

New starting point(s): Marx, technological revolutions and changes in the centre-periphery divide¹

Novo(s) ponto(s) de partida: Marx, revoluções tecnológicas e mudanças na divisão centro-periferia

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RESUMO: Este artigo apresenta o último livro que Marx resenhou em sua vida: *La Physique Moderne*, escrito por Hospitalier e publicado em 1882. O último caderno de Marx (B156, nos arquivos do IISG) contém pistas de outras questões que ele estava pesquisando em 1881 e 1882: sociedades na periferia. Essa combinação de questões – uma revolução tecnológica emergente e sociedades na periferia – pode contribuir para uma melhor compreensão das conexões entre as revoluções tecnológicas e a divisão centro-periferia. Revoluções tecnológicas, fontes de novos pontos de partida, têm moldado e reconfigurado a estrutura e a natureza dessa divisão.

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PALAVRAS-CHAVE: Revoluções tecnológicas; centro-periferia; metamorfoses do capitalismo; Marx.

ABSTRACT: This paper presents the last book that Marx excerpted in his life: *La Physique Moderne*, written by Hospitalier and published in 1882. This last Notebook (B156, in the IISG's archives) contains hints of other issues that he was researching in his last years, especially societies at the periphery. This combination of issues – an emerging technological revolution and societies at the periphery – may contribute to a better understanding of connections between technological revolutions and the centre-periphery divide. Technological revolutions, sources of new starting points, have been shaping and reshaping the structure of that divide, its nature and structure.

KEYWORDS: Technological revolutions; centre-periphery; metamorphoses of capitalism; Marx.

JEL CLASSIFICATION: B14; B31.

INTRODUCTION

Before and after the publishing of Volume I of *Capital*, 150 years ago, Marx had planned investigations, readings and studies for a broader understanding of global capitalism.² This is one of the reasons for the constant delays in his writing process of Volumes II and III. Among many other subjects, he thought to investigate a connection between technological innovations and the changes in the relationship between centre and a periphery in the global system. It might not be casual that one of his last notebooks – the Notebook B162, which he composed between 1881 and 1882 – contains excerpts on topics related to those two issues: his studies of Java and India, and his readings of a book on electricity, as shown in Figure 1.

The apparent disconnection among those subjects might be illusory. As we will show, those notes might all be connected to a more general research on a broader dynamic of capitalism, which was becoming increasingly global. In fact, the materials that Marx organized in Notebook B162 might also bring new arguments for Teodor Shanin's interpretation of his "late Marx": "to admit the specificity of late Marx is (also) to see Marx in his creativity" (1983, p. 31). Those excerpts add new elements to the understanding of late Marx and his creativity. This paper suggests that we may find in Marx's works – published and unpublished – hints, clues and insights of those connections between technological changes and the centre-periphery divide. Those insights might even provide elements for a better understanding of capitalism today. Marx's great interest in science is well known. Engels, for instance, in his speech at Marx's grave said:

² See the letters to Engels, April 22 1868 (*Briefe über das Kapital*, p. 127) and to Danielson, October 7 1868 (*MEW*, v. 32, p. 563). To Danielson, Marx says that the *Capital's* second volume should not be finished "until certain official Enquêtes about last year (and 1866) in France, United States and England are carried out, completed and published".

Figure 1: Contents of Notebook B162
(1881-1882)

[Heft CXLVI], XII.1880-III.1881, Englisch, Deutsch, Franz. 204 S
S. 1: Inhalt von Engels;
S. 2-3: Bibliogr. Notizen;
S. 4-101: L.H. Morgan , *Ancient Society* , 1877;
S. 102-130: J.W.B. Money , *Java, or how to manage a colony* , 1861;
S. 131-157: J. Phear , *The Aryan Village in India and Ceylon* , 1880;
S. 157-161: R. Sohn , *Fränkisches Recht und Römisches Recht* , 1880;
S. 162-199: H.J.S. Maine , *Lectures on the Early History of Institution* , 1875;
S. 199: Notiz;
S. 200-203: E. Hospitalier , *Les Principales Applications de l'Electricité.* ;
S. 204: Inhalt.
NB. digitalisiert IISG-Original B 146.

Source: IISG, <https://search.socialhistory.org/Record/ARCH00860#A072e534c62>.

“Such was the man of science. But this was not even half the man. Science was for Marx a historically dynamic, revolutionary force. However great the joy with which he welcomed a new discovery in some theoretical science whose practical application perhaps it was yet quite impossible to envisage, he experienced quite another kind of joy when the discovery involved immediate revolutionary changes in industry, and in historical development in general. For example, he followed closely the development of the discoveries made in the field of electricity and recently those of Marcel Deprez” (CW, v. 24, p. 468; MEGA² I/25, p. 403ff).

This interest was so great that Wilhelm Liebknecht, writing about his first conversation with Marx in the beginning of July 1850, remembered Marx’s enthusiasm and excitement about the progress of science and mechanics. He expressed his belief that “Natural Science was preparing a new revolution.” (Liebknecht, 1908, p. 57).

