Paakat
Revista de tecnología y sociedad

Impact of technological changes on the social relations of production. Steel and automotive industries

Impacto de los cambios tecnológicos sobre las relaciones sociales de producción: industrias siderúrgica y automotriz

http://dx.doi.org/10.32870/Pk.a11n21.586

Lourdes Carolina Hernández Calvario*
http://orcid.org/0000-0003-2479-5146
Universidad Autónoma Metropolitana, Mexico

Received: November 25, 2020
ccepted: June 22, 2021

ABSTRACT

This article aims to analyze the development of the productive forces as a central element to understand the modifications generated in the social relations of production, as shown by the technological changes incorporated into the production process in the automotive and steel industries in Mexico. This work was based on the most recent technological revolutions and the productive reconfiguration that results from them. In a second moment, the impact of technological advances on the social relations of production upon the aforementioned industries was analyzed. Through the dialectical method, elements were proposed to suggest that the technological development achieved in these cases has led to a production process that functions as a global chain of social events, which generate social products, where the trend in innovation is to implement cooperative practices of international partnership.

Keywords
Technological revolutions; production process; manufacturing industries

RESUMEN

El presente artículo tiene como objetivo analizar el desarrollo de las fuerzas productivas como elemento central para comprender las modificaciones generadas en las relaciones sociales de producción, como se muestra con los cambios tecnológicos incorporados al proceso productivo en las industrias automotriz y siderúrgica en México. Para este trabajo se tomaron como base las revoluciones tecnológicas más recientes y la reconfiguración productiva que de estas se desprende. En un segundo momento, se analizó el impacto de los avances tecnológicos sobre las relaciones sociales de producción en las industrias mencionadas. Mediante el método dialéctico se propusieron elementos que ayudan a sustentar que el desarrollo tecnológico alcanzado en estos casos ha propiciado un proceso de producción que funciona como una cadena global de actos sociales, que generan productos sociales, en los que la tendencia en la innovación es la implementación de prácticas cooperativas de asociación internacional.

Palabras clave
Revoluciones tecnológicas; proceso productivo; industrias manufactureras

* Full-time research professor at the Universidad Autónoma Metropolitana, Iztapalapa unit, Mexico. Her lines of research focus on the analysis of transformations in the work process in Mexican industry and their effects on labor relations. E-mail: hernandezcalvariol.carolina@gmail.com

Introduction

Capitalism –not surprisingly– functions under the logic of constantly transforming its productive organization, changes that begin, in a general way, in the productive bases (technical bases). However, these must be seen as elements of analysis of a broader concept: productive forces. The other element is the labor force, which encompasses the workers who will make use of these new technologies and, therefore, require skills and abilities that will enable them to fulfill this function.

Taking up this idea, developed by Karl Marx (1973), allows us to affirm that social relations are intimately linked to the development of productive forces, since –with the acquisition of new productive forces– people change their way of producing and, with it, their social relations.

This paper develops this approach with the steel and automotive industries as the object of analysis. These industries were selected because of their relevance in the Mexican economy (in the current context in which outward economic growth is privileged), as well as for being representative of different paths of economic and technological transformations. As data to illustrate the first consideration, between 1993 and 2018, national exports multiplied eight times, going from 52 to 409 billion dollars (ECLAC, 2018), which places our country as one of the thirteen most important exporters worldwide, and the first in the Latin American and Caribbean region. Regarding technological transformations, as these are one of the fundamental determinants of production relations, we conceive them as one of the main causes that explain the way in which our country was inserted into the global production logic of these industries.

Technological revolutions and their impact on productive reconfiguration

Since the globalization of technological developments in the world manufacturing industry, Mexico has not been on the margins of the great transformations in productive organization. It has been documented that, since the first technological revolution, the country has been the destination of machines that favor the mechanization of labor (Cerutti, 2000). By mechanization of work we understand "the division of productive processes into a series of operations and the execution of each one of them by machines that replace human labor" (Rumiantsev, 1963, p. 220).

Later, at the beginning of the 20th century, with the use of electric power and the implementation of the assembly line that accompanies it, our territory also became the scene of the second technological revolution. With the incorporation of the semi-automatic production line, production times are reduced: there is a better handling of work objects, as well as a reduction (and even elimination) of the displacement of workers. From this moment on, important differences began to appear in the way of producing and in the structure of employment in the industries (the automotive and steel industries are good examples).

