labour in the direct production process, leading to a crisis in the measure of value based on labour-time. Italian autonomist Marxist perspectives, known as *operaismo* and *post-operaismo,* produced interpretations of the *Fragment on Machines* that emphasized that the proliferation of new types of labour that does not produce a material product, or 'immaterial labour', is the historical condition that will lead to the crisis in the measure of value based on labour-time and to the development of a communist mode of production. Further, Italian *operaist* Mario Tronti suggested that as the capitalist economy develops, it overtakes both the state and society, an argument known as the 'social factory thesis'. This integrated article thesis analyzes Marx and autonomist Marxist perspectives in relation to the advanced development of information technology. The approach contributes to the field of library and information science (LIS) by introducing Marx's materialist conception of history to the study of social consciousness, information and information technology and materialist conceptions of information. The thesis statement reemphasizes Marx's position that the replacement of labour with machines in the direct production process is the historical condition that leads toward a crisis in the measure of value based on labour-time, which I suggest also leads to the development of what I refer to as the *autonomous mode of production.* Next, building on Tronti's analysis, the thesis suggests that network information technologies have become capital and the capitalist state's means of controlling and producing 'the social factory'. Case study analyses of Industry 4.0, Uber and smart cities support the claims of the thesis statement. The conclusion examines the social and political implications of the capitalist development of the autonomous mode of production and capitalist and state control of network information technology, and it offers an alternative path toward the collective ownership and collective development of the autonomous mode of production.

Keywords

Karl Marx, Historical Materialism, Fragment on Machines, The General Intellect, The General Artificial Intellect, Autonomous Machines, Big Data, Industry 4.0, Uber, Smart Cities

Co-Authorship Statement

I wish to acknowledge Simon Schaupp, at Seminar für Soziologie, University of Basel, Switzerland (simon.schaupp@unibas.ch), as a co-author with respect to the empirical data and theoretical development of the chapter on Industry 4.0.

Dedication

This thesis is dedicated to my late father and Professor Emeritus, Dr. Salim Diab. I also wish to thank the members of my immediate family, including my partner Dr. Snezana Ninkovich, my daughter Vivian Ninkovich-Diab, my mother Mary Beth Diab, my brother Kahlil Diab, my sister Anna Leheney and her husband Sean Leheney, my father-in-law Radomir Ninkovich, my mother-in-law Dara Ninkovich, my sister-in law Gordana Ninkovich. Special thanks to all of the other family members and friends who have supported me along the way.

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Preface

This integrated article thesis is an analysis of autonomist Marxist interpretations of a portion of Marx's *Grundrisse*, known as the *Fragment on Machines*, that focuses on the historical development of fixed capital in the form of autonomous machines. In doing so, it builds on Marx's concept of the general intellect found in the *Grundrisse* to present the new abstract category of *the general artificial intellect*. Based on both a critique and an alignment of autonomist analyses of Marx, chapter one builds upon and modifies autonomist thought to present an alternative historical materialist approach to the study of social consciousness, information and information technology as material forces of production. This approach was both developed from, and contributes to, the philosophy of information and document theory within the field of library and information science (LIS) with respect to the study of the ontology and epistemology of information. However, in direct contrast to the usual approach of the field of LIS, it begins first with Marx's political economic categories and then analyzes the role of information as an extension of the political economic structures of bourgeois society rather than privileging the study of information in isolation from the relations that determine its social function.

This approach developed in this thesis is used to analyze Marx's prediction about the capitalist development of autonomous machines that is found in the *Fragment on Machines* with respect to the recent wave of technological development that has been called the 'fourth industrial revolution' using three case studies that examine the capitalist appropriation of advanced information technology in the sphere of production, the circulation sphere and capitalist and bourgeois state appropriation of advanced information technology in cities. The first case study is an analysis of the capitalist appropriation and development of cyberphysical systems and internet of things technology in manufacturing, known as Industry 4.0. The second case study examines the capitalist appropriation and development of advanced information technology and autonomous vehicles in the ride-sharing services, specifically, Uber. The third case study examines both bourgeois state and capitalist appropriation of advanced information technology in the development of smart cities, using specific examples, including Google's partnership with Sidewalk Labs to develop Toronto's Waterfront, Amazon's collection of big data from hundreds of cities as the means of determining and objectifying the rationality of capitalist development and

other cases that highlight the collection and use of big data in smart cities as the means of determining and objectifying the rationality of the bourgeois legal and political superstructure and the bourgeois state.

Chapter 1

1 Introduction

Unfolded over twenty pages of Marx's *Grundrisse* are passages that have been referred to as the *Fragment on Machines.* In these pages, Marx projects a future in which the capitalist mode of production develops to a point where capital increasingly absorbs the total general knowledge within society, or 'the general intellect', into the fixed capital of automatic machines, or 'automatons', that then become the means of replacing manual labour in the direct production process. In Marx's description of this future world, automation of the direct production process leads to the development of the general intellect as a direct force of production instead of direct labour, which stands aside the production process, acting as regulator or watchman.[1] For Marx, the total replacement of labour-power with automatons expressed *the* central internal contradiction of the historical development of the capitalist mode of production that was so critical it threatened its very foundations.[2] This is because the law of value and the law of competition that compels industrial capitalists to extract surplus value from labour within the production process also compels capitalists to increasingly replace labour-power with machines, and thus, the unpaid labour-time that is the source of surplus value that is necessary for the reproduction of industrial capital.[3]

Interpretations of the implications of the *Fragment on Machines,* and specifically, Marx's reference to the general intellect, have been applied to the analysis of the historical development, current landscape, and future projections of the capitalist mode of production. Beginning with the publication of the *Grundrisse* in the 1960s, the Italian Marxists associated with the *operaismo* and *post-operaismo*[4] tradition who contributed to

[1] Marx, *Grundrisse*, 694.
[2] Ibid, 706.
[3] Ibid.
[4] See Wright, "A Party of Autonomy?" 73-106. *Operaismo* refers to the Italian "workerist" perspective that originated in the late 1950s in tandem with the working class resistance that developed in response to the post-war capitalist restructuring of Italy. *Post-operaismo*, however, refers to a faction of Italian Marxists who broke from the *operaismo* perspective in response to the changing class composition of the working class marked by the proliferation of service workers and cultural produces that displaced the factory worker as the political centre of labour organizing and resistance. Many theorists working from the *post-operiasmo* perspective in turn became aligned with the radical social and political movement of Autonomy operaismo that emphasized workers political autonomy from formal labour organizations that emerged first

the development of the autonomous Marxist perspective, mostly notably interpreted translations of the *Fragment on Machines* to produce a wide range of concepts and insights into the changing forms of work brought on by advanced capitalist development. The general methodological and theoretical perspective of these authors was rooted in the analysis of class struggle rather than in the analysis of capital.[5,6,7] Hence, where Marx focused on capital as a subject, what has been broadly categorized as autonomous Marxism takes class composition and class struggle as its subject.

Post-operaismo interpretations of the *Fragment on Machines* tend to emphasize that the general intellect is an attribute of living labour, which develops its creative powers from within the class struggle against capital. Due to the method and object of study, *operasmo* and *post-operaismo* perspectives have purposefully abstracted from the specific forms of fixed capital that the general intellect produces. The *operaismo* and *post-operaismo* method of analysis therefore appears to adopt Marx's dialectical perspective from the position of the working class that the historical development of the productive powers of the general intellect is contradictorily created by capital's exploitation of labour. Hence, the development of the capitalist mode of production also develops the productive forces of the working class, and thus, creates the historical conditions for its supersession by the communist mode of production. In contrast, authors associated with the accelerationist perspective, and who have partially allied with autonomist positions, have interpreted the *Fragment on Machines* with an emphasis on the implications of the advanced development of automation technology for creating free time and the possibility of a post-capitalist, or even, post-work world.[8,9] Thus interpretations of the *Fragment on Machines* contain implications for the future of the capitalist mode of production and the specific

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in the United States and in several European countries and that gained political traction in the late1970s. Hence, autonomist Marxism was developed from various alignments with and breaks from the original Italian *operaismo*.

[5] See Wright, *Storming Heaven*, 23-31 and his analysis of the role of sociological research within the *operaismo* tradition that focuses on the analysis of the development of bourgeois society from the perspective of working class struggle and that therefore departs from Marx's analysis of *Capital*.

[6] See for example, Lukacs, *History and Class Consciousness* as the foundational work of Western Marxism that positions the worker as the historical and revolutionary subject that would influence Tronti in particular and the operaismo perspective more broadly.

[7] See Tronti, *Workers and Capital* as this text introduced new methods of analysis of capitalist society from the perspective of workers with the *worker's inquiry, co-research* and the concept of *class composition*.

[8] See Mason, *Post-Capitalism: A Guide to Our Future.*

[9] See Srnicek and Williams, *Inventing the Future: Post-Capitalism and a World Without Work.*

mechanisms—either factory automation at the point of production or proletarian revolution—that will lead toward its supersession by a new mode of production.

In the course of the following literature review, I suggest that *operaismo* and *post-operaismo* interpretations of the general intellect abstract from the form of its objectification in fixed capital due to the method and object of study of *operaismo* and *post-operaismo,* which focuses on analyzing worker behaviour, class composition and class struggle. This leads toward projections about capital's contradictory development of a self-liberating, revolutionary proletariat that will overthrow the capitalist mode of production. Based on the literature review, I suggest a contrary interpretation of Marx's *Fragment on Machines* that emphasizes the development of fixed capital in the form of automation technologies at the point of production is the historical condition that will lead toward a crisis in the measure of value based on labour-time.

1.1 Literature Review

The formation of *operaismo* emerged as both a research method and political praxis by dissidents from the Partito Comunista Italiano (PCI) during the Italian post-war reconstruction period.[10] *Operaismo's* dissent from the PCI was one that was both methodological and political in that early authors such as Raniero Panzieri, Sergio Bologna, Romano Alquati and Mario Tronti reformulated the method of Marx's *Capital* and applied it to the real Italian context of the capital-relation. This led them to a rejection of Marxist-Leninist dialectical materialism (diamat) and the top-down vanguard party system of control over the political expression of class struggle and labour-organizing that would shape subsequent autonomist interpretations of the *Fragment on Machines.* Where Marx focused on capital as the subject of investigation, *operaismo* inverted dialectical materialism and analyzed class struggle as its subject.[1112] In an outline of *operaismo's* theoretical and practical approach to radical activity, Tronti noted that past approaches:

[10] Wright, *Storming Heaven,* 3.
[11] Wright, *Storming Heaven,* 27.
[12] See Trott, *Operaismo.*

> …have worked with a concept that puts capitalist development first, and workers second. This is a mistake. And now we have to turn the problem on its head, reverse the polarity, and start again from the beginning: and the beginning is the class struggle of the working class. At the level of socially developed capital, capitalist development becomes subordinated to working class struggles; it follows behind them, and they set the pace to which the political mechanisms of capital's own reproduction must be tuned.[13]

As a consequence of this inversion, *operaismo* began with the experiences of the working class in the midst of class struggle while its research and political programme also analyzed the effects of capitalist development on the changing technical, class and political composition of labour as determinative of a developing revolutionary proletariat.

In the *operaismo* view, class struggle occurs *within* and *against* capital because labour is the source of surplus value. From this logic, *operaismo* developed the political perspective that the liberation of labour from capital develops from the internal conflict of the capital-labour relation, a perspective derived from Marx's analysis of the logic of capitalist crises, which held that the capitalist mode of production creates the means of its own destruction through its development of the revolutionary subjectivity of the working class. To validate this approach, *operaismo* relied on Marx's analysis of the class struggle that led to the *Factory Acts* in Britain that would create the development of education for the working class and that would force the bourgeois state to introduce legal limits to the length of the working day, thereby creating the conditions for capital's shift from the appropriation of absolute to relative surplus value.[14] With the changing forms of the working class as a revolutionary subject as its object of study, *operaismo* therefore developed concepts such as *class composition* and *self-valorization.*[15] For *operaismo,* contemporary forms of class struggle have taken on various forms against capital, ranging from the refusal of work to the sabotage of the workplace, to political demonstrations and militant insurrection, which *operaismo* supported both intellectually and politically. However, at the same time, capitalist development is driven by capital's reaction to the resistance of the working class.

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[13] Tronti, *Lenin in England*, para. 4.
[14] Ibid, 37.
[15] Negri, *Marx Beyond Marx*, xxvi.

Thus the *operaismo* perspective held that the antagonistic relation of labour to capital is expressed in the continuous formation, development and manifestation of new cycles of struggle.

In what may be considered early autonomist inflections, *operaismo* developed the premise of the political autonomy of the working class by emphasizing its independence from the capital-labour relation and from the control of formal political organizations such as trade unions, the PCI and other centralized forms of control of the political expression of class struggle that were seen as aligned with the political vanguard of the Soviet system.[16,17] Methodologically, the *operaismo* perspective was concerned with the technical composition of labour, its specific class composition and its form of expression that determined its specific political composition. In this sense, the general methodological orientation of *operaismo* focused on the development of the social and political forms of class struggle in opposition to the capitalist class. Broadly, *operaismo* therefore did not emphasize the advanced development of automatic machinery at the point of production that leads to the dissolution of value creation based on labour-time that Marx outlined in the *Fragment on Machines.* Rather, following Marx, *operaismo* emphasized that the capitalist mode of production contradictorily creates the means of its own means self-dissolution through the revolutionary subjectivity of the working class that develops in the course of class struggle.

This is evident in the *operaist* identification of the revolutionary figure of the *mass worker* as the dominant class composition and its antagonistic relation with the industrial managers, or 'the bosses' in Italy.[18] Research into workers' struggles at the point of production were informed by Marx's concept of real subsumption, an historical stage of capitalist development in which capital seizes control of the labour process and reorganizes it according to the demand for relative surplus value. The *operaismo* research approach involved a 'worker's inquiry' and what would become known as co-research into workers' lived experiences within actual Italian factories. Analyses of the figure of the mass worker

[16] Ibid, 3.
[17] Wright, *Storming Heaven*, 18.
[18] Ibid.

at the point of production appeared in the foundational *operaist* journals *Quaderni Rossi*, *Classe Operaia*, and *Potere Operaio.*

In 1962 and 1963, Romano Alquati's *Report on the New Forces* provided detailed case studies of the working conditions under real subsumption at the point of production in the factories of Fiat and Olivetti.[19] Alquati's analysis of Olivetti emphasized capital's use of information technology and the application of cybernetics as a means of production in the direct production process, where he suggested that information was 'becoming value', expressed in the concept of 'valorizing information'. Valorizing information referred to the function of information in the production process as "a mediator between variable capital and fixed capital, workers and machinery."[20] In Alquati's view, 'information' was something that living labour possessed and which capitalists extracted and used to monitor and control the labour process. In Matteo Pasquinelli's interpretation, Alquati's analysis implied a distinction between 'living information' and 'dead information' that appears to draw a parallel to Marx's conception of 'living labour' in relation to 'capital as dead labour'.[21] Alquati's analysis of information technology in industrial production advanced Marxist thought concerning the new forms of informational control over the labour process. However, Alquati did not include an analysis of capital's extraction of information about the movements and activities of the labour process that had been a part of the history of scientific management decades earlier. Rather, Alquati limited his analysis to capital's extraction of knowledge from the subjectivity of workers in the labour process, yet manual workers were not described as a part of the general intellect, nor were distinctions drawn between the specific forms of knowledge that workers possess and the specific forms of its objectification. In effect, Alquati's analysis of the information technologies used in the Olivetti factory also expressed *operaismo's* focus on the figure of the mass worker. Alquati's focus, therefore, subsequently abstracted from the productive forces of the general intellect that were absorbed by capital for the production of the information machines, which were then sold as commodities and re-appropriated by capitalists as means of production, and thus, appeared as fixed capital at Olivetti. However, Alquati's work forms an insightful and important building block for explicating capital's extraction

[19] Ibid, 47.
[20] Pasquinelli, "To Anticipate and Accelerate," 183.
[21] Ibid, 183-184.

of information from workers at the point of production as advanced information technologies may now be found across a wide range of industries beyond industrial manufacturing and within the relations of the spheres of circulation and consumption.

Around the same time of Alquati's publication, Mario Tronti argued in his essay, *Factory and Society*, that capital's development of machines for the real subsumption of labour may have begun first within the production process, but that as capitalist development advances, the process of real subsumption extends beyond the immediate relations of production, with capital developing an organic relation with the bourgeois state and with society.[22] Tronti's essay, referred to as 'the social factory thesis', held that capital has subsumed all of society, transforming all relations inside and outside the point of production into "moments of production" at which point the boundaries of the factory become unrecognizable.[23,24] As a result of the 'diffusion, expansion and re-enclosure of the factory walls' around all of society, the productive forces of labour are developed by institutions that appear to have originally developed with relative autonomy from the factory walls. Thus Tronti posited that as the organic relation between capital, society and the bourgeois state develops, social relations develop in a form adequate to capital.

The social factory thesis served early on to broaden *operaismo's* initial focus on the mass worker to what Marx referred to as 'unproductive labour' as it occurs outside the factory walls, forming a common thread with feminist perspectives that had long recognized capital's indirect exploitation of unpaid domestic female labour.[25] This expressed early internal dissent from *operaismo's* initial productivist orientation that would develop into a radical political insurgency inclusive of several other categories of non-industrial workers, 'unproductive workers' and members of other social movements over the subsequent decades. This gradual shift appeared to culminate in the late 1970s and 1980s, when Negri argued that the era of the figure of the mass worker was at an end due to capital's counter-attack on the proletariat with the introduction of new technologies at the point of production

[22] Tronti, *Factory and Society.*
[23] Ibid.
[24] Thoburn, *Deleuze, Marx and Politics.*
[25] Campbell, *Anthropology and the Social Factory,* 4.

and the political decimation of the Italian trade unions and labour organizations following the insurgencies of the late 1960s.[26]

In effect, Negri argued that capital's socialization of labour both within and outside the point of production had produced what he referred to as the new figure of the *socialized worker,* a bourgeoning revolutionary subject that had transcended the mass worker.[27] As Marx suggested in the *Fragment on Machines*, the replacement of direct labour with automation technologies in the production process reduces labour to the indirect function of a 'watchman' that oversees the production process. The replacement of direct labour with automation technologies therefore leads to the free-time and development of the social individual outside the point of production, which capital reabsorbs as a new source of surplus value:

> What capital adds is that it increases the surplus labour time of the mass by all the means of art and science, because its wealth consists directly in the appropriation of surplus labour time; since *value directly its purpose,* not use value. It is thus, despite itself, instrumental in creating the means of social disposable time, in order to reduce labour time for the whole society to a diminishing minimum, and thus to free everyone's time for their own development. But its tendency always, on the one side, *to create disposable time, on the other, to convert it into surplus labour*.[28]

Advanced automation at the point of production therefore produces free-time for the development of the social individual for capital's own purposes, and thus, to the development of the general intellect as a direct force of production.

However, Negri claimed that Marx's analysis in the *Fragment on Machines* of the social individual as an indication of a developing transformative crisis in value production based on labour-time was premature.[29] Negri therefore stopped short of suggesting that the emergence of the socialized worker meets the necessary conditions for the immanent

[26] Dyer-Witheford, *Cyber-Negri*, 137.
[27] Negri, *The Politics of Subversion*, 83.
[28] Marx, *Grundrisse*, 708.
[29] Ibid, 83-84.

collapse of value production based on labour-time. Rather, consistent with the methodology of *operaismo*, Negri focused his analysis of the social combination of the productive forces of the socialized worker, described as free-floating outside of the point of production and embedded in the process of capital's subsumption of society within the world economy.[30] Here the social function of the socialized worker for capital is presented in direct contrast to the mass worker:

> The socialized worker is more productive than that of the mass worker. It is endowed with a very high level of productive potential because it is capable of setting in motion the productive potentiality of the whole of society, and of actualizing all the dead labour which resides in it. […] But the raw material we know of which is suitable for an intellectual and inventive labour force - is *science, communication and communication of knowledge.* Capital must, therefore, appropriate communication. It must expropriate the community and superimpose itself on the autonomous capability of managing knowledge, reducing such knowledge to a mere means of every undertaking of the socialized worker. This is *the form which expropriation takes in advanced capitalism* - or rather, in the world economy of the socialized worker. [31]

Negri conceived the means of communication as both the means of reproducing the socialized worker's intellect, or 'raw material', and as a social product that capital alienates from the socialized worker. Consistent with the social factory thesis, Negri therefore suggested that the content of the means of communication has become subject to capital's conditioning:

> Production consists not only in the production of commodities, but in all the conditions necessary for the existence of productive subjectivities. Just as, for the mass worker, capital generated adequate wage conditions, so today, for the socialized worker, capital tries to establish the social conditions in which communication is to take place. *Communication is to the socialized worker what the wage relation was to the mass worker.* […] But communication is life. In advanced capitalism, therefore, conflict, struggle and diversity are focused on communication,

[30] Negri, *The Politics of Subversion*, 102-114.
[31] Ibid, 115, 116.

> with capital, by means of communication, trying to preconstitute the determinants of life.[32]

Hence, as capital attempts to control and condition the means of communication, the socialized worker tends to act as a communicative conduit to capital's pre-structuring of social life. While Negri suggested a division between communication and its embodiment in information and he also cautioned against the inadequacy of this division due to the mutual entanglement of both information and communication as a determination of the artificial constitution of reality,[33] he appears to have abstracted from the relation of production of the means of communication and from a technical analysis of the means of communication.

Based on this expanded analysis of the social factory, and therefore, on an expansion of the condition of capital's real subsumption and socialization of labour, Negri posited that a crisis in the measurement of value based on labour-time was developing with the emergence of the current class composition of the socialized worker, and that this was the realization of what Marx described in the *Fragment on Machines* as the developing transformative crisis in the capitalist mode of production.[34] Therefore Negri posited that the development of the socialized worker expressed the development of the conditions of communism from within the capitalist mode of production:

> The socialized worker represents the final resolution of the dialectic between liberation and emancipation at the liberation end of the continuum. […] The socialized worker is a kind of actualization of communism, its developed condition. The boss, by contrast, is no longer even necessary for capitalism. But as far as we are concerned, the situation is profoundly different: *we have gone beyond Marx, and the socialized worker has become a reality.*[35]

Hence, for Negri, the advance of real subsumption that produced the socialized worker was the historical condition that would eventually lead to the dissolution of the measure of value based on labour-time. However, while Marx posited that capital both develops and

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[32] Ibid, 118.
[33] Ibid, 119.
[34] Negri, *The Politics of Subversion*, 77-79.
[35] Ibid, 81-84.

subsumes the free-time of the social individual, he did not claim that the development of the social individual is the determining condition that leads toward a crisis in the measure of value based on labour-time. Rather, Marx indicated that it was *the development of full automation of the direct production process* that would lead to a transformative crisis in value production based on labour-time. Negri's interpretation therefore emphasized capital's development of the productive human forces of the general intellect rather than the advanced development of machinery that is necessary for the automation and replacement of labour in the direct production process, and thus, for the development of the productive forces of the general intellect as a direct force of production.[36]

While Negri's positing of the real subsumption of the figure of the socialized worker is consistent with Marx's explication of the dialectical logic of capital's tendency to both produce and reabsorb the free-time of the social individual as a new source of surplus value, it displaces the necessary conditions for Marx's crisis in the measure of value based on labour-time from the capitalist development of full automation of the direct production process to the development of the social individual, and thus, the general intellect as a direct force of production. Negri's anticipation of a becoming-communism was therefore an error precisely because it abstracted from Marx's analysis of the logic of capitalist development of the material forces of production that leads toward the total replacement of direct labour with autonomous machines in the production process as the necessary condition for a transformative crisis in the production of value based on labour-time. Rather, Negri placed this necessary condition in the development of the broader general intellect and the social relations within the social factory that contribute to value production but which are unproductive of surplus value. Hence, while Negri does, in fact, note the significance of automation in the era of the socialized worker in *The Politics of Subversion*, his reading of the *Fragment on Machines* adheres to the method of *operaismo,* evident in his emphasis on the development of the productive forces of the general intellect that appears separated from capital's absorption of the productive forces of the general intellect in the fixed capital of automation technologies.

[36] Ibid, 82.

Operaismo's tendency to abstract from capital's development of the material forces of production stems from its method and focus on the analysis of changing class composition for the purpose of identifying the development of the revolutionary subjectivity of the working class. The figures foregrounded at the centre of *operaismo*'s analyses exemplify this abstraction, evident in Negri's shift from the figure of the mass worker to the figure of the socialized worker. Although *operaismo's* identification of the revolutionary potential of central figures is based on historical analyses of changing class composition and the development of labour's structural power within the capital-relation to refuse work through mass strike actions, it lacked a deeper technical analysis of the material forces of production that dialectically determine the development of capital's dependency on the exploitation of the new forms of labour, the subsequent transformation of class composition, and the revolutionary potential of these central figures.

Negri's analysis of capital's subsumption of the means of communication of the socialized worker similarly mystifies the role of both capital and the bourgeois state's in forcing labour to produce the material and technical means of capital's subsumption of subjectivity and communication outside the point of production. Negri's analysis of the socialized worker is explicated from the perspective of the development of the general intellect, abstracted from the dialectical relation of capital's exploitation of the general intellect to the historical development of the material forces of production or fixed capital. Therefore if Negri's adherence to the method of *operaismo* resulted in a one-sided abstraction from the historical development of the fixed capital of the means of automation as the necessary condition for the emergence of the socialized worker, then his analysis of capital's real subsumption of the socialized worker similarly abstracts from capital's absorption of the productive forces of the general intellect in information technology as capital's means of controlling the subjectivity of the socialized worker. Thus *operaismo* and *post-operaismo* appear to overemphasize the revolutionary potential of the working class and the historical development of the general intellect at the expense of analyzing both capital's development of the material forces at the point of production as the necessary historical condition that Marx identified as leading toward the dissolution of the capitalist mode of production and capital and the bourgeois state's development of the material forces outside the point of production as the means of suppressing the revolutionary potential of the working class.

Negri's fusion with autonomist thought in the late 1980s and 1990s not only accelerated the politics of the refusal of work but it centred more directly on the emancipation of labour *from itself*. Nevertheless, his shift from the analysis of the development of the productive forces of social labour at the point of production to the development of the productive forces of the general intellect within the social factory signalled a major break with the productivist tendency of *operaismo.* The *post-operaismo* perspective emphasized that the general intellect refers not only to scientific knowledge, but to different forms of sociality, affects and social relations that capital has subsumed under new forms of waged labour. According to *post-operaist* authors, autonomists and regulation theorists, industrial capital flight and subsequent capital investment in the service industries transformed the Fordist era of manual labour and the mass production of commodities into a production process characterized by the customization of commodities according to consumer demand and the proliferation of *immaterial labour* in a new regime of accumulation referred to as the 'post-Fordist era'.

The category of immaterial labour was defined as labour that produces no discrete material product but rather, "…produces the informational and cultural content of the commodity."[37] Examples of immaterial labour include various forms of service labour, informational labour and emotional labour that do not produce individual material commodities, but rather, experiences, information and other 'process-oriented' or 'immaterial' commodities. Analyses of immaterial labour were accompanied by other categories such as 'cognitive labour', 'intellectual labour', and 'affective labour', that were used to describe the new waves of proletarianization. For *post-operaismo,* the development of the socialized worker therefore no longer signalled the becoming-communism of the capitalist mode of production. Rather, the figure of the socialized worker appears to have been absorbed by capital and turned into immaterial labour-power. A common assertion among *post-operaismo* authors is that capital's creation and appropriation of immaterial labour has produced a new form of capitalist production that has created a hegemony of immaterial labour over manual labour.[38] The revolutionary potential of the socialized worker therefore

[37] See Lazzarato, "Immaterial Labor."
[38] See Trott, "Immaterial labour and World Order."

appears to have shifted to the revolutionary potential of immaterial labour in new cycles of struggle.

The *post-operaismo* perspective was concretized and elaborated in the book *Empire*, in which Hardt and Negri analyzed capital's appropriation of information technologies, the decline of material labour and the rise of immaterial labour in western countries. Hardt and Negri argued the capital's development and appropriation of digital information technology within the sphere of production was transforming the relation of production to consumption within the service sectors of North America and in the industrial sectors of Germany and Japan.[39] This process of advanced technological development of the sphere of production was referred to as the "informatization of production', a concept that also included capital's absorption of new human sources of information. For example, Hardt and Negri argued that informatization included the Toyota method of manufacturing, which incentivized workers to provide informational feedback for managerial decisions, the reorganization of production and quality improvement. Yet, for Hardt and Negri, informatization also referred to the development of digital information technologies that were used for the lean manufacturing paradigm and 'just-in-time' production, which allowed the tailoring of stock and the timing of production to demand as determined by informational feedback from the consumption sphere.[40] It was argued that these developments were transforming the relation of consumption to production, with feedback from the consumption sphere increasingly determining production in an emerging post-Fordist model of "networked production'.[41]

Hardt and Negri also extended the analysis of the reach of capital within the social factory by introduced the concept of biopolitical production, a term that draws on Foucault's concept of biopower and that refers to the advance of capitalist development that is turning social life itself into a source of value. This perspective appears to link to arguments of feminist scholars concerning capital's indirect appropriation of unproductive labour. In this view, capital appears to have subsumed not only the general intellect, but the also the human body and every moment of life itself. Consistent with the *operaismo* method, Hardt and Negri argue that capital's deepening into the moments of social life itself is the process

[39] Ibid, 286.
[40] Ibid, 289-290.
[41] See Hardt and Negri *Empire,* 280-303.

of capital's empowerment of the multitude, and therefore, capital is again creating the means of its own undoing. This occurs through the development of the hegemony of immaterial labour and its central role in the development of a new revolutionary potential within the proletariat though its re-appropriation of networked information technology, though Hardt and Negri stop short of suggesting that the potential exists for immaterial labour to communicate and organize through digital communication at the global level.[42]

Hardt and Negri's analysis in *Empire* more directly acknowledged the significance of capital's development of the material forces of production in the specific form of digital information technology. However, information technology was not explicated as an objectification of the scientific knowledge of the general intellect, nor were information technologies differentiated according to their specific function as object of labour, means of labour, means of controlling labour and/or the means of controlling the means of production. Further, the argument that global capitalism has become dominated by the hegemony of immaterial labour appears abstracted from both the dominance *and* interdependence of immaterial labour with manual labour. This may be directly contrasted with the continued dominance of manual labour in countries where capital exploits the lower cost of manual labour-power through outsourcing and offshoring and where a smaller proportion of immaterial workers persist.

