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# The Formation of Karl Marx's Technological Thought

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## Abstract

At the beginning of 1845, Marx (1818-1883) began his studies that led him to develop and mature his technological thinking, focusing on it in 1851 and maintaining this interest in 1860. In these early studies, Marx used sources and a German bibliography, in particular the writings of J. Beckmann (1739-1811) and J. H. M. von Poppe (1776-1854). In this paper, we will study the main influences that Marx received from the aforementioned authors, from his works published in the first half of the 19th century, and then, also highlight some influences arising from the English thinkers of the Industrial Revolution in England Charles Babbage (1791-1871) and Andrew Ure (1778-1857).

## Keywords

History of Technology, Economy and Technology, Marx's Technological Thought, Technology and Industrial Revolution

## 1. Introduction

Due to the importance that technology has in the modern world, in the middle of the 4th Technological Revolution, accompanied by a transition to a new industrial system, the so-called industry 4.0, a return to Marx's technological thinking also takes on a new meaning at the present time.

The question of technology is central to Marx's thinking (Vadée, 1982). It occupies a primordial place and composes his more general vision of society and its possibilities of transformation, based on the unity of man and nature, a unity that is realized above all in the field of economic production than in consumption. It is in production that man uses the means that interpose between him and the object of his action, through work. These means are tools, instruments, apparatus, devices, industrial installations, constructions, etc. and that are distinguished from your own body. It is also in this way that men are distinguished from animals as he stated in his German Ideology: *One can refer to conscience*, *religion*, *and anything else as the distinction between men and animals*; *however*, *this distinction only begins to exist when men start producing their means of life*, *a step forward that is a consequence of their bodily organization. By producing their means of existence*, *men indirectly produce their own material life* (German Ideology, Vol. 1, Chap. 1, p. 19).

In his main work, *Capital*, Marx analyzes human activity differently, placing finality at the center of his analysis. His action implies an orientation, towards a goal and towards which he channels his imagination and intelligence. However, the two analyzes complement each other and converge in man's ability to use means that are interposed between him and his conscious action, but it is directed towards a completed activity.

A more general analysis of Marx's technological thinking involves a broader study of his economic works, as the technological issue is inextricably linked to the evolution of his economic thinking (Saito, 2017). Thus, in this work, in its first part, we will make a small investigation into the formation of Marx's technological thinking, relating mainly his formulations regarding technology and that appear in *Capital*, with that of the German thinkers who most influenced him, Johann Beckmann and Johann Poppe. And then we will complement our study with the influences properly received by him from the thinkers of the Industrial Revolution in England, mainly Charles Babbage and Andrew Ure.

The main objective of our study on Marx's technological thought is to bring to the debate a series of important elements for understanding the technological issue and its social implications. In addition, we also intend to show that some of these elements are already in development in Marx's work.

## 2. The Technological-Historical Notebooks

Enrique Dussel, in his Technological-Historical Notebook, published by the Autonomous University of Puebla, in 1984 (Dussel, 1984), makes a detailed presentation of Marx's Technological Notebooks, especially Notebook XIX (B 56), in the nomenclature used by Marx, written in London in August 1852. This notebook deals with technological changes, and it is where Marx looks at the works of J. Beckmann (one work) and J. H. M. Poppe (five works), in addition to studying the thought of Andrew Ure (one work), which already belongs to a more mature phase of the Industrial Revolution.

Studies of a theoretical technology appeared in Germany in the 18th century, first in Halle and later in Göttingen. It was in the latter city that J. Beckmann taught, since 1776, as a professor of philosophy, mathematics, physics and natural history. From 1804 onwards, he assumed the chair of agronomy and technology, being attributed to him the creation of the concept of technology. Poppe was his student at Tubingen.

In this work, with regards to German thinkers, we will focus our attention on

Notebook B 56, with special attention to Poppe's work entitled *History of Technology*, written in three volumes, published in Göttingen between 1807 and 1811 (Poppe, 1807). Marx dedicates 26 pages of his notebook, more than half of it, going through the work page by page of its three large volumes, with 505, 622 and 445 pages, respectively. It is a history of technology in the abstract sense, not mentioning its social and economic context. It is interesting to note that Marx, in *Capital*, will refer to the complete inexistence, until that moment, of a critical history of technology (Marx, 2012). As a complement to Notebook B 56, we will present some excerpts from Marx's letter addressed to Engels on January 28, 1863, as it presents important and complementary aspects to footnote 89, also studied in this article.

