Making Innovation in the Mexican Silicon Valley: The Early Years of *El Centro de Tecnología de Semiconductores* (1981-2001)

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Abstract:

This article tells the early story of *El Centro de Tecnología de Semiconductores (CTS)* as a site of innovation. It argues that, along with economic and scientific development goals, *CTS* furthered political and geopolitical change agendas for IBM and Mexico. These included reorganizing labor around global supply chains and maintaining specific power dynamics between the Global North and South. Throughout the nineties, *CTS* was key in Mexico's innovation project. It operated as a laboratory for business models built directly on computing supply chains and was an example of successful industry-academia alliances. However, not everyone in the cluster benefited from Mexico's search for innovation. The country's innovation policies involved the adoption of "outsourcing"—a flexible labor regime that remade labor in the cluster by weakening workers' rights. In so doing, the article also explores the logistical dimension of the prototype and innovation.

> The world is experiencing a battle for dominance in electronics; Americans, Japanese, and Europeans compete in the international market. This competition, which is also a fight for survival, necessarily implies that nations like Mexico allocate more resources to their domestic product for scientific and technological research.
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> Jalisco Governor Enrique Alvarez del Castillo, *CTS* Inauguration (*El Informador* on November 15th, 1988, pp.1-2c).

> Companies are changing production strategies to make more money. One of the most common is what they call "productivity", which is nothing more than by-demand production. That is, a client requests a very large order [a project], and the company must deliver it on a certain date. The company recruits many workers to fulfil the order. Once the workers fulfilled the order, they are fired.

Introduction

In the last two decades of the twentieth century, Mexico's economic development policies radically transformed from protectionist to neoliberal. Referred to by Mexican authorities and media as the "Mexican economy's internationalization," this transformation required the country's industrial sectors to become competitive in increasingly globalized markets [26]. Federal guidelines to achieve this longed-for international competitiveness centered around technological innovation, understood as researching and developing computing technology for industries (agriculture, energy, and manufacturing, for example) [53]. To do this, the country was to cultivate key domestic scientific communities, such as telecommunication and electronic engineers.

Mexico was not alone in its innovation efforts. Between the eighties and nineties, several countries across the Global South embraced neoliberal change agendas and boosted research centers to better reap the benefits of globalization, understood as the global relocation of processes of economic activity [21, p. 2]. This global competitive environment made countries, corporations, research centers, and ultimately individuals, perform as if they were in a constant fight for survival.

Operating under the purview of *la Comisión de Inversiones Extranjeras de la Secretaría de Comercio y Fomento Industrial* (*SECOFI*)[1], *El Centro de Tecnología de Semiconductores* (*CTS*) was a key piece in Mexico's innovation project. First, it operated through an alliance between the Mexican Federal Government and the International Business Machine Corporation (IBM) meant to connect the country's industrial sector and scientific communities. In that sense, it reflected Mexico's new approach to national development. Second, once in operation, *CTS* became a laboratory for business models that built directly on computing supply chains. Throughout the nineties, *CTS's* engineers experimented with lean management and design styles to better adapt to the increasingly modular computing industry. These experiments—or prototypes [79], [15], [49]— spilled over to the rest of the Jalisco information technology (IT) cluster via industry-academia partnerships such as *el Programa Avanzado de Diseño de Tecnología de Semiconductores (PADTS)*, an industry training program for engineers.[2]

However, not everyone in the Jalisco IT cluster benefited from Mexico's search for innovation. The country's economic policies towards internationalization involved the adoption of "outsourcing"—a

[1] The now *Secretaria de Economia* (Secretariat of Economy) was until 2000 *La Secretaría de Comercio y Finanzas (SECOFI)* or Secretariat of Commerce and Finance. Before SECOFI (between 1976 and 1982) its name was *La Secretaría de Patrimonio y Fomento Industrial (SEPAFIN)* or Secretariat of Patrimony and Industrial Development.