With a similar expansive focus, *post-operaismo* author Paolo Virno centres on the primary attribute of post-Fordist living labour as its capacity for *mass intellectuality*, a form of the general intellect that cannot be absorbed into machinery, or fixed capital.[43] Virno's emphasis on mass intellectuality appears to be a continuation of the identification of a central figure in the epochs of class struggle that began with the mass worker, shifted to the socialized worker and then to the general social condition of intellectuality. Again, by abstracting from the historical development of fixed capital, Virno departs from Marx's dialectical exposition of the relation between the general intellect and the means of its objectification. In effect, Virno's concept of mass intellectuality as the primary social condition of post-Fordism exemplifies *post-operaismo's* expanded conception of the social

[42] On this point, see Dyer-Witheford, *Cyber-Negri*, 153.
[43] Virno, "General Intellect," 6.

factory thesis, but it also appears to leaves room for the autonomy of the general intellect outside of capital. As Pasquinelli noted, "according to Virno the error of traditional Marxism is to consider the general intellect only as fixed capital crystallized into industrial machinery and not as living labour diffused across the whole linguistic activity of the metropolis…"[44] However, while for Virno the general intellect refers to *intellectuality in general*, he does not specify whether he considers mass intellectuality an attribute of living labour, or of human existence outside of the category of labour, or both. Insofar that mass intellectuality is held as evidence of capital's development of the social conditions of its own supersession, then the narrative of the development of the revolutionary subjectivity of the multitude demonstrates continuity with the limitations of *operaismo's* method of analysis.

Within *post-operaismo* is the hypothesis of 'cognitive capitalism', a perspective that builds on both *operaismo* and *post-operaismo* analyses of capital's development and subsumption of the productive forces of the general intellect. According to the hypothesis, the industrial capitalism that superseded mercantile capitalism has now been superseded by a third form of capitalism, namely, *cognitive capitalism*.[45] For Vercellone cognitive capitalism expresses a third stage of capital's real subsumption of the labour process that succeeds the stage of capital's formal subsumption and real subsumption of the labour process. According to Vercellone, formal subsumption occurred during the stage of advanced mercantilism and while the transition to real subsumption resulted in industrial capitalism. Capital's appropriation of the labour-power of the general intellect began with the extraction of knowledge and skills of the 'mass worker' in tandem with the appropriation of surplus value during the Fordist era that occurred alongside the gradual development of the productive forces of the general intellect though the system of state-funded education.[46] The development of the assembly line and the replacement of labour-power with machines in the Fordist factory system revolutionized the division of labour that created the social conditions for the emergence of primarily 'intellectual workers' leading to the crisis of Fordism that would lead to post-Fordist development and the knowledge economy. With the emergence of the new cognitive form of capitalism, cognitive workers are employed not

[44] Pasquinelli, "Italian *Operaismo* and the Information Machine," 9.
[45] See Moulier-Boutang, *Cognitive Capitalism.*
[46] See Vercellone, "From Formal Subsumption to General Intellect."

only within sites of material production but they are also employed in service industries as a new type of labour-power that produces different forms of intellectual, cognitive or affective commodities.[47] Thus previous stages of capitalist development created the historical precondition for the development of a third stage of subsumption, referred to as cognitive capitalism, where capital now exploits the new forms of social intellectuality, skills and divisions of labour adequate for the production of material commodities and new 'immaterial' commodities.[48]

While Moulier-Boutang appears to suggest that the extraction of surplus value continues under cognitive capitalism, Vercellone argues that, "this new phase of the division of labour is accompanied by the crisis of the law of value-labour and by the strong return of mercantile and financial mechanisms of accumulation. The principal elements of this new configuration of capitalism and of the conflicts that derive from it are, in large measure, anticipated by Marx's notion of the general intellect."[49] Cognitive capitalism at times, therefore, appears consistent with *post-operaismo's* general claim that capital's development of immaterial labour and the general intellect is creating a crisis in measurement and value production based on labour-time, and therefore, is leading to capital's own self-dissolution through its development and exploitation of the autonomous power of immaterial labour and the general intellect.

In summary, the theme of the self-dissolution of the capitalist mode of production is consistent throughout *operaismo* and *post-operaismo's* interpretations of Marx's *Fragment on Machines*, which contain implications of the development of the general intellect and capital's subsumption of the general intellect into new forms of immaterial labour-power. These interpretations, however, have followed the *operaismo* and *post-operaismo* model of capital's self-dissolution that focuses on the changing technical, class and political composition of labour, while abstracting from the value composition of labour and both the technical and value composition of advanced machinery. I turn now to an analysis of the *operaismo* and *post-operaismo* interpretations of the *Fragment on Machines* that centres on the assertions of an impending transformative crisis in value production based on labour-

[47] Ibid, 47-48.
[48] Ibid, 25-26.
[49] Vercellone, "From Formal Subsumption to General Intellect," 16.

time. From the implications of this analysis, I argue for a reinterpretation of Marx's *Fragment on Machines* that shifts from the development of the productive forces of the general intellect to its objectification in the fixed capital of advanced automatic machinery as the necessary condition that leads to the transformative crisis in value production based on labour-time.

1.2 Analysis of *Operaismo* and *Post-Operaismo* Interpretations of the *Fragment on Machines*

As discussed, the *operaismo* perspective held that while capitalists exploit the working class, exploitation simultaneously develops the revolutionary subjectivity of the working class, which will lead the proletariat to either overthrow the capitalist mode of production or to the self-abolishment of labour entirely. While Tronti's social factory thesis appears to have identified the tendency of advanced capitalist development that has led to the opening of the factory walls and capital's real subsumption of state and society, Negri's extension of the social factory thesis shifted the emphasis from the mass worker to the development of the socialized worker as the new revolutionary potential that will lead to the dissolution of the capitalist mode of production. However, Negri's subsequent analysis of capital's attempt to subsume the means of communication in *The Politics of Subversion* introduced both possibilities and limits to the development of the revolutionary subjectivity of the socialized individual. On this point, autonomist insights have famously highlighted that the antagonism of the labour-capital drives capital's learning and adaptation to the resistance of labour, and thus, to the development of new tactics and strategies that capital and the bourgeois state use to suppress the revolutionary activities of the proletariat. Therefore, while Hardt and Negri analyze capital's development of network information technology and the potential for working class re-appropriation of these technologies in *Empire*, their analysis abstracts from a technical analysis of the military and intelligence services'

contemporary development of the Internet infrastructure[50,51] as the means of subsuming the bourgeois state and society, and thus, as the means of enclosing, and producing, bourgeois society within the social factory. It therefore appears that the dialectical logic of capitalist development that leads the system toward its own destruction through its development of the revolutionary subjectivity of the working class has become increasingly mediated and managed cybernetically by the historical development of the Internet infrastructure that serves as both the means of social communication and the means of surveillance.[52] Thus with capital and bourgeois state development of network information technology as the means of the social and political repression of the proletariat, it appears that the dialectical unfolding of the *material forces of production* is more likely to determine the supersession of the capitalist mode of production, rather than the dialectical unfolding of the social and political resistance of the proletariat.

On this point, *post-operaismo* authors have suggested that with the general intellect increasingly producing value outside of the direct production process, capital cannot capture this value, and therefore, the advanced development of the capitalist mode of production is creating the means of its own dissolution. Hence, post-operaismo authors have suggested that the continued development of immaterial labour in western countries accelerates the development of a communist mode of production that will supersede the capitalist mode of production. On these premises, *post-operaismo* interpretations of the *Fragment on Machines* have led to the widely held assertion that capital's subsumption of

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[50] Bernstein, "The CIA and the Media," *Rolling Stone Magazine*, Reprinted at http://www.carlbernstein.com/magazine_cia_and_media.php. With the development of *Operation Mockingbird*, the CIA's infiltration and co-optation of broadcast media networks, journalists, intellectuals and student organizations appeared to operationalize the techniques of psychological and information warfare in the broadcast media space.

[51] See Levine, *Surveillance Valley*, 101-184. For example, the *Cambridge Project* was a counterinsurgency military project that allowed intelligence analysts and military planners to upload several forms of information to the ARPANET that could then be used to generate predictive models and simulations about third world countries and left-wing groups. This was developed into another counterinsurgency military project called *Project Camelot*, officially titled "Methods for Predicting and Influencing Social Change and Internal War Potential," in which ARPANET technology was used as a predictive warning system intended to prevent far-left social and political movements.

[52] See Levine, *Surveillance Valley*, 185-217. See, for example, the history of ARPANET as a tool of predicting and suppressing left-wing socialist movements. This history, combined with Edward's Snowden's revelations that the NSA was collecting big data about populations through the front-facing commercial Internet appears to exemplify the autonomist insight capital and the bourgeois state have developed this infrastructure as a result of the inputs of populations, including the resistance of social and political movements from below.

the general intellect under the wage form, and thus, the transformation of the general intellect into immaterial labour-power is leading to Marx's infamous transformative crisis in value production based on labour-time as outlined in the *Fragment on Machines*. However, this is at odds with Marx's dialectical analysis of the logic of the capitalist mode of production's self-created transformative crisis in the measure of value based on labour-time as outlined in the *Fragment on Machines* because it misplaces the necessary conditions that determine the dissolution of the capitalist mode of production as residing in the historical development of the general intellect rather than in the fixed capital of autonomous machinery that the capitalist class forces the general intellect to produce and that dialectically leads to the full development of the general intellect as a direct force of production. Rather, Marx's emphasis was on capital's absorption of the productive forces of the general intellect in the advanced development of the fixed capital of autonomous machines, and the implications of the total replacement of direct labour in the production process as the necessary condition that will lead to a crisis in value production based on labour-time. Thus *operaismo* and *post-operaismo* interpretations of Marx's *Fragment on Machines* appear to have abstracted from Marx's emphasis on the development of the fixed capital of autonomous machines.

According to Marx, direct labour creates value in the production process on the condition of capitalists' exchange of the wage-form of variable capital for labour-time based on the necessity of the specific forms of labour-power that are required for setting the production of use values in motion. As Marx noted, the exchange of living labour for objectified labour in the sphere of production formed the value-relation, and thus, labour-time as the measure of value.[53] In the production process, labour transfers the cost of the means of production and the cost of its own labour-power to the product. Labour therefore creates *value*, but the production of commodity-values beyond the costs of labour-power, and thus, the capitalist exploitation of unpaid labour-time produces *surplus value*. Therefore, "labour-time as the measure of value posits wealth itself as founded on poverty, and disposable time as existing in and because of the antithesis to surplus labour time; or, the positing of an individual's entire time as labour time, and his degradation therefore to mere worker, subsumption

[53] Marx, *Grundrisse*, 704.

under labour. The most developed machinery thus forces the worker to work longer than the savage does, or than he himself did with the simplest, crudest tools."[54] As the law of competition forces industrial producers to increase the production of surplus value and lower the costs of production, the employment of labour-saving machinery in one branch of production therefore creates the demand for labour-saving machinery across industries.

As capitalist appropriation of the scientific knowledge of the general intellect is absorbed in the re-organization of the labour process and in the production of labour-saving machinery, capitalists therefore continuously revolutionize and re-appropriate labour-saving machinery in order to extend or replace the productive forces of labour-power in the sphere of production, which tends to reduce the skills and motive power of labour required for the direct production process[55] and leads capitalists to reduce the total number of workers employed in the sphere of production.[56] As outlined in *Capital*, a total average reduction in workers in relation to machines in the sphere of production leads to tendency of a fall in the rate of profit. As Marx outlined in the *Grundrisse*, with the advanced development of the capitalist mode of production, capitalist appropriation of the productive forces of the general intellect leads to the historical development of manually operated labour-saving machinery into *automatic systems of machinery*,

> As long as the means of labour remains a means of labour in the proper sense of the term, such as it is directly, historically, adopted by capital and included in its realization process, it undergoes a merely formal modification, by appearing now as a means of labour not only in regard to its material side, but also at the same time as a particular mode of the presence of capital, determined by its total process -- as *fixed capital.* But, once adopted into the production process of capital, the means of labour passes through different metamorphoses, whose culmination is the *machine*, or rather, an *automatic system of machinery* (system of machinery: the *automatic* one is merely its most complete, most adequate form, and alone transforms machinery into a system), set in motion by an automaton, a moving power that moves itself; this automaton consisting of numerous mechanical and intellectual organs, so that the workers themselves are cast merely as its conscious linkages. In the machine, and even more in machinery as an automatic system,

[54] Ibid,
[55] Marx, *Capital: Volume I.*
[56] Ibid.

> the use value, i.e. the material quality of the means of labour, is transformed into an existence adequate to fixed capital and to capital as such; and the form in which it was adopted into the production process of capital, the direct means of labour, is superseded by a form posited by capital itself and corresponding to it. In no way does the machine appear as the individual worker's means of labour. Its distinguishing characteristic is not in the least, as with the means of labour, to transmit the worker's activity to the object; this activity, rather, is posited in such a way that it merely transmits the machine's work, the machine's action, on to the raw material -- supervises it and guards against interruptions.[57]

As Marx outlined further into the text, with the total replacement of direct labour with autonomous machines,

> Labour no longer appears so much to be included within the production process; rather, the human being comes to relate more as watchman and regulator to the production process itself. (What holds for machinery holds likewise for the combination of human activities and the development of human intercourse.) No longer does the worker insert a modified natural thing [*Naturgegenstand*] as middle link between the object [*Objekt*] and himself; rather, he inserts the process of nature, transformed into an industrial process, as a means between himself and inorganic nature, mastering it. He steps to the side of the production process instead of being its chief actor. In this transformation, it is neither the direct human labour he himself performs, nor the time during which he works, but rather the appropriation of his own general productive power, his understanding of nature and his mastery over it by virtue of his presence as a social body – it is, in a word, the development of the social individual which appears as the great foundation-stone of production and of wealth. *The theft of alien labour time, on which the present wealth is based,* appears a miserable foundation in face of this new one, created by large-scale industry itself. As soon as labour in the direct form has ceased to be the great well-spring of wealth, labour time ceases and must cease to be its measure, and hence exchange value [must cease to be the measure] of use value.[58]

While Marx appears to suggest that a fully autonomous direct production process would require the indirect labour of a regulator or ‘watchman’ for the monitoring, maintenance

[57] Ibid, 692.
[58] Marx, *Grundrisse*, 704-705.

and adjustment of autonomous machines, indirect labour that is employed in a fully automated direct production process does not set in motion a labour process that directly produces use values. Hence, it would appear that because indirect forms of labour-power cannot produce value, nor surplus value, the measure of value based on labour-time would indeed cease. Therefore Marx's dialectical exposition revealed that with advanced development of the capitalist mode of production, the total replacement of direct labour, and thus, the source of surplus value with autonomous machines,[59] is the realization of the internal contradiction of the capitalist mode of production that will lead to the dissolution of the measure of value based on labour-time, and thus, the dissolution of exchange value as the measure of use value. As Marx noted, this leads to the creation of wealth based not on labour-time, but on the general development of the scientific knowledge of the general intellect and its application to the production process:

> But to the degree that large industry develops, the creation of real wealth comes to depend less on labour time and on the amount of labour employed than on the power of the agencies set in motion during labour time, whose 'powerful effectiveness' is itself in turn out of all proportion to the direct labour time spent on their production, but depends rather on the general state of science and on the progress of technology, or the application of this science to production.[60]

Thus *post-operaismo's* view that the historical development of the hegemony of immaterial labour is leading to a dissolution in the measure of value based on labour-time appears to be a result of a focus on the technical, class and political composition of labour as the subject instead of the development of the fixed capital in the form of advanced machinery at the point of production as the subject.

As discussed in the review and analysis of the literature, the method of *operaismo* and its focus on the technical, class and political composition of labour has shaped the method and focus of *post-operaismo* and its interpretations of *Fragment on Machines*. While the insights developed by the autonomous Marxist school of thought have been grounded in the history of class struggle, its development proceeded from *operaismo's* inversion of

[59] Ibid, 704-706.
[60] Ibid.

dialectical materialism, which was motivated less by scientific reason, and more by the political reactivity of the Italian Marxists who dissented from the top-down control of the PCI and other formal organizations involved in the political representation of labour. In particular, *operaismo's* methodological inversion of dialectical materialism was based on the concept that capitalist development has been driven by the resistance and struggle of the working class, which capital reacts to antagonistically through new laws, tactics and violence in order to secure the subordination of the working class. Thus *operaismo* subsequently viewed capital's real subsumption of society as a process that is driven by class struggle against capital.

Operaismo's method of inversion has led to attempts to theorize capital's self-dissolution through its development of the revolutionary subjectivity, self-organization and/or self-empowerment of a particular class composition that emerges from the cycles of struggle. Hence, *operaismo's* inversion method has led to its focus on the technical, class and political composition of labour as a subject while abstracting from the value composition of labour and both the technical and value composition of autonomous machinery. This is both a theoretical orientation and research strategy that appears to have carried over to the *post-operaismo* perspective in varying degrees and among various authors who emphasize the role of a particular form of labour that, either through direct revolutionary activity, labour's self-abolishment and/or self-organization of social reproduction, or by virtue of the very development of a particular segment of the working class, is the embodiment of capital's own dissolution of value production based on labour-time.

As a direct consequence of the inversion method, subsequent *post-operaist* interpretations of the *Fragment on Machines* have displaced Marx's necessary conditions for the transformative crisis in value production based on labour-time by removing them from the development of autonomous machines at the point of production, and placing these conditions instead with the development of the general intellect both within and outside the direct production process. As a result, *contra* Marx, *post-operaismo* authors focus on changes to the technical composition of labour expressed in the concept of the socialized worker and immaterial labour, capital's indirect exploitation of unproductive labour and social relations as evidence that value production has become immeasurable. Therefore it

would appear that *post-operaismo's* emphasis on the technical composition of immaterial labour, while abstracting from a systematic analysis of the value composition of immaterial labour, or abstract labour, has led to a fetishization of the specific forms in which the general intellect has been turned into wage labour, which is then extended to claims concerning its role in the process of the dissolution of value production and in the development of its revolutionary potential. Thus because *post-operaismo's* emphasis on the development of the general intellect abstracts from capital's role in absorbing the general intellect for the production and development of fixed capital in the form of advanced autonomous machinery, *post-operaismo* also abstracts from Marx's necessary conditions for the development of a crisis in value production based on labour-time as residing in the full automation of the sphere of production.

The literature has been summarized with respect to the knowledge of the general intellect and its objectification as fixed capital in the specific form of information technology. The relation between capital's absorption of the labour-power of the general intellect in the development of fixed capital may be understood as the general relation between living labour and capital as past labour. A focus on the productive forces of the general knowledge embodied in living labour has been the more prevalent focus in the contemporary literature concerning the general intellect in relation to the fixed capital that absorbs the labour-power of the general intellect. On the grounds outlined above concerning *operaismo* and *post-operaismo's* interpretations of the *Fragment on Machines,* I suggest a return to the investigation of capital advances a contemporary interpretation of the *Fragment on Machines* that suggests the historical development of the fixed capital of network information technology has become the means of enclosing and producing bourgeois society within the social factory, which has therefore led to the development of advanced autonomous machines at the point of production as the necessary historical condition that will lead to a transformative crisis in the measure of value based on labour-time *that will lead to the supersession of the capitalist mode of production,* rather than the development of the revolutionary potential of the working class.

1.3 Thesis Statement

Due to the object of study and method, *operaismo* and *post-operaismo* emphasized capital's creation of immaterial labour-power and the general intellect as an indication of realization of the dissolution of the measure of value based on labour-time and a becoming-communism. However, as Marx indicated, it is the historical development of the fixed capital of automatic machinery that replaces direct labour in the production process that is the necessary condition for the development of the general intellect as a direct force of production and that will lead to the transformative crisis in the measure of value based on labour-time. The alternative explanation for the proliferation of immaterial labour offered by this thesis is that the manifestation of the global expanded reproduction and differentiation of the capitalist mode of production has led to capital's development, subsumption and transformation of the general intellect into new forms of labour-power.

The *operaismo* and *post-operaismo* perspectives were developed from Marx's perspective that capital contradictorily develops the revolutionary potential of the working class. However, Tronti's social factory thesis and Negri's expansion on this concept through his analysis of capital's attempt to subsume the means of communication has been realized with the bourgeois state and capital's absorption of the scientific consciousness of the general intellect in the global development of the Internet infrastructure, which contains both the means of communication and the means of surveillance as the cybernetic means of the real subsumption of society. This has shifted the historical condition that will lead to the supersession of the capitalist mode of production from the development of the revolutionary potential of the working class to the development of the material forces of production.

As the historical development and combination of information technology with machinery was a necessary condition for the development of autonomous machinery at the point of production, this integrated article thesis therefore necessarily introduces a historical materialist approach to the development of social consciousness, information and information technology as *material forces of production*. The thesis introduces an

interpretation of the *Fragment on Machines* that expands on Marx's concept of the general intellect to propose a new category, termed *the general artificial intellect,* which refers to the total processing power of information technology that exists within global capitalist society, ranging from the most basic calculators to the most sophisticated forms of artificial intelligence and quantum computing. As network information technologies are produced according to the capitalist method of production, the elements of the general artificial intellect therefore appear in the commodity-form. Competition for the extraction of surplus value compels capitalists to re-appropriate the elements of the general artificial intellect as a means of production to extend, replicate and/or replace both direct labour-power and indirect labour-power in the sphere of production and in the circulation sphere.

As Marx noted, the transition from the feudal mode of production to the capitalist mode of production was defined by capital's formal subsumption of labour under the wage form within specific sites of production, while the real subsumption of labour was defined by capital's reorganization of the labour process through the application of science and labour-saving machinery. This thesis suggests that the replacement of direct labour with automatic machinery is the necessary condition for a transformative crisis in the measure of value based on labour-time that Marx outlined in the *Fragment on Machines*, but insufficient for the supersession of the capitalist mode of production. Rather, as unpaid labour is the source of surplus value, the gradual replacement of *all* direct and indirect labour-power with automatic machinery in the global sphere of production and thus, the replacement of all variable capital with constant capital, sets in motion the supersession of the capitalist mode of production by what I refer to as the *autonomous mode of production.* The bourgeois state and capitalist re-appropriation of the elements of the general artificial intellect for the development of smart cities exemplifies the network digitalization of the social factory and the expanded production of big data as the means of materializing global capitalist development.

1.4 Approach to the Analysis of the Means of Representation, Social Consciousness and Information Technology as *Material Forces of Production*

Based on the limitations of autonomist Marxist approaches that have overemphasized the historical development of the general intellect, this integrated article thesis introduces an approach to the analysis of the historical development of the specific forms of fixed capital. While other authors in the field of library and information science literature (LIS) have analyzed and critiqued *operaismo* and *post-operaismo's* interpretations of Marx's concept of the general intellect and concepts of value and social capital in the information society,[61, 62, 63] the approach of this thesis goes further by returning to Marx's materialist conception of history and extending his method to the phenomena of social consciousness, information technology and information by drawing on materialist conceptions of information technology and information from LIS.[64, 65, 66, 67] The method of this integrated article thesis adopts Marx's dialectical method and approach to the analysis of the logic of capital found in the core works of *The German Ideology*, *The Grundrisse* and *Capital*. This includes elements of what has been referred to as contemporary value theory,[68] but what I see simply as a necessary element of Marx's dialectical analysis of the political economic relation of use value to exchange value.[69, 70] Finally the thesis uses this approach to reformulate the content of autonomist Marxist insights regarding the contemporary development of the new forms of labour that have arrived with the development of new forms of information technology in the post-Fordist era with an emphasis on the historical development of the fixed capital of information technology as outlined in the literature

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[61] See Witheford, "Autonomist Marxism and Information Society."
[62] See Day, "Social Capital, Value and Measure." Ron Day's work, noted here, was significant in introducing autonomist Marxist concepts to the field of LIS, specifically, the concept of social capital and the measure of value. In addition, Day critiques mentalistic and/or unobservable notions of information as mystical and rather argues in favour for social and materialist conceptions of information.
[63] See Dyer-Witheford, "Antonio Negri: Information and Empire."
[64] See Buckland, "Information as Thing."
[65] See Lund, "Document Theory," for a review and analysis of social theories of documents and information.
[66] See Smith, "Texts and the Ontology of Organizations and Institutions."
[67] See Frohmann, "Revisiting 'What is a Document'?"
[68] See Heinrich, *An Introduction to the Three Volumes of Karl Marx's Capital*.
[69] See Marx, "The Value-Form."
[70] Also on this point, see Backhaus, "On the Dialectics of the Value-Form."

review. Thus the approach draws upon and contributes to the LIS literature a historical materialist analysis of the development of the forces of social consciousness, information and information technology within he historically specific relations in which they are found.

Hegel's dialectical logic on the premises of idealism posited that the thought determinations of human consciousness are *forms of reference* that are *self-determined*.[71] Marx's reformulation of the Hegalian dialectical on the premises of materialism, however, held that consciousness reflects the historically specific social and material relations within which it is found on definite and verifiable materialist premises.[72] This approach re-posits and expands on Marx's materialist premises as a general informational process. Based on a modification of the data, information, knowledge and wisdom hierarchy, [73, 74, 75] 'data and information' are posited all means of representation that are external to social consciousness, while 'knowledge' refers to as one aspect of the internal ideal content of consciousness.

As the necessary means of reproducing human life, all content of the external world is either a direct product of nature or a product of nature that has been transformed by the expenditure of human energy. All content of the external world is therefore posited as a material means of human reproduction that are, at the same time, a *means of representation*, or what is commonly referred to as the qualitative and quantitative aspects of 'data and information'. I refer to the qualitative aspects of 'data' as any means of representation that appear to human consciousness and that require additional human or machine processing for the production of meaning, while 'information' refers to any readily interpretable means of representation. [76] Any information that becomes

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[71] Hegel, *Science of Logic*.
[72] Marx, *The German Ideology*, 47.
[73] See Zins, "Conceptual Approaches for Defining Data, Information and Knowledge."
[74] See Rowley, "The Wisdom Hierarchy: Representations of the DIKW Hierarchy."
[75] See Frické, "The Knowledge Pyramid: A Critique of the DIKW Hierarchy."
[76] While this thesis draws a general categorical distinction between 'data and information' as all phenomena external to consciousness and 'knowledge' as the content of consciousness on materialist premises, it adds elements of the noted approaches of other LIS authors to the distinction between data and information. In this case, whether a means of representation is 'data' or 'information' is determined by whether it requires additional processing in order to produce a content that carries meaning. The dissolution of the meaning of a particular means of representation is therefore the dissolution of 'information' into a state of 'data'. Information for one observer may therefore appear as data for another and visa versa. The determination of the distinction therefore is subjective and therefore a matter of convention.

uninterpretable, and that requires additional human or machine processing for interpretation, therefore becomes ‘data’.

On the one hand, the senses of the body *mediate* the means of representation and *objectify it* ideally through signals sent to the brain.[77] While this movement appears as a metamorphosis of the material into the ideal, the objectification of the means of representation in consciousness also develops the brain *materially.* The material content of the external world is therefore an abstract determination of both the ideal and material content of consciousness. The material development of the brain’s capacity to identify and recall the content of consciousness, and thus, to re-objectify the ideal content of consciousness *in* consciousness, is the precondition for the development of *self-consciousness,* and appears as a necessary precondition for production.[78]

The means of representation of the external material world produces in consciousness a *social form of reference* that refers to a *content of reference*. An *immanent means of representation* produces a social form of reference that refers back to itself as its content of reference.[79] However, an immanent means of representation may also produce a social form of reference that alienates itself as the content of reference, appearing in consciousness as also an *ideally detached means of representation* or a *materially detached means of representation*. An ideally detached means of representation produces an ideal content of consciousness as a social form of reference that is ideally *detached* from an external material content of reference.[80] In contrast, a materially detached means of representation

[77] On this point, it critical to note that the content of the means of representation is independent from the individual functions of its idealization.

[78] On this point, see Marx, *Grundrisse*, 85: “No production possible without an instrument of production even if this instrument is only the hand. No production without stored-up, past labour, even if it is only the facility gathered together and concentrated in the hand of the savage by repeated practice.”

[79] See Marx, *Capital, Vol I*, 126-127. What I refer to as an *immanent means of representation* is derived from Marx’s analysis of the natural quantitative, qualitative and functional properties of use values.

[80] See Marx, *Grundrisse*, 101. What I refer to as an *ideally detached means of representation* is derived from Marx’s critique of Hegelian philosophical consciousness. For example, the ideal concept of philosophical thought, mathematical abstraction, fictional stories, etc. and other ideal states of consciousness do not refer to an external material content.

produces an ideal content of consciousness as a social form of reference that is ideally *attached* to another external material content of reference.[81, 82]

On the other hand, the movement of the objectification of the means of representation *in* social consciousness is merely a one-sided abstraction of its negation in the movement of the objectification *of* social consciousness. The other side of this abstraction is found in Marx's *Grundrisse*, which contains descriptions of the objectification, and thus, materialization, *of* the ideal content of social consciousness.[83] On this point, the brain objectifies the ideal content of consciousness through the body and through any other material means of objectification[84] as the means of *materializing* the ideal content of

[81] See Marx, *Grundrisse*, 145. What I refer to as a *materially detached means of representation* is a general conceptual extension of Marx's analysis of the relative value-form and equivalent value-form of the commodity that has been applied to the material and ideal aspects, and thus, the form and content, of data and information. As Marx noted, the material or natural aspects of a commodity appear as its use value. The commodity as it appears as a use value in consciousness is therefore a form of reference that is *immanent* to its material form as a content of reference. As Marx noted, however, the use value of commodity A in an exchange relation appears as an *exchange value* that appears immanent to commodity A, but is actually determined by its *value relation* to commodity B. Thus, the value of commodity A is a content of reference that is determined by its relation to commodity B as the form of reference as it has been materially detached from its content of reference.

