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Marx and Ricardo on Machinery: A Critical Note.

By

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Abstract

This paper critically discusses the important and relevant—not to mention controversial—views of Ricardo and Marx on the impact of machinery on labor productivity, the organization of production, and the wages and employment prospects of the working class during the capitalism of their day. First, the paper turns to Ricardo’s assessment of the introduction of machinery and its likely effects on the laborer and the rate of profit and accumulation—one which went through a substantial revision (and reversal) between the first and third editions of his *Principles of Political Economy and Taxation*. Then we discuss Marx’s own critical analysis of the historical development of machinery and its impact on the labor process, the so-called “compensation principle,” and how the rising organic composition of capital ostensibly generates a “redundant or surplus-population” during the course of capitalism development. We highlight Marx’s intellectual debt to Ricardo (and John Barton) insofar as his theory of technological unemployment is concerned. Lastly, the paper summarizes the views of Ricardo and Marx and offers some concluding remarks.

JEL Codes: B10; B12; B14

Keywords: Capital; compensation principle; fixed vs. circulating capital; gross vs. net income; machinery; rate of surplus-value (profit); Say’s Law of Markets; surplus-population; time of production; turnover of capital

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I. Introduction.

The transition from manufacturing industry based on the simple division of labor and cooperation under one roof during the 18th century into the large-scale machine industry of the 19th and 20th centuries became the hallmark of capitalist production. It signaled an immense stride forward in the application of scientific and technical knowledge to practical tasks and the development of the productive forces of capitalism. The application of machinery, by economizing on the use of labor and taming the forces of nature, led to a vast increase in the productivity of labor based on an even deeper and broader division of labor among different enterprises and industries. Its introduction took place first in the light consumer textile and wool industries of the 18th century and then progressed to heavy industries such as huge steel mills and chemical plants in the 19th century (see Mandel, 1971; and Rubin, 1979). During the 20th century and beyond, new developments and discoveries in science and technology have progressed to such a degree that they have ushered in a new era of automation and robotics (and genetic engineering) that has radically changed the workplace and threatens to alter fundamentally the (property) relations of production and the social fabric of contemporary capitalism.¹

¹ For example, in the October (2017) issue of *The New Yorker* it is reported that automation of the workplace has proceeded to such a degree that, "McDonald's is introducing 'digital ordering kiosks' that are expected to replace human cashiers at fifty-five hundred restaurants by the end of 2018. Meanwhile, companies like Uber and Google are investing heavily in autonomous-driving technology, betting that such vehicles will reshape transportation." The magazine goes on to report that even construction jobs are threatened by automation by citing the case of a "New York-based firm that has introduced a laser-guided system that can lay eight hundred to twelve hundred bricks a day, more than twice as many as an average mason." In a widely cited March 2017 NBER paper, Acemoglu and Restrepo report large and robust negative effects of robots on wages and employment in the U.S. during the 1990-2007 period. Their estimates suggest that one more robot per thousand employees reduces the employment to population ratio by about 0.18-0.34 percentage points and wages by 0.25-0.5 percent. It is evident that we are beginning to see "new machinery" in the form of robots and computer-assisted processes in the workplace replacing or threatening to replace thousands upon thousands of low-skilled workers in the not too distant future

Needless to say, under the capitalist mode of production the introduction of new technologies in the form of better and faster machines (and robots) was not (and is not), as some would contend, “to lighten the day’s toil of any human being” or to merely cheapen the production of commodities. No. Its intensive and extensive application has only one overriding goal, viz., to enable the capitalists to increase their profits and the rate of capital accumulation by “...shortening that portion of the working-day, in which the labourer works for himself and increasing that other portion in which the labourer performs surplus labour” (Capital I, p. 371). In other words, as both Ricardo and Marx well-understood, the introduction of machinery—for a given working day—increased the production of relative surplus-value or profit for the capitalist class—the *raison d'être* of the capitalist mode of production.

In this brief essay, we critically discuss the important and controversial views of Ricardo and Marx on the impact of machinery on labor productivity, the organization of production, and the wages and employment prospects of the working class during the capitalism of their day. First, we turn to Ricardo’s views on the application of machinery and their likely effects on the laborer and the rate of profit and accumulation—one which went through a substantial revision (and reversal) between the first and third editions of his *Principles of Political Economy and Taxation*. Then we will turn to Marx’s own critical analysis of the historical development of machinery and its impact on the labor process, the so-called “compensation principle,” and how the rising organic composition of capital ostensibly generates a redundant or surplus-population during the course of capitalism development. Lastly, the paper offers some concluding remarks.

II. Ricardo on Machinery.

In the third edition of his celebrated *Principles of Political Economy and Taxation* [henceforth, *Principles*] published in 1821, David Ricardo shocked his followers by reversing himself on a major corollary of Say's Law of markets, thus making a key concession to his long-time friend and intellectual adversary, Thomas Robert Malthus (see Blaug, 1986; Hunt and Lautzenheiser, 2011; Roll, 1992; Rubin, 1979; and Schumpeter, 1986 [orig. 1954]). In the newly added Chapter 31 entitled, "On Machinery," he admitted that the introduction of machinery, while increasing the productivity of labor and the expected profits of the capitalist, would not just impose temporary (relocation) hardships on the affected workers until the necessary market price adjustments had taken place, but result in a permanent displacement of a portion of those workers. Previously, Ricardo had concluded that the application of machinery would benefit all classes by increasing the supply of goods and lowering the prices of the commodities produced by machinery, and thereby, for a given money value of wages and profits, boosting the real incomes (in terms of use-values or "riches") of capitalists, workers, and landlords. In his words,