[2] R. Parra Michel, private communication, January 2022.

flexible labor regime that supported experiments in modular management and production styles like those prototyped at *CTS* [23], [52], [30]. Known by tech assembling workers at the Jalisco IT cluster through terms such as "productivity" and "flexibility," these lean approaches to innovation remade labor in the cluster by weakening rights established for workers in the Mexican constitutions [50].

In this article, I draw on archival research and Jalisco IT cluster's participants' firsthand accounts to tell the early story of *CTS* as a site of innovation. I argue that, along with economic and scientific development goals, *CTS* furthered political and geopolitical change agendas for IBM and Mexico. These explicitly included the reorganization of labor around the global supply chains of computing and the maintenance of specific power dynamics between the Global North and South. I also explore the logistical dimension of the *prototype*.

This article is divided into five sections. After the introduction lays out the relevance and stakes of the project, the second section presents my analytical approach to the (critical) study of innovation and my methods for researching the early years of *CTS* in the broader context of the computing industry's globalization. In the third section, I analyze the connection between work, technology, and development in Mexico before *CTS*, tracing the origins of academic-industry research partnerships back to Mexico's protectionist industrialization model and Latin American economic theories of peripheral capitalism [66].

In the fourth section, I examine in detail *CTS* organizational experiments, both academia-industry partnerships, and the outsourcing of services to the Jalisco IT cluster. I also analyze how state officials, IBM, the media, and members of *CTS* framed these two practices as working towards national development. I also explore the logistical imagination behind innovation discourses in Mexico and the situated practices that performed them inside *CTS.* In the fifth section, I build on tech-assembling workers' archives to explore how IBM and Mexico's change agendas remade labor in the Jalisco IT cluster via outsourcing. Finally, in the conclusion, I draw broader connections between the logistical imagination, technological innovation, and the history of technology assembly labor in the Jalisco IT cluster.

1. Innovation as a Conservative Project: Change Agendas, Labor, and Power in the Computer Industry

In their now classic text on work redesign and technological and organizational change, critical innovation scholars Suchman and Bishop [79] argued that innovation is a conservative project. According to them, framing agendas as working "towards innovation" is often a strategic move to get support in pursuing very different goals. "Change agendas"—they explained—"may actually be directed at least as much at the reproduction of existing organizational and economic orders as at their transformation" [79, p. 331], [42]. Whether they aim at intensifying ongoing activities within an existing market or to extend

these activities into different ones, discourses of innovation—they conclude—work in the service of conservative projects that reproduce existing power relations [79, p. 331].

Drawing on this work along with feminist and postcolonial science and technologies studies (STS), I take innovation and change as inherent aspects of any organization. I argue that the change often attributed to *CTS* took place through its actors' mundane practices of adapting given resources to given circumstances [79, p. 332], [15]. Rather than telling a story of singular inventions, change agents, and radical transformations at *CTS*, I am interested in unpacking the story of *CTS'*s prototypes, understood as actors' artful integrations and reconfigurations of familiar environments and repertoires to produce new things [79, p. 332], [80 13].[3]

The early history of *CTS* presents an example of innovation as a conservative project in the computing industry at a larger scale than the single organization (analyzed by Suchman and Bishop [79]) and the nation (examined by other critical innovation scholars [49], [40]). At a national scale, innovation practices at *CTS* advanced imaginaries of development via technology in Mexico [44]. Such imaginaries valued creative work over the menial labor of repair, maintenance, data entry, cataloging, and assembly [81], [64],[16]. In time, these narratives of national development legitimized the uneven redistribution of the benefits and costs of innovation [41], [67], [4]. Besides serving the nation, *CTS* was part of IBM's expansion plan in Latin America. Consequently, it served the bigger goal of maintaining the company's advantage in the global computing industry [17], [61]. Boosted by IBM's transnational expansion efforts, nineties' innovation discourses in Mexico remade labor in the Jalisco IT cluster. However, rather than creating something new, innovation perpetuated old anti-union managerial strategies and reproduced long lasting geographies of production and labor.