As we will see in the following pages, Marx inherited the concept of technology from Beckmann and Poppe, in addition to being inspired by Linnaeus (1707-1778) and Darwin (1809-1882), especially the former, who studied the adaptation of natural objects to social uses (Frison, 1993).

All these ideas appear prominently in *Capital* and in manuscripts dealing with technological issues, including studies made by Marx, based on English thinkers of the Industrial Revolution such as Peter Gaskell (?-1841), Andrew Ure (1778-1857) and Charles Babbage (1791-1871).

## 3. Biographic Notes

As we know, the two German thinkers Johann Beckmann and Johan Poppe exerted a significant influence on the formation of Marx's technological thinking. Therefore, we include below short biographical notes on these two authors.

### 3.1. Johann Beckmann

He was born on June 4, 1739, in Hoya, in the district of Nieburg, in Lower Saxony, Germany. He was educated in Stade, a city also located in Lower Saxony and in Göttingen, belonging to the same region, where he studied theology, mathematics, physics, and natural history. These studies were complemented with classes in public finance and administration. After completing these studies, in 1762 he traveled to Brunswick and then Holland, where he visited mines, factories, natural history museums, and universities.

After his mother's death in 1762, Beckmann was deprived of means of support and was invited to teach natural history at the Lutheran Gymnasium in St. Petersburg, Russia. In 1765, he left this institution and traveled to Denmark and Sweden. That's how he met Linnaeus in Uppsala. In 1766 he returned to Göttingen where he took up the chair of philosophy, teaching political economy. In 1768 he founded a Botanical Garden based on the principles postulated by Linnaeus.

From the period mentioned above, Beckmann (**Figure 1**) concentrates his work on the analysis of arts and crafts and that is how his book *Beiträge zur Geschichte der Erfinduagen* appears, later translated into *Contribution to the His-*

*tory of Inventions*, *Discoveries*, *and Origins*, in which he relates the origins and history of various machines, utensils and devices (Beckmann, 1846a, 1846b). Thus, he was considered the founder of scientific technology, a term he was the first to use from 1772 onwards (**Figure 2**).

His relations with the French Enlightenment are notorious and his texts on technology reflect the work of Diderot (1713-1784) and d'Alembert (1717-1783) in the *Encyclopedie*. It is important to highlight his participation in several Academies of Sciences in Europe. In 1790 he was elected to the Swedish Academy of Sciences and in 1809 he became a member of the Royal Netherlands Institute. Beckmann died on February 3, 1811.

### 3.2. Johann Heinrich Moritz von Poppe

He was born on January 16, 1776, in Göttingen and died on February 21, 1854, in Tubingen (**Figure 2**). From 1784 to 1791 he attended the secondary school in Göttingen, having also learned the trade of watchmaker in his father's workshop. From 1793, he studied mathematics and physics at the University of Göttingen, with Abraham Gotthilf (1727-1783) and Georg Lichtenberg (1742-1799).

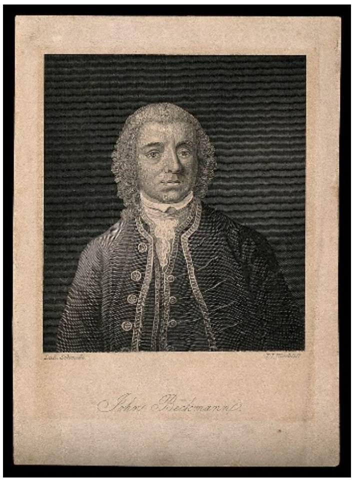

**Figure 1.** Johann Beckmann.

**Figure 2.** Johann von Poppe.

In 1803, he obtained a doctorate from the University of Helmstedt and received a license to teach. In 1805, Poppe became professor of mathematics and physics in Frankfurt. From 1812 to 1814, he was a professor at Lyceu Carolinun, a University of Frankfurt, where he was also involved in the founding of a Polytechnic Society, which in its beginnings aimed to familiarize artisans with technological progress, fulfilling a complementary training action. Poppe was elected its first president.

In 1818 he became professor of technology at the University of Tubingen and held the professorship until his retirement in 1841.