This paper explores Marx’s interest in the development of science and technology. We use new evidence provided by the *Marx Engels Gesamtausgabe* edition, especially Marx’s excerpts on science – chemistry and electricity – that were published, mostly for the first time, in volume IV.31. Those notes were taken between 1877 and 1883 from some of the last books he read. The material offers new possibilities to interpret Marx’s agenda in the end of his life and his plans for further research. They also add new elements to the comprehension of aspects yet to be fully explored about the “late Marx” and his creative process. We try to integrate those readings from 1882 and its respective excerpts in a broader framework, investigating two specific issues that might be deeply interrelated in Marx’s developments – the technological revolutions and the centre-periphery divide – along with his trajectory of changing conceptions, learning new subjects and recognizing, as

Shanin suggests, the existence of a plurality of roads in the development of global capitalism.

In a previous paper (Paula et al, 2016) we have discussed how Marx might have begun to see crises and institutional reactions/responses to them as moments of a structural transformation of capitalism. That paper showed how Marx learned with new events and took advantage of his researches on them, updating and improving his theoretical views accordingly. Even after publishing the first volume of *Capital* in 1867, he was still developing long investigations on the dynamics of capital accumulation. Now we study two of those important issues related to changes in the world – and in the economy – and correspondent improvements and renewal of Marx’s elaboration: the technological revolutions after 1867 and the spread of industrial capitalism from England to the rest of the world.

MARX IN 1850-1851: A MODEL OF AN ELECTRIC ENGINE AND NOTES ON MACHINERY

Wilhelm Liebknecht remembrances of his first meeting with Marx go beyond his excitement about the development of science. According to him, “the conversation slowly assumed a wider scope”, reaching Marx’s expectations about a new revolution in technology, which impressed Liebknecht’s memories:

“[s]oon we were in the field of Natural Science, and Marx ridiculed the vigorous reaction in Europe that fancied it had smothered the revolution and did not suspect that Natural Science was preparing a new revolution. That King Steam who had revolutionized the world in the last century had ceased to rule, and that into his place a far greater revolutionist would step, the electric spark. And now Marx, all flushed and excited, told me that during the last days the model of an electric engine drawing a railroad train was on exhibition in Regent street” (Liebknecht, 1908, p. 57).

Is this an early indication of Marx’s insights on a very specific feature of the nature of capitalist system: that the industrial revolution – and King Steam – was only the first among others that might come? In 1850 and 1851, Marx had more interest in technology than the model of an electric engine suggests. In 1851, he read extensively about technology, certainly preparing himself to understand the scientific and mechanic background of the Industrial Revolution. Hans-Peter Müller (1982, 1992) prepared two books with a detailed attention to the 1851 Notebooks. Figure 2 shows the content of Notebook B51.

The notes deal with A. Ure’s book on technology and Poppe’s book on history of technology and sciences. Readings from Ure and Babbage preceded this Notebook. In 1845, for instance, Notebook B33 contained excerpts from both authors. Babbage is excerpted also later, in Notebook B91a (1858-1862). It is interesting to point one specific topic of Marx’s concerns: the railways. Notebook

Figure 2: Contents of Notebook B51
(1851)

[Heft LVII], ca. X.1851, Deutsch. 44 S
S. 1-3: J.H.M. Poppe , *Lehrbuch der allgemeinen Technologie* ;
S. 3-10: ders., *Die Physik vorzüglich in Anwendung auf Künste...* , 1830;
S. 10-11: ders., *Geschichte der Mathematik...* , 1828;
S. 11-37: ders., *Geschichte der Technologie...* , 1807-1811;
S. 37-44: Andrew Ure , *Technisches Wörterbuch* , 1843-1844;
S. 44: Beckmann , *Beiträge zur Geschichte der Erfindungen* , 1780-1805.
NB. digitalisiert IISG-Original B 56.

Source: IISG, , <https://search.socialhistory.org/Record/ARCH00860#A072e534c62>.

B51 shows that, after excerpts on Steam engines from Ure's book, Marx took notes on railways and more specifically from one historic event in technology – the first travel of a steam locomotive, the Rocket, between Liverpool and Manchester.³ It is also important to highlight this because, for Perez (2010, p. 190), this new technology – steam locomotive – represents the big bang of a second technological revolution. In this sense, Marx was following in 1851 the emergence of a new technology developed in 1829 – with broader implications in the coming years.