Ever since I turned my attention to questions of political economy, I have been of opinion that such application of machinery to any branch of production as should have the effect of saving labor was a general good, accompanied only with that portion of inconvenience which in most cases attend the removal of capital and labor from one employment to another... the class of laborers, also, I thought, was equally benefited [along with capitalists and landlords] by the use of machinery, as they would have the means of buying more commodities with the same money wages, and I thought no reduction of [money] wages would take place because the capitalist would have the power of demanding and employing the same quantity of labor as before, although he might be under the necessity of employing in the production of a new or, at any rate, different commodity... These were my opinions, and they continue unaltered, as far as regard the landlord and the capitalist; but I am convinced that the substitution of

machinery for human labor is often very injurious to the interest of the class of laborers (*Principles*, pp. 291-92).

Marx, upon reading this passage, commented in *Theories of Surplus-Value, Part II*, that “This [chapter], which Ricardo added to his third edition, bears witness to his *honesty* [emphasis in original] which so essentially distinguishes him from the vulgar economists” (p. 555). Ricardo explains that his “mistake” arose from assuming erroneously that the introduction of machinery would not only increase the net income [profits and rent] of society, but its gross income [profits, rents, and wages] as well. That is, previously he had thought that mechanization would not lead to a permanent decrease in total real wages or the wages fund of society (see Schumpeter, 1954, p. 681). Ricardo understood now that this would not be the case if the introduction of new machinery directly (or indirectly) cheapened the “food and necessities” of the working class, as opposed to decreasing the cost of “luxuries” consumed by capitalists and landlords. He argued that, for a given absolute real wage (in terms of wage goods) and gross output, the profits and rent of society would increase in terms of commodities or use-values (and in terms of exchange value), while society’s gross income was being reduced (both in terms of exchange value and in commodity terms).²

² Marx observes in *Theories of Surplus Value, Part II* that Ricardo is not entirely consistent in terms of his own distinction between “riches” (use-values) and exchange value, as determined by the socially necessary labor time expended in producing a commodity. Ricardo mistakenly says in the chapter on machinery that the “application of machinery always leads to the increase of the net produce [in terms of commodities] of the country, although it may not, after an inconsiderable interval, increase the [exchange] value of that net produce” (p. 296). Marx rightly counters that “It will always increase that [exchange] value whenever it diminishes the value of labour [labor-power]” (p. 570). See also Ricardo’s cogent presentation of the distinction between “riches” and exchange value in Chapter XX of his *Principles* entitled, “Value and Riches, Their Distinctive Properties.”

Using an arithmetical example, Ricardo first assumes that a capitalist (farmer) employs his capital of £20,000 in the manufacture of “food and necessities” on a yearly basis, with £13,000 of his capital representing circulating capital (to support the employment of his workers) and £7000 invested in buildings and implements (fixed capital). Ricardo assumes that the prevailing rate of profit is 10 percent which, in terms of his example, translates into an annual profit of £2000. Thus, before the introduction of machinery, £15,000 represents the capitalist’s gross income and £2000 his net income or profit (he ignores the net income accruing to the landlord or, for that matter, the wear and tear of his fixed capital). The introduction of machinery by the capitalist is motivated by the expected (temporary) profits attached to its introduction, before they are competed away as a result of its eventual adoption by other firms in the marketplace. Ricardo argues that if half the workmen who were previously employed in producing food and necessities worth £13,000 are now employed in producing a machine of half the exchange-value of the workers’ means of subsistence [£7500], then, in the next year, the capitalist’s “means of employing labor would be reduced in the proportion of £13,000 to £5500 [£7500 minus £2000], and consequently, all the labor which was before employed by £7500 would become redundant ... and the situation of the laboring classes will be that of distress and poverty” (pp. 293-94).

In this numerical example, the wages fund decreases from £13,000 to £5,500 while the value of the capitalist’s capital remains the same at £20,000; yet, to use Marx’s terminology, the organic or value composition of the capitalist’s capital has changed more toward “technological capital” and away from “wage capital.” Thus, at the end of the competitive process, the

capitalist's profit rate is reduced to the level that prevailed before the introduction of the machine, commodities have fallen in price, and the demand for labor is permanently reduced.

Following the lead of Kurz (2010), this case can be illustrated more formally as follows:

Assume that W denotes total wages, P total profits, R total rents, and V is the value added by the socially necessary labor expended in production, while the subscripts 0 and 1 refer to the periods before and after the introduction of the new machine. Ricardo's net income is represented by sum of P and R , while his gross income refers to sum of W , P , and R . Thus, after the introduction of improved machinery, the net income of society rises as follows:

$$(1) \quad P_1 + R_1 > P_0 + R_0$$

While the gross income of society falls,

$$(2) \quad V_1 = W_1 + P_1 + R_1 < W_0 + P_0 + R_0 = V_0$$

If we assume that rents are unaffected and that the total capital, K , is constant, then the introduction of a machinery which lowers cost of the food and necessities of workers will raise the profit rate (pr) as follows:

$$(3) \quad pr_1 = P_1/K > pr_0 = P_0/K$$

In words, with the introduction of machinery workers are diverted from the production of wage goods to the production of capital goods, thus reducing the demand for labor in the machine producing industry. Moreover, when the machine is put to use in the production of other commodities, fewer workers are needed because more jobs are destroyed in the machine using industries than are created in the machine producing ones. That is, profit-maximizing

capitalists will only employ a machine or a robot if it costs them less than the labor [labor-power] that it replaces. [Of course, the accumulation of capital and economic expansion that accompanies the adoption of new machinery and technology will counteract this tendency by inducing an extra demand for labor which we will further discuss in the next section.] Thus, Ricardo is led to conclude reluctantly that “the opinion entertained by the laboring class, that an employment of machinery is frequently detrimental to their interests, is not founded on prejudice and error, but is conformable to the correct principles of political economy” (p. 296).