Poppe has built an enormous scientific reputation through numerous publications in the field of mechanical engineering and technology. Many of these publications were aimed at a broad audience and young people. One of the characteristics of his books is that they have a descriptive and encyclopedic nature.

Finally, it is important to point out that in addition to teaching activities in the technological area, Poppe has always brought with him a wide practical experience in the field of watchmaking, acquired since his youth. His main works are: *Handbook of Technology in General* (1809), *Physics Essentially Applied to Arts*, *Manufactures*, *and Other Useful Crafts* (1830), *History of Mathematics from Antiquity to Modern Age* (1828), *History of Technology* (1807-1811) and *The Mechanics of the* 18*th Century and the Early Years of the* 20*th Century* (1807).

## 4. Footnote 89 of Book I of Capital

This footnote appears in Chapter XIII: Machinery and Modern Industry in Book I of Marx's Capital and he was referring to John Wyatt's (1700-1766) spinning machine that Wyatt announced in 1735.

*Before him, spinning machines were used, though very imperfect, and Italy was probably the country where they first appeared. A critical history of technology would show that hardly an* 18*th century invention belongs to a single individual. To this day, this work does not exist. Darwin interested us in the history of natural technology, in the formation of organs, plants and animals as instruments of production necessary for the life of plants and animals. Does not the history of the formation of the productive organs of social man, which constitute the material basis of all social organization, deserve equal attention? And is it no longer possible to reconstitute it since, as Vico says, human history is distinguished from natural history, because we have done one and not the other? Technology reveals man's way of proceeding with nature, the immediate process of producing his life, and thus elucidates the conditions of his social life and the mental conceptions that derive from them. Even a history of religion that sets this material basis aside is not a critical history. In fact, it is much easier to discover the earthly core of nebulous religious representations by analyzing them than, going the opposite way, to discover, starting from the relationship of real life, the corresponding celestial forms and these relationships. The latter is the only materialistic and therefore scientific method. The flaws of abstract mate-*

*rialism founded on the natural sciences, excluding the historical process, are immediately noticed when we stop at the abstract and ideological conceptions of its spokesmen, whenever they venture to go beyond the limits of their specialty.*

### Comments on Footnote 89

In this note, already studied by many historians and economists such as David Harvey (Harvey, 2010) and Fumikazu Yoshida (Yoshida, 1983), the latter having stated that Marx wrote it from observations taken from Poppe's book History of Technology, Marx addresses a number of illuminating questions about his view of technology and has become an inexhaustible source of many studies and commentary. Marx begins the note resenting the absence of a Critical History of Technology. Before going into its merits, it is worth emphasizing the analogy that Marx makes between "the instruments of production necessary for the life of animals and plants", evidently their organs and limbs, as a natural technology for their survival with the "formation of productive organs" of "social man", because therein lies the key to studying the re-elaboration of the concept of technology that Marx received from his predecessors, now belonging to the new context of capitalist production. Marx's technological conception, in the footnote, is clearly the way in which man intervenes in nature, for the production of his material life and, in this way, reveals his conditions of social life and the resulting mental conceptions.

Regarding the absence of this critical history, it is important to add that it raises a series of other questions related to his method of work, the method of dialectical materialism as opposed to abstract materialism, which we do not intend to discuss further in this work. However, in the afterword of the second edition of Capital, written in 1873, we can read: *Undoubtedly, the mode of exposition according to its form must be distinguished from the mode of investigation. The investigation has to appropriate the matter (Stoff) in its details, analyze its different forms of development and trace its internal nexus. Only after such work has been completed can the real movement be adequately exposed. If this is successfully accomplished, and if the life of matter is now ideally reflected, the observer may have the impression that he is faced with an a priori construction* (Capital, Book I, p. 79). About the Critical History of Technology, what would differentiate it from the histories that existed until then, in the works of Beckmann and Poppe, and others, is that they make a history of technology in itself, abstracting a series of important determinations about its development, such as the economy, ideology, culture, etc. In a critical history, a set of multiple determinations, as Marx would say, would lead the analysis from the abstract to the concrete, that is, to the most general historical process, representing the concrete (its totality) (Marx, 1857-1858).