MARX IN 1867: INDUSTRIAL REVOLUTION AND A NEW INTERNATIONAL DIVISION OF LABOR IN *CAPITAL*

In the first volume of *Capital*, Marx explained technology and its impact in shaping a world divided by what is now called centre-periphery. It is possible to identify a clear linkage between the two topics of this paper – after the Industrial Revolution, Marx suggests a “new and international division of labour” emerged. To understand this connection, he first needed to explain the Industrial Revolution. The chapter on “machinery and large-scale industry” (Chapter 13, Part IV, Volume 1) explains the emergence of machinery, factories and machines system. Here, Marx's readings of Ure and Babbage are very important, since they are references for the explanations on how machines, factories and their mechanics work – for Babbage, see page 337; for Ure, see page 333ff, both in the section on “development of machinery” (MEGA² II/10).

In this chapter Marx also discussed the relationship between science and capital, a subject that he had explored previously in his *Grundrisse*. There is a new

³ Müller (1982) deciphered and transcribed this passage. The reference to this steam locomotive is as follows: “Man entschied sich f. d. letztre *Prämie* ausgeschrieben, d. October 1829 die /Maschine:/ “Rocket” von Stephenson gewan” (1982, p. 162).

relationship, opened by the mechanization of production, since large-scale industry “[...] makes science a potentiality for production which is distinct from labour and presses it into the service of capital” (Marx, 1867, p. 482; MEGA² II/10, p. 326).⁴ This approach of the science role in capitalism may be a good reference to understand why Marx kept reading about science until the end of his life. It is possible to advance a conjecture: for Marx, investigations about science might be investigations about a social force that capital would always use in its favour.

Marx’s elaboration on how a revolutionary change in one specific position in the production may have broader impacts might be an early illustration of a model for technological revolutions. His perspective illustrates how changes in one point of production can have forward and backward impacts. As Marx writes: “the transformation of the mode of production in one sphere of industry necessitates a similar transformation in other spheres” (p. 505). Those effects spread throughout the economy: “machine spinning made machine weaving necessary, and both together made a mechanical and chemical revolution compulsory in bleaching, printing and dyeing” (p. 505). Backwards, “the revolution of cotton-spinning called forth the invention of the gin, for separating the seeds from the cotton fibre”. Changes in industry and agriculture made necessary changes in “means of communication and transport” (p. 506), and later to “produce machines by means of machines” (p. 506) (MEGA² II/10, p. 344ff).

The impact of those machines on workers was tragic. It is interesting for our argument that Marx presents those effects articulating the effects on England and India in the same paragraph, in a comparison between different speeds of the spread of machinery “when machinery seizes on an industry by degrees, it produces chronic misery among the workers who compete with it. Where the transition is rapid, the effect is acute and is felt by great masses of people” (p. 557). “World history offers no spectacle more frightful than the gradual extinction of the English hand-loom weavers; this tragedy dragged in for decades” (p. 557). “In India, on the other hand, the English cotton machinery produced an *acute* effect” (p. 558) (MEGA² II/10, p. 388).

It is important to highlight how the changes brought by machinery were revolutionary for the relationship between India and England. Earlier, in the 18th Century, “India’s textile exports met the basic requirements of cloth in several parts of south-east Asia and the Middle East. The competitive power of this line of trade – based on very low costs of production – is evident in the need felt by the British textile industry for protective tariffs despite the high cost of inter-continental trade” (Raychaudhury, 2014, p. 32). Darwin (2007, p. 193) stresses that “[p]erhaps 60 per cent of global manufactured exports in the eighteenth century were produced in India, the textile workshop of the world”. After the industrial revolution, the English textile production was able to decimate the Indian textile manufacture.

⁴ Quoted by Rosenberg (1974, p. 134). The relationship between science and capital is also discussed in the *Grundrisse* (see pp. 580-582), for example: “capital [...] calls to life all the powers of science” (MEGA² II/1.2, p. 582).

Those changes affected the whole world, giving room to a revolutionary change in the global economy. Marx articulates those two dimensions, explaining how two very different global regions emerged. The Industrial Revolution at the centre “converts one part of the globe into a chiefly agricultural field of production for supplying the other part, which remains a pre-eminently industrial field” (p. 580). This is the first centre-periphery divide: an industrial centre and an agricultural periphery.⁵ This is, Marx writes, a “new and international division of labour” (p. 579) (MEGA² II/10, p. 406).⁶ What is new in this transformation? On one hand, world market is a precondition for capitalist development in *Capital*, (p. 247; MEGA² II/10, p. 131ff). On the other hand, the initial capitalist development changed this world market, reshaping the divide centre-periphery. Internationally, there are multiple effects of the Industrial Revolution. First, there is the “cheapness of products” [...] and “conquest of foreign markets” (p. 579). Second, there is the ruin of handcraft production. This ruin compels India “to produce cotton, wool, hemp, jute and indigo for Great Britain” (p. 579) – in other words, the destruction of manufactures in India pushes it to concentrate in agricultural products. Third, a new world market grows, transforming, for instance, Australia in “a colony for growing wool” (p. 579) (MEGA² II/10, p. 406ff).