[82] Ibid. With the historical development of money, the means of expressing value were objectified in the object of money as a form of reference that stands outside the commodity and that serves as the quantitative expression or general equivalent of the value of the commodity as its content of reference. In this sense, the determination of the value of commodities is objectified, and thus, materially and ideally separated, in the general equivalent of money, which takes the place of the equivalent commodity as the quantitative expression of value, and thus, stands externally as the form of reference in relation to all commodities as its contents of reference. As Marx wrote in the *Grundrisse*, "The definition of a product as exchange value thus necessarily implies that exchange value obtains a separate existence, in isolation from the product. The exchange value which is separated from commodities and exists alongside them as itself a commodity, this is–money. In the form of money, all properties of the commodity as exchange value appear as an object distinct from it, as a form of social existence separated from the natural existence of the commodity. (This to be further shown by enumerating the usual properties of money.) (The material in which this symbol is expressed is by no means a matter of indifference, even though it manifests itself in many different historical forms. In the development of society, not only the symbol but likewise the material corresponding to the symbol are worked out–a material from which society later tries to disentangle itself; if a symbol is not to be arbitrary, certain conditions are demanded of the material in which it is represented. The symbols for words, for example the alphabet etc., have an analogous history.) Thus, the exchange value of a product creates money alongside the product."

[83] See Marx, *Grundrisse*, 832. "The bourgeois economists are so much cooped up within the notions belonging to a specific historic stage of social development that the necessity of the objectification of the powers of social labour appears to them as inseparable from the necessity of their alienation vis-à-vis living labour".

[84] See Marx, *Capital, Volume I*, 134. "If we leave aside the determinate quality of productive activity, and therefore the useful character of the labour, what remains is its quality of being an expenditure of human labour-power. Tailoring and weaving, although they are qualitatively different productive activities, are both a productive expenditure of human brains, muscles, nerves, hands etc., and in this sense both human labour. They are merely two different forms of the expenditure of human labour-power."

consciousness that is developed from the social and material relations of the life process.[85] The means of objectifying the content of consciousness include any movement of the body, vocalization and any external material. The objectification, and thus, the materialization of consciousness is therefore, in turn, the material production of a means of representation, which also produces an ideal content of consciousness. The objectification of the material content of consciousness, however, appears as a metamorphosis of the ideal into the material.[86]

It is the conceptual unification of the objectification *in* social consciousness and the objectification *from* social consciousness that results in a *double* movement of the material to the ideal and the ideal to the material that is simultaneously the movement of the ideal to the material and of the material to the ideal.[87] Therefore, *material production is at the same time 'immaterial production' (ideal production), while immaterial production (ideal production) is at the same time material production*. However, despite the appearance of the ideal aspects of this dialectical relation, both movements are *material forces of production.*It is the *social reproduction* and *autonomization* of a means of representation that produces historically specific social forms of reference as part of the *general social consciousness, or general intellect.* 'Social consciousness' therefore refers to the historical specific ideal content that is developed from historically specific social and material relations, while the *objectification* of the content of this social consciousness materializes it within historically specific social and material relations. Thus analysis of the dialectical relation of the objectification *in* social consciousness to the objectification *of* social consciousness may be approached on the premises of *historical materialism.*

Capital's development and reabsorption of the productive forces of the general intellect has driven the historical development of the material forces of production. This includes the historical development of energy sources that have led to the production of material-processing machines driven by natural and animal forces, machines driven by human

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[85] This introduces *materialist premises* to the objectification of social consciousness as a material force of production, which Marx notes with respect to the concept of the general intellect in *The Fragment on the Machines*, but which was never elaborated in the *Germany Ideology*.

[86] On this point, it is critical to note that the ideal content of consciousness is independent from the *social* functions of its materialization.

[87] On this point, see Marx, *Grundrisse,* 89, "The person objectifies himself in production, the thing subjectifies itself in the person…"

forces, and machines driven by coal, oil, natural gas, and solar and wind power. With respect to information-processing machines, I have developed the category of *the general artificial intellect* to refer metaphorically to the historical development of the total processing power of information technology in global capitalist society as a product of the materialization of the productive forces of the general intellect, ranging from the most basic calculators to the most sophisticated forms of artificial intelligence and quantum computing.

The relation of the general intellect to the general artificial intellect includes various combinations of the relations of humans to machines, machines to humans and machines to machines. 'Data' and 'information' are therefore refers to all means of representation that produce the ideal content of human consciousness and the 'ideal content' of 'machine consciousness' of information technology. The materialization of the ideal content of both human and 'machine consciousness' includes a range of various combinations of forces such as the materialization of data and information through human-directed machine actions, machine-influenced human actions, human to human actions and machine to machine actions. The historical development and combination of material-processing machines with information-processing machines has also led to the advanced development of electrically-powered autonomous machines that have been used to extend or replace labour-power in various forms of production.[88] However, with the development of the fourth industrial revolution, the integration of network information technology, or the 'internet of things', with autonomous machines has produced cyber-physical systems that have the potential to entirely replace various historically specific forms of the objectification of human consciousness, including both direct labour-power and indirect labour-power in the production process.[89] The approach of this thesis interprets and

[88] See Ramtin, *Capitalism and Automation*, 29-90. The concept of the combination of material-processing machines and information-processing machines that I have outlined is described in detail in *Capitalism and Automation.* In this book, Ramtin describes the historical development of mechanical control, numerical control and the combination of these technologies in the development of machines that function as both the means of conceptual automation and the means of automating execution in the production process, which is a division in the functions of machines that I suggest appears to parallel the human division of labour between conception and execution in the labour process.

[89] Ibid. While Ramtin outlines historical development of the technologies of automation as material forces of production, the distinction between the development of individual automation technologies and the technologies of Industry 4.0 is the development of the *means of coordinating the behaviour and functions of automation technologies* with network information technologies in the production process to create an 'internet of things', which has produced what has been defined as *cyber-physical systems*.

expands upon Marx's reformulated categories of political economy developed in *Capital* and the capital-logic outlined in the *Fragment on Machines* to include an analysis of the advanced development of the elements of the general artificial intellect as the means by which capital realizes its autonomization from labour-power in the sphere of production and in the circulation sphere, and as the means of both subsuming and reproducing the social factory. In doing so, it analytically separates the historical development and distribution of network information infrastructure from the data and information it circulates to analyze the transformation in the relations of production, circulation, and social reproduction that result.

1.5 Outline of Chapters

The following three case studies analyze the elements of the general artificial intellect as a means of production in the sphere of production, the circulation sphere and in smart cities. The case studies draw on concepts from both the *Grundrisse* and Marx's critique of political economy, academic literature, industry reports, white papers and other secondary sources. Chapter two analyzes capital's appropriation of the elements of the general artificial intellect as a means of production in the development of Industry 4.0's smart factories. The circulation of big data, or 'capital's cybernetic form', is analyzed in relation to the movement of the 'moments of capital' and as the means of cybernetic control that flow both within, and between, the moments of production and consumption. Hence, the integration of network information technologies in the production process are analyzed as the development of the self-organization of capital that I suggest advance the historical process of real subsumption toward a third stage of capital's autonomization from labour-power, a process in which the realization of the contradiction of the historical development of the capitalist mode of production is set in motion, which results not only in a crisis in the measure of value based on labour-time but also, the supersession of the capitalist mode of production by the *autonomous mode of production*.

Chapter three analyzes the elements of the general artificial intellect that appear as fixed capital in the transport industry. While Uber sells ‘change of place’ as immaterial commodities for both human transport and commodities, the chapter focuses the cybernetic relation between the labour process and circulation of big data for human transport. Uber’s development of autonomous vehicles appears to follow the same logic of autonomous subsumption occurring in the circulation sphere, which may raise the organic composition of capital of the transport industry, leading toward the autonomous circulation of commodities and people. Chapter four suggests both global intercity competition for the attraction of capital and labour and the demand for reducing traffic congestion, energy waste and pollution caused by capital’s fragmented, uneven spatial patterns of building construction and general conditions of production has created the demand for smart city development. It analyzes the integration of the network elements of the general artificial intellect with what Marx referred to as the *general conditions of production* such as the means of communication, transport infrastructure and energy infrastructure in smart cities as the cybernetic means of subsuming the social factory. Drawing on the three case examples, chapter five is an analysis of the social and political implications of the development of the autonomous mode of production, autonomous circulation, and the development of smart cities as the cybernetic means of subsuming and producing the social factory.

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Chapter 2

2 Capital's Autonomization from Labour-Power in the Sphere of Production: The Appearance of the Elements of the General Artificial Intellect as Fixed Capital in Industry 4.0

If the stage of formal subsumption was marked by capital's subsumption of labour under the wage system and the extension of the working day, and capital's real subsumption of labour was characterized by capital's reorganization and introduction of machines to the labour process under the demand for relative surplus value, then the gradual replacement of labour-power with autonomous machines in the sphere of production is marked by a third stage of capital's autonomization from labour-power. As Marx explicated in *Capital Volume I*, the demand for surplus value among competing capitals in industrial manufacturing compels industrial capitalists to extend or replace the motive power of labour with machinery for the purpose of reducing socially necessary labour-time in order to increase the rate of surplus value. As outlined in the *Grundrisse*, the internal contradiction of the development of the capitalist mode of production is realized as labour-power is increasingly replaced with autonomous machines in the direct production process, leading to a crisis in the measure of value based on labour-time. As the elements of the general artificial intellect are produced according to the capitalist method, they appear in the commodity-form and when re-appropriated by capitalists as means of production, information technologies reappear as fixed capital.

While the industrial revolution has been conceptualized as defining moment in the history of the capitalist mode of production, it has been theorized that the material forces of production have since undergone several industrial revolutions. [90,91] For example, it has been often suggested that the first industrial revolution was characterized by the development of steam power and mechanization, while a second industrial revolution was marked by the electrification of production and a third industrial revolution was identified

[90] See also Fuchs, "Industry 4.0: The Digital German Ideology," 281.
[91] See Schwab, *The Fourth Industrial Revolution*, 7-8.

by the computerization and automation of production.[92] It has been suggested that a current wave of technological development that involves the development of advanced networked automation technologies comprised of cyberphysical systems, internet of things, artificial intelligence, big data and cloud computing, is advancing a *fourth industrial revolution*.

This chapter examines one component of the fourth industrial revolution that has been referred to as "Industry 4.0."[93] 'Industry 4.0' is term that was coined at the Hannover in Germany in 2011 to describe how the development and integration of advanced digital networks and distributed automation technologies in the sphere of production will affect the reorganization of value chains.[94] While the concept originated in Europe, the discourse and ideology was popularized in the United States, China and other heavily industrialized countries where governments and private sectors have developed their own national initiatives for the digitalization and networking of the production process in industrial manufacturing. For example, in the United States, the National Network for Manufacturing has enacted an initiative called 'Advanced Manufacturing Partnership 2.0', the United Kingdom has introduced 'Catapult-High Value Manufacturing', and China is pursuing its 'Made in China 2025' initiative.[95] Private sector initiatives include the Industrial Internet Consortium in the United States, the Industrial Value Chain Initiative in Japan and Industrie 4.0 in Germany.[96] According to a survey of over 2,000 respondents in 26 countries, Price Waterhouse Coopers (PwC) reported that firms are planning to invest nearly 5% of capital derived from revenue per annum, or US $907 billion dollars in digitization,[97] an investment expected to result in approximately US $421 billion dollars in cost savings from efficiency gains with a US $493 increase in revenue per annum.

As cyber-physical systems and 'Internet of things' technologies are commodities that are produced as a result of capital's exploitation of the scientific labour-power of the general intellect, the chapter suggests that the material hardware of Industry 4.0 technologies as appear in the commodity-form, and when re-appropriated by capitalists, appear as fixed

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[92] Ibid.
[93] Fuchs, "Industry 4.0: The Digital German Ideology," 280-281.
[94] Schwab, *The Fourth Industrial Revolution*, 7-8.
[95] Oks et al., "An Application Map for Industrial Cyber-Physical Systems."
[96] Ibid.
[97] Price Waterhouse Coopers [PwC], "Industry 4.0: Building the Digital Enterprise."

capital in the sphere of production. Using case examples from the literature, this chapter explicates the functions of Industry 4.0 technologies as a means of production, and thus, as fixed capital, including how the fixed capital-value of such technologies is transferred to commodity-capital through the medium of the circulation of big data during the production process. Following Marx's capital-logic expressed in the *Fragment on Machines*, the analysis of Industry 4.0 concludes that the advanced development of digitization and automation in industrial manufacturing sets in motion the development of the stage of capital's real subsumption of the labour process toward a third and final stage of capital's autonomization from labour-power.

2.1 The Rotation and Metamorphosis of Industrial Capital

As Marx explicated in *Capital*, commodities appear with the two-fold character as a use value and as an exchange value.[98] Use value refers to the material qualities of useful products while exchange value refers to the comparison of one use value to another in an exchange relation.[99, 100] Money, is therefore, the means of expressing the magnitude of a commodities exchange value quantitatively. Under the capitalist mode of production, labour-power, in turn, appears in the two-fold character of the commodity-form of abstract labour and concrete labour.[101] Abstract labour refers to 'labour in general', or labour as it appears abstracted from all qualitative aspects of the expenditure of energy through human activity, and made commensurate with money's quantitative expression of value while concrete labour refers to differences in the qualities of labour, abstracted from all quantitative aspects of the exchange value of labour-power.[102, 103]

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[98] Marx, *Capital, Volume I*, 125-126.
[99] See Marx, *The Value-Form.*
[100] Ibid.
[101] Marx, Capital, *Volume I*, 125-130.
[102] Ibid.
[103] The transformation of labour into the commodity labour-power is the purchase of the general human expenditure of energy that is expressed as various forms of the objectification of social consciousness that have been abstractly categorized as manual or mental labour, but in fact both categories are present in all forms of the objectification of social consciousness *as labour*.

The historical conditions that created the necessity of the exchange relation of industrial capitalists to the proletariat in the sphere of production set in motion the reproduction of the circuits of *money-capital, productive capital and commodity-capital.* As Marx noted, the three circuits of productive-capital is, "a movement, a circulatory process through different stages, which itself in turn includes three different forms of the circulatory process."[104] Hence, capital is not a static thing, rather, capital is a relation mediated by the moving contradiction of use value and exchange value.[105] Marx examined this circulatory process as the movement and metamorphosis of capital-value as it changes material forms, rotating between money-capital, productive-capital, commodity-capital and back to the money-form.[106] The circuits of productive capital therefore appear as a form of circulation interrupted by the production process, represented in M-C-P(mp, lp)-C'-M'.

In the market, industrial capitalists' purchase of the material elements of production opens the circuit of money-capital, beginning with the exchange of money-capital, M, for commodities, C, which consists of means of production (mp) and labour-power (lp). When the commodities C (mp, lp) purchased by industrial capitalists are destined for productive consumption, they are represented as productive capital, P (mp, lp). Marx conceived of the total productive capital, P (mp, lp) that capitalists employ in the sphere of production as the organic composition of capital, a ratio comprised of the technical composition of capital and the value composition of capital.[107] The technical composition refers to the material aspects of production and consists of a ratio between all means of production (mp) and labour-power (lp) that are both separated from, and unified with, its value composition, which corresponds to a ratio between what Marx referred to as constant and variable capital (c/v).[108] The technical composition of the means of production that are used in the labour process is further divided according to its function as means of labour or object of labour while the combination of the productive forces of the means of production and labour create the *forces of production*.

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[104] Marx, *Capital, Volume II*, 185.
[105] Ibid, 184.
[106] Ibid, 118.
[107] Ibid, 762.
[108] Ibid.

In the course of the production process, labour transfers the value advanced for labour-power and the value of the means of production to the final commodity, which therefore establishes the minimum sale price of the commodity. The value composition of the means of production (mp) that labour uses in the production process is further divided into *fixed capital* and *circulating capital* as determined by the way in which labour transfers the value of the means of production to the commodity. Circulating capital refers to commodities that must be purchased and renewed for each production process while tools and machinery appear as forms of fixed capital because its material and, hence, its value are not immediately used up in each production process, it does not enter materially into the commodity, and thus, it does not leave the sphere of production.[109] Rather, labour transfers the fixed capital-value of machinery to the commodity in the production process bit by bit until the machine is worn out and must be replaced, or when competition necessitates the accelerated replacement of machinery with more technologically advanced machinery. Thus all commodities used for capitalist production circulate no matter what their material form.

The magnitude of a commodity's value is determined by the quantity of abstract labour objectified in the production process, or what Marx described as the unobservable social substance of 'congealed quantities' of socially necessary labour-time.[110] When labour produces a magnitude of commodity-value that replaces the value that is advanced for the exchange of labour-power, this equalizes the exchange relation between capital and labour. However, as labour-power is the only commodity that has the capacity to produce more value than exchanged for it,[111] when the production of a magnitude of value embodied in commodities exceeds the magnitude of value that industrial capitalists advance for the exchange of labour-power, labour produces *surplus value*. Therefore as *unpaid productive labour-time* is the source of surplus value that is embodied and, therefore, valorized in commodity-capital, C', the labour process is unified with the valorization process. As commodity-capital, C', is both produced by, and alienated from labour as the property of industrial capitalists, realization of the surplus value embodied in commodity-capital through its sale results in industrial capitalists realizing more money, M', than originally

[109] Ibid, 238.
[110] Marx, *Capital, Volume I*, 129-130.
[111] Marx, *Capital, Volume I*, 300.

invested in the productive capital. The appearance of capital's 'self-expanding value' is therefore derived from industrial capitalists' unequal exchange relation with labour, which is masked by the rotation and metamorphosis of money-capital to productive-capital, commodity-capital and back to the money-form.

2.2 Appearance of the Elements of the General Artificial Intellect as Fixed Capital

As the elements of the general artificial intellect are produced according to the capitalist method, information technologies are products that appear in the commodity-form with its two-fold character of use value and exchange value. The use value aspects of the means of production required for the production of information technologies determine the particular forms of labour-power required by capital; however, exchange value and capital's logic of 'accumulation for the sake of accumulation' shapes the quality, form and design of information technologies. The use value of information technologies is analytically divisible according to the hardware layer, or material form of information technologies, and the software layer, or the symbolic and logical form of information technologies as digital software cannot run without a material form such as computer hardware while computer hardware cannot be considered a use value in the typical sense without the software layer. Therefore the combination of the hardware layer and the software layer constitute the use value of information technologies. The production of the material layer of information technologies occurs throughout the global division of labour that separates conception from assembly[112] throughout the global value chains of labour exploitation. For example, the design of hardware devices such as the iPhone occurs in California but its production is outsourced to Shenzhen, which indicates capital's exploitation of material labour remains a necessary component for the production of information technologies.[113] Therefore under the capitalist mode of production, capital exploits the productive forces of the manual and intellectual labour-power of the general intellect, resulting in the material elements of the general artificial intellect that exit production as commodity-capital.

[112] Braverman, *Labor and Monopoly Capital.*
[113] Dyer-Witheford, *Cyberproletariat.*

As Marx noted, "the society's total product, and thus its total production process, breaks down into two great departments: I. Means of production: commodities that possess a form in which they either have to enter productive consumption, or at least can enter this. II. Means of consumption: commodities that possess a form in which they enter the individual consumption of the capitalist and working classes."[114] The hardware layer and software layer of information technologies may be exchanged separately and enter the consumption sphere as the means of communication and they may also arise from one labour process to enter another labour process as means of production.[115] Therefore, when used as means of communication, the elements of the general artificial intellect appear as multiple, many-sided use values that are used in the reproduction of social relations, commodity exchange and knowledge production. When used as means of production, however, the elements of the general artificial intellect exit production as commodity-capital, are purchased, and re-enter the production process as fixed capital. The hardware layer of information technologies exit production as commodity-capital, and through the process of circulation, may re-enter the sphere of production, and therefore, re-appear as fixed capital. However, the software elements of the general artificial intellect may be purchased as commodities, or may be used as freeware in which case capitalists pays nothing for the labour-power required to produce it. Or, the software elements may be leased as means of production, or directly produced within the sphere of production and interwoven into production processes within a particular industry. Finally, capitalists may simply pay for network access to the processing power of 'the cloud' in exchange for money in the form of rent.

Industrial capitalists purchase the elements of the general artificial intellect that constitute the new technologies of Industry 4.0 as means of production and therefore these technologies appear as fixed capital. Industrial wireless networks (IWN) are used to connect smart objects and processes to the Internet within factories,[116] which allows for networked cyberphysical control, automated data collection, processing and feedback that would integrate direct production with higher level planning in factories.[117] A distinction may be found in the technological ecosystem of Industry 4.0, divided according to the two

[114] Marx, *Capital: Volume I*, 471.
[115] Marx, *Capital, Volume II*, 240.
[116] Li et al. "A Review of Industrial Wireless Networks in the Context of Industry 4.0."
[117] Hirsch-Kreinsen, "Digitization of Industrial Work," 2.

broad technological paradigms of cyberphysical systems (CPS) and the Internet of things (IoT). These technologies have the potential to replicate, extend and/or replace the labour-power, and therefore, the unpaid labour-time that reproduces capital. CPS refers to automated sensor-based technologies that replicate, reduce, extend and/or replace labour in direct production while IoT refers to the infrastructure analytical technologies used for automating the production planning process that otherwise would require the labour-power of production managers and planners. The integration of both technologies constitutes the technical realization of Industry 4.0.[118]

The industrial application of cyberphysical systems (ICPS) predates the industrial application of the IoT. In early forms of factory computerization, process manufacturing initially relied on an operator required for monitoring and responding to production based on the information generated by computers designed to monitor the production process in an open-loop form of feedback that would eventually become a closed-loop through automation. Industrial cyberphysical systems were developed primarily by the engineering community and integrated in mechanical, electrical and chemical production processes processes.[119] The first industrial applications of what were known as cyberphysical systems were called 'computer-integrated manufacturing' (CIM)[120] and 'mechatronics', which referred to the integration of mechanical processes and information technology.[121] Closely related technologies were 'embedded systems' that relied on a cyberphysical control relation between sensors that collect information from the physical environment and actuators that translate numerical values into physical effects.[122] Thus as products of the scientific labour-power of the general intellect, the development of elements of the general artificial intellect in the form of cyberphysical systems advanced automation at the point of production.

With Industry 4.0, the use of ICPS has been designed to integrate cybernetic control over flexible production processes according to higher levels of digital abstraction. Kosci and Olah have noted that industrial cyberphysical systems are designed to "monitor the physical

[118] Ing and Göhner et al., "Cyber-Physical Systems for Production Technology."
[119] Feeney et al., "Cyber-Physical Systems Engineering for Manufacturing," 81.
[120] Ibid.
[121] Jeschke et al., "Industrial Internet of Things and Cybermanufacturing Systems."
[122] Marwedel, *Embedded Systems Design*, 8.

processes, make decentralized decisions and trigger actions, communicating and cooperating with each and with humans in real time."[123] As such, industrial cyberphysical systems rely on a closed feedback loop between information and the physical environment.[124] The second aspect of Industry 4.0 refers to implementation of the Internet of things (IoT) characterized by the objectification of the labour-power of computer scientists in the production of Internet technologies such as broadband infrastructure and open networks that are used to cybernetically control ICPS.[125] The phrase 'Internet of things' was first used in 1999 to refer to the use of computers for gathering knowledge about 'things' and the efficiencies this knowledge could bring to industry.[126] The paradigm of IoT developed from the implementation of the Internet, that, as noted began as a US military project and moved to the University system,[127] the circulation and consumption sphere, and that now appears to be moving into the production sphere with Industry 4.0.

Early industrial applications of IoT, known as IIoT, may be traced to the introduction of systems that have been used to organize, control and coordinate the flow of data, workers and processes in industrial production including product data management and product lifecycle management.[128] The software layer of IIoT includes the industrial Internet of services (IIoS), which are networked software application that may be delivered as needed to specific points within the ICPS and IIoT infrastructure.[129] These may include on-demand software infrastructure as a service (SaaS) applications such as customer relationship management (CRM), enterprise resource planning (ERP), management information systems (MIS), content management (CM) and other software suites. Thus IIoT refers not only to physical 'things' that are digitalized, but the software that delivers processing logic[130] of the elements of the general artificial intellect.

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[123] Kocsi and Olah, "Unique Manufacturing and Industry 4.0," 390.
[124] Jeschke et al., ""Industrial Internet of Things and Cybermanufacturing Systems."
[125] Göhner, "Cyber-Physical Systems for Production Technology."
[126] Ibid.
[127] Ceruzzi, *Computing: A Concise History.*
[128] Jeschke et al., "Industrial Internet of Things and Cybermanufacturing Systems," 5.
[129] Mosterman and Zander, "Industry 4.0 as a Cyberphysical System Study."
[130] Jeschke et al., "Industrial Internet of Things and Cybermanufacturing Systems," 4.

Production of the software layer from within the sphere of production requires that capitalists pay for the labour-power required to develop it as a means of production rather than directly purchasing the software layer as a commodity or by renting access to both the hardware and software layer of the cloud. In this case, capitalists exploit labour-power for the development of the software layer of the fixed capital of the general artificial intellect through activities such as writing code, designing algorithms, configuring servers, building applications, etc. The productive forces of the general intellect are therefore objectified in the elements of the general artificial intellect, appearing as rich concentrations of fixed capital sunk into data centres, servers, cloud infrastructure, distributed computers, information systems and other high performance computing technologies. In this production process, information technologies therefore appear both means of labour and object of labour. However, when not sold as a commodity, the value of the variable capital that industrial capitalists have exchanged for the labour-power of the general intellect, and that has subsequently been transferred to the software layer, cannot be realized as money-capital at the point of exchange but rather remains objectified in the software layer as fixed capital. It therefore becomes the imperative of industrial capitalists to find a way to transfer and/or valorize the fixed capital-value of their information technology to the final commodity being produced. Insofar as capital exploits indirect labour-power beyond the costs of labour-power and insofar as this surplus is objectified in the fixed capital of information technology within the same commodity production process, the automated transfer of this fixed capital-value to the final commodity bit by bit through machine-power transfers the surplus value that has been objectified in it to the final commodity that is produced. Thus the software layer of the means of automation that is produced from capital's objectification and alienation of the productive forces of the general intellect reappears as capital's own automated productive forces.

The integration of ICPS and IIoT in Industry 4.0 forms the technical means for the horizontal and vertical integration of factories. As elements of the general artificial intellect, ICPS, IIoT and IIoS are distributed and networked[131] means of production. Horizontal integration of ICPS on the shop floor ranges from 'self-aware' objects that transmit data about operational status to cyberphysical machinery that autonomously and

[131] See Li et al., "A Review of Industrial Wireless Networks in the Context of Industry 4.0."

directly produces commodities, while vertical integration refers to the informational and computational determination of production processes based on analytics and higher level industrial planning. Various combinations of fixed and circulating capital may be subsumed under cybernetic control by materially affixing the hardware layer of ICPS and IIoT to pre-existing means of production. This will transform the pre-existing forces of production and reorganize the relations of production under the control of the general artificial intellect. For example, cyberphysical control may be networked between pre-existing machines by attaching embedding sensors and other devices,[132] or entirely new 'smart' machines that already contain digital components may replace older machines,[133] a process of digitization of the means of production that adds to the total fixed capital of a particular enterprise. Raw materials that enter production may be digitalized by adding scannable barcodes, RFID, sensors, NFC, and other devices that transmit data about a particular smart object, including status, location, operation and use.

With respect to vertical integration, smart objects on the shop floor are connected via digital networks to control systems such as manufacturing execution systems (MES) at the management production level, while these control systems are further connected to global monitoring control systems such enterprise of resource planning (ERP) systems at the 'top floor',[134,135] resulting in a dual closed-loop feedback system in which "one loop consists of physical resources and cloud, while the other loop consists of supervisory control terminals and cloud."[136] Networking all 'things' and processes in factories from shop floor to top floor, would transform the ERP pyramid of traditional factories to the structure of digital or 'smart factories'.[137,138] Smart factories would enable a global system of managerial planning and control in which the factory itself would become a cybernetic ecosystem of objects and humans based on the concept that "everything – ranging from local production processes up to global value chains shall be digitally connected and decentralized."[139]As Kagermann et al. describe the capabilities and requirements of smart factories,

[132] Roblek et al., "A Complex View of Industry 4.0," 4.
[133] Ibid.
[134] For example, see Faller and Feldmüller, "Industry 4.0 Learning Factory for Regional SMEs."
[135] Berger et al., " Application of CPS in Machine Tools," 383.
[136] Wang et al., "Toward Smart Factory for Industry 4.0," 159.
[137] Krumeich et al., "Prescriptive Control of Business Processes."
[138] Kocsi and Oláh, "Unique Manufacturing and Industry 4.0," 390.
[139] Pfeiffer, "Robots, Industry 4.0 and Humans," 17.

> Smart products are uniquely identifiable, may be located at all times and know their own history, current status and alternative routes to achieving their target state. The embedded manufacturing systems are vertically networked with business processes within factories and enterprises and horizontally connected to dispersed value networks that can be managed in real time – from the moment an order is placed right through to outbound logistics. In addition, they both enable and require end-to-end engineering across the entire value chain.[140]

Thus capital's appropriation of the elements of the general artificial intellect vertically and horizontally integrates network cyberphysical control within the production process. The elements of the general artificial intellect electrically circulate big data that represent the 'moments of capital' through the networks of smart factories, and thus, as a secondary means of production that are analyzed and materialized by autonomous machines in the direct production process.