## 5. Excerpts from Marx's Letter to Engels on 01/28/1863

The excerpts reproduced below are from the Selected Correspondence of Marx

& Engels, pages 137-139, first published in 1955 by Progress Publishers of Moscow. It is a much longer letter dealing with many of the technological issues that are the subject of our study, but which we reproduce only a part of.

*Reading the technological-historical section again, I came to the conclusion that the inventions of gunpowder, the compass and the press are preconditions for the development of the bourgeoisie, that is, from the period in which handicrafts, from the* 16*th century to the* 18*th century, it developed until it became manufactures and reached an authentic large-scale industry. This had two material bases with which it was formed within the manufactures and as previous objects in the constitution of the mechanical industry* [*and they were*]: *the clock, the mill* (*in the beginning as a mill and later as a hydraulic mill*), *both transmitted from antiquity.* (*The hydraulic mill* [*existed*] *since the time of Julius Caesar and was brought to Rome from Asia Minor.*) *The clock was the first automaton applied to practical uses* [*automaton concept: automatic music clock*], *and* [*foundation*] *of the theory on the development of the production of a constant movement* [*the pendulum movement: Huygens, Bernoulli; escape theory: Lagrange. According to the nature of the thing, the articulation of semi-artisanal techniques with the theory itself is achieved. Cardan wrote, for example,* (*and gave practical recipes*) *on the construction of clocks. German writers of the* 16*th century call watchmaking:* "*Craftsmanship that is practiced before learning* (*without association*)". *In the development of the clock, it could be shown how totally different the relationship between theory and praxis is on the basis of crafts, as is also the case with large-scale industry. There is no doubt that in the* 18*th century the clock gave the first idea of applying automata* (*spring-driven*) *in production* [*Farfler and Hautsch's spring-powered car. Vaucanson's attempts in this field* [*the flutist*] *greatly impressed the imagination of English inventors seeking to realize* [*mechanically said*] *legend. On the contrary, in the case of the mill, since the discovery of the hydraulic mill, the differences in the machine parts have been known as an organism. Mechanical driving force. The first engine is the means for everything to move. Transmission mechanisms. Finally, a work machine materialized as an autonomous and contradictory mode of existence. The theory of friction and the investigations carried out on the mathematical forms of the gear mechanism, teeth etc., all in the mill etc., the aforementioned applies the theory that allows measuring the driving force* [*current counter*]: *and its best use is* [*channel theory*], *etc. Almost all the great mathematicians* [*Newton, Mariotte, J. and D. Bernoulli, d'Alembert, Euler, etc.*], *since the mid-seventeenth century, relied on the simple hydraulic mill, and concentrated on applied mechanics as much as possible to theorize it later. This is the case of the* "*mule*" (*mill*) *which appeared during the period of manufacture and was used in all practical applications as a motive mechanism…*

*The Industrial Revolution begins when the mechanism is applied wherever human labor has been required since ancient times; and not there where* [*this work is not performed*], *as happens with all those instruments in which the ma-*

*terial that has to be worked has never been related to the human hand*; *that is to say*, *there where man*, *according to the nature of the thing*, *not only acts as a simple* "*power*"…

### Considerations on Marx's Excerpts

The letter that Marx wrote to Engels in January 1863 (Marx & Engels, 1973), from which we extract some parts presented above, brings some elements that allow us to establish a connection with Poppe's work, especially his *History of Technology*. Among these elements we can mention the history of mills and clocks. The very detailed history of the mills appears in that work, in its Second Section, First Chapter and the history of clocks, in this same Section, Sixth chapter. Marx will build his conception of the machine, divided into three parts, drive, transmission system and tool device, calling the set a machine-tool, based on studies of the development of mills and clocks. This appears clearly in Poppe's aforementioned book in his description of the history of the mills. Marx also considered the invention of the clock as a fundamental part of the Industrial Revolution, although he recognized that its triggering took place in the textile sector and with the increasing mechanization of production ranging from crafts to manufacturing and from this to industry. The nexus of these ideas about the structure and functionality of machines built by German thinkers with the ideas developed by Babbage and Ure's thinking about the Industrial Revolution is shown in item 7.