In *Capital*, therefore, Marx systematically presents two general features of capitalist system: on one hand, technology and expansionary effects of accumulation – that globally reorganizes the production; on the other hand, the strong push towards foreign countries – foreign trade is listed among the main countertendencies to the fall of the rate of profit in Volume 3 –, a dynamic international expansion of capital that, at that stage, divides the world in an industrial centre and an agricultural periphery.

MARX IN 1879: RAILWAYS AS A “NEW STARTING POINT”

After publishing the first volume of *Capital*, 150 years ago, Marx continued his researches, and returned to the British Museum to read about the crisis of 1866 and monetary and financial aspects of that crisis (Krätke, 2001). Notebooks B108, B109 and B133 show the focus of his investigations (Takenaga, 2014; Paula et al., 2013, 2016). Beyond these investigations on the crisis – monetary and financial dimensions, actions of the Bank of England –, railways are a very important topic of Marx’s inquiries. Indeed, as a financial innovation, railway shares and railway

⁵ Celso Furtado (1978) also makes this connection between the industrial revolution and a new international division of labor.

⁶ Furthermore, as Darwin writes, “India’s contribution to British world power was not left to chance or self-interest. It was deliberately shaped by British rule. After 1870, the Indian economy was developed rapidly as a major producer of export commodities: wheat, raw cotton, jute and tea, among others. It also became an ever more important market for British exports, especially cotton textiles and iron and steel” (Darwin, 2009, p. 182).

debentures were very important to the evolution of the crisis. Marx excerpted news from *The Economist* and from *The Money Market Review* on railways, foreign investment and foreign railways – see, for instance, *The Money Market Review*, May 5th, 1866, pp. 618-619 (excerpted by Marx).

Darwin explores the role of a “railway mania” in the transformation of Britain in an “investing economy” between 1830 and 1875: “the mobilization of savings that ‘railway mania’ had encouraged, as well as domestic prosperity, created a fund for investment abroad, at first in government bonds and then, increasingly, in the building of railways and other infrastructure in India, the Americas and Australasia” (Darwin, 2009, p. 59). Describing the global impact of that “railway mania”, on how railways spread globally, Darwin continues: “a marked tendency to invest abroad was visible before 1880s. ... The major impetus came from the construction of railway overseas, which, unlike most commercial or industrial ventures, required a large immediate return before any return was forthcoming. British confidence in railway technology, the early development in British market in railway shares and the prominent role of British railway contractors overseas combined to make this an especially attractive outlet for British surplus funds. As the international railway boom developed in the 1870s, a huge stream of British capital flowed abroad” (Darwin, 2009, p. 116). This “international railway boom” was a subject of Marx’s attention. A letter written in 1879 shows how close he kept following those changes. Writing to to Nicolai Danielson (April 10), Marx presented a very detailed and organized analysis of the implications of that “international railway boom”.

First, railways were a “couronnement de l’oeuvre”, in a different sense from what he had written in *Capital* (p. 506). For Marx “[t]he railways sprang up first as the couronnement de l’oeuvre in those countries where modern industry was most developed, England, United States, Belgium, France, etc.⁷ I call them the “couronnement de l’oeuvre” not only in the sense that they were at last (together with steamships for oceanic intercourse and the telegraphs) the means of communication adequate to the modern means of production, but also in so far as they were the basis of immense joint stock companies, forming at the same time a new starting point for all other sorts of joint stock companies, to commence by banking companies” (CW, v. 45, p. 356; MEW, v. 34, p. 372).

This approach of railways as a “new starting point” is very important – since it is new vis-à-vis what had been written in *Capital*. Something new in a new phase of capitalism? Probably. Why? Marx continues his elaboration: railways “gave in one word, an impetus never before suspected to the concentration of capital, and also to the accelerated and immensely enlarged cosmopolitan activity of loanable capital, thus embracing the whole world in a network of financial swindling and

⁷ According to Carlota Perez (2010, p. 190), the Akwright’s mill in Cromford (1771) was the big bang of the Industrial Revolution, while the test of the Rocket steam engine for the Liverpool-Manchester railway (1829) was the big bang for the “Age of Steam and Railways” – the second technological revolution in her view.

mutual indebtedness, the capitalist form of “‘international’ brotherhood.” (CW, v. 45, p. 356; MEW, v. 34, p. 373).⁸ Marx discusses how a technological innovation – railways – can impact the international division of labour, how the “railway mania” affects the whole world. He explains that “the appearance of the railway system in the leading countries of capitalism allowed, and even forced, states where capitalism was confined to a few summits of society, to suddenly create and enlarge their capitalistic superstructure in dimensions altogether disproportionate to the bulk of the social body, carrying on the great work of production in the traditional modes.” (CW, v. 45, p. 356; MEW, v. 34, p. 373). In sum: the “railway system” forces the enlargement of a “capitalistic superstructure” everywhere, even in countries with limited capitalistic development.

