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"The Importance of Human Capital for Economic Growth within the Context of Rapid Technological Change in Ciudad Juárez, México"

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Dedicatoria

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Abstract

This dissertation examines the role of human skills and abilities in the process of creating wealth under conditions of rapid technological change using Ciudad Juárez, México as the unit of analysis. The theoretical apparatus progresses from general theories of growth—exogenous (Solow) and endogenous (Lucas, Romer)—to substantive approaches centered on human capital (Schultz, Becker), technological change (Nelson, Arrow, Freeman), and regional development (Vázquez-Barquero). Schumpeter's concept of *creative destruction* complements these perspectives by explaining how innovation and entrepreneurial dynamics reshape production structures and generate new sources of growth. Using data from INEGI's *Censos Económicos* for 2003, 2008, 2013, and 2018, the study applies Camagni's (1984) sectoral typology to analyze the relationship between productivity and employment growth across fifteen economic sectors. Productivity is measured as Gross Value Added from the Census (GVAC) per hour worked. Results reveal a gradual transformation from a labor-dependent economy to one increasingly defined by efficiency and innovation. Manufacturing (33), the city's dominant sector, consistently lies near the isoquant in Camagni's diagrams, establishing the average reference for productivity and hors worked. In contrast, knowledge-intensive activities—Information (51), Professional, Scientific, and Technical Services (54), and Administrative and Support Services (56)—led the post-crisis recovery, exemplifying the Schumpeterian mechanism of innovation-driven restructuring. The findings confirm that as technology advances, the economic value of human capital rises, and regional growth increasingly depends on the alignment between workforce skills and innovation processes.

Resumen

Esta tesis examina el papel de las habilidades y capacidades humanas en el proceso de creación de riqueza bajo condiciones de cambio tecnológico acelerado, utilizando a Ciudad Juárez, México, como unidad de análisis. El marco teórico es un recorrido desde las teorías generales del crecimiento —exógenas (Solow) y endógenas (Lucas, Romer)— hacia las teorías sustantivas centrados en el capital humano (Schultz, Becker), el cambio tecnológico (Nelson, Arrow, Freeman) y el desarrollo regional (Vázquez-Barquero). El concepto schumpeteriano de destrucción creativa complementa estas perspectivas al explicar cómo la innovación y la dinámica empresarial reconfiguran las estructuras productivas y generan nuevas fuentes de crecimiento. A partir de los Censos Económicos del INEGI correspondientes a 2003, 2008, 2013 y 2018, el estudio aplica la tipología sectorial de Camagni (1984) para analizar la relación entre el crecimiento de la productividad y el empleo en quince sectores económicos. La productividad se mide como el Valor Agregado Censal Bruto (VACB) por hora trabajada. Los resultados revelan una transformación gradual de una economía dependiente del trabajo hacia otra cada vez más definida por la eficiencia y la innovación. El sector manufacturero (33), actividad dominante en la ciudad, se ubica de manera constante cerca de la isoquanta en los diagramas de Camagni, estableciendo la referencia promedio de productividad y horas trabajadas. En contraste, las actividades intensivas en conocimiento —Información (51), Servicios Profesionales, Científicos y Técnicos (54) y Servicios Administrativos y de Apoyo (56)— encabezaron la recuperación poscrisis, ejemplificando el mecanismo schumpeteriano de reestructuración impulsada por la innovación. Los hallazgos confirman que, conforme avanza la tecnología, el valor económico del capital humano aumenta y el crecimiento regional depende cada vez más de la alineación entre las habilidades laborales y los procesos de innovación.

1. Introductory Chapter: How Individual's Abilities are So Important to Foster Development

México, the country where I have lived my whole life, characterizes itself by remarkable contrasts. Differences in the landscapes are evident for anyone traveling across the national territory due to the natural diversity, but the variations go beyond the realm of nature if one observes deeply. While urban population centers in the northern and central parts, industrialized, are home to some of the richest families and individuals in Latin America and, rural localities present underdevelopment characteristics comparable with the poorest countries in the world.

The people's way of life differs notoriously depending on the latitude of the country one visits. Such divergence is not only shown in the habits and traditions of the inhabitants, but also in their capacity to meet their needs, individually and as communities. In some parts of the country the citizens have access to certain services and goods that in others are unreachable. The disparities one can see between regions are also observable within each of the regions when comparing the zones by their degree of urbanization.

If the observer can juxtapose the scenery of México to that of a developed country like the United States, disparities amplify, and imbalances of other nature become apparent. Differences in people's physiognomy due to greater diversity, as well as notable improvements in infrastructure are visible to everyone positioning to compare the two contexts. In such a situation, curiosity easily leads to questions about the roots of those differences.

I had the opportunity to witness all those contrasts as an infant. Living near the Mexican northern boundaries, I had the chance to see parts of the life beyond those limits. Also, due to family ties I had the opportunity to visit the central and southern part of México. Probably because of my context, son of a Professor of Economics and an employee of a government office that served holders of communal land for agriculture, several aspects of those trips called to my attention in the way those issues can influence the thinking of an elementary school child.

As I grew up, the opinions of adults around me, along with the information obtained from the media and at school, as well as my own experiences, sculpted my criteria on that kind of topic, and raised a serious interest in the issue. Particularly, I remember the impression I got from the despair state of the infrastructure within my own country the first time I traveled to the shores of Oaxaca on a road trip by myself, all the way from the city of Chihuahua, more than 2,000 kilometers north. At that time, México was amid the greatest economic turmoil in the modern times. With all the economic indicators plumbing, public conversation was overwhelmingly dominated by the matter. Our currency, for instance, had lost half of its value by the time I returned home two weeks later.

Having done all that during my last year of high school, it had a heavy influence on my decision to study economics to obtain a better understanding of such phenomena and— as a youth dream— contribute to the solution. Listening to all the media and people around me talking about the state of the economy, the problems faced by families and the actions of the government in solving them, I could do nothing but ask how all those economic variables influence the lives of people. I recall having asked myself and in conversation with others if the environment (*i.e.* the state of the economy and the degree of development of a community) determines the standard of life of a person or is the person that, through his actions, can change the conditions around and generate development—an ongoing debate on the modern digital battlefield of social media.

By the time I started studying for my bachelor's degree, I already had a slight knowledge of economics due to my family background, but I was not aware of the complexity of a science in which human behavior is so involved. Even though the program I took, as the immense majority of those I know, centered on neoclassical paradigms, I learned about the weight of people's choices, or even expectations in the explanatory power of economic models. Having understood that the matter I had chosen to specialize in is a social science, I took conscience of its limitations, but also of its power in explaining some of the phenomena that raised my interest since I was a child.

Since then, I have spent most of my professional life working for organizations dedicated to fostering economic development, in my hometown of Juárez, Chihuahua and surrounding region. After obtaining my degree, my interest in the topic did nothing but deepen. Like most young professionals, I started to search for spaces where I could employ

my academic luggage in an area of my own interest. Even though, in the beginning circumstances took me along a distant path, my desire to find answers to economic problems eventually took me to the places where I have worked for more than 15 years now.

Professional practice has taught me that, theoretically and conceptually, the ways to economic development are straightforward in the sense that ideas are logically explained with ease. However, reality rarely fits in with conceptual frameworks of the theory because human behavior, individually and in groups, seldom compiles with assumptions in neoclassical models. Gradually, it became clear to me that statistics and mathematics alone are insufficient to answer the questions of how individuals and collectives make their way to better lives. After having studied the master's in science of economics in a program with strong empirical orientation, while working in the same field, I started feeling frustrated about not being able to establish the connection between economic theory and real-life problems. Eventually, I reflected on the need to acquire abilities to approach the problems in a more analytical way, both to understand them myself, and explain them to my everyday audience (*i.e.,* businesspersons, politicians, and other stakeholders in the region as well as students). In that way, reading authors from fields related to social behavior became a necessity to improve my communicational abilities. Once I assimilated the importance of understanding, at least slightly, other disciplines in the realm of social sciences to approach my phenomenon of interest (*i.e.*, economic development), the selection of a PhD program in the area became obvious.

One of the main ballasts for the improvement of life standards in the city where I live and work is the inability of the growth model to meet expectations created when it was established more than half a century ago. For more than 60 years, the economic activity of the city has leaned on the manufacture and assembly of goods for export. These operations, initially promoted as a source of jobs, and generator of commerce and innovation for the country, have only partially accomplished the first promise, but have fallen far short of the others. Most of the jobs in the mentioned industry have traditionally paid low wages, while the technology transfer and opportunity for local companies to insert in the value chain simply have not materialized.

Every debate on how to create a prosperous environment in this region includes adjusting the current model living up to expectations. I personally agree with the idea that it

is necessary to change the type of industrial processes coming to the area, procuring to attract high value-added activities. That, along with policies fostering efficient salaries and the creation of a local suppliers' base are minimum requirements to lift the life standards in a region.

It is my belief, which this thesis tries to prove that knowledge acquisition has given us greater power to influence historical shifts in all aspects of our lives and has gained importance throughout history as a factor for humanity to shape the environment. Regarding the ways we produce satisfiers for our needs, the pace of the changes is increasing exponentially. Nowadays the use of more advanced technologies in goods, but overall, in the process of producing them determines the economic value they bring to our lives. Higher value-added activities relate to intensive use of technology, making knowledge a critical input for the processes.

My place of residence and its problems were not the only drivers for my selection of an area of specialization and the topic for the research; historical context was also a determinant factor. We live in a permanently changing world; historically, human's quest for fulfilling our material and non-material needs, has conducted said transformation. In today's world, human abilities are more important in production processes than ever before. That is why, to achieve the doctoral degree in Social Sciences, and in contribution to the development of the place I have formed as a professional, I decided to study The Importance of Human Capital for Economic Growth Within the Context of Rapid Technological Change in Ciudad Juárez, México.

Antecedents

Nowadays, it is known that economic development is a multifactor phenomenon. From the very first effort to understand what makes a nation prosperous, the approaches to the matter have incorporated elements revealing its complexity. In the western world, the earliest attempts to find efficient ways to create wealth are attributed to the philosophers of the fifth and fourth century B.C. in Greece. Since then, human societies have changed radically in every aspect. Over the years, humans have incorporated new ways to combine resources at reach to transform them into goods to meet needs. Sometimes, those changes have been so deep that not only have impacted production, but the political and social

structures. When that happens, innovative approaches are required to study what is called the economic problem.

Like many of the intellectual pursuits in western world, the search for efficient ways to manage productive resources dates to ancient Greece. Murray Rothbard, (1995) explains how philosophers of that time, known as the classical period of philosophy, held debates on the better ways to assign the resources to produce and how to distribute the outcomes. Schumpeter (1971), one of the most influential economists of the twentieth century, assures that, even though there are blank spaces in history of economic analysis, advancements on the matter of the eighteenth and nineteenth centuries would be impossible without the writings of Plato and Aristotele. Economic historians also explain how, after these thinkers, during the time of the Roman Empire, and the Middle Ages afterwards, philosophical and intellectual discussions aligned material prosperity to religiously conceived ethical and moral behavior of individuals.

Gradual advancements in production technologies led to the decline of Europe's prevailing feudal order, resulting not only in political changes, but also changing the ways of studying the economic problem. When progress in the modes of production yielded production surpluses, a stratum capable of challenging feudal lords emerged, altering the existing political order (Varoufakis, 2024). Approaches to the issue of economic well-being then turned sights to commercial balance as the primary factor. According to the thinkers of the epoch, the wealth of a nation depended on the difference between the goods it sold and those it bought Mercantilism, as this school of thought is known, dominated the discussion for three centuries (Barber, 2009). Technological advancements were decisive in dismantling feudal structures and paving the way for the rise of what today is recognized as early capitalism.

As the production techniques moved forward, analysis of nation's economies also advanced to more methodical approaches. In the first half of the eighteenth century, the Physiocrats introduced the logic of natural sciences to the study of economics. An example of that is the use of taxonomy to classify the participants in the production process into classes, according to the role played in the process. That analytical stream was born in France, a country with an economy based on agriculture at that time. As such, it placed that activity as the only source of wealth (Rothbard, 1995). Even though they conceded importance to the

tools used in the process (*i.e.,* capital goods), land was the most important productive resource in their analysis. Work, considered homogeneous, was not that relevant.

North of the English Channel, other explanations for the creation and accumulation of wealth developed in parallel. Adam Smith, a Scottish philosopher, gave birth to what we now know as the classical period of economics, considered by many as the cradle of modern science of economics (Schumpeter, 1971; Barber, 2009; Rothbard, 1995). Anglo-Saxons emphasized the capacity of a nation to organize its productive resources. Classical economists employed the concept of social classes introduced by Physiocrats but, being situated within a more industrialized context, they focused on machinery and labor (Barber, 2009; Rothbard, 1995). Given the type of processes emerging in this latitude, they were the first to observe workers' specialization. Machinery, for the first time employed in mass production, was the central element in production for these thinkers.

As industrialization advanced, economists centered the study of development on the amount of capital *(i.e.,* equipment, tools, and machinery) an economy could accumulate. In the mid-nineteenth century, the German economist, Karl Marx developed another school of thought around his critiques of the prominence of capital to the detriment of workers' lives in the production process. Marginalists, for their part, deepened the introduction of the scientific method rooted in the natural sciences to explain production. Based on the same classification of the participants involved in the process used since the Physiocrats, they presented the manufacturing process as a mathematical function of the quantity of inputs employed (Schumpeter, 1971). Since then, the use of classes according to the role in the productive process has remained constant in the study of economics.

For decades, economists saw the accumulation of productive inputs as the pathway for economic development without distinguishing it clearly from the mere growth. By the middle of the twentieth century, after the Second World War, development became a branch of economic science by itself. At that point, economists started measuring development through a nation's production levels and the consumption capacity of its inhabitants. Nevertheless, the way to improve such indicators remained focused on the accumulation of productive inputs, especially capital (Vázquez, 2007). Thus, while economic thinking evolved to measure development more comprehensively, it continued to rely heavily on input accumulation as the primary means to achieve it.

During the second half of the last century, students of the topic implemented technology as an exogenous component of the production function. For the analysts of development, the characteristics of input employed, and the way they are organized within the process, became an explanatory component of the amounts of goods that an economy can produce (Aghion & Howitt, 2009). At that time, the features of machinery—and not the mere quantity—gained explanatory power and, in turn, the abilities of workers to use and develop more complex technologies started to attract the attention of the thinkers trying to explain the expansion of production capacities.

Having a labor force with the skills to manage the latest technology is not enough these days to pursue economic progress. Societies in general must develop the ability to generate and absorb new knowledge. Since the last few decades of the 1900's the abilities of workers, tagged then as human capital, have taken relevance in the studies of growth and development. The learning capacities of an economy's worker became a matter of study, and a theory of Human Capital emerged. Nowadays, the ability of an economy to generate, absorb, and manage technological change is one of the greatest concerns of economists inquiring about economic expansion and progress.

Problem Statement

The sudden disruption of innovative technologies into the production processes represents changes in every aspect of human life. As new technologies threat part of the population, they are opportunities for others. On the one hand, managing large amounts of information, generating and storing more energy, or improving communications systems promise us to enhance our life standards (Rifkin, 2011). On the other hand, the ease with which human labor can be replaced by automation, or the possibility for a few to gather vast amounts of information exemplify potential calamities such as unemployment and exacerbated inequality (World Bank, 2019). Technology advancements have come not only to change ways to organize production, but also the ways people live their lives.

Despite the constant propensity to change demonstrated by humankind since the first cognitive revolution tens of thousands years ago (Harari, 2014), and despite technological advancements have spurred changes in society across history (Coleman, 1956), the nature of technological changes we are now being part of, differs from those from the past in its velocity, depth and omnipresence (Schwab, 2016). New human abilities like extended and

immediate connectivity, the increasing power of gathering and processing data, and the rising capability to storage and distribute energy creates a scenario for massive changes in all aspects of human life (Rifkin, 2011).

Experts around the World foresee major changes as result of the implementation of technological advancements to several aspects of human life and admit having uncertainties about the outcomes of the entire process. Thomas Siebel states that "We are at the midst of a massive disruption and constant change. The scope of digital transformation and its implications are still above it, and its impacts are still to be understood" (2019, p. 18). The idea of this work is to analyze the changes in the approach to the problem of economic growth resulting from the massive introduction of modern technologies into the production processes, specifically those related to the role of work and the workers in the economy.

Multilateral agencies dedicated to promoting the improvement of human life in facets that include work and other types of social interaction have expressed at least any worry about the pace of technological changes. The World Economic Forum explains that the so-called *Fourth Industrial Revolution* represents entirely new ways in which technology becomes embedded within societies and even our human bodies (Philbeck & Davis, 2018). The Organisation for Economic Cooperation and Development (OECD, 2017) recognizes technological progress as one of three main drivers of the major change in values and preferences that humanity will experience in the years to come. The International Labour Organization refers to technological changes as an inevitable dynamic process that creates new jobs but has the potential to destroy or transform those currently existing by affecting the way production is organized (ILO, 2015).

Multilateral financial entities have also expressed worries about the lack of preparation of labor force across the world to embrace this economic and institutional conversion. Jim Yong Kim, former President of The World Bank Group, expresses his preoccupation about the effects that the incorporation of recent technological developments to the various aspects of human life. Mr. Yong refers to the effect on the way people work. He addresses the need for new skills needed by the workers nowadays, which he refers to as human capital (World Bank, 2019).

The discussion of these transformations plays a crucial role in shaping government policies and social action in areas such as education, healthcare, and workforce development.

According to the institution cited above, one reason governments do not invest in human capital is the lack of political incentives. Few data are publicly available on whether health and education systems are generating human capital across world's economies. "This gap hinders the design of effective solutions, the pursuit of improvement, and the ability of citizens to hold their governments accountable" (World Bank, 2019, p. 10). This research intends to contribute to the discussion by an anlytical approach to the problem, backed by the existig empyrical evidence to develop actionable insights that can inform policy decisions on the matter.

Research Strategy

This research aims at measuring the relative importance that skills and knowledge of local labor force have in the process of wealth creation in Juárez, Chihuahua within the current context of rapid technological change. The spatial context of the research is a municipality on the Mexican northern border that is the center of one of the largest manufacturing hubs in North America. As such, the place hosts the most advanced production technology in the world. This work intends to demonstrate how human capital gains in relevance as a productive factor when technology advances. Describing the role of human abilities in processes of transforming matters in this region might yield to achieve a generalization of the relationship between technological change and economic growth in different economic contexts within the same technological framework.

General Objective

This study seeks to analyze and quantify the evolving role of human skills as a determinant of economic growth within rapidly technologizing economies, with a focus on regional development contexts. To achieve such goal, this research relies on the theories of human capital that posits the economic returns yielded from investment in improving capacities of people (Becker, 1993; Schultz, 1961) with those emphasized knowledge spillovers and innovation as drivers of progress (Arrow, 1962; Romer, 1986; Lucas, 1988). By bridging these paradigms, the research asserts that skills and other attributes of human capital -beyond their individual returns—generate collective productivity gains through mechanisms like learning-by-doing (Arrow, 1962), and technological diffusion (Romer, 1990). Such synergies, as noted by the World Bank (2019) , are critical for regions navigating automation

and digitization. This theoretical synthesis positions human capital not merely as an input but as a catalyst for systemic adaptation to technological disruption.

The information discussed here aims to inform policies and investment decisions that prioritize human capital formation as a cornerstone of equitable growth. Drawing on cross-regional data from North America, the analysis identifies scalable thresholds of skill intensity required to leverage emerging technologies without exacerbating inequality. By aligning findings with the ILO's (2015) call for "future-proof" labor markets, the framework offers replicable template for policy makers in regions facing similar techno-economic transitions. The goal is to transform theoretical insights into actionable strategies, ensuring adaptability across diverse institutional and geographic settings.

Specific Objectives

Characterizing the velocity and scope of technological change is pivotal to contextualizing its economic impacts. Peemans' (1992) framework—defining revolutions as periods of abrupt transformative driven by new technologies—anchors the analysis, which contrasts current trends with historical precedents like the so-called Third Industrial Revolution (Schwab, 2016). Metrics such as automation adoption rates (OECD, 2017), capital investment in digital infrastructure (World Bank, 2019), and sectoral employment volatility (ILO, 2015) operationalize this assessment. This delineation clarifies whether contemporary shifts represent evolutionary adaptation or radical rupture, grounding abstract debates in measurable phenomena.

Building on this foundation, the study intends to quantify human capital's evolving contribution to economic growth by examining how productivity gains interact with employment dynamics across sectors. Rather than isolating productivity purely through factor decomposition, the analysis employs Camagni's (1984) quadrant framework, which relates growth in productivity to change in labor input. This approach makes it visible whether sectors are achieving skill-driven productivity gains with employment expansion, or whether technological change instead substitutes labor, creating contexts of reconversions and restructuring. In this sense, the model operationalizes Arrow's (1962) learning-by-doing concept but grounds it in sectoral shifts where skills may either amplify cushioning the disruptive impact of automation.

To translate these insights into actionable strategies, the final objective aligns empirical results with institutional priorities for equitable growth. The ILO's (2015) "future-proof" labor market agenda and the OECD's (2017) lifelong learning guidelines provide frameworks to convert skill-intensity thresholds into targeted investments. Regional case studies, such as the Paso del Norte manufacturing corridor, exemplify how education reforms and industrial policies can synchronize with technological adoption. This synthesis equips policymakers with replicable tools to navigate techno-economic transitions while curtailing disparities highlighted by the World Bank (2019).

Research Question

The accelerating integration of advanced technologies into production processes raises critical questions about the evolving role of human capital in economic growth. While Schultz (1961) , Becker (1993), and Arrow (1962) establishes foundational links between skills, health, and productivity, endogenous growth theorists like Romer (1986) and Lucas (1988) further emphasize knowledge spillovers as drivers of long-term development. However, the extent to which technological advancements amplify the relative importance of human capital attributes—compared to traditional inputs like capital, land or even homogenous labor—remains understudied. Existing frameworks often assume static relationship between human capital and growth, neglecting how automation, digitization, and artificial intelligence recalibrate production functions. This gap motivates the central inquiry of this research: As productive technologies advance, do attributes of labor force—education, experiential learning, and health— as well as institutional development gain prominence as determinants of economic growth and at what rate?

To answer this, the study analyzes Juárez's adaptation to new production paradigms though the lens of labor-intensity shifts. By locating key industries—such as manufacturing and professional, technical, and scientific services—with Camagni's quadrants, the research tests whether technological upgrading reduces reliance on raw labor while elevating demand for specialized expertise. The results aim not only to identify the direction of technological adaptation, which is widely acknowledged, but also to assess its intensity by comparing sectoral trajectories against the average growth threshold. In doing so, the analysis provides policymakers with empirical benchmarks for designing workforce development strategies that address both the opportunities and inequalities of an economy in rapid technologization.

Hypothesis

The irruption of recent technologies in the productive sector—and, by extension, in the labor markets, represents a change in the paradigm employed to explain production, and therefore, economic development. Traditional production functions, which prioritize physical capital and land, increasingly fail to account for the disproportionate role of human capital in technologizing economies. As automation, artificial intelligence, and digitization advance (Schwab, 2016; Rifkin, 2011), education, experiential learning and health, as components of human capital, have become more important as explanatory variables of the modern growth models. This shift manifests in regions like México's northern border, where manufacturing sectors have transitioned from labor-intensive to skill-driven activities, demanding technical expertise over raw labor inputs. In this reconfigured paradigm, human capital's coefficient in the production functions eclipses that of traditional factors, reflecting its critical role in sustaining competitive advantage amid technological disruption.

In Juárez's context, this hypothesis posits that the region's integration into global value chains, due to the cross-border manufacturing, accelerates demand for advanced skills. Schultz (1961) and Becker (1962) argue that human capital investments yield compounding returns, while Lucas (1988) and Romer (1986) emphasize that knowledge spillovers are growth accelerants. Juárez's evolving industrial landscape, marked by automation adoption and digital infrastructure investments (World Bank, 2019), provides an empirical test of these assertions. If validated, the findings will demonstrate that skill thresholds, especially in technology-intensive sectors—like advanced manufacturing and professional services—correlate with productivity gains. Outpacing contributions from physical capital land.

Conclusion

This introductory part raises a case where current historic developments affect the process of generating goods and services (*i.e.,* wealth) and therefore they impact society as such. This evolutive process also impacts on the forms of studying economic phenomena and concludes that technological determinism forces the look for new ways to approach the overly complex current scenario of rapid technological change. The following parts delve into rhetoric and discussion about technological change, to then continue to apply these concepts into the region of Ciudad Juárez, the geographical unit of study. While limited due to the lack of data at a municipal level, the research conducts a statistical analysis and remarks on the necessity

of tracking statistics to implement econometrical tools that help proper measures of the phenomenon.

2. Historical Premises of the Growth Paradigms: Technological Change and Labor in the Study of Wealth Creation

A critical step towards understanding the role of labor in growth paradigms lies in tracing how economists have historically conceptualized work, technology, and wealth creation. From the pre-paradigmatic reflections of ancient Greek philosophers and Mercantilists to the systematized set of ideas of Physiocracy, and Classical Economics, the following analysis deals with how technological innovations disrupt production processes, redefine labor's role, and catalyze new economic frameworks. By exploring these historical transitions, this chapter contextualizes the central thesis of this research that human abilities gain prominence as a determinant of growth in technologizing economies, within a lineage of ideas dealing with the interplay of work, technology, and production.

Understanding this evolution is critical to the research's objectives in many dimensions. First, it uncovers that economic paradigms have always emerged in response to technological upheavals, from the feudal system to industrial capitalism. Second, it highlights how labor conceptualization shifted from a "degradant activity" in ancient Greece (Pereira, 2008) to a quantifiable input in classical economics (Smith, 2007), foreshadowing modern debates about skill-driven growth. Finally, the chapter underscores that technological progress does not merely alter production methods but redefines power dynamics, social hierarchies, and policy priorities—a pattern mirrored in ongoing digital transformation.

The chapter's exploration of economic thought from antiquity to the classical period reveals that technological disruption has permanently driven paradigmatic shifts in societies' conceptualization wealth and the role of labor in its creation and distribution. Advances from the domestication of plants and animals to navigation, and mechanized manufacturing not only did transform production methods, but also redefined social hierarchies and policy frameworks, as seen in the transition from feudalism to capitalism and the conceptual clashes between Mercantilists and Physiocrats (Rothbard, 1995; Harari, 2014; Varoufakis, 2024).

Central to these shifts is the evolving role of labor, a once dismissed activity that eventually emerged as economic input vital to the musing of economic activity. This historical narrative unveils disputes over the relative importance of differentiated labor versus land as productive factors prefigure contemporary tensions surrounding automation, skill thresholds, and equitable growth. By contextualizing modern human capital theories within this lineage, the chapter affirms that technological progress inherently recalibrates the value ascribed to labor, positioning skills, education, health, and experiential learning as both a driver and a consequence of economic transformation.

The Pre-paradigmatic Stage of Economic Thought

The study of how to manage available resources to meet needs has been a fundamental concern of humanity since ancient times. Barber (2009) recognizes Adam Smith as the father of modern economics, while Rothbard (1995) reserves such distinction for Richard Cantillon, a French thinker from the epoch of physiocracy. Nonetheless, both acknowledge the existence of economic thinking prior to the appearance of those two. The former does not go so far in history as he limits to Mercantilists and the Physiocrats in the fifteenth to eighteenth centuries. The latter goes all the way back to the ancient Greece to spot the first economist philosophers. Lapidus (1997) support the idea of Greeks as pioneers in attempting to explain natural or social phenomena, using taxonomies and establishing relationships among events they observed to understand what they called “the natural law”. The forms employed by humans to satisfy necessities did not escape from their inquiries.

Ancient Greeks had their own concept of work within their economic thinking. They characterized work as a degradant activity, reserved for the lower layer of population (Pereira, 2008). Following the philosophical advancements of the classical period in Greece, the more influential legacy for the western culture comes from the Roman Empire and Christian clergy (Lapidus, 1997). Rothbard (1995) reviews the contributions of the Romans to economic thought, as well as those of the scholastics during the Middle Ages after the fall of the Empire. According to the author, a system of religious beliefs guided the thoughts of both the Romans and the scholastic thinkers. For them, the role of every individual in society, and by extension, social interactions, were predefined by divine power, (Pereira, 2008). Thinkers of these societies often explain economic prosperity as a function of compliance with religious standards.

The development of the first systematized way of thinking about economic problems was a matter of a couple of centuries. The first ever structured study of production and distribution originated during the transition from the feudal system into early capitalism, a process that lasted more than two hundred years according to authors such as Marx and Engels (1994), Rothbard (1995) and Varoufakis (2024). In one way or another, these authors attribute transition to advancements in production technologies that yielded to the existence of surpluses of commercial scales, and the emergence of new elites. New ways of conducting business resulted in new social dynamics in which merchants and the owners of means of production acquired the power to challenge feudal lords. As the new social and political order emerged, the ways of studying economic behavior shifted as well, giving birth to the idea that prosperity of a nation has its origin in commerce. That stream of thought received the name of mercantilism. Therefore, advances in technology foster development, and that is also related to political and social changes.

The concept of Work in the History of Economic Thought

Work has been a central concept to economics since its very beginning as a science, allegedly traced to 1776 when Adam Smith published *An Inquiry into the Nature and Causes of the Wealth of Nations* (Smith, 2007). This philosopher dedicates the first of two volumes to the productive power of *labour*[1] and its specialization. In his previous *oeuvre*, *The Theory of Moral Sentiments,* the author appointed the human's habit of working as one of three pillars of what he called the natural order of society (Smith, 1979)

The concept of work—or labor, as it is also commonly employed in literature, is defined as the time and effort that people devote to transform matter within an organization dedicated to the production of goods and/or services for consumption or commercialization. According to current paradigms of economic analysis, the units of work are differentiable among them based on the specific activity they are used on or by the education, training, and working experience of each worker.