Also, in order to understand Marx's technological thinking, it is important to note the importance he attributes to the theoretical developments that emerged from the advances and evolutions achieved in those mechanisms and devices. He mentions that artisanal and practical knowledge in mills and clocks led to the emergence of theories that not only supported practical work, but also helped to overcome certain technological bottlenecks. He cites the case of the "production of a constant motion" developed by Huygens (1629-1695) and Daniel Bernoulli (1700-1782). In his *Horologium Oscillatorium*, Huygens makes an exhaustive study of the mechanism of the pendulum, both theoretically and experimentally (Huygens, 1673). Marx also adds that the great mathematicians of the 17th century, such as Newton (1642-1727), Mariotte (1620-1684), John Bernoulli (1667-1748) and Daniel Bernoulli, d'Alembert and Euler (1707-1783), were involved with studies of applied mechanics, based on the mechanisms of the simple hydraulic mill.

Marx thus develops a concept of technology as a fusion of theory and practice, similar to what we know today as technoscience. It is also common for scholars of Marx's thought to consider technique as part of the material base and technology as a science involving theory and practice.

## 6. Capital and Technology

It is in *Capital*, where Marx presents the question of technology in a more coherent and dialectical way (Marx, 2012). Thus, we can summarize its multiple approaches as follows:

1) Technology as an instrument of work in general—*The productive force of work is determined by multiple circumstances, among others by the average level of dexterity (Geschickes) of the worker, the stage of development in which science and its technological applications are found, the social coordination of the production process, the scale and efficiency of the means of production, natural conditions* (Capital, Book I, Chapter 1).

Technology is then presented in its broadest sense, as a subjective moment (worker skill) and objective (science, technical knowledge, material instruments: machines, etc. In this sense, it is always a determination of the work process, to produce value of use, which in turn is the material substratum of exchange value.

2) Technology as capital—it can present itself as constant capital, a part of capital that is transformed into means of production (auxiliary materials and means of work). As constant capital, technology can have two different functions. First, as a traditional work instrument to obtain absolute surplus-value, or, second, as machinery, industry, etc., to obtain a qualitative and quantitative increase in productivity aiming at relative surplus-value.

3) Technology as the organic composition of capital—with technology in greater proportion in a given branch of production, it tilts the balance in favor of competition and increased profit, based on the increase in relative surplus value, ultimately, favoring a certain branch of production over another. In this way, we can analyze the competition between nations, through the confrontations of the different organic compositions of capital.

## 7. Marx and the English Thinkers Babbage and Ure

As we have noted, in addition to the German thinkers Beckmann and Poppe, Marx also relied heavily on the works of Charles Babbage and Andrew Ure, the latter two having served as the basis for Marx to write many chapters of *Capital*. In this section we will limit our analysis of technological issues to their relationship to the expansion of machinery and the division of labor. We will mainly use the two works by Babbage and Ure directly linked to our central theme: by Babbage, *On the Economy of Machinery and Manufactures* (1832) and by Ure (1835), *The Philosophy of Manufactures, or An Exposition of the Scientific, Moral, and Commercial Economy of the Factory System of Great Britain*.

It should be noted that in Babbage's aforementioned book, its first part deals with the various applications of machines to the manufacturing process, and, in its second part, it analyzes political economy, that is, the general effects that the manufacturing industry has on the manufacturing process. unlimited way in which machines are used in production. In Ure's book, on the other hand, there is a thematic inversion, that is, its initial chapters deal with the more general issues of manufacturing and in the subsequent chapters a more detailed analysis of the aspects, particularities and functionalities of the machines can be made.

It is important to emphasize that Marx, when referring to these two thinkers, said: *Doctor Ure*, *in his apotheosis of large industry*, *emphasizes the particular characteristics of manufacturing better than later economists…and even in relation to his contemporaries*, *or for example*, *Babbage*, *who is far superior to him in mathematics and an authority on mechanics*, *but who does not understand*, *however*, *large industry except from the manufacturing point of view* (Marx, Capital, t. 2, p. 40).

Let us begin with Babbage's own definition of the machine: *When*, *by the division of labor*, *each particular operation has been reduced to the use of a simple instrument*, *the union of all these instruments*, *put into action by a single engine*, *constitutes a machine* (op. cit., p. 230). Now it is Ure who also refers to the division of labor on page 19 of his quoted work, as follows: *When Adam Smith wrote his immortal elements of economics*, *automatic machinery was well known*, *and he was properly led to observe the division of labor*, *as the great principle of the development of manufacture*… In other words, it is in the context of production and the division of labor, according to Babbage and Ure, that the transformations in the economy take place. Marx also focuses his analysis in this same context, as we will see shortly.