The introduction of these innovations in the automotive industry occurred from the moment the first automotive vehicle manufacturing companies were installed in the country. This immediately led to Mexican workers –who from the beginning began working in this industry– acquiring levels of qualification above the national average. The same does not occur in the case of the steel industry, since it is an industry that operated in the country previously, and when these systems for reducing production times are incorporated due to the simplification of tasks, it causes a displacement of the labor force.

In this regard, the emergence of the Mexican steel industry is driven by the demand for inputs in the construction of the railroad network since the second half of the 19th century, which explains the emergence of the Fundidora Monterrey company in 1900. The automotive industry, on the other hand, was driven by the expansion of U.S. companies into Mexican territory: the first automobile assembly plant installed in Mexico belonged to Buick, a General Motors company, in 1921.

The third revolution dates from the second half of the 20th century and is characterized as a multipolar process led by the United States, Japan and the European Union, which facilitates its relatively homogeneous extension to the rest of the world. It is identified with the incorporation of electronics and computers, the so-called information and communication technologies. The great change of this stage is the capacity for storage, processing and transmission of information that accompanies the application of new electrical and digital mechanisms, used for industrial data processing and transfers via the Internet.

The fourth revolution –nowadays in force– retakes several of the fundamentals of the third revolution, but with broader scopes, for example: 1) a great leap in terms of the increase in data storage capacity (the so-called big data), which allows companies to modify their administrative methods (with the incentive of reducing storage costs), in addition to promoting the use of computational systems not only within production activities, but also towards consumers; 2) the use of artificial intelligence systems –one of the most relevant transformations so far– that is, digital programming to enhance the capabilities of processing machines with the aim of making their functions as similar as possible to those performed by humans.

Beyond the temporal change, an essential feature that differentiates the fourth revolution from the other three mentioned is that in the first three, what was sought were conditions for: 1) encouraging the strategy of international fragmentation of production, 2) greater homogenization of productive tasks, 3) increased automation of the productive process, and 4) segmentation of the productive process. In the fourth revolution, item 2) will not be part of the strategy for greater surplus generation.[1]

Impacts of technological advances on the social relations of production

The analysis of the current technological base involves the study of its two main elements: 1) the characteristics of the machinery and equipment with which it is produced, and 2) the organization of labor that allows this production, i.e., the social relations of production. This differentiation makes it possible to conceive the worker as the main actor in the productive process, not only as an appendix of the machines and new technologies, which is relevant in a context in which the presence of increasingly sophisticated machines makes the work of people seem secondary.

One of the main motivations of companies when incorporating new technologies into the production process is to increase worker discipline and labor intensity, since this increases productivity and quality levels. In the two industries under study, there are records of technological innovations, technological systems and technological revolutions. These concepts are often used interchangeably, thus limiting the interpretations that are made in their environment. The difference between invention and innovation lies in the fact that the former will be understood as "something" that occurs in the scientific-technical sphere and can remain there indefinitely, while innovation should be understood as the transfer from the scientific-technical sphere to the economic sphere, i.e., an invention applied to the productive process. This approach, which was proposed by Schumpeter (1978) and taken up by Neffa & De la Garza (2020), and Amaro & Robles (2020), will be the basis for documenting the innovations and technological systems that have occurred in the steel and automotive industries.

The innovations that are part of what is called the fourth technological revolution, in addition to the increase in data storage capacity, allow companies to modify their administrative methods (Csath, 2018). Hence the imposition of the use of computational systems within production activities; of course, without omitting the use of artificial intelligence systems, which –beyond seeming like something out of a Philip K. Dick[2] novel– is one of the most relevant transformations as it involves computational programming created with the intention of enhancing the capabilities of processing machines so that their functions are as similar as possible to those performed by humans.

I would like to point out that the word robot has its origin in Czech literature, in the work written by Karel Čapek, R.U.R. (Rossum's Universal Robots), in which he deals with the theme of automatons working as laborers on a lost island, and which alludes to forced labor in a company dedicated to the manufacture of mechanical creatures in the image and likeness of the human race, which are used as a slave labor force. This visionary Czech author foresaw in 1920 –when he first published his work of fiction– what would happen almost 100 years later: that the cost of labor in manufacturing would become higher than the cost of a robot. This is what ECLAC (2018) reports when it points out that this is what is expected as of 2018, although the incorporation of robots into the automotive production process in our country has been documented since at least the 1990s (Martínez & Carrillo, 2019; Carrillo *et al*., 2016; Sandoval, 2017).