[1] According to the online version of the Cambridge Dictionary, labour is the world employed in the United Kingdom to define the work that implies physical work, the most common at the time when the book was written (https://dictionary.cambridge.org/es/diccionario/ingles/labour). From this spot on, the word labor is also employed to refer to that concept, at it is the use in the United States.

Mercantilism is not typically described as a school of economic thought because, despite systematizing beliefs grounded on the same fundamentals, it was developed separately by thinkers spread over several countries during a span of three centuries. Its early origins can be traced back to the fall of Roman Empire in the fifth century, which gave rise to the socio-economic system known as feudalism. During this period, most people—referred as servants—lived and worked on land owned by a lords who received large proportions of the produces (Rothbard, 1995; Barber, 2009; Varoufakis, 2024). Most of the production was for self-consumption, but servants were forced to give up every surplus of production to the lord. Servants worked on agriculture as craftsmen, but none of the goods they produced were for exchange (Nell, 1967). The structure of limited exchange and centralized control of the described period, laid the groundwork for the economic ideas that would later emerge under mercantilism, shaped by evolving notions of production, trade, and sovereignty.

Under such conditions, the concept of investment was absent, as lords typically channeled surpluses for private use rather than land improvement. Nonetheless, technological advancements in agriculture were slowly developed. By the eleventh century, accumulation of small technological developments yielded to permanent production of surplus (Lambert, 2020). Consequently, lords augmented their demand for luxury goods, often brought from distant latitudes. The high demand for imported goods empowered a group of people dedicated to commerce, leading them to constitute a class in the production process.

Back then, increasing productivity—driven by gradual technological advancements—fostered the growth of commerce, allowing merchants to retain increasingly larger portions of the surplus generated through expanded trade. As demand for tradeable goods surged, merchants saw themselves in need of larger labor, forcing them to hire complete families of farm workers for manufacturing processes (Varoufakis, 2024). With the proliferation of increasingly larger factories, guilds' regulations disappeared, leading to one of its major changes in labor history. The production process got fragmented, and workers began to specialize in specific tasks. Production for self-consumption ceased to be the standard, and work transmuted from an end to a means (Pereira, 2008; Barber, 2009). The gradual erosion of artisanal autonomy and the restructuring of production reflected a broader transition in the meaning and organized labor.

As commerce expanded and merchant capital grew, this emergent class gained influence and the power to challenge the traditional power of nobility. Coleman (1980) notes how growing wealth of merchants allowed them to gain increasing leverage over political authorities, particularly in the contexts where rulers depended on commercial taxes or loans to finance the pursuit of their interests. The pressure to secure and expand fiscal revenues led many feudal lords to seek alliances with neighboring domains or to absorb them, contributing to the consolidations of monarchies and the formation of early states (Heckscher, 1936). Monarchs, aiming to stabilize their rule and centralize authority, established royal courts composed of advisors versed in diverse fields, out of which commerce and finance were among the more important along with war. Merchants and financers, often admitted into their circles, became influential participants shaping policies (Pincus, 2012) . The entwining of political centralization with commercial ambition reshaped the mechanism, of governance and laid institutional groundwork for modern economic states.

In their quest for internal security, newly formed nations started to accumulate gold, silver, and other precious metals, which were already universally accepted as a method of payment for mercenary armies, merchants, among other providers. The quantity of metals in a state's coffers became then one of the main power parameters. That idea is now known as "Metalism", and it is one of the first currents of mercantilism (Rothbard, 1995).

The early modern state's pursuit of fiscal and geopolitical strength led to widespread belief that national wealth could be measured by the stock of precious metals held within its borders. As Hecksher (1936) explains, this conviction gave birth to mentalism (also referred to as bullionism), an early strand of mercantilism that regarded mentioned minerals—mainly gold and silver—not merely as mediums of exchange but as embodiments of wealth. Accepted by armies and merchants alike, became critical instruments of power and security. Lapidus (1997), on his end, shows how bullion accumulation was strongly connected to the emergence of absolutist state and their centralized fiscal apparatuses. Khon (2005) adds that these policies were not driven by abstract monetary reasoning, but by the practical need of rulers to fund standing armies and expansionism. The global race of European states for filling their treasures with metals, sustained by transoceanic colonial conquest, and extractive labor systems, especially in the Americas, sparked important advances in navigation. As markets expanded and more resources became available, merchants consolidated their means

of influence and pushed policies in their favor (*i.e.,* protectionism). I this evolving configuration, the accumulation of metallic wealth, political centralization, and imperial control over trade became mutually reinforcing elements of early economic power.

Increasing demand for manufactured goods across three centuries created a subsequent demand for labor for the manufacturing centers, absorbing artisans, peasants and their children into an expanding urban working class. The following century then witnessed a sustained transformation in production methods, described by Hoppit (1990) as an "industrial evolution" rather than a sudden rupture, given the incremental nature of technological change through the fifteenth to seventeenth centuries. Berg and Hudson (1992) support his notion of gradualism, although they recognize that England experienced a marked acceleration of industrial innovation during the last decades of the eighteenth century. In contrast, France remained anchored in agricultural predominance, where industry held a marginal role compared to land-based production (Rothbard, 1995). These diverging trajectories would soon find theoretical expression in the rise of competing paradigms: one rooted in the enduring centrality of land and agriculture, and the other in the disruptive force of machinery and factory labor.

Work in physiocracy

Whie England's industrialization reshaped its class structure around manufacturing, French society remained deeply rooted in agrarian hierarchies that defined its modes of production. Rothbard (1995) describes the physiocratic views as divided among three functional classes: landlords (including clerics, nobles, and the monarchy), the bourgeois (a minority of merchants and crafts persons), and the farmers, who cultivated the land they did not own , and for which they had to pay rent, tithes and taxes. In this context, the physiocrats argued that only agricultural work generated surplus, from which all other classes subsisted. This views, says Franklin (1962), emerged from a highly fragmentated society out of which, agrarian capitalists—large-scaled farmers at that time—sought economic liberalization in a system still dominated by feudal privileges. Heckscher (1936) reinforces this regarding by framing physiocracy as countermovement to distortions of mercantilism-oriented policies, favoring land-based wealth creation and economic simplification through policies such as the single land tax. Within this intellectual and institutional terrain, physiocracy positioned labor in agriculture as the productive engine of national prosperity,

Amid the agrarian foundations of French society, Physiocrats pioneered in applying natural science-type of scientific reasoning to economic phenomena, trying to uncover the laws governing wealth creation process. The physician François Quesnay, leading person of the stream, published *Tableau Éonomique,* a schematic depiction of how wealth circulates among social classes through production, consumption, and exchange. Rothbard (1995) recognized that as the first systematic use of natural-science-type of method to explain the functioning of economy. Heckscher (1936) position the *Tableau* as the analytical core of Physiocracy and a direct reaction to the commercialism of mercantilism, replacing trade-based models with a return to land as the sole productive factor. Labor held a paradoxical place in this scheme: although central to agriculture production, laborers themselves were subsumed into broader organicist view in which the social order functioned like a living body, with each class playing a fixed role. Scachter (1991), emphasizes this mechanistic metaphor, observing that Quesney simplified the economic analysis into a closed circuit of income and expenditure. Yet, while the Tableau elegantly mapped economic flows, it left little room for labor as transformative force, viewing workers less as agents of innovation than as conduits of preordained natural order.

Ann Robert Jaques Turgot is one of the most remarkable disciples of Quesnay and among the few physiocrats who gained direct influence over monarchy. Heckers (1936) attributes Turgot the abolition of craftsmen guilds and use that as an example of physiocrats' commitment to dismantling corporate restrictions and promotion of "natural" economic order grounded in agriculture surplus. Scachter (1991) notes that Turgot's policies extended logic of the *Tableau Économique* into realm of governance, replacing traditional hierarchies with mechanisms of liberation. Coleman (1980) situates these reforms within the broader Enlightment project, arguing that Turgot saw the suppression of guilds not merely as an economic measure but as philosophical affirmation of individual liberty and rational progress. Through these reforms, physiocracy reached beyond abstraction and into the fabric of French institutions, albeit briefly and amid mounting political resistance.

While both mercantilists and physiocrats sought to define the foundations of national wealth, they diverged sharply in their treatment of work and its role in the productive process. Mercantilists, concerned primarily with the accumulation of precious metals by means of commercial surplus, favored monetary and fiscal controls over a structural analysis of

production. In contrast, physiocrats placed labor—specifically agricultural labor—at the center of economic value. The *Tableau Économique,* formalized the idea of interdependence among classes and inputs, and sought to describe the economy as an organic system governed by natural laws. Another major difference is that, while mercantilists approached economic problems in fragmented domains, physiocrats adopted a systemic view, linking production, consumption, and distribution in a unified framework. This difference in epistemological scope also revealed distinct political commitments: where mercantilism emphasized state control, physiocracy advanced the idea of natural order and individual contribution, with farmers elevated as the true creators of national prosperity.

The Paradigmatic Stage of Economic Thought

The theoretical tensions between mercantilists and physiocrats laid the intellectual groundwork for the emergence of economic analysis paradigms. While mercantilists emphasized trade surpluses and the accumulation of bullion, physiocrats placed agricultural production at the center of wealth creation. Despite their contrasting views, both traditions contributed foundational concepts about surplus, value, and production that informed the analytical turn described by Kuhn (1997) as paradigmatic.

By the last decades of the eighteenth century, as industrialization advanced, in England, the limitations of both doctrines, lack of systematization, became evident. A new generation of thinkers surged in this context, synthesizing elements of earlier thought while redirecting attention toward the growing role of manufacturing, capital accumulation, and division of labor. A series of technological inventions and structural transformation in productive processes created what we know today as the First Industrial Revolution (Coleman, 1956; Schwab, 2016). Such transformations gave rise to a new intellectual orientation. Classical economists reframed the taxonomy of productive inputs—land, capital, and labor—and redefined the role of manufacturing as a central engine of wealth creation. In doing so, they established a coherent framework for analyzing the interplay of factors within capitalist production.

Adam Smith, the First Classical Economist, and his Views on the Role of Work in The Economic Problem

The convergence of Enlightenment philosophy, scientific reasoning, and the initial stages of industrial transformation articulated the synthesis resultant of the debate between

mercantilists and physiocrats giving rise to classical economics. The moral philosopher Adam Smith stands at the intersection of these forces providing analytical rigor and social reflection to its study (Barber, 2009). In *The Theory of Moral Sentiments* (1759) , he introduces the idea that social order stems from natural instincts such as self-interest, sympathy, and the desire of freedom—alongside the habit of labor and the propensity to exchange (Smith, 1979). Such a philosophical foundation helped set the stage for a systematic exploration of economic behavior rooted in what Smith considered natural human conduct.

Smith's exchanges with figures of the physiocratic tradition, viewed through the lens of the Enlightenment and increasing influence of scientific reasoning shaped his vision of a system governed by natural laws. In 1763, when this thinker visited France, Britain was undergoing a cumulative restructuring of economic organization later known as the Industrial Revolution (Coleman, 1956). It was in this context that Smith composed *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776), the first systematic exposition of capitalism. The oeuvre combined empirical observation with philosophical insight to produce a paradigm where machinery and specialized labor, rather than land or metal, stood as central forces behind wealth creation and economic growth.

Adam Smith's concept of the division of labor, central in *The Wealth of Nations,* laid the groundwork for understanding modern economic productivity and specialization. Smith famously illustrated tits significance through the example of a pin factory, where 10 to 12 workers, each specializing in a specific task, could produce up to 48,000 pins per day—a volume 240 times greater than what a single generalist could achieve (Smith, 2007, p. 109). Even artisans of the epoque used the method to increase production (Coleman, 1956; 1980).

Smith identified increased dexterity through repetition, the elimination of time lost due to switching between tasks, and the innovation of tools by experienced workers as the source of productivity enhancements resultant from the division of work. He believed these efficiencies were far more applicable to manufacturing than to agriculture, where tasks were homogenous, hence less divisible. Thus, in contrast to physiocrats, Smith considered manufacturing to be the more productive sector due to its greater scope for labor division.

Following the physiocratic tradition, Smith viewed labor as the main source of a nation's wealth but distinguishes between two types: productive and unproductive. The former, he says, creates tangible goods whose value can be reinvested; the later encompassed

services that, though valuable, did not generate reproducible output. Merchants and capitalists fall into the first category as their activities result in tangible goods for exchange (Smith, 2007).

Smith's concern with labor extended beyond its role as an input. While he acknowledged that price in capitalist economies is set by the interaction of supply and demand, he emphasized that the value of a good is determined by the quantity of labor embodied as he argue that "What is bought with money or with goods is purchased by labour as much as what we acquire by the toil of our own body" (Smith, 2007, p. 30). With increased specialization and exchange, individuals came to depend more on others' labor to meet their needs.

The author of the Wealth of nations explained that, in early societies based on barter, labor was the common denominator for determining the value of goods, measured in time. In capitalist system, however, goods became too numerous and diverse to calculate value this way. Furthermore, as labor became more specialized, an hour of work in one activity could not be equated anymore to an hour in another. The introduction of capital as a factor complicated value estimation further, yet Smith maintained that labor remained the foundation of all value, as even money itself reflect effort (Smith, 2007).

Along with the workers, Smith's theory of value also bases on the contribution capitalists and landlords, each of them representing one factor of production—labor, capital, and land. In that sense, production need to generate enough revenue to pay wages, profit, and rent with the combination of them forming what he called the "natural price of the goods"—the cost of production- (Smith, 2007, p. 67) . Such formulation holds that wages—the price of labor—must at least cover the worker and his family's subsistence before paying for rent and the profits. These components had average values in each society, which Smith referred to as their natural levels. The natural price of a good thus reflected the cost of labor, capital, and land at these levels. The market, or "real" price, fluctuated around the natural price based on supply and demand, scarcity, and seasonality (Smith, 2007).

Despite recognizing the economic benefits of specialization, Smith also warned of its adverse social effects. Monotonous work could dull a worker's intellect and hinder their capacity to perform unfamiliar tasks. He acknowledged the power imbalance between workers and capitalists, noting that while the former sought higher wages, the latter aimed to

minimize labor costs. Capitalists' control of machinery and production inputs gave them leverage during disputes over distribution.

Smith viewed capitalism as a system that harnessed self-interest for collective benefit. The natural order of economic activity would guide individuals to roles where their labor produced the greatest value. He advocated for economic freedom and rejected protectionist measures championed by mercantilists. In his vision, labor would naturally gravitate toward its most productive use, ensuring maximum prosperity for the whole society (Smith, 2007).

Conclusion

Technological change has consistently reshaped societies and refined their approach to economic problems, specifically the study of growth, throughout history. Since the ancient Greece, the transition from the scholastic views to mercantilism, and later to physiocracy and classical economics, reveals a pattern in which each change in basic assumptions emerged in response to transformative innovations, whether in agriculture, navigation, or industrial mechanization. Central to these shifts was the evolving conceptualization of work, from a "degrading activity" in the times of Aristotle, to the productive force conceived by Adam Smith mirroring its growing empirical and theoretical importance in the process of wealth creation. As productive methods advanced, so too did the recognition of labor's differentiated value, foreshadowing modern debates about skill hierarchies and human capital's role in technologized economies.

The clash between mercantilist and physiocratic thought underscored a pivotal tension between the role of exchange and production in wealth creation. Yet both traditions acknowledged that technological progress recalibrated the relative importance of each class of productive factors (labor, land, and capital). The insights of the classicists regarding the division of labor and wage dynamics highlighted how industrialization not only amplified productivity but also entrenched labor as a quantifiable, if contested, input—a precursor to contemporary models where skills and education determine growth trajectories. The progression of such historical events demonstrates that technological disruption invariably reconfigures both production functions and the value ascribed to the inputs, a phenomenon observed through history which current Juárez's dynamics is not an exception.

The chapter affirms that economic paradigms consistently reflect the material and social conditions forged by technological change. From guilds to factories, and from agrarian

surplus to industrial capital, each epoch's theorists grappled with labor's shifting role—anticipating today's challenges of automation and skill-biased growth. By contextualizing these transitions, the analysis sets the stage for examining how the evolution of Juárez industrial landscape, much like the historical cases surveyed here, hinges on the interplay of technology, labor adaptation, and institutional responses to both.

3. Theoretical Framework: Technological Determinism on the Approaches to the Economic Problem

The intention of this chapter is to construct a theoretical framework to analyze the phenomenon of economic growth applicable to the context prevailing in the municipality of Juárez, Chihuahua. The analysis starts by unstringing of the concept of economic growth—the quantitative expansion of output—from that of economic development—the qualitative transformation of institutions, capabilities, and well-being. These concepts, often conflated in classical and neoclassical economic literature, are critically disentangled to contextualize this research. Anchoring one of the largest cross-border populations in the world on a border, the region studied here hosts a labor market increasingly defined by high-skill manufacturing and technical services, producing billionaire bi-national trade every year.

To explain this dynamism, the following paragraphs critique mainstream neoclassical growth theories, epitomized by Harrod-Domar and Solow-Swan models, which prioritize equilibrium and capital accumulation while reducing labor to a substitutable, homogenous input. In contrast, Schumpeterian perspective, centered on innovation, disruption, and human agency, reframes growth as a process driven by *creative destruction* and skill-intensive adaptation. Subsequent sections introduce endogenous growth models, like those developed by Arrow (1962) and Lucas (1988) to argue that skills, knowledge, and health are not mere inputs but catalysts for systemic transformation. The theoretical synthesis included in the lines below prepares groundwork to later examine Juárez´s labor market, where cross-border industrial integration and technological disruption demand a workforce defined by technical expertise, and adaptability—qualities often neglected by deterministic paradigms.

Introduction to the Theoretical Framework

Finding more efficient forms of satisfying needs is an ancient endeavor to which humankind has devoted major efforts. After having ensured its prevalence as a species and having discovered the way to domesticate plants and animals, human species started to worry about its survival though the accumulation of food and other satisfiers (Harari, 2014). Since then, we have not stopped thinking about how to produce more with less.

Sen (1988) traces the formalization of the study of economic growth, as we know it nowadays, to the late seventeenth century in western Europe. This author credits the British philosopher and statistician, Sir William Petty for being the first in register the national product by means of both the income and the expenditure methods. He also credits Petty, along with Francoise Quesnay, Antoine Lavoisier, and Joseph Louis Lagrange, known today as The Physiocrats, for being pioneers on questioning how to translate the wealth into people's happiness. The ruminations of that period, labeled as preparadigmatic, subsidized the first school of economics with recognition as a science, the Classical School, inaugurated in late eighteenth century with the publication of Adam Smith's, *An Inquiry into the Nature and Causes of the Wealth of Nations* (Barber, 2009; Rothbard, 1995). Since then, claims Sen (1988), the problems of growth and development started to be studied as a single question in economic analysis.

It would be impossible to review all, or even a substantial proportion of the existing literature on the problem of growth in preparation for this thesis work. The number of studies on the topic is just as vast as that developed for Economics itself. Since this research is on the effects of the evolution of human capacities for production and their impact on the process of wealth creation under a specific context, within a delimited region, the materials organize according to its transcendence for the academic goals declared at the beginning of the project. The present chapter starts with explaining the theoretical domain of the study, and the works and authors that are useful to raise a case in favor of explaining the hypothesis: human capital gains relative importance in the process of wealth creation as technology moves forward.

Prior to that, this part of the thesis states an important clarification of the differences between the concepts of growth and development, as they appear mixed in the early literature on the matter, even though they observe remarkable differences nowadays. A clear separation

of those concepts is significant to the objective of this thesis as it deals exclusively with production and its expansion (*i.e.*, economic growth).

This study, focused on the importance of the human productive capacity in the process of wealth creation within a given technological context, takes the classification proposed by Aghion & Howitt (2009) as the starting point. These authors describe the evolution of the paradigm employed by most of the development economists since the mid-twentieth century, along with its ramifications. The progression presents divided into three stages, each of them incorporated in a model: the New Classical Growth Model, the AK Model, and the Product-Variable Model. A fourth of the paradigms -also contained in a model- is the Schumpeterian approach.

For this research, these categories are presented as paradigmatic assumptions. Even though the early three can be seen as a chain of improvements in seeking a more realistic explanation of the historical evolution of economies, they are analyzed as separate systems of ideas, since all of them remain useful under certain contexts. The fourth of the ways of thinking the economic growth used for this classification grounds on Schumpeter's idea of creative destruction. Even though that last category does not follow the path of the other three, it holds a symbiotic relationship with them.

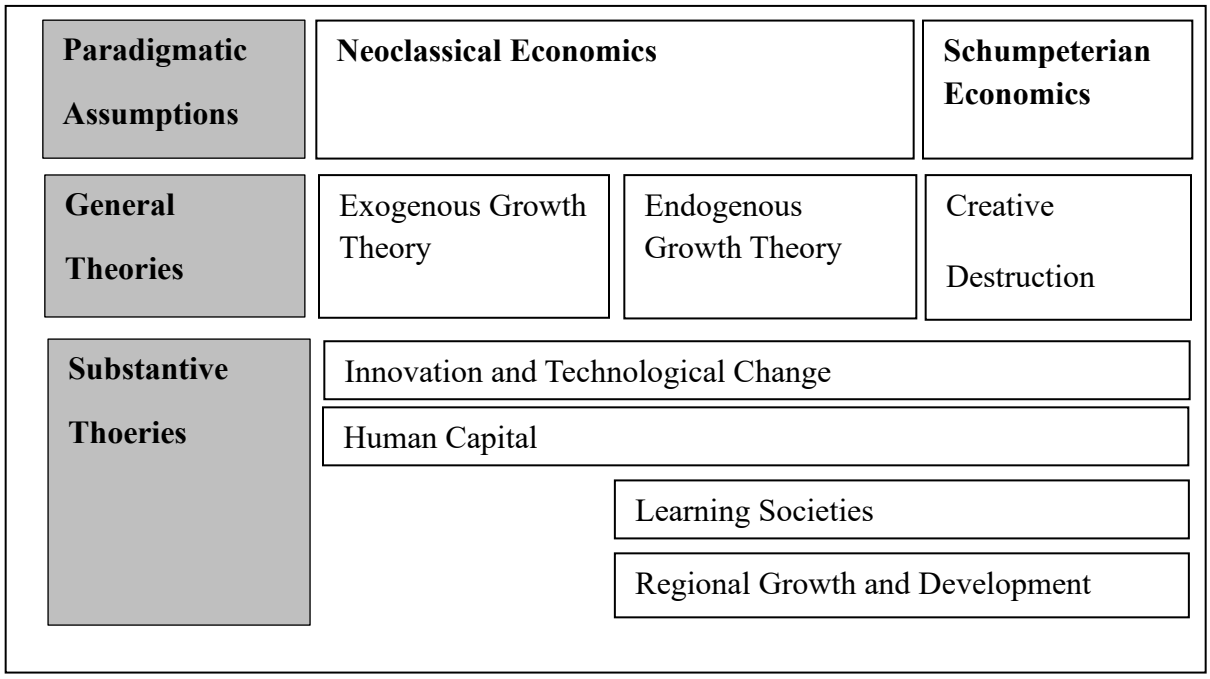
Three of the main theories of economic development flourish from the assumptions listed in the previous paragraphs. The exogenous growth theory, the endogenous growth theory, and the creative destruction theory appear in the document under the classification of general theories. The first two share neoclassical foundations and differentiate from each other for the theoretical elaborations on the origins and of the technology. As such, they frame into the first three of the paradigmatic assumptions explained in the respective section. Given that common origin, neoclassical economics is mentioned here as the source of the general assumptions from which the analyzed theories deploy. Theories covering more specific topics under the headline of substantive theories, in which those appear because they are relevant for the sake of the investigation. Theories on regional growth and development are included among them. Since the study has its focus on a specific territory, the municipality of Juárez, in the Mexican state of Chihuahua.

The human capabilities are, of course, of immense importance to the document, so the theories about the topic are addressed in depth in this chapter. Figure 1 shows a theoretical

matrix elaborated under the scheme proposed by Sautu, Boniolo, Dalle, and Elbert (2005). In the graphics, the general and substantive theories align according to the paradigm they belong to, as per the approach of Aghion and Howitt (2010).

Figure 1

Theoretical Framework



Note: Self elaboration based on (Sautu, Boniolo, Dalle, & Elbert, 2005) with the classification proposed by Anghion & Howitt (2010)

On the Difference Between Growth and Development

Differentiating the concepts of economic growth and economic development is not a trivial matter for the purposes of this thesis work, nor an easy task. Even today, in the light of a large amount of literature dealing with both concepts separately, the practice of using them as synonyms persists. In the field of economics, this confusion can be attributed to the overlapping of the two concepts in early literature. At the end of the Second World War, when economists and policymakers started to worry about the living standards in different countries, and the differences among them, the terms were employed indistinctly, even though authors such as Joseph A. Schumpeter had stablished a difference since the early twentieth century (Schumpeter, 1944). There are a handful of works that can support such affirmation (Coleman, Industrial Growth and Industrial Revolutions, 1956; Rosenstein-

Rodan, 1943; Rostow, 1959) only Relatively new works on the matter, such as that of sustain the belief that increasing the product of an economy implies qualitative change in the society (Lucas, 1988).

Studying the problem of development has been one of the main purposes of economists across history, yet there is not a single definition for the concept itself. To approach the issue raises first a philosophical question, and then an epistemological one. In the first place because it is necessary to define what is to be understand by the concept of development, based on what is expected to bring happiness to people. Once the concepts are defined, the question becomes methodological. Researchers must decide if established if an empirical approach is useful, if a more analytical explanation is required, or anything in between. Lucas (1988) states that a theory of economic growth refers to those aspects of the process "…we have some understanding of and development to those we don't" (p.13).

Sen (1988) says that the problem might be even methodological, as there is a disjunctive between analyzing the problem of development separately or related to the rest of the economic problems. For Sen, the answer to this is clear: economics and development cannot be separated because the latter must be the final goal of the former. Even though standard economics has turned sights to issues such as profits and revenues in micro spectrum, and to the production, prices, and employment on the domain of the macroeconomics. Professor Sen affirms that tools employed to analyze such topics are useful to approach the problems of inequality, poverty, misery, and well-being.

Even though in seeking an explanation of the living standards, the aggregate production has been surpassed as the only parameter, accounting for the value of what an economy produces keeps practical applications in Economics. Measuring the amounts of goods and services that an economy produces might be necessary to broach the subject of development, as satisfaction of wants is essential to improve, for example, an individual's freedom of choice and other aspects of development included by authors such Sen (1999) in their explanations of the concept of development. It is worth studying the achievements every person manages to complete during a lifetime, following objectives according to personal experiences and surroundings.

For Joseph Alois Schumpeter, economic development relates to the expansion of consumption possibilities to satisfy human wants, but it is also a matter of other factors such

as socio-cultural facets of people's life. In his *Theory of Economic Development* (1944), he states that the interest of humankind in this matter is a decisive part of universal history. He assures that, at any given time, people's economic state is a consequence of historical developments. In his thinking, this analyst separates development from the mere growth of production, and states that the former can only be achieved from within a society due mostly to non-economic factors. Schumpeter's theory on economic development diverges from those prevailing at his days by saying that it is not the accumulation of productive means, but the reorganization of those existing in new processes what generates economic growth, and therefore, development.

From the paragraphs above, it can be concluded that growth is a quantitative measure of economic performance while development is a more qualitative one. The former deals specifically with the amount of goods and services that an economy produces, measured in monetary terms; the latter has more to do with the way people live. The study of how a nation produces and accumulate wealth can be traced to the earliest stage of economics as a science, when Adam Smith published his more recognized work: *An Inquiry into the Origins and Causes of the Wealth of Nations* (Barber, 2009; Rothbard, 1995). Development economics as a separate subject, meanwhile, is a relatively new theoretical body that saw the light less than a century ago, specifically, in the mid twentieth century (Todaro & Smith, 2015).

Growth lost its main place in Economics to development in the late 1940's when, at the end of the Second World War, world leaders started to worry about population's life standards beyond consumption. Helping the less developed countries to catch up with the most developed ones became the goal of development economists. Nonetheless, the efforts of scientists and political leaders remained centered on consumption capability for some decades. Production levels, however, remained important for politics and academics as a necessary, even though not sufficient, condition for life enhancement (Aghion & Howitt, 2009; Todaro & Smith, 2015) Efficiency, or to produce more -goods or services- with less -resources-, is the broad object of study to Economics being in turn to Economics of growth. The latter uses most of the guidelines, theoretical concepts, and methodologies employed by the former in its elaborations on the matter, thereby it is studied under the same paradigms as defined by Kuhn (1997) classified as proposed by Sautu, Boniolo, Dalle, & Elbert (2005).

Paradigmatic Assumptions: Differences Between Mainstream and the Austrian School

The study of economic development has long been divided between competing theoretical frameworks, some of the most notably are the neoclassical tradition and the so-called Austrian School. While neoclassical school evolved from early convergence theories to incorporate constant-returns-to-scale, it retains its core reliance relies on mathematical formalizations to explain its main concepts of equilibrium, factor accumulation, and incremental growth. The Austian school—embodied here by the Schumpeterian thinking—adopts a heterodox approach centered on disruptive innovation, institutional development, and entrepreneurial dynamism. This section examines this paradigmatic bifurcation, first outlining the neoclassical assumptions that dominated postwar development economics, then contrasting them with Schumpeter's focus on technological leaps and institutional adaptability. By synthesizing these approaches, the analysis provides theoretical ground for assessing how Juárez's industrial evolution reflects both incremental neoclassical dynamics and Schumpeterian transformation, particularly in its human capital trajectory.