So that we can establish some important connections between Marx's thought expressed mainly in Capital and these two thinkers already mentioned. Let us pass on Ure's classification of the structure and functionality of machines, which appears on page 27 of his *The Philosophy of Manufactures*: *analyzing the manufacturing industry*, *the general functions of machines*, *and the effects of their developments*, *must be well considered*. *The machines are of three types*: 1) *Machines referring to the production of force*; 2) *Machines related to power transmission and regulation*; 3) *Machines referring to the application of force*, *to modify the various forms of matter in objects of commerce*. He then details each of the three previously mentioned items.

Regarding the classification above, some comments must be made. First, the question of language. We prefer to translate the term "power" as force rather than energy or power, since it was not until the late 1840s that the principle of conservation of energy would be enunciated and established (Kuhn, 1996). Thus, in item 1, instead of producing force, it would be more appropriate to produce energy or power, which we now call motors. In item 2, instead of machine, the term mechanism would be more appropriate and thus this item refers to mechanisms or systems of transmission and regulation of movement and not of force. In item 3, the most appropriate would be to talk about carrying out work to change the subject to be worked on. This is made clearer by the quotation from Marx taken from Capital, t. 2, p. 60: *The machine tool is*…*a mechanism which*, *having received the proper movement*, *performs with its instruments the same operations as the worker previously performed with similar instruments*. Marx refers to the part of the machine that operates the matter to obtain the product and in reality, the machine tool is a mechanism and a part of the machine that performs the final operation.

Marx complements his earlier quote with the following: *Since the instrument, leaving the hand of man, is moved by a mechanism, the machine-tool has taken the place of the simple tool. A revolution then takes place even if man remains the motor* (Capital, t. 2, p. 60). And Marx adds: *The steam engine itself will not lead to any revolution in industry. On the contrary, the creation of machine tools made the revolutionized steam engine necessary* (Capital, pp. 61-62). What is decisive for Marx in the difference between the machine and the tool is that the essential change is not so much in the nature and power of the engine (for example, the steam engine), but rather in what took place in the "working machine" (*arbeitsmachine*).

For Marx, the revolution is made in the structure and functionality of the machine and not in its power or in the use of steam. Only when the machine reaches this stage of complexity can it revolutionize production. This statement by Marx puts the very beginning of the Industrial Revolution on other bases, taking its main focus from the steam engine and placing it in the very division of labor and the complexification of the tool system operated by the machine. Marx also notes that the steam engine was invented and went about half a century without causing any revolution. Only when the machine reaches that stage of development does a revolution begin.

## 8. Final Comments and Conclusion

From what has been presented here, we can say that the concept of technology in Marx comes from Poppe, who, having been a student of Beckmann, implies a line of continuity between the two German thinkers. Furthermore, that Marx reworks this concept from the reading of the aforementioned works of Charles Babbage and Andrew Ure, mainly. With this Marx expands his vision of production, articulating the concept of technology with the concepts of use-value, exchange-value, within the production process. This aspect of the formation of Marx's technological thinking is an important innovation of the very work he did in economics.

The origin of the concept of the use-value of commodities can also be found in Beckmann in his "commodity science" (Waarenkunde), which was a discipline created by Beckmann. Marx also innovates in the way of analyzing technology. In Book III of *Capital*, he states: *Technology as the impersonal principle of modern industry of breaking down each process into its constituent movements, without considering its possible execution by the hands of man, created the new modern science of technology*. This confirms that Marx's view of technology is close to what we today call technoscience, expressing the close relationship between technology and science, but that they are not confused, technology having characteristics similar to scientific knowledge, but maintaining their specificities, mainly the search for efficiency (Cupani, 2006).

Finally, we must add that the study presented here represents an introduction to the study of Marx's technological thinking aiming at a better understanding of

Marx's technological thought focused on the interpretation of the meaning and specificities of the Industrial Revolution in England.

There are many other lines of investigation to be carried out so that a more general view of Marx's thought in the technological field is finally unveiled. Just as an example we can mention the works of Justus von Liebig (1803-1873) on soil fertility and its social implications analyzed by Marx, and which bring important elements to the understanding of current concepts such as ecology and sustainability.

## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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