Given the position that Jalisco's IT cluster occupied as an important site of technology assembly in the global computing industry during the nineties— hence the nickname: Mexican Silicon Valley—, *CTS*'s early prototypes did not incorporate only end-users feedback [80], but directly built on computing supply chains. Consequently, its story uniquely connects globalizing discourses of innovation originating in Silicon Valley, the modularization of computing supply chains, and the rise of what anthropologist Anna Tsing [83] calls "supply chain capitalism," a regime of value based on the logistical and subcontracting possibilities that emerged from the globalization of key industries such as computing—for example, outsourcing (see also "logistical imagination" in [37]).

[3] My focus on practices of integration, alignment, articulation in the production of technological innovation draws on a long tradition in feminist and postcolonial epistemologies that question diffusionist models of technoscientific knowledge. In that sense, my work is also indebted to the new sociology of technology [7]— social construction of technology (SCOT) and actor-network theory (ANT) [6], [47]

Methods and Methodology

My methods include archival research and interviews. Between 2022 and 2023, I conducted three visits to the National Newspaper Archives to research how *CTS*'s story was portrayed by the media of the time. As part of a collaborative project, I spent six months of 2023 cataloging the archives of *El Centro de Reflexión y Acción Laboral* (*CEREAL*). Located in Guadalajara, Jalisco since 1997, *CEREAL* is a nongovernmental organization that offers support to workers in the Mexican manufacturing industry. Its archives (which begin in 1997) include zines, workshop materials, workers' periodical publications, meeting notes, as well as annual reports about the state of electronic assembly labor in Mexico. I also reviewed the online archives of Mexico's Official Gazette.

Finally, I interviewed two engineers that worked at *CTS* during the eighties and nineties: Doctor Jose Luis Leyva Montiel, *CTS*'s former director, and Doctor Ramón Parra Michel, the current director. To supplement these first-hand accounts, I reviewed Mexican scholarship's critical accounts of Jalisco's IT cluster evolution and the role *CTS* played in it. I also extensively reviewed United Nations Economic Commission for Latin America and the Caribbean (ECLAC) theories of peripheral capitalism.

Building on situational analysis as a methodology [11], my data analysis included the production of situational, relational, and positional maps of key events in *CTS*'s history. These maps helped me grasp the scope of each situation or event, the social relations at play, and stakeholders' positions regarding specific issues, for example, the success of given organizational forms and labor regimes.

2. Technology and National Development in Mexico before *CTS*

The production of *CTS* as a site of innovation precedes its material creation in 1988. The idea of a research center cofounded by both IBM and the Mexican Federal Government was first publicly presented in 1985. In 1984, IBMs had announced its intention to expand its manufacturing facilities in El Salto, Jalisco. Referred to in the media as "IBM's microcomputer investment," this announcement led to a public controversy regarding Mexico's protectionist industrialization policies and the broader development model furthered in the region by ECLAC. The computer program, a policy that granted foreign computer companies access to Mexico's cheap labor and booming market provided they partnered with domestic firms and yield the majority share to them, was front and center in this debate.[4] IBM requested, and was eventually granted, an exception allowing the company to operate outside the computer program—that is, to fully own and control its operations in the country and directly compete with Mexico's emergent and so-far-protected domestic computer industry.[29], [84].

[4] Elsewhere [82], drawing on the work of [64], [63], [33], I examined this debate as a case of postcolonial computing articulated around the politics of the copy.

1.1. The computer program and ECLAC's Theory of Peripheral Capitalism

There was a Mexican electronics Industry as early as 1930. In the 1940s, Mexican firms began manufacturing radios and radio components, adding televisions and related parts in the 1950s [84], [86]. In 1960s, via the maquiladora program[5], the development of the transistor led to further advances in the sector. However, the quality of Mexican products was poor and the prices high—almost 30% in comparison to devices from developed countries like the United States [84]. It is in this context that Mexico first began importing computers. By the mid-1970s not only had the country become an important consumer of these devices, but a plan for developing a stronger domestic computer industry had become a priority [88].