Neoclassical Economics

The Neoclassical school of economic thinking was conceived as a positivist response to the dominance of the political economy as an explanatory of political phenomena during the mid-nineteenth century. In the face of technological advancements of the period of technological advancements known as the Second Industrial Revolution, economic ideas of the classic school started to fall short in explaining reality. In that scenario, Karl Marx's analysis of capitalism surged as a plausible alternative (Barber, 2009).

The Marginalist school emerged as an attempt to install economics as an exact science, as opposed to the more critical approach of the Marxist and the classical traditions. During the subsequent decades, European academic circles adopted the language and system of ideas promoted by Marshall, giving form to a paradigm known as neoclassical economics (Barber, 2009). With the publication of his essay *Principles of Economics* in 1890, The English economist, Alfred Marshall provided a systematic framework to the work of Leon Walras, Stanley Jevons, and Karl Menger, considered seminal to Neoclassical approach. Marginalists turned to a fully empirical approach to study the processes of production and consumption, eliminating social relations and class conflict as a matter of study in economics. Centered on individuals, marginalists, or neoclassical economists, neglect the principles of

political economy. According to economists of this school, individuals, not classes, or any other type of collective, shape the economy with the aggregate outcome of their individual decisions (Marshall, 1957).

The economic agent, name given by the neoclassical economists to the individual person or individual firm that makes economic decisions, became the subject of study. Unlike classic and Marxist paradigms, which explain the economic phenomenon through the interaction of *classes of individuals* within the production process, neoclassical economists provide individuals with agency to guide the course of the economy with their actions. Even though the individualist character conceded to economic decisions, marginalists propose laws of universal application based on some common features of all economic agents. In short, they assume that individuals are rational in the sense that they are always looking for maximization of benefits (Barber, 2009).

One of the pillars of neoclassic economics is the existence of a static equilibrium that all economies tend to achieve under the guidance of market forces. Specifically, marginalists focus on the last unit of labor to incorporate in a productive process, and in the last unit to be produced (*i.e.,* the marginal unit). For them, the market determines the value of merchandise and production inputs, including labor, on marginal basis. One of the main critiques to that school of thinking is that not all the variables of the production function can be divided by the unit to determine its marginal value (Schumpeter, 1944).

The Schumpeterian Paradigm

The Austrian School of Economics, while united by emphasis on methodological individualism, subjectivism, and dynamic process, encompasses divers perspective—From Menger's marginal utility to Hayek's critique of central planning (Schumpeter, 1971). Within this tradition, Joseph Alois Schumpeter stands apart for his focus on the process of *creative destruction,* a framework that rejects static equilibrium and linear growth models (Simpson, 1983). Unlike neoclassical economists, who abstracted markets into mechanical equilibria, or Keynes, who prioritize demand management, Schumpeter positioned economic evolution as a cyclical process driven by technological disruption, entrepreneurial innovation, and the inevitable collapse of outdated structures. His theory rooted in the Austrian tradition's evolutionary view of institutions, reframed economic growth as a socially embedded

phenomenon, where crises were not mere market failures but transformative phases of the capitalism itself.

At the beginning of the twentieth century, in the aftermath of the Great War -today known as the First World War- The United States emerged as an economic world power. Western economies, and the United States in particular, seemed to be in the middle of an epoch of endless economic growth. Optimism led individuals to invest their savings in the stock market. At the light of the lack of regulation, companies received huge inflows of investment and augmented their production to levels well above the demand supported by the market. Such excess supply forced factories to stop producing and expelling workers. The value of companies fell, and people's savings vanished. The crisis dragged all segments of the economy, especially the financial sector, causing bankruptcy of several banks. With all this happening in the new economic powerhouse of the world, all the other economies started to suffer the consequences (Rauchway, 2008).

The forces of the market did not avoid the collapse of the global economy, as the economists of neoclassical tradition would suggest. It was John Maynard Keynes who raised the concept of Welfare State on the basis of a critique to the idea of a self-corrected free market previously imposed by economists from the classical and neoclassical schools (Medina, 1998). Contrary to the suggestions of neoclassical economics, Keynes introduced the idea of using the fiscal policy as an instrument to spur the demand as a necessary step to achieve full employment. For Keynes, getting people to work was the key for the economic recovery (Cabrera, 2014).

Joseph Alois Schumpeter disagreed with all approaches to the economic problem existing at his time. The vision of classical tradition, centered in the availability of productive resources; the struggle of classes proposed by Marx as the explanation for economic dynamics; and the expert management of economics instituted by Keynes, were insufficient for him to explain the functioning of the economy and the phenomenon of economic growth.

Tools provided by neoclassical economists were not enough either. In Schumpeter's mind the economy is not an exact science to be analyzed under the assumption of static equilibria or a steady, linear evolution. In his theory of creative destruction, Schumpeter describes the economy as a matter of cycles and constant disruptions (Schumpeter, 1944). Apart from the classes described by classicists and the Marxists, and from the economic agent

conceived by marginalists. Schumpeter assures that all previous approaches lack of the socio-cultural element and let the economic growth, and development to be determined by technology (Montoya, 2004).

To explain the evolutionary mechanism of the economy, Schumpeter provides a very comprehensive critique of schools of economic thinking preceding him. From the classicists to marginalists, without forgetting Marx´s ideas, pass through the lens of his analysis. For some, he rivaled John Maynard Keynes for the spot as the most influential economist of the first half of the twentieth century. In his oeuvre, Schumpeter provides an analysis of the economic phenomena considered to be the most disruptive one since Marx's contemplations on the First Industrial Revolution and its social implications. Schumpeter, just as Marx, imprinted a broad vision to his study of capitalist society which he observed -and explained- from economic, social, and political standpoints, clearly establishing linkages among these dimensions (Montoya, 2004).

One of the most relevant aspects of Schumpeter's heritage is his explanation of the circular flow of economy, which he employed as the starting point for his several elaborations on economic cycles, economic growth, and economic development. Within a competitive, free market-oriented economy, explains Schumpeter, the preferences of economic agents, as defined by marginalists, generate the flows of productive factors (*i.e.,* labor, and natural resources), and the respective counterflows of money within a balanced system. According to Schumpeter's vision, such system operates under a general equilibrium yielding a stationary state of the economy characterized by a routinary circular dynamics among its variables, which represents a hurdle, more than a spur, to the expansion of production (Schumpeter, 1944).

When Schumpeter compares the circular flow of economy to "the circulation of blood in an animal organism" (Schumpeter, 1944, p. 60), it resembles the *Tableau Économique* employed by Francois Quesnay and the physiocrats in the eighteenth century to describe the economic dynamics. Schumpeter, however, recognizes that in the case of the organism changes follow a progressive, unidirectional pattern. The economy, on the other hand, while still observing periods of smooth trend, also experiences disruptive modifications from time to time. Such discontinuities in the process alter the dynamics itself, and force theoretical paradigms to change.

In coincidence with marginalists, Schumpeter states that every person is an economic agent. Every individual, he says, makes decisions oriented to the satisfaction of needs by means of production or exchange, and the aggregation of the outcomes of those decisions shapes the economy. In that order of ideas, the economic conduct of individuals places each of them within a class that determines his or her role in the collective, specifically within the productive process. An idea in accordance with the classicist and Marxist concept of classes.

The assumptions of an exchange-based economy, private property, division of labor, and free competition (*i.e.,* capitalism) are also basic to Schumpeter's description of the functioning of an economy. Within this context, goods are produced for self-consumption or for exchange purposes. Whatever the case, the process requires several pieces of information. From the very beginning it is necessary for the producer to be familiar with the production process and with the quantities required by the market. Information flows through the system by diverse channels and in different shapes that range from informal word of mouth transmission, or self-experience in small firms, all the way to elaborated training methods, and scientific research in more complex processes. The same holds with the process of exchange as both the producer and the individual that acquires the good for the satisfaction of its own needs must be aware of the prices, quantities available, and alternatives -of supply and demand, if they exist in the market.

The history of Economics as a science is marked by a debate on which of the productive factors are more important. Physiocrats, known to be the last of the schools of thinking of the pre-paradigmatic period of economics, gave the predominant role to the land, as they considered labor as homogeneous, and uncapable of creating wealth (Rothbard, 1995). This is the only common ground between Schumpeter and the thinkers from the mentioned tradition, nonetheless he disagrees with everything else. When Adam Smith and the classical economists took over the main role in the study of economic phenomena, coinciding with the advent of the capitalist mode of production, labor started to gradually gain ground to the land as explicative of the final product in the production function (Barber, 2009). In the theory of Schumpeter, both labor and land are equally important in the process of wealth creation, an argument he shares with marginalists whose theory he revised.

One of Schumpeter's criticisms to the Classic theory relates to Adam Smith's distinction between productive and unproductive labor. In short, Smith separates the work of

those that adds value to the subject upon which it is conferred and that of those who do not (Smith, 2007), a difference that Schumpeter does not consider of relevance when talking about the social product. Schumpeter also downplays the importance of the difference between "mental and manual" and between "skilled and unskilled" labor.

The distinctions that Schumpeter consider most important are those between *directing and directed*, and that between *independent and wage labor*. In the case of the former, the author states that the difference lies in the fact that directing labor allocates itself in a governing position with respect to directed labor within a hierarchical structure. In the case of the latter, independent labor can be compared to directing in the sense that an individual can make decisions on the production process, but also can turn into directed, as the same individual can be in the position of execute the tasks himself. On the other hand, wage labor is always in the position of being governed by someone else in a higher hierarchical position.

All the parties involved in the process of production, however, are subject to the command of the demand side of the market. When it comes to the quantity of production, both directing and directed workers follow the leading of the consumers' needs. Even the independent, and of course the wage salary will work under the same conditions. Besides the demand, also methods of production available will determine the quantity of labor and natural resources to employ.

Schumpeter explains, as Marginalists did before him, that additional employees are included in the process only if their participation generates a revenue exceeding the cost of hiring them. Another important characteristic of work introduced by Schumpeter, several years before the proponents of the endogenous growth model, is the diminishing marginal return to labor. The returns are measured by the value of the unities of the good produced with a certain number of units of the productive factors. The marginal productivity of each factor stands for the value of the production achieved by the least unit. In this way, the participation of each of the factors -land or labor- can be measured and, in turn, valued.

General Growth Theories

In the context of economic research, general theories provide overarching frameworks to explain the problems of production and distribution. Following the methodological guidance of Sautu et. al. (2005), such theories serve as scaffolds for structuring inquiry, yielding to the organization of empirical observations into coherent systems of concepts that transcend

isolated phenomena. These theories abstract complex realities into fundamental principles—such as capital accumulation, labor dynamics, or technological progress—to identify universal drivers of economic growth. Following the authors, general theories are platforms to organize empirical observations—such as the composition of Juárez's labor market—into coherent systems. By abstracting complex realities into universal principles, such as capital-labor ratios or skills spillovers, they provide conceptual tools to interrogate why deterministic models falter in explaining the economic evolution of a place like Juárez. The exogenous and endogenous growth theories lay at the most basic epistemological abstraction for this research, framing the theorization of production expansion methods within evolving economic paradigms. Rooted in neoclassical principles, exogenous growth theories (*e.g.,* Harrod-Domar, Solow-Swan) anchor analysis in accumulation of quantifiable inputs—physical capital, labor, and land—as they account for technology as determined outside the equations employed to explain economic enlargement. In contrast, theories on growth known as endogenous (*e.g.,* Arrow, Lucas) internalize innovation, human capital, and institutional learning as drivers of systemic transformation. In Juárez, this dichotomy manifests as tensions between policies oriented to the attraction of labor-intensive processes, and those promoting skill-driven sectors remain.

Exogenous Growth Theory

The following analysis instrumentalizes fundamentals of neoclassical tradition of macroeconomic aggregation and factors accumulation as tools for an inquiry on the Juárez´s economic performance. By framing growth analysis within savings-driven and assumptions of diminishing returns to capital, Solow-Swan and Harrod-Domar models enable parsimonious explanation of growth trajectories suitable for Juárez's capital-intensive manufacturing sector and cross-border trade dynamics. However, these approaches sideline the human-centric, path dependent processes that redefine production in technologizing economies. This section does not ignore the critiques to this approach to the topic that obscures the role of skills, innovation, and learning.

The Harrod-Domar Model.

As Neoclassical Economics gained influence, mathematical models became the norm within the academic circles. The first recognized formalization of neoclassical ideas in a model resulted from the combination of the works of Roy F. Harrod in 1939 and Evsey Domar in

1946. Harrod-Domar model assumes a given rate of population growth as well as a fixed technology (*i.e.,* a mode of production), both constant. In this model, accumulation of capital goods determines the rate of growth of an economy (Hahn & Matthews, 1964).

The formulation assumes that a fixed proportion of the outcome proceeds is saved for investment purposes. Under such circumstances, growth is a linear process that depends on the portion of the income that an economy manages to save and invest in new capital. Due to the constraints imposed in the assumption, Harrod-Domar production function presents decreasing marginal productivity of all factors. Two implications for that are: 1) there is no growth in the long run; and 2) less developed economies eventually converge with the most developed ones, at least in the rate of growth. That model is seminal to the so-called exogenous growth theory due to the assumption that technology and the amount of labor available are exogenously determined.

One of the main critiques of the marginalist precepts aims at the static character of the analysis. In 1939, Roy F. Harrod came out with an essay he defined as "an outline of a dynamic theory" (Harrod, 1939, p. 14). In his work, the author provides a revision of the said static approach, but also, he offers a review of the Keynesian line of thinking about the relation between income, investment, and employment with economic growth.

The goal of Harrod's essay is to confirm that, contrary to the idea of a general equilibrium, in the long run there are several possibilities of equilibrium with unemployment but with economic growth. The work emulates static theory as the author relies on an axiomatic system to prove his point, just as the static theories do. The three main axioms of Harrod's system are: 1) The income level of a community is the main determinant of its own supply of savings; 2) Demand for savings is a function of the rate at which income expands; and 3) The system is in equilibrium if savings demand and supply remain equal. Those assumptions presented by Harrod as truisms represent the analytical framework to analyze the economy under constant changes of supply and demand.

The analysis of Harrod assumes a static economy as a starting point and then he describes how the supply and demand forces guide the economy into a dynamic mechanic. Using an analytical methodology, the author describes the dynamic equilibria using differentiation of variables. The sequence of equilibrium points resulted from the calculations

draws a curve tagged in the model as the guaranteed growth path, which indicates the rate of growth needed to satisfy all economic agents at any given moment (Harrod, 1939).

According to Harrod (1939), the exogenously explained state of technology determines the amount of capital required to increase the outcome. In the referred essay, producers' incentive to increase their investment is a function of the savings and the state of technology. In what he calls the "fundamental equation", Harrod determines that guaranteed growth is the quotient between the proportion of savings and the capital required to increase the outcome in one unit. As a function of savings, guaranteed growth depends on decisions of economic agents related to the fraction of their income they decide to save. guaranteed growth is then a function of the growth in the previous period.

The divergence between the rate of growth observed at any time and the guaranteed growth is considered by Harrod (1939) to happen only because of random, non-economically explained causes. The actual rate of growth is the result of dividing the proportion of the income saved by the amount of capital employed to obtain an additional unit of production. The actual growth is calculated in the traditional way, by dividing the difference between the output of any given period and the previous one by the level of the previous period. The guaranteed rate, as mentioned in the lines above, is the rate of growth at which production is strictly necessary. A difference between those two rates might suggest that agents are irrational and that they are producing more or less than the quantities demanded in the market. That difference is only possible because of a distortion in the information or expectations of the agents, specifically the producers, regarding the demand and the technology available for production.

Been interested in the development of dynamic theory, Harrod (1939) places his sights on trends of economic indicators. The main questions he raises in his essay have to do with the rate of the changes that a system would observe, or if operating forces would generate an inertia. He asks, for example, what happens to an economy when exports and labor-saving innovations are introduced. While equations employed in the static model explain adjustments of the system in the face of one-time altering events around a static equilibrium, Harrod's mathematic developments aim at the analysis of the effects of perennial transformations. Such questions cannot be answered but by a change in the mindset from static to dynamic.

In a dynamic system it can be anticipated that alterations of the market forces will cause changes in the agents' expectations, acting as "centrifugal forces" to exacerbate those changes. A change in demand, caused for example by the expansion of the exports[2], is an incentive for an expansion in production that will, in turn, bring the prices down, causing the demand to grow again. In the case of the introduction of an innovation in the production process, Harrod says that it will diminish the aggregate demand, given the reduction of purchasing of intermediate goods, creating a downwards spiral. In the Keynes' theory the changes in exports and in technology are the accelerators of the economy, and the times the growth rates adjust are the multiplier (Keynes, 1991).

Harrod analyzes the differences between the actual and the guaranteed rates of growth using savings and required capital, the two components of his fundamental equation. Just as in any other comparison between two numbers, there are three possible outcomes of the comparison between the actual rate of growth and the guaranteed growth: the latter is greater than the former, the former exceeds the latter, or they are equal. The case of equality does not require further analysis because it describes a situation in which all the agents meet their expectations. In the case when the *actual* growth does not comply with expectations, it may be caused by a shortage of savings or because of an excess in the capital employed. In the first case, the agents will adjust by consuming less and saving more, while in the second the incentive is to not acquire new capital, causing the aggregate demand to fall, and *actual growth* to deviate even more from the guaranteed growth. Conversely, when actual growth is greater than the guaranteed growth, agents will consume more and save less, and the incentive is to increase capital, the gap will increase too, but in the upward direction.

Finally, the situation in which an economy does not generate the level of employment to meet the population growth, but still grows, is the said long-term equilibrium in which both growth of the outcome, and unemployment coexist. Natural growth is the growth rate attained by an economy using all its productive resources at full capacity. If the guaranteed growth equals that rate, it is a full employment, growing situation. If the *guaranteed growth* exceeds natural growth, desired savings are larger than possible to push productive capacity upwards. When, on the contrary, the guaranteed growth places below natural growth, savings

are less than those required to maintain full employment, and the economy fails to generate the employment necessary to absorb the growth of population. Such an economy is in equilibrium because producers are not motivated to increase their stock of capital to complement the growth of labor force. This situation is known as structural unemployment.

Natural growth cannot be smaller than the actual growth, but in Harrod's (1939) work it can be less than the guaranteed growth because in his mind, structural unemployment is a natural condition of the economy. Based on that assumption, his work analyses two possibilities: one with the guaranteed growth larger than the actual growth, and the other with the result of the comparison inverted. Both comparisons, with *natural* growth surpassing each of the two other rates, result in the same scenario described in the paragraph above. The agents will adjust their behavior with respect to savings and the requirements of capital, and those actions function as centrifugal forces fostering the actual growth.

There are two options to maintain the *actual growth* around the guaranteed growth, and that one close to the natural growth or full employment. The first of them is to increase the desirable rate of savings, the other is to reduce the capital required as a proportion of total capital. Those actions imply the risk of a recession as might push *actual* growth below guaranteed growth. That situation is known as Harrod's Paradox (Shaikh, 2009).

The complement to the exogenous growth theory is Evsey Domar's essay Capital Expansion, Rate of Growth *and Employment* Domar (1946). As for any other follower of Keynesian tradition, Domar worried about the problem of unemployment as one of the main topics in growth economics—the other two are prices, and production—. This economist states that the study of unemployment from the perspective of investment and capital accumulation is so old, it could be traced to Marx, more than a century before him, but so actual -at his own time- that it remined under observation by John Maynard Keynes and his followers, among which Shaikh (2009) includes Roy Harrod. Just as Harrod himself did before him, Domar approaches the issue by means of a dynamic model, relying on differential equations.

To explain the problem of growth, and unemployment, Domar (1946) states that the endeavor is so complex that it requires of a set of simplifying. Among those he listed deep constant prices, and, unlike Harrod, he does not include lags in his analysis, meaning that both the amount of savings and level of investment in his calculations belong to the same

period. Also, he accounts for depreciation in net terms making the assessment with the total cost of replacing the capital to maintain productive capacity. As per the methodology employed in measuring savings, investment, and depreciation, it can be said that history does not have a role in his analysis. Finally, the author measures the productive capacity in units of outcome.

In line with Harrod's explanation, Domar (1946) says that an economy reaches full employment equilibrium when national income reaches productive capacity. The value of the latter is set at the level of total outcome attainable when all the inputs available are employed at full capacity. On the other hand, the actual outcome that an economy achieves at any given moment is a function of physical and technological faculties, but it also depends on structural and institutional aspects. In his essay, the author claims that one of the main problems of economic growth is that most of the authors measure the labor force in a single and homogeneous unit: the worker-hour. Those studies, says Domar, do not develop a theory on workers' productivity and its changes. Before Domar, studies on growth only established that any expansion of the full employment will automatically translate into a growth of income. Domar considers this system to be incomplete because it does not take market forces, such as demand, into account. Leaving demand outside is an important omission since it neglects the potential income stream coming from additional sales and its impact on productive capacity. Unlike other Keynesian analysts before him -including Roy Harrod- Domar sees the aggregate demand, more than technological progress as the main determinant of the augmentation of productive capacity. It can be deduced when he states that:

"Labor productivity is not a function of technological progress in the abstract, but technological progress embodied in capital goods, and the amount of capital goods in general. Even without technological progress, capital accumulation increases labor productivity, at least to certain point." (Domar, 1946, p. 138)

The fundamental equation of Keynesianism in which employment is a function of national income and productive capacity is basic for Domar to develop his own model (Shaikh, 2009). An innovation with respect to Keynes is the introduction of the long run into the analysis. Domar's formulations employ differential equations to find the potential capacity of investment to increase production, which is the ratio of the evolution of productive capacity to the investment. That ratio is accounted for as an aggregated variable,

meaning that it does not explain the income distribution. Such calculations can be completed even if productive inputs and technology do not remain unaltered.

Domar (1946) claims that an economy remains in equilibrium if total income and production capacity grow at the same rate. Calculating the productive potential of investment is key to Domar's findings on economic growth process. Assuming investment and its productivity growing at a constant rate, he defines the supply side of his fundamental equation. That arrangement equals the total value of investment, measured by its own productivity, to the temporal variation of investment divided by the marginal propension to save (*i.e.,* the growth of production in time). According to this, and based on the Marshallian idea of equilibrium, the supply of savings equals the demand when the productivity of the investment equals the rate of its own differential in time to the marginal propensity to save. At that point, the system is in equilibrium (Marshall, 1957). The resulting function of that equilibrium is an exponential one in which to remain in equilibrium, investment must grow at a positive, increasing pace.

The mathematical arrangement proposed by Domar (1946) recalls Harrod's fundamental equation in which savings amount is divided by the amount of capital employed in increasing outcome. Domar's formulation divides growth of income, on the demand side to the growth of productive capacity at the supply end, for comparison purposes. In that way, the models of Harrod and Domar connect beyond the use of same variables such as savings and investment to explain growth (Shaikh, 2009). The Analyses of Roy Harrod and Evsey Domar resulted in a model recognized as seminal to the study of economic growth in the post-World War era. According to those analysts, economic growth is the result of how an economy manages savings and investment to transform into capital goods and combine them with labor for the creation of wealth.

The labor force is accounted for in both models by the number of workers available and the rate at which that number increases. The speed at which the labor force grows is taken as natural, not explained by economic forces. The value of labor in the model is also given by the productive capacity of the laborers. The model considers, in turn, that the productivity of the workers is also a function of the combination with the capital goods incorporated in the process. Intrinsically, the model includes technology to explain growth, by means of the

ratio of capital to outcome, but neither Harrod nor Domar deploy a theory on how this combination makes any of the factors more productive or less productive.

One of the main implications of Harrod and Domar is that there is a natural divergence between the effective rate of growth and the rate of equilibrium because the natural growth of labor is completely independent of income, savings, and investment. The model assumes that such differential leads agents: investors and producers, to decisions that deepen the gap. Therefore, instability and cyclical behavior are inherent to every economic system (Harrod, 1939; Domar, 1946).

The Solow-Swan Model

The Harrod-Domar Model provides fundamental assumptions for the study of growth from the neoclassical perspective. However, the formalization resulted from the works that Robert Solow and Trevor Swan conducted separately in 1956 enjoys the recognition of the seminal work to economic growth in modern era (Aghion & Howitt, 2009; Todaro & Smith, 2015). The difference with Harrod-Domar consists of the introduction of a theoretical development of the labor as explicative variable, and the technology as a framework that, although exogenous to the formulation, appears determinant to the outcome.

In *A Contribution to the Theory of Economic Growth* (1956), Robert Solow argues that some crucial assumptions employed by Harrod and Domar are dubious, therefore, the conclusions of the model are incomplete. In the view of Solow, the impossibility of input substitution yields to a very unstable equilibrium, making difficult to maintain a balanced rate of growth. Neglecting the concept of technical substitution makes the Harrod-Domar model a very rigid scheme to explain the process of economic growth. The proposal of Robert Solow shares fundamentals with that of Harrod and Domar, yet differs, among other things, on the dispense of the assumption of fixed proportions.

Throughout a series of algebraic arrangements, and differential equations, Solow defines a production function with physical capital and labor as explanatory variables. In the formulations, the former is a stock that increases every period by the proportion of the income that the economy does not consume (*i.e.,* savings rate), while the later variates at a fixed rate not explained by economic forces, just as in the elaborations of Harrod and Domar. In this model, the quantity of capital employed in every period depends upon the stock achieved at

any given point. One of the main assumptions of the model is that the labor is fully employed, adjusting wages to the marginal productivity of labor.

The productivity of labor, measured by the output per worker as a function of capital per worker. According to Solow's explanations, when the ratio of capital per worker does not vary across periods, the capital stock must vary at the same rate as the labor force does. Nonetheless, he assumes that the mechanics by which productivity of workers varies after the ratio of capital to work is exogenous to the model.

Solow (1956) shows that full employment conditions are possible even when productivity varies. In his work, he conducts a comparison between an economy in which marginal productivity diminishes at a slow rate, always slower than the growth of labor force. On the other hand, there is a less productive economy, where marginal productivity remains below the growth of the available labor force. In the first case, the capital per worker, as well as per capita the outcome always increases. The second scenario shows an economy so unproductive that, to maintain full employment, per capita income is always decreasing.

Anghion and Howitt (2009) state that "the starting point for any study of economic growth is the neoclassical growth model" (p. 21). The first formalization of that model is in the work of Robert Solow, but also in that of Trevor Swan. According to the latter, any economic policy aiming at spur economic growth must encourage people to save (Swan, 1956). Unlike Harrod and Domar, his model eliminates the possibility that advancements in technology, occurring for non-economic causes, yield to growth in the long run. The difference manifests itself when the author implies that workers have a limit on the output they can produce, even if increasing physical capital is introduced into the system. Such a limit is given by the state of technology.

The Solow-Swan Model departs from the assumption of an economy with a fixed endowment of labor and a given state of the technology. In that case, the aggregate amount of physical capital that the economy manages to incorporate marks the limit of the attainable output. The economy is also assumed to be in a state of full employment. In terms of the Harrod and Domar Model, it is said that actual and natural growth rates are the same. As per the assumption of diminishing marginal returns of the inputs, it can be said that the physical capital shows a direct relation to production at a decreasing rate to the point it reaches zero (Aghion & Howitt, 2009; Todaro & Smith, 2015).

Accumulation of physical capital is so important to neoclassical views that Solow-Swan's fundamental equation has the derivative of capital with respect to time as the explained variable (Aghion & Howitt, 2009; Todaro & Smith, 2015). In the model, the fraction of the income that people save, as well as the proportion of its value that capital goods lost in time, remain constant. As savings are assumed to always turn into new capital, the net investment is given by the amount of savings achieved minus the depreciation of capital goods. Like Harrod and Domar, Solow and Swan employ analytical approaches based on differential equations to analyze the behavior of the variables in time.

The growth of production is, in consequence, derived from the difference between savings and depreciation. In the Solow and Swan model, the former has a direct but diminishing relation to capital, while the latter increases at a constant rate. Given those characteristics, even if the amount of savings surpasses the losses of depreciation at the beginning, both quantities tend to converge giving place to a unique stationary state of the economy.

When physical capital is less than the level of equilibrium, additional units are highly productive, therefore, the ratio of national income to capital is too high. Solow (1956) and Swan (1956) imply that, as capital stocks get larger marginal productivity diminishes. As a result of the diminishing marginal returns of the input, national income grows at a slower pace and savings do so in consequence. Depreciation rate is constant, so at a certain level, where the amount of physical capital of equilibrium is attained, savings become insufficient to cover the losses of value that time causes to assets. In the end, the inability of the physical capital to maintain its productivity diminishes the incentive of people to save for investment purposes.

Under the assumptions of the Solow-Swan Model, variations of are not only a function of the accumulation of physical capital, but also of labor. Assuming the number of workers variable at a constant rate, production level remains as a diminishing function of physical capital. In any case, productivity of both labor and physical capital depends upon the state of technology. From Solow (1956) and Swan (1956) can be concluded that, under a given, unaltered state of technology, if physical capital grows at the same rate as labor, production will increase at that same pace.

When computing on a per capita basis, physical capital per worker grows at the same proportion each person saves. Depreciation can also be accounted for on a per capita basis. Increases in labor force, assumed in the model as natural and constant, diminishes per capita physical capital by a rate that is the product of the growth of the former times the grow of the latter. At the end, per capita physical capital grows at a rate defined by savings per person, the growth of population, and depreciation.