These two mentions in the universal literature show the coexistence of humans with artificial intelligence as an announced reality, as documented in works such as those of Bensusán *et al*. (2017). We are thus introduced to the analysis of the use of artificial intelligence and robotics in the productive process in Mexican manufacturing, particularly in that destined for export. Also to the increasingly widespread use of CAD-CAM (Computer Aided Design-Computer Aided Manufacturing), CAE (Computer Aided Engineering), Just in Time (JIT), Total Quality Control (TQC), modular production and, in general, the widespread use of information technologies.

Once the use of these sophisticated mechanisms has been exposed, the question arises as to where the participation of the workforce is heading in the current technical configuration of production, since, with the incorporation of these technological developments, the strategy and organization of the production process change radically. Let us think of the effects brought about by the improvement of machines, particularly in the displacement of blue-collar workers by mechanical workers.

In the Mexican economy, and taking as a reference the estimates obtained from the Expansión magazine (2017), it is expected that 52% of jobs may be replaced in the coming years by machines or robots. In absolute values, we are talking about 25.5 of the 49.3 million jobs that are currently registered. So the risk is that one out of every two employees could be replaced.

But let's not go that far, the automation of the production process is something present in our country: for some time now, surveys of manufacturing industries have been reporting it. However, it is also recorded that, where before there was a worker (with the typical overalls) who made a machine work, now there is an operator who supervises the automated equipment that is part of the production plant. This means that, in this type of company, highly qualified workers (with engineering or postgraduate degrees) do not appear as bosses, but as a member of the working class without a higher hierarchy.

Transformations in the automotive industry

The threat of rising unemployment levels due to the use of robots in the production process is gaining more and more strength. However, it is striking that these forecasts do not mention –at least not with sufficient emphasis– that this has already occurred in the automotive industry, and the displacement effects are far from those predicted. On the contrary, there was an increase in the number of workers, going from 420 000 jobs in 1990 (CEFP, 2002) to 500 000 in 2007, and to 822 000 in 2017 (INEGI, 2018).

This reconfiguration occurred as a consequence of production logistics schemes aimed at developing flexible assembly lines, which required strong amounts in investment. According to data from Global Innovation 1000, assembly companies have earmarked investments exceeding 690 billion dollars (bdd). To give some figures, the German company Volkswagen reported an investment in the order of 277 billion dollars in this area, followed by the Japanese Toyota (which invested 259.8) and the American Ford with an investment of 156.8, all three with a presence in the country. In a report published by the Mexican Association of the Automotive Industry (AMIA) in 2014, there are 360 facilities in the country focused on research and development in this industry, of which 106 correspond to design centers, 247 laboratories –driven by academia and other research centers– and seven vehicle testing centers.

As a result of these strong investments in research and technological development, the use of digital mechanisms, robots and the implementation of algorithms are an integral part of the productive processes in the industry. To give us an idea, Bensusán *et al*. (2017) shows the type of vehicles produced today. Beyond the modifications in the characteristics of new vehicles –and with it the changes in consumption patterns–, think about the way they are produced, the use of highly sophisticated elements (such as artificial intelligence, the internet of things, greater connectivity and the use of alternative traction systems), to the point that the putting into circulation of cars with autonomous driving is already seen as a reality.[3]

Other noteworthy technologies are virtual reality and augmented reality, used to recreate computerized artificial environments. Also the sensory mechanisms through which workers explore environments projected in 360º, which enable safety strategies aimed at preventing operator risks; as well as generating simulators of the operation of new machines, contributing to the design of protocols for the use of new technologies applied to the production process, and adjusting automation processes in production lines. All this increases productivity levels, derived from real-time decision making and the expansion of flexible production.

Among the questions generated by new technologies on social relations are the skills required of workers. Generally speaking, these can be classified into two types: a) those related to the programming and control of computer devices, and b) the skills for learning new routines. Both are fundamental within the new models of learning and organizational development, based on the open exchange of information within the industry and the technical cooperation of tasks. These elements require –and therefore encourage– the participation of workers in decision making. For some authors such as Covarrubias (1998), Contreras *et al*. (2006), Carrillo *et al*. (2017) and Sandoval (2017), this situation is explained by the creation of industrial parks that favor the proximity of companies with their suppliers, as documented in Genzlinger *et al*. (2020).