Although Mexico had a draft of the computer program as early as 1977, it was not until 1981 that the Lopez Portillo administration implemented it [88]. In its first version, the computer program had three goals: to develop a domestic computing manufacturing sector to supply international and national markets, to strengthen the Mexican economy by diminishing the negative impact of computer imports on the balance of payments, and to favor greater technological development [84]. To fulfill these goals, the program operated by attracting foreign direct investment and reorienting it towards the development of a domestic computer industry. The program granted foreign companies exclusive market access, preferential procurement benefits as well as fiscal and credit incentives (while committing them to use 35-40% of domestic parts and components, to invest in research and development, and to create research and training centers, like *CTS)* [84]. In this way, the program partnered the domestic industry and scientific communities with foreign companies while maintaining decision-making power within domestic firms.

The computer program was designed under an import-substitution industrialization (ISI) model of development, hence it shared some of this economic program's principles, strategies, and goals [29]. For one, it conceived technology as a path for producing equilibrium. Drawing on evolutionary theories of economic change [75], [57], ECLAC economists lead by Raúl Prebisch, its founder and director, argued that capitalism operated differently in its center and its periphery, although the two were interconnected. Centers gatekept technical progress and concentrated the benefits of growing productivity, boosting the development of the periphery only to the extent of their interests [66], [87]. This generated a tendency

[5] The maquiladora as a model of production is at the core of most industrial policies in Mexico. Aiming at incentivizing foreign direct investment by offering tax exceptions for goods to be manufactured in Mexico but sold elsewhere, the maquiladora program started on the border in 1969. By 1972 it had expanded to the rest of the country (see also "temporary import" in [24]). In 1980, the *Programa de Importación Temporal para Producir Artículos de Exportación* (*PITEX*) offered same benefits for domestic companies. In 1994, NAFTA did the same for the US and Canada. In the 2000s, the *Programa de Promoción Sectorial* (*PROSEC*) did the same for specific industries in Mexico, regardless of if they imported or exported [10]. Since the computer program closed, most computing contract manufacturing companies in the Jalisco IT cluster alternate between being affiliated to the maquiladora program and *PITEX.*

towards global disequilibrium—between centers and peripheries—and towards internal disequilibrium—between elites and popular classes—in the periphery. According to Prebisch, centers actively worked to maintain this disequilibrium. They strategically propagated forms of consumption, institutions, ideas, and ideologies, while managing to keep their industrial knowledge away from penetrating the social structure of the periphery. In this strategy, foreign companies—like IBM—played an important role. They contributed more to the internationalization of forms of consumption among peripheral middle classes than to introduce forms of production that would generate equilibrium [38].

Although guided by models of development created at the centers, peripheral development—the sort that takes place in Mexico, for example—occupies a subordinate role in global capitalism. It operates as an appendix of the centers that supplies them with primary products at low cost, for which they must open without reserve to the international economy, attracts foreign capital without conditions, and adjusts to the principles of the international division of labor [51], [28]. Meant to be temporary, protectionist policies—such as the computer program—were to counter this tendency by ensuring the peripheries' industrialization. This late industrialization was to take place via "the copy" or the adaptation of innovations generated in industrialized societies. Late industrialized countries within ISI models, like Mexico, were not only to received industrialized countries' technological knowledge, but to generate new knowledge as they adapted these technologies to a new industrial organization model that would work for the periphery [46], [45]. This copied technology was also meant to alleviate the growing social inequality between elites and popular classes in the peripheries by bringing new forms of value production, consumption, and redistribution. Ultimately, the computer program and other ISI industrialization programs aimed to produce local innovation or technological trajectories that the state could control, at least within the boundaries of its territory.