Both Solow (1956) and Swan (1956) observed that, contrary to the stipulated by neoclassical economics, empirical evidence showed no signals of diminishing returns of physical capital, and advanced economies remained growing at high rates. Since the First Industrial Revolution in the nineteenth century, it was observed that technological advancements cancelled the effects of diminishing returns (Aghion & Howitt, 2009). To explain such phenomenon, Solow-Swan Model introduces a parameter that accounts for the current state of technology. The speed at which this parameter grows is the result of science and technology advancements, and the acquisition of new knowledge. That coefficient, considered to be exogenous and growing at an exponential rate, explains the gains of productivity of productive inputs.

The effective supply of labor, according to this model, includes the number of workers available for hiring plus their productivity. The rate of growth of effective labor is the addition of the rate of growth of productivity (*i.e.,* technological advancement), plus the natural rate of growth of labor-force. When multiplied by the number of workers, the coefficient of technological advancement produces a number that is called the e*fficiency units of labor*.

Both Solow (1956) and Swan (1956) places high interest in the proportional contribution of new savings to the output per efficiency unit, nowadays known as the rate of savings per *efficiency unit*. Depreciation has its own role in the evolution of the output per efficiency unit, labeled in the model as the *depreciation per person*. The physical capital per *efficiency unit* falls at the same rate as the productivity of physical capital does. The change of the physical capital per *efficiency unit* is given the same factors determining the ratio of physical capital to labor, but with the addition of the rate of growth of effective supply of labor. Output per *efficiency unit*, and capital per *efficiency unit* tend to converge, when that happens, the economy falls into stationary state. The authors demonstrate mathematically that savings can make the total outcome of an economy grow more than productivity because

of technological advance in the short term, but not in the long run. For more prolonged periods, growth is tied to technological progress, which is exogenous to the model they propose.

The theory of conditional convergence states that if two economies observe different levels of GDP per capita, they will converge only if technology and fundamentals are the same, but If technical advancement and the rest of the variables involved differ, there is no reason to think of convergence. Neoclassical economics neglects the difference in technologies, under the claim that technology is available globally. On the other hand, the ability to accumulate physical capital obeys structural conditions which vary from one economy to another (Aghion & Howitt, 2009; Todaro & Smith, 2015). Neoclassical economics offers a theory on growth with a trend to a convergence, not necessarily in the per capita income, but in terms of the rate of growth. The theory implies that countries with the same technology tend to grow at the same rate in the long term. In other words, the rhythm of technological progress marks the pace of economic growth.

Endogenous Growth Theory

Endogenous growth theories emerged to address the empirical and theoretical flaws of neoclassical models, particularly their inability to explain persistent global inequalities in income and growth. While the neoclassical framework models (*e.g.*, Solow-Swan) predicted convergence through diminishing returns to capital, history showed widening gaps between nations. Not only analysts from the global south such as Prebish (1996), but also from those in the so-called industrialized economies (Arrow, 1962; Barro, 1996; Lucas, 1988) reacted to such evidence, It was the latter who reconceptualize technological progress, shaped by human decisions, institutional learning, and cumulative knowledge as endogenous to the growth process. Contemporaneous with the seminal works of Becker and Schultz on human capital, the endogenous approach internalizes education, health, and innovation as core drivers for economic growth. By rejecting neoclassical assumptions of exogenous models' new formulations reframed divergence as a path-dependent process (Todaro & Smith, 2015). This shift lays the groundwork for explaining how regions like Juárez, with unique industrial ecosystems, defy deterministic convergence. Central to this framework is the rejection of technology as divorced not only from the economic process, but also from the social aspects of production. Arrow's *learning-by-doing* concept posits that knowledge accumulates

through production, with physical capital becoming both cause and effect of skill development. Such insights shed light on the causes of the divergence between economies with similar endowments of capital and labor. For a place like Juárez, and other México's export manufacturing centers, this implies that knowledge spillovers and labor adaptability –not just accumulation of capital through savings—anchor its technological trajectory. Endogenous growth theories thus provide the tools to analyze how skills, innovation, and institutional context recalibrate production in an era of disruption.

One of the main theses of Neoclassical economics is the idea of convergence due to the decreasing marginal returns of physical capital (Aghion & Howitt, 2009; Todaro & Smith, 2015). At the light of empirical evidence, several authors observed a perennial and increasing gap between nations in the per capita income, and in the rates of growth (Prebisch, 1996). Lucas (1988) presents statistical evidence of the growing differential between developed and developing economies during a significant portion of the 20th century. Nonetheless, he recognizes the value of neoclassical precepts to the study of growth and development problems. To develop his theory, explanatory of the process of economic growth, the author relies on neoclassical fundamentals, but removes some assumptions such as immobility of factors, and introduces the idea that economies differ according to an initial technological status. According to his findings, neither population growth, nor income shares to labor, explains the difference in growth between countries in a neoclassical sense. In neoclassical economics, says the author, technology is taken as disembodied from the rest of the social aspects of an economy. He considers that treating technology as an exogenous factor is not theoretically correct, nor useful to explain the differences in development between economies, as they all depart from different status in this aspect.

In the last decades of the twentieth century, important economists suggested that one of the main reasons for the theory of convergence failure is the exclusion of technological progress of endogeneity in neoclassical models (Arrow, 1962; Barro, 1996; Lucas, 1988; Romer, 1986). What those economists identify is that the long run growth, non-existent in models of the exogenous growth theory but present in the reality, can be explained by accounting for technological progress as determined within the production function of an economy.

The AK Growth Model

Endogeneity is key to explain why, contrary to the conclusions achieved by previous models, physical capital shows increasing returns. In words of Arrow (1962), by the end of the decade of the 50's and the beginning of the 60's it was "…incontrovertible that increases in per capita income cannot be explained simply by increases in the capital-labor ratio." (p.155). According to the new current of thinking, one of the most important limitations of the exogenous growth theory is the consideration of technological progress as independent to economic forces (Aghion & Howitt, 2009). Amid the lack of an explanation for the observed divergence between developed and developing economies, a new theoretical framework emerged after the work of Arrow entitled *The Economic Implications of Learning by Doing* (1962). Since then, that is known as the endogenous growth theory.

The formal expression of the theory sparked by Arrow, known as the AK Model, grounds on neoclassical fundamentals, as Arrow's and subsequent ideas follows the trail of Harrod-Domar, and Solow-Swan. One of the underlying ideas of the AK model is that a way for an economy to increase its production is providing workers with more units of physical capital. The novelty presented in Arrow's work is that the accumulation of physical capital helps workers to enhance their production techniques. Such learning process yields to an increment of marginal productivity, contrary to the decreasing returns assumed in a system where technology remains still (Arrow, 1962). As explained before, for a given amount of available labor, and in the absence of technological progress, accessibility to physical capital marks the limit of growth.

For Kenneth J. Arrow, technical progress is an important determinant to economic growth. His views, however, do not align with neoclassical principles regarding the role of knowledge in the process of wealth creation. What distinguishes his work from that of previous researchers on the topic is the idea that knowledge is cumulative, it can be measured, and it is affected by the production process itself. In other words, it is endogenous to the model employed in the explanation of growth.

Arrow also departs from the neoclassical rudiments when he acknowledges that different economies have different production functions. The differences in the way each economy organizes its production base are not only on natural resources endowment or the size of its labor force, but on the divergences in the knowledge, both across the regions and

throughout the time. For Arrow, the process of learning or accumulating experience because of economic activity has a significant role in the capacity of an economy to produce. The returns of learning, however, diminishes due to the routine, says Arrow, but when innovation is present in production, knowledge piles up at an exponential rate. The model specified by Arrow to prove his hypothesis employs cumulative gross investment as a proxy for experience. According to him, introducing new machinery into the production process maintains the impulse and increasing returns of learning.

Lucas (1988) reinforces the ideas of cumulative character of knowledge and agrees to recognize innovation as a detonator for growth. He explains how, in a family, at least a portion of the human capital attained pass through the next generation. In macroeconomic terms, he says that introducing new products into the market offsets the diminishing returns of experience because skills employed to produce the old one just enhances.

Intending to account for learning in the production function, Arrow incorporates some assumptions following the model of Solow (1956). First of them is that new capital goods represent the totality of technical change as they embody all available knowledge. The other, is that the productivity of machinery remains unaltered even in the presence of new learning. In Arrow's formalization, therefore, introducing new units of capital may result in rising the outcome with the same workers or even with less of them.

The amount of labor needed to produce a given level of output is not increasing when new physical capital integrates into the process. At the same time, the productive capacity of new units of physical capital is assumed to be at least as large as that of the units employed before. Therefore, it is assumed that it is always feasible to replace old units of physical capital with new ones.

Parallel to the work of Arrow, the study of human capital was born as a theoretical field of interest. Eexpenses caried out by families in the acquisition of knowledge and skills started being considered as an investment in economic accounting (Schultz, 1961). On the side of Growth Economics, of capital, by saying that technological improvement is a consequence of growth Paul Romer (1986) explains the externalities itself. Posterior to Romer, Robert E. Lucas, Jr. published *On the Mechanics of Economic Development* (1988), where he distinguishes between physical and human capital with the latter being cumulative to a constant rate enhancing the productivity of both, work and physical capital. Afterwards,

Robert Barro (1996) offers his own explanation on how economic growth yields to enhancement of both physical and human capital.

Robert E. Lucas (1988) observed and documented huge differentials on per capita income and growth rates among countries. In his study, he attributes those inequalities, not only to economic causes, but to the social structures in each territory. However, he recognizes that such figures, measured in monetary terms, do not necessarily yield to fair comparisons of living standard or consumption capacity. Even though he does not elaborate on a potential correlation between the actual size of an economy and its growth rate, he assumes such dependance.

Lucas observes a correlation between per capita income and a variability of the growth rates in time. For the wealthiest countries, trends are steady, and more volatile among the backward economies. Trying to develop a theory to explain and propose solutions to such differences, Lucas conducts a revision of Solow's model and tries to make clear why that model does not explain the economic growth process. For Lucas, Solow's neglection of the effects of human capital accumulation on growth is a major flaw. To achieve his goal, Lucas introduces the analysis of the interaction between physical and human capital (*i.e.,* technology), specialization of labor, and the role of trade.

The Theory of Creative Destruction: The Schumpeterian Approach

In an era defined by rapid technological disruption and globalized production networks, Joseph Alois Schumpeter´s theory of creative destruction offers a critical lens to analyze economic growth in dynamic regions like the municipality of Juárez. While mid-twentieth-century context prioritized Keynesian and neoclassical equilibrium models, Schumpeter's framework—overshadowed at that time—resonates today. At its core, the theory postulates that innovation, driven by entrepreneurial vision, perpetually dismantles old production methods, replacing them with new systems that redefine productivity and market structures. Unlike static models that assume predictable inputs (*e.g.,* capital, labor), Schumpeter foregrounds *disruption* as an engine of progress, emphasizing cyclical transformations shaped by cultural, institutional, and technological shifts.

For Juárez, at the center of a globally important manufacturing hub, Schumpeter's insights acquire renewed relevance. The regions' industrial ecosystem—marked by automation, global value chains, and skill-driven adaptation—exemplifies the tension

between long-established practices and disruptive innovation. Schumpeterian *entrepreneurs* here are catalysts for the reconfiguration of production systems through recent technologies and organizational methods. By framing growth as a path-dependent process sparked and guided by human agency and institutional learning, this theory fills gaps left by exogenous and endogenous growth models, which often overlook the socio-cultural dimensions of technological adoption. In contexts like Juárez prevailing rapid industrial evolution in coexistence with structural inequality, *creative destruction* provides the basis to inquiries about how skills, adaptability, and institutional support mediate the trade-offs of economic transition hinged on technological advances.

Under capitalism, it is impossible for an economy to remain stationary according to (Schumpeter, 1944). Qualitative leaps are constant, hence characterized by disruptive changes that he describes as revolutions. In Schumpeter's analysis, innovation, meaning the appearance of new products in markets or industrial application of new methods of production, are the main source of economic growth and development. The appearance of an economic agent in charge of introducing those innovations yields production increasing.

In his attempt to explain the dynamics of economic growth, Schumpeter envisions a central figure he calls the entrepreneur. This new category he introduces into the analysis explains the flexibility of capitalism to resist several shocks. Schumpeter's entrepreneur does not only respond to economic stimulus, as the rational agent from the neoclassical models, but responds to cultural factors. After the idea of the entrepreneur, Schumpeter introduced the concept of Creative Destruction. According to him, when a new product, or new forms of producing or marketing goods emerge, the whole system is shocked and is forced to adapt (Gutiérrez, 2014).

Schumpeter concludes that innovation is the main reason for production growth. He also explains that those events are cyclical, and that they are not only of an economic nature, but it also responds to other aspects of the life of a society such as intellect, social interaction, and other cultural characteristics. That process, he remarks, causes the rise and, at the same time, the fall of several families, firms, and entire industries, and that is why the process is known as Creative Destruction.

When there are no alterations in data, meaning that production methods remain unaltered, consumed or exchanged quantities suffer only incremental changes that present

themselves in a smooth, linear trend. Then, production and trade conditions persist, and the economic system turns into precise machinery, highly predictable in its operation. Such a situation provides stability to the interaction of all economic agents that are, at the same time, the buyers and sellers of goods and services available in the economy.

Predictability of the markets functioning, both goods and productive inputs, ease the assimilation of empirical information to adjust economic decisions related to production and consumption. Surplus or shortages are eliminated from both sides of the market -except for external shocks such as wars or weather contingencies-. Under such conditions, says Schumpeter, there is no possibility of increasing production in real terms.

Schumpeter also introduces the appearance of new technical facts into the mechanism to explain what he calls *the boom*, described as a period in which production expands. Production is a matter of satisfaction of wants, it is the latter that, within certain constraints, regulate the use and development of technology within the production processes. Schumpeterian thinking considers that, at every moment in history, and at every stage of the life cycle of any product, employed technology reflects the most efficient way at hand to combine productive resources, always pursuing economic objectives.

Technology holds an explicative role in the production function, a mathematical expression that reflects the proportion in which productive factors bundle to produce different quantities of any good. Within this expression, the relative participation of each of the factors is accounted for by a coefficient. Production function helps to quantify the rate at which each of the factors can be replaced by the other, given an available technology. In Schumpeter's elaborations those factors are represented by human effort and natural resources. There are, of course, other types of inputs conceived by the author as useful in the production process, but he claims that all of them result from the combination of labor and the gifts of nature.

The market value of goods is a function of the value of the means of production employed in its fabrication. The decision to employ existing resources to produce a good over the alternatives carries a cost of opportunity. Schumpeter expresses that cost in terms of the most valuable one among discarded alternatives. In his calculations, the cost equals the revenue obtained from the effectively produced good, less the value of those resigned. Along with the law of diminishing returns, the theory of creative destruction adopts the Ricardian assumption of the competitive advantage to determine how an individual -or a firm- will

employ the resources at hand to produce. In other words, Schumpeter assumes that productive entities devote their resources to the production of the goods in which they deliver the best return. It is important to establish that such a decision is tied to the information available. In an economic system with no alterations or disruptions, judgment lies on experience or reasons of habit.

In the absence of disruptions, economic systems tend to balance. Under such circumstances, in general, value of labor and natural resources equals marginal productivity, making it impossible to obtain profits. Profit, Schumpeter remarks, "is a symptom of imperfection" (Schumpeter, 1944, p. 31). Within a stable economic system, markets tend to acquire the characteristics of perfect competition. The value of both labor and land, therefore, eventually declines to points below the market price of the goods they produce. That process continues as long as the method of production remains unaltered.

There are different forms of disrupting the stability of the circular flow described by Schumpeter. Naturally, he is aware of the possibility of alterations in both economic and non-economic conditions. Events such as wars, natural disasters, or sudden changes in economic policy, among other shocks of the type, could unexpectedly happen at any time and alter the normal flow of goods and/or the correspondent counterflow of money within an economic system. Such events, however, are not part of the Schumpeter theory of economic development given the randomness in its occurrence.

According to Schumpeter, those who participate on the supply side of the economic system are in capacity of introducing disruptions. Modifications in the supply, tagged as innovations, consist of the introduction of new satisfiers or new methods to deliver existent ones. Said modifications can also be the fruit of a gradual evolution of the traditional methods. When this is the case, says Schumpeter, they do not produce qualitative changes in the economy, but only quantitative ones. Whatever the case, innovations represent new relationships between the productive resources within the process (*i.e.,* a new production function).

The theory of Creative Destruction describes five types of innovation. The first one, and the most elementary, is the launch of a product unknown to the consumer at that moment. Qualitative improvements to an existing product fit inside this category. The introduction of different methods of production, resulting or not from scientific discovering, is the second

class described. In third place, opening a new market for a given branch of manufacturing. Fourth, the conquest of new sources of natural resources or intermediate goods. Finally, the fifth is the reorganization of a whole industry.

The theory admits the possibility that innovations are conducted by individuals within the industry in which they occur, even though it suggests that normally new actors pioneer them. Theory also says that those new production functions always materialize themselves in new firms that rarely spin off from the old ones. New firms, according to this theory, always flourish side by side with the old ones, but in a competitive environment, the latter end up vanishing.

Schumpeter assumes that, due to non-economic causes, there are always unused productive capacity in the form of unemployed workers, unexploited raw materials, idle machinery, and so forth. Even though such waste of resources can foster the emergence of new productive combinations of resources, Schumpeter does not consider it to be a major source of innovation. It is a particularly important assumption in this theory that such a waste of resources does not exist in an equilibrated circular flow.

Whatever the case, conducting new methods of production always means reconverting productive resources from the tasks they were employed in to perform new assignments. Such conversion receives credit from Schumpeter as the source of qualitative changes in economy and society. Even though he recognizes the need for the accumulation of savings and means of production as prescribed by neoclassical precepts, he states that "Different methods of employment, and not saving and increases in the available quantity of labor, have changed the face of economic world in the last fifty years" (Schumpeter, 1944, p. 68) Differentiation of labor between directing and directed one, claims its importance at this moment as performing new production functions requires the command over the productive forces. Changes generate resistance, and in this case, economic agents tend to try going back to more familiar methods. Unless there is effective leadership avoiding the retroversion, innovation will never happen. The Schumpeterian entrepreneur embodies that agent that organizes and leads such transitions.

The capitalist, another classification employed in Schumpeter's work, plays the role of financing the transition through credit for the gathering of new productive means. Eventually, the substitution of the old methods by new ones causes pain in society as

productive resources become obsolete. The main problem for those organizing the new productive processes is to finance the replacement of the productive means. Some of them pay for the conversion with funds obtained in previous periods, while others turn to people in possession of wealth to support the enterprise. Thus, both roles, the entrepreneur and the capitalist, are necessary, according to Schumpeter's proposal, to start up innovative productive processes.

Contrary to previous theories of development, in Schumpeter's view the entrepreneur is not any person who just organizes means of production to perform a process, but that who performs the endeavor in an innovative manner. The individual receiving such label shall not be confused with the independent laborer, described in lines above. Any person in the capacity to introduce new products to the market, new forms of combining productive resources, or any other form of innovation, can be an entrepreneur regardless of her/his position in the organization. Despite he does not consider entrepreneurs as a social class like workers or landowners, and despite he describes that entrepreneurship is, in general, a temporary attitude, the author assigns this type of person enough attributes to treat as a subject of study within his theory of economic development.

Intending to explain entrepreneur's behavior and its importance to economic development, Schumpeter establishes three fields with a collision of two opposite forces within each of them. In the first place, he contrasts the theoretical tendency towards equilibrium to the disruptions generated within the economic system itself. In second place, stablishes a comparison between the static approach, a theoretical perspective in fashion at the time he developed his theory, and the dynamic character of the economic system. Finally, he distinguishes between the conduct of the entrepreneur and that of the manager. In short, he concludes that the entrepreneur is that with the mental, and not few times, physical ability, and with the will to perform, not the best empirically tested production process, but the best possible one. On the other end, the mere manager is a person that, even when in a directive position, conducts her/his action according to traditional methods sheltered by certainty of custom.

With the introduction of the capitalist, embodied in a person who provides funds for the new initiative via credit, Schumpeter also challenges prevailing theories of development. While most of the theorists rely on savings and accumulation of productive factors to explain

development, Schumpeter includes a complete elaboration of the creation of purchasing power via the credit to finance new production processes and the acquisition of new goods in markets. Newly created means of payment has not a function in growth when circular flow is on the track dictated by custom, where development is not possible, according to Schumpeter's opinion.

The lack of empirical evidence, social and institutional context, and theoretical elaborations on the origins of the entrepreneur are some of the critiques to Schumpeter's work. Several scholars argue flaws in Schumpeter's theory of Creative Destruction. The theory, some of them says, is based mostly on abstract reasoning (Baumol, 1990; Gintis, 1991) Some other remark the absence of a theoretical development of the figure of entrepreneur, and the over emphasis on its role, neglecting that of society, and institutional factors (Commons, 1931; Davis & North, 1970).

Substantive Theories of Regional Economic Growth Within a Context of Rapid Technological Change

This section explores theories directly dealing with the interplay of technology, human capital, and regional growth. These are considered substantive to the analysis of Juárez's evolution as an economy exposed to the latest advances in technology. Technological determinism gives innovation the role of an engine of societal change (Veblen, 2017; Schumpeter, 1944), yet critiques reveal its path dependency and the human factor as blind spots (Pérez, 2003). Nelson and Winter's (1982) evolutionary theory rejects static equilibrium models, instead framing technological change as dynamic, path-dependant process driven by firm-level routines—tacit knowledge and skills that shape technological absorption. Human Capital theory, attributed to Schultz (1961) and Becker (1993) bridges this gap, framing skills, health, and training as investments that mediate technological adoption. Regional models, pioneered by Alfred Marshall (1957), and expanded by Vázquez (2007), help to contextualize Juárez's reality as a globalized manufacturing hub buoyed by cross-border integration. Persistent strains imposed by skill mismatches and structural inequalities in the region are also analyzed here using the lens of the structuralist Raúl Prebisch (1996).

Innovation and Technological Change

The term *technological determinism* refers to the influence that progress in the modes of production has on the evolution of society. The term first came out after the argumentation of Thorstein Veblen (2017) about the way in which technological advancements drive the way people live their lives by shaping economic institutions and social norms. Veblen argues that technological progress creates a new distribution of wealth. The author also claims that changes of modes of production even create new forms of power, concentrated in the hands of the individuals and institutions in control of the technological means of production. Changes in production technology, says Veblen (2017), create new forms of industry and commerce, which in turn shape people's behavior and customs. In summary, *technological determinism* bases on the idea that technology shape society by driving the performance of an economy.

In the field of economics, the term is commonly associated with Schumpeter's theory of creative destruction. Several authors highlight the coincidences of Schumpeter's and Veblen's thinking on the evolution of society and economy in relation to technology. Schumpeter's analysis of economic growth of development gives central importance to new modes of production in the displacement of existing industries and the rise of new ones—a process later refined by Nelson and Winter (1982), who recast creative destruction as an evolutionary outcome of firm-level routines and heterogenous capabilities. The theory of *creative destruction* is commonly seen as deterministic as its creator posts technological innovation as the driving, if not sole, force behind economic change (Nelson & Winter, 1982; Arthur, 2009). However, the Schumpeterian determinism is also considered to be very simplistic, as said analyst does not deepen into sociocultural factors (Pérez, 2003) and assuming uniform firm responses to innovation, a limitation Nelson and Winter (1982) address by emphasizing organizational inertia and skill-based adaptation.

The theory of technological change is a complete field that delves into the form in which innovation, translated into new ways of production, leads to improvements in efficiency and productivity. The impact of innovation in an economy is a function of the form in which technological advancement is developed, adopted, and diffused (Rogers, Singhal, & Quinlan, 2019). According to Nelson (1982) and Pérez (2003), the incorporation of knowledge into innovation and therefore, technological progress, is a complex process that

involves a wide range of factors of economic, social, political, and cultural order. In that sense, the change is described as path-dependent and cumulative, meaning that the changes occurring at any time and place are shaped by the existing technology, knowledge, and institutions, and those changes, in turn are the base for upcoming advancements (Deaton, 2015). Nelson and Winter's evolutionary framework explicitly links this path-dependency to firm routines—standardized procedures embedding tacit skills—which determine how technologies are absorbed and adapted.

The theory of technological change remarks the importance of historical developments to understand the mechanism by which changes in production techniques occur, and how they shape the economy and the society (Abramovitz & David, 1973). Technological progress enjoys recognition as a key driver for economic growth because of the enhancement of productivity and efficiency because of applied innovation. After Schumpeter, most of the literature on the topic recognizes the importance of institutions, social norms, and other factors for technological progress to result in economic growth and development. The process is also described as one of long-term that, even though is cumulative, does not follow a linear path but takes place in cycles of experimentation and learning (David, 2000)—a view aligned with Nelson and Winter's (1982) emphasis on trial-and-error innovation and Arrow's (1962) learning-by-doing.

The cumulative nature of technological progress ensures that advancements in one field often enable breakthroughs in others, amplifying their effects on economic performance. This endogenous relationship stems from knowledge spillovers and learning-by-doing processes that occur as firms and workers interact with new technologies (Arrow, 1962; Romer, 1986). Certain transformative technologies—exemplified by Bresnahan and Tajtenberg's (1995) concepts of general-purpose technologies—demonstrate this dynamic most vividly, as their adoption reshapes production processes across multiple sectors simultaneously. However, even incremental innovations contribute to this virtuous cycle by expanding the collective skill base and creating new problem-solving paradigms (Nelson & Winter, 1982).

Some of the authors from the theory of technological change emphasize the role of human skills in the process of technology adoption and diffusion. Knowledge is an important aspect of technological advancement (Becker, 1993). Practical training is another important

vehicle for the transmission of technology (Arrow, 1962). Nelson and Winter (1982) deepen this by framing routines as repositories of collective skills, which either enable or constrain technological absorption. Other important aspects, needed for introducing human features to the production process, such as migration and health, were introduced into the analysis as factors to describe the input of workers to progress in efficiency and productivity. The accumulation of those elements started to be seen under the same scope used to analyze physical capital, and the expenditures of persons and states on the matter, dealt with as an investment (Schultz, 1961; Becker, 1962).

Collectively, these theories dismantle the myth of technology as a self-sufficient growth driver. Instead, they position human capital investment as determinant of whether the introduction of innovative technologies entrench disparities or fosters equitable development. The regional perspective brought to the analysis by Vázquez (2007) further confirms that spatial factors—including cross-border integration and institutional thickness—modulate these effects in an economy like Juárez. This theoretical framework directly aligns with the study's objective of centering human capital as the core variable of growth models of emerging technological paradigms.

Human Capital Theory

Since the decade of 1960's human abilities to produce has been a topic in the study of economic growth. In the paper *Investment in Human Capital* (1961) Theodore W. Schultz pioneers in introducing human skills as explicative for differential in economic growth between economies. One year later, the Nobel laureate Gary Becker published *Investment in Human Capital: A Theoretical Analysis* (1962), explaining the idea that people engage in activities aiming at enhancing their abilities with the expectation of a larger income in the future. Both Schultz, and Becker enjoy recognition as precursors of the *human capital theory,* (Acemoglu & Autor, 2010; Murphy & Topel, 2016; Lemoine & Munoz, 2021) nurtured afterwards by several authors and concepts clarifying the relation with economic growth.

Parallel to the emergence of the *endogenous growth theory,* Schultz's work contributed to the introduction of the concept of *human capital* to the study of economic growth and development. In the early literature on the topic, researchers seem to converge with this Schultz and Becker in defining human capital as the cumulus of knowledge, skills, and physical aptitudes attained by labor force to contribute to create economic value (Nelson

& Phelps, 1966; Mincer, 1981) According to scholars in the field of economic growth and development, formal education has an impact on individual earnings but also influences the total output of the economy (Hansen, 1963; Mincer, 1981). Education has been even included in the study of well- being (Bowen, 1964). In the early literature of human capital, education is considered as a factor to determine individual earnings. However, researchers rapidly turned their sights to its external effects of macroeconomic order (Haveman & Wolfe, 1984).

Another factor commonly recognized has a factor of economic development is practical training. Arrow (1962) is known to be the pioneer of endogenous growth models as he remarks the importance of the force of practice in the productivity of labor force. Mincer (1962) advocates for the inclussion of the topic as a matter of economic analysis beyond its effects as a matter of investment by the worker, as previously suggested by Schultz (1961). Mincer call the attention to the implications of the practical instruction by the labor force as he presents a classification of the types of training that firms provide to their workers, according to the applicability of acquired knowledge. In this case the author separates the training that is only applicable in the providing company, labeled as *specific training;* and that of general purposes, tagged as *general training*. The implications of acquiring skills by participating in productive processes remain as an object of study in the field of economic growth. Nowadays, learning is not only seen as a factor for increasing productivity, but also because it helps to open new markets and reduce transaction costs (Lombana & Santiego, 2017).

Health is also considered a critical component of human capital in modern theories on the matter. Health, says Schultz (1961), is significant from both microeconomic and macroeconomic perspective. It is especially important for an individual to remain healthy for an individual to take advantage of knowledge acquired through formal education or by force of experience. According to the same author, the aggregation of healthy individuals forms a more efficient and productive labor force.

The most recent theories, aiming towards comprehensive and qualitative approaches, do not neglect the importance of health and healthcare to the productivity and efficiency of an economy. Analysts of the human development approach (UNDP, 1990) consider health as a precondition for economic growth: improvements in health lead to increase in productivity as healthier individuals are better able to work, learn and contribute to the economy (Haq,

1991). When an individual is not in good health, it will be very difficult to acquire knowledge and skills and, even for prepared persons, it is difficult to take advantage of skills if they are not healthy (Sen, 1999). There seems to be a consensus on the importance that investing in health holds for national economies (Bloom, Canning, & Sevilla, 2004; Jagrič, Brown, Boyce, & Jagrič, 2021).