Despite Ricardo’s misgivings about the effects of the introduction of machinery on the laboring class, by no mean did this imply that he advocated discouraging its extensive application. Far from it as evinced by the following passage:

The employment of machinery could never be safely discouraged in a state, for if capital is not allowed to get the greatest net revenue that the use of machinery will afford here, it will be carried abroad, and this must be much more serious discouragement to the demand for labor than the most expensive employment of machinery.... By investing part of a capital in improved machinery there will be a diminution in the progressive demand for labor; by exporting it to another country the demand will be wholly annihilated (*Principles*, p. 300).

In fact, Ricardo believed correctly that the introduction of machinery is analogous to the extension of foreign trade, for the latter enables the country to obtain food and necessities more cheaply than if it produced them at home. He is careful to point out, however, that not all foreign trade is equal in terms of raising the country’s profit rate—the latter will only be raised if the relatively cheaper goods being imported directly or indirectly go into the consumption of the working class, as opposed to that of capitalists and landlords. In his famous chapter entitled, “On Foreign Trade,” he observes that, “the rate of profits can never be increased but

by a fall in wages, and that there can be no permanent fall of wages but in consequence of a fall of the necessities on which wages are expended. If, therefore, by the extension of foreign trade, or by improvement in machinery, the food and necessities of the laborer can be bought to market at a reduced price, profits will rise.... But if the commodities obtained at a cheaper rate, by the extension of foreign commerce, or by the improvement of machinery, be exclusively consumed by the rich, no alteration will take place in the rate of profits" (pp. 84-84).³

Interestingly enough, Ricardo's analysis in his chapter on foreign trade is not entirely consistent with that presented in his chapter on machinery, and few students of the history of economic thought have caught this inconsistency [see footnote 2]. For example, in the arithmetical example given above he assumes that the capitalist in question "carries on the joint business of a farmer and manufacturer of necessities [for the workers]" (p. 293). However, if that is the case, then the introduction of machinery which cheapens the "food and necessities" of workers will not leave the profits in value terms (and the profit rate) of the capitalist unaffected at £2000 as he assumes, although it certainly increases the net produce of the capitalist (in terms of cheapened commodities or use-values). Another problem with the example that Ricardo gives in his chapter on machinery (and elsewhere in the *Principles*) is his neglect of the depreciation of fixed capital of £7000 in the determination of the gross income of the capitalist, as well as his identification of circulating capital with capital advanced for the hire

³Marx makes exactly the same point as Ricardo in *Capital*, and Ricardo's influence is clearly discerned in the following passage. He writes, "foreign trade partly cheapens the elements of constant capital, and partly the necessities of life for which the variable capital is exchanged, [thus] it tends to raise the rate of profit by increasing the rate of surplus-value and lowering the value of constant capital. It generally acts in this direction by permitting an expansion of the scale of production" (see *Vol. III*, p. 237). See also Schumpeter (1954, p. 681) on this point.

of workers (i.e., variable capital in Marx's terminology). That is, he ignores circulating capital in the form of raw and auxiliary materials used in the production of food and necessities, not realizing that by the use of the new machine (and fewer workers) the capitalist will produce more commodities which, in turn, requires more raw materials. Thus, a growing portion of the gross product must replace not only the value (depreciation) of the machinery, but the growing raw materials used up during the year (i.e., constant capital in Marx's terminology). Lastly, Ricardo confuses profit with surplus-value (and the profit rate with the rate of surplus-value) throughout the *Principles* because he ignores, like Adam Smith, that part of the value of a commodity represented by constant capital (fixed capital in his terminology), viz., the value transferred by machinery, equipment, and raw materials during their various turnovers (see Rubin, 1979; and TSV, II).⁴

Before concluding our discussion of Ricardo's views on the impact of machinery on the demand for labor, it is important to highlight his remarks (towards the end of the chapter) on economist John Barton because they are particularly relevant when it comes to discussing Marx's views on the subject below. Ricardo, like Smith before him, had been previously of the opinion that with the accumulation of capital the demand for labor increases by the same proportion, but, in light of the evident [growing] use of fixed capital relative to circulating capital in the emerging capitalism of his day, he came to understand that this is unlikely to be

⁴ Contrary to the Ricardian model, the rate of profit, $r = s/(c + v)$, in the Marxian system can fall even when the rate of surplus value ($s' = s/v$) remains constant or increases. c refers to constant capital or value of means of production; v is variable capital or value of labor-power; and s is profits or surplus-value which goes to capitalists. Marx generally assumed that the accumulation of capital would lead to a tendency for the average rate of profit to fall because, *ceteris paribus*, the organic composition of capital ($q = c/v$) would rise more rapidly than the rate of surplus value (s'). For further details on the long-standing and controversial debate surrounding the falling rate of profit, see Meek (1956); Moseley (1997); Ramirez (2012); and Sweezy (1970; orig. 1942).