Over the years of its tenure, foreign pressure, neoliberal reforms, and trade agreements debilitated and limited the content and outcomes of the computer program.[6] For example, although implemented in 1981, it remained unpublished in Mexico's Official Gazette, partly due to international pressure against developing countries' protectionist regulations [22, p. 122]. This omission led some international

[6] By the 1970s, ISI policies in Latin America were getting criticism from both radical and conservative sides [35]. Both argued that not only had the much-protected domestic industries failed to enter international markets—during what was called ISI second phase—but the developmentalist policies had not succeeded in solving long-standing problems of social inequality in the region. As support for ISI declined, a new orientation in policy—towards trade liberalization, privatization, and market deregulation—emerged. International organizations such as the Monetary International Fund (MIF) and the World Bank started promoting neoliberalism as a path for development. Advised by technocrats abroad and at home, countries around the world lowered trade barriers, encouraged unrestricted foreign investment, and undertook deregulation and privatization programs [84, p. 2]. In the case of Mexico, the critical situation in its balance of payments since 1981 due to the oil crisis led to the country's early adoption of neoliberal measures [85].

observers to believe that the terms of the computer program weren't legally binding, making it easier to argue in favor of IBM's investment later in 1984 [88], [43]. Moreover, the liberalization of three other policy instruments contributed to the program's limited outcomes. The 1973 Foreign Investment Law (officially, the Mexican Investment Promotion and Foreign Investment Regulation Law) and Technology Transfer Law (officially, the Control and Registration of Technology Transfer Rights Law) were modified in 1982. Then, in 1986, Mexico entered the General Agreement on Tarif and Trade (GATT), further relaxing the country's trade policy. However, it was not until the IBM microcomputer investment that foreign companies had a neoliberal alternative that directly competed with the program.

1.2. The Production of CTS as Innovation: Articulating the New and the Old

Although the idea of a research center cofounded by the State and a foreign company dated to the computer program, it was not until the public debate sparked by IBM's proposal that the idea was discussed in the media. Almost immediately after IBM's microcomputer investment announcement, members of the domestic computer industry expressed their opposition in a public letter published in two newspapers, El *Heraldo* and *El Financiero* [13], [12]. In the letter, they urged the Mexican President, Miguel de la Madrid, to finally publish the computer program in Mexico's Official Gazette and not grant the exception to IBM [13], [12]. In the same way, representatives of Apple and Hewlett-Packard (HP), two transnational companies which, in line with the computer program, had ceded majority ownership of their operations to Mexican partners, opposed the plan [68], [54].

On January 19th, 1985, the government denied IBM's request. However, this position was not supported by everyone in the Mexican Government [88], [2]. The pressure exerted by these actors, along with pressure from the Reagan administration, resulted in the final approval of the investment in July 1985 [34, p. 52].

After months covering IBM and Mexico's intense negotiations, on July 25th, 1985, the newspaper *La Jornada* published a brief note announcing the final agreements. The note identified IBM's comprehensive program, especially the semiconductor technology center, as the cause of the approval. The center was to develop computing infrastructure and train human resources. Both services, the note concluded, were to serve all manufacturing companies in the Jalisco IT cluster. [69].

According to Suchman and Bishop [79], innovation is as much about changing as it is about maintaining power relations. It is about reconfiguring familiar environments into new things. *CTS* was a site of innovation. The outcome of almost 18-months of negotiations between Mexico and IBM, it articulated familiar inward-development strategies and language[7] into a neoliberal change agenda that

[7] For example, the use of the term "sovereignty."

aimed at weakening inward development policies like the computer program. Despite its public commitments to foster Mexico's autonomous development of technology, IBM's aim was to control technological trajectories in Mexico [17], [61]. Its investment in *CTS* sought to maintain the same relations—between the industry and scientific communities—encouraged by the computer program. However, in direct opposition to the program's goal, IBM used these partnerships to further influence Mexico into becoming an alternative to state-led computer policies being advocated in Brazil and India [68].