2.3 'Moments of Production' and the Circulation of Big Data in Smart Factories

When used as a means of production, the fixed capital-value of the hardware and software layer of information technologies cannot transfer to the commodity in any other way except through the production, processing and productive use of big data. In smart factories, the 'moments of production' that constitute the circuits of capital generate a circuit of big data as the digital means of representation about the production process. This circuit of big data consists of (1) human and non-human activities within the moments of production that are represented in big data by networked information technologies, (2) system processing and analysis of this big data (3) and specific forms of human and/or nonhuman feedback either directly or indirectly to machine-power, labour-power, or to the commodity. As an extension of the use value of information technology, the circulation of big data requires capitalists to pay for the electrical costs necessary for its collection, storage and processing,

[140] Kagermann et al., "Implementing the Strategic Initiative Industrie 4.0," 5.

which appears as a form of circulating capital. Without completion of the circuit of big data and without the correspondence of big data to the space and time of real objects and process, the use value of big data cannot be fully formed and, hence, the fixed capital-value of information technology and the circulating capital-value of the electricity necessary for processing big data cannot be transferred to the commodity. Thus as the circulation of big data is necessary for valorization of the fixed capital-value of information technology, the circuit of big data appears as *capital's cybernetic form.*

The distribution of big data inputs is determined by the distribution of the elements of the general artificial intellect across specific objects and processes of production. While network decentralization of these elements also serves to decentralize data collection, the transfer of big data to parallel processing infrastructure, or the back-end tech stacks of data centres, servers, and other network infrastructure centralizes the general artificial intellect's processing of networked objects according to the logic of capital. The depth and breadth of sources, the frequency of data capture, and the total number of objects, activities and processes connected within a network of information technologies, determines the total volume of big data, while the variety of data collected depends both on system design and the specificity of the objects and processes that are digitally represented.

At input, big data collected from smart objects within the moments of production become an electrically circulating means of production. 'Smart objects' are generally referred to as 'intelligent' when materials have been engineered to transmit data about the internal or external status.[141] Described as the 'location of intelligence', big data generated at the level of a smart object are the means of knowledge about an object's internal components, which are differentiated from intelligence at the network level that generate big data about the external status of a smart object.[142] Real industrial processes, for example, may be represented as a time series of events based on measurements taken at specific points in time while stream processing refers to the continuous collection of data. The use value, and hence, capital-value of the means of production that the elements of the general artificial intellect produce from processing big data may take the digital form of either human-

[141] Oxford English Dictionary cited in Berger et al., "Application of CPS in Machine Tools," 378.
[142] Berger et al., "Application of CPS in Machine Tools," 379.

interpretable information or machine-interpretable data.[143] As a form of private property, the total volume of big data produced within the sphere of production is analytically divisible according to its claim of ownership. Therefore, insofar as the circuit of big data does not leave the site of production from which it originates, it remains the intellectual property of its capitalist owners. However, big data may also leave the production sphere when exchanged as a commodity in data markets, in which case its ownership changes hands between the industries that produce and sell big data as a commodity byproduct of the process of production.

In the processing stage, prescriptive analytics consisting of reporting and/or dashboard functions[144] are used for monitoring smart objects and processes.[145] The use value of descriptive analytics refers to the representation of the past moments of production and may be used for immediate feedback to the production process and/or stored for feedback at a later time. Predictive analytics are defined by the use of statistical techniques to predict the future behaviour or state of a particular phenomenon.[146] The use value of predictive analytics refers to predictions that may be used to generate feedback in anticipation of future events as they are predicted by the inputs of past events. The use value of prescriptive analytics builds on prediction with the addition of machine recommendations or directly automated events as a form of feedback in anticipation of predicted events.

As the length of data storage increases prior to processing and/or following processing, the latency period in the course of feedback increases and therefore the referential stability of the link between the circuits of big data and the objects and processes of productive capital to which it refers may weaken, thereby depreciating the use value of big data as means of production and, hence, its value. Technical reasons for latency may also be distinguished from strategic reasons for latency. Technical reasons for latency are determined by the capacities and limitations of the information technologies used in the production process, which ranges from batch processing to real-time or in-memory processing.[147] At one end of

[143] See Franks, *The Analytics Revolution.*
[144] Krumeich et al., "Prescriptive Control of Business Processes," 267.
[145] See Franks, *The Analytics Revolution,* 10-18.
[146] See Kline, *The Cybernetics Moment.* Predictive analytics most closely resemble Claude Shannon's statistical approach to communication and Norbert Wiener's cybernetics with respect to the behavioural and teleological premises that underlie its epistemology.
[147] Ohlhorst, *Big Data Analytics*, 104.

the spectrum, batch processing refers to processing large data sets at specific intervals that increase the latency of feedback, while at the other end, edge computing optimizes cloud computing systems by processing data near its source with no required storage, which enables real-time feedback. Finally, strategic reasons for latency prior to processing and/or prior to feedback are determined by the requirements of the production process. Upon completion of the circuit of big data, the results of descriptive, predictive and prescriptive analytics may be materialized as feedback either directly through ICPS and IIoT technologies in the direct production of commodities or indirectly through either machine or human feedback to the labour process, which transfers the fixed capital-value of information technologies and the circulating capital-value of the electricity necessary for processing big data to the commodity bit by bit over time.

In addition to the development of smart factories, Industry 4.0 marks an increase in the circulation of big data derived from the exchange of digitalized commodities, money and communications between industries.[148] The circulation of big data extends the spatial and temporal limits of material commodities through the electrical means of representation, thereby integrating sites of production that feed a complex and intertwining electrical-material circulation of commodities travelling between branches of industrial clusters.[149] In this way, increasing the total exchange of data and information between industries with IIoT would reciprocally determine production according to the cybernetic feedback of prices and commodity specifications between such industries but expanded reproduction would continue according to the fractal and uneven nature of capitalist development between each department. Thus the expansion of data points that reciprocally circulate between the points of demand and points of production planning would also expand the abstract determinations of value that command capitalistic planning of industrial commodity production within each smart factory.

As the production planning systems at the top floor of smart factories are typically networked with the IIoT that connect production management level and shop floor levels, the vertical and horizontal control of production could become increasingly determined by market demand and competition. Therefore feedback from the demand and competition of

[148] Described by Hardt and Negri as the ‘informatization of production’ in *Empire,* 280-303.
[149] Götz and Jankowska, “Clusters and Industry 4.0.”

other industries would continue to more fully determine the timing, pacing and specificity of industrial commodity production within each smart factory. Within each smart factory, the forms of cybernetic feedback generated by the rotation of industrial capital-value begin and end as *material forces of production* that both direct, and are directed by, the objectified fixed capital of the general artificial intellect. Thus the flexibility and control created by market demand and competition would be met by the dynamic and adaptive cybernetic structure of smart factories that could reduce waste and increase efficiencies that may, therefore, increase the velocity of the turnover of capital-value.

The circuits of big data may be automated in varying degrees by different forms of the elements of the general artificial intellect, ranging from basic "information handling, to problem notification and decision making."[150] Depending on the level of automation, big data analytics that become means of production for generating feedback to the production process may occur at any level of a smart factory and may be summarized as (1) networked cyberphysical control of circulating capital as a result of communications from human and/or machine planning and production management and/or (2) networked cyberphysical control of other means of production in the direct production process, which may or may not involve human labour-power in direct production. In smart factories, feedback sent by top floor planning and received at the level of production management systems may be used to shape direct production based on market demand. The specificity of the production process depends on the type of industry, the use value of the commodity being produced, and the forms of labour-power required.

As part of the lean manufacturing paradigm, feedback of big data from market demand and competition could be used to generate predictive and prescriptive analytics that direct human production planners or machines to adjust stock levels, production levels and/or product lines in anticipation of future demand.[151] The capital-value of the elements of the general artificial intellect and the analytics that it generates would therefore transfer indirectly to commodity-capital through human and/or machine feedback to the adjustment of the purchase of commodities destined for productive consumption, which would reduce

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[150] Berger et al., "Application of CPS in Machine Tools."
[151] Sanders et al. "Industry 4.0 Implies Lean Manufacturing."

slow downs in production due to under-stock, reduce the waste associated with the natural depreciation of over-stock that would otherwise remain idle and reduce the overproduction of commodities that are in low-demand. Once digitalized, materials that enter the sphere of production would circulate big data that represent identity, status and location which could be used to generate predictive and prescriptive analytics that monitor and organizes inventory and the flow of commodities in the production process. The capital-value of the elements of the general artificial intellect and the predictive and prescriptive analytics would therefore be transferred indirectly to commodity-capital through human and machine feedback that organizes and adjusts the flow of circulating capital, which could reduce the natural depreciation of disorganized or unaccounted for materials, and therefore, reduce the costs associated with material waste.

With respect to fixed capital, digitalized 'smart machines' would continuously circulate data about internal machine status and external events[152] between the shop floor and production management systems. As noted, industrial machinery, labour gradually transfers the fixed capital-value of machinery to commodity-capital, which results in the gradual depreciation of a machine's use value, and hence, its value over time. In smart factories, big data generated by machines could be used as inputs for predictive and prescriptive analytics, which would generate 'in-time' or 'proactive' automated machine maintenance or human feedback to anticipated machine breakdowns.[153] The capital-value of the elements of the general artificial intellect and the analytics would be transferred to smart machines through feedback in the form of predictive maintenance, which may circumvent impending breakdowns, and therefore, interruptions to the velocity and flow of the production process and, hence, may increase the velocity of the turnover of capital-value.[154]

As noted, the process industries that have developed since the early twentieth century have already reduced the amount of labour-power by computers in the direct production process. However, it has been noted that the integration of IIoT with planning and production management systems in these industries could be used to monitor and control production

[152] Krumeich et al., "Prescriptive Control of Business Processes."
[153] Ibid.
[154] Marx, *Capital: Volume II.*

processes through cyberphysical feedback. In one example of process manufacturing, steel production consists of various stages and mixtures of synthetic and analytical processes of material transformation, including reduction, steelmaking, casting, rolling/forming and fabrication.[155] In this form of process manufacturing, 'event pattern data' and 'event streams' are derived from sensor networks that have been physically attached to other means of production at the shop floor. The flow of the production process would continuously reproduce circuits of big data, which form the inputs to production management systems that generate descriptive, predictive and prescriptive analytics. As Krumeich et al. have noted, "eventually, this technological progress will enable the establishment and continuous enrichment of databases containing sufficient manufacturing data in order to compute highly accurate process predictions possessing the capability to control processes."[156] Databases and analytical software at the production management level of smart factories would be used to detect, store and process single event data, aggregate events and complex events that occur within the production process at different levels of abstraction. The analytics that become means of production would then control the flow of materials either through closed-loop cyberphysical machine automation or open-loop human feedback back within the production process.[157] The capital-value of the elements of the general artificial intellect and the analytics would be transferred to the production process by optimizing the material complexity of processing manufacturing for the production of commodity-capital.

At the shop floor in particular industries, the use of IIoT and ICPS to increase automation may replicate, extend and/or replace labour-power in the direct production process. In industries where capitalist exploitation of human labour-power continues to occur in the direct labour process, it has been suggested by Industry 4.0 developers that ICPS could be used as means of production to cyberphysically control the labour process. In recent interviews with Industry 4.0 leaders and developers, wearable smart glove technology and smart workstation technology were tested as means of production, which are designed to react to the activities of the process through cybernetic feedback.[158] Smart glove

[155] Ibid, 272.
[156] Ibid, 263.
[157] Ibid.
[158] Schaupp and Diab, "From the Smart Factory to the Self-Organisation of Capital." [Forthcoming].

technology uses the hand movements of labour within the labour process as inputs for cyberphysical feedback to the labour process, while labour uses cyberphysical feedback as a signal to adjust the labour process. Smart workplace technologies use worker status as inputs to cybernetically adjust the work environment of the labour process in order to improve worker motivation.[159] In these examples, smart glove and smart workplace technologies are designed to reduce wasteful movements, improve motivation and increase the appearances of worker self-organization by adding a form of cybernetic work to the direct production process. Additionally, reverse feedback from labour to production management systems provide engineers data as the means of adjusting the algorithms, and symbolic logic of the elements of the general artificial intellect to achieve dynamic feedback. As part of Industry 4.0 development, both smart glove and smart workstation technologies could be designed to connect direct production processes on the shop floor more directly to market forces, by automating management and planning at the top floor.[160] The fixed capital-value of the elements of the general artificial intellect and analytics would therefore be transferred through cyberphysical feedback to the labour process that results in the production of commodity-capital.

The production of commodity-capital that has been digitalized would circulate big data about the identity, status and location of as it leaves the production sphere and enters circulation destined either for productive consumption in the circuits of industrial material production or as a commodity to be sold to the sphere of consumption. By re-entering the sphere of production, digitalized commodities would re-enter the rotation of industrial capital as means of production. However, by entering the sphere of consumption, digitalized commodities would continue to transmit big data to retailers such as Amazon, Target and other large companies that use predictive analytics to indicate when the means of consumption require replacement with new commodities.[161]

[159] Ibid.
[160] Ibid.
[161] Lom et al. “Industry 4.0 as a Part of Smart Cities.”

2.4 Capital's Autonomization from Labour-Power in the Sphere of Production

As Marx outlined the internal contradiction of the historical development of the capitalist mode of production in the *Fragment on Machines*,

> Capital itself is a moving contradiction [in] that it presses to reduce labour time to a minimum, while it posits labour time, on the other side, as sole measure and source of wealth. Hence it diminishes labour time in the necessary form so as to increase it in the superfluous form; hence posits the superfluous in measure as condition—question of life or death—for the necessary. On the one side, then, it calls to life all the powers of science and nature, as of social combination and of social intercourse, in order to make the creation of death independent (relatively) of the labour time employed on it. On the other side, it wants to use labour time as the measuring rod for the giant social forces thereby create, and to confine them within the limits required to maintain the already created value as value.[162]

In the later stages of the historical development of the capitalist mode of production, capital's absorption of the productive forces of the general intellect in the form of new scientific knowledge, methods and technologies develops machines into 'automata' that capitalists use to reduce, and eventually replace, the total number of workers required in the direct production process,

> But, once adopted into the production process of capital, the means of labour passes through different metamorphoses, whose culmination is the *machine*, or rather, an *automatic system of machinery* (system of machinery: the *automatic* one is merely its most complete, most adequate form, and alone transforms machinery into a system), set in motion by an automaton, a moving power that moves itself; this automaton consisting of numerous mechanical and intellectual organs, so that the workers themselves are cast merely as its conscious linkages.[163]

As the development of machinery advances, labour stands aside of the direct production process and instead fulfills a watchman or overseer function of the direct production

[162] Marx, *The Grundrisse,* 706.
[163] Ibid, 692.

process.[164] As unpaid labour-time in the direct production process is the source of surplus value, the replacement of labour-power with the machine-power of autonomous machines in the direct production process is therefore the realization of the internal contradiction of the capitalist mode of production that results in a crisis in the measure of value based on labour-time. As Marx noted, the development of the material forces of production transforms the relations of production to the point of advancing a new mode of production:

> At a certain stage of development, the material productive forces of society come into conflict with the existing relations of production or—this merely expresses the same thing in legal terms—with the property relations within the framework of which they have operated hitherto. From forms of development of the productive forces these relations turn into their fetters. Then begins an era of social revolution. With the change of the economic foundation the entire immense superstructure is more or less rapidly transformed.[165]

As capital's formal and real subsumption of the labour process created the historical development of the capitalist mode of production, and thus, the circulation of labour-power in and out of direct production with each production cycle as a form of circulating capital, the historical development of the replacement of direct labour with the fixed capital of autonomous machines has set in motion the historical process of labour exiting its circulation with the capital-relation, and thus, a third stage of *capital's autonomization from labour-power* that will lead to the supersession of the capitalist mode of production by what I refer to as the *autonomous mode of production*.[166]

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[164] Ibid, 705.

[165] Marx, *A Contribution to the Critique of Political Economy*, 12.

[166] See Thoburn, "Autonomous Production?," 86. The concept of capital's autonomization from labour-power presented in this chapter may be directly contrasted with the concept of immaterial labour becoming increasingly autonomous from capital, as theorized by Negri. In his version, autonomous production refers to the emergence of the immaterial labour of the general intellect as developing its own productive forces independent of capital. Here is where the concept of autonomous production that I have outlined departs from Negri in that the productive forces of the general intellect are re-appropriated by capital, objectified in the general artificial intellect, appearing as capital's own productive forces. The end state of capital's full autonomization from labour-power across the entire globe is the necessary historical condition for the dissolution of the capital-relation based on the category of labour as it has been historically formed as the source of capital's self-expansion within sphere of production. But this in no way suggests the outcome of such a contradictory development would necessarily lead to crisis or, on the other hand, the re-appropriation and conversion of the means of production from private property to property held in common.

In the context of Industry 4.0, cyber-physical machines that replace the functions of direct labour are distinct from other forms of autonomous machines and artificial intelligence that extend and/or replace the functions of indirect labour. When applied to the sphere of production, the former appear to replace, reduce and/or extend aspects of manual labour at the shop floor while the latter appear to replace, reduce and/or extend aspects of the mental labour of management and production planning at the mid and top floor of factories.[167] As demonstrated in the case examples of smart glove and smart workstation technology, the development of Industry 4.0 technologies at the shop floor appears to increase the autonomy of labour from human management while increasing the cybernetic management of labour through the automated direct monitoring of the location, movement, and activity of manual workers in the direct labour process and/or indirect monitoring of the activities of direct labour through smart machines that are operated by labour. Indirect labour-power employed in the sphere of production does not *directly* produce surplus value. Rather, the value of indirect labour-power is therefore transferred to the means of production and the organization of direct labour in the form of increases in labour efficiency and increases in the velocity of the direct production process. Therefore changes to the direct labour process that increase the velocity of production valorize the value of indirect labour-power.

With the global development of various forms of automation in smart factories, the exploitation of various forms of indirect labour-power for the management and engineering of the direct production process would still be required. As the advanced development of cyber-physical systems at the shop floor leads to the replacement of labour-power with autonomous machines in the global sphere of production, the total constant capital of industrial production would expand while the total number of workers, and therefore, the total variable capital in the sphere of production would be reduced. With the global reduction of labour-power in the direct production process, and therefore, the reduction of variable capital, capitalist exploitation of unpaid labour-time would theoretically also be reduced to a minimum.[168] Therefore, the contradiction of capital accumulation would manifest in the tendency of a falling rate of profit in industrial

[167] See Hirsch-Kreinsen, "Digitization of Industrial Work."
[168] Marx, *The Grundrisse.*

production as a whole.[169] However, as Marx noted, the tendency of a falling rate of profit may be slowed or even reversed by counteracting tendencies. These tendencies include, among others, cheapening of the elements of constant capital, cheapening the cost of labour-power and/or increasing the rate of exploitation,[170] and the effects of monopoly capital on price.

In two reviews of research, Hirsch-Kreinsen et al. and Sommer summarize both optimistic and pessimistic projections, ranging from significant job losses to significant job gains.[171,172] In Germany, where industry 4.0 may advance significantly in manufacturing, the situation appears mixed. Both positive job growth and net job losses are projected from the 484,494 enterprises that are engaged in industrial trade of the total 2.2 million enterprises in the country.[173] Small to medium-sized enterprises (SMEs) account for 99 percent of all enterprises in Germany, providing approximately two-thirds of the country's source of employment, while large enterprises comprise only 1 percent of all enterprises, accounting for 40 percent of the country's source of employment. Large enterprises in Germany seem to have taken the Industry 4.0 initiative seriously, but the pace of digitization in SMEs has been criticized as stunted amidst the competitive frenzy over industrial digitization, a structural hesitation that has been attributed to lack of strategy, weak management and leadership, concerns over data privacy, security and other human organizational impediments.[174]

In the United States, it has been projected that Industry 4.0 will result in initial job losses throughout a range of industries but that these will be more than made up for by long-term gains in employment, while other reports suggest that sweeping job losses will be permanent, occurring either immanently with rapid transformation in employment or gradually in a slower process of employment shedding and industrial transformation.[175] For

[169] Marx, *Capital Volume III,* 342-372. Marx explained this as the tendency in the rate of profit to fall. Full automation of the direct production process and the total replacement of direct labour is the full realization of capital's tendency toward not only a crisis in capital accumulation, but a transformative crisis in the measure of value based on labour-time.
[170] Marx, *Capital Volume II,* 339-347.
[171] Ibid.
[172] Sommer, "Are German Manufacturing SMEs the First Victims of this Revolution?"
[173] Statistisches Bundesamt, "Produzierendes Gewerbe und Dienstleistungen im Überblick," cited in "Sommer, "Are German Manufacturing SMEs the First Victims of this Revolution?" 1514.
[174] Sommer, "Are German Manufacturing SMEs the First Victims of this Revolution?"
[175] Ibid.

example, Frey and Osborne projected 47% of all jobs in the US labour market could be automated over the next two decades,[176] a figure that was determined by a categorical analysis and ranking of job skills thought replaceable by machine automation. A similar projection has been made about the social effects of Industry 4.0, specifically in the high concentration of service industries of North America and UK,[177] as the capabilities of the general artificial intellect are advancing to the point of being able to perform cognitive, affective and interactive service jobs that were created in the post-Fordist era. For example, PwC has reported that 30% of all jobs in UK, or 2.25 million jobs in the wholesale and retail industry, 1.2 million jobs in the manufacturing industry, 1.1 million jobs in administrative support and social services and 950,000 jobs in the transport and storage industry are at risk for replacement due to advances in artificial intelligence.[178]

Projections concerning the social effects of Industry 4.0 on unemployment may be summarized according to technical analyses of (1) how industries function, change and react to widespread offerings of new forms of automation, and (2) how automation technologies specifically relate to lower skills, full replacement and/or advancing the skills of labour, and (3) how the use values of commodities and subsequent production processes require specific forms of standardization, which determine the specific mix of machines, labour-power and forms of automation demanded by capital. Organizational barriers, the technical limits of automation and new requirements for the standardization of production appear as necessary considerations for determining industry behaviour with respect to the trajectory and pacing of capital's autonomization from labour-power. On this point, Krzywdzinski notes important findings from the sociology literature in the 1980s and 1990s that assert managerial decisions to adopt new production technologies that are not reducible to cost considerations, but are determined, rather, by complex negotiations between capital and labour.[179] However, it may be equally logical to state that, while necessary, technical and relational considerations are insufficient for determining whether automation would be implemented when such decisions affect the reproduction of capital-value. For example, labour competition creates the conditions for capitalists to replace

[176] Frey and Osborne, "The Future of Employment," 38, cited in Hirsch-Kreinsen, "Digitization of Industrial Work."
[177] Hirsch-Kreinsen, "Digitization of Industrial Work," 3-6.
[178] Elliot, "Millions of UK Workers at Risk of Being Replaced by Robots, Study Says."
[179] Krzywdzinski, "Automation, Skill Requirements and Labour-Use Strategies," 250.

existing workers with workers willing to accept an even lower wage instead of replacing them with labour-saving machinery if labour-power can be obtained more cheaply than machine-power.[180] Further, Robert Schiller has suggested that a robot tax should be considered if artificially intelligent robots replace human jobs,[181] which would effectively introduce further barriers to the capital's full autonomization from labour-power by de-incentivizing automation in the sphere of production. In both cases, the advance of capital's autonomization from labour-power would therefore be held in check by the law of value regardless of organizational, technical and/or production considerations. However, as industrial capitalists replace direct labour-power with cyber-physical systems as a result of fixed capital accumulation in the sphere of production, a rise in the organic composition of capital may be expected on the condition that jobs lost as a result of automation are not replaced with other forms of labour and that the replacement of labour-power is proportional through the entire global sphere of production.[182]

The global replacement of direct labour-power with the power of autonomous machines would indeed lead to the dissolution of labour-time as the measure of value, as Marx asserted in the *Grundrisse*. Marx, however, did not specify whether the indirect labour of managers, production planners, or the 'watchman' are employed in an unequal exchange relation with capitalists. Insofar as *any* form of labour-power, *or labour capacity*, appears as abstract labour, it may enter into a value relation with the money-form of capital in the unequal exchange and alienation of labour-time that is the necessary relation of the capitalist mode of production.[183] As Marx noted, labour transfers the value that capitalists advance for the purchase of labour-power and means of production to the commodities that are produced.[184] Direct labour, the means of production and the labour-process itself are the objects of indirect labour. The objectification of the productive forces of indirect labour-time therefore transfers the value of its labour-power to the production and management of the direct labour process and the means of production.

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[180] See Marx, *Capital, Volume III*, 339.
[181] Elliot, "Millions of UK Workers at Risk of Being Replaced by Robots, Study Says."
[182] Marx, *Capital, Volume III,* 339.
[183] Labour-capacity
[184] Marx, *Capital, Volume I*, 51.

While the socially necessary labour–time of the indirect labour process is indeterminable due to the lack of measure of value based on labour-time, there are other forms of the capital-relation in which socially necessary labour-time appears incalculable, yet value and surplus value is both calculable and realized. As Marx noted in *Capital, Volume I*, piece-wages tie the wage form directly to the number of commodities produced and not to a specific number of working hours. This makes it appear that socially necessary labour-time does not occur in piece-wage work because it cannot be calculated according to the labour-time that is required for the production of each commodity. As Marx noted,

> Piece-wages are not in fact a direct expression of any relation of value. It is not, therefore, a question of measuring the value of the piece by the labour-time incorporated in it. It is rather the reverse: the labour the worker has expended must be measured by the number of pieces he has produced […] Only the labour-time which is embodied in a quantity of commodities laid down in advance and fixed by experience counts as socially necessary labour-time.[185]

Piece-wages tend to create individualized forms of self-competition amongst labourers and, therefore, there may be variability with respect to socially necessary labour-time. However, labour exploitation is not incalculable as the unpaid labour-time required for the production of each piece could be calculated against the wage paid per commodity produced.[186] The difference between time-wages and piece-wages is the means by which the exploitation of unpaid labour-time is masked; hourly wage versus per-piece produced. However, as Marx noted, "piece wages become, from this point of view, the most fruitful reductions in wages, and of frauds committed by the capitalists."[187]

With the dissolution of direct labour-time as the measure of value and the development of the general intellect as a direct force of production, indirect labour-power would objectify its productive forces, and thus, transfer the value advanced to it in changes to the production, monitoring and maintenance of the fixed capital of autonomous machines that sets in motion the direct production process. Autonomous machines would then simply

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[185] Marx, *Capital, Volume I*, 693-694.
[186] Ibid, 693-696.
[187] Ibid, 693-694.

automatically transfer the value of the indirect labour-time absorbed in it bit by bit to the total mass of commodities that are produced. Differences in the productive forces of autonomous machines would therefore determine differences in the velocity of production between competing capitals. The production of surplus value in a fully automated direct production process would therefore no longer be determined by the labour-time of direct production. Rather, the surplus value indirectly produced by indirect labour-power in a fully automated direct production process would be calculated by the difference between the variable capital advanced to indirect labour-power over a definite amount of time against the total value of the commodities produced over that same period of time. Thus contrary to Marx's assertion that the measure of use value by exchange value would cease with the replacement of direct labour with autonomous machines, the objectification of indirect labour-time in the development of autonomous machines would continue the measure of use value by exchange value.

With the advance of the capitalist development of the sphere of production, the continuous growth of the big data collected, stored, processed and used in the course of the production process of smart factories would be used to continuously advance the technical development of machine learning of the elements of the general artificial intellect.[188] With the development of artificial intelligence as the means of replacing the indirect labour of management and production planning, the elements of the general artificial intellect, rather than the elements of the general intellect, would autonomously materialize the logic of capitalist production through the objectification of 'machine consciousness' in the direct production process.

It has been theorized that the replacement of both direct and indirect labour-power with machine-power would lead to the development of autonomous manufacturing, in which 'smart' materials would autonomously transmit production specifications to surrounding machines.[189] Specifications transmitted by smart materials would be processed as inputs either at the object level or network level to automatically form local rules that are then actualized by surrounding machines. Smart machines designed with flexible and adaptive

[188] Faller and Feldmüller, "Industry 4.0 Learning Factory for Regional SMEs."
[189] Siemens, "Industrie 4.0 - The Fourth Industrial Revolution."

'emergent behaviour'[190] would fulfill such specifications through cyberphysical feedback in the production process.[191] 'Lights out' factories, or autonomous manufacturing are actually existing smart factories that run mostly, if not entirely, automatically.[192] The development of autonomous production may be also be found in mining and other industries that extract the raw materials necessary for the manufacturing industries.[193] With capital's autonomization from both direct and indirect labour-power in the global sphere of production, all commodities would be produced entirely by autonomous machines. Theoretically, with the full realization of the autonomous mode of production, the replacement of *all* labour-power with autonomous machines, and thus, the total replacement of all variable capital with constant capital suggests a global 'levelling', or 'equalization', of the value-relation of the costs of production in relation to the production of commodity-values within the global sphere of production.

2.5 Conclusion

The development of Industry 4.0 was analyzed as a concrete example of the broader capital-logic of the historical development of the capitalist mode of production that Marx outlined in both *Capital* and the *Fragment on Machines*. The capitalist appropriation of and integration of ICPS and IIoT technologies in the development of smart factories connect shop floor production processes to production management systems and top floor production planning systems. As the circuits of big data were presented as an electronically circulating form of fixed capital, this was presented as 'capital's cybernetic form'. The specificity of how the fixed capital-value of the elements of the general artificial intellect are transferred through the medium of big data as capital's cybernetic form to commodity-

[190] Mosterman and Zander, "Industry 4.0 as a Cyberphysical System Study."
[191] Ibid, p. 18. For example, "mymuesli.com allows a user to configure an individual muesli mix. As the muesli package is moving through the factory, the 'smart package' communicates to each of the machines how much of each of the corresponding ingredient should be filled."
[192] The Fanuc Corporation, for example, has factories run by robots that autonomously produce robots.
[193] See Rylnikova et al., "Intelligent Mining Engineering Systems in the Structure of Industry 4.0."

capital was theorized using examples from the literature that describe the capabilities of smart objects in the smart factories of Industry 4.0.