the case. Now, he realized that, for a given production function, capitalists would be incentivized to substitute machines for workers if the money wage rate rose and the profit rate fell (see Blaug, 1986; and Schumpeter, 1954). In this connection, Ricardo commends Barton for taking the “correct view” that, “The same cause that raises labor [higher prices for food and necessities] does not raise the value of machines, and, therefore, with every augmentation of capital, a greater proportion of it is employed on machinery. The demand for labor will continue to increase with an increase of capital, but not in proportion to its increase; the ratio will necessarily be a diminishing ratio” (p. 299).⁵ Thus, the growing accumulation of fixed capital relative to circulating capital during the course of capitalist development is endogenous to the rise of the wage rate (and food prices) as a growing population forces capitalist farmers to cultivate lands of diminishing fertility. Ricardo is thus led to conclude that, “Machinery and labor are in constant competition, and the former can frequently not be employed until labor rises” (p. 299). As discussed in the next section, this characteristic feature of capitalist production plays a contradictory role in generating a “reserve army of the unemployed.”

III. Marx on Machinery.

Marx, as opposed Ricardo, not only analyzes the impact of machinery on the working class and why it has become a salient feature of the capitalist mode of production, but goes beyond Ricardo by giving a detailed explanation in Chapter XV, *Capital I*, of what a machine really is and what it does. In what follows, we will give a very selective account of the first section of this chapter entitled, “On Machinery and Modern Industry.” Clearly, to do justice to this highly

⁵ John Barton’s work is entitled, “Observations on the Circumstances which influence the Condition of the Labouring Classes of Society,” and it was published in London in 1817.

interesting, informative, and historically rich account of the development of machinery would necessitate a far lengthier discussion than the one given below. Still, the more salient points can be highlighted to drive home the main message of this section (and chapter).

Machinery and its Historical Roots

Marx begins the chapter by ridiculing those “mathematicians and ... English economists” who have the audacity to “.... call a tool a simple machine and a machine a complex tool” (*Capital I*, p. 391). For if this is the case, then just about anything can be called a machine, ranging all the way from the screw driver and the wedge to the giant steam-hammers of Marx’s days. In similar fashion, he discards the notion that a machine emerges when man (woman) is no longer the motive power of its transmitting mechanism. For on the basis of this account,

A plough drawn by oxen, would be a machine, while Claussen’s circular loom, which, worked by a single labourer, weaves 96,000 picks per minute, would be a mere tool ... this very loom, though a tool when worked by hand, would, if worked by steam, be a machine. And since the application of animal power is one of man’s earliest inventions, production by machinery would have preceded production by handicrafts [!]” (ibid, p. 372).

Indeed, Marx is quick to point out that what is wanting in both of these explanations is the historical element. That is, what was the organization of production upon which the development of machinery was founded? He answers this question in a roundabout fashion by first proceeding to examine what is common to most machines. He finds that they can, for all practical purposes, be broken down into three essentially different parts, namely, the motor mechanism, the transmitting mechanism, and last but not least, the tool or working mechanism. The first two of these mechanisms simply set the machine in motion, while the

remaining mechanism supplants the work previously performed by the manufacturing laborer. It is this mechanism, above all others, which is the basis of the industrial revolution ushered in by John Wyatt and his “spinning machine” in 1735. Never mind, says Marx, that the motive power is man (woman), nature or some other machine, once the tool is taken from man (woman) and accommodated into the working mechanism, we have before us a machine. A machine which, moreover, can bring into play simultaneously a number of tools; this is, according to Marx, what strikes us even when “.... man himself continues to be the prime mover” (*Capital I*, p. 374).

Of course, the historical element in this explanation is that the various tools fitted into the working mechanism during the emergence of machinery were, in many cases, exactly those tools used by the handicraftsman or manufacturing laborer. For instance, in the original form of the power-loom one easily recognizes the ancient loom used in simple manufacture. Hence, cooperation based on the division of labor under one roof (i.e., simple manufacture) by giving rise to a variety of tools, as a result of the detail labor characteristic of this organization of production so eloquently described by Smith’s pin factory example, provided a suitable basis for the development of machinery under industrial capitalism.

Marx, however, is quick to point out that as long as manufacturing remains the basis of machine production it constrains the emergence of modern industry and the further development of the productive forces of society. In this regard, he writes, “Modern industry was crippled in its complete development, so long as the characteristic instrument of production, the machine, owed its existence to personal strength and personal skill, and depended on muscular development, the keenness of sight, and the cunning of hand, with

which the detail workmen in manufactures ... wielded their dwarfish instruments" (*Capital I*, p. 382). It is only when a certain level of development of the technological forces of society is attained (Marx identifies it with the decade preceding 1866) that a radical change takes place in the size of the prime movers, transmitting mechanisms, and the complexity and regularity of the machine proper.⁶ That is, modern industry comes into its own when it takes ownership over the production of its characteristic instrument, the machine, and begins to "construct machines by machines." Marx describes machines such as the modern hydraulic press, the modern power loom, cyclopean steam-hammers, and the modern carding engines, as examples of machines that could have never been produced on the basis of simple manufacturing. He even gives examples that presage the extensive automation of industrial processes in the decades to come when he describes a mechanical tool that replaces the hand and is used to make geometrically accurate detailed parts of new machinery such as cylinders, cones, planes, spheres (*ibid.*, p.385). By the use of machine tools which replace not only some particular tool but the hand itself, Marx contends that with the advent of modern industry "it became possible to produce the forms of the individual parts of machinery 'with a degree of ease, accuracy, and speed, that no accumulated experience of the hand of the most skilled workman could give'" (*ibid.*). He then goes on to describe in extensive detail the construction of machinery to replace the tools of manufacturing, but now on a scale and scope that would have been unimaginable just a few