As some researchers analyze the effects of a healthy labor force on economic growth, others do the other way around. Causality between economic development and health care is not very clear as some literature employs economic growth as explanatory to the coverage and quality of health care in an economy (Elmi & Sadeghi, 2012). In some literature, the relationship has been proven both ways (Bedir, 2016). In some other literature, authors go further as they search for differences in the health care expenditure between economies of varied sizes. Jakovljevic, et.al. (2020) employ a comparisson between two groups of countries (*i.e.,* G7 and EM7) to analyze the effects of the growth of an economy on its health care system. The results of the research seem to be consisten in showing that such effects are a function of the size of the economy itself.

In the seek for a theory that explain the mechanics of economic growth, within a neoclassical framework, (Lucas, 1988) compares the models that emphasize accumulation of physical capital, to those centered in the creation of human capital through schooling and/or practical training. According to the author, differentials in technology across countries cannot been explained by knowledge in general because he considers knowledge as homogeneous around the world. He attempts to formalize the individual decision of acquiring knowledge as an economic one. In the macroeconomic spectrum, he summarizes the impact of all personal choices, studied as investment decisions, on productivity. Analogically to physical capital, the sum of skills that all individuals within an economy manage to accumulate in a period, is the stock of human capital of an economy. Lucas' model studies how the skill possessed in a period affects production at this time, and how the time devoted to the creation of other activities impacts future ability to produce, not only of labor itself, but of the rest of the factors.

The theory of human capital has been object of criticism from various perspectives, most of them referring to its limitation in the practice. Some of the most common refer to the hardness of measuring human capital, lack of considerations about social and cultural factors,

and the risk of downplaying the importance of physical capital in the production process. The investment approach, which gives the capabilities of workers the category of capital, presents, according to the critiques, two problems: the difficulty evaluating the assets that people obtain by devoting time to becoming more efficient at work, and the difference of returns that individuals obtain for such investment according to the context. Other more analytical approaches, such those of Marxist basis, deepen in how this theory deals with work as a merchandise neglecting its nature as a human activity.

Conducting empirical analyses of investments in human capital is a challenging task because the results of assigning resources to the acquisition of capabilities vary with the context. Traditional market mechanisms, essential to the neoclassical framework, depend on objective criteria to assign value to the assets. Assigning value to people as productive assets presents too many variables which makes it difficult for empirical analysis (Weisbrod, 1961). Even more than half a century after the emergence of human capital theory, researchers struggle to establish a feasible method to assess the contribution of knowledge and skills to the production (Abraham & Mallatt, 2022).

Early literature on human capital, especially that of neoclassical nature, neglects the relevance of social and cultural factors when an individual gets to collect the returns of an investment in human capital. During the first half of the twentieth century, development economists and policy makers thought of years of schooling as the main tool to equalize societies. When human capital came up as a matter of more conscious studies, it was demonstrated that structural aspects affect the impact of the years of schooling on individual incomes and in productivity (Bowles, 1972).

Regional Growth and Development.

Investing in the enhancement of health and skills is a process inherently tied to regional dynamics, just as the absorption of the results from R&D activities. Aghion and Howitt (2009) refine the views of endogenous growth theory scholars, as they demonstrate how localized competition and institutional incentives determine the pace of technological adoption. Growth and development approaches align with endogenous growth theory by emphasizing the importance of disparities in knowledge diffusion and absorptive capacity in explaining the spatial disparities in development. Regions with robust human capital bases,

such as innovation hubs, leverage these endogenous mechanisms to sustain growth, while lagging territories face compounding disadvantages. This interplay between place-specific learning and macroeconomic performance underscores why endogenous growth theory remains vital to understanding regional divergence.

During the decade of 1970, the region became the subject of study to economists in the field of growth and development. One of the main changes in approaching the topic occurred when analysts turned their sights to the behavior of economic units and its effect on a territory's economic performance. To study the dynamics and interaction of economic forces within regions it became necessary to explain the expansion of production in the long run.

The consolidation of globalization got the regions in a competition not only with adjacent territories, but with geographically remote regions. Vázquez (2005) marks the early 1980's as the starting point of the modern stage of the process. It was during that period, says the author, that advancements in communication technologies allowed financial capitals to flow, and the production processes to spread over several territories. Major political reinforced the process, as developing countries started to reform their internal law frameworks in favor of more economic openness (Stiglitz, 2008). By the end of the decade, the fall of the Soviet Union yielded to an expansion of the markets across the territories of its former block. An exacerbation of the international division of work, and the establishment of global markets forced regions and organizations within to reorganize and improve their processes.

The concentration of economic activity in specific regions is the result of the reinforcement of special forces by local agents. Krugman's (1991) explains how skilled labor and industries cluster in urban centers, generating agglomeration effects that amplify productivity and innovation. His core-periphery model illustrates why some regions become hubs of human capital while others lag, trapped by lower economies of scale and weaker knowledge spillovers. These dynamics are particularly relevant for technologizing economies, where the geographic distribution of talent shapes competitiveness.

Economic development is not a linear process, neither is the growth path. Even in a scenario of integrated markets, regions follow different trails in the process. Structural

differences among regions cause asymmetries in the forms of each national economy, or even each region increase their product (Gutiérrez, 2014). Urban communities tend to be recognized as more productive than rural. The so-called modern sector very often concentrates within the cities, while the rural areas commonly dedicate to agricultural production. Economic activities developing within the larger, and more concentrated population centers use the more advanced technologies. Currently, most microelectronics, biotechnology, robotics, aerospace, and other industries related to digital conversion occur in the cities. Urban zones are also more diversified, service-based productive activities such as technical assistance, financial or legal services, installed in the cities around the manufacturing centers.

Vázquez (2005) explores a variety of regional development models with different pathways. His classification has its basis on regional criteria about the integration degree of local firms and the place where decisions are made. In that taxonomy, the more innovative regions are those in which several local-based companies integrate among them. Such a level of integration and capacity for decision making creates a labor market with a logic of its own that facilitates exchange of ideas. On the other end he describes those regions in which larger firms are part of an externally based value chain and have no significant ties to the local productive landscape. These regions are characterized by concentrated labor markets and low levels of innovation, very often dominated by larger firms.

Perspectives on the role of human capital in growth and development cannot be separated from the institutional environment they operate in. Acemoglu, Gallego and Robinson (2014) emphasize that institutions determine whether investments in education and training programs translate into economic progress. Weak property rights, inefficient governance, or rent-seeking behavior can stifle innovation, even in regions with abundant human capital. This institutional lens helps explain why some areas struggle to harness globalization's opportunities despite skilled workforces. Without supportive frameworks, the benefits of knowledge and innovation risk being confined to isolated enclaves.

According to the Vazquez's (2005) findings, firms from the most advanced economies create most of the innovations and dominate labor markets of regions where they operate. Monopoly power resulting from such supremacy widens the gap with the developing countries, contrary to the precepts of the theory of convergence. Concentration of

technological progress is one of the factors that the theory of dependance uses to explain divergences of development (Prebisch, 1996).

Not only innovations in products are relevant for the differences in productivity. Vázquez (2007) says that new knowledge introduces into the productive processes through changes in organization of the inputs. In that sense, productivity is a function of the ability to find more efficient methos of production. In response to the empirically observed divergence in growth rates due to the differences in innovative capacity, regional development policies since the 1970's focus on spreading knowledge and innovation internally.

Achieving economic growth and development of a region depends upon having the resources and being able to coordinate them. Among the "immediate forces of development", defined as resources at hand for an economy to increase its product, Vazquez-Barquero cites availability of labor and equipment, as well as social capital, which can be defined as the efficiency in interaction between agents. A deeper analysis of cited factors implies an assessment of the firms in terms of productivity and originative capacity, functioning of institutions, and the qualification of labor force.

The ability of the agents to adapt to changes in the environment is also important for a region to improve its productivity. At strategic level, diversifying products incentive innovation and spurs investment (Romer, 1986). Such phenomenon is a matter of the regional growth theory since the coordination of acting forces is required. Recognizing differences between regions makes it difficult to elaborate a unique theory that explains the phenomenon of economic growth in every region, making case studies a more adequate technique for the endeavor.

Barber (2009) credits Alfred Marshall the idea that it is not the size of its firms that determines the ability of a region to generate economic growth, but the way that they interact and within the territory because of, among other external economies, the flow of knowledge and resulting innovations. Diffusion and adoption of new knowledge is the force of development relevant to this research. It is assumed that the introduction of knowledge produces economies of scale that favor productivity and expand markets.

Marshall's theory on Industrial Districts, tied, by definition, to a territory, is seminal to regional economics. theorist. He takes them as the unit of study in his elaborations on

economic growth and explains the mechanism by which they facilitate the exchange of existing knowledge and the creation of new one. Other authors point out that socio-cultural factors intervene in the creation of an industrial environment in which forces of development flourish.

The specific force that any industrial network depends on the needs of integrated firms. According to the nature of their activity, some firms require the development of, for example, a source of raw materials. More innovative sectors require an environment apt for the development, attraction, and retention of qualified labor force. Universities, training centers, and research centers play a significant role in the first part. An offer of cultural and leisure services helps the other two. A proper base of qualified workers and technology-based industry also help to develop, attract, and retain skilled workers.

The presence of firms with financial capacities to invest in R & D, and the technical ability to benefit from such ventures favor endogenous growth. Interaction with local firms fosters the transmission of knowledge. The acceleration in the process of globalization forces the companies to establish an R & D joint venture with other companies in the same region to generate economies of scale and gain in competitivity. Investment decisions are a function of the expected benefits but also changes the structure itself. The wideness and depth of the changes depend upon previous conditions of the economy, for instance, the vias for transmission of knowledge, and the ability of other firms to assimilate it. Innovations and their effects on an economy are endogenous in territorial sense because they depend upon the interaction between firms within a geographical area. Models of the Endogenous Growth also refer to the phenomenon as endogenous because it is a positive correlation between production and investment in R & D activities. The new knowledge created by the result of R & D being conducted gets into the economy though the improvement of production technology that, in turn, translates into accumulation of capital, a base for economic growth.

Schumpeter (1944) does not elaborate theoretically about the effects of R & D investment on economic development of the regions, but he points out the firm as a main agent in technological progress and resultant economic growth. According to him, it is within those entities that knowledge gets into productivity by means of day-to-day activities. Vázquez (2005) classifies those routines in three types according to the aspect of the firm that they impact: operative processes, systems and criteria for decision making, and learning

mechanisms. The last one, says Vázquez-Barquero, in the production techniques and increases productivity in the long run. The effects of learning vary across firms according to its own organization capacities and the technological features of the industry (Cohen & Levinthal, 2007) A continuous learning process is vital for a firm to adapt and prevail within a constantly changing environment.

Investing in physical and human capital has a diffuser effect that depends upon the connections between firms within an economy. Arrow (1962) says that the introduction of new capital goods, which incorporate knowledge, impacts all the aspects of the relevant market and increases the total stock of knowledge in the economy. Knowledge, in turn, is a public good, because once it is employed by the generating firm, it becomes available for the rest of the agents in the economy. The portion of the knowledge that spills over the economy after being released by originating firm is a function of the firms encompassed. Education and training of labor force explain, in part, the stock of Human Capital of an economy (Lucas, 1988). Providing workers with knowledge and skills makes them more productive, and more capable of acquiring and introducing new knowledge to the productive process. (Cohen & Levinthal, 1990)

The role of the region, in its geographic and social scope, is key to creation and diffusion of innovation (Vázquez, 2007). A region can be defined, from the social perspective, as the forms in which agents organize their economic activities. Relationships between the economic agents within a territory, but also the economic and technological history of the geographic area are explanatory to the learning processes occurring inside its boundaries. The stock of knowledge that a region manages to pile across time, and the customs of the agents define the velocity at which knowledge is created, and the wideness it spreads.

Vázquez (2005) points that knowledge travels across firms when they exchange goods and services and when workers rotate from one company to another. That process, however, is not a homogeneous one. The way in which the transfer occurs depends on certain preconditions of the economy. Since the last decade of the twentieth century, and at the beginning of the twenty first, development policies in more advanced economies have turned around the facilitation of knowledge and innovation diffusion. Theorists like Schultz (1961), and Becker (1993) acknowledge the importance of tacit knowledge transference, happening

mostly within the firms, in the process of improving human capital; economic policies in the most advanced economies consider these types of processes.

Urban development is an important aspect to review when analyzing the preconditions for economic performance of a region. Due to the concentration of industrial activity, and higher levels of aggregate demand, the cities are considered by many as the epicenter of the productive activity of the economies. Concentration of population, specifically experts, facilitates endogenous development by means of the creation of networks. Besides, as investment decisions depend upon the expectation of returns, those in possession of physical or human capital seek each other to increase their respective productivity.

The need for specialized workers in urban centers, due to the concentration of industrial processes, increases the stock of human capital for several reasons. Diversification of activities in industrial processes favors the division of work, and therefore, specialization. Firms generate external economies for the formation and enhancement of workers' abilities. Companies with common needs, in terms of skills and knowledge, share the costs of creating and operating research centers as well as formation and training facilities. The presence of technology-based industries makes a region attract qualified workers because they expect to be more productive there. Finally, Lucas (1988) describe the cities as a generator of innovative ideas due to the interaction between

Vázquez (2005) describes four types of industrial spaces according to the kind of technological advancements that gives them for. In the first place, he lists the excellent models, formed by networks of firms producing novelty goods or services, and/or employ new methods in their processes. These systems nurture from a base of qualified human resources, entrepreneurship, adequate infrastructure, R & D investment, and effective institutions. The second group is the technological pole, that encompasses innovative companies clustered in a territory endowed with a qualified labor force, R & D centers, access to expanding markets, and financing availability. The third one is the development pole, which encompasses companies of incremental innovations. These clusters are normally started up by foreign companies that arrive in a given territory in search of economies in productive resources or fiscal benefits. Finally, the author proposes the local system of

companies, resulting from endogenous industrialization processes. They tend to surge in medium size and small communities with entrepreneur capacities.

The interplay between endogenous growth, special forces, and institutional reveals human capital as the cornerstone of modern development. While endogenous theorists highlight its role in driving innovation, authors mentioned in the paragraphs above clarify why the impact of such actions varies across regions. Agglomeration effects and institutional quality either amplify or undermine the returns on skills and knowledge. For policymakers, this means that strategies to boost human capital must be spatially aware and institutionally sensitive. Only by addressing these dimensions can a region fully harness technological change for inclusive growth.

The Latin American Approaches

By the beginning of the twentieth century, international trade was organized with the northern, more industrialized economies importing raw materials from the southern less industrialized countries. The latter used to employ money inflows to buy finished goods from the former. The Great Depression of the decade of the 1930's represented a massive shock in the demand for commodities by developed countries, and the correspondent lack of capacity of the less developed to keep pace in purchasing of manufactured goods. Within the framework of Keynesian ideas in economic policies around the world, governments of undeveloped countries implemented the Imports Substitution Industrialization process, consisted of producing internally what otherwise, they would have had to import (Ríos, 2007).

Latin American countries implemented such policies with relative success in the production of consuming goods. In the larger economies of the region like Argentina, Brazil and México, the model yielded good dividends. The history is different when it comes to the production of capital-intensive goods such as vehicles, ships, and other machinery, which continued to be imported due to the incapacity of southern economies to produce them at competitive costs. As a result, the technological advantage held by the richest countries grew, and the income gap widened.

After the Second World War, economists and politicians of the Western Hemisphere started to worry about the problem of differentiated development and raised the question of

what the less developed countries should do to catch up with the industrialized economies. Following the recommendations of Classical and Neoclassical schools, economists from industrialized world, aimed their sights back at a system of international trade based on the theory of comparative advantage, in which undeveloped countries should specialize on the production of raw materials, while the more advanced economies placed in charge of the production of the value-adding activities (Prebisch, 1996).

According to developing theorists of those years the international division of work was a natural process that would unfailingly yield to a convergence between the undeveloped, and the developed countries (Aghion & Howitt, 2009; Todaro & Smith, 2015). One of the main theories lined up behind the argument of the convergence, was the one championed by Walt W. Rostow (1959). According to his theory, all the economies must go through the same process to achieve growth. Such a process, says Rostow, is linear and consists of the same historical stages that it starts at the traditional economy, based on agriculture. Afterwards, the nation sets the conditions for the so-called "take-off", so that would be, naturally, the next stage. Takin off leads to a status of maturity, which yields to an era of mass consumption. When time passed by, Rostow and other economists saw their expectations about the *catch-up* unfulfilled.

As empirical evidence showed a divergence in the growth path of the economies, instead of predicted convergence, other economists from universities in the industrialized world came up with new theories to try to explain the phenomenon. During the same period, Latin American specialists started to contemplate the same problems, but from the perspective of less favored economies. Argentine economist Raúl Prebisch published *El desarrollo económico de la América Latina y algunos de sus principales problemas* (1996). Also known as the Latin American Manifesto, Prebisch's oeuvre gave birth to a whole new school of economic analysis known as Structuralism. Structuralism then is a critique of the economic system of ideas based on the International Division of Work paradigm. For theorists of this stream, the differences in development among countries hold historical roots grounded in the colonial epoch that have done nothing but deepen and stand on throughout time.

For structuralists, the involvement of Latin American governments in their respective economies is necessary to modify the structures that obstruct the growth. Adherents to the

stream warn that such changes demand a long-term, deep intervention of the state to break with what he calls the dominant thinking about ruling economic relationships between developed and developing countries. One of the main ideas that Structuralism presents is the conception of an economic center, and an economic periphery. According to this theory, the former carries on the capital-intensive processes, while the latter, of which Latin America is part, is condemned to merely extractive activities. The high value and diversified endeavors of the central economies procure them high income levels and the correspondent standard of life, while it stretches those in the periphery to undiversified, less productive activities.

While Prebisch's center-periphery model exposes the structural imbalances of international trade, later structuralists revealed how these disparities became institutionalized through the systematic lack of human capital formation systems. Celso Furtado (1961) emphasized how dependent industrialization perpetuated technological backwardness. Ovaldo Sunkel (1969), on his side, exposes how translational corporations deepen the gap impeding their subsidiaries in "…our countries—with a few exceptions—to acquire the ability to adapt and create their own technology…" (p. 31). Structuralism emerged as a systematic critique of international division of work paradigm, demonstrating how heterogenous productivity structures became entrenched in peripheral economies (Pinto, 1970).

The economic structures of the center tend to homogeneity as they perfect and standardized the production techniques thanks to the practice, while in the periphery they are heterogenous because a part of society works in activities aimed at supplying the international markets with no real connection to the process. As a result, Latin America suffers a huge inequality that manifests in several forms. For this work, the most relevant of those differences is that presented in the labor force, where some workers hold world class skills, while others do not possess a relevant ability for the modern economy.

Structuralist theorists argue that peripheral economies face systemic barriers to human capital development, exacerbating the gap in their growth with respect to the most advanced economies. While the founders of the stream put the emphasis on constraints related to the terms of trade, other authors also highlight the divergences in the formation of human capital across, and within Latin American economies. Fajnzylber's (1988) argues that such divergences, which he labels as "truncated technological learning", are the result of

domestic institutional choices more than external dependency. Rivera (2014) echoes that view through an analysis of the economic trajectory of Brazil and México during the second half of the twentieth century. The author explains how the former enabled industrial upgrading and higher-value manufacturing through the expansion of the "spaces of social mobilizarion" (*e.g.,* education and technical training), while the latter's fragmented elites prioritized rent-seeking over long-term human capital investment, relegating much of its workforce to low-skill, informal sectors. These divergences are only a sample of how institutional priorities within national economies—occasionally in conjunction with global asymmetries—determine whether peripheral economies cultivate human capital for development or perpetuate cycles of technological backwardness.

In their explanation about the Structuralism, Todaro and Smith (2015) remark that underdevelopment is a consequence of the historical development of capitalism, under which, the growth and development of certain countries, based on traditional economy (*i.e.* primary production), directly depends on the development of other group of more industrialized countries. For the structuralists, the demand for products of the underdeveloped countries, most of them an outcome of extractive processes, depends on the growth of more industrialized countries. At the same time, the production in the countries of the first group relies on the import of capital goods from those in the second group. In other words, industrialized countries in the center hold the potential to expand by self-impulsion, while the economies in the periphery depend on international commercial relationships that resulted in unequal and, very often, unfair.

Just as in the majority—if not the total—of the technology-intensive economic sectors, the also called western economies hold an advantage over the developing nations, included the Latin American countries. As a result of the historic application of the International Division of World model, Latin America has neglected the creation of basic conditions for the development of new information and communications technologies, while the central economies have expanded theirs, generating a network effect that widened the development gap. But the impediments to industrialization in Latin America not only respond to external factors. There are several internal conditions in the region that explain the backwardness. Diverse theories on regional growth and development explain those conditions that red tape the growth in Latin America. One of the main obstacles to expansion

of production and achievement conditions of development is the lack of coordination that causes markets malfunctions. Rosenstein-Rodan (1943) say that small markets are not fertile ground for investment. In an economy with low levels of aggregate demand, firms have no incentives—they do not even have the revenue—to invest in returns to scale technologies, therefore industrialization is not possible.

Human Capital

Coinciding with the appearance of the idea of Learning by Doing conceived by Kenneth Arrow at the beginning of the 1960's decade, Schultz (1961) challenged the notion of homogenous work employed by both classical and neoclassical economists in their models. The author also disputed the concept of investment included in those models as he assures that the expenses made by people in the acquisition of knowledge and skills, and even those allocated for healthcare must be accounted for as investment for the purposes of economic growth. For Schultz, the exclusion of people's investment in human capital, had several explanations. One of them is the hardness of calculations. If it is measured in monetary units, it is difficult to establish the impact of, let us say, a dollar on individual's productive capacities.

Another Nobel Prize Laureated, Gary Becker (1993), also an economist from Chicago, affirms that all capital yields, by definition, to return. The main difference he establishes between the physical and human capital is that the latter cannot be separated from the person who made the investment for its acquisition. The author uses a historical analysis to determine that it is differentials in human capital, and not in the physical one or in the endowment of natural resources, the main explanation for the divergent growth rates among countries.

Gary Becker is one of the most recognized theorists in the field of Human Capital. In the third edition of his oeuvre on the matter, *Human Capital: A theoretical and Empirical Analysis with Special Reference to Education* (1993), he points at the increasing interest in the productive capabilities of individuals as explanatory to economic growth and development. Nonetheless, he observes, the multiple studies devoted to the topic exclude important components of Human Capital other than years of schooling or on-the-job training. Some of the findings and discussion of this book shed light on the connection between

investment in human capital and economic growth. Those are analyzed in the following paragraphs.

In Becker's (1993) definitions, the concept of capital, whether physical or human, always implies a return. Technology has an impact on the expected returns when persons invest in gaining Human Capital. Gary Becker states that the first industrial revolution caused families to start investing more in their children's education and shows evidence of an increasing demand for educated laborers as expenditures on research and development, and military technology grew in the mid twentieth century. Author's conclusions suggest that investment in human capital generates substantial income differentials in all types of economies. Based on historical data, he observes that the logic of productive factors accumulation does not explain the substantial, long run growth of income in the United States and other western economies. In seeking an explanation of the differences between developed and undeveloped and planned economies,

To analyze the improvements of human capital as a matter of investment, Professor Becker (1962) conduct a study to measure the impact of education and training on personal incomes from the microeconomic perspective, and its impact on the aggregate performance of an economy. Findings suggest that increases in productivity generated by technological advancements surpass loose caused by the diminishing returns of factors anticipated by the neoclassical idea. Countries presenting perennial, or at least the longest periods of continuous economic growth, are those that invest the most in the preparation of their labor force to generate and handle technological advancements. In the case of Japan, and other Asian countries known for having reported rapid growth rates in the decades after the Second World War, Becker attributes the phenomenon to the participation of a not only well-educated, but more than that, well-trained and conscientious labor force.

Agriculture is a sector in which the influence of technology and human capital on economic growth shows better. Technology plays a very small role in the farms of the underdeveloped world, while is every time more present in those of the advanced economies. The gap in productivity between those types of countries grows bigger and bigger, according to the evidence shown by Becker, who claims that in the developed nations, rural workers are as well trained and educated as industrial laborers. On the other hand, farmers living in less favored economies form the less educated group of their respective peoples.

There are several ways of increasing people's productive capabilities, according to Gary Becker (1962). Formal education, acquired through schooling, medical care, migration, and knowledge of markets are among the forms of human capital identified in his studies. All the forms of human capital report pecuniary and psychic benefits for people. Regarding the former, all the research dealing with the impact of knowledge and skills on personal income, with respect to the latter, the author expresses that education –both formal and informal— influences personal habits of workers, and therefore the personal and collective productivity. Schooling, says the author, equips recipients with knowledge and critical thinking, even though it is not of great benefit in terms of productivity. Causality between formal education and productivity goes the other way around, according to his analysis of human capital. Conclusions of the study states that if the people with more years of schooling are more productive it is not because those years made them more productive, but because more productive people reach higher degrees. Even though Becker admits that high school and college education provide workers with information necessary to enhance their productivity in technological advanced economies.

Performing a task in a productive process or receiving training within a productive unit is also an important source of human capital, states Becker. The forms of receiving on-the job training is several and range from informal word of mouth transmission of knowledge to well-structured programs according to the complexity of the process involved. One of the main differences he establishes between physical and human capital is that the latter cannot be separated from the person who, literally, embodied the investment. Those countries with the ability to attract, or retain well educated and trained labor force, enjoy a competitive advantage over those that do not.

Advocates of human capital as a factor of growth and development have faced criticism. One of the most recurrent aims towards the correlations established between investment in human capital and personal income. Critics of the idea suggest that what ties both variables could be a covariance, instead of a correlation. For them, people within the more privileged groups have access to better opportunities, not necessarily as a product of their performance in school, in which they tend to spend more according to their possibilities.

Edward F. Denison (1985) credits improvements of human capital, more precisely years of schooling, for approximately a quarter of the growth in productivity of the United

States' workers. This author studied the period from the Great Depression of the 1930's to 1982 from the perspective of several metrics trying to explain the growth of national income. Even though his findings report a fall in both potential national income and the ratio of real national income to potential national income, they yield to conclusions on the importance of schooling for productivity. The study is inconclusive about the determinants of national income, including those related to human capital such as health care, on-the-job training or migration.

The mechanism by which workers enhance their abilities being part of a productive process is widely discussed in economic growth development theories, such as Kenneth Arrow's (1962) learning by doing theory. Even though Gary Becker mentions that such effects are practically absent in the firm behavior theory, he states that workers may learn new skills or perfect those they already possess when performing day-to-day tasks. Since ability enhancement can increase outcomes in future periods, firms can assume the learning curve as part of the costs of training. According to the marginal analysis, they will decide to incur in such cost if they expect revenues in the future.

Becker classifies on-the-job training in two categories according to the potential use of acquired skills. He labels those training activities providing abilities that are useful in other firms, or even in other economic sectors such as General Training. When a company equips its workers with very customized knowledge, only applicable within the self process, it is known as Specific Training. The former generates positive externalities in the economy, while the latter does not, even though it contributes to the aggregate productivity of the sector and the economy itself as it supposes to increase productivity within the company. The effects of the training vary depending on the general conditions of the economy, mainly on the structure of the labor market.

Schooling and on-the-job training are not the only way of acquiring human capital. Other knowledge complements worker formation according to Becker's thoughts. Depending on the type of task, a worker might need more years of schooling or more practical training, but a bundle of these two methods is very common in the process of knowledge transference. The other aspect of human capital is the ability to gather, analyze, and use information in the decision-making process. Professor Klaus Schwab (2016) label this as contextual intelligence, and places it as one of the four more important aspects of the labor force of the

twentieth first century, along with emotional intelligence, purpose, and body intelligence. Both physical and emotional health, another form of describing the emotional and body intelligence cited by Schwab, are very important aspects of Becker's theory on human capital.

In comparison with physical capital in terms of depreciation, Becker states that machinery and equipment usually lose economic value as time passes by, which is not the case for human capital. Human capacities normally present an ascending trend to a certain point as people grow old. The length of the increasing period of a person's human capital stock relates to age, and in turn to health. An investment in laborer's health through medical care or a proper diet can help to enhance their productivity. Reducing the risk at work by means of the right equipment, or correct process design also contributes to a healthy and more productive labor force.

The possibility of replacing units of labor with physical capital within a productive process is a matter of interest in Becker's theoretical scheme. The rate at which human work can be replaced by some units of physical capital has always been of interest in the field of economic growth. Using time series regression analysis of the behavior of different economic sectors, Becker found that the elasticity of substitution between human capital and physical capital varies across different sectors and economies depending on the general conditions of the markets. It has also varied through the years as technology advances.

Theoretical State-of-the-Art: The Learning Societies

In a World where information and communications technologies are every time more accessible, investment in human capital holds an unprecedented importance. Developed economies in the post-industrial era have increased their base of knowledge workers at a very rapid pace. In certain ways, social mobility improves as education, in the sense of formal education and the ability to learn represents a pathway to climb the professional and social hierarchy. In a society with access to advanced information and information technology, acquisition of knowledge does not depend on formal education but on the ability to select and interpret the huge amount of information available (Eastmond, 2005). This author emphasizes that the information technologies will only help society to prevail in the long run if they are used to enhance capacities and liberties of broad population's sectors.