While this chapter interpreted the development of Industry 4.0 in relation to the broader development of the capitalist mode of production, the concrete development of the autonomous mode of production will likely be determined by capital's uneven development, the monopolizing forces that develop from the concentration of capitals, and the law of value that counteracts the capital's tendency of a falling rate of profit that results from the realization of the contradiction of capital's autonomization from labour-power. Therefore under the current global capitalist system, this chapter has not suggested that capital's autonomization from labour-power may or may not ever be fully realized. Rather, this chapter has used the capital-logic of the *Fragment on Machines* to explore the theoretical and logical limit of the development of autonomous machines as the means of replacing both direct and indirect labour-power in the global sphere of production. However, if the historical process of the internal contradiction of capital's autonomization from labour-power is ever fully realized according to its logical limit, the contradiction of the measure of value based on labour-time would be resolved and realized as the replacement of the *surplus value-creating* powers of labour with the *value-levelling* power of machines.

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Chapter 3

3 Capital's Autonomization from Labour-Power in the Circulation Sphere: The Appearance of the Elements of the General Artificial Intellect as Fixed Capital at Uber

As discussed in chapter two, labour-time in the direct industrial production process determines the magnitude of a commodity's value and capitalists' exploitation of labour-time determines the magnitude of surplus value. However, as the circulation of commodities adds no new value to the material commodities that are sold and transported as part of the circulation process,[194] the transportation of commodities appears as a cost to capitalists invested in retail and as revenue to capitalists invested in the transportation industry. Capitalists invested in the transport industry exploit the labour-power required for the movement of commodities and people in the circulation sphere. The integration of advanced network information technologies in the transportation industry is expected to advance the development of autonomous vehicles. The development of the automated means of transport for the circulation of commodities and people suggests that capital's autonomization from labour-power is also occurring in the circulation sphere. Therefore, as 'one moment' of capital, it appears that automation of the transportation industry will lead to the development of the autonomous circulation of commodities. While Uber sells transport for both commodities and people, the chapter focuses in depth on the function of Uber as a transport service for the movement of people. Uber operates a globally distributed platform that connects the company's 'tech stack' to the front-facing Uber application used by its drivers. Uber's distributed platform captures data from within the labour process of its drivers and leverages this data to control the future time and space of work using predictive algorithms and feedback.

I suggest that the very technical structure of the platform determines the form of labour - power required, which Rosenblat and Stark have described as 'on-demand' labour[195] to

[194] Marx, *Capital:Volume II*, 203.

[195] Rosenblat and Stark, "Algorithmic Labor and Information Asymmetries."

reflect the flexible, twenty-four hour availability of the work and its precarious nature with respect to hiring, termination, compensation, labour rights and lack of benefits. In this way, working for Uber resembles the exploitation of unpaid labour that social media companies use to generate revenue from advertisers. Uber's plans for replacing on-demand labour-power with autonomous vehicles appears to exemplify the concept of the third stage of capital's autonomization from labour-power in the circulation sphere, however, as the chapter focuses on only one company within the broader transport industry, the implications of autonomous vehicles are limited to the capital-relation at Uber.

3.1 The Transport Industry

The transport industry consists of private owners and producers who own the means of transport and who use these means for the extraction of surplus value and the accumulation of capital. Marx described the use value of commodities in the transport industry as the useful effect of 'change of place' from one place to another in exchange for money:

> But what the transport industry sells is the actual change of place itself. The useful effect produced is inseparably connected with the transport process, i.e. the production process specific to the transport industry. People and commodities travel together with the means of transport, and this journeying, the spatial movement of the means of transport, is precisely the production process accomplished by the transport industry. The useful effect can only be consumed during the production process; it does not exist as a thing of use distinct from this process, a thing which functions as an article of commerce and circulates as a commodity only after its production. However the exchange-value of this useful effect is still determined, like that of any other commodity, by the value of the elements of production used up in it (labour-power and means of production), plus the surplus-value created by the surplus labour of the workers occupied in the transport industry.[196]

The use-value of commodities in the transport industry is expressed as a useful effect (i.e. change of place) that has been made ideally into a measurable unit of exchange (unit of

[196] Ibid, 134-135.

transportation). To create the useful effect of an exchangeable unit of transportation requires labour-power to use vehicles to circulate people and commodities. This form of production produces a 'product' (change of place) that lacks a discrete object or unit for calculating the embodiment of surplus-value in 'commodity-capital', which reflects the problem of the measurability of exploitation in service labour, informational work, etc.[197]. While the value-form of transport commodities may be obscured by the fact that these products often lack an objective material body, labour-power still produces exchangeable use-values, and therefore, commodity-values. Thus, the transport industry as a whole involves a form of production that circulates material commodities and people because the labour-power it exploits does not produce discrete material use-values.[198]

With respect to the circulation of people, the rotation of capital in the traditional taxi industry contrasts with the rotation of money-capital in industrial production. In the taxi industry, uncompensated labour-time occurs during the time it takes to drive to pick up a consumer, and thus, prior to direct working time. Further, in the case of leasing arrangements, taxi drivers must pay owners to operate a vehicle while also providing uncompensated labour-time.[199] This uncompensated labour-time limits the wage income of taxi-cab drivers. The circulation of both the commodity labour-power and consumers occurs within the geographical boundaries of the taxi market, and therefore the location of the market determines the location in which value circulates. On the side of labour, the unpaid labour-time that occurs before and during direct working-time together forms the total production-time. The direct working-time during which labour that produces the transport commodity occurs at the same time as the process of consumption,[200] during which time consumers are not only purchasers of the commodity but are part of the production process as well. Therefore, unlike industrial production, no delay exists between production-time and circulation-time for the creation and realization of value. Workers appear both as direct producers and as merchant labour because exchange occurs immediately following production, while the moments of capital that are divided by the moments of the production and consumption of the commodity are unified prior to the

[197] See Braverman, *Labor and Monopoly Capital.*
[198] See Hardt and Negri, *Empire.*
[199] See Mathew, "The Neoliberal Form and Nested Subsumption."
[200] Heinrich, *An Introduction to the Three Volumes of Karl Marx's Capital*, 41-42.

moment of exchange. As labour-power does not produce a commodity in the form of a discrete material bearer of value that circulates prior to its sale, a stock of commodity-capital, C', does not appear in the taxi industry. The only form in which C′ appears is in the number of trips, or number of times a taxi driver moves consumers within a given time-frame, which are consumed in the process of production. As a result, there can never be an overstock of C′ but there may certainly be an oversupply of labour-power. Assuming taxi drivers produce more value than they receive in the form of a wage, this may be one of the means by which the taxi industry's exploitation of labour-time creates surplus-value.

3.2 Appearance of the Elements of Fixed Capital in the Taxi Industry

Historically, the US taxi industry was forged from the mass production of automobiles, the financial crisis that resulted in the mass unemployment of the great depression and the formation of industry regulations. In New York and Chicago, the early taxi industry was operating within a loose regulatory environment.[201] Prior to the early 1930s, anyone could pay a rental fee to a cab owner and operate it in an arrangement that has been compared to contemporary leasing or what has been referred to as 'horse-hiring'.[202] Following the stock market crash of 1929, a large mass of the unemployed began seeking work as taxi drivers.[203] Unemployment and desperation had produced an oversupply of labour-power that led to turf wars and 'bandit cabs' driven by workers who operated outside of the law in the taxi cab market.[204] Drivers who operated bandit cabs had few to no labour regulations to curtail the length of the working day or to improve dangerous working conditions such as operating uninsured cabs that were often in disrepair.[205] Over the course of just a few years, the oversupply of drivers created competition that plummeted incomes, leading to labour strikes.[206]

[201] Mathew, "The Neoliberal Form and Nested Subsumption," 2053-2054.
[202] Ibid, 2054.
[203] Harding et al., "Taxi Apps, Regulation, and the Market for Taxi Journeys," 16-17.
[204] Ibid, 16.
[205] Ibid.
[206] Mathew, "The Neoliberal Form and Nested Subsumption," 2052.

In response, the US government included taxis in the Interstate Commerce Act to provide the each state with the ability to regulate prices.[207] In New York, the Hass Ordinance introduced the medallion to the taxi market while other major cities enacted legislation to regulate the market.[208] Medallions are a taxi permit that are also exchanged as a commodity in a market, the purchase of which allows the owner to operate one cab on the road.[209, 210] By introducing only a limited number of medallions, regulators were able to control the number of taxi cabs on the street but this also drove up the price of a medallion due to the artificially limited supply of permits.[211] In Chicago, an employer-employee arrangement was in place for the next forty years and as a result of union organizing and collective bargaining, drivers received minimum wage and labour protections such as contracts, sick days, vacation days, benefits and standardization of the twelve-hour work day.[212] In both Chicago and New York, taxi company revenues within the employee-employer arrangement were derived from splitting fares between drivers and owners instead of lease payments.[213]

While these changes appear to have benefited the side of labour, it has been suggested that the move from the loosely regulated leasing arrangement to an employee-employer arrangement may be read more broadly as capital's advance from the formal to real subsumption of the labour process in the taxi industry.[214] For example, under the previous relation, drivers were required to provide medallion owners a lease payment on a daily or weekly basis in order to drive a vehicle, which gave drivers a negative wage balance that must first be worked off in order to make a positive wage.[215] With the removal of leasing, drivers no longer had to advance a lease payment to medallion owners in order to drive a taxi cab.[216] Consequently, worker's wages became more directly dependent on the fares that had to be split with ownership, a method of compensation that resembles piece-wage work because drivers are not paid per hour, rather, drivers are paid per commodity

[207] Harding et al., "Taxi Apps, Regulation, and the Market for Taxi Journeys," 17.
[208] Ibid.
[209] Mathew, "The Neoliberal Form and Nested Subsumption," 2053-2054.
[210] Williams, "Cabs, Community, and Control," 6-7.
[211] For example, in 2012 in New York the average market price has been cited as $1.3 million (Mathew 2015) and in 2013 in Chicago the average market price has been cited as $348,000 (Williams 2015).
[212] Williams, "Cabs, Community, and Control," 7.
[213] Mathew, "The Neoliberal Form and Nested Subsumption," 2054.
[214] Ibid, 2055-2058.
[215] Williams, "Cabs, Community, and Control," 7.
[216] Mathew, "The Neoliberal Form and Nested Subsumption," 2054.

produced. Fare-splitting also shifted the ownership and management's interests toward controlling the direct labour process of its drivers.[217] Thus the regulations that benefited workers in the employee-employer relation in the US taxi industry in the mid-twentieth century appears to have also created the conditions for capital's real subsumption of the labour process as the introduction of information technologies reduced worker autonomy and control over their own work.[218]

As part of the process of real subsumption, capitalists reorganize the labour process by applying new scientific knowledge and technologies in order to increase the extraction of relative surplus value. In the taxi cab industry, the division of labour separates the direct transport of consumers and the coordination of these transactions through management and/or dispatch. Management and dispatch work involves tasks such as coordination, communication and informational work while taxi cab work involves tasks such as operating the vehicle, communicating with consumers and navigating the trip. As capital's means of control of the labour process, the gradual integration of information technologies to the labour process of taxi drivers introduced data collection for the purposes of monitoring the exchange of commodities and money to prevent loss of revenue, while the eventual digitalization of the relation between management, dispatch and the labour process introduced communications and control that determined the assignment of fares. In many forms, these information technologies replicated, extended, reduced and/or replaced the indirect labour-power of managers, dispatch workers and many of the cognitive tasks required by taxi drivers while increasing the fixed capital of the taxi industry.

In the early stages of real subsumption, it has been noted that taxi companies may have used human 'agents' to circulate the streets and surveil the activities of drivers and to ensure they did not sit idle.[219] As a form of managerial surveillance, the function of these agents was to collect data about the activity of workers and then feedback was used to increase the productivity of taxi drivers.[220] Another control technology termed the 'hot seat' was used to ensure that the meter began as soon as a customer sat in the passenger

[217] Ibid, 2054-2055.
[218] Ibid, 2057-2058.
[219] Ibid.
[220] See Beniger 1989 for a social analysis of human and non-human data processing in capitalist society.

side of the vehicle, which served to surveil the customer transaction for the purpose of ensuring that drivers did not collect unreported fares outside of the fare split agreement with ownership.[221] Thus the use of this technology appears to have replaced the use of human agents to control the labour process.

By the late 1970s the taxi industry experienced significant deregulation of labour protections, transforming the capital-relation back to the leasing arrangement. As Mathew has noted, this was significant because "the taxi industry became amongst the first to abandon the employee–employer model of the Fordist era and shift to independent contractor-ship based on leasing. Well before subcontracting, offshoring, outsourcing and downsizing became corporate watchwords, the taxi industry in NYC had moved to leasing."[222] The neoliberal period had reintroduced the leasing arrangement while the introduction of brokers increased capital's control over the labour process. The reintroduction of the lease was not, however, simply a return to the original days of medallion-controlled leasing. Rather, deregulation allowed for brokers to consolidate several medallions and lease them to drivers on the condition that drivers purchase the vehicle, known as the 'driver owned vehicle' arrangement, which offloaded the costs of the means of production to taxi drivers.[223]

The introduction of new state regulations in the neoliberal period also advanced real subsumption by introducing standardized data collection from within the labour process.[224] This began with the introduction of the 'trip sheet', which was a record of driver activities that was required to be completed and handed in to the fleet supervisor at the completion of every shift.[225] It was incumbent on the driver to accurately and honestly enter data into the trip sheet, which drivers would regularly circumvent in order to resist the exploitive relation with capital and maintain a degree of autonomy.[226] Management's introduction of an electronic meter to taxi cabs advanced capital's real subsumption of the labour process by automating the process of data collection about total bookings. While electronic meters

[221] Mathew, "The Neoliberal Form and Nested Subsumption," 2054-2055.
[222] Ibid, 2055.
[223] Ibid, 2062.
[224] Ibid, 2063.
[225] Ibid.
[226] Ibid.

did not improve the granularity of data collection, they provided management another 'objective' source of data that could be used to verify the self-reported activities of the labour process noted on the trip sheet.[227] Management's collection and integration of these two data sources and types prevented labour from circumventing capital's appropriation of surplus value, which also reduced the autonomy of the labour process.

The introduction of information technologies to the relation between the labour process, management and dispatch has also advanced the process of real subsumption. Taxi markets are divided into 'cruising' and 'dispatch' in which some taxis were either restricted to one or the other while others are allowed to utilize both methods to locate fares.[228] The cruising market refers to the circulation of taxi drivers on the streets and the direct hailing of cabs by consumers. The dispatch market refers to the organization and communication of specific consumer requests for transportation between drivers and dispatch operators or what has been referred to as 'official collaboration' or the communication that occurs between drivers and their companies or dispatching services.[229]

Twenty-four hour dispatch services require labour-power and hence, variable capital, so only larger taxi companies with presumably large capital reserves can typically afford these services.[230] For smaller companies, CB radios are the alternative to large numbers of human dispatch workers, but in recent years this technology has been either replaced or supplemented with a networked technology called 'the Gandalf'.[231] As Williams has described the system,

> The Gandalf is a computerized data terminal attached to the dashboard of a cab. A driver logs into the Gandalf with a specific coding system based on his location in the city and will see a list of fares awaiting pick-up in that zone. Dispatchers in a remote location receive calls from customers and these requests are entered into the system from a desktop computer and placed in a queue for the respective zone where the customer is located. This queue is the list that a driver sees when he logs in from the vehicle. If a driver decides to accept a fare he will go through a series of prompts ending with the customer's address. If a driver sees that all the

[227] Ibid.
[228] Harding et al., "Taxi Apps, Regulation, and the Market for Taxi Journeys," 17.
[229] Mathew, "Taxi Apps, Regulation, and the Market for Taxi Journeys," 9.
[230] Ibid.
[231] Ibid.

> fares already have assigned drivers, he will be placed in a queue in order to receive the next fare in that zone, assuming he does not drive out of the zone.[232]

Drivers in Chicago who lease their vehicles, for example, cannot choose which technologies are used in the vehicle and none of the drivers that rely on dispatch have access to the location of fares, which indicates a hierarchical distribution of fare information.[233] Thus the Gandalf dispatch system reorganizes the labour process while reducing the cognitive tasks associated with dispatch work.

As information technologies are commodities that appear as fixed capital when purchased and used as means of production, the gradual integration of information technologies to the taxi industry appears to have advanced capital's real subsumption of the labour process while increasing the total fixed capital of the taxi industry. Unlike the history of gradual integration of information technologies in the taxi industry, Uber has introduced a global platform that appears to have replicated, reduced, extended and/or replaced specific aspects labour-power in the transport industry. The platform, therefore, has embodied the real subsumption of the labour process since its introduction to the taxi market. However, the company's development of autonomous vehicles could advance the process of real subsumption toward capital's autonomization from labour-power where labour would not be required in the direct production process, thereby creating a form of autonomous circulation.

3.3 Appearance of the Elements of the General Intellect as Fixed Capital at Uber

In contrast to the complex historical development of capital's regulatory and technological control over the labour process of the traditional taxi industry, the introduction of the Uber platform already contained capital's means of real subsumption of the labour process of its drivers because it converges the multiple functions of previous information technologies found in the taxi industry into a massive, globally distributed, and mostly automated, big-data platform. As a form of fixed capital, the hardware layer of the Uber platform consists

[232] Ibid, 10.
[233] Williams, "Cabs, Community, and Control," 11.

of distributed, networked back-end 'tech stack' information technologies and the front-facing Uber application, which mediates a general division of labour between Uber's engineers, a technical support staff, and company drivers. Uber's engineers consist of computer programmers and data analysts who use the tech stack as both means of labour and object of labour, shared across several engineering offices,[234] while a technical support staff appears to take the place of formal managers, and a global supply of drivers is involved in the direct production process.

Uber engineers are divided into teams according to the various functions of each section of the tech stack.[235] A tree metaphor illustrates the functions of the various sections of the tech stack with the 'bottom' as foundational to the 'middle trunk' and 'branches' at the top.[236] Uber's information technology infrastructure may be considered the bottom or core of its platform, which consists materially of a hybrid cloud model of several data centres and cloud providers.[237] 'Platform teams' develop the core platform that provides the means of production for other engineering teams to develop the software layer of programs, apps and features.[238] Uber's engineers continuously transform the tech stack in response to the expanding volume of drivers, consumers and their transactions, as exemplified in the company's decision to break up its codebase from a 'monolithic' architecture toward a service-oriented architecture (SOA) made up of multiple codebases and hundreds of interacting microservices in order to adapt the tech stack to the growing scale of its operations.[239]

Uber's 'marketplace' stack may be considered the 'middle layer' of the tech stack and the entry-point for the big data that flows from real-world locations, transactions and requests into Uber's software logic.[240] Engineers working within the marketplace stack are organised into a data team, an integration team, and front-end and back-end engineers who build infrastructure and develop services for handling its big data.[241] Uber's engineers develop the software layer according to the demands of capital, as its functions are in a

[234] Lozinski, "The Uber Engineering Tech Stack, Part I."
[235] Ibid.
[236] Ibid.
[237] Ibid.
[238] Ibid.
[239] Haddad, "Service-Oriented Architecture: Scaling the Uber Engineering Codebase As We Grow."
[240] Ibid.
[241] Ibid.

direct cybernetic relation with the material movement of drivers and consumers and thus commodities and money. Uber records all work performed by Uber engineers; therefore, if a piece of code fails or if a service becomes buggy, the engineer responsible may be contacted and engineers may be on call to respond to any failures.[242] Finally, engineers develop the 'top' of the tech stack as their object of labour, which contains the interfaces for all web and mobile services of the Uber application.[243]

Engineers objectify their knowledge in the production of software, algorithms and other elements of fixed capital as the means of production for the company. The labour-power of the general intellect therefore transfers the variable capital paid in the form of salary, plus unpaid labour-time, to the production of the Uber platform that therefore appears as fixed capital. In response to growth in the circulation of transport commodities and money, continuous technical development of the platform expands the total value of Uber's fixed capital as a result of the exploitation of the labour-power of general intellect. Finally, as capitalists employ labour capacities over a definite amount of time, the variable capital advanced for the purchase of the labour-power of technical support workers, plus unpaid labour-time is transferred to the total value of the transport commodities that are produced by their support of the flow of operations and customer transactions.

The Uber platform automates several human-coordination, communication and control functions that would have been found in the traditional taxi industry. For example, the hiring process may replace live interviews with an online form.[244] Employee termination may occur by remote deactivation of a driver's access to the Uber app, thereby replacing managerial interaction.[245] The replacement of dispatch services with the Uber platform replaces human control over fares with Uber's algorithms.[246] Uber's built-in payment system relies on consumer credit cards registered with the company that mostly replace cash payments.[247] The Uber application uses the built-in GPS navigational technology of smart phones to allow anyone with the minimum ability to drive a vehicle and to follow instructions to drive for the company in any city, no matter their familiarity with the

[242] Lozinski, "The Uber Engineering Tech Stack, Part I."
[243] Haddad, "Service-Oriented Architecture: Scaling the Uber Engineering Codebase As We Grow."
[244] Uber 2017.
[245] Rosenblat and Stark, "Algorithmic Labor and Information Asymmetries."
[246] Ibid.
[247] Uber 2017. Although it should be noted that Uber does allow cash payments in select cities.

streets.[248] This lowers the depth and breadth of driver knowledge, which potentially expands the free movement of labour. Thus the objectification of the labour-power of the general intellect, absorbed in the fixed capital of Uber's information technology platform replaces the taxi industry's demand for drivers with experience and knowledge of roads, destinations and cities.

Unlike the history of the taxi industry, Uber entered the transport industry despite state regulations, rather than being determined by state regulations. Indeed, Uber ignored and disrupted the existing taxi markets in several countries. For example, Uber bypasses the permit system of the taxi industry, which has allowed the company to leverage a much larger supply of labour- power, giving the company a competitive advantage over the traditional taxi industry.[249, 250] The Uber platform allows the company to exert more direct control through digitalization over its drivers' labour process, resulting in further vertical and horizontal integration of the sector.[251] In several countries, Uber has claimed that its legal status is that of a technology company, and that it only provides the technical means for drivers and consumers to exchange money and commodities, and that therefore its drivers are independent contractors.[252] However, the Uber platform controls access to fares and determines when and where work takes place, which would suggest that its drivers should be considered employees.[253] Finally, the Uber platform allows drivers to work any time and for as long as they want, since the platform runs twenty-four hours per day, seven days a week.

While the company advertises the 'always on' aspects of the platform as a feature that allows for greater worker autonomy, this has created the potential for unfettered extension of the working day, determined not by the coercive character of management, but rather as

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[248] Rosen, "The Knowledge, London's Legendary Taxi-Driver Test, Puts Up a Fight in the Age of GPS." Though the introduction of GPS began in the traditional taxi industry, the aggregate impact of the knowledge and skill required to become an Uber driver may be directly contrasted with the standardized and regulated test of taxi driver knowledge and skill in London, UK, called 'the knowledge'. It may take a potential driver three to five years of preparation to take 'the knowledge', which sets a notoriously high standard for drivers of London's black taxis.
[249] Harding et al., "Taxi Apps, Regulation, and the Market for Taxi Journeys."
[250] Cassano, "How Uber Profits Even While its Drivers Aren't Earning Money."
[251] Rogers, "The Social Costs of Uber," 89-90.
[252] Crank, "COMMENT: O'Connor v. Uber Technologies."
[253] Rosenblat and Stark, "Algorthmic Labor and Information Asymmetries."

determined by the coercive character of piece-wage work. Capitalists use piece-wages as a more precise method for labour exploitation because workers are only paid per piece produced and not for the labour-time required to produce a given number of products. Hence, piece-wages tie exploitation more directly to each commodity produced and not to the labour-time required to produce a number of commodities. As Marx noted,

> Piece-wages are not in fact a direct expression of any relation of value. It is not, therefore, a question of measuring the value of the piece by the labour-time incorporated in it. It is rather the reverse: the labour the worker has expended must be measured by the number of pieces he has produced. In time-wages the labour is measured by its immediate duration, in piece-wages by the quantity of products in which the labour has become embodied during a given time.[254]

In similar respect to the taxi industry, Uber pays nothing to its drivers for the labour-time required prior to direct production time until the transport commodity (change of place) has been produced in exchange for a fare, after which time payments are issued to the driver at regular intervals.[255] Thus the automated aspects of the Uber platform, the legal uncertainty of the employment category of its drivers and a form of compensation that resembles the piece- wage system determines the labour conditions for 'on-demand' drivers.[256]

With respect to the organic composition of capital, the total cost of Uber's engineers, technical-support staff and the company's global large surplus of on-demand labour-power (lp) appear as variable capital (v), which takes the form of a salary for Uber engineers and technical support staff and the fare received by Uber drivers, minus commission for each commodity sold through piece-wage work. Uber's means of production (mp) include the data centres and software layers required for the Uber platform, corporate offices and energy usage, which therefore appear as constant capital (c). As noted, as a portion of this constant capital, the software layer was not purchased as a commodity. Rather, through the development of the software layer, the variable capital that is paid to Uber engineers and then transferred to the platform must then be used productively in the direct production process.

The big data generated and processed during production appears as a circulating form of

[254] Marx, *Capital, Volume I*, 693.
[255] Uber.com
[256] Crank, "COMMENT: O'Connor v. Uber Technologies."

constant capital (c), produced by Uber drivers and consumers both directly and indirectly. However, Uber pays its on-demand drivers and consumers nothing for the big data it uses as means of production but the company does bear the energy costs of collecting, processing and using it productively. Vehicles, fuel and smartphones are also means of production (mp) that are required for Uber's productive consumption but these commodities must be purchased and maintained by Uber drivers for production to occur, a necessity for being an Uber driver that appears first as a negative balance against earned wages for on-demand labour.

Uber's distributed platform operates within the production process based on a cybernetic relation between the engineers who work on the tech stack and on-demand workers in the direct labour process. Within this cybernetic relation, the platform acts as both the means and object of labour for Uber engineers and as the means of labour for on-demand drivers, while the Uber application acts as the means of communication for consumers to request and purchase transport commodities. As Lozinzki notes, Uber's 'collection of systems acts as the eyes, ears, and immune system of Uber Engineering around the world'.[257] Extending this metaphor, the 'sensory inputs' to the 'objectified brain' of the elements of Uber's general artificial intellect would be the circuits of big data that flow throughout the division of labour, the sphere of consumption and the tech stack in relation to the flow of commodities and money, which must be processes in real-time in order for Uber to keep to its mission statement of 'providing transportation that is as reliable as running water'.[258] Uber's production process may therefore be analysed as a relation between the moments of the production process and the circuits of big data that appear as capital's cybernetic form and that realize the total capital-value in motion.

3.4 'Moments of Production' and the Circulation of Big Data in Uber's Production Process

[257] Lozinski, "The Uber Engineering Tech Stack, Part I."
[258] Ibid.

The Uber platform collects big data about every moment of the entire production process, including the metadata of its drivers outside of direct working time and of its consumers outside of direct consumption whether the Uber application remains open or shut down.[259] Due to the platform's networked, distributed cybernetic relation of the spatial and the digital, Uber drivers and consumers circulate in a dual sense prior to the production and consumption of a transport trip. As a whole, the platform processes all big data generated by past moments of Uber's material-digital marketplace and used as means of production to control the future realization of value through cybernetic feedback. The fixed capital-value of the elements of the general artificial intellect are transferred bit by bit over time while the value of Uber's big data transfers to the labour process, and hence, valorization process of its on-demand drivers. Thus the electric circuits of big data produced by Uber's global marketplace are intertwined with the material circulation of commodities and money. As a result, the circulation of commodities and money both reproduces and are reproduced by the continuous reproduction of the circuits of big data.

Uber drivers begin work by logging on to the application and 'going online'. Drivers may remain idle or drive around randomly, which is labour-time that occurs prior to a fare request.[260] Uber's mapping services visualize this circulation of on-demand labour and consumers within the application interface.[261] Once a driver receives a notification for a pickup request from a consumer within the Uber application, the driver is given 15 seconds to accept the request. [262] If the driver accepts the request, the built-in navigational system directs the driver to the pickup location that the consumer has indicated. Once the request has been accepted, Uber's mapping services visualize the driver's geolocation, navigation and the estimated time of arrival for the consumer. During this time, the consumer receives a continuous flow of information that displays the driver's location and estimated time of arrival. If necessary, the Uber application may be used to exchange text messages or phone calls between the driver and consumer for the purpose of coordinating the pickup. At pick-

[259] Conger, "Uber Begins Background Collection of Rider Location Data."
[260] Lozinski, "The Uber Engineering Tech Stack, Part II."
[261] Lozinski, "The Uber Engineering Tech Stack, Part I."
[262] Ibid.

up the driver and consumer confirm their identities, and direct working- time commences. During direct working-time, the driver is directed by the navigational system within the Uber platform on the best route. [263] Once the destination has been reached, consumers are dropped off and payments are automatically processed within the Uber application. Uber drivers may end their shift at any time by simply 'going offline' from the application. [264]

Both on-demand drivers and consumers continuously reproduce the big data generated and collected both within and without the direct production process, and this may include metadata such as the geolocation, time and content about the communications and movement of labour and consumers. The Uber platform collects and uses the big data derived from past moments of the production process[265] as a cybernetic input that circulates electronically from the front-facing Uber application to the various sections of the tech stack and back to the front-facing application. Feedback of big data through analytics, therefore, transfers the value of the Uber platform and the value of its big data to the labour process that produces the transport commodity (change of place). The big data collected and used by Uber therefore become means of production that are necessary for various cybernetic functions of the platform's material production processes. These functions include the reproduction of the company's material–digital market-place, the management of on-demand labour, control over the time and place of production, and control over the balance of supply and demand through pricing algorithms.