⁶ Mandel (1971) in his classic work on Marxist economic theory describes the impact of machinery on labor productivity (and unit labor costs) in the cigarette industry in the United States. He reports that, "in the 1860s a skilled worker could roll no more than 3,000 cigarettes in a working day of ten hours. In 1876 the wages cost was 96.4 cents per 1,000 cigarettes of a certain brand ... Bonsak [an inventor] came forward in 1881 with a rational machine which produced between 200 and 220 cigarettes a *minute* and cut wages from 96.4 to 2 cents [!] per 1,000 cigarettes. A single one of these machines could have produced all the cigarettes made by hand in the United States in 1875" (p. 141).

decades beforehand. He draws the reader's attention to "cyclopean" razors, drills, and steam hammers "... of such a weight that not Thor himself could wield it" (ibid.)

Without doubt, there is an immense trove of historical detail and knowledge contained in this chapter on machinery and modern industry by Marx—not to mention prescience—far greater than that offered by Ricardo or any of his contemporaries on this particular topic. As indicated above, to do it justice would necessitate a more thorough discussion that can be undertaken in this short essay. But suffice it to say that the main message or take away from this section is that modern industry, as opposed to simple manufacture, is characterized by an immense increase in the social productivity of labor and a fundamental change in the organization of production. A change not just of degree but in kind, so that, in opposition to manufacturing, where the organization of production is subjective and based on a simple division of detail laborers, "Modern industry has a productive organism [the machine] that is purely objective [and] in which the laborer becomes a mere appendage to an already existing material condition of production" (ibid., p. 386). To paraphrase and play a bit on the title of the article noted in footnote 1, Marx already understood in the second half of the 19th century that instead of "machines (robots) assisting workers, it's the other way around."

The Impact of Machinery on the Working class

As we indicated above, Marx praised Ricardo's dispassionate and objective assessment of the impact of the introduction of machinery on the laboring classes. He understood implicitly that, under industrial capitalism, the machine is not introduced to economize on the use of labor generally, but only if it enables the capitalist to obtain more unpaid labor (relative surplus-

value) for a given length and intensity of the working day. For Marx, the worker is nothing but “a machine for the production of surplus-value,” while the capitalist, as personified capital is, “in its eyes only a machine for the conversion of this surplus-value into additional capital” (*Capital I*, p. 595). The driving force of capitalism is the development of the productive forces via technical change embodied in new machinery and equipment in order to generate additional surplus-value (profit) for further accumulation. That is, in order to create surplus-value by means of advanced capital in the form of machines, the capitalist mode of production compels the individual capitalists, on penalty of extinction, to repeat their production and circulation circuits over and over again on an ever quicker and expanding scale.⁷ That is, the capitalist will only introduce a new machine or robot if it costs him less than the labor power it replaces.

But what about the often heard counterargument that the workers displaced by the new machinery or robots will be able to be rehired in other expanding (machine-producing) industries not without, of course, some hardship for the workers during the transition period? Ricardo also posited the possibility that the introduction of machinery would enable the net produce of society to increase to such a degree (in terms of commodities) that even the gross produce would rise, thus benefiting all classes. He argues that the stimulus would come from, “the increased demand for menial servants; ... from the stimulus to savings from revenue [in

⁷ Marx believed correctly that with the development of capitalism both the time of production and circulation would be significantly shortened. Anything, therefore, that decreases the time of production, such as investment in new plant and machinery as well as technical improvements will, *ceteris paribus*, shorten the turnover period of capital, thus boosting the creation of surplus-value and profit (see Chapter III, Vol. II of *Capital*). He also connects explicitly the expanded use of credit with the faster turnover of capital and the growing size of firms (concentration of capital) associated with the more rapid development of the productive forces of labor induced by the introduction of machinery. See his discussion in Chapter XXX, Vol. III of *Capital*; and Ramirez (2014).

terms of use-values] which such an abundant net produce will afford; and ... from the low price of all articles of consumption on which their wages are expended" (*Principles*, p. 297).

Marx counters the so-called "compensation principle" by arguing that fewer jobs are created in the machine-producing industries than are lost in machine-using industries, and that the workers who have lost their jobs are not necessarily or even likely the ones who find employment in these new industries. He writes, "It is true that in the long run the labour that has been released together with the portion of revenue or capital that has been released, will find an opening in a new sphere of production or in the expansion of the old one, but this is of more benefit to *those who succeed the displaced men* [emphasis in the original] than to the displaced men themselves" (*TSV II*, p. 560). Marx also makes the keen observation that the revenue (capital) that has been "set free" by the discharge of workers in the contracting industry "will hardly be sufficient ... to absorb that part of the increased population which each year streams into each branch of production, and which is now debarred from entering the old industry" (*ibid*, p. 558) . Moreover, with the development of large-scale machinery, capitalists resort, more and more, to unskilled labor, the lengthening (intensification) of the workday, and to the labor of women and children because the use of machinery enables capitalists to employ workers with slight muscular strength and limited work experience (skills). It also enables them to further reduce wages (value of labor-power) by spreading the value of the formerly employed male's labor-power over his entire family, thus increasing surplus-value and profits. In this connection Marx observes,

To purchase the labour-power of a family of four may cost ... more than it formerly did to purchase the labour-power of the head of the family, but, in return, four days' labour takes the place of one, and their price falls in proportion to the excess of surplus-labour.