The diffusion of railways around the world was based on different institutional and financial arrangements from the English case, it took different paths of capitalist development – national states had a different role vis-à-vis the UK case. According to Marx, “[t]here is, therefore, not the least doubt that in those states the railway creation has accelerated the social and political disintegration, as in the more advanced states it hastened the final development and therefore the final change of capitalistic production. In all states except England, the governments enriched and fostered the railway companies at the expense of the Public Exchequer. In the United States, to their profit, great part of the public land they received as a present, not only the land necessary for the construction of the lines but many miles of land along both sides the lines, covered with forests, etc. They become so the greatest landlords, the small immigrating farmers preferring of course land so situated as to ensure their produce ready means of transport” (CW, v. 45, p. 356; MEW, v. 34, p. 373).

Finally, this letter deals with another important topic for our argument: implications for global capitalism, in an articulation between the spread of railways and its effect on a general adaptation to a new international division of labour. Marx evaluates that “[g]enerally the railways gave of course an immense impulse to the development of foreign commerce, but the commerce in countries which export principally raw produce increased the misery of the masses” (CW, v. 45, p. 357; MEW, v. 34, p. 374). We would like to stress a new movement in the international division of labour hinted by Marx, a consequence of this “immense impulse to the development of foreign commerce”. According to him, “[n]ot only that the new indebtedness, contracted by the government on account of the railways, increased the bulk of imposts weighing upon them, but from the moment every local production could be con-

⁸ Chandler (1977), with the advantage point of writing in the second half of the XXth Century, illustrates this relationship. He organizes his book on the large firms in the US starting from the maturation of the railways in the post-Civil War period, since the spread of railways throught the US enabled the emergence of the largest domestic market of the world and provided basis for economies of scale and scope to be explored by first movers that would reshape the US economy. Chandler’s book explains how the railways prepared the basis for the second industrial revolution in the US, a industrial revolution based on electricity, chemistry and steel. Chandler’s book, therefore, illustrates how railways could be a “new starting point” for global capitalism – part of the hegemonic transition described by Arrighi (1994).

verted into cosmopolitan gold, many articles formerly cheap, because unvendible to a great degree, such as fruit, wine, fish, deer, etc., became dear and were withdrawn from the consumption of the people, while on the other hand, the production itself, I mean the special sort of produce, was changed according to its greater or minor suitability for exportation, while formerly it was principally adapted to its consumption *in loco*” (CW, v. 45, p. 357; MEW, v. 34, p. 374).

This letter suggests a very important and new rearrangement of what Marx had described 12 years earlier as a “new and international division of labour”. This division of labour, after the “international railway boom” is further developed, pushing changes everywhere “according to its greater or minor suitability for exportation”. In sum, after 1867, Marx highlights two points: 1) a new technology – railways – forcing regions where capitalism was not so developed to “enlarge their capitalistic infrastructure”; 2) reorganization of production and changes in other countries, derived from “greater or minor suitability for exportation”. A new starting point at the centre but with huge implications for the rest of the world – railways at the periphery and a new international division of labour in 1879.⁹

MARX IN 1879-1882: THE PERIPHERIES, RUSSIA AND INDIA

After the publishing of *Capital*, there is also a broadening of Marx’s interests. Probably the experience within the International pushed him to a broader view of global capitalism, to new issues. According to Scaron. “[i]f from this point of view it is certain that Marx is one of the principal founders of the International, it is no less certain that it contributed [...] to develop Marx’s internationalism, freeing him from certain elements contradictory by this same internationalism “ (Scaron, 1972, pp. 9-10). On the other hand, the defeat of Paris Commune in 1871 had tremendous impacts in the history of the International. Kevin Anderson mentions that, after 1871, “Marx focused again on resistance to capital outside Western Europe and North America” (2016, p. 196). Anderson then lists strands of Marx’s evolution: changes in the French edition of *Capital*, “1879-1882 excerpt notebooks on non-Western and precapitalist societies” and texts on Russia (2016, p. 196). Pradella (2015, p. 173) highlights how Marx’s notebooks “of the late 1870s and early 1880s [...] shed light on a relatively unknown phase of his life, revealing his growing interest in pre-capitalist societies and the emerging science of anthropology”.

This interest on non-Western regions is probably connected with the same perception shared with Danielson in 1879. It becomes even clearer in the drafts of Marx’s letter to Vera Zasulich (Shanin, pp. 97-126). He wrote in the various drafts that “Russia does not live in isolation from the modern world” (p. 106; MEGA² I/25,

⁹ Marx also noted in the same letter: “The United States have at present overtaken England in the rapidity of economical progress, though they lag still behind in the extent of acquired wealth”. Hegemonic transition in sight?