3. Prototyping Logistics: *CTS*'s Early Years and the Rise of the Mexican Silicon Valley

Published only days after *CTS's* inauguration in November 1988, a news report in the newspaper *El Nacional* summarized a public meeting between Jalisco entrepreneurs and *SECOFI's* Foreign Direct Investment and Technology Transfer Subsecretary on the topic of "modernization and simplification of the state apparatus to fit new foreign direct investment policies." In the meeting the subsecretary emphasized the need for a common effort from all sectors to make incoming foreign direct investment (FDI) and technologies work towards national development. Among the many ways to better channel these foreign resources that were discussed, he highlighted the development of enterprises with foreign capital, especially those connected to the computing industry [53].

As an example, he singled out the Jalisco IT cluster. According to the subsecretary, the development of high-tech companies with foreign capital in the western region of the country had created an environment conducive to national development. Global Computing and telecommunications brands like IBM, Motorola, Intel, Uniskys, Hewlett Packard, and Honeywell had stimulated the use of regional resources, generated production capacity, and boosted employment. The subsecretary especially highlighted *CTS* as an example of industry-academia relations that better supported technological innovation [53].

The Jalisco IT cluster was key for Mexico's internationalization plan. First, the cluster was an important site of foreign direct investment (FDI), temporary imports, and service exports [36]. Unlike the maquiladora industry—another important site for FDI and temporary imports—the cluster had managed to create a network of domestic suppliers around the foreign companies that made up its core [20], [55]. Consequently, it was often presented to the public as somehow better than the northern maquiladora industry since its organization allowed for a more dynamic technology transfer process [25, p. 329].

Second, the cluster was part of the computing industry; a global leader in setting organizational trends along with the automotive industry. Led initially by IBM (in the late 1960s) and later by Silicon Valley, the computing industry's globalization had led to its modularization and its partition into smaller independent subsystems [1], [70]. Using modularity as an organizational principle, the computer industry

articulated a network based on firm-to-firm contractual relations or outsourcing [3], [74]. Beginning in the late 1970s this form of industrial organization spread to other industries [72].

Throughout the early nineties, Jalisco's central region presented some features that resembled the dynamics of the original Silicon Valley in Northern California, for example the creation of start-ups and spin-offs companies [58, p. 326], [59]. These similarities led the media to rename the Jalisco central region as the Mexican Silicon Valley [59]. This nickname led the Jalisco Government and the local chapter of la *Cámara Nacional de la Industria Eléctronica, de Telecomunicación e Informática (CANIETI Occidente)* to launch a successful campaign for promoting central Jalisco as a global IT manufacturing site [59]. Soon, companies like Kodak joined IBM and HP in the Mexican Silicon Valley. However, by the mid-nineties this style of development had slowed, giving way to contract manufacturing and a new regime of mass production based on radically decentralized and modular network architectures and communications [52], [19], [77]. Nevertheless, the name "Mexican Silicon Valley" remained.

Public narratives that blurred the line between innovation in the cluster and national development often highlighted *CTS* as a model of successful organization. Inaugurated in late 1988*, CTS (El Centro de Tecnología de Semiconductores)* was a joint project funded by Mexico's Federal Government and IBM. In 1986, both institutions invested 11 million dollars each to build and equip it [76]. Located near Guadalajara in El Salto, Jalisco, *CTS* aimed to increase the use of integrated circuits (high-tech semiconductors with low cost and high reliability) in products developed and manufactured in Mexico [69]. The center was hosted by *el Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional (CINVESTAV Guadalajara)*, an advanced research center operating under the purview of *El Instituto Politécnico Nacional* (*IPN*). Doctor Juan Milton Garduño, at-the-time head of the electronic engineering department at *IPN*, was charged with the center's direction and early organization.