In order that the family may live, four people must now, not only labour, but expend surplus-labour for the capitalist. Thus we see, that machinery, while augmenting the human material that forms the principal object of capital's exploiting power, at the same time raises the degree of exploitation (*Capital I*, p.395).

Insofar as Ricardo's "net produce argument" is concerned, Marx recognizes that the introduction of machinery enables society to dramatically increase the means of subsistence (and luxuries) available for the maintenance of both productive and unproductive workers (menial servants, lawyers, government functionaries, etc.), but he argues that it is irrelevant to the workers who have been discharged because they do not have the means (wages) to purchase them! A propos Marx writes incisively, "More of the commodities will now be present in the market, although for the workers thrown on the street, they have ceased to exist [as objects of consumption] or have ceased to exist in their previous quantity" (*ibid.*, p. 562). He goes on to observe that even if a part of this increased revenue is converted into circulating capital rather than in the hire of unproductive workers, it is likely to give employment to new entrants into the labor force (as a result of the growth in population) rather than to "the artificially created surplus population" (*ibid.*, p. 563). Marx, as opposed to Ricardo, makes the cogent and compelling observation that there is no necessary connection "between the revenue that has been set free and the workers that have been set free of revenue" (*ibid.*, p. 558).⁸

⁸Marx criticizes Ricardo on this point by noting that "Ricardo imagines quixotically that the entire bourgeois social mechanism is arranged so nicely that if ... men are discharged from their work, the means of subsistence of these men—now set free—must definitely be consumed in one way or another by the ... men and that otherwise they could not be sold; as if the mass of semi-unemployed or completely unemployed were not forever crawling around the bottom of this society—and as if the capital existing in the form of means of subsistence were a fixed amount" (*TSV II*, p.560).

Marx, as was his custom, also sardonically remarks that, “This progressive transformation of a section of the workers into servants is a fine prospect [indeed]. For the worker it is equally consoling that because of the growth of the net product, more spheres are opened up for unproductive workers, who live on his product and whose interest in his exploitation coincides more or less with that of the directly exploiting classes” (*TSV II*, p. 571). And then a few pages later, he develops this idea further and makes an important and somewhat surprising observation, in light of his earlier views in the *Communist Manifesto* and even *Capital*, about the growing economic and political role of the middle class in the course of capitalist development. He writes that “The middle classes maintain themselves to an ever-increasing extent directly out of the [growing] revenue, they are a burden weighing heavily on the working base and increase the social security and power of the upper ten thousand” [the “one percent” of his time!] (*ibid.*, p. 573).

The Rising Organic Composition of Capital and Technological Unemployment

As indicated at the end of the previous section, Ricardo held the work of John Barton in high esteem and, undoubtedly, he (and, to some degree, Marx) borrowed the idea that the progressive accumulation of capital causes a relative decrease in the demand for labor (see Schumpeter, 1954). This is contrary to Adam Smith’s and Thomas Robert Malthus’ view (previously held by Ricardo) that the demand for labor grows in direct proportion to capital accumulation. In this connection, Ricardo writes in a footnote towards the end of his chapter on machinery the following:

It is not easy, I think, to conceive that, under any circumstances, an increase of capital should not be followed by an increased demand for labor; the most that can be said is,

that the demand will be in a diminishing ratio. Mr. Barton, in the above publication, has, I think, taken a correct view of some of the effects of an increasing amount of fixed capital on the condition of the laboring classes. His essay contains much valuable information (*Principles*, p. 299).

Without question, Marx's own conception of the rising organic composition of capital (and its impact on employment) has its origins in John Barton's work and Ricardo's more nuanced elaboration to be discussed below. From the outset, it should be noted that Marx defines the organic composition of capital as the value composition of capital (the ratio of constant to variable capital, c/v) insofar as it directly mirrors or reflects the technical or material composition of capital (the means of production relative to the labor employed). That is, changes in the organic composition of capital measure how the value composition would have changed had the individual values for means of production in terms of machinery, equipment, raw materials, and labor power remained the same (see Brewer, 1984; 1990). Both Marx and Ricardo understood that the progressive accumulation of capital under the pressure of competition leads to an enormous rise in the productivity of labor (in terms of use-values) which, in turn, reduces the value of labor power, newly employed machinery, and devalues that of existing capital equipment (Marx refers to it as "moral depreciation"). Thus, the value composition of capital rises more slowly than its organic composition or material (technical) composition (in terms of use-values or commodities). He gives the following simple example in *Wages, Price and Profit* to illustrate the idea: "If the proportion of these two elements of capital [constant and variable] was originally one to one, it will, in the progress of industry, become five to one, and so forth. If of a total capital of 600, 300 is laid out in instruments, raw materials ... and 300 in wages, the total capital wants only to be doubled to create a demand for 600

working men instead of for 300. But, if of a total capital of 600, 500 is laid out in machinery, materials ... and 100 only in wages, the same capital must increase from 600 to 3600 in order to create a demand for 600 workmen instead of 300. In the progress of industry the demand for labour keeps, therefore, no pace with the accumulation of capital” (pp. 76-77). Marx, of course, connected this discussion of the rising trend in the organic (and value) composition of capital to his controversial and much debated falling rate of profit thesis in Vol. III of *Capital* which would take as too far afield to discuss in this brief essay (for further details, see Meek, 1956; Moseley, 1997; Ramirez 2012; Roll, 1992).