What is most interesting about this new way of organizing production is the trend towards the collectivization of technology. As part of the principles of continuous improvement to increase productivity levels, the strategy was based on the application of novel programs that globally became known as Effective Ideas: workers' proposals for improvement in equipment operation, reduction in travel times and process synchrony.

In other words, new innovation networks began to be traced which, according to authors such as Sandoval (2017), are characterized by forming permanent construction processes, which can occur in multiple spaces, and asynchronously, since they function as open, multicentric and hetero-hierarchical systems through interaction and dynamic and diverse exchange among the actors (Lopes & Carvalho, 2018). This allows the enrichment of each of the participants as a consequence of the multiple relationships they develop with others, thus optimizing learning by being socially shared.

In short, the acquisition and assimilation of workers' knowledge and skills is encouraged. Documentation of these cooperative practices (collectivization of labor) can be found in Rivas & Flores (2007, p. 92), Sandoval (2017, p. 187) and Garcia (2017, p. 179).

Transformations in the steel industry

Technological transformations in the steel industry have occurred more slowly than in the automotive industry. This is not a novelty, considering that during the 20th century there were documented signs of deterioration and obsolescence in the installed equipment (Avila, 2002), to the point of bankruptcy of important companies, such as Fundidora de Monterrey, Sicartsa, Hylsa and Tampsa.

The most outstanding modernization efforts in the industry can be analyzed in three main stages: 1) from 1957 to 1960, and consists of the creation of the flat steel department and the consequent incursion into the production of flats (plates, sheets and tin plates), as well as to the building of a 44,000 kw thermoelectric plant, as well as a plant to manufacture laminates; 2) from 1964 to 1967, with outstanding facilities, such as the use of more blast furnaces (three in the case of Fundidora Monterrey), open hearth furnaces, ingot reheating furnaces, billet mills and turbine supply; and 3) between 1973 and 1976, in the midst of one of the greatest crises ever recorded in the industry, derived from the decrease in demand, and whose main investments were directed to the creation of an iron ore concentrator plant and an iron ore pelletizer plant, as well as the expansion and modernization of blast furnaces and flat steel.

In the years prior to the economic opening, the major technological advances were the replacement of Siemens Martin steelmaking furnaces with oxygen-based converters (Basic Oxygen Furnace, BOF), the method of casting steel in ingot molds by continuous casting, and the first approaches to computerized technologies (Rueda, 1994; Martínez & Barragán, 2019).

After the 1990s –and as part of the privatization processes–, new technologies were incorporated. According to Guzmán (2002), there are ten that stand out: three of American origin, three Brazilian, and the rest of German, English, Chilean and Canadian origin. According to this author, most of these advances are aimed at reducing energy consumption and connection times, flexibility in the use of raw materials and improved product quality.

Among the technical base that makes up the productive forces in this industry, the electric furnaces, scrap baskets, casting pots, cranes and transformers stand out for their importance and function. These equipment and installations reflect the complexity of the production process that takes place there. Toledo & Zapata (1999) explain this process well for the Mexican case and Byun (2020) in developed countries. Consulting the description of the steel production process highlights the technical complexity of the fragmentation of the production process in this industry.

For the steelmaking process in the form of billets and slabs, the requirements range from the use of BOF oxygen converters and electric furnaces, to the use of pot furnaces that allow deeper refining, as well as the use of hydrogen stripper. This causes traditional forms of work organization to remain in force, in what seems to be a harmonious coexistence, with characteristics that involve: a) a vertical division of labor –from a centralized command– with horizontal elements, through the production line; b) constant supervision and control of work; c) different levels, internal hierarchies and command styles (De la Garza, 1993), but with the novelty that the quality circle and total quality schemes have been incorporated (Martínez & Barragán, 2019).

However, this industry is beginning to incorporate innovations inherent to the 4.0 Revolution, through advances in nanotechnology, quantum computing, biotechnology, the Internet of Things, fifth-generation wireless technologies, 3D printing (or additive manufacturing) and fully autonomous vehicles. Tools that, according to the technology departments dedicated to their development, can improve a business model and generate new revenues.