Studies of Learning Societies center their interests on knowledge embedded not only in individuals, but in firms and the societies. Theories of this new current recognize that knowledge is created by individuals and transferred from one person to another within firms. Afterwards, knowledge passes from firm to firm, the velocity of transmission is a characteristic of a learning society. It can be said that Stiglitz and Greenwald (2019) points that creating a learning society is a matter of coordination, in the sense presented by Todaro and Smith (2015) in which several things must mech well enough to achieve success, first of all, individuals must be motivated to learn. Authors state that the tendency of workers to invest in their own training depends on the expectation about what other workers would do.

A Review of the Discussed Theories

There is an extensive theoretical body that tries to explain the expansion of production and economic development. Luis Gutiérrez, (2014) compiles various theories that explain the mentioned phenomena, attending to a spatial dimension. This author states that regional growth theories overlap in some respects and are complementary in others. According to the author, there is no definitive regional growth theory, in the sense that, even though the postulates of several of them could be amalgamated, the result would not completely cover all the variables involved in the growth process of an economy.

Theories derived from neoclassical economics give a framework to most studies on the subject at the academic level. The models that make up this theory (*i.e.*, Solow-Swan) are useful for broadly explaining basic concepts in growth theories, such as the productivity of production factors. This theory postulates that growth occurs only as a result of the accumulation of production factors (*i.e.*, physical capital and labor), which combined by certain technology - which is fixed and is given exogenously to the model - will produce a certain level of production. This theory also considers the growth of the labor factor to be exogenous and assumes that the growth of physical capital occurs only proportionally to it. As a result of the absence of technological change, this theory assumes that the marginal product of the production inputs is decreasing, and at a given moment they reach a steady state that prevents a per capita growth in production.

Chronologically, neoclassical theories of neoclassical theory are followed by endogenous growth theories. In these theories, the exogeneity of technological progress and, therefore, the diminishing marginal productivity attributed to the factors of production in the

models of neoclassical theory are ignored. In contrast, it refers to the fact that technological development takes place in the model and, due to this, the productivity of the factors is increasing. The above helps to better explain long-term growth. The theory of endogenous development indicates that technological advances occur within the growth model, and that human capital is an integral part of the model as an explanatory variable. The most finished works in this current are perhaps those of Paul M. Romer, who incorporates the positive externalities of investment in human capital as one of the variables of his model (Romer, Increasing Returns and Long-Run Growth, 1986).

Before the establishment of the endogenous growth theory, the so-called innovation and technological change theory had already emerged. As Gutiérrez (2014, p. 13) explains, it goes back to the end of the 1960s, when Joseph A. Schumpeter (1944)emphasizes that it is the entrepreneurs - who distinguish the capitalists and the inventors - and innovation are the main ones and perhaps only true sources of economic growth. According to the author, Schumpeter incorporates, throughout several works, the introduction of new goods in the market, or new ways of producing and selling existing ones as sources of growth. Schumpeter, says Gutierrez (2014), distinguishes two types of reactions to a change in economic factor or variable. The first is called “adaptive” and refers to the accumulation of units of a productive factor; he calls the other "creator," thanks to which practices.

The most recent approaches center on the individual as the unit in which development must be measured. This concept has always been pursued by people studying the problem of development. One of the most developed theories on the matter, although is not matter for this research, was developed by the end of the 20th century by Professor Amartya Sen, who coined the concept of “capacities” to refer to the people’s success in living (Sen, 1988).

Conclusions

Mainstream economic theories, particularly neoclassical models, provided fundamental understanding of economic growth during industrialization’s early phases, emphasizing quantifiable inputs like physical capital and labor. These models explain basic mechanisms of output expansion but faltered as technological advancements gained momentum, exposing their rigidity. By treating technology as exogenous and labor as homogenous and static, they overlook the dynamic interplay of human capital, institutional learning, and path dependency—critical to the development of regions like Juárez, which evolved from low-

skill maquila processes to increasingly skill-demanding manufacturing and services. Similarly, early endogenous growth theories, while internalizing innovation and skills, underestimated socio-cultural dependency. These frameworks reduced growth to abstract equilibria, neglecting the realities of regions navigating asymmetrical globalization.

A renewed Schumpeterian approach, however, offers tools to analyze Juárez's current technologizing economy. Schumpeter's *creative destruction* captures the disruptive nature of today's industrial conversion into a highly automated and digitized one, where old labor-intensive old industries decline. Yet, this theory gains nuance when integrated with Human Capital Theory and regional development models. Unlike deterministic neoclassical and endogenous models, this hybrid framework recognizes that innovation's benefits are not automatic, but they hinge on a workforce capable of absorbing technological change.

The concept of *learning societies* (Stiglitz & Greenwald, 2019) further challenges models rooted in neoclassical paradigms, and expands endogenous views by emphasizing knowledge coordination across individuals, firms, and institutions, a critical lens for analyzing Juárez's globally integrated industrial base, and how it is reinforced (or weakened) by the skill set of its labor force. By synthesizing Schumpeterian dynamism with human capital and learning frameworks, these theoretical scaffolding shifts focus from abstract growth equilibrium to the lived interplay of technology and skills. It positions Juárez as a dynamic test case for studying how regions navigate the current technological conversion on an uneven terrain. Subsequent empirical analysis will assess whether these theories illuminate the mechanisms by which human capital reconfigures production functions in emergent technological paradigms.

4. Formation of Juárez´s Industrial Structure as a Result of Development Policies Directed at the Border.

This chapter reviews the economic history of Juárez, focusing on the development and impact of the export-oriented manufacturing industry and its role in shaping region's economic dynamics. By analyzing the integration of Juárez and the State of Chihuahua in North America—a relationship driven by geographic position, as well as Mexican, U.S. and Canadian policies-- the chapter highlights how globalization and state-led strategies

transformed Juárez into a critical node in North America supply chains. The first section reviews key historical milestones in regional economic integration, emphasizing how U.S. industrial needs and Mexican policy incentives (*e.g.,* border development programs) catalyzed industrial growth. Subsequent sections analyze the structural conditions with Chihuahua—including infrastructure, labor markets, and institutional frameworks—that enabled technological adoption and skill development. Through this historical les, the chapter challenges the perception of Juárez as merely a source of cheap and abundant labor at a privilege position, demonstrated instead how transnational manufacturing investments, coupled with local human capital, facilitated the region's integration into advanced technological paradigms.

The Municipality of Juárez, Chihuahua has experienced significant changes in its economic structure since the end of World War II. These changes have been influenced by the forces of globalization. This chapter aims to analyze the evolution of Juárez's economy and its industrial structure emphasizing the role of globalization, technology, and government policies. Specifically, the chapter aims to analyze the factors that have contributed to the growth and development of the industries that have or have had a presence in the region. The perspective of the study includes the role of technology, government policies, and economic trends. By providing a comprehensive understanding of the historical evolution of the economic apparatus in Juárez, Chihuahua, this section seeks to contribute to the knowledge base of regional economic development.

To achieve such an objective, the study traces the evolution of Juárez Municipality's economic apparatus by means of a historical approach. The research begins by examining the historical and political context in which the region was born and has developed, paying special attention to the impact of government policies and other globalization trends affecting the region. The study then proceeds to identify and analyze the key industries that have emerged in the area, with a focus on the factors that have contributed to their growth and development over time.

The Unites States of the America hosts the largest market in the World if measured by Gross Domestic Product[3]. México shares a border of approximately 3,200 kilometers with

[3] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?most_recent_value_desc=true

this country. Since the decade of the 1960's, Mexican Government has implemented a series of policies that seek to take advantage of such a privileged location. Said policies have been directed at the attraction of manufacturing activities and have had the northern border strip as the main target. Its strategic position of the Juárez, Municipality, right in the middle of that borderline, has given the Juárez, Chihuahua Municipality a central role in the application of such strategies, giving form to the current economic landscape in the region.

This chapter includes a historical review of the México-United Sates border to explain its emergency as a key industrial hub for North America. The following three sections count several programs implemented by the Mexican government and a series of conjunctural global, national, and local events that affected industrial environment of the Mexican northern border, with an emphasis in Juárez, Chihuahua. In parallel, the chapter develops a description of the historic evolution of the manufacturing industry under the light of social and political events, which yields some preliminary conclusions on the relationship between those types of phenomena and technological advancements.

Juárez in the México – United States Border

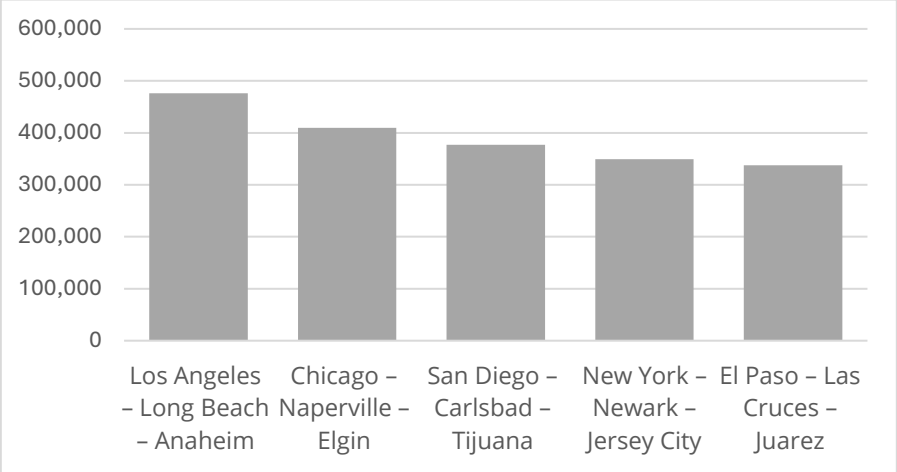
The municipality of Juárez, and its neighboring communities north of the border, are among the most important connection points between México and the United States. Its location provides connectivity to all the United States territory through the Inter-State highways system (See Figure 1). This location allows the region to be the fifth largest manufacturing hub in North America by number of jobs, and the second one across the borderline by number of jobs behind Sand Diego – Carlsbad – Tijuana (See Graphic 1). Over the five years prior to this research, 12% of all the recorder border crossing by individuals in the studied border occurred at one of the five ports connecting the municipality of Juárez to the United States (BTS, 2025). Juárez´s ports also see 20% of the total value of goods exported from México to the United States (INEGI, n.d.). By any measure, the role of Juárez and its ports is critical in facilitating the economic integration between México and the United States.

But the border is not only the epicenter of the economic and social interaction between México and the United States, but it is also where negative aspects of the bilateral relationship materialize. Mendoza (1981) states that "In the background of the relations between both countries, in their respective border areas, the economic, demographic, and cultural differences that characterize them are always present" (p. 49). Safety, migration, and

trade are commonly the main topics on the agenda. These persistent differences highlight the complexity of the border region, making it a focal point for both collaboration and contention in the relationship between the two countries.

Graphic 1

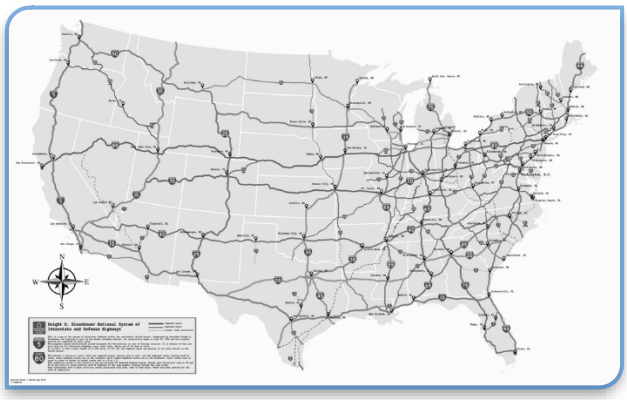
North America Manufacturing Hubs by Number of Jobs



Source: Bureau of Labor Statistics; Statistics Canada; Instituto Nacional de Estadística y Geografía (INEGI)

Figure 2

The Paso del Norte Region Connectivity



Source: https://www.reddit.com/r/MapPorn/comments/8e904d/map_of_us_interstate_highways/

The current economic landscape of Juárez and the surrounding area has been shaped across the centuries by its natural scenery. In the epoch when the Spaniard colonized the region known as Paso del Norte, located at the middle of the border strip, this area is of a

great importance to bi-national trade conquerors started their expeditions to the north, this place with two large mountains flanking a river resulted ideal to settle (Ibañez, 2024). As technology advanced, providing the inhabitants of the zone with agency over the landscape, and political events occurred, the region acquired characteristics of an *economic region* in terms of Espejo (2003). Juárez's evolving economy—sparked by its landscape, has established as a global manufacturing hub through a history of trade and continue socio-political and technological progress.

Political decisions in both México and the United States have contributed to shape what the Paso del Norte Region is today. The centralist regime adopted by México since its independence created a power vacuum in northern territories that fostered Texans settlers to seek for their annexation to the United States. Later, Mexican´s internal divisions facilitate the decision of the United States government to invade México to accomplish their expansionist plan (Mendoza, 1981). Since the establishment of the border line along the Rio Bravo -or Rio Grande as known in the United States-, as a result of the Guadalupe-Hidalgo treaty, Juárez was left on the new border, for which its vocation centered in commerce and services to satisfy the needs of people commuting between the two countries. Political decisions from the north in the first half of the twentieth century, such as the prohibition of alcohol and engagement in two large wars, consolidated the orientation of the city towards the services for travelers. Some of the political and economic dynamics we observe today in this region are the direct result of these events that occurred during the past two centuries.

Since the mid 1900´s Juárez switched from a pass for travelers to a magnet for migrant populations that started settling, especially for economic reasons. At the beginning of the 20th century, only 10% of the population of the Mexican northern border lived in cities with more 15,000 inhabitants, that where only four. Ciudad Juárez, the main locality of Juárez Municipality, was not one of them (Turner, 2006). By 1930, the city not only reached such figures, but became the most populated one on the dividing line. In 1942, the United States opened its borders to migrant workers in the search for a solution to the labor shortage due to the mobilization of men to battlefields in Europe and the Pacific (Fuentes & Fuentes, 2004). Unable to cross the border, families of men traveling to work in the United States under the Bracero program, made Juárez their home (Lorey & Buj, 1991). As a result, demographics of the border states. Since then, Juárez remained as the most populated city on

the dividing line, until the beginning of the current century, when it lost the place to Tijuana (See Graphic 1).

Ciudad Juárez, the main population center of the municipality of Juárez, is also the largest metropolitan area of a binational region known as Paso del Norte, that also encompasses the counties of El Paso, Texas and Doña Ana, New México. Due to the constant social, cultural, and economic interaction between them, explaining dynamics of each of those demarcations separately, often requires the inclusion of the others in the analysis.

Institutional Development

Given the importance of region for the border dynamics, the presence of government agencies, dealing with the main topics of the bi-lateral agenda, becomes necessary. Lee (2015) describes how public offices, both from local and federal spheres of influence, as NGO's and private firms from both sides of the border align their efforts to facilitate bi-lateral cooperation. It is expected that policies adopted by the governments of each of the countries will reflect first, and with a bigger impact on this geographic area.

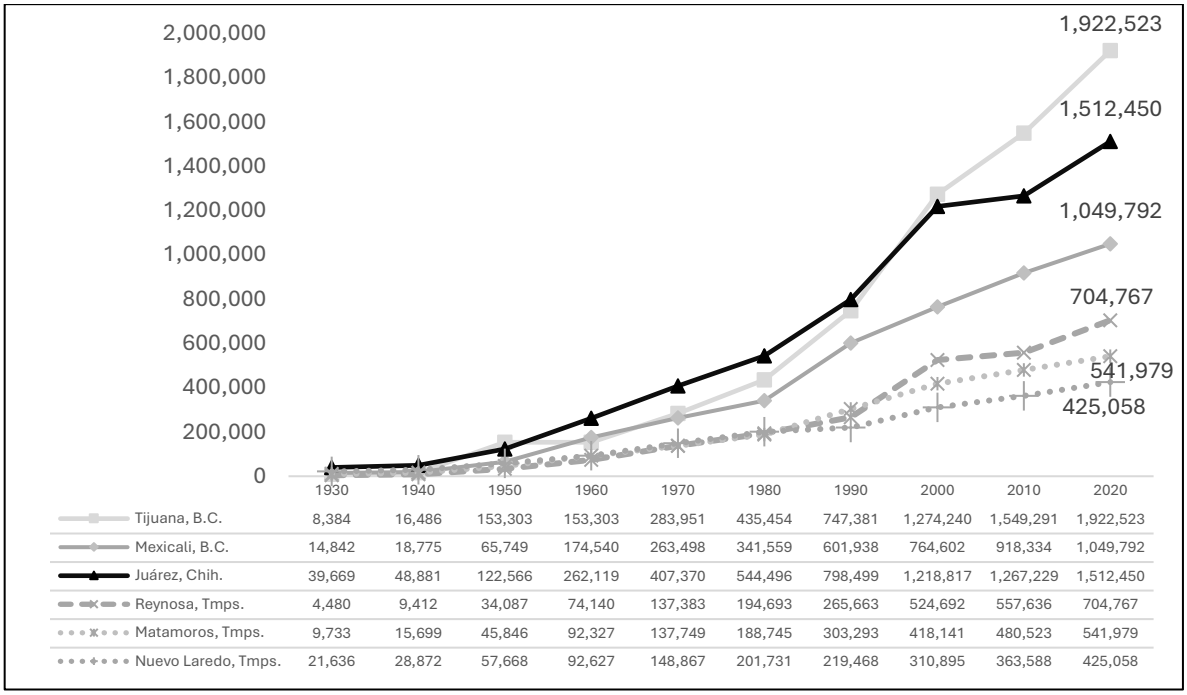
Lee (2015) describes how several governmental agencies -both local and federal- (*e.g.,* commerce, transportation, customs, etc.), as well as non-governmental organizations (NGO), and even private companies from both countries align efforts to facilitate cooperation between countries. According to the author, security and commerce are among the priorities of the constant dialogue that authorities from both countries maintain, given the volume of goods, services, and investment going back and forth between them. Lee says that it is Texas, among the states from the north side of the border, the one with the largest interaction with the Mexican economy, in part because roughly two thirds of the border line is in its territory. Even though located at the very western end of the state, the border between Juárez and El Paso is of foremost importance to the commerce between the two countries.

The isolation forced the quest for locally centered economic development initiatives. In recent times it is more common to see that those initiatives are conducted in conjunction with the communities across the border. Evidence suggests that the larger the metropolitan center, the greater the trend to implement joint initiatives. In that sense, Tijuana/San Isidro, and Juárez/El Paso-Las Cruces are the more integrated border communities according to the study. Said regions strongly relay on two activities: manufacturing and logistics. Both main economies in the region are of high aggregated value, and attractive to specialized human

capital. The region of Juárez/El Paso is also favored by its geographic location at the center of the borderline, having connectivity to the whole territory of the United States.

Graphic 2

Population in border cities



	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020
Tijuana, B.C.	8,384	16,486	153,303	153,303	283,951	435,454	747,381	1,274,240	1,549,291	1,922,523
Mexicali, B.C.	14,842	18,775	65,749	174,540	263,498	341,559	601,938	764,602	918,334	1,049,792
Juárez, Chih.	39,669	48,881	122,566	262,119	407,370	544,496	798,499	1,218,817	1,267,229	1,512,450
Reynosa, Tmps.	4,480	9,412	34,087	74,140	137,383	194,693	265,663	524,692	557,636	704,767
Matamoros, Tmps.	9,733	15,699	45,846	92,327	137,749	188,745	303,293	418,141	480,523	541,979
Nuevo Laredo, Tmps.	21,636	28,872	57,668	92,627	148,867	201,731	219,468	310,895	363,588	425,058

Source: Self elaboration with data from (Turner, 2006; Margulis, 1981; INEGI, n.d.; INEGI, n.d.)

Along with the cited situation of isolation, some global macroeconomic trends, enounced in the document as “megatrends”, have brought some local initiatives to life. Among others, trends include the increasing salaries in Asia, that have been an opportunity for the region to bring back those companies that fled to the far east during the last decades (CIDAC, 2014). Such opportunity has fostered cooperation in the transborder communities, particularly the larger ones. Such initiatives find support in the competitive advantages of the region: bilingualism, multiculturalism, diverse markets, and diversity of human capital. Complementarity, as opposed to competition seems to be the result of new World’s economic order based on regional blocks. Participants of the forums organized by the Woodrow Wilson Center agreed on classifying complementarity as a competitive strength of the border region.

The industrial and economic history of the Paso del Norte region, as an epicenter of a binational social, cultural, and economic relationship, is sensitive to developments of

World's economic scenario. Changes in the paradigms of global commerce have fostered a series of economic policies and programs aimed at the development of the area, resulting in an evolution of the region's industrial tissue. Activities in the area have progressed from basic activities such as sewing and data capture to more specialized ones related to automotive, electronics, and aerospace industries. Additionally, the presence of such industries in the city impulses the demand for professional services in the whole region. Legal, financial, and logistics services are the most common. Commercial exchange and joint production processes have also generated the need for educational and job training services.

First 20 years of the industrialization process (1960 – 1980)

Economic conditions of the decade of 1960's favored the economic integration of the Mexican and the United States economies, a phenomenon that was to occur at the border. At that time, México was facing high unemployment, especially in the north. Cancellation of the Bracero Program expelled 200,000 farming workers that arriving in México found a declining agricultural production in the region, and other macroeconomic problems (Fernández, 1981; Pedrero & Saavedra, 1987). At the same time, manufacturing industry was under a major transformation process due to technological advancements taking place. Due to the state of available technologies, textiles, and processing food industries were the first to take their processes aboard to benefit from the cheaper labor south of the border.

By the moment of the first programs' implementation, labor cost in México was one fourth of that in the United States. Even though the salary differentials were even larger in far Asia, the distance to the market in the United States gave Mexican Border locations a competitive advantage in terms of investment attractions, especially for manufacturing processes. Having the possibility of importing capital goods on a temporary basis helped companies to maintain productivity. Regional development programs in the Mexican northern border, provided Mexican government a solution for the unemployment problem and foreign companies, especially in the United States, a large base of workers for a competitive cost.

Attending to the conjuncture, Mexican government implemented a series of targeted policies that caused certain border communities to shift their focus from services to manufacturing. Pedrero and Saavedra (1987) locate the origin of border-specific development programs in 1961, with the creation of the National Border Program (PRONAF

by its acronym in English) that Mexican government implemented to integrate the zone to the rest of national territory from socio-cultural, but also an economic perspective. Regarding the industry of transformation, the program was framed within the Stabilizing Development Strategy and the import substitution mechanism. The first foreign investment in the textile and food processing sector arrived in the Mexican side of the border under this program.

Other authors say that a real industrialization process did not start until the mid the 1960´s decade. Lee (2015), as well as Fuentes and Fuentes (2004) establish that the Border Industrialization Program (PIF, by its acronym in Spanish), implemented in 1965 is the real origin of the export manufacturing tradition in México, especially at the northern border. That program, hold the said authors, transformed the Mexican northern border in a magnet for Mexican nationals looking of economic opportunities, and for financial capitals in the search for profits based in labor intensive activities.

It was the companies dedicated to textiles and food processing the first in coming to México under the maquiladora scheme, but the rest followed them immediately. Firms engaged in labor-intensive processes were in need for abundant labor force, not available at competitive costs in the United States, installed the first plans on Mexican soil. The first of them stagnated rapidly, losing relative importance, while the other, even though it did not stop growing, started losing share in more complex processes such as electronics that grew up constantly during the following decades. (Pedrero & Saavedra, 1987).

The program not only attracted companies from the United States, but other countries also sent capitals to start operations in the region, even Mexican capitals took advantage of the program. Industrial plants of varied sizes installed in México since the beginning, the origin of the capital, even though clearly dominated by the United States, was also variated; some of the plants were even the result of a mix of capitals from México and the United States. It is known that during the first 20 years, most of the largest plants (more than 250 employees) were of foreign capital. Among those with a headcount below 100, more than a third were Mexicans (Pedrero & Saavedra, 1987).

As soon as the regional development programs started to give results, Juárez assumed the leadership in the sector, at least from the total employment standpoint. During the first 8 years, manufacturing firms operating as maquiladoras absorbed approximately 73,000 workers. Around one fourth of the maquiladora Jobs settle in the Juárez municipality, which

led the border in this aspect. Even though México lost 2,000 job positions in manufacturing because of the 1973 global economic crisis, Juárez saw an increase of 1,200 jobs, increasing its participation to 27% of the maquiladora employment in the country. Pedrero and Saavedra (1987) report that, after having passed 20 years of the first program aiming to develop the border strip, employment kept a constant 25% annual growth rate, reaching 200,000 nationwide by the beginning of the 1980s. Available data suggests that the program attained its goals despite a volatile economic situation around the World.

Despite the progressive openness of Mexican economy, Juárez, Chihuahua remained as the leader in the country in number of maquiladora establishments during the first two decades of the programs designed to attract those operations. Mexican government allowed the installation of maquiladora process throughout the entire territory since 1971. However, by 1985, 90% of the manufacturing establishments operated by multinationals were in the border municipalities due to a series of logistical considerations not limited to proximity to the market. Juárez, Chihuahua remained its leading position since the beginning, hosting 23.1% of the plants, surpassing Tijuana by 1.1 percentual points. Factories located in Juárez were also larger than those of the Baja Californian border city, with Juárez´s share in that category reaching 36% (Pedrero & Saavedra, 1987). This dominance highlights Juárez's strategic importance in the maquiladora industry and its significant role in México's economic landscape.

The New World Paradigm: Full Commercial Openness

Along with the export manufacturing activities, Juárez gained in importance as world economy opened. In 1983 the World Economy shifted towards models based on commercial openness. México was not the exception adopting the export-based growth model, which remains in place to this day (Turner, 2006). During the following years, maquiladora did nothing but grow in importance to Mexican economy, both in terms of jobs creation and capital inflows, not only at the border, but nationwide. This dynamic underscore the pivotal role of the maquiladora industry, and the border communities in México's economy

In 1986 México entered the General Agreement on Trade and Tariffs (GATT), assuming the compromise to implement legal reforms, which eventually resulted in the opening of more maquiladora plants across the national territory. Just one year later was the source of more than 5% of the total revenue in the current account. That same year, Mexican

border strip hosted 1,063 maquiladora plants with a total headcount of 300,000, more than 11% of the total of the industrial workers in the country (Herrera, 1989).

In November 1987, Mexican and United States governments signed the Memorandum of Understanding for Trade and Investment with the objective of facilitate the commercial relationship between the two countries (BANCOMEXT, 1988). According to de declaratory of principles of the document, one of the main considerations was "the special role of commerce in the development of the border region and the need for cooperation in cross-border trade" (p. 67).

All the efforts made to give impulse to the maquiladora activity resulted in multiplied the number of these processes by three. Maquiladoras grew from 620 to 1,703 during the decade of 1980s (Turner, 2006). Along the border strip, the expansion was from 544 to 1,529, out of which 311 were in Chihuahua, more than half in Juárez (INEGI, 2022).

The Mexican National Development Plan 1989 -1994 specified the priority character of the impulse and promotion to export manufacturing industry. This spirit reflects in the Decree for Promotion and Operation of the Export Manufacturing Industry, in which this type of establishment is considered to have the ability to influence in a positive way on the national industry's competitiveness. Both the plan and the decree, show a strategy focus on the commercial openness by Mexican Federal Government. The epitome of all this process is the signature of the North America Free Trade Agreement (NAFTA) that came into effect on January 1st, 1994.

In that way, maquiladora expanded 68% during the last five years of the 20th century. According to data shown by Turner (2006) the number of establishments went from 2,130 to 3,590. In the same period, the number of Jobs grew in 640,000 positions, reaching 1,285,000. On the border, growth proportions during the five years following the implementation of the agreement were 55% in establishments and 85% in employment. In the State of Chihuahua establishments grew by 38% and the employment increased by 72%.

The Evolution of Maquiladora Industry in the 21st

Carrillo and Hernández (2020) identify four phases of the evolution of the Mexican industrial policy that. The first of them is the assembly phase, which is the one that better explain the early stages of the industrialization process in the Mexican northern border (Fuentes & Fuentes, 2004; Lee, 2015; Lee & Wilson, 2015). The Mexican economy runs this phase

during the first 20 years after PIF's implementation. The next step occurred in the mid of the 1980s decade, when more complex manufacturing techniques, such as lean manufacturing, and other derived from Japanese philosophy of production. Operations based on those systems last to the day as predominant in the industries with a majority presence in Juárez Municipality such as electric electronics and automotive.

The third stage relates to the research and development activities (R & D), while the fourth involves the installation of centers to coordinate processes spilled over different parts of the World (Carrillo & Hernández, 2020). One of the factors that forced México into these stages, as soon as 21st century started, was the China's incorporation to the World Trade Organization (WTO). That event represented the entrance of a new competitor for investment in manufacturing, pushing México to employ other attributes to counter the differential in labor with respect to the then largest population in the World (CIDAC, 2014).

Additionally, to competition from China, México, and the rest of the developing countries had to deal with an economic deceleration in the United States derived from terrorist attacks of September 2001 and all the political sequels. Consequently, México lost 207,000 jobs and a production for two billion dollars in manufacturing. The crisis of the stock markets sparked in the United States in 2008, is another conjunctural event that affected the industrialization of the Mexican northern border. Disturbances in investment inflows and demand for goods at a global level forced the reconfiguration of entire industries. Given the interconnection between economies, Juárez did not remained exempt from such alterations.

Parallel said developments, the World started its transit through a course of technological conversion that yields to the reconfiguration of productive processes. Paradigmatical changes in energy and telecommunications sectors represent, in the words of Rifkin (2011), an industrial revolution. Even though it is already possible to obtain some conclusions on how these changes affect some industries and its firms, major aspects of this transformation are still to be reveal (Siebel, 2019).