It is evident then that there are strong parallels between Marx’s discussion of the rising organic composition of capital and Ricardo’s (and Barton’s) discussion of the deleterious effects of the introduction of machinery on the working class.⁹ One highly important point that has received hardly any discussion in the extant literature is the influence Ricardo had on Marx in terms of the development of his theory of the surplus population or “reserve army of the unemployed.”¹⁰

Marx, in *Theories of Surplus Value*, Part II, goes out of his way to commend Ricardo for making a significant advance over Barton in terms of understanding that “... the demand for labour does not grow *proportionally* with the development of machinery, but that the machines

⁹ Marx also highlights the work of British economist George Ramsay in *TSV II*, whom he credits with a more precise formulation of Barton’s original idea because he does not limit constant capital to just fixed capital (although he continues to call it that) but includes raw and auxiliary materials in the definition as well. On the contrary, variable capital (which he calls circulating capital) is restricted to include only capital laid out in wages (see p. 579).

¹⁰ Steedman (1982) is one of the few Marxist scholars who argues that Marx is strongly indebted to Ricardo for his theory of technological unemployment. More recently, Kurz (2010) makes a compelling and cogent case in tracing Ricardo’s influence on Marx’s views concerning the impact of machinery on the working class. Finally, Schumpeter (1954) also emphasizes Ricardo’s indebtedness to Barton’s analysis insofar as his chapter on machinery is concerned, and the important influence it had on Marx’s own theory of technological unemployment.

themselves ‘*render the population redundant*’ ... i.e., create a surplus population ... Essentially ... the whole absurd [Malthusian] theory of population [to which Ricardo subscribed!] was thus overthrown” (p. 578). Marx is here referring to several passages in Ricardo’s chapter on machinery where the latter discusses the possibility of the population becoming redundant even in the case where there is an increase in the gross output of society (see, e.g., pp. 295, and 298-99 in the *Principles*). If this is the case, then the “vulgar” notion espoused by the economists of his time, viz., that in order for workers to improve their lot they should strive to keep their numbers below the rate at which capitalists hire them would prove futile. The latter would only incentivize capitalists to substitute capital for labor. Apropos, Marx writes that Ricardo understood that “... to keep down the laboring population, thus diminishing the supply of labour, and ... raising its price, would only accelerate the application of machinery, the conversion of circulating [variable] capital into fixed [constant] capital, and hence, make the population artificially “redundant” ... redundancy exists, generally, not in regard to the quantity of the means of subsistence, but the means of employment, the actual demand for labour” (ibid).

Marx clearly rejected the Malthusian population doctrine, however, what is less apparent (and surprising to say the least), is that Ricardo did so as well (at least, implicitly) by the time he had published the third edition of the *Principles*. It is no wonder that this edition has created so much controversy and debate ever since its publication (see Blaug, 1986; Hunt and Lautzenheiser, 2011; and Schumpeter, 1954). Of course, Marx, building on Ricardo’s and Barton’s insights went on to develop an endogenous theory of relative population in *Capital*; i.e., one determined by the needs of capital accumulation and independent of any particular

assumption about the growth rate of population, whether positive, or even negative. For Marx, capitalist production cannot (and will not) be constrained by “the natural increase in population ... it requires for its unrestricted activity an industrial reserve army which is independent of those natural limits” (Vol. I, pp. 637-38). That is, it requires a pool of redundant workers that can be quickly deployed to expanding industries and away from contracting ones according to market conditions. In Marx’s eloquent words, “every special mode of production has its own laws of population, historically valid within its limits alone. An abstract law of population exists for plants and animals only, and only in so far as man has not interfered with them” (Vol. I of *Capital*, p. 632).

Marx expected the reserve army of the unemployed to grow in relation to the active part of the laboring class during the course of capitalist development as the following passage indicates:

The greater the social wealth, the functioning capital, the extent and energy of its growth, and, therefore also the absolute mass of the proletariat and the productiveness of its labour, the greater is the industrial reserve army. The same causes which develop the expansive power of capital, develop also the labour-power at its disposal. The relative mass of the industrial reserve army increases therefore with the potential energy of wealth. But the greater this reserve army in proportion to the active labour-army, the greater is the mass of a consolidated surplus-population, whose misery is in inverse ratio to its torment of labour (*Capital I*, p. 644).

Whether labor-saving technological change is sufficiently strong to generate an increasing reserve army of the unemployed is by no means a settled question in the Marxian paradigm. In this connection, Brewer (1984; 1990) and Howard and King (1985) contend that there are, at least, three major factors at work which make it difficult to make an *a priori* determination, namely: the increasing composition of capital (which reduces the demand for labor), the

accumulation of capital (which increases the demand for labor), and the growth in the size of the laboring population as a result of demographic and social factors.

Marx believed that, as accumulation proceeded, the higher labor productivity in the newly expanding machine-producing industries relative to the declining ones would prevent those industries from absorbing all the workers “set free” by the backward ones (including non-capitalist sectors such as agriculture). As indicated above, the introduction of large-scale machinery would also permit greater utilization of women and children, thus further increasing the profits of capitalists and the size of the reserve army of unemployed. However, as argued by Howard and King (1985) and even suggested by Marx himself above, the very same economic forces that increase the relative surplus population (and depress wages) will also incentivize capitalists to use capital-saving (labor-using) technology when there is a relative shortage of capital, as happens during the trough or bottom phase of the industrial cycle. Moreover, even if the growth rate in the demand for labor declines over time, the growth rate in the supply of labor would have to decrease even more for the relative surplus population to rise over time.