3.1 A Model and a Process: CTS as a Prototype

"Modularity" describes relations between a system and its parts. A modular system comprises smaller components or modules that fit within an established architecture [70]. Announced in 1964, the first modular computer was IBM's System/360. Its designers achieved modularity by dividing the product into the system's overall architecture and its components [3, p. 150]. This division allowed IBM to open the system's overall architecture so that different companies could design and produce its components [71]. By the late eighties, the computer industry's organization relied more on these interfirm relations and external economies than on the internal structure of vertically integrated corporations. This new organization granted tech companies great flexibility, which exponentially boosted the industry's rate of innovation [74]

Computing modularity emphasizes the use of prototypes across spaces of technology making [3]. Prototypes are artifacts that work to align multiple and discontinuous social worlds [15], [49]. Technology prototypes—like those designed at *CTS*— configure socio-material artefacts—practices, policies, hardware, and software, for example—to produce partial alignments across different sites of technology design, production, and use [80].

To better align with this networked organization, once it opened in 1988 *CTS* not only produced technology prototypes, it operated as one. Its engineers experimented with different versions of public-private partnerships and academia-industry collaborations [55]. IBM was fundamental in guiding this learning process. Director of the research center, Dr. Milton Garduño, had hired three IBM engineers as consultants to help set up the research center— that is, selecting the design software and creating the design flow of integrated circuits. The same consultants remained at *CTS* to train its engineers in project management strategies.[8]

According to STS scholar Sylvia Lindtner, the term "prototype" refers to both "the normative modeling—the making concrete or realizing—of specific ideas and the making of an alternative, which carries the potential for contestation and intervention" [49, p. 3]. *CTS* operated simultaneously as a non-protectionist alternative model of technology development for Mexico and Latin America, and as a site for testing how such non-protectionist models would look in practice.

Mexico's officials and IBM featured the research center (and the broader Jalisco IT cluster) as a model or embodiment of a technology development path alternative to the protectionist one offered by ECLAC economists. *CTS* and the Jalisco IT cluster were also the focus of advertising campaigns. For example, in a one-page advertisement in the newspaper *El Informador*, on February 23rd, 1989, IBM presented the center as a site of technological development and transfer within IBM's broader plan for supporting technological innovation in Mexico. "The common denominator of our programs"—the advertisement explained— "is their shared final objective" [39]. The objective was to promote better collaborations between academic and industrial sectors by supporting technological research and training towards innovation that addressed Mexican contexts.

To perform Mexico's innovation discourse, *CTS* tested different possible configurations of this model to find the one that better aligned the different interests coalescing at the center. Although the publicly announced goal of *CTS* was to develop semiconductor design capacity in Mexico for companies established in the country—ideally in the Jalisco IT cluster—this soon proved to be easier to say than to do.[9] Initially, *CTS*'s engineers offered their design services to members of the cluster (Motorola, IBM, Hewlett Packard and Kodak), but they soon realized that these companies' subsidiaries in Mexico didn't

[8] J. L. Leyva Montiel, private communication, January 2023.
[9] J. L. Leyva Montiel, private communication, January 2023.

have decision-making power over their products' design. They then reached out to government enterprises—PEMEX, Telmex, and *La Comisión Federal de Electricidad*. These large state-led companies were willing to buy the final products but were not interested in financing their designs[10] [25]. Finally, in 1995 they decided to offer the center's services in the United States. Advised by IBM, they reached out to IBM Kingston, a technology development company based in New York, which agreed to commission two hardware design projects from them. After succeeding in their first projects with IBM Kingston, IBM subsidiaries in Austin, Boca Raton, Poughkeepsie, and Raleigh requested *CTS*'s design services. This professional collaboration lasted until 2005. Over the years, *CTS* listed other international clients such as HP, AT&T Paradyne, and Intel.[11]

In its collaborations with IBM, *CTS* produced partial alignments across different social worlds. It demonstrated the relevance of its designs in a broader modular system while also working as the embodiment of new technological possibilities in the market [80, p. 173]. Additionally, it served as a model for a non-interventionist path for developing innovation within IBM's expansionist program. *CTS* was also meant to further Mexico's innovation efforts in the region, but this proved to be impossible in the conditions of Jalisco's IT cluster in 1994. It was not until the late nineties that *CTS* was able to take better advantage of the industry's modularity.