In a binational, industrial zone like the Paso del Norte region a well prepared labor force is essential to advantage of the opportunities in highly technical industries attracted by its geographical position. Soberanes (2015) claims that "The binational nature of the –Paso del Norte—region presents a range of opportunities to leverage the comparative advantages in skills and in educational and training institutions on each side of the border " (p.105). In

that sense, the author declares that having the coverage and quality in education and job training as well as the ability to attract and retain the talent is crucial for the performance of an economy.

Labor Characteristics and Human Capital in the Region

Developing and attracting talent has been key to Ciudad Juárez in the conversion from a labor-intensive economy to one based on value-added activities. Being at the border with the United States represents a benefit for Juárez, not only because of the access to the largest market in the world -measured by GDP-, but also because that country is recognized by its highly innovative and prepared human capital. The United States hold the sixteenth place out of 122 countries in the World Economic Forum Human Capital Index, as cited by Soberanes (2015). Additionally, Mexican nationals residing on the border have access to higher education institutions in the United States (Vega, 2016), worldwide recognized by its research and teaching capacities, due to preferential tuition fees that the universities in the United States border states give up for students proceeding from México. Approximately half of the Mexican nationals studying higher education in the norther neighbor are enrolled in schools at border states. The University of Texas at El Paso alone has one tenth of the total of Mexican students in the United States.

México, on the other hand, holds 58th place in the previously cited Human Capital Ranking. Main problem seems to be coverage of the educative system. Less than one out of each five persons of 25 years or older holds a high school diploma. Another problem cited by Soberanes (2015) is the lack of coordination between the institutions in charge of the education policy and the productive sector. On the demand side of the labor market, researchers remark that the scarcity of opportunities for qualified workers, and bumpers to innovation affect economic development, not only of the border communities, but that of the whole country.

Researchers conclude that the larger urban centers -those with at least 500 thousand inhabitants-, Ciudad Juárez among them, were the most affected by this phenomenon, while the rural communities did not see a significant enlargement. 80% of the population of the border belt concentrates in 10 cities, all of them with more than 100,000 inhabitants. Ybáñez (2009) remarks that on the United States side the growth of the border urban centers has been even faster in the last few years. Such trend, not seen equally clear in the rest of the Mexican

territory, is especially true for the state of Chihuahua, which population is strongly concentrated in the municipality of Juárez, specifically in its main locality, Ciudad Juárez.

The inflow of migrant workers to Ciudad Juárez, mostly domestic, driven by high labor demand from *maquiladoras* has strained public infrastructure and social cohesion while simultaneously contributing to economic growth through the accumulation of human capital. As Jusidman and Mireles (2007) note, rapid increasing of population pressures public services and governance, exacerbating inequalities in the city. Yet, Vázquez Guzman and Ramírez Lozano (2023), demonstrate that investment influx contributes to the expansion of production through the accumulation of technical expertise and workforce training programs. The clustering of skilled labor –particularly in manufacturing—enabled Juárez to transition from low-skill assembly lines to higher value activities, embedding tacit knowledge withing the regional labor force. Such dual dynamics highlights the trade-offs inherent in technologized growth in which human capital improvements play a significant role projected in the evolution of educational patterns.

The escalating demand for skilled technicians in Ciudad Juárez's maquiladora sector spurred manufacturing firms to forge partnerships with local educational institutions, establishing technical high schools and specialized training centers to address the needs of the industry un terms of human capital. As transnational corporations introduced advanced production processes, the need for technicians outpaced local capacities. According to INEGI, the number of technicians employed in Juárez's maquiladoras surged tenfold between 1975 and 1990, far outpacing total employment growth (less than sevenfold), elevating technicians' share of the workforce from 4.6% to 12.6%. As Dutrénit & Vera-Cruz (2009) document, such a rapid-increasing demand prompted collaborations with state entities, resulting in establishment of the *Centro de Asistencia y Servicios Tecnológicos* (CAST) and *Centro de Entrenamiento en Alta Tecnología* (CENALTEC). These alliances not only addressed immediate skill gaps but also generated knowledge spillovers, as firms like Philips integrated practical training programs—80% hands-on—certified by international standards. Such institutional adaptations underscore how industrial demands catalyzed localized human capital formation, a dynamic that laid the groundwork for subsequent shifts in educational attainment patterns, in Juárez and the rest of the state.The Role of

Globalization in the Human Capital Development in Juárez, Chihuahua: A Review of the Recent History Labor

Juárez's location has been determinant in the configuration of its industrial structure and, in turn, in the development of its human capital. Since the last decades of the past century, and during the years of the current, manufacturing has become one of the main components of the Mexican economy. Supported by information from *Censos Económicos* conducted between 2003 and 2018 (INEGI, n.d.), it is safe to say that manufacturing contributes a large proportion of Mexican economic indicators such as total investment (30%), employment (25%) and total gross production (42%) (See Graph 1). Currently, while Juárez hosts barely 1.3% of the México's economic active population, the municipality is home to 5.1% of the manufacturing workers nationwide (IMSS, n.d.; INEGI, n.d.) (See Table 1).

Table 1

Proportion of workers in manufacturing industry in Juárez

	Total Eap	Manufacturing Employment	Proportion Of Manufacturing Workers
National	61,370,334	6,077,360	9.9%
Juárez, Chihuahua	784,223	311,545	39.7%
Juárez's Proportion	1.3%	5.1%	

Note. Data from Datos abiertos, IMSS (http://datos.imss.gob.mx/mapas-interactivos) and Encuesta Nacional de Opcupación y Empleo, INEGI (https://www.inegi.org.mx/sistemas/infoenoe/Default_15mas.aspx)

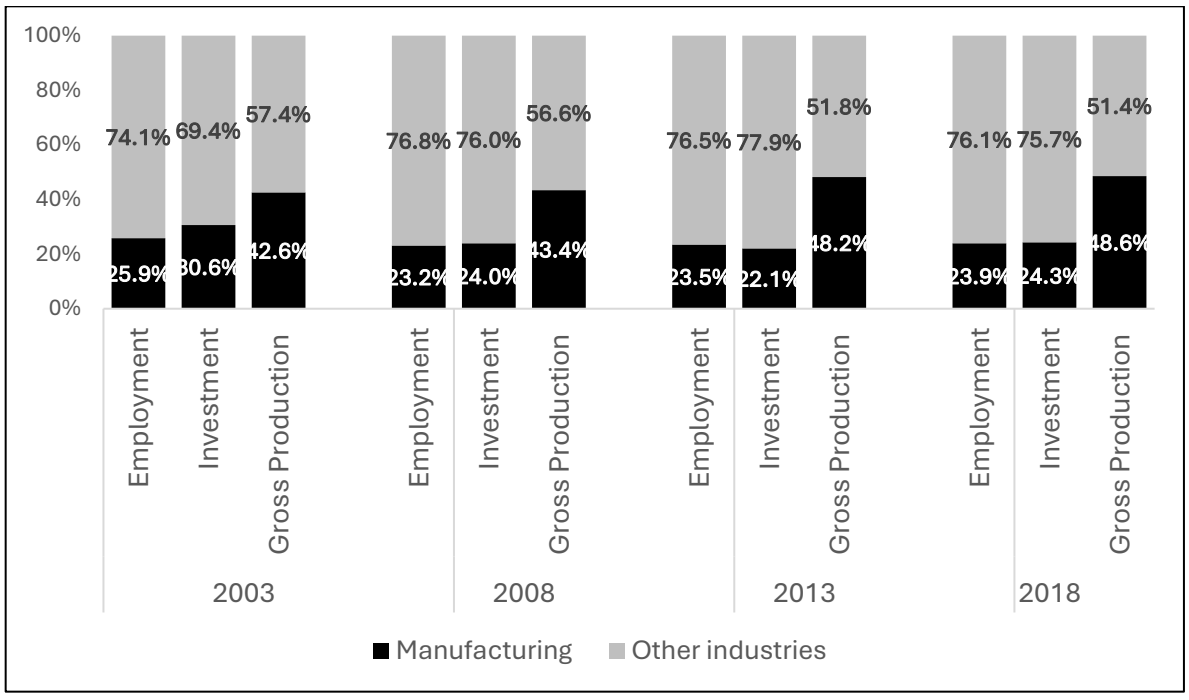
Globalization has had a profound impact on the industrial structure of cities across the world (Jin, 2012), and the Mexican Northern Border region is no exception. The global market has become an important driver of industrial growth in this region, and as such, it has shaped the development of local industrial structure. In recent decades, communities on the border between México and the United States has seen significant growth in manufacturing. The region has become a hub to produce goods such as electronics, medical devices, and automotive parts, all of which are increasingly produced for the global market (Kose, Meredith, & Towe, 2004). This shift towards production for the global market has been driven by the increasing importance of free trade, which has made it easier for firms to locate

their operations in areas where labor and other inputs are less expensive (Fuentes & Fuentes, 2004).

Technology has played a significant role in facilitating the globalization of production processes. The development of advanced communications and transportation technologies has enabled countries and companies to exchange goods, services, and information across the world at a much faster pace (Rifkin, 2011). This has led to the integration of national and regional economies into the global economy and the emergence of global value chains, where different stages of production locate in different sites all over the world (Jin, 2012). Technology has facilitated operations of firms' activities to spread globally, allowing them to take advantage of lower production costs, across, access new markets, and input sources from around the globe (Castells, 1995). Therefore, technology, particularly Information Technologies, has been a key driver for globalization reshaping the industrial structure of cities and regions.

Graphic 3

Contribution of Manufacturing to Mexican Macroeconomic Indicators



Note. Data from *Censos Económicos* from 2003 to 2018, INEGI (https://www.inegi.org.mx/app/saic/).

In Northern México, and the municipality of Juárez, Chihuahua particularly, the proximity to the United States, the availability of relatively cheap qualified labor, and a

favorable regulatory environment have been factors for the attraction and retention of multinational companies, especially in the manufacturing sector. In addition to manufacturing, the municipality of Juárez has experienced growth in the service sector, particularly in industries such as transportation and logistics. As with manufacturing, this growth has been driven by the region's strategic location, as it provides a crucial link between the United States and México (Cañas, Coronado, Gilmer, & Saucedo, 2013)

Overall, Juárez, Chihuahua has undergone significant changes in recent decades, driven by the forces of globalization influenced, in turn by technological and political changes. While this has brought about significant economic growth and development, it has also presented challenges that will need to be addressed in the upcoming years. Globalization, characterized in part by the integration of national economies into an interconnected system, has had a significant impact on regional development. The ease that firms enjoy nowadays to direct their investments to places with the best returns cause increasing competition among regions which seek to enlarge their respective economies. Perceived opportunities have led policy makers to orbit around the idea of competitivity (Di Gregorio, Musteen, & Thomas, 2009). Arguably, the participation of regions in global value chains cause economic growth and development in the regions. The impact of globalization on regional development is complex and depends on a range of factors, including a region's existing economic structure, resources, institutions, and availability of human resources. In the context of globalization, policymakers guide their efforts to fulfill the requirements of global economy in terms of infrastructure, human capital, and institutional capacity to compete in the global economy (Porter, 1996).

With the acceleration of the globalization and economic integration the processes, Juárez became part of a global productive chain, hosting parts of productive processes located in different sites. The interaction between regions has created technological and economic interdependence. Its geographical location, right on the Mexican northern border, makes the city the recipient of considerable amounts of investment for manufacturing activities to serve the markets of the United States. It is expected that the economic conditions and the evolution of the North American market influence the economic evolution of the studied region.

The conduction of this study represents several challenges that limit its scope. The unique characteristics of the border between México and the United States make studies on

the region to be very particular and, even though the global impact of its economic activity, only a well-defined niche shows interest. Finding literature on the economic evolution of the region, and on Juárez in particular, is not an easy task. The number of scholars specialized in the topic is limited, making it hard to find data and references for theoretical approaches. The uniqueness of the region is also an obstacle for the replicability of the study. Political, economic, cultural, and social differences must be considered to employ a similar methodology in a different area of the world.

Conclusions

The trajectory of the manufacturing sector in México explains through policies implemented by the governments of the United States and México within a globally integrated economic context. In the case of the former, policies obey the need of its markets for affordable goods. Since the mid last century, technification of production processes has helped firms in specific industries to reduce costs, but others have faced limitations that force them to remain labor-intensive, the firms in those industries where the first in search of places with abundant labor force to relocate. In the case of Mexican government, economic policies design has been motivated by macroeconomic conjunctures.

It can be said that technological advance and geographic position have influenced both México and United States decisions on economic policy. Policies such as Programa Bracero, implemented for political reasons, have been possible due to geographic proximity. algunos eventos de este tipo han seguido dando forma a la configuración industrial de la frontera norte de México por la vía de las decisiones económicas. La proximidad geográfica con el mercado más grande del mundo ha ayudado a moldear la estructura económica de la frontera norte de México y del municipio de Juárez en particular. Adicionalmente, las características propias de las diferentes industrias, sobre todo sus estados tecnológicos y requerimientos logísticos, han determinado dónde deben de colocarse las diferentes operaciones de cada firma. Para sacar provecho de ello, el gobierno mexicano ha diseñado e implementado, a lo largo de los años, una serie de programas y políticas públicas que se supone atraigan a las diferentes empresas a localizar sus operaciones en la frontera norte, ayudando así a todo el país.

Chihuahua, along with other northern states of México, has cultivated a human capital landscape that extends beyond manufacturing skills to encompass significant expertise in

engineering, planning, and administration. The State Government report an average of 10.1 years of academic attainment for the 2021-2022 school cycle, surpassing the national mean of 7.8. Furthermore, México's emphasis on STEM education is evident, with 25% of all bachelor's degrees awarded in these fields, according to ANUIES . Despite this robust educational foundation, professionals in these areas often receive compensation significantly lower than their global counterparts. For instance, software developers in México earn an average of $33,000 annually, whereas similar roles in California command salaries around $165,000. This disparity underscores the region's capacity to supply advanced technical and managerial talent, albeit at comparatively modest wage levels.The scarcity of literature on the region and data at municipal level in México limits the results of the study to a set of broad conclusions. The absence of comprehensive and updated data basis at local level impedes the elaboration of conclusions on an empirical basis. As more analytical methods are often required to explain the findings of these kinds of studies, outcomes tend to depend more on the perspective and theoretical background of the researcher.

5. Statistical Considerations on the Industry Sector of Chihuahua State: Technological Change Evidence

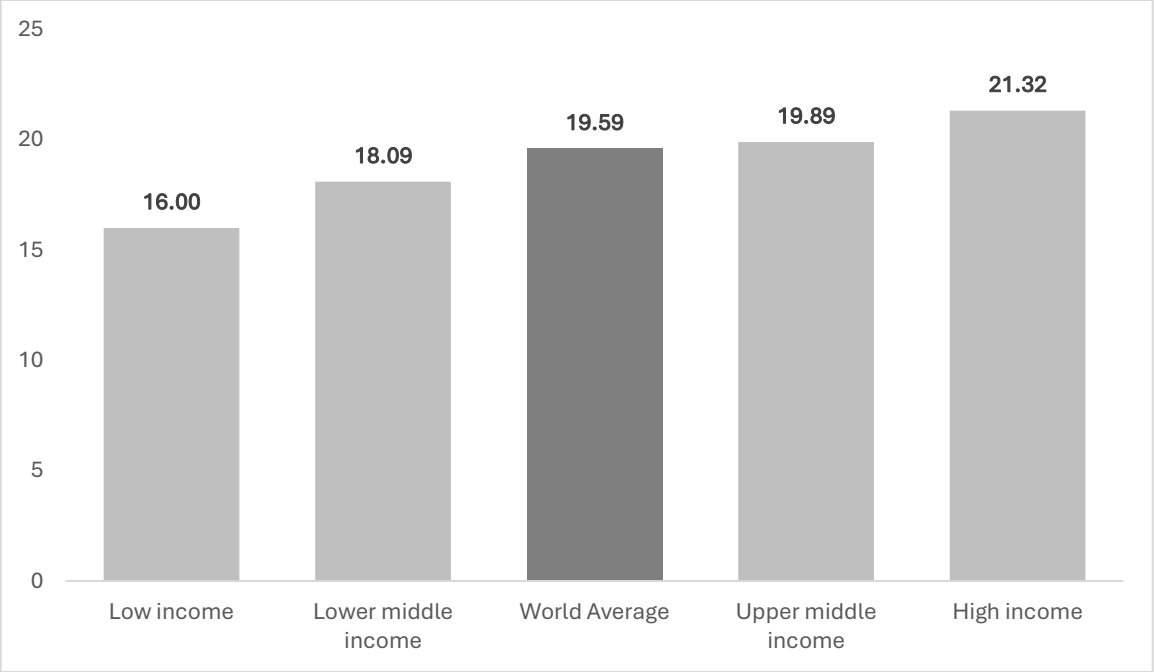
Employment related indicators are often used as an approximation to the attainable living standards in a community. Regional development is an overly broad field of study that gives rise to many concepts. As such, the development of a region can be explained by means of different variables. Production growth and employment level are among the most used indicators for these purposes. Employment related indicators inform about the situation in which the members of an economy can use their physical and intellectual efforts to transform surrounding reality. Considering the double role that individuals play in an economy as producers and consumers, participating in productive processes gives individuals the opportunity to consume more goods for need meeting.

The mechanism of adding value to available resources, and that is why it is the main productive activity for humanity at this point in history, is manufacturing. According to The World Bank (2025) 19.59% of the world’s labor force dedicate to industrial activities. The percentage according to the same website increases in each country in direct proportion to its

income (See Graph 3). Multilateral corps such as the United Nations itself have declared inclusive and sustainable industrial development as one of three pillars to achieve sustainable goals for 2030 and has created a dedicated agency: The United Nations Industrial Development Organization (UNIDO). That organism has the mandate "to promote, dynamize and accelerate industrial development" (UNIDO, 2024). Industrial activity seems key to economic growth and employment.

Graphic 4

Percentage of the world's labor force participating in industrial activity (2023)



Note. Self-elaboration with data from (World Bank, 2025)

México is one of the countries that has set a strategy to attract manufacturing processes to its territory to create jobs. Transformation and assembling of goods has been so important to Mexican economy in the last decades that, in the last five of them Mexican states that concentrate such activities observe highest growth rates (Jesús-Almonte, Andrés-Rosales, & Carbajal-Suárez, 2020). Manufacturing represents one quarter of the total formal employment in México, according to Rendón Rojas, Andrés Rosales, and Mejía Reyes (2019), besides having an important role for job generation in other economic sectors. As a upper middle-income economy, México relies heavily on industrial activity to generate growth.

The selected method to address the proposed task is Shift and Share Analysis, employed in this study in both its traditional and spatial iterations. In the traditional form, this approach is instrumental in capturing the dynamic special effects of the variables of interest -particularly employment- while also yielding readily interpretable results that facilitate evidence-based conclusions for public policy design. The special variant, conversely, elucidates interaction dynamics between the target region and its neighboring areas. (Rendón, Andrés, & Reyes, 2019)).

This section encompasses four phases. The first one outlines the literature that supports the employment of the method for the sake of the thesis' goals and emphasizes the originality of the research. The second part details the data sources, their characteristics and the applied methodology to ensure replicability and scientific rigor. The following analyzes the municipal-level employment structure and its changes throughout the current century. The last section presents the findings and conclusions that test the hypothesis that human capital becomes more important to regional economic growth as technology advances.

Literature Review

A set of core concepts underprints the relevance and significance of this study. Aligned with its stated objective, the analysis synthesizes established definitions of key concepts to construct a cohesive analysis of the composition of labor force in Juárez, and the effects of its changes in production.

One of the most significant factors historically used -and still used today- to measure the development of a region is its ability to provide its inhabitants with opportunities for personal and professional development, enabling them to act as agents of change in both their own lives and their surroundings through work. The importance of work in economic studies predates the formal establishment of a scientific paradigm for its analysis. Economists from the most traditional schools such as of thought, such as Adam Smith, recognize in their oeuvre that labor, beyond its function as a means of income generation, holds a social significance as a vehicle for attaining status within a collective (Wisman, 2019). From a different perspective, critical to capitalism, Marxist thought also assigns labor a central role in both the economy and human well-being. For Marx and the economists who follow his theoretical framework, labor is the primary source of value creation, but its significance extends beyond

the economic sphere. They argue that creative labor distinguishes humans from other animals, granting them agency to shape the environment (Fromm, 1962).

Following the Great Depression that shook the world between 1929 and 1933, macroeconomics emerged as one of the foundational pillars of economic science. John Maynard Keynes redefined the approach to economic problems, positioning employment as one of the key axes around which economic policy should revolve - alongside production and prices. He argued that immediate unemployment should be addressed primarily through fiscal policy tools, even while acknowledging the potential long-term challenges this approaches entail (Parkin, 2009).

Currently, employment remains one of the key indicators that local and national governments, multinational organizations, and academic prioritize more intensely. Institutions of all types dedicate significant efforts not only to maintaining adequate levels in the present but also to studying the phenomenon with prospective sights. The World Bank Group (2019) published a report titled "*The Changing Nature of Work",* that predicts that the rapid pace of technological advancements will significantly alter the nature of work, leading to profound social transformations. This warning aligns with the insights of Klaus Schwab (2016), founder of the World Economic Forum, whit similarly emphasizes the far-reaching implications of said changes. Thus, the volving nature of work, driven by rapid technological advancements, underscores the imperative for continuous human capital development as a cornerstone of sustainable economic growth and social resilience in the twenty first century.

Manufacturing jobs continue to play a pivotal role in employment generation, particularly in the high-income and upper middle-income economies like México. The World Bank Group (2019) states that manufacturing employment in developed countries has declined by 10% over the past decades. However, it acknowledges that this sector remains a significant source of jobs in middle-income countries. Nevertheless, while the so-called digital transition is inevitable, México's growth in manufacturing employment during the previous years places the sector as one of the most dynamics within its regions. Thus, México's manufacturing growth not only highlights the resilience of this sector but also underscores its potential to drive regional economic dynamism amidst the broader digital transformation.

The implementation of the North America Free Trade Agreement (NAFTA) positioned manufacturing as a critical sector for México over the past three decades. With an average growth rate of 32%, manufacturing has significantly outpaced other sectors, compared to the overall GDP Growth rate of around 2% (CIDAC, 2014). The report further underscores that México's geographic proximity to the world's largest market offers a competitive advantage in consumer goods manufacturing, particularly for border states, making it preferred destination for investment. Additionally, the CIDAC (2014) report notes that México holds substantial potential for attracting manufacturing investments. However, given resources limitations, it is essential to strategically prioritize the most profitable sectors, counting for both conditions required for establishment and the value-added they can generate.

Manufacturing holds a significant role as a value generator and a driver for economic growth in both developing and developed countries. Researchers' interest in the economic sector and its structural behavior at the regional level reflects in the extensive body of literature dedicated to it. Szirmai and Verspagen (2015) provide a long-term perspective on the relationship between manufacturing jobs and economic growth finding that the sector struggles to maintain its preeminent role as generator of economic growth and other types of service-related activities gaining ground. Thirion (2023) is one of the authors that recently examined the structural trends of manufacturing employment. In a work focused on the subsector of automotive industries with a regional emphasis on the 12 Mexican states with the highest specialization in the area -including Chihuahua-, the author reached mixed results with manufacturing remining as the main driver for economic development and professional services taking over the first place in others. While manufacturing remains a key driver of economic growth, tertiary activities are increasingly gaining importance, reflecting a shift in economic landscape.

Econometric techniques have proved to be useful for the analysis of employment dynamics at a regional level. De Jesús-Almonte, Andrés-Rosales, & Carbajal-Suárez, (2020) employ spatial panel models to demonstrate that large firms on the Mexican border states drive employment growth, yet automation inversely links production increases to job reductions. In another example, Heart-Bandara (2024) applies standard *Shift-and-Share* and Location Quotient (*LQ*) analyses to the study of the employment structure in the 5 regions of

Virginia, U.S. identifying national growth and regional competitiveness as key employment drivers. Econometric tools -through their capacity to disentangle multifaceted influences, quantify spatial interdependencies, and provide a robust framework for decoding employment dynamics transcend the limitations of purely descriptive approaches.

The Shift-and-Share method is a cornerstone of regional economic analysis, prized for its capacity to isolate drivers of employment and production dynamics. Arias, Sánchez, Oviedo, and Torres (2011) exemplify this by applying a spatial modified Shift-and-Share -pioneered by Nazara and Hewings (2004)- framework to Costa Rica's Chorotega region, expanding the traditional three-component model to four. Their analysis not only identifies a structural shift toward employment in the sector of services but also uncovers mismatches between regional specialization and competitive advantages. Similarly, Solís y García (2017) utilize the method to analyze manufacturing employment trends in Tamaulipas' burgos Basin, attributing most variations to national growth effects while revealing divergent development pattern across subsectors. In a third case, Rendón, Andrés y Mejía (2019) analyze the uneven growth across municipalities and subsectors thought the Shift-and Share method reaching the conclusion that manufacturing employment volatility in México's Valle de México post-2008 links to the economic cycle in the United States. By dissecting economic trends into differentiable components, this methodology transforms empirical findings into actionable insights, underscoring its employability in studies like this one

The spatial Shift-and-Share method retains the core objective of its traditional counterpart -quantifying sectoral changes within a region- but critically incorporates interdependence with related economies. Unlike the traditional approach, which assumes regional interdependence, this framework explicitly accounts for geographic spillovers, enabling localized diagnostics grounded in regional economics. Its primary strength lies in assessing sector-region integration and identifying intra-regional disparities driven by uneven geographic specialization. However, this added spatial granularity comes at a cost: results demand more nuanced interpretation compared to the intuitive outputs of traditional Shift -and-Share. Despite this trade-off, the method's ability to map interdependence is localized specialization solidifies its role in advanced regional analyses.

Data and Methodology

The analysis of human capital's role in wealth creation within a context of rapid technological change requires a methodology that captures both sectoral dynamics and the institutional framework. This chapter operationalizes the relationship between skills and productivity growth in Juárez through a dual approach. The chapter relies on the quantitative sectoral analysis proposed by Camagni (1984) and, complementarily, it deploys an analytical examination to achieve valid inferences about the increasing role of human skills in the process of wealth creation. By mapping sectors across productivity-labor input axes, the quantitative tool reveals how technological integration reconfigures production functions—a process further contextualized through the review of policies related to the creation of workforce skill development. The synthesis bridges neoclassical growth theories and Schumpeterian economics, offering a diagnostic framework for emerging economies.

Methodologically, the study confronts the challenge of limited longitudinal data at the municipal level. While Mexican *Censos Económicos* provide sectoral snapshots for the 2008–2018 period, the absence of granular workforce metrics necessitates proxy variables to describe the dynamics of the local economy. In that sense, this study banks on productivity per unit of labor input to measure human capital. This adaptation aligns with endogenous growth models, where the marginal product of human abilities rises with technological complexity—a hypothesis tested through Juárez's sectoral trajectories.

The diagnostic power of Camagni's Sectoral Model, as the employed methodology is known, lies in the visualization of asymmetric adaptation. Sectors identified in the analysis by their growing productivity along with increasing employment of labor input exemplify successful complementarity between human capital improvement and technological modernization. Conversely, the combination of decreasing productivity in combination with a remission of labor input reflects path dependencies. An isoquant curve—drawn at the average growth rate of all sectors, divides the quadrants with mixed trends (*e.g.,* growing productivity with diminishing labor input or declining productivity with increasing labor input), into two groups, to separate the sectors undergoing restructuring from those in reconversion as well as inefficient ones from the stagnant ones. The model helps to draw an inference about the validity of Schulz's (1961) thesis that skill investment determines technological payoffs in Juárez.

Empirically, the chapter's approach transcends Juárez's maquiladora legacy. By pairing Camagni's spatial analysis with institutional data (*e.g.,* technical schools enrollment, and training centers outcomes) it isolates human capital thresholds—the point at which skills enable technological absorption. Early results suggest that sectors surpassing this threshold, like that those labeled under NAICS code as 54 (Professional Services) and 62 (Healthcare) exhibit steeper learning curves *à la* Arrow (1962), while other remain trapped in low-value-added equilibria. This bifurcation underscores the urgency of education-production technology alignment—a lesson for policymakers navigating technologization's uneven reward.

Data

This study employs data from 15 years span at a 5-years Intervals provided by Mexican *Censos Económicos* conducted by INEGI. Although data generation has improved in México in the last decade—yielding access to figures at municipal levels that were not available five years ago—conducting empirical analysis with series longer than 10 years remains a challenging task. *Censos Económicos,* however, provide detailed information by economic sector (under NAICS) as required for this research. Calculations of productivity follow the methodology of Korkmaz and Korkmaz (2017) who use the total production per hour worked as the unit for their study on the labor productivity and economic growth in the OECD countries. In the absence of data on GDP at municipal level, this study relies on Gross Value Added at the Census (GVAC), while hours worked remains the divisor. GVAC isolates value creation by excluding intermediate inputs, while hours worked standardize labor metrics across sectors—together offering a robust gauge of how production dynamics tend to be less dependent of the quantity on labor.