p. 220). For instance, since late 1860s the railways in Russia were calling Marx's attention. In Notebook B113, pages 75 and 76, he excerpted news on Russian railways, from *The Economist*, 18th July 1868, pp. 816-817 (Paula et al., 2013, p. 172). In the drafts for the letter to Zasulich, Marx mentions how railways and other capitalist institutions could be "acclimatised" to Russian conditions (Marx in Shanin, p. 115; MEGA² I/25, p. 226). It is striking how Marx explored other possibilities of capitalist development, and how the institutional conditions of that development would be different from the classic English case. Furthermore, these drafts show how capitalist development in non-capitalist regions would require a stronger presence of the state. Marx writes: "[At the peasant's expense, it grew as in a hothouse those excrescences of the capitalist system that can be most easily acclimatised (the stock exchange, speculation, banks, share companies, railways), writing off their deficits, advancing profits to their entrepreneurs, etc. etc.]. At the peasant's expense, the state [lent a hand to] grew in hothouse conditions certain branches of the Western capitalist system which, in no way developing the productive premises of agriculture, are best suited to facilitate and precipitate the theft of its fruits by unproductive middlemen" (Marx, in Shanin, p. 115; MEGA² I/25, p. 226).

Which exactly are those "hothouse conditions"? Davies (1998, p. 7) describes the development of iron and steel industry in Russia during the 1870s: "The state guaranteed foreign loans for railway construction and provided substantial sums for railway construction from the budget. From the end of the 1870s it also actively encouraged the production of rails and rolling stock by Russian industry [...] Foreign companies were encouraged by the state to invest in the iron and steel industry" (p. 7). Those might be the "certain branches of Western capitalism" that Marx mentions; however, it is clear that Marx understood how the periphery was not homogeneous. He distinguished the Russian case from the Indian: Russia has not "fallen prey, like East Indies, to a conquering foreign power" (Marx, in Shanin, p. 106; MEGA² I/25, p. 226). Even a certain development of industries at the periphery should be evaluated, as the Russian case indicated.

Those drafts, therefore, show a growing awareness by Marx on the differentiation in periphery – not a simple division between an industrial and an agricultural world anymore (as in *Capital*, 1867, p. 580; MEGA² II/10, p. 406); not only a broader and finer adaptation of all regions of the agricultural world to "its greater or minor suitability for exportation" (as in the letter of 1879). In the drafts to Vera Zasulich, there are broader differences, different paths, that might be related to different roles of states, colonial powers and historical roots. Shanin (1983, p. 29) describes this acceptance by Marx of "the multiplicity of roads within a world in which capitalism existed and became a dominant force". Shanin stresses different new meanings of this "multiplicity of roads", and we would like to highlight the following: "an anticipation of future societal histories as necessarily uneven, interdependent and multilinear in the 'structural' sense"; and "first steps toward the consideration of the specificity of societies which we call today 'developing societies'" (p. 29). Later, Shanin discusses the relationship between this multidirectionality and interdependence: "the acceptance of multidirectionality also

within a capitalist-dominated (and socialism-impregnated world of mutual dependence, indeed, of heterogeneity resulting from that very interdependence” (p. 31). It is important to notice that the title of Shanin’s important book mentions *peripheries*, in the plural.

For his part, Kevin Anderson (2016, p. 167) writes about the differentiation of movements towards the periphery, making distinctions between India, China and Russia, regarding the speed of the process and the presence of “direct political forces”. According to him, “[i]n China and Russia, where global capital lacked the ‘assistance’ of ‘direct political force’ as in colonized India, the change came even more slowly” (p. 167). K. Anderson helps the investigation of this broadening interests of Marx informing the scope of his 1879-1882 notebooks, that comprised “a wide range of societies and historical periods, including Indian history and village culture, Dutch colonialism and the village economy in Indonesia; gender and kinship patterns among Native Americans and in Ancient Greece, Rome and Ireland; and communal and private property in Algeria and Latin America” (p. 196). Those investigations may be seen in Figure 1 (see Introduction), where the readings of Marx in early 1880s are shown: Java, India, primitive societies.

Therefore, overtime the periphery became more complex, heterogeneous and diversified – “peripheries”, as Shanin highlights. The new and international division of labour became more complex and heterogeneous, even with indications of initial industrialization at the periphery, in very special conditions (“hothouse conditions”) – the peripheries are not anymore only raw material producers.

MARX IN 1882: AN EMERGING TECHNOLOGICAL REVOLUTION

In 1882 Marx, together with other studies (according to Figure 1, readings about Java, India, etc.), excerpts a book on electricity and its applications (Hospitalier, 1882). The contents of this book can be seen in Figure 3 – a very up-to-date book, a fresh second edition published after an exhibition in Paris in 1881 (*Exposition d’électricité au Palais de l’industrie*), which hosted a meeting of scientists to define units of measurement of that emerging technology – standardization in process (Hospitalier, 1882, p. 6).¹⁰ At this stage, the interest of Marx on experiments with electricity was very important, as we can read in his letter to Engels in 8 November 1882: “Dear Fred, What do you think of Deprez’s experiment at the Munich Electricity Exhibition? It was almost a year ago that Longuet promised to procure Deprez’s works for me (notably his demonstration that electricity makes it possible to convey energy over considerable distances by means of a simple telegraph wire)” (MEW, v. 35, p. 104).