Uber uses big data to generate a digital performance record for each driver, which consists of consumer feedback, automobile telematics and acceptance rates. Uber uses this performance record as means of production to dynamically control the labour process through various forms of direct and indirect feedback. Following exchange, consumers are prompted by the Uber application to provide a rating of their driver on a scale of 1 to 5 stars. [266] The rating system affects the employment status of an on-demand driver because if a driver's rating dips below a threshold of 4.6 out of 5, he or she may be locked out of the application. [267] Uber provides recommendations for achieving higher ratings, such as

[263] Ibid.
[264] Ibid.
[265] Cassano, "How Uber Profits Even While its Drivers Aren't Earning Money."
[266] Uber has recently added additional features for feedback, including comments and tipping.
[267] Uber, "How the Uber App Works."

keeping the vehicle clean and in good working condition, and providing bottled water and other options such as phone chargers, which add costs to drivers. [268]

The rating system optimises the coercive nature of the piece-wage relation to increase the exertion of labour since it bypasses the mediation of managerial feedback concerning performance, relying instead on evaluations crowd-sourced directly from the sphere of consumption. Ratings are made visible to Uber, on-demand labour and consumers, which shape both the consciousness and behaviour of labour because feedback demands self-correction, increased costs and further expenditure of affective labour. By introducing self-competition, Uber exacerbates the tendencies of piece-wage work to raise the quality of the commodity, which automatically disciplines the total pool of on-demand labour-power without the need for human managers in this regard.

As a process of labour subjectivation, the materialization of information in the form of 'self-management' and 'positive social interactions' tend to generate higher ratings from consumers. This may be considered a form of affective and communicative labour which the rating system enforces atop the normal activities of driving a taxi cab. As Marx noted regarding the effects of piece-wages on the labour process, 'the wider scope that piece-wages give to individuality tends to develop both that individuality, and with it the worker's sense of liberty, independence and self-control, and also the competition of workers with each other'.[269] Thus, part of the value of the Uber platform and the value of the performance record generated by the rating system transfers to the commodity through feedback that manipulates the subjectivity of labour, which in turn increases labour exploitation.

Uber recently added telematic data as another input into the performance record of its drivers, collected from GPS, accelerometer and gyroscope technology built into smartphones. [270] In the course of the labour process, the tech stack automatically collects this big data and processes it using trip-service and vehicle-movement algorithms that allow the company to determine the velocity, braking and acceleration of its drivers, [271] perhaps

[268] Rosenblat and Stark, "Algorithmic Labor and Information Asymmetries," 3775.
[269] Marx, *Capital:Volume I*, 697.
[270] Wiseniewski, "Uber Says Monitoring Drivers Improves Safety."
[271] Bernstein and Sumers, "How Uber Engineering Increases Safe Driving with Telematics."

the most direct method of monitoring the labour process.[272] In this form of cybernetic management, Uber drivers may receive notifications about past driving behaviour that increase the self-management of future driving behaviour by engaging the self-control of Uber drivers around the safety and security requirements of the direct labour process. This may also affect a driver's rating because low consumer feedback regarding poor driving could be either verified or discredited by means of telematic data. This data may also be used to generate feedback in the form of interventions from law enforcement if drivers are found to have violated traffic laws. Thus feedback transfers part of the value of the Uber platform and the value of telematic data to the commodity indirectly by reducing overall risk and therefore reducing the costs of accidents in the flow of drivers and consumers.

The acceptance rate provides the third input into the performance record, determined by how often a driver accepts a request from a consumer within the 15-second window. The Uber platform has been engineered for 'blind passenger acceptance', in that drivers are given no information as to whether the request will be beneficial for their income prior to acceptance of the request. [273] While Uber has argued that blind acceptance has been designed to prevent discrimination, it has consequences for total wage earnings because drivers must make decisions based on sparse information about the distance and the fare. At the same time, non-acceptance of fares are noted on the driver's record and if the acceptance rate falls below Uber's threshold of 90%, it may result in disciplinary action and/or termination. [274] Thus Uber's threshold for acceptance rates conditions on-demand labour to accept fares that may be detrimental to their wages when measured against the costs of driving for Uber, a policy that appears based on Uber's need to keep the supply of on-demand labour and the demand of consumers at an equilibrium within its market in order to meet its mission statement of 'providing transport as reliable as running water'.

Uber also uses its big data for artificially balancing the total quantity of on-demand labour in relation to the total quantity of consumers by using analytics and logistics to optimize the spatiotemporal positioning of on-demand labour within its marketplace. Supply and demand are controlled and directed through Uber's dispatch optimization system (DISCO),

[272] Ibid.
[273] Rosenblat and Stark, "Algorithmic Labor and Information Asymmetries," 3762-3765.
[274] Ibid.

designed to process one million rides per second.[275] The value-creation process depends on how Uber engineers develop and maintain the company's microservices for artificially controlling the material–digital circulation of supply and demand. Uber uses 'surge pricing' as a specific form of dynamic pricing designed to increase or decrease supply by adjusting fares in order to meet demand. As part of this process, the Uber platform uses historical and real-time data to predict the location and timing of surges in consumer demand,[276] then it increases fares according to the region in which surges occur. Both online and offline on-demand drivers are notified of regional fare increases, which are visualized and mapped within the Uber application.[277] As Uber has made the timing and location of the circulation of on-demand labour-power cybernetically-adjustable according to anticipated surges in demand, data generated by consumer demand becomes a cybernetic input into calculation and feedback of price. Consumers within a surge region who attempt a trip request are given notification of fare increases that are intended to lower demand. Thus as an instrument of the realization process, the Uber platform transfers the value of its big data to the commodity by positioning the location and timing of the labour process in relation to the location and timing of consumer demand and by pricing the commodity according to supply and demand.

Uber uses another strategy to balance supply and demand, known as 'surge positioning', where predictive feedback and notifications influence on-demand labour to move to locations in anticipation of real surges that may not always result in a high number of fares.[278] On this point, Harding et al. have noted that surge pricing creates the appearance of an abundance of supply and demand among drivers and consumers when there may not actually be such an abundance.[279] For example, working under Uber's cybernetic control of supply and demand in combination with the determinations of acceptance rate thresholds may result in what are referred to as 'dead miles' if a surge in the number of fares does not materialize along with the price surge, resulting in uncompensated labour, fuel costs and wear and tear on a driver's vehicle expended during the circulation-time required for

[275] Ranney, "Scaling Uber's Realtime Market Platform."
[276] Rosenblat and Stark, "Algorithmic Labor and Information Asymmetries," 3765-3771.
[277] Ibid.
[278] Ibid, 3766-3767.
[279] Harding et al. "Taxi Apps, Regulation, and the Market for Taxi Journeys."

driving to the surge zone.[280] Finally, while Uber uses its big data to engage in dynamic pricing, the platform also allows for experimentation with 'financial engineering'. As Kenney and Zysman have noted, once a platform-driven firm is locked into a market, it may quickly change its terms by modifying its code and algorithms.[281] For example, Huet describes Uber's experimentation with adjusting the commission it takes from its drivers.[282] Typically, Uber takes a commission of 20% of each fare. In one of its pilot programmes, however, Uber experimented with 'tiered commissions', which have been set at levels of 20%, 25%, and 30%. What a driver receives would be determined by the number of hours worked per week. Thus Uber may increase its revenue stream by adjusting the rate of exploitation per commodity sold as a function of piece-wage work, about which Marx noted, "piece-wages become, from this point of view, the most fruitful source of reductions in wages, and of frauds committed by the capitalists."[283]

Uber has tested tiered commissions by analyzing the effects of the reactions of on-demand labour to increases or decreases in the commission in specific regions of the global taxi market where the company has a presence. The reactions of on-demand labour to commission adjustments provide Uber with feedback about the minimum fare on-demand drivers will accept. Big data collected about these reactions, telematic activity, the continuous flow of supply and demand, and further expansion of the elements of capital's artificial intellect within the labour process all provide reverse feedback to Uber for research and development. Uber's collection and use of this reverse feedback, combined with the introduction of autonomous vehicles, could be used to remove on-demand drivers from the direct production process entirely.

3.5 Capital's Autonomization from Labour-Power in the Circulation Sphere

Currently valued at US$62.5 billion, Uber has consistently generated large net revenues,

[280] Cassano, "How Uber Profits Even While its Drivers Aren't Earning Money."
[281] Kenney and Zysman, "The Rise of the Platform Economy."
[282] Huet, "Uber Tests Taking Even More of its Drivers with 30% Commission."
[283] Marx, *Capital:Volume I*, 694.

with one estimate expecting Uber to have reached US$1.5 billion by the fourth quarter of 2016. [284] At the same time, however, the company posted losses of US$750 million in each of the last three quarters of 2016.[285] This indicates quite clearly that while Uber operates in 61 countries and continues to scale its presence globally, it has not achieved overall profitability.[286,287] At the same time, Uber's large private capital reserves of US$6 billion and an additional credit line of US$2 billion have funded the company's process of capital accumulation. Thus Uber's large investments are not becoming 'self- expanding value' but rather are being exchanged for the continuous expansion in the number of new drivers, advertising for the acquisition of new consumers, and developing the platform, a strategy that appears to be designed to capture the market ahead of direct competition from Lyft and other platform- driven transport companies.

It has been argued that much of Uber's losses are due to the company subsidizing its drivers, which prevents Uber from achieving profitability. As Uber continues the process of capital accumulation and moves toward an initial public offering, it is very possible that these driver subsidies will be removed in an effort to demonstrate profitability once Uber's operations become subject to the demands of public shareholders.[288] As a result, Uber's on-demand drivers may face a significant reduction in wages and may be replaced with autonomous vehicles. As the Uber platform has expanded across the globe and the total number of on-demand drivers and consumers increases, the capabilities of the tech stack will therefore develop in response to increases in consumer demand.

Marx theorized that a transformation in the organic composition of capital occurs in the course of capital accumulation, characterized by the tendency of capitalists to increase relative surplus-value by constantly applying revolutions in machinery to the production process. This tends to result in the gradual replacement of labour-power (lp) with machinery (mp), which therefore raises the ratio of constant capital (c) to variable capital

[284] Crowdability, "2017's Uber IPO."
[285] Ibid.
[286] See Newcomer, "Lyft is Gaining on Uber."
[287] Uber claims, however, to have achieved profitability in the United States, but not across all countries in which it operates.
[288] See Dickey, Uber Lays Off Another ~350 Across Eats, Self-Driving and Other Departments." On this point, note the recent developments regarding Uber's quarterly losses and layoffs of 350 employees from various departments within the company.

(v) within industry, leading to the tendency in the rate of profit to fall. As noted, Marx projected that the machinery will have reached a point of development in the later stages of capitalism such that they become an autonomous machine for the near complete replacement of human labour-power in the production process.[289] In the most advanced development of machine automation in the sphere of production, "labour no longer appears within the direct production process; rather, the human worker comes to relate more as a watchman and regulator to the production process itself."[290] While Uber's engineers perform a dual function as developers and 'watchman' over the mostly automated tech stack that controls the labour process of on-demand drivers, achieving full automation in the direct production process may be a gradual process of replacement that will unfold based on testing the autonomous elements of the general artificial intellect in the direct production process of the transport industry. [291]

In Uber's third generation of autonomous vehicles, optical cameras, radar, LiDAR, and ultrasonic detectors have been attached to the exterior of the vehicle for the purpose of collecting data from the environment with a computer and data-storage unit in the trunk of the vehicle to allow for real-time data processing. [292] An iPad in the vehicle assists the consumer in beginning the trip, reminding passengers to fasten their seatbelt and confirm their destination, which are communicative functions that previously would have been performed by a human driver. [293] Uber has already integrated autonomous vehicles into its Pittsburgh and San Francisco operations – however, drivers are still required to sit in the vehicle to monitor the driving process. [294] At this stage, the functions of on-demand labour that are required in the transport production process are reduced to that of the 'watchman' or regulator role. However, Uber's development goal is to introduce autonomous vehicles in order to replace the regulator role of on-demand labour entirely. In the most advanced stage of vehicle automation, the direct production process in the transport industry would therefore occur automatically and entirely without human labour. While Uber engineers and technical support staff would still likely be required, the replacement of on-demand drivers

[289] Marx, Grundrisse, 692.
[290] Ibid, 705.
[291] It should also be noted that Uber has benefited significantly from DARPA's research and development of autonomous vehicles.
[292] Etherington, "Uber's Self-Driving Cars Start Picking Up Passengers in San Francisco."
[293] Ibid.
[294] Ibid.

with autonomous vehicles would raise the organic composition of capital in the transport industry, and thus, lead to the autonomous transportation of people and commodities.

3.6 Conclusion

This chapter has analyzed the Uber platform as it is powered by capital's absorption of the productive forces of the general intellect, objectified in network information technologies, and appearing as the productive forces of capital, a necessary precondition for the emergence of the circuit of big data, or 'capital's cybernetic form' as a circulating means of production. Analytical separation of the circuit of big data from the moments of production was presented in order to illustrate the cybernetic relation between the material and the digital that is unified in the total movement of capital-value. Uber's platform was analyzed as the fixed capital of the general artificial intellect, the value of which is transferred through the circulation of big data as capital's cybernetic form. Uber's production process was then presented as the movement of a relation between the material and digital forms of capital, where the circulation of labour and consumers reproduces the big data that Uber uses as means of production for controlling the labour process through predictive analytics, and hence, the value-creation process within its artificial market of supply and demand.
It was suggested in chapter two that the historical stage of capital's real subsumption of the labour process develops toward a third and final stage of capital's autonomization from labour-power in the sphere of production, which would result in the realization of the autonomous mode of production. With respect to Uber, the final analysis suggested that if Uber replaces on-demand labour-power with autonomous vehicles in direct production process then this would result in the autonomous transportation of people and commodities. If the company does achieve profitability by eliminating driver subsidies, on the surface, the replacement of on-demand labour with autonomous vehicles would appear to result in the tendency of the rate of profit to fall. As Marx noted, however, the organic composition of capital refers to the total social average.[295] Since the Uber company exists within a global taxi market, the introduction of autonomous vehicles to its production process

[295] Marx, *Capital, Volume III*, 318.

appears as a change in the value-composition of capital within one company. Therefore the tendency of the rate of profit to fall would occur throughout the entire industry only if the organic composition were to rise throughout the entire social capital of the taxi industry. [296] The degree to which the autonomous transportation ultimately affects the total organic composition of capital throughout the taxi industry remains to be seen. However, if autonomous vehicles become ubiquitous at Uber and throughout the global transport industry, rates of profit could fall while the autonomous circulation of both people and material commodities would create a significant increase in unemployment and therefore, this would indeed create new forms of class struggle among the working class employed in the circulation sphere. As other forms of transportation such as trucking, trains, ships and drones are becoming automated for the circulation of commodities, and as the automation of the means of communications and retail at the point of exchange develops, this suggests that the historical stage of capital's autonomization from labour-power that is occurring in the sphere of production is also occurring in the sphere of circulation.

[296] Ibid, 339.

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Chapter 4

4 The Smart City: General Artificial Intellect as the Means of Subsuming and Reproducing the Social Factory

Historically, the bourgeois state and the capitalist class have collaborated in the exploitation of labour to directly produce and control land development, city services and the production and maintenance of what Marx referred to as the general conditions of production.[297] Globally, less than one-third of people lived in urban centres in 1950 and this figure grew to fifty-four percent living in urban centres in 2014, a number expected to reach 66 percent by 2050.[298] Advanced capitalist development has intensified the demand for dense concentrations of capital and labour in urban centres while the development of land according to the rationality of the law of value has produced an uneven pattern of urban and suburban development.[299]

The spatial logic of capitalist development that created dense urbanization has also increasingly created problems with energy inefficient buildings, decaying infrastructure, traffic congestion, and pollution. As a contradiction of capital, this has negatively affected both the reproduction of capital and the reproduction of labour. With globalization and capital flight having established capital's leverage for global city competition, local municipalities are increasingly compelled to make their urban spaces more attractive for capital investment and the migration of skilled labour while financial crises have uprooted and displaced rural communities to urban centres.[300] Due to the social effects of financial crises and capital's demand for dense urban development, cities both produce and consume use values and, thus,

[297] Marx, *The Grundrisse*, 524-533. As forms of state-produced and state-owned, and/or privately-produced and privately-owned property, the general conditions of production include the means of transport and the means of communication that are necessary for the circulation of both commodities and people to the point of production and to the point of realization.
[298] United Nations, "World Urbanization Prospects," 7.
[299] See Harvey, *Rebel Cities.*
[300] Ibid.

exchange values in higher proportions than rural communities.[301]

These conditions have led to the marketing and ideology of the 'smart city', a concept that appears to refer to the improvement of the function, efficiencies and/or general state of well-being of a city's infrastructure, spaces and services, but that often emphasizes, either explicity or tacitly, the use of network information technology as a means to achieve these ends.[302] The development of the technologies that would be used to develop smart cities began in the 1950s when defence contractors RAND corporation, McDonnell Douglas and TRW sought new markets for their information technologies, which initially involved the use of punch cards and computer simulations for the purpose of advancing urban development. [303] Futuristic visions of technologically advanced cities continued to emerge throughout the 20th century, and have included the concept of the 'informational city'[304] the 'wired city', 'electric urbanism', and the 'knowledge society'.[305] Contemporary concepts of 'smart cities' contain similar elements of futurism that have, in many ways, been actualized.

In recent years, technology companies have intensified the development and marketing of advanced information technologies that are sold to local and national states for the creation of smart cities on the premise that these technologies will provide a competitive advantage for attracting and absorbing surplus capital and surplus labour while improving the integrated functioning of city services and general conditions of production that have been created by the free-market ideology of development. According to IHS, "annual investment on smart city projects reached slightly over $1 billion in 2013, but will go on to surpass $12 billion in 2025."[306] As a result, smart cities are expected to increase four fold, with the global number of smart cities reaching 88 by 2025.[307] Smart cities are developed either from the ground-up as found in Songdo, South Korea, Masdar City, United Arab

[301] Hayat, *Smart Cities: A Global Perspective*, 179.
[302] See Mosco, *The Smart City in a Digital World*, 23.
[303] Ibid.
[304] See Castells, *The Informational City.*
[305] Angelidou, "Smart Cities: A Conjecture of Four Forces."
[306] Ibid.
[307] IHS Technology.

Emirates, and Living PlanIT in California, or existing general conditions of production such as water and energy grids, transport infrastructure, buildings and houses are retrofitted with networked information technologies.

As noted in the introduction, Tronti's social factory thesis posited that capitalist development leads toward capital's subsumption of both the state and society. In the case of smart city development, insofar that the bourgeois state and capitalist class appropriate advanced information technologies in the development of smart cities for the reproduction of capital and/or the relations and institutions of bourgeois society, the elements of the general artificial intellect appear as the means of both subsuming and reproducing the social factory. This chapter analyzes the bourgeois state and capital's appropriation of networked information technologies in the development of smart cities, which creates new sources of big data that are collected for multiple purposes of enhancing the efficiencies of city services, the integrated functioning of general conditions of production, the commodification of the 'moments of social reproduction' for the purpose of objectifying the rationality of the law of value, the rationality of the legal and political superstructure and the rationality of the bourgeois state.

4.1 Financial Capital's Demand for Economic Growth

The term 'economic growth' masks the contradiction between use value and exchange value unified in the commodity form of land development and in the production of the general conditions of production.[308] As found in industrial production, capitalist production of the use values of land, city services and general conditions of production reproduces the logic of "accumulation for the sake of accumulation'. Since the 1920s, the US federal government had supported the autonomy of cities to control market-driven land and agricultural development.[309]

[308] See Logan and Molotch, *Urban Fortunes*, 17-50.
[309] Krueger and Gibbs, "'Third Wave Sustainability?'" 1267.

However, in response to rapid expansion and speculative crises,[310] the government introduced a federal land use policy in the 1960s but eventually abandoned it by the 1970s, leaving each state with the autonomy to reform, direct and/or control urban growth.[311] 'Economic growth' through urban land development was organized by a 'pro-growth' capitalist class alliance between bankers, developers and construction companies, which generated social opposition to the rapid development of retail shopping centres and other sprawling sites of commodity exchange in local cities and municipalities.[312]

Social opposition to the growth machine opposed growth for the sake of growth and, therefore, opposed the interests of the capitalist class. On this point, Ackerman has also noted that city planners and environmentalists argued, "that unplanned growth leads to urban sprawl that creates economic inefficiencies in transportation linkages, increased costs for infrastructure, higher crime rates, and more air pollution."[313] As such, political opposition to market-driven growth was given the label of "anti-growth',[314] a designation which abstracts from the contestation of specifically capitalist forms of economic growth in the general conditions of production and the new conditions of class reproduction this produces. In response, the federal government intervened in market-driven growth by regulating land development with a wave of reforms that would initiate an era of "growth control'.[315]

The introduction of fiat money removed the material limitations of monetary circulation. With the development of international tax competition, the conditions for capital flight from the US were developing along with capital's leverage for domestic growth. The globalization of industrial capital flight, and with it, outsourcing and offshoring accompanied the development of a service-based or 'post-industrial' economy in the West where capital absorbed new forms of labour-

[310] Harvey, *Rebel Cities,* 32.
[311] Ibid.
[312] Ibid.
[313] Ackerman, "Growth Control Versus the Growth Machine," 149.
[314] Krueger and Gibbs, "'Third Wave Sustainability'?" 1267.
[315] Ibid.

power.[316] Capital's demand for labour market flexibility had decoupled the wage share from labour productivity throughout all capitalist countries.[317] Accompanying a multi-decade decline in the rate of capital accumulation was the development of financial globalization, which expanded through the liberalization, and therefore, opening of governments to foreign investment.[318] Thus with a multi-decade increase in labour productivity coupled with wage suppression, the reproduction of capital proceeded at a growing rate of exploitation that deepened wealth inequality and worsened the class conditions of social reproduction.

Following the stock market crash of 1973, the government withdrew federal funding for urban centres under the guise that the urban crises created by suburbanization had been resolved.[319] The result of the bourgeois state withdrawing funding created, "…a crisis in urban services, with all of the terrifying consequences of degeneration in public schooling, public health, and availability of affordable housing from the late 1970s onwards in the United States."[320] However, , cities increasingly appeared to the capitalist class as 'growth machines' due to their capacity of cities to absorb high concentrations of surplus capital and surplus labour.[321]Pro-growth-machine ideology held that 'market freedom' gave people the personal freedom to vote with their feet', thereby allowing them to move into the specific urban areas of their choice to avoid the areas of urban decay that had been created by capital.[322] This ideology was derived from the "Tiebout hypothesis', a view that held the urban development would be driven by residents who would choose their residence based on their choice of taxes and services offered by each local jurisdiction. However, as Harvey has noted, the problem with the Tiebout hypothesis was that as wealthier residents are able to more easily "vote with their feet," this increases the division between wealthier and poorer neighbourhoods, and thus, leads to exacerbates uneven urban development.[323]

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[316] Hardt and Negri, *Empire.*
[317] Streeck, "The Politics of Public Debt," 147.
[318] Harvey, *A Brief History of Neoliberalism.*
[319] Harvey, *Rebel Cities,* 63.
[320] Ibid.
[321] Molotch, "The City as a Growth Machine."
[322] Ibid, 319.
[323] Harvey, *Rebel Cities,* 82.

In years prior to the 1980s, the opening of consumer credit markets deepened the culture of consumerism while the political and media infrastructure deepened the ideology of tax resistance, reappearing as votes for tax cuts that served to decrease the portion of the surplus value appropriated by the bourgeois state. With the bourgeois state under pressure to provide welfare provisions, and with less tax revenue to do so, deregulation, declining economic growth rates, tax resistance and international tax competition created the conditions for the bourgeois state to become more directly subject to the law of value through the mechanisms of debt-financing.[324] The financial system had, therefore, intervened into the welfare state's circuit of reproduction as the reductions in tax revenues were supplemented by credit-money. Thus declining economic growth, the loosening of barriers to capital flight had therefore created the conditions for the neoliberal revolution.

The deregulation of growth control in the 1980s gave way to a second wave of planning reform termed "growth management'.[325] The regulatory bourgeois state had conceded to capital's demand for accumulation by using cost-benefit analyses that supplanted strict regulatory controls.[326] Amidst this pressure, and with the development of debt-financing due to dwindling tax revenues, the bourgeois state found itself under pressure from a capitalist class that would force it to transfer state assets and functions to private interests that expanded capital accumulation through a variety of state-market arrangements such as privatization, monetization, and/or the marketization of private services in contractual relation with the bourgeois state, known as public-private partnerships (PPP).[327] Through the mechanisms of privatization and marketization, representatives of the capitalist class had therefore used the political and legal superstructure to take control of the welfare-state, and thus, private interests gradually entered more directly into production of city services and the general conditions of production, which therefore expanded the proliferation and exploitation of wage-labour, creating 'flexible labour markets' in

[324] Ibid.
[325] Krueger and Gibbs, "'Third Wave Sustainability'?" 1267.
[326] Ibid.
[327] Birch and Siemiatycki, "Neoliberalism and the Geographies of Marketization."

industries such as land development, communications, transport and energy. Though capital advanced, retreated and even developed seemingly contradictory state-market formations in the era of neoliberalism, its general historical trajectory was that of deepening control over the reproduction of the general conditions of production and general social conditions of production.

Through the use of soft power, the US and UK led the global transformation of welfare states, socialist states, and quasi-capitalist states with neoliberal transformation and economic growth, advancing notably in East Asia, West Germany and Japan.[328] In contrast, developmental states appeared to provide protections from the free market, as Harvey has noted:

> Developmental states become consistent with neoliberalization to the degree that they facilitate competition between firms, corporations, and territorial entities and accept the rules of free trade and rely on open export markets. But they are actively interventionist in creating the infrastructures for a good business climate. Neoliberalization therefore opens up possibilities for developmental states to enhance their position in international competition by developing new structures of state intervention (such as support for research and development). But, by the same token, neoliberalization creates conditions for class formation, and as that class power strengthens so the tendency arises (for example in contemporary Korea) for that class to seek to liberate itself from reliance upon state power and to reorient state power along neoliberal lines."[329]

Through World Bank, IMF and WTO policies, however, state governments and large cities that had been closed to the neoliberal state form were opened to foreign investment in a process that transformed several former communist and socialist state-controlled assets into private property. China's economy, however, was largely controlled by a state-owned banking system and state-owned enterprises (SOEs), which provided the stability and security for planning and development.[330] But with the development of the private sector, the Chinese state form was forced to engage

[328] Harvey, *A Brief History of Neoliberalism*, 89.
[329] Ibid, 72.
[330] Harvey, *A Brief History of Neoliberalism* 124.

in debt-financing when SOEs became less profitable and reforms served to gradually open the country to foreign investment that absorbed cheap surplus labour.[331] At the conclusion of the 1980s and with the collapse of the Soviet bloc, the IMF's neoliberal 'shock therapy' had absorbed the last remaining political opposition to global capital with the privatization of state assets and the rise of an oligarchic capitalist class in Russia.[332] US-led wars and coups, and financial and cultural forms of soft power had transformed political, social, and regulatory regimes to meet capital's demands for accumulation.

As the loosening of state barriers continued, the Washington consensus' neoliberal model had accelerated the mobility of finance capital, which put demands on each state to create the political conditions necessary for capital investment, such as favourable tax rates, deregulation, and a supply of cheap surplus labour. As the use value of land development, city services and general conditions of production increasingly became commodities with exchange value, the law of value therefore determined the production, maintenance and sale of these use values. The relation of capital to the bourgeois state in the neoliberal era had therefore been transformed, which indicates the extent of capitalist development. As Marx noted:

> The highest development of capital exists when the general conditions of the process of social production are not paid out of deductions from the social revenue, the state's taxes –where revenue and not capital appears as the labour fund, and where the worker, although he is a free wage worker like any other, nevertheless stands economically in a different relation –but rather out of capital as capital. This shows the degree to which capital has subjugated all conditions of social production to itself, on one side; and, on the other side, hence, the extent to which social reproductive wealth has been capitalized, and all needs are satisfied through the exchange form; as well as the extent to which the socially posited needs of the individual, i.e. those which he consumes and feels not as a single individual in society, but communally with others –whose mode of consumption is social by the nature of the thing –are likewise not only consumed but also produced through exchange, individual exchange.[333]

[331] Ibid.
[332] Ibid, 122.
[333] Marx, *Grundrisse,* 531.