Comparison of technological changes among the industries studied

By the incorporation of the assembly line into the production process, the guideline is given for the systematization of the movements made by the workers. This led Frederick W. Taylor to propose a process manual specifying the precise tasks (movements) that workers had to perform in each of the phases of the process, thus laying the foundations of the so-called Taylorist method, defined from the set of three principles: the dissociation of the work process from the expertise of the workers –which refers to the way in which the work process is presented independent from the trade,[4] knowledge, and even the tradition of the workers–; the separation of conception from execution (which is nothing more than the separation of manual work from mental or intellectual work); and the use of the monopoly of knowledge to control each step of the work process and its execution, linked to schemes of pre-planning and pre-calculation of all the elements of the work process.

In the case of the vehicle manufacturing industry, Taylorist principles were the basis for subsequent technological developments. Consider the logic of division between managerial control (on which design activities fall) and the execution of production activities. The situation is different in the steel industry where, in most segments of the production process, the principle of decoupling the work process from the expertise of the workers does not apply.

The reason is that the steel work process still depends to a large extent on the workers' skills and knowledge, acquired in the traditional way, which makes it difficult to introduce practices that involve a greater participation of fixed capital. Derived from this condition, the second principle of Taylorism –that of the separation of conception from execution– is also limited, since the productive activities carried out in the steel industry require reasoning and logic that cannot be limited to the execution of simplified instructions given by management.

The gap will widen even further in the 1990s, when neither Taylorism nor Fordism will have been fully implemented in the steel industry, while in the automotive industry these modes of production organization are already in the process of dissolution. Nevertheless, both industries have implemented the JIT and TQC production organization system, which allows them to resort to suppliers capable of offering low costs and maximum quality and flexibility.

In the automotive industry, the transfer of the design and manufacturing of automotive components, which used to be carried out by assemblers, to apparently smaller companies are being promoted. In works such as those by Contreras *et al*. (2006) and Contreras & Díaz (2017), there is talk of the transition from integrated to modular manufacturing –due to the redefinition between assemblers and suppliers– and the new complex system that, since the 1990s, has been created from the new way of interrelating. It is also due to innovation systems in networks that are in a constant process of construction, and which, by occurring in multiple spaces and in an asynchronous manner, function as open, multicentric and hetero-hierarchical technological systems.

An important convergence that is beginning to be observed across industries is the strategy of decoupling the skills and abilities of the performers. In the steel industry it was never fully implemented, while in the automotive industry it is beginning to show signs of obsolescence, since the companies that make up this industry –rather than seeking a reduction in the cost of the labor force by disarticulating its simplest elements, i.e., that the labor force would lose its degrees of skill, Rather than seeking to reduce the cost of the labor force by dismantling its simplest elements, i.e., to reduce the degree of training of the workforce so that it can be purchased at a lower price, they are seeking to make the workforce capable of performing multiple functions, including the planning of part of the production process, so that productivity and quality levels of production can be higher.

Final considerations

Nowadays, productive activity in manufacturing industries has become part of a global mechanism in which the most developed productive forces are setting the course of social forms of production. In the case of the automotive industry, the incorporation of technology (a product of the 4.0 Revolution) generates models of productive organization that are considerably different from those previously known.

There is now a trend towards greater labor cooperation, not only within production units –with the incentives that workers have to propose ideas that contribute to increased productivity and the elimination of the separation of manual labor from intellectual work– but also because the most sophisticated technological systems have the characteristic of being open systems (which are improved through interaction with workers) and necessarily adaptive, otherwise they become obsolete sooner.

In the case of the steel industry, there is still not enough evidence to determine the type of organizational model that has the greatest influence. Although, from the records, some of the forms of work organization that it shares with the automotive industry in the country are: (a) Total Quality Control mechanisms, based on quality control circles, statistical process control and a zero error policy; (b) implementation of the JIT scheme; (c) modifications in hiring categories, which seek to expand the functions of workers and establish mechanisms for polyvalence; (d) derived from the previous point, it seeks to encourage the reintegration of production functions performed by workers, that is, to break with the rigidity characteristic of the Taylorist model, which demands greater involvement of workers in the production process.