¹⁰ According to Hospitalier (1882, p. 6), “[a]près huit années de travaux et d’expériences, le comité publia un rapport très détaillé et détermina les unités électriques [...] Le Congrès international des électriciens, réuni à Paris le 15 Septembre 1881 a sanctionné l’emploi de ces unités [...]”.

Figure 3: Contents of Hospitallier's *La Physique Moderne*

I^{re} PARTIE. — Les sources d'électricité.....		1
CHAP. I.	Les piles électriques.....	3
CHAP. II.	Les piles thermo-électriques.....	27
CHAP. III.	Les machines électro-dynamiques.....	40
CHAP. IV.	Les transformateurs et accumulateurs électriques.....	84
II^e PARTIE. — L'éclairage électrique.....		105
CHAP. I.	Les régulateurs.....	115
CHAP. II.	Les bougies électriques.....	148
CHAP. III.	L'éclairage par incandescence.....	164
CHAP. IV.	Les applications de l'éclairage électrique.....	183
III^e PARTIE. — Téléphones, microphones, radiophones et photophones.....		211
CHAP. I.	Téléphones musicaux.....	212
CHAP. II.	Téléphones d'articulation.....	217
CHAP. III.	Téléphones spéciaux.....	250
CHAP. IV.	Les applications du téléphone.....	273
IV^e PARTIE. — La mécanique électrique.....		297
	Les moteurs électriques.....	298
	Le transport électrique de la force à distance.....	306
	La distribution de l'électricité.....	316

Source: HOSPITALIER (1882).

Deprez is mentioned by Hospitalier (1882, p. 320), and the editors of Volume IV.31 of MEGA² suggest that Marx might have read first the whole Hospitalier's book, and only then he began to excerpt it (MEGA² IV.31, p. 876 and p. 879). Hospitalier's book, as shown in Figure 3, discusses a wide range of aspects of emerging technologies. References to Siemens, Edison, Bell, Deprez and others are present in this book. An electric locomotive is shown in Hospitalier's book – Figure 126, page 310, which shows a “locomotive du premier chemin de fer électrique ayant fonctionné à Berlin in 1879”, an experiment prepared by Werner Siemens. Therefore, in 1882, Marx had new evidence about scientific advances in a technology that would challenge King Steam. Not only a model, but preliminary experiments of electric traction and concrete measures about standardization were necessary for a full development of this new technology. Why would Marx read with such interest a book on electricity? Why would he read on other scientific developments as chemistry,¹¹ according to the excerpts published in MEGA², volume IV.31?

First, was there a general interest in the development of sciences, something beyond very concrete applications in industry? Rosenberg (1974, p. 136) suggests

¹¹ For the role of organic chemistry for industrial innovation in leading German firms by 1870s, see Murmann (2003, pp. 120-121).

that Marx's views include a relative autonomy of science, that "factors internal to the realm of science must be conceded to play a role independent of economic needs". Moreover, science studies would have many motivations. One should not disregard some dose of Hegelianism, that means, Marx was indeed interested in the movements of the human spirit. Another reason is marxian great curiosity about the sciences in general; hence, he studied chemistry, physiology, agronomy, geology, physics, etc. But Marx had a well-formed view of the role of science in the capitalist economy. Rosenberg (1974) wrote about it in a very positive way. One of the things that Rosenberg emphasizes is Marx's perception of certain properties of the advance of science – from simple to complex, first to physics (Newtonian), then chemistry, etc. Here too, there would be an element of caution: Marx's gigantic curiosity would arm him to understand several future developments, such as a leap forward towards more science-based technologies than before (electricity and chemistry will have a direct impact on industry ... from the 1870s). Murmann (2003) investigates the history of the chemical industry and writes about the stages of the industry formation contemporary to Marx: "science unbound" is the title of the period between 1866-1885, and MEGA IV.31 suggests that Marx was trying to follow that evolution.

Second, was there a relation between investigations on science and new opportunities of technological development? The editors of MEGA² IV.31 write about Marx's earlier studies of sciences, since 1833. His interest on Liebig and Johnston, for instance: "Marx based himself on the insights of Liebig and Johnson to corroborate his argument against the 'law of diminishing productivity of land', respectively, with the clarification of the question whether agricultural economy, given its technical and scientific principles, could be able to supply food for a growing population and to continually provide the industry with raw materials" (p. 641).