With capital's demand for exponential economic growth in global cities, rapid expansion, fragmented and uneven patterns of development reappeared in the quality and reliability of city services such as energy, water, sewage, waste collection and roads, at times with or without adequate state regulation and oversight, while the social and financial costs of 'negative externalities' such as pollution, traffic congestion, and waste, were left for the bourgeois state and the public to bear.[334]

4.2 Financial Capital's Demand for Smart Cities

Capital's reduction of regulatory barriers, the demand for labour-market flexibility, privatization, and the coordinated neoliberal transformation of the bourgeois state had increasingly opened the production of city services and the general conditions of production to the free market, creating the conditions for capital to more directly control spatial patterns of urban development. For example, Troutman has described the history of growth in San Diego as an alternating pattern of urban growth and growth control regulation as a cycle in which "the negative consequences of rapid growth leads to calls for more planning and slower growth. As the boom collapses, efforts to slow or manage growth are overshadowed by efforts to stimulate the economy. This process has repeated itself in approximately 10-year intervals."[335] With state debt-financing the norm and with financial globalization, large cities were more directly subject to the global intercity competition for the attraction and retention of capital under the possibility of capital strikes and/or flights and for the attraction and retention of labour under the possibility of 'brain drains' in order to maintain exponential growth curves. Capital's continuous spatial reorganization affects the location of waged labour, and therefore, the class conditions of social reproduction. Thus globalized capital's alternating patterns of investment and

[334] Harvey, *A Brief History of Neoliberalism,* 50.
[335] Troutman, "A Growth Machine's Plan B," 613.

divestment continuously shift global patterns of class decomposition and recomposition.[336]

'Smart growth' regulations introduced in the US and the UK had removed the cost-benefit analysis of the bourgeois state's growth management strategies, relying instead on consumer demand and financial speculation to more directly determine market-driven patterns of development.[337] The smart growth model sought to increase urban density using a strategy of efficient land use, waste reduction, and environmentally sustainable development in direct contrast to the market-driven development of urban sprawl. As the dual meaning of 'sustainable growth' referred to both economic and environmental aspects of development, 'smart growth' synthesized the pro-growth alliance of the capitalist class and various factions of the 'slow growth' coalition of environmentalists, planners and community representatives in a new alliance for sustainable capital accumulation.[338] Thus smart growth appeared as an environmentally sustainable market-driven solution to the problems created by the deregulation of land-use and free market ideology that had created urban sprawl, inefficient city services, energy waste and environmental pollution.

The smart growth model was directed toward the development of livable urban spaces for attracting and absorbing surplus capital and surplus labour-power for the growing service economy while intercity competition put pressure on states to brand cities as marketable living spaces through promotion and advertising campaigns.[339] However, despite the smart growth movement, and perhaps because of its underlying alignment with the logic of capital accumulation, dense land development patterns continued to reproduce increases in transport congestion, energy waste, environmental pollution. As industrial capital accelerated its flight from the US in the 2000s, de-industrialized cities continued to be developed as hubs

[336] Dyer-Witheford, *Cyber-Marx*, 142-147.
[337] Krueger and Gibbs, "'Third Wave Sustainability'?" 1268.
[338] See Herrschel, "Competitiveness and Sustainability."
[339] See Klingmann, *Brandscapes: Architecture in the Experience Economy.*

for the attraction of the productive forces of the general intellect, namely, the labour-power required for creative work, services, software production, etc.[340]

Cities continued to compete to attract, develop and retain the workers required for the creative industries, information technology companies, human service organizations and other symbolic and the affective industries of an emerging service sector that continued to supplant the outsourcing and offshoring of industrial production. The global financial crisis in 2008 that had created a global rise in unemployment also deepened intercity competition for the concentration of capital and labour. As Hollands has noted, "strapped for cash, cities began to compete with one another in attracting in global capital and marketing themselves as world leading cultural creative, or smart brand cities. With the global financial crisis, followed by a nearly worldwide politics of austerity, this governance trend has continued with an increased emphasis on efficiency savings, privatisation and the promise of a high-tech future."[341]

Capital's renewed leverage in the demand for growth also accelerated global urbanization and land development that produced vacant high-rise housing and commercial buildings that were produced for financial speculation in major cities such as New York, Beijing, Toronto and San Francisco. In China, India and Japan, urbanization advanced quite rapidly, with the concentration of capital and social labour in megacities such as Tokyo reaching 38 million people, Delhi with 25 million, Shanghai with 23 million and Mexico City and Mumbai with 21 million people.[342] In many respects, China's urbanization has created increased demand for urban land development that has led to consistently high economic growth rates in the last decade.[343] However, China's state-controlled market for speculative land development has also produced several 'ghost cities', fully developed ahead of the required residents.

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[340] See Marx, *Grundrisse,* 711-712. The development of social labour-power, appearing as capital's development of fixed capital in a form demanded by industry, or capital's social condition of production, currently referred to as 'human capital',
[341] Hollands, "Critical Interventions into the Corporate Smart City," 68.
[342] Ibid, 13.
[343] Harvey, *A Brief History of Neoliberalism*, 127.

Global increases in urbanization have increased the demand for transport, water, and energy infrastructure in cities while privatization and marketization of the commons has increasingly tied reproduction of the general conditions of production to the law of value resulting in fragmented spatial patterns of land development that have produced increases in traffic congestion, and energy and water inefficient buildings and housing.[344] In turn, this has created 'externalities' such as increases in pollution and greenhouse emissions that negatively affect health, mobility and, therefore, both the reproduction of capital and social reproduction. Therefore even sustainable growth puts additional pressure on national and local states to remain globally competitive for the attraction and retention of capital and labour in cities, as Hodson and Marvin have noted that security concerns over urban infrastructure now include the urban ecology.[345] Thus capital's global demand for exponential growth manifests the contraction of use value and exchange value that have created its own material, social and environmental barriers to exponential accumulation.

In relation to global intercity competition, smart cities are designed to dynamically optimize city services and the general conditions of production to compete for surplus capital while creating the conditions of social life that attract the skills and creative powers of social labour. The marketing and advertising campaigns of technology companies give the impression that the integration of network information technologies with existing city services and general conditions of production for the creation of smart cities will increase each city's competitiveness for the attraction of capital and the forms of labour it requires in two respects. First, technology companies claim that the integration of networked Information technologies with existing services and general conditions of production would create efficiencies and cost savings for the bourgeois state and/or individual capitals that have privatized control of these entities.[346] Second, technology companies claim that once network information technologies are integrated with city services and general conditions of production, local and national states may develop

[344] Dirks and Keeling, "A Vision of Smarter Cities," 7-8.
[345] Ibid, 207.
[346] Dirks et al., "Smarter Cities for Smarter Growth."

centralized operations centres to monitor and control a smart city's 'system of systems' in order to reduce the economic and social costs of traffic congestion, energy waste and environmental pollution that have been created by capital's uneven market-driven spatial patterns of development.[347]

4.3 Capitalist and Bourgeois State Appropriation of the Elements of the General Artificial Intellect in the Development of Smart Cities

As part of a multi-faceted strategy designed to meet the demand for smart city development, technology companies such as ARUP, IBM, Cisco, Hitachi, Forester and Siemens have marketed various ICTs solutions and strategies.[348] With smart city 1.0, the direction and strategies of smart city projects was determined by the recommendations of technology companies. Smart city 2.0 devolved development to the local state and private sector while the current trend of smart city 3.0 devolved development to the co-determination of local states and residents.
In this respect, with the changes to local state governance brought on by the integration of technology companies with state decision-making,[349] various phases of smart city development appear to follow the neoliberal pattern of development and the devolution of control over decision-making and implementation to private interests. Smart city implementation may include the integration of the IoT, IoS, CPS, cloud and big data analytics with various private and state-owned city services and general conditions of production. Insofar as the private producers and owners of city services and general means of production purchase advanced network information technologies, these technologies appear as fixed capital. However, insofar as the bourgeois state uses tax revenues to purchase smart city information technologies, these technologies appear as state expenses necessary for the reproduction of city services and the general conditions of production.

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[347] See Angelidou, "Smart Cities: A Conjecture of Four Forces."
[348] Goodspeed, "Smart Cities," 83.
[349] Mosco, *The Smart City in a Digital World*, 42.

The development of advanced smart city network infrastructure creates a dual cybernetic control relation between privately owned and/or state-owned network information technologies and the material and social processes that these technologies are designed to control in a smart city. The components of land, city services and general conditions of production that may be digitalized include transport infrastructure, water delivery systems, buildings, houses and the energy grid.[350] In addition to the integration of network information technologies with city services and general conditions of production, IBM, Siemens and other technology companies have been marketing and developing operations centres as a solution to integrate the multiple network privately and/or state-owned information technologies that control the multiple material processes of city services and general conditions of production under centralized control.[351] Operations centres therefore integrate the big data that are generated by the multiple network devices and infrastructures, including mobile smartphones, IoT, IoS, CPS, and the IoE, at various levels of smart cities, and in various combinations. Quantification and processing of big data within operations centres allow for dashboard displays of messaging, key performance indicators (KPI) and smart city analytics.[352] Descriptive and predictive analytics allow for integrated cybernetic feedback, and therefore, control of the multiple dynamic and nonlinear social and material processes of individually digitalized city services and general conditions of production in smart cities.[353]

As noted in the introductory chapter, the Internet infrastructure was first developed as a top level military and intelligence infrastructure that began with the creation of ARPANET that was later extended to the development and commercialization of a

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[350] See Rifkin, *The Zero Marginal Cost Society.*
[351] See Mosco, *The Smart City in a Digital World*, 64-67. As Mosco notes, IBM developed Rio de Janeiro's operations centre in 2010 initially for the purposes of disaster relief and city management of emergency services, but later became the state's means of surveillance of dissent and social protests. In addition, Mosco noted Siemen's development of Singapore's operations centre and the digital hub for the entire southeast Asian region.
[352] Zhuhadar et al., "Review of Smart Cities Intelligent Operations Systems."
[353] Zanella, "Internet of Things of Smart Cities."

front-facing infrastructure. As indicated by the Snowden revelations,[354] the big data collected by the digital infrastructure in smart cities is therefore also necessarily collected by the military and intelligence infrastructure of the bourgeois state.[355] Capital and the bourgeois state's appropriation of the elements of the general artificial intellect for the development of smart city infrastructure within the existing relations of bourgeois society therefore expands the production, collection, and analysis and feedback of big data from within the 'moments of social reproduction' as multi-sided, and multiple means of objectifying the rationalities of bourgeois society. As noted in chapter one, Tronti's social factory thesis posited that as capitalist development proceeds in its organic relation with the bourgeois state and society, it transforms the moments of the reproduction of social life into an articulation of the moments of production:

> The more that capitalist development advances, that is, the more the production of relative surplus value penetrates and extends, the more that the circle-circuit production-distribution-exchange-consumption is necessarily closed. That is, the relation between capitalist production and bourgeois society, between factory and society, between society and State achieves, to an ever greater degree a more organic relation. At the highest level of capitalist development, the social relation is transformed into a *moment* of the relation of production, the whole of society is turned into an *articulation* of production, that is, the whole of society lives as a function of the factory and the factory extends its exclusive domination to the whole of society. It is upon this basis that the machinery of the political State tends to ever more identify with the figure of the *collective capitalist*; it is turned ever more into the property of the capitalist mode of production and, as a result, *function of the capitalist*.[356]

With capital and the bourgeois state's global deepening and expansion of the digital means of representation, the moments of social reproduction appear as controllable, and therefore, programmable computational objects that are used according to the rationalities of bourgeois society. In this respect, the integration of smart city infrastructure with operations centres creates a 'system of systems' that optimizes fragmented city services and general

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[354] Wills, *Tug of War*.
[355] Ibid.
[356] Tronti, *Factory and Society*, 9.

conditions of production that has been created by privatization and marketization,[357, 358] but the big data that are processed in operations centres are also being used to generate feedback in the form of state actions, decisions and interventions that are designed to transform social consciousness and social behaviour and to advance capitalist and bourgeois state development. Thus, as the means of objectifying the rationality of the law of value and capitalist development[359], or what Shoshana Zuboff refers to as *surveillance capitalism*,[360] smart city infrastructures that are controlled and implemented by private interests may function to further rationalizing the delivery, maintenance and reproduction of services according to consumer demand, while the integration of these same sources of big data in operations centres are also being used to as the means of objectifying the rationality of the legal and political superstructure and the rationality of the bourgeois state.[361]

[357] Birch and Siemiatycki, "Neoliberalism and the Geographies of Marketization," 184.
[358] Dirks and Keeling, "A Vision of Smarter Cities," 9-10.
[359] For example, see Etezadzadeh, "Smart City – Future City?"
[360] See Zuboff, *Surveillance Capitalism*.
[361] On this point, as Marx notes in the *Grundrisse*, 160, with the development of the autonomization of the world market, institutions arise that are designed to measure commodity prices, and with it, the development of the means of communication: "In the lists of current prices , where all values are measured in money, it seems as though this independence from persons of the social character of things is, by the activity of commerce, on this basis of alienation where the relations of production and distribution stand opposed to the individual, to all individuals, at the same time subordinated to the individual again. Since, 'if you please', the autonomization of the world market (in which the activity of each individual is included), increases with the development of monetary relations (exchange value) and vice versa, since the general bond and all-round interdependence in production and consumption increase together with the independence and indifference of the consumers and producers to one another; since this contradiction leads to crises, etc., hence, together with the development of this alienation, and on the same basis, efforts are made to overcome it: institutions emerge whereby each individual can acquire information about the activity of all others and attempt to adjust his own accordingly, e.g. lists of current prices, rates of exchange, interconnections between those active in commerce through the mails, telegraphs etc. (the means of communication of course grow at the same time). (This means that, although the total supply and demand are independent of the actions of each individual, everyone attempts to inform himself about them, and this knowledge then reacts back in practice on the total supply and demand. Although on the given standpoint, alienation is not overcome by these means, nevertheless relations and connections are introduced thereby which include the possibility of suspending the old standpoint)." The development of the institutions and means of communication may therefore be understood as extending historically from the collection of information for the measure of prices to the collection of information about individuals and social and material processes as the means of determining the value of the social and material world, and thus, the potential for capitalist development. With the development of smart cities, in addition to bourgeois institutions, the very material and social infrastructure of bourgeois society are becoming the means of collecting information about individuals and social and material processes as the means of determining the value of the social and material world, and thus, the potential for capitalist development.

4.4 The ‘Moments of Social Reproduction’ and the Circulation of Big Data as Instruments of Bourgeois Society

The relations and processes of the ‘moments of social reproduction’ that could become digitalized within a smart city include the moments of social communication, consumption, commodity circulation and exchange, and moments of the material functions and processes of smart city services and general conditions of production such as transport, water and energy delivery, and facility operations of buildings and housing. The reproduction of the moments of social reproduction in bourgeois society therefore reproduces big data in smart cities as an instrument of bourgeois society. As the means of objectifying the rationality of the law of value, the big data that are generated by the elements of the general artificial intellect that have been integrated with transport infrastructure such as roads, bridges and tunnels and manual and autonomous vehicles may be used to monitor, predict and optimize traffic routing through cybernetic feedback. Traffic congestion creates a spatial barrier to capital accumulation due the additional time that it takes to transport labour to the point of production and to transport consumers to exchange money for the means of consumption at the point of realization. However, a report by Intel suggests that the use of big data in smart cities would lead to improved public health and street safety that would save citizens 125 hours per year.[362] The big data that are generated by the smart city infrastructure that has been integrated in buildings are used to monitor, predict and optimize the cyberphysical control of air quality and temperature for improved energy efficiency, which reduces energy costs.[363, 364] The big data that are generated by the IoE may be used to monitor, predict and optimize electricity distribution for buildings, houses, water and city lighting.[365] As water and energy waste in buildings also adds costs to owners of the means of production, and therefore acts as a general barrier to capital accumulation, smart city optimization of water and waste management therefore indirectly reduces the costs of production for the capitalist class as a whole.[366] Thus the big data that are processed in

[362] Mosco, *The Smart City in a Digital World*, 65.
[363] Dirks et al., “Smarter Cities for Smarter Growth.”
[364] Thomas and Cook, “Activity Aware Energy-Efficient Automation of Smart Buildings.”
[365] Zanella, “Internet of Things of Smart Cities.”
[366] See Mosco, *The Smart City in a Digital World*, 64. As Mosco notes, according to a report by ABI Research, smart city infrastructure is expected to reduce annual repair and maintenance costs by 30% while

operations centres optimizes the use value of city services and general conditions of production while reducing the costs and therefore the barriers to capital accumulation that occur outside the point of production but that affect costs of production.

As a case example of the capitalist nature of smart city development, Google's Alphabet company Sidewalk Labs has partnered with a municipal, provincial and federal government-created and controlled corporation called Waterfront Toronto to develop 12 acres of Toronto's Waterfront into a small smart city from the "Internet up" that could eventually develop into an 800 acre smart city.[367, 368] With Canada contributing 10.9 billion, Ontario 2.2 billion and Toronto 1.7 billion for a total investment of 14.8 billion CAN combined with Sidewalk Labs' proposed 1.3 billion dollar US investment in the Toronto smart city project, a document produced by Sidewalk Labs estimates that the new district would create 93,000 new jobs within the smart city, 174,000 construction jobs and 14.2 billion in annual GDP output by 2040.[369] The preliminary plans of Waterfront Toronto and Sidewalk Labs for the design of Toronto's smart city includes the development of a *physical layer and a digital layer*.[370] The physical layer has been designed to include an underground infrastructure for the transportation of city waste, a public realm that includes mid-rise apartments, office, shops and a school with buildings that have been prefabricated with eco-friendly components, and designed with modularity to allow the spaces to be changed and reconfigured for different uses,[371,372] and the mobility system will rely on autonomous vehicles as the transportation system integrated with heated streets and sensors that monitor traffic and protect pedestrians.[373,374] The digital layer has been designed to connect the functions and services of the each

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the introduction of smart manufacturing plants, more energy-efficient transport using drones and semi- and fully-autonomous vans and trucks is expected to save businesses $14 billion dollars annually.

[367] Barth, "The Fight Against Google's Smart City," August 8, 2018.
[368] Wakefield, "Tomorrow's Cities: Google's Toronto city built 'from the Internet Up'," May 27, 2018.
[369] Sidewalk Labs, "Toronto Tomorrow," 494-503.
[370] Bliss, "When a Tech Giant Plays Waterfront Developer," January 9, 2018.
[371] Ibid.
[372] Barth, "The Fight Against Google's Smart City," August 8, 2018.
[373] Wakefield, "Tomorrow's Cities: Google's Toronto city built 'from the Internet Up'," May 27, 2018.
[374] Gilles, "Three Waterfront Toronto Directors Involved with Google Wired Community Deal Fired by Ontario Government," December 7, 2018.

component of the physical layer with sensors that will monitor noise and air quality, electric grid performance and waste collection.[375,376]

While Waterfront Toronto owns most of the land that is to be developed into a smart city, it has been suggested that Google's Sidewalk Labs will control the intellectual property of the IP addresses and aggregate big data that is generated by Toronto's smart city infrastructure.[377] Further, Google's servers are located outside of Canada and are subject to the jurisdiction of US law.[378] But the proposed corporate ownership of intellectual property in the big data that will be produced by residents in Toronto's smart city has generated public challenges to the balance of corporate and/or state control, and thus, to the potential loss of state governance and citizen control of urban development to corporate ownership and control of the smart city.[379] Despite reports that Sidewalk Labs has indicated that the big data generated and collected within Toronto's smart city will be fully anonymized, the expansion of digital sources collected about the daily life of its inhabitants has caused public concern that the Toronto smart city is being designed with the unequal power of expanded corporate and state surveillance.[380] Amidst these concerns, however, the Toronto smart city project appears to be moving forward with rather sparse public knowledge of the project details and limited public input into the planning and development of the smart city.[381]

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[375] Bliss, "When a Tech Giant Plays Waterfront Developer," January 9, 2018.
[376] Wakefield, "Tomorrow's Cities: Google's Toronto city built 'from the Internet Up'," May 27, 2018.
[377] Mosco, *The Smart City in a Digital World*, 81-82. At the time of writing, however, the question of who will retain ownership of the intellectual property of Toronto's smart city remains unclear. For example, while earlier reports have indicated that Sidewalk Labs could retain control of the intellectual property of Toronto's smart city, it has also been suggested that a government agency would retain control of Toronto's smart city data collection: https://business.financialpost.com/technology/revised-terms-of-waterfront-project-take-data-control-out-of-sidewalk-labs-hands
[378] Global Staff, "Sidewalk Labs's Vision and your Data Privacy."
[379] Flynn and Valverde, "Planning on the Waterfront," 772. This point is evidenced by Toronto Waterfront's apparent lack of control over the proposed smart city's intellectual property to the advantage of Google, and recent political reshuffling and high-profile resignations among the project's leadership as a result of this isssue.
[380] Balsillie, "Sidewalk Toronto has Only One Beneficiary, and it is not Toronto," October 5, 2018.
[381] See Goodman and Powles, "Urbanism Under Google," 3-4.

The development of Toronto's smart city would lead to the production of big data as a use value that could be used to monitor and optimize city services and functions.[382] Regardless of reports of data anonymization,[383] the aggregate big data generated in Toronto's smart city could become either commodified and sold to third party capitalists or could become Google's means of production for corporate development of new product and service commodities or the means of capitalist planning and development of the smart city itself. The expansion of smart city infrastructure would therefore leads to an expansion in the total aggregate of big data that could potentially become available to the capitalist class as a freely-produced use value, and thus, as a means of production. Thus, while corporate and state investment in smart cities appears for the purpose of the optimization of use values, and thus, for the overall improvement of urban life, just as the private ownership of the use values of land, buildings, city services and general conditions of production is also for the purpose of either directly or indirectly optimizing the realization of exchange value, smart city infrastructure and the big data it collects are also use values that are similarly becoming the means of expanding capital-value.

The collection of big data produced by smart cities as well as existing cities is also used to materialize the spatial logic of capitalist development that results in the reorganization of city services and general conditions of production, which both determines and transforms the class conditions of social reproduction. On this point, capitalists and the representatives of the bourgeois state have used different material forms of data and information as the means of advancing capitalist planning and development of urban centres. However, with the development of smart city infrastructure, the volume, and potentially, the velocity and variety of digital big data necessarily expands, and with it, the potential for the intensification and acceleration of competition for access and use of this data.

An example of the use of big data for capitalist development is Amazon's introduction of an application for cities to bid to host their second headquarters. According to Business

[382] Bliss, "When a Tech Giant Plays Waterfront Developer," January 9, 2018.
[383] Balsillie, "Sidewalk Toronto has Only One Beneficiary, and it is Not Toronto," October 5, 2018.

Insider, Forbes, and CBS, Amazon received applications from 238 cities to host their second headquarters. While Amazon chose only one city for their second headquarters, the company retained demographic, infrastructure and investment data from each city. As the means of reproducing the rationality of capitalist development, Amazon's collection of big data therefore allows the company to materialize their competitive intelligence for strategic development and investment opportunities in 238 cities.

The big data collected within a smart city's infrastructure also has the potential to become the means of objectifying the rationality of the bourgeois legal superstructure through law enforcement's protection and reproduction of private property relations and the apprehension of the non-violent crimes and crimes of poverty created by bourgeois society in the interests of the for-profit prison-industrial complex.[384] In the US and other Western countries, African-Americans, Latinos and other marginalized groups in particular have suffered at the hand of law enforcement and the bourgeois state. [385,] Incarceration rates for these groups have increased as the for-profit system of cash for bail, plea deals, and other coercive forms of value extraction have become increasingly intertwined with the prison-industrial complex[386] that has become a major 'growth industry' and therefore a source of capital accumulation. [387] On this point, it has been argued that the use of predictive policing in impoverished neighbourhoods extends law enforcement's excessive monitoring and apprehension of historically oppressed and marginalized groups who otherwise would not have had interaction with the criminal justice system.[388] This suggests that law enforcement's use of networked information technology and predictive analytics reinforces the institutional oppression of social groups already historically, systematically and violently exploited and by the representatives of the capitalist class and the bourgeois state.[389, 390]

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[384] Goldberg, "Surplus Value: The Political Economy of Prisons."
[385] Ibid.
[386] Marable, "How Capitalism Underdeveloped Black America."
[387] See Dencik et al., "Prediction, Pre-emption and Limits to Dissent."
[388] Brayne, "Big Data Surveillance."
[389] See Marable, "How Capitalism Underdeveloped Black America," on the level of incarceration of African-Americans as of the year 2000.
[390] See Goldberg, "Surplus Value: The Political Economy of Prisons."

The circulation of big data has also expanded geometrically the power and hegemony of the rationality of the bourgeois state, which has been used as the means of determining the space and time of dissent as the means of materializing the suppression of dissent to capital and the bourgeois state. For example, as the speculative bubble that developed in the US housing market leading up to 2008 burst and caused the chain reaction that would lead to the global financial crisis, the state responded with bank bailouts, stimulus spending and quantitative-easing that reinvigorated the capitalist class.[391] At the same time, austerity measures were introduced with based on the neoliberal ideology that cutting public spending was necessary in order to cut the debt, a global strategy among the debt-states that was met with global protests.[392] In major cities across the globe, Occupy Wall Street and other protest movements surfaced as social responses with alternatives to the capitalist system being proposed, circulated and debated. In these political expressions of class struggle, new solidarities and social movements were formed through the use of mobile smartphones and social media.[393] However, as both the representatives of the capitalist class and the bourgeois state use the elements of the general artificial intellect to collect big data about these social movements, analyze it, and thus, to use it to manage and reproduce the relations of bourgeois society,[394, 395, 396] the global social unrest caused by the financial crisis and the deepening of austerity therefore appeared to the representatives of the capitalist class and the bourgeois state as a social phenomenon that was to be cybernetically managed and controlled rather than as the ongoing historical manifestation of capitalist crises that indicates the social need for a new economic system.

In recent years, the strategy of the bourgeois state appears to have shifted from the use of network information technology to anticipate and respond to dissent during times of social and political upheaval to a strategy of using network information technology to preemptively control social behavior. In the US, this strategy has materialized in perhaps a

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[391] See Skidelsky, "Ten Years on from the Financial Crash, We Need to get Ready for Another One." https://www.theguardian.com/commentisfree/2018/sep/12/crash-2008-financial-crisis-austerity-inequality
[392] News Wires, "Anti-Bank Protests Spread Around the World."
[393] Jost et al. "How Social media Facilitates Political Protest."
[394] On this point, Juris in "The New Digital Media and Activist Networking within Anti-Corporate Globalization Movements," indicates that the surveillance of protest movements through digital networks was well established prior to the 2008 financial crises.
[395] Uldam, Julie. "Corporate Management of Visibility: Social Media and Surveillance."
[396] See Dyer-Witheford, *Cyber-Proletariat: Global Labour in the Digital Vortex*, 147-167.

more secretive way through the front-facing commercial Internet infrastructure in a corporate 'social credit system'. For example, Forbes has reported that New York's Department of Financial Services (NYFS) will allow life insurance companies to determine the premiums of its customers by accessing their social media posts.[397] As the article details, due to the global reach of social media, this appears to extend the reach of the reach of New York's insurance companies well beyond the physical borders of New York.[398] Other examples of a corporate social credit system include the ability of social media companies to unilaterally ban users, financial companies like PayPal, Venmo and Patreon to restrict a person's access to the marketplace, and the ability of Uber and AirBnB to ban people from accessing transport and accommodation.[399] While these examples are based on the policies and practices of individual capitalist enterprises, in the era of surveillance capitalism, it is an open question as to whether each of these companies, or the bourgeois state, have access to the personal data of its citizens outside the domain of each corporate platform, a question that becomes even more pertinent in the context of the potential for the expansion of personal sources of big data in smart cities.

In China, however, the shift toward the strategy of preemptive social control appears as a a more total and publicly open integration of the corporate and bourgeois state Internet infrastructure. For example, the Chinese government has mandated the development of a 'social credit system' which is a national information infrastructure that collects, integrates and analyzes the big data generated from all sources of network information technology used by its citizens, including smart city infrastructure.[400, 401] The Chinese social credit system generates a social credit score for each citizen, which, depending on the score, materializes class-structured barriers or possibilities for mobility, access to credit and enforcement of what the Chinese bourgeois state considers positive social behaviour.[402, 403] The big data collected by the social credit system have therefore become the means of determining and objectifying the rationality of the representatives of the Chinese bourgeois

[397] Baron, "Life Insurers Can Use Social Media Posts to Determine Premiums."
[398] Ibid.
[399] Elgan, "Uh-Oh: Silicon Valley is Building a Chinese-Style Social Credit System."
[400] Hatton, "China's 'Social Credit.'"
[401] Hodson, "Inside China's Plan to Give Every Citizen a Character Score."
[402] Ibid.
[403] Humphries, "Every Chinese Citizen Will Soon Have a Score Based on How They Live and Conform."

state. Thus the degree to which other smart cities and states have implemented or are developing similar social credit systems indicates that the abstract determinations of capital's laws of motion must necessarily include the cybernetic relation of the moments of social reproduction and the circulation of big data in smart cities that are collected, processed and fold back on to bourgeois society as another abstract determination of the reproduction of bourgeois society.

4.5 Conclusion

The development of global city competition for capital and labour was created by the historical global expansion of finance and industrial capital. As this has transformed the welfare-state of foreign and domestic governments across the globe toward a neoliberal order, complex state-capital formations have increasingly used market-driven strategies for the production of the general conditions of production and city services. As a result of free market ideology, this has produced global problems with traffic congestion, energy and water waste and environmental pollution in urban centres. Technology companies have offered solutions and strategies for private and/or state owners of city services and general conditions of production to optimize service delivery and infrastructure maintenance while reducing traffic congestion, energy and water waste and pollution.

Consistent with the neoliberal model of development, the integration of new technologies in cities brings with it complex changes to the governance of city services and general conditions of production. Local and national state development of operations centres introduces new modes of cybernetic control to the integration and management of a city's 'system of systems.' The integration of the IoP with smart city infrastructure allows for capitalist development based on the knowledge produced from big data that are produced from the moments of social life. Feedback in this cybernetic form of development occurs through the human activities, decisions and actions that transform the general conditions of production and the class conditions of social reproduction. The logic of smart city development

therefore appears to reproduce the spatial logic of capitalist development guided by the cybernetic control of operations centres.

With the development of smart cities, global intercity competition for capital and labour would likely intensify, and along with it, the process of urbanization. As capital's spatial logic of accumulation for the sake of accumulation has created the uneven social development that depends on the geographical specificity of the global value chains of labour exploitation for the production and circulation of commodities, the development of smart cities may appear to repair or even slow social and ecological degradation in specific areas of the globe, while in others, capitalist production of the means of production required for smart city development continues to reproduce the capital-relation. Therefore, insofar as smart city infrastructures accelerate and extend the relations of bourgeois society, smart city development has the potential to create concentrations of highly organized and advanced urban living while intensifying gentrification, and thus, the division of class disparities. Thus the global development of smart cities must be understood as a manifestation of the uneven development that capitalist development produces and that determines the new social and material dynamics of class struggle.