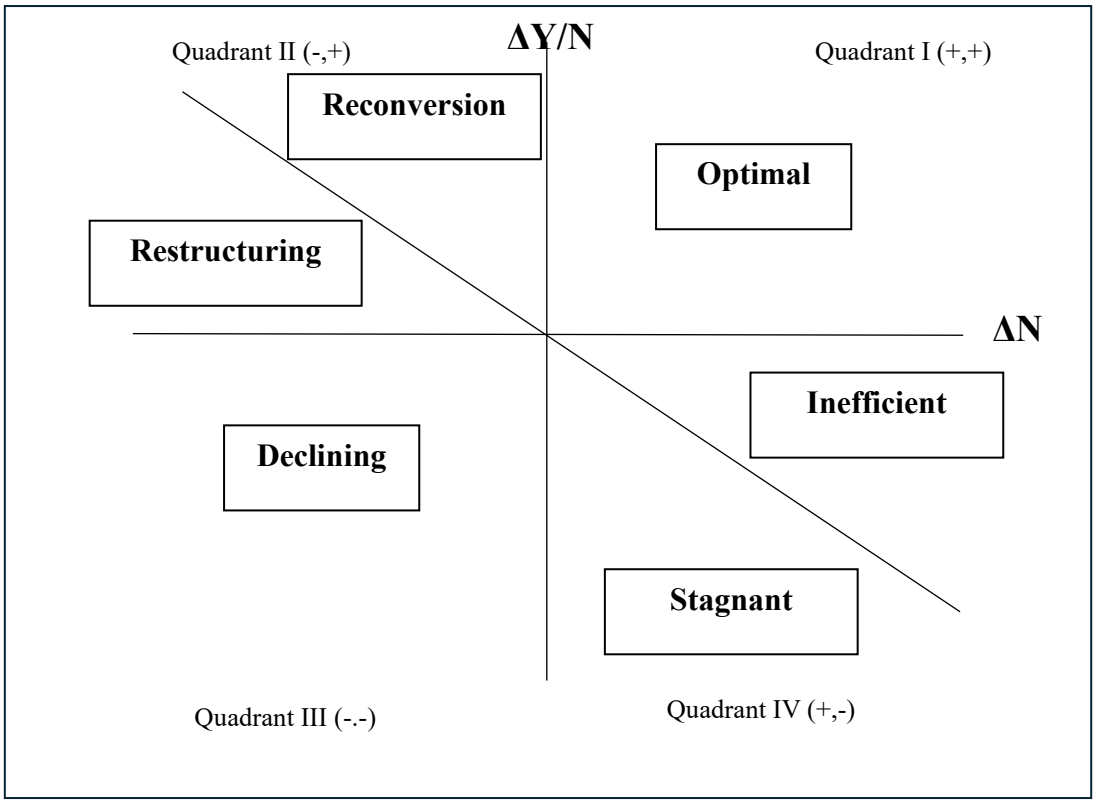
Methodology

Juárez's adaptation to new production paradigms is analyzed through shifts in labor-intensity serving as a proxy for technological advancement. The model proposed by Camagni (1984) operationalizes the relationship between growth rate of productivity—measured as the quotient of total production to quantity of labor ($\Delta Y/N$)—and quantity of labor (N) in a Cartesian framework. The author locates sectors exhibiting simultaneous growth in both productivity and employment in Quadrant I, which represents optimal technological adaptation, while those declining in both dimensions (Quadrant III) signal declination.

Quadrant II, showing increasing productivity and decreasing labor, contains the sectors considered in under reconversion and those in restructuring. Finally, stagnant and inefficient sectors converge in Quadrant IV. The threshold distinguishes the status of the sectors in quadrants II and is an isoquant drawn at the average growth rate of all sectors (See Figure 1). Camagni's model offers a diagnostic tool for economies undergoing technologization, as labor-intensity shifts between quadrants visibly trace the reconfiguration of production processes.

Figure 3

Camagni's Sectorial Analysis Model



Note. Self-elaboration Based on Camagni (1984)

The evolution of the relationship between productivity. INEGI (2014) defines Gross Value Added from the Census (GVAC) as the value added to goods and services during the production process, which is the variable considered in this research as the production to build a Camagni's-type model. In the horizontal axis, labor is accounted for by the number of worked hours in the period.

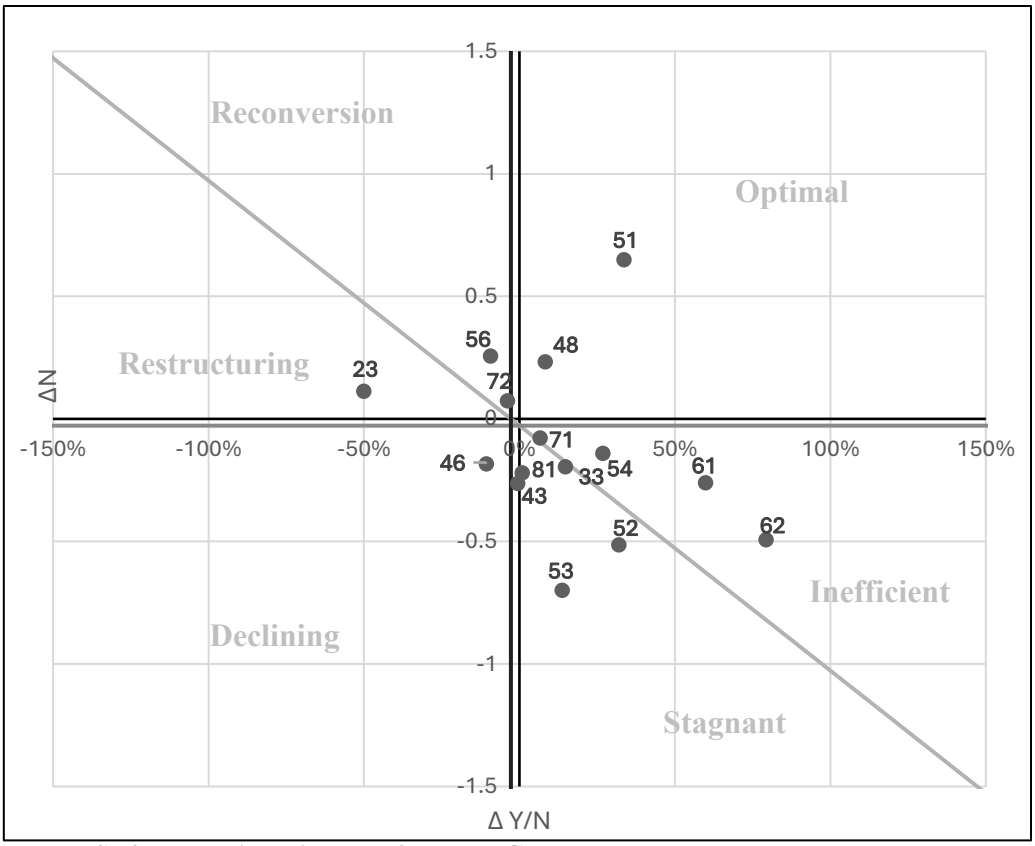
The dynamics of the 2003-2008 period reveal Juárez's economy caught between technological potential and systemic inefficiencies. Only two sectors –Information and Transportation and Warehousing (51 and 48-49 respectively)—achieved the status of the optimal in Camagni's model, combining employment and productivity gains. The clustering of most sectors outside Quadrant I exposes widespread structural problems. From Construction's (23) notable decline to Manufacturing's (33) precarious position directly on the isoquant with a negative performance in productivity, barely avoiding stagnation. Camagni's model instrumentation confirms Juárez's productive ecosystem entered the century with weaknesses facing technologization.

The quadrant distribution shown in Graphic 5 exposes a troubling hierarchy of sectoral vulnerabilities. Finance (52) and Real Estate (53) languish as stagnant sectors, as their employment growth fails to generate more value because of the decrease in productivity. Education (61) and Healthcare (62) showed a similar problem but with grater employment growth, locating above the isoquant of the average growth as inefficient sectors. Most concerning is Manufacuring's (33) position straddling the isoquant, its 15% increase in employment growth unable to prevent a 20% productivity crash. This bifurcation between a handful of adapting sectors and many failing ones foreshadows that Juárez was on the verge of a period of crisis.

Camagni's model diagnoses 2003-2008 as a period of divergent trajectories and systemic warnings. The lone Quadrant I sector (Information, 51) achieved productivity gains alongside employment growth (34% more hours worked and 65% more value per hour worked) demonstrating the potential for human capital-driven growth. In stark contrast, Manufacturing's (33) precarious position—teetering on the isoquant with 20% productivity decline despite 15% job growth—signaled an unsustainable reliance on labor volume over skill intensity. Meanwhile, sectors in Quadrants II-IV (*e.g.,* Construction or Healthcare) exhibited productivity collapse or job cuts, revealing widespread inefficiencies. These patterns served as clear warnings of Juárez's structural weakness (Dutrénit & Vera-Cruz, 2009), with human capital deficits emerging as the critical bottleneck

Graphic 5

Sectorial Analysis Model of Juárez's Economy 2003-2008



Note: Self elaboration with data from INEGI

The 2008-2013 period was marked by a global deterioration of economic performance, triggered by the financial crisis of 2008, of which Juárez was no exception. According to Oulton and Sebastiá-Barriel (2016), financial crises can have long-term negative effects on labor productivity, capital accumulation, and total factor productivity, especially in developing economies, where institutional fragility and credit constraints exacerbate the damage. The structural effects of such economic turmoil create permanent losses in the capacity of the markets for the productive factors. The municipality of Juárez, highly dependent on export-oriented manufacturing and cross-border dynamics, was not immune to these global effects.

The observed decline in production alongside a percentage increase in hours worked necessarily implies a loss in production, which is substantial for the period studied. According to the data, production declined by 9.2% on average considering the 15 sectors in

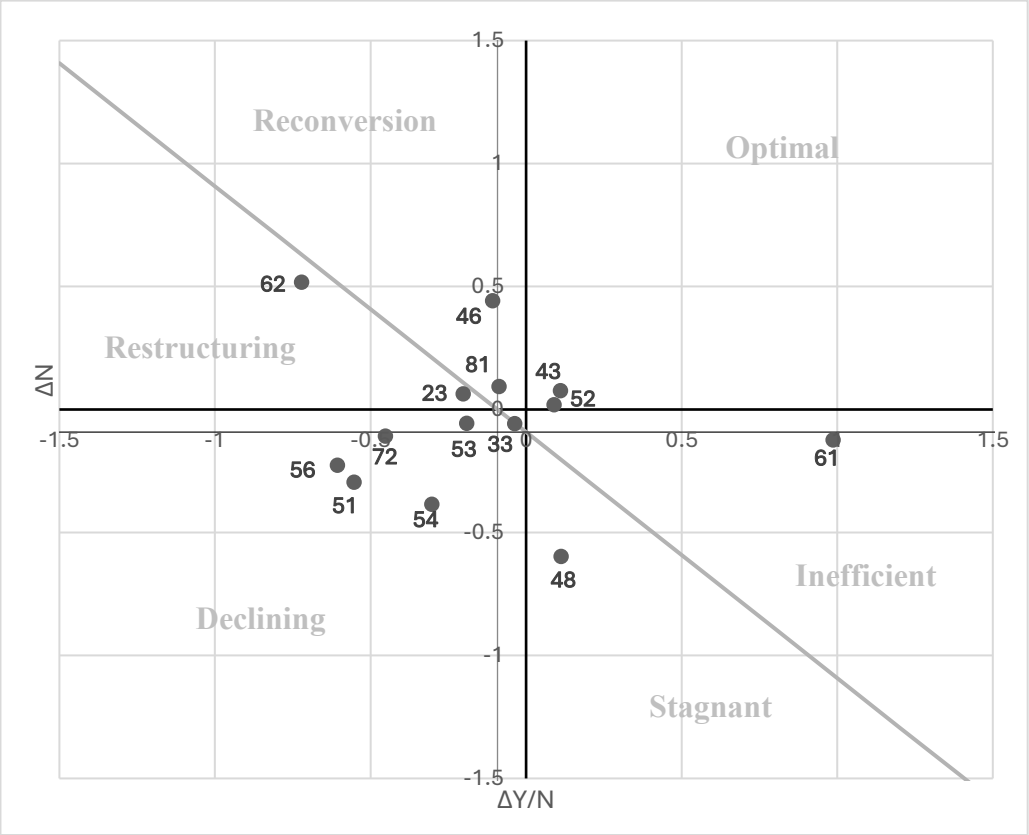
the sample, while hours worked increased by 37%. However, this average growth in the latter, is skewed by the Arts, Entertainment, and Recreation (71), a small sector that registered a 752% increase in the variable—a clear statical outlier. With said sector excluded the average change in worked hours shifts from +37% to -14.4%, indicating the most sectors reduced labor input. This mathematical clarification offers a more accurate picture of the real deterioration in productivity during the period and supports the argument that the financial crisis disrupted both output and productivity.

The reduction of the productivity indicator confirms the idea that output contractions were not matched by equivalent reductions in labor input, leading to efficiency losses. The 3% average decline in productivity supports the pessimistic scenario outlined by Oulton and Sebastiá-Barriel (2016), in which productivity levels fall and fail to recover their pre-crisis trend, especially in emerging markets like the one Juárez is part of. Out of the 15 sectors analyzed, only seven experienced productivity gains, and only two registered simultaneous growth in both production and productivity, a condition for positioning within Camagni's "optimal" quadrant. This pattern reinforces the conclusion that productivity losses during the period were widespread, and that true efficiency gains were limited to exceptional cases.

Analyzing sectoral outliers reveals the heterogeneity of responses to the economic shock and helps identify patterns in behavior across productive sectors. Graphic 6 displays the new configuration of economic sectors in the city for the 2008-2013 period following Camagni's methodology. Particularly sharp declines in productivity were observed in Transportation and Warehousing (48) as well as in Professional, Scientific, and Technical Services (54), which fell 60% and 39% respectively during the 2008-2013 period. The former went from inefficient to declining in the scheme, while the latter downgraded from efficient to stagnant despite maintaining the same pace of growth in labor input. Such changes suggest deep restructuring or inefficiencies in the use of labor. Information (51) also experienced a significant productivity drop of one third, which may reflect the contraction of demand for high-skill services or underinvestment in tangible assets. That conclusion is reinforced by the fact that INEGI (n.d.) reports that this sector was the only one to register a negative gross fixed capital formation. Contrasting these examples illustrates the uneven evolution of sectors in the face of a crisis of this scale.

Graphic 6

Sectorial Analysis Model of Juárez's Economy 2008-2013



Note: Self elaboration with data from INEGI

In contrast, some sectors demonstrated resilience and even improved labor efficiency during a general economic contraction. Healthcare and Social Assistance (62) and Real Estate and Rental Services (53) gained 52% and 62% respectively in productivity, despite their modest participation in the overall economy of the city. Notably, the most important sector of the municipality by any measure—Manufacturing (33)—registered a drop in productivity (-6%) and gross value added (-9%) reflecting a mild but significant contraction in a sector that typically anchors local growth. Such changes located Manufacturing (33) in the declining quadrant of Camagni's diagram, though notably positioned right on the isoquant of the average growth across all sectors. These divergences in sectoral trajectories underscore the need to interpret aggregate trends with caution and reaffirm the importance of sector-

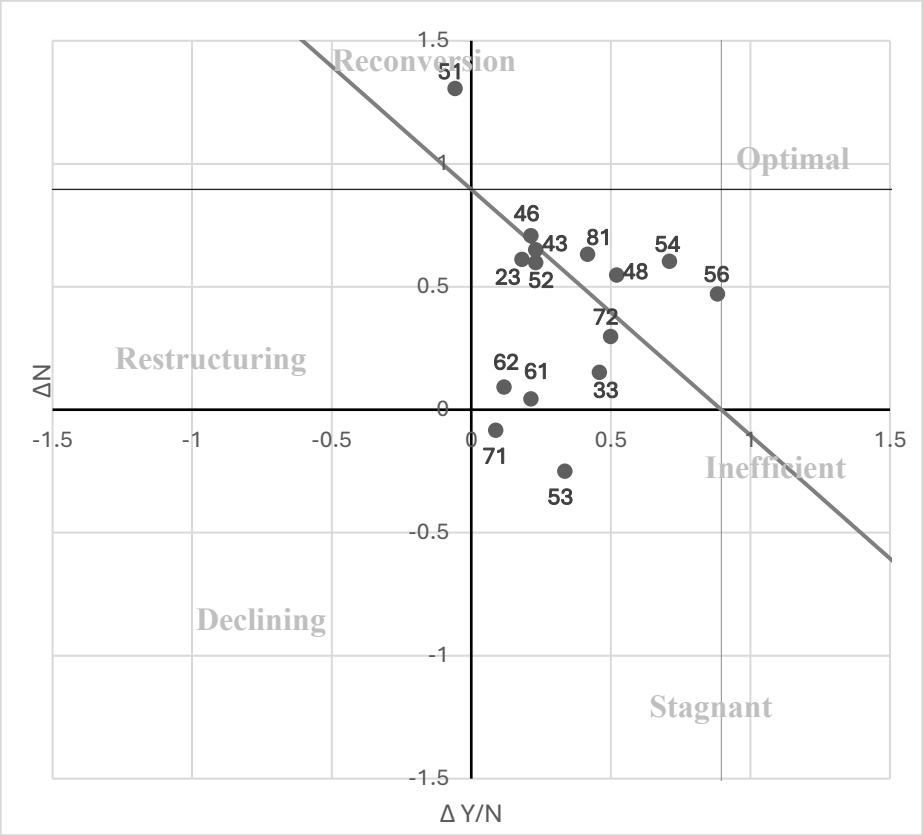
specific analysis when assessing productivity dynamics, especially in the context of a crisis of this magnitude.

In line with Oulton and Sebastiá-Barriel's (2016) findings, the impact of financial crisis seems to have had more persistent effects on productivity and employment than merely a temporary reduction in output. This is relevant for interpreting structural changes in the regional economy of Juárez, Chihuahua and supports the idea that human capital becomes relevant during times of technological economic disruption, as some sectors adapted better than others.

The final period studied (2013-2018) was marked by a significant recovery in economic activity in the world, as all sectors rebounded from the global downturn of the previous years. Data from *Censos Económicos* show that average growth in production across all sectors in Juárez reached 90%. The average growth in hours worked also returned to positive territory at 24%, and productivity increased across the tables (See Graphic 7). This aggregate behavior signals a successful adaptation to post-crisis conditions, consistent with findings by Odoardi and Muratore (2019), who emphasize the importance of human capital and firm-level innovation in labor productivity growth during the recovery phases. These figures suggest that the economy of Juárez entered a new expansionary cycle driven, in part, by efficiency improvements. Significant improvements in output were not equally distributed across all sectors. The sectors with the strongest production growth were Administrative and Support Services (56) and Professional. Scientific, and Technical Services (54), with increases of 176% and 174%, respectively. These were followed by information (51), which grew by 117%, while simultaneously achieving the highest productivity gains of the period. This group of high-performing sectors is notable not only for their recovery but also for their orientation toward knowledge-intensive activities. Sector 54 is widely recognized as an innovative one, as noted by the OECD (2016) , which remarks the role of professional and scientific services. In enhancing productivity and technological adoption. Their performance in Juárez reflects a local manifestation of that global trend.

Graphic 7

Sectorial Analysis Model of Juárez's Economy 2013-2018



Note: Self elaboration with data from INEGI

On the other end of the spectrum, Arts, Entertainment, and Recreation (71) showed the weakest result in terms of production growth (-.035%). Real Estate and Rental Servies (53) essentially stagnated with marginal growth of .018%, while Health Care (62) and Education (61) expanded only 22% and 27% respectively—well below the average of 90% registered for all the sectors. These disparities highlight the uneven pace of recovery across the economy. The position of sector 51 is particularly notable as it was the only sector to reduce labor input, and yet more than twofold productivity, confirming its shift toward capital-intensive and technologically sophisticated production. According to *Censos Económicos,* Information (51) had the second highest gross fixed capital formation per economic unit, only after Manufacturing (33), reinforcing its role in the new productive paradigm.

The case of Information (51) illustrates the growing role of capital and technology in boosting productivity and how it contributes to making labor more productive. Despite being the only sector to reduce hours worked during the period, it recorded the highest productivity increase with an expansion of over 130%, highlighting the success of technological adoption and capital deepening. According to INEGI's 2018 *Censos Económicos*, only Manufacturing (33) recorded higher gross fixed capital formation per economic unit. These findings suggest that the productivity surge in the sector is the result of a reconfiguration of its production process. As a result, this economic activity becomes a benchmark for understanding the transformation toward a high-productivity, less labor-intensive model. This is also a demonstration of how the combination of increased physical capital can jointly drive productivity growth, especially in a context where knowledge and digital assets are gaining importance.

The post-crisis period reveals an unusually strong pattern of sectoral alignment that suggests a structural shift in the local economy. Applying Camagni's analytical framework to the data shows a striking configuration: only three sectors (51,71, and 53) failed to fall in Quadrant I of the diagram, meaning they experienced simultaneous growth in productivity and labor input. This indicates broad-based efficiency gains across sectors, tied to better integration of technological processes and workforce development. Graphic 7

visually demonstrates this clustering, underscoring the systemic nature of recovery. According to Kwiecien (2022), such alignment is a typical marker if post-crisis economies where productivity rebounds are powered by successful absorption of new technologies through skilled labor. This positioning in the optimal quadrant reinforces the notion that the city experienced not just recovery but transformation un how growth was generated. However, while most sectors improved in both productivity and labor use, their positioning below isoquant representing 90% average production growth suggests their contribution to overall output was positive but moderate. In Camagni's model, being in the optimal quadrant signals improvement, but being below the isoquant line means that such sectors are catching up, not leading expansion. Such dynamics reinforces the idea that the dynamism of the post-crisis recovery was concentrated in a few high-performing sectors such as Professional, Scientific, and Technical Services (54), Administrative and Support Services (56), as well as information (51), that pushed the average up. Therefore, the model not only shows which

sectors improved, but also helps identify the real engines of growth, distinguishing between broad recovery and sectoral leadership. This distinction is essential to understanding the transformations process and the significant role of advanced, knowledge-intensive sectors in leading to a change of the economy.

The sectoral behavior observed across the three periods reflects a gradual transition from a fragmented productive structure toward one increasingly defined by efficiency gains and technological adaptation. After the widespread decline registered between 2008 and 2013, most sectors recovered their pre-crisis positions, though at different speeds and degrees of productivity improvement. Table 2 summarizes these trajectories, consolidating the movement of each industry across Camagni's quadrants and revealing the extent to which recovery was uneven. While knowledge-intensive sectors such as Information (51) and Professional, Scientific, and Technical Services (54) advanced toward the optimal quadrant, labor-dependent activities like Manufacturing (33) and Construction (23) remained near or below the isoquant, underscoring the structural duality of Juárez's economy.

The comparative behavior of sectors across the three periods reveals a progressive but uneven structural transformation of Juárez's economy. Between 2003 and 2008, only a few sectors, notably *Information (51)* and *Transportation and Warehousing (48–49)*, combined growth in productivity and employment, while most activities remained stagnant or engaged in restructuring processes. The subsequent crisis of 2008–2013 deepened these disparities, pushing several sectors into regression or inefficiency. By contrast, the 2013–2018 period marked a broad recovery, as nearly all sectors moved into the dynamic quadrant of Camagni's model, reflecting improved efficiency and labor absorption. Table 1 summarizes these trajectories, showing how sectors such as *Professional, Scientific, and Technical Services (54)*, *Administrative and Support Services (56)*, and *Manufacturing (33)* became key drivers of post-crisis growth, whereas activities like *Real Estate (53)* and *Arts and Entertainment (71)* continued to lag behind.

Table 2

Sectoral Movements Across Camagni's Quadrants (Juárez, 2003–2018)

Sector	2003-2008	2008-2013	2013-2018	Interpretation
Construction (23)	Restructuring	Restructuring	Optimal	Recovery trajectory following two stages of structural adjustment; productivity and employment growth after 2013.
Manufacturing (33)	Inefficient	Declining	Optimal	Shift from inefficiency to contraction during the crisis, then recovery with moderate productivity improvement.
Wholesale Trade (43)	Declining	Restructuring	Optimal	Progressive structural improvement culminates in balanced productivity and labor expansion.
Retail Trade (46)	Declining	Reconversion	Optimal	Sectoral upgrading from regression to sustained post-crisis expansion.
Transportation & Warehousing (48–49)	Optimal	Stagnant	Optimal	Early dynamism, temporary stagnation during the crisis, strong recovery afterward.
Information (51)	Optimal	Declining	Reconversion	High initial performance, crisis contraction, later recovery through technological reconfiguration.
Finance & Insurance (52)	Stagnant	Optimal	Optimal	Efficiency loss during crisis followed by restoration of productivity and employment growth.
Real Estate (53)	Stagnant	Declining	Stagnant	Stagnation gives way to sustained optimal performance.
Professional, Scientific & Technical Services (54)	Inefficient	Declining	Optimal	Sharp decline during the crisis followed by strong expansion driven by innovation and skilled labor.
Administrative & Support Services (56)	Restructuring	Declining	Optimal	Employment contraction in crisis years, followed by rapid growth in the recovery phase.
Education (61	Inefficient	Inefficient	Optimal	Prolonged inefficiency prior to later productivity and employment gains.
Healthcare & Social Assistance (62)	Inefficient	Restructuring	Optimal	Transition from inefficiency to restructuring and then joint gains.
Arts, Entertainment & Recreation (71)	Inefficient	Optimal	Stagnant	Volatile pattern with intermittent gains.
Accommodation & Food Services (72)	Reconversion	Declining	Optima	Gradual shift from productive reconversion to contraction and later dynamic recovery.
Other Services (81)	Inefficient	Reconversion	Optimal	Steady movement toward higher efficiency and employment.

Note. **Self-elaboration based on results obtained through the application of Camagni's (1984) model.**

The overall configuration confirms that Juárez's productive structure evolved from a fragmented and labor-dependent system into one increasingly shaped by technological and organizational upgrading. The clustering of most sectors in the dynamic quadrant during the final period indicates a generalized recovery supported by rising productivity and renewed employment creation. Nevertheless, the persistence of stagnant and low-productivity activities, particularly in real estate and recreational services, highlights the coexistence of modern and traditional segments within the local economy. These contrasts underscore that Juárez's transformation, though significant, remains an ongoing process of structural convergence rather than a completed shift toward a knowledge-based model.

Conclusions

Juárez's economic trajectory during the analyzed time lapse clearly reveals that sectors combining technological adoption with human capital accumulation had a better performance in recovering from the crisis. Schultz (1961) posited that technological advances elevate economic value of skills, which was evident in sectors like information or professional, scientific, and technical services, whose productivity surge after 2013 coincided with the expansion of training programs and technical schools in the city. Conversely, manufacturing remains labor-dependent and vulnerable to crises as demonstrated by its productivity contraction during the 2008-2013 period and its modest growth during the recovery period. Clark's (1967) "hierarchy of labor productivity" explains why knowledge-intensive sectors outperformed, based on their adaptability to recent technologies. Juárez's growth engines shifted decisively towards sectors where human capital complemented technology, validating Schultz's hypothesis that the value of human capital as a productive input increases with technological complexity.

Arrow's (1962) *learning-by-doing* theory illuminates why some sectors rebounded faster post-2013, while others languished. Sectors with a stable workforce (*e.g.,* Information) retained cumulative knowledge, enabling steeper learning curves during recovery—as evidenced by a 130% growth in the 2013-2018 period. In contrast, Construction (23) and Retail Trade (46), which shed labor aggressively during the 2008-2013 period saw productivity gains erode aligning with the displacement effects described by Acemoglu and Restrepo (2019). Notably, Healthcare (62) and Education (61), despite an increase in the use of labor input, remained stagnant due to low-skilled labor saturation, underscoring that

quantity of labor without quality cannot drive productivity (Becker, 1993; Schultz, 1961). *Learning-by-doing* effects were strongest where human capital investments preserved continuity.

Sectoral performance in Juárez's economy confirms the idea that innovation rewards skill-intensive sectors while penalizing those heavily relying on labor. The transformation observed in Information (51) after the second period studied, with a 130% increase in productivity, exemplifies the complementarity between capital and skills. Meanwhile, Manufacturing's (33) reliance on labor left it trapped near the isoquant. Regional development models further clarify this divergence: Juárez's export-oriented maquiladoras initially thrived on cheap labor but faltered when technology raised the skill floor.

The 2013-2018 recovery underscores how targeted training programs (*e.g.,*CENALTEC and CECYTECH) can accelerate human capital accumulation, aligning with regional development paradigms. Professional, Scientific, and Technical Services (54) and administrative services-related sectors showed the highest growth of value, as they benefitted from the localized knowledge spillovers from the growth of training programs as anticipated by Lucas (1988). Conversely, lagging sectors such as those related to arts and real estate, lacked comparable interventions, perpetuating low-value-added activities. Results observed in the sectoral analysis for the last stretch of the time span suggest that policy-driven skills investment was pivotal in transitioning Juárez toward a knowledge-based economy.

While Camagni's model and productivity metrics employed in the analysis serve as proxy measures for human capital effects on economic growth, a prolonged time series on skills formation would strengthen causal claims. The absence of granular workforce data (*e.g.,* education levels by sector, on- and off-the-job training programs) limits the analysis to indirect inferences. Future research could pair quadrant analysis with wage or certification data to isolate skill effects. Structural equation modeling could formalize links between the different forms of skills acquisition for job and sectoral productivity growth. The experience obtained in this research invites deeper study of how skill-building institutions—formal and informal—mediate technological transitions.

Juárez's trajectory confirms that human capital's economic value rises with technological complexity, but unevenly across sectors. The visions of theorists like Schultz

(1961) and Becker (1993) where human capital is the engine of growth materialized in sectors such as Information (51) and Professional, Scientific, and Technical Services (54), while Clark's (1967) hierarchy explains Manufacturing's (33) relative stagnation. Learning curves steepened where training and technology fused, consistent with Arrow's (1962) fundamentals; however, policy gaps left other sectors behind. Regional development theory clarifies why Juárez maquiladora legacy initially hindered this shift—yet post-2013 policies signaled a breakthrough. As technology advances, wealth creation will increasingly hinge on aligning education policy with innovation—a lesson for emerging economies worldwide.

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