With this analysis, a question of great controversy arises: are there elements to argue that, due to the accelerated level of technological development, it is possible to generate machines and robots capable of carrying out the productive processes in a more integral way, and thus open the possibility of gestation of a new type of social relations that transcend the current mode of production? This question, far from being seen as a product of science fiction, is pertinent.

A review of the known forms of productive organization shows that, roughly speaking, Taylorism initiated the planned management of work within the new productive unit, the factory, while individual production was transformed into social production: the first sign that collective work tends to be more productive than work carried out individually. With Fordism and the assembly line, the characteristic that emerged from the factory was strengthened: the collective work of the workers. Now, with the fourth generation models, there are elements to affirm that the production process functions as a global chain of social acts, generating social products, in which the trend in innovation is the implementation of cooperative practices of international association.

REFERENCES

Amaro, M. & Robles, E. (2020). Measuring innovation in the context of emerging and converging technologies: some methodological reflections. *Paakat: Revista de Tecnología y Sociedad*, *10*(18), 1-22. http://www.udgvirtual.udg.mx/paakat/index.php/paakat/article/view/415

AMIA. (2014). Inventario de capacidades nacionales para el desarrollo tecnológico automotriz. Proyecto financiado con el apoyo del PRODIAT de la Secretaría de Economía. https://www.netcar.com/estadisticas/INA

Ávila, J. Ó. (2002). La tecnología en la industria siderúrgica mexicana: el caso Fundidora Monterrey. *Revista Ciencia UANL*. México: Universidad Autónoma de Nuevo León, 447-455. https://www.redalyc.org/pdf/402/40250403.pdf

Bensusán Areous, G.; Eichhorst, W. and Rodríguez, J. M. (2017). Las transformaciones tecnológicas y sus desafíos para el empleo, las relaciones laborales y la identificación de la demanda de cualificaciones. Santiago de Chile: Cepal/Ministerio de Asuntos Exteriores de Noruega.

Byun, S. (2020). Managing the interdependence among successive stages of production in steel industry. *Annals of Business Administrative Science*, *19*(6), 293-305. https://www.jstage.jst.go.jp/article/abas/19/6/19_0201111a/_article

Carrillo, J.; Bensusán, G. y Micheli, J. (2016). El debate sobre innovación y el progreso sociolaboral. In A. Covarrubias, S. Sandoval, G. Bensusán (coords.), *La industria automotriz en México. Relaciones de empleo, culturas organizacionales y factores psicosociales* (pp. 47-72). México: Colegio de Sonora.

Carrillo, J.; Bensusán, G. and Micheli, J. (2017). ¿Es posible innovar y mejorar laboralmente? Estudio de trayectorias de empresas multinacionales en México. Ciudad de México: UAM Azcapotzalco.

Csath, M. (2018). Competitiveness Based on Knowledge and Innovation. *Public Finance Quarterly*, State Audit Office of Hungary, vol. 63(1), pages 64-79. https://ideas.repec.org/a/pfq/journl/v63y2018i1p64-79.html

CEFP. (2002). Análisis Económico y Fiscal del Sector Automotor de México, 1990-2001. México, Cámara de Diputados. https://www.cefp.gob.mx/intr/edocumentos/pdf/cefp/cefp0312002.pdf

Cerutti, M. (2000). *Propietarios, empresarios y empresa en el norte de México: Monterrey: de 1848 a la globalización*. México: Siglo XXI.

CEPAL. (2018). La inversión extranjera directa en América Latina y el Caribe 2018. Santiago de Chile. http://repositorio.cepal.org/handle/11362/43689

Contreras, Ó.; Schnierle, L. R. and Solís, V. (2006). Reestructuración y trabajo de la industria automotriz. In E. de la Garza and C. Salas (coords.), *La situación del trabajo en México* (pp. 255-276) México: UAM.

Contreras, O. & Díaz, M. (2017). Ford Motor Co. en México: una plataforma de bajo costo y alta calidad para la exportación. In J. Carrillo, G. Bensusán and J. Micheli (coords.). *¿Es posible innovar y mejorar laboralmente? Estudio de trayectorias de empresas multinacionales en México*. México: UAM.

Covarrubias, A. (1998). Flexibilidad y productividad laboral: el caso de la planta Ford-Hermosillo. In F. Zapata, *¿Flexibles o productivos? Estudio sobre la flexibilidad laboral en México* (pp. 175-228). México: Colegio de México.