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Chapter 5

5 Conclusion

The historical development and reproduction of the capital mode of production was set in motion through the process of primitive accumulation that created the relation of capitalist to proletariat, or property owners to the propertyless. As the reproduction of capital is derived from the theft of unpaid labour-time, the capitalist class was made dependent on the exploitation of labour while the proletariat was in turn made dependent on the capitalist class for the means of subsistence. Capital is therefore a relation of 'value in motion' that acts as an alien power that both reproduces the relations of production and is continuously reproduced on an expanded scale by the relations of production. In the course of capitalist development, capital has increasingly absorbed the productive forces of the general intellect to produce new types of cognitive, affective and service labour-power,[404] as well as labour-saving machinery that industrial capitalists re-appropriate and apply to the sphere of production.

As noted in the literature review, *operaismo* and *post-operaismo* interpretations of the *Fragment on Machines* have emphasized that it is the historical development of productive forces of the general intellect and its transformation into immaterial labour-power that is the historical condition that will lead to a crisis in the measure of value based on labour-time. However, my interpretation of the *Fragment on Machines* has emphasized that Marx indicated it is the historical development of the fixed capital of autonomous machines as the means of replacing direct labour-power at the point of production that is the historical condition that leads to the crisis in the measure of value based on labour-time. The development of the hedgemony of immaterial labour in (post)industrial countries may therefore be understood not as an indication of a becoming-communism, but as a manifestation of the expanded reproduction, mobility and globalization of industrial and financial capital. While Tronti's social factory thesis originally emphasized that the historical development of the capital leads to the subsumption of the bourgeois state and

[404] Vercellone, "From Formal Subsumption to General Intellect."

society and Negri's extension of the social factory thesis emphasized capital's subsumption of the means of communication, this thesis examines the bourgeois state and capital's appropriation of the elements of the general artificial intellect as the means of subsuming the social factory. The approach of the thesis has therefore suggested an re-emphasis on the historical development of the fixed capital of autonomous machines at the point of production as the means of replacing direct labour-power and the historical development of the means of communication as the bourgeois state and capital's means of subsuming and reproducing the social factory outside the point of production.

The approach of the thesis has introduced Marx's method of historical materialism to the field of library and information science. In so doing, the thesis has introduced a full dialectical conception of the relation of the objectification of the means of representation *in* social consciousness to the objectification *of* social consciousness on materialist premises. The general concept of the means of representation was developed from materialist conceptions of information found within the LIS literature. The thesis therefore contributes an approach to subfields in LIS such as the philosophy of information, document theory and information studies that allows for further expansion and development of a dialectical analysis of the relation of social consciousness to information and information technology in global capitalist society. As an extension of Marx's concept of the general intellect, I have suggested that with the development of information processing machines, capital's absorption of the scientific knowledge of the general intellect has produced the elements of the *general artificial intellect*, or the total processing power of information technology in society.

As machinery is produced according to the capitalist method, it exits the sphere of production as a commodity and is purchased as either the means of communication or re-enters the sphere of production as means of production. The combination of machines designed to extend or replace the motive power of labour with information machines designed to extend or replace the objectification of the mental power of labour has led to the development of the means of automation that capitalists have re-appropriated in the direct production process. Insofar as individual capitalists replace labour-power with the means of automation without expanding the total workforce, automation technologies raise

the organic composition of capital at the level of industry, which leads to the tendency of a falling rate of profit. Counteracting tenancies to the tendency of a falling rate of profit brought on by the acceleration of automation in the sphere of production include cheapening the cost of labour-power rather than advancing automation of the direct production process. As the law of competition that compels capitalists to replace labour-power with autonomous machines also removes their source of surplus value, I have suggested capital's autonomization from labour-power is therefore the gradual realization of the contradiction of the historical development of the capitalist mode of production that Marx noted in the *Fragment on Machines.* In contrast to the autonomist emphasis on the development of immaterial labour as the historical condition that will lead to a becoming-communism, I have argued that the historical condition that will lead to the supersession of the capitalist mode of production is not only the replacement of labour-power in the direct production process as Marx emphasized in the Fragment on Machines. Rather, it is the *total* replacement of labour-power with the fixed capital of machine-power in the entire global sphere of production. Thus as Marx defined the historical development of the capitalist mode of production according to the stages of capital's formal subsumption and real subsumption of the labour process, this thesis has suggested a third stage of capital's autonomization from labour-power has is the realization of the set in motion the internal contradiction of the capitalist mode of production with the development of what I refer to as the *autonomous mode of production*.

With Industry 4.0, the integration of cyberphysical machines and the internet of things as fixed capital in the sphere of production demonstrates the historical process of capital's autonomization from labour-power in the sphere of production that could potentially replace the labour-power involved in the direct production process entirely, as well as the indirect labour-power of management, production planning and other forms of work that are employed outside of the direct production process within smart factories. Uber's development and integration of the Uber platform with autonomous vehicles as fixed capital is part of a broader process of capital's autonomization from labour-power in the circulation sphere that could, in turn, lead to the different forms of the autonomous circulation of people and commodities.

When information technologies are purchased and used by the private sector as means of production for the production, delivery and/or maintenance of particular and general conditions of production, these technologies also appear as fixed capital. However, when the representatives of the bourgeois state purchase the elements of the general artificial intellect to produce operations centres that integrate control and optimization of the particular and general means of production in smart cities, these technologies appear as expenses derived from tax revenues or debt-financing. The introduction of various forms of automation in smart cities may replace the labour-power of city management, resulting in automated smart cities. As the elements of the general artificial intellect appear, therefore, as the means of materializing the reproduction of bourgeois society, smart city infrastructure appears as the means of subsuming the social factory. Thus capital and the bourgeois state's attempt to control and automate every social process outside the point of production according to the finance capital's demand for smart cities are creating new cybernetic conditions of class struggle.

5.1 Political Perspectives on the Implications of Capital's Autonomization from Labour-Power

There are several perspectives concerning the relation of the development of automation technologies to the creation of new conditions of class struggle. As this thesis has demonstrated, the replacement of direct labour-power with autonomous machines in the sphere of production leads to the dissolution of value based on labour-time as Marx outlined in the *Fragment on Machines*, while the dissolution of both direct and indirect labour-power in the sphere of production leads to the supersession of the capitalist mode of production by the autonomous mode of production. Therefore, while the new social, economic and political conditions that the autonomous mode of production will create for the working class will necessarily be met by new modes of resistance and class struggle, the very nature of the stage of capital's autonomization from labour-power will open questions into the very nature of resistance, the possibility of freedom from work and the self-abolishment of the commodity labour-power brought on by advanced automation

could prove for the working class a mere surface appearance of bourgeois ideology worth resisting or a substantive reality worth accelerating. As shown by chapters two and three, analyses of the implications of autonomous AI machines appear divided between claims that the replacement of manual labour-power with machines will lead to a proliferation of jobs that require intellectual work, and thus, to an expansion in levels of employment, and claims that the development of AI and automation technologies will advance the replacement of both manual and intellectual labour-power, and thus, lead to an expansion in levels of unemployment over the next several decades. However, the actual changes that occur in the sphere of production and in the circulation sphere, and the levels of employment or unemployment that result, will likely be determined in the first instance by the market demand for advanced autonomous AI machines, which is further determined by the pace and costs of technology development, and thus, whether the market for scientific activity becomes concentrated on the production of machines that are designed for the replacement of manual labour-power or intellectual labour-power. However, regardless of the pace of development and type of autonomous AI machine development, general increases in the replacement of labour-power with autonomous machines will create new conditions of class struggle over the forms and intensity of automation that affect the labour process, the wage share and health benefits, and thus potentially, to new forms of labour organizing.

Capital and the bourgeois state's response to the opposition of organized labour have come in the form of labour reforms in the OECD countries that has enforced a multi-decade decline in unionization, which has been shown to be associated with the global increase in wealth inequality.[405] As the capitalist class is defined by their ownership of the means of production, and therefore, control access to the means of consumption through the wage-form, the historical development of the capitalist mode of production has created the historical development of the necessity of labour organizing and union representation for securing access to the means of consumption, and therefore, the means of social reproduction. While mass labour strikes led by labour organizations and labour unions are effective at temporarily halting the capitalions and labour the means of consumption, and therefore, the means of ation could provebourtal's autonomization from labour-power will

[405] See Legree et al., "The Effect of Labour Relation Laws on Unionization Rates."

o class for better working conditions, higher wages and health benefits advances access to the means of subsistence for productive labour while reproducing the labour-capital relation within the constraints of the legal and political superstructure of the bourgeois state. Thus while necessary in a capitalist society, the political directionality of labour-organizing and trade unionism appears to remain within the relational dynamics of the wage-form and the reproduction of the labour-capital relation under the legal and political superstructure of the bourgeois state.

In contrast, accelerationism has critiqued the political directionality of the left. Rather than foment political resistance to automation, accelerationists argue for unleashing the productive forces of labour from within the existing relations of the capitalist mode of production and for repurposing the material forces of production toward a post-capitalist future. [406] For example, accelerationist views have suggested that the political directionality of class struggle should move in a direction that supports increased automation in the capitalist mode of production precisely because this will lead to the replacement of difficult, mundane or otherwise labour intensive work while potentially expanding the free time of the proletariat.[407, 408] Paradoxically, as part of the historical continuity of the development of the capitalist mode of production, the acceleration of automation at the point of production appears to move in a political direction opposite of the socialization of the means of production while also freeing labour from its exploitative relation with capital.

In addition to the argument for accelerating automation at the point of production, others have suggested that reorganizing the bourgeois state to guide the development of automation for the purposes of socialist development would contribute to the development of a post-capitalist society.[409] However, the accelerationist argument for automation tends to overlook the historical and geographical specificity of the advanced development of the means of production and capitalist reproduction. The acceleration of automation at the point of production would also likely occur within countries that have the means to

[406] See Williams and Srnicek, #Accelerate Manifesto for an Accelerationist Politics." http://criticallegalthinking.com/2013/05/14/accelerate-manifesto-for-an-accelerationist-politics/
[407] See Mason, *Postcapitalism: A Guide to Our Future.*
[408] Srnicek and Williams, *Inventing the Future.*
[409] Mason, *Postcapitalism: A Guide to Our Future.*

automate. These means are produced and circulated according to the global division of labour created by capital's fractal pattern of global development that has concentrated wealth in (post)industrialized countries as a result of the global exploitation of labour located in developing countries. Global differences in the exploitation of labour may be found, therefore, in the relation of wealthier countries to poorer countries and this is likely to produce major regional differences as a consequence of the bourgeois development of the elements of the general artificial intellect. Accelerationism appears to overcome the problem of the reproduction of the labour-capital relation as increases in automation could create increases in free time for the working class. However, absent a revolutionary transformation of the relations of production, the acceleration of automation also accelerates capital's alienation of the means of production, and thus, the means of subsistence from labour.

While capital's social development of the productive forces of labour creates both new forms of exploitation and the human potential of labour to organize itself, without proletarian control of the means of production and the social cooperation necessary to collectively organize production, bourgeoisie control of the means of production leads to the reduction of socially necessary labour-time not for the purpose of freeing labour from the direct production process but for the purpose of extending the portion of the working day beyond what is socially necessary to reproduce the cost of labour-power in order to extend the production of relative surplus value. Bourgeoisie control of the means of production therefore reproduces the labour-capital relation and extends working time beyond what is socially necessary rather than reducing the necessity of work. The core barrier to the supersession of the capitalist mode of production is, therefore, bourgeoisie control of the means of production. Thus, with the historical development of capital's autonomization from labour-power, the social and political movement for the self-abolishment of labour-power must consider the relations of ownership of the means of production at the global level.

5.2 Realization of the Contradiction of the Capitalist Mode of Production with the Development of the Autonomous Mode of Production

The historical development of the autonomous mode of production and its implications for the possible dissolution of the labour-capital relation at the point of production opens new social and political questions regarding the very nature of resistance to capital and the bourgeois state. Authors such as Mason and Srnicek and Williams have suggested that with the development of full automation of the direct production process, the possibility of a post-capitalist future could be realized.[410, 411] Capital's automation of repetitive, mundane or otherwise repressive forms of work could bring about increases in free time for industrial workers. However, increasing automation within an entire industry would raise the organic composition of capital, leading to the tendency of a falling rate of profit and the countertendency of industrial capitalists to increase the intensity of labour-exploitation. Therefore, due to the law of competition, it is only when capital becomes fully autonomous from labour-power at the level of the entire global sphere of production that the implications of the autonomous mode of production for the value-form are fully realized. With the gradual global development of fully autonomous production, the dissolution of the reproduction of surplus value at the point of production would manifest as increases in the intensity of competition for cheaper means of production, which would thus intensify the forces of competition that would subsequently compel producers in underdeveloped countries to reduce their prices either by cheapening the cost of labour or by cheapening their costs of the means of production in relation to other producers along the supply chains, and so on.[412]

The potential social and political crises that manifest from capital's gradual autonomization from labour-power include widespread unemployment and a subsequent fall in consumer demand for commodities. The response of the bourgeois state to the lack of effective demand could come in the form of the expansion of welfare systems and/or increases in the

[410] *Postcapitalism: A Guide to Our Future.*
[411] Srnicek and Williams, *Inventing the Future.*
[412] Caffentzis, "On Africa and Self-Reproducing Automata," 37. On this point, Caffentzis notes capital's use of the tactic of the replacement of labour-power with machine-power as a type of leverage that acts to lowers the cost of wage labour.

availability of credit-money, while in the short-term, the social and political demand for a universal basic income will become not only more prevalent feature of class consciousness, but a structural necessity for proletarian access to the means of subsistence, and with it, increasing calls for universal health and universal education. Recent arguments for the creation of a universal basic income would appear to assist in the bourgeois state's provision of the means of consumption, and therefore, the means of social reproduction, while increasing consumer demand. Indeed, a universal basic income would establish a baseline level of access to the means of consumption within each country. However, between each country, capital's historical geography of reproduction of the relations of production would remain subject to the global value chains of labour exploitation that reproduce the class system of wealth inequality. While the expansion of consumer credit and welfare systems create effective demand for the reproduction of capital, the deepening wealth inequality would likely produce further social unrest, protests, and military and intelligence-backed bourgeois revolutions. Thus the dissolution of the capitalist mode of production with the rise of the autonomous mode of production would not spell the end of capital.

5.3 Communisation of the Autonomous Mode of Production

With labour standing to the side of not only the direct production process, but outside the sphere of production entirely, the purchase, and indeed, very category of labour-power would cease. On this front, the appearance of the bourgeoisie and the accelerationists' mutual interest in the development of the full automation of the sphere of production would not preclude, however, the necessity of developing revolutionary social and political movements in response to the social crises that would be set in motion as a result of the lack of proletarian access to the means of subsistence that would have otherwise been secured by the continued reproduction of wage labour. Revolutionary social and political movements would therefore need to examine the tactics, strategies and long-term goals toward which their activities are directed.

As an alternative to the bourgeois development of the autonomous mode of production that would lead to the continued existence of capital. While this thesis has suggested that capital and the bourgeois state's appropriation of network information technology decreases the likelihood of a proletarian revolution, the free time produced by the autonomous mode of production could lead revolutionary social and political movements to develop new strategies aimed at transforming the bourgeois legal and political superstructure and the bourgeois state the purpose of communising the autonomous mode of production based on a scientific understanding of the dialectical logic of the organic metabolism of humans in relation to nature. As outlined in this thesis, while even the full capitalist realization of the autonomous mode of production would lead to the dissolution of the production and extraction of surplus value, insofar that private property, and thus, the relations of exchange remain, the measure of use value by exchange value would remain. Therefore, in addition, social and political movements could begin the long-term process of the development of revolutionary social consciousness as the necessary precondition for the communisation of the autonomous mode of production[413] by advancing the demand for the transformation of the legal and political superstructure in order to materialize universal ownership of the means of production. This, however, presupposes a revolutionary social and/or political response that contains the capacity to effectively materialize collective ownership of the autonomous means of production so as not only to communise ownership of the means of production, but to obliterate entirely the reproduction of the very capitalist social forms, 'value', 'capital' and 'labour', that reproduce the relations of bourgeois society.

The successful dissolution of private property, and thus, the dissolution of the capital-relation, the dissolution of the material relations that mediate and determine the reproduction of the relation of the capitalist class to the working class, would in turn remove the class division in the social consciousness of the general intellect. With fully autonomous, universally owned means of production, the general intellect would be free to collectively reorganize and develop the elements of the general artificial intellect into

[413] Dauvé, *From Crisis to Communisation*, 53. On this point, while Dauvé's assertion that the process of communisation would necessarily be sudden rather than gradual, the necessary precondition of the social and political development of revolutionary consciousness that precedes the process of communisation is a historical process.

collectively controlled distributed networks for the purpose of coordinating all determined global sites of autonomous production and circulation through Internet and telecom infrastructure and AI control centres. As the large scale collection of big data already contains the means of representing, and thus, determining human need, rather than the capitalist use of big data for the exploitation of human need for the purpose of accelerating the realization of exchange value the general intellect could repurpose the use value of big data and predictive analytics within decentralized AI control centres for the autonomous production and circulation of use values based on human need, effectively leading to the dissolution of the measure of use value by exchange value, and thus, the dissolution of the interest-bearing capital-relation, and thus, the financial capitalist class.

With the development of the social conditions for the free circulation of both the means of consumption and the means of representation, the general intellect could develop and materialize scientific knowledge of renewable energy within the processes of autonomous production and circulation and scientific knowledge of sustainable consumption in the organic metabolism of humans in relation to nature. Therefore, rather than global society collectively producing their means of consumption with commonly held means of production, communisation of the autonomous mode of production would lead to a global society that collectively owns and determines the autonomous production and circulation of their own means of consumption based on human need.[414] With the communisation of the autonomous mode of production, the general intellect could then gradually objectify the functions of a communised legal and political superstructure in the collectively owned and distributed AI superstructure, rendering the representatives of the state superfluous to the means of materializing collective governance of the economic base.[415] With the dissolution

[414] With the communisation of the autonomous mode of production and circulation and the supersession of bourgeois society, Marx's infamous quote in the *Critique of the Gotha Program* that became the slogan of the socialist movement, "From each according to his ability to each according to his needs!" would therefore become, "From each according to his [her, they, etc.] needs, to each according to his [her, they, etc.] needs!"

[415] See Marx, "Critique of Hegel's Doctrine of the State," 88-89. On this point, Marx's analysis of the development of democracy from a representational state is illusory, as a true democracy can only develop from *the disappearance of the representative political state* and with the return of the *immanence* of the power of the state to its objects of reference, and thus, to the full self-determination of its citizenry. The model of a global communised society developed here, suggests a supersession of the democratic model of society with the development of not only the collective self-determination of the legal and political superstructure but the collective self-determination, self-reproduction, self-governance and thus, full

and network distribution of the state, and with the elimination of the law of competition, the conflicts and wars fought on the bourgeois premises of resource scarcity would be eliminated, thereby creating the universal conditions for the free movement, free expression and unlimited creative development of social life.

collective control over the materialization of the production and circulation of the means of social reproduction and the legal and political superstructure.

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Curriculum Vitae

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My research interests are in historical materialist approaches to the study of information and information technology in global capitalist society. I also have research interests in the history of information technology, document theory, the philosophy of information, information studies, Marxist-Feminism and gender and sexuality studies. The objective of my work is to develop critiques of the global capitalist political economy for the purpose of producing alternative design plans for the development of new societies that are based on the advanced technological development and the science and practice of communisation.

Education

September 2012 – February 2020
London, ON
University of Western Ontario (FIMS) - PhD Library and Information Science

September 2009- August 2011
Detroit, MI
Wayne State University – Master of Library and Information Science
& Graduate Certificate in Records and Information Management

GPA: 4.0/4.0

- Library management and administration
- Database, web development and web analytics
- Electronic information resource management
- Organization and cataloging of information resources
- Knowledge of legal research, reporting and regulatory environment of information creation, use, storage and court orders
- Knowledge of rules of evidence, healthcare law, ISO standards and Federal regulations for records management and information policy
- Knowledge of operational risk management and disaster/recovery planning
- Student Spotlight

September 2003- August 2004
Windsor, ON
University of Windsor – Honours Bachelor of Social Work

- GPA: 11.44/13
- Honour Roll 2003-2004
- Graduated with Distinction
- Individual, group, family counselling Interviewing and communication skills
- Resource and service planning

September 2000- May 2003
Windsor, ON
University of Windsor – Honours Bachelor of Arts – Psychology

- GPA: 11/13
- Honour Roll 2002-2003
- Graduated with Distinction
- Research theory and methods
- Abnormal, industrial and organizational, educational, developmental, cultural psychology

Course Work / Teaching Assistance

Fall 2019

- Thesis Development

Summer 2019

- Thesis Development

Winter 2019

- Thesis Development

Fall 2018

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- Thesis Development
- Teaching Assistant for MLIS 9001: Perspectives on Library and Information Science

Fall 2017

- Thesis Development
- Teaching Assistant for MLIS 9003: Information Sources and Services

Winter 2016

- Thesis Development
- Teaching Assistant for MIT 2100: Political Economy of Media

Fall 2014

- Audit: MLIS 9842: An Introduction to Critical Theory in Library and Information Science
- Teaching Assistant for MIT 1700: FYI: Information and its contexts

Summer 2014

- Directed Study: Data Science and Biopolitical Labour
- Teaching Assistant for MLIS 9203: Records management

Winter 2014

- Directed Study: Information infrastructure and information practices
- Teaching Assistant for MIT 1500: The Matter of Technology

Winter 2013

- LIS - 9806 - Statistical Methods
- Directed Study: Social Epistemology and the Philosophy of Information
- Teaching Assistant for MIT 1700: FYI: Social Contexts of Information

Fall 2012

- LIS - 9862 - Technology and Society
- LIS - 9809 - Research Methods
- Teaching Assistant for MLIS 9003: Reference Services and Sources

Educational Projects

June 2011 - Fall 2014
Independent Project

- Developed, coded and maintained a journal article and video library for an emergency department
- Managed all website content including monthly staff schedules, memos, hospital initiatives and notices
- Maintained all communications as webmaster including email, user IDs and passwords

May 2011 – August 2011
Wayne State University – MLIS Practicum at Windsor Regional Hospital

- Access 2007 Database Project for Patient Transport Bookings. Windsor Regional Hospital – Summer Practicum 2011. Includes data dictionary, user manual, re-design presentation.

May 2009 – August 2011
Wayne State University – MLIS Program

- Research Proposal Developed for Study of Law Librarian Attitudes, Liability
- Concerns and Service Response Toward Pro Se Patrons – Summer 2011
- Developed Organizational Website, Project Management Plan and Information Policy – Fall 2010
- Developed Individual Portfolio Website – Winter 2010.
- Competitive Intelligence Project. Use of Google Analytics to Enhance and Align Wayne State LIS Website Toward End User Information Behaviour – Winter 2010

Publications

- Diab, Ramon. “Becoming Infrastructure: Datafication, Deactivation and the Social Credit System” *Journal of Critical Library and Information Studies*, First Issue, 2017. https://journals.litwinbooks.com/index.php/jclis/article/view/19

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http://ephemerajournal.org/contribution/smart-factory-self-organisation-capital-‘industrie-40’-cybernetisation-production

Presentations/Conferences

- Diab, Ramon. “The Historical Development of AI Machines: Instruments of Bourgeois Society or the Means of Superseding It?” CSCW Good Systems, Ethical AI Workshop, Austin, Texas, November 10, 2019.

- Diab, Ramon. “The Weaponization of Computational Social Science: Studying Tactics and Strategies of Cyberwar.” Oxford University Media Policy Summer Institute – Oxford, United Kingdom, August 14, 2019.

- Oxford University Media Policy Summer Institute. Participant. August 5-16, 2019.

- Diab, Ramon. “A Critique of Computational Social Science: Big Data and Social Reality” DOCAM Conference - Toulon, France. June 12-14, 2019.

- Peer Reviewed Article for *Big Data and Society Journal*. May 2019.

- International Labour Process Theory Conference. Attendee. Buenos Aires, Argentina. March, 21-23, 2018.

- Diab, Ramon. “A Theory of Cybernetic Capitalism: Uber’s Big Data Labour Process Platform” International Labour Process Conference - Sheffield, United Kingdom. April 4-6, 2017.

- Diab, Ramon. “Digital Self/Shadow" FIMS Research Day - University of Western Ontario. April 14, 2016.

- Diplohack Conference - Ottawa, Ontario. May 26-27, 2015.

- "Big Datafication: A Source View of Capital Accumulation." Big Data Days @ Western. University of Western Ontario, London, ON. March, 15, 2014.

- Utrecht Summer School Course Participant. *Critical Theory, Culture and Citizenship*. Utrecht, Netherlands. August 12-16, 2013.

Recognition

- Awarded Best PhD Paper, April 2017, International Labour Process Conference

- WSU Student Spotlight, Winter 2011
- University of Windsor, Faculty of Arts and Social Sciences Dean's Honour Roll 2003-2004
- University of Windsor, Faculty of Arts and Social Sciences Dean's Honour Roll 2002-2003

Employment

September 2012 – August 2018
London, ON
University of Western Ontario - Teaching Assistant

- Lead tutorials for class of 20-30 students
- Plan tutorial discussions and reviews
- Grade all papers, mid-terms and final exams
- Provide office hours and student guidance as necessary

December 2011 – May 2012
Garden City, MI
Garden City Hospital - Medical Librarian

- Medical library management
- Cataloging, collection development, circulation, document services and reference
- Maintain print and online collections
- Vendor negotiations and budgeting
- Web development and video library creation

May 2011 – July 2011
Windsor, ON
Windsor Regional Hospital, Metropolitan Campus – LIS Practicum

- Develop database system for patient transportation booking
- Database and applications training of switchboard operators
- Assistance with system redesign and improvement of health record systems, resource access and personnel education
- Assist with records centre systems planning and personnel integration
- Experience and training with Manager of Health Information Services (H.I.S.)
- Trained switchboard staff on re-designed transport bookings and database interface

January 2010 – December 2011
Detroit, MI
Wayne State University Arthur Neef Law Library - Student Assistant, Reference Desk

- Academic law reference service
- Law reference and research instruction for library patrons
- Technology instruction for accessing legal materials using Westlaw, Lexis Nexis and other databases
- Assistance with government document organization and imaging Legal research and reference instruction for the public
- Legal reference assistance for lawyers, paraprofessionals and faculty
- Telephone reference
- Circulation desk experience
- Closing duties

November 2009 – May 2010
Windsor, ON
Hotel Dieu Grace Hospital Library and Health Information Services – Volunteer

- Experience processing medical journals
- Literature reviews for medical professional
- Fulfilled information requests
- Provided research assistance and technological instruction

April 2008 – March 2009
Windsor, ON
Canadian Mental Health Association - Justice Support Program Case Manager

- Case management for clients with concurrent mental illness and legal involvement
- Court and probation support
- Linkages with primary healthcare
- Housing support
- Safe bed management
- On-call duties
- Crisis intervention
- Record keeping and compliance

September 2004 – April 2008
Waterloo Region, ON
Waterloo Region Assertive Community Treatment Team (ACT-Team) - Social Worker

- Psychosocial and mental health assessment, planning and intervention
- Mental health symptom management and education for individuals and families
- Medication instruction and education for individuals and families
- Health teaching regarding activities of daily living (ADL's) for individuals
- Focus on clients with serious mental illness and concurrent substance dependency
- Assistance with coordination of Community Treatment Orders (CTO)
- Knowledge of psychotropic medications and treatment of major mental illnesses
- Knowledge of Mental Health Act, Health Care Consent Act and Substitute Decisions Act in Ontario
- Facilitate family meetings, education and support
- Discharge planning with Regional Mental Health Care, London
- Housing support
- Crisis intervention
- Assistance with McMaster University ACT Research Project
- Utilized InfoMed software for statistics and organization of health information
- Learned and applied principles of motivational interviewing to practice
- Record keeping and compliance

September 2000 – September 2004
Windsor, ON
University of Windsor, Centre for Teaching and Learning – Audio/Visual Technician

- Book, setup and troubleshoot A/V equipment for University lectures
- Instruction provided to professors, students and guests on use of audio/visual equipment in delivery of lectures, presentations and conferences
- Night supervisor from September 2003-May 2004
- Assist with inventory maintenance
- Assist with staff scheduling

May 2004 – August 2004
Windsor, ON
Legal Assistance of Windsor – Social Work Practicum

- Social work experience within a legal context
- Organized and maintained legal documents
- Case management and consultation with lawyers Observed court proceedings
- Knowledge of ODSP and OW laws and regulations Knowledge of Landlord Tenant Act

September 2003 – May 2004
Windsor, ON
Drouillard Place – Social Work Practicum

- Social work experience within a multi-service community agency Macro-level community practice
- Housing needs assessment
- Youth drop-in assistance

Training / Service / Skills

October 17-18th, 2016
London, ON
University of Western Ontario

- Internal Reviewer for Graduate Program Review - Mathematics Department

May 2016
London, ON
University of Western Ontario - Teaching Support Centre

- Completion of Advanced Teaching Program Workshop

September 2012
London, ON
University of Western Ontario - Teaching Support Centre

- Completion of Teaching Program Workshop

Technical Competency

- Database development knowledge and experience
- Experience with Website Development, including HTML, CSS, XML, ASPX, MS Expression Studio, Silverlight
- High Proficiency – Windows and Macintosh OS and Applications
- High Proficiency – Microsoft Office Suite, Including Word, PowerPoint, Excel, Access Database