Following the lead of Howard and King (1985), this can be shown more formally by denoting the growth rate of variable capital can be expressed as

$$(4) \quad G_v = \Delta v/v$$

Where v denotes variable capital. Let β represent the share of capital allocated to variable capital and $(1 - \beta)$ the share devoted to constant capital. If capitalists save a constant fraction (α) of

surplus value (s), then, in equilibrium, the saving and investment ratios are equal. The share of total investment allocated to variable capital can be written as

$$(5) \quad \beta I = \beta \alpha s$$

substituting equation (5) into equation (4) gives,

$$(6) \quad G_v = \beta \alpha s/v = \beta \alpha e$$

Where $e = s/v$ is the rate of surplus-value or exploitation. That is, for a given α , Marx believed that, as capital accumulation proceeds, β would decline at a faster rate than e , thus G_v would decline. However, there is nothing necessary about this because the rate of decrease in β may decline through the adoption of labor-using (capital-saving) technology which, in turn, would also raise e . Moreover, α is likely to increase as a result of greater concentration and centralization of capitals during the course of capitalist development. Finally, even if G_v declines, the growth of the supply of labor-power would have to exceed the decline in G_v for the relative surplus population to rise over time (see Howard and King, *op. cit.*, p. 198).

IV. Concluding Remarks

This brief essay has critically discussed the important and controversial views of Ricardo and Marx on the impact of machinery on labor productivity, the organization of production, and the wages and employment prospects of the working class. Although there are strong parallels in their views on the subject, there are also some important differences that were highlighted in this note. First, both authors agree that capitalists introduce new machinery in order to reduce wage (production) costs so as to undersell competitors and increase profits or surplus-value (for

a given length and intensity of the workday). Both Ricardo and Marx concur that the increase in the social productivity of labor is only a by-product of this relentless pursuit of additional surplus-value (profit) for further capital accumulation.

Insofar as the impact of machinery on the working class is concerned, Ricardo at first thought that it would have a beneficial effect both in terms of consumption possibilities (cheaper and more plentiful “food and necessities”) and employment prospects, although not without some transition costs as market prices and wages adjusted. By the time the third edition of the *Principles* was published, Ricardo reversed himself completely on the employment question and believed that the introduction of machinery would have a permanent and adverse effect on the laboring classes. This represented a significant concession to Thomas Robert Malthus and an implicit repudiation of Say’s law--no wonder it shocked his followers and the profession. Still, he strongly advocated the introduction of machinery as a way of promoting the development of the productive forces of society and likened it to the expansion of foreign trade in terms of increasing the riches of society and the profits of capitalists, thus furthering capital accumulation and averting the onset of the stationary state.

Marx, on other hand, was never under the illusion that the introduction of machinery would not have injurious and permanent effects on the wages and employment possibilities of workers, let alone radically change the organization of production (to the detriment of the worker and his family) as he describes in rich historical detail in his chapter On Machinery and Modern Industry in Vol. I of *Capital*. He also repudiated the “compensation theory or principle” in all its forms, something that Ricardo did not entirely do when he posited the possibility that the net revenue (in terms of commodities) of society might increase to such a degree as to generate an additional

demand for “menial servants” or unproductive workers. Needless to say, Marx ridicules this argument by countering that the additional net revenue is likely to give employment to new entrants into the labor force (as a result of the growth in population or rural-urban migration) rather than to the workers displaced by machinery and, in the unlikely event that they were hired, it would be at drastically lower wages that would render these workers a short step away from the “swamp of pauperism.”

Finally, both authors owe a debt of gratitude to the relatively obscure work of John Barton who, along with British philosopher and economist George Ramsay, were one of the first economists to recognize that as accumulation proceeds during the course of capitalist development the proportion of fixed to circulating capital has a tendency to increase, thus diminishing the relative, if not the absolute demand for labor. Clearly, this forms the basis of Marx’s own idea of a rising organic composition of capital (the secular growth in the ratio of constant to variable capital in value terms), and plays an integral role in his analysis of a rising surplus laboring population and the tendency of the rate of profit to fall. In this connection, Ricardo, as was his wont, makes an important and subtle contribution by arguing that the endogenous rise in the price of labor-power during the course of capitalist development will only accelerate the substitution of machinery for labor, thus generating a redundant or surplus-population that keeps the pretensions of the working class in check. In doing so, Ricardo not only implicitly repudiates the Malthusian theory of population (which he explicitly avowed) but shows that capitalism endogenously creates a “redundant population” (independent of the growth of population) that serves the needs of capitalist accumulation. Marx is clearly indebted to Ricardo for this insight

in terms of the development of his own theory of the surplus-population or “reserve army of the unemployed.”

The essay was brought to a close by pointing out that it is difficult to make an *a priori* determination about whether labor-saving technological change à la Marx is sufficiently strong to generate an increasing reserve army of the unemployed. It will depend on at least three factors whose secular trend is by no means evident, namely: the increasing value composition of capital (which reduces the demand for labor), the accumulation of capital (which increases the demand for labor), and the growth in the size of the laboring population as a result of demographic and social factors.

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