De la Garza, E. (1993). *Reestructuración productiva y respuesta sindical en México*. México: Universidad Nacional Autónoma de México, IIEC.

García, R. (2017). Cooperación tecnológica, innovación y competitividad: una perspectiva teórica institucional. *Análisis Económico*, *32*(79), pp. 177-199. http://analisiseconomico.azc.uam.mx/index.php/rae/article/view/9

Genzlinger, F.; Zejnilovic, L. and Bustinza, O. (2020). Servitization in the automotive industry: How car manufacturers become mobility service providers. *Strategic Change*, *29*(2), pp. 215-226. https://doi.org/10.1002/jsc.2322

Guzmán, A. (2002). *Las fuentes del crecimiento en la siderurgia mexicana: innovación, productividad y competitividad*. México: Porrúa/UAMI.

INEGI. (2018). Encuesta Nacional de Trabajadores Manufactureros. México: INEGI.

Lopes, A. & de Carvalho, M. (2018). Evolution of the open innovation paradigm: Towards a contingent conceptual model. *Technological Forecasting and Social Change*, 132, pp. 284-298. https://ideas.repec.org/a/eee/tefoso/v132y2018icp284-298.html

Martínez, J. & M. Barragán. (2019). ArcelorMittal en México: Integración industrial y flexibilidad productiva. *Economía y Sociedad*, (39), pp. 65-86. http://www.economiaysociedad.umich.mx/ojs3/index.php/ecosoc/article/view/13/9

Martínez, A. & Carrillo, J. (2019). Evolución de la política industrial en regiones emergentes: el caso de la industria automotriz en Guanajuato, México. *Estudios sociales. Revista de alimentación contemporánea y desarrollo regional*, *29*(54), 4-30. https://doi.org/10.24836/es.v29i54.757

Marx, C. (1973). Trabajo asalariado y capital. In *Marx y Engels. Obras escogidas* T. I, pp. 61-92. Moscú: Progreso.

Neffa, J. & De la Garza, E. (coords.). (2020). *Trabajo y crisis de los modelos productivos en América Latina. Argentina, Brasil, México, Venezuela, Colombia, Chile y Uruguay*. Buenos Aires: CLACSO.

Redacción. (2017). Las 500 empresas más importantes de México. *Revista Expansión*. https://expansion.mx/las-500-2017

Rivas, L. & B. Flores. (2007). La gestión del conocimiento en la industria automovilística. *Estudios Gerenciales*, *23*(102), pp. 83-100. https://www.redalyc.org/pdf/212/21210203.pdf

Rueda, I. (1994). *Tras las huellas de la privatización: el caso de Altos Hornos de México*. México: Siglo XXI.

Rumiantsev, A. (1963). La estructura de la clase obrera de los países capitalistas. Materiales de intercambio de opiniones organizado por la *Revista Internacional Problemas de la paz y del socialismo 1960-1961*. Praga: Paz y socialismo.

Sandoval, S. G. (2017). Procesos de innovación en la Planta Ford de Hermosillo: centros de responsabilidad regional y gestión del conocimiento (1986-2016). In S. Sandoval y A. Covarrubias. *Rumbo al auto del futuro*. México: El Colegio de Sonora.

Schumpeter, J. (1978). *Teoría del desenvolvimiento económico*. México: FCE.

Toledo, D. & Zapata, F. (1999). *Acero y Estado. Una historia de la industria siderúrgica integrada en México*. México: UAM.

[1] The incorporation of new technologies into the productive process is explained by the expectation of a greater surplus. In capitalism, this turns out to be a necessary condition for increasing –or, failing that, maintaining– expected profit levels.

[2] Science fiction author. Perhaps his best known novel is *Do Androids Dream of Electric Sheep*, first published in 1968.

[3] In Foreign Direct Investment in Latin America, published by ECLAC in 2018, it is recorded that automakers (such as Mercedes Benz, Audi, BMW, Volvo, Nissan, Honda, Hyundai and Toyota) announced that commercial models with autonomous driving would be manufactured before 2020. By 2021, BMW will manufacture a driverless vehicle.

[4] Trade is understood as the knowledge that allows a worker to understand and constantly overcome the difficulties that arise in the execution of productive tasks, not only in the tools and materials, but also in working conditions.