Third, understanding science is a precondition to understand later applications by the economy and industry, applications demanded by them. This leads us to a very specific question: would those readings published in MEGA² IV.31 (Chemistry and Electricity) have the same role as the reading of Babbage and Ure to the understanding of machinery – and the industrial revolution? Our guess is a positive answer to this question. Did Marx have hints and clues of a new industrial revolution? Was he exploring another "new starting point"? Certainly, Marx did explore some emerging technologies of his time. However, the key event – other elements about the big bang that would trigger the third technological revolution had not yet taken place – according to Freeman & Louçã (2001, p. 141) this key event was Thomas Edison's New York Electric Power Station, inaugurated in September 1882, therefore not covered by Hospitalier's book – the second edition was published in 1882, but the book was prepared in 1881 – see his "préface de la deuxième édition", dated from "Décembre 1881" (p. VIII). Those data show how difficult it is to forecast emerging technological revolutions. W. Liebknecht stresses this point: "Forty-five years and a half have passed, and no railroad train is yet driven by an electric engine. The few street cars and whatever else are operated by electricity do not signify much on the whole, however much it may appear. And in spite of all revolutionising inventions it will take some time yet before lightning, completely

tamed, will allow itself to be hitched to the yoke of human labour and will drive King Steam from his throne. Revolutions are not accomplished in a sleight-of-hand fashion. Only the sensational shows in politics are called revolutions by the wonder-working rustic faith. And whoever prophesies revolutions is always mistaken in the date” (W. Liebknecht, 1896, p. 58).¹²

CONCLUSION: REMARKS ON TECHNOLOGICAL REVOLUTIONS AND THE PERIPHERIES

Was Marx trying to investigate the future of capitalism in the late years of his life? Probably yes. This leads us once again to our introduction: is it an accident that Marx reviewed Hospitalier and Morgan in Notebook B51, as shown in Figure 1? Our answer is no. Throughout his life, Marx faced a sequence of “new starting points”, for him and for capitalism. As suggested in the sections related to the selected years of 1850, 1867, 1879-1882 and 1882, there is a rich history of changes, new issues and a sequence of “new starting points”. In a certain sense, this could be a way to look ahead for the future of capitalism: this system might have “new starting points”. However, those “new starting points” could be articulated in the history of capitalism with its new implications for the rest of the world – a divide centre-periphery seems to be always changing, following the structural changes brought forward by each technological revolution.

Marx followed two of those technological revolutions – according to Perez’s chronology. Therefore, it is possible to connect Marx’s analysis of changes at the centre with their implications for the periphery. It is also possible to compare the implications of the first technological revolution or the first big bang – machines in England, destruction in India; industries at the centre, agriculture at the periphery (*Capital*, 1867, volume 1, p. 579; MEGA² II/10, p. 406) – with the impacts of the second technological revolution or the second big bang – railways spreading globally, reorganization of local economies to export for leading economies (letter to Danielson, 1879). New developments were explored in his drafts for Vera Zasulich (1881), as a peripheral economy like Russia may suggest special (“hothouse”) conditions for development of “certain branches of Western capitalism” (domestic production of steel and iron for railway construction), an indication of non-agricultural production at the periphery, that means, there was a change in course from the initial centre-periphery divide between an industrial centre and an agricultural periphery suggested in 1867, the early signs of a new international

¹² Although a subject that might be beyond the specific objectives of this paper, it is important to stress that late Marx did not share a “naive prometeanism” of his times (Saito, 2016, p. 302). As Saito (2016, p. 303) puts forward, reading his notebooks and following his process of elaboration “it is actually difficult to believe that he has shared the naive progress optimism of infinite growth”.

division of labour. In sum: insights on how each technological revolution reshapes the international division of labour.

The third technological revolution or the third big bang could not be described or discussed by Marx. Nevertheless, he was following its scientific preconditions and first experiments with technologies that would challenge King Steam. Could Marx be regarded as an investigator of emerging technologies? We could guess – and W. Liebknecht’s memory suggests this: Marx had a clear vision that new revolutionary changes in science and technology would happen. In less than 40 years after his reading of Hospitalier, UK would be overtaken by USA and Germany, new industries, new products, and a new international division of labour would emerge, the division between an industrial centre and an agricultural periphery would not be enough anymore, since industries began to develop in the periphery.

Two observations and cautionary notes are necessary as concluding remarks.

First, Marx cannot be seen as a Kondratiev avant-la-lettre. On one hand, Marx was not a systematic scholar of technological revolutions. On the other hand, in his time there was not enough empirical evidence for further reflection, as they existed for Kondratiev and van Gelderen in the 1920s. But Marx went through everything that was later seen as technological revolution or the different industrial revolutions. What he studied and wrote about was very interesting to a researcher here in the 21st century, like that letter on the railroads to Danielson and the insight of “new starting points”.

Second, did Marx elaborate a theory of structural change? Beyond *Capital*, Marx had insights about this: Notebooks B108, B109 and B112, the 1879 letter. Although he did not develop this systematically, he left enough evidences and perceptions in this direction. Our question is how to deal with this sequence of insights, non-systematized perceptions, and notes for later development etc. What we can do is once more indicate possible avenues for further development. That’s why MEGA² is so important.

Finally, the investigation of connections between technological revolutions and changes in the centre-periphery divide is a broad and open agenda for further research. This investigation is basic for an understanding of today’s capitalism and for an elaboration of a program for alternatives to it.

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