3.2 CTS's Lean Styles and the Logistical Imagination

CTS's main goal was to create semiconductor design capacity in Mexico and sell it to any company established in the country, especially in the Jalisco IT cluster. This was not possible during the early years of the cluster. However, after NAFTA (1994), contract manufacturing—a modular form of organizing production that decouples design from manufacturing [52]— established itself as the primary modular strategy in the cluster. The nineties also introduced efficiency discourses and business logistics to Mexico; an organizational science based on military procurement practices [18]. These changes created a new market for *CTS* [20], [18].

Modularity had led to specific forms of value production based on constant competition between segments of the computing supply chain or value chains [32]. Each segment sought to cheapen other segments' value to raise their own market prices [77]. This intense competition created a situation in which logistics—that is, efficient time and space management [37], [19]—became the prerequisite for competition [18, p. 104]. Coined "the logistical revolution" [18], [9], the rise of logistics[12] as a strategy

[10] J. L. Leyva Montiel, private communication, January 2023.
[11] J. L. Leyva Montiel, private communication, January 2023.
[12] Although developed in the United States during the sixties [18], Boltanski an Chiapello identify the mid-nineties as the period when developing countries that abandoned the policy of development via import

within the firm shifted worldwide corporate practices from a focus on minimizing after-production costs to concentrating on adding value across circulatory systems [18, p. 24].

IBM consultants trained *CTS'*s engineers in these efficiency-based design and managerial approaches.[13] A key concept in this approach, the model of the "lean firm" reconceptualized the firm as decoupled from their less profitable tasks through processes of outsourcing [8]. Following business logistics principles [18], the lean firm connected the new (lean) organization of the firm to that of the "lean factory," a model of production drawn from the observation of Japanese firms like Toyota [89], [48]. Both organizations—lean firm and factory—shared principles such as just-in-time, total quality, the process of continual improvement (Kaizen), autonomous production teams, and a project-based organization. The lean configuration gave these organizations flexibility to reconfigure work within the firm with each new project by outsourcing everything but their core business [8], [5].

This flexible form of organization proved useful for *CTS's* aligning goals, which, over the years, had proven to be a moving target. As more companies in the computer industry either moved or outsourced part of their design operations to Jalisco, *CTS*'s engineers reassessed the research center's original component-design-based business model. For example, during the late nineties *CTS* increasingly experienced waves of talent-flight. The research center couldn't prevent this since the cluster offered the highest salaries in the market. *CTS's* director at the time, Dr. Jose Luis Leyva, an electronic engineer involved in *CTS* from its beginning, approached this talent-flight problem as a business opportunity. Following Stanford University and Massachusetts Institute of Technology's models of university-industry linkages [27], [62], *CTS* partnered with *El Consejo Estatal de Ciencia y Tecnología de Jalisco* (COECyTJAL) and CINVESTAV to train engineers for specific roles in the cluster.

In 2003, they launched *el Programa Avanzado de Diseño de Tecnología de Semiconductores* (*PADTS*), an industry training program for engineers. *PADTS'* first cohort of engineers went on to occupy important positions in Jalisco's IT cluster. This is only one example of the different services *CTS* provided to the cluster over the years, and the different forms of organization they embodied during the nineties. By early 2003, *CTS* offered not only training, but design services for printed circuit boards, manufacturing processes, and telecommunication systems, as well as testing and simulation services and component documentation production [23, p. 56].

Critical innovation scholars have focused on how prototypes allow the incorporation of end user feedback [80]. They have also examined the design studio and other sites of prototyping as sites of future-

substitution—like Mexico—started incorporating and discussing—in management science publications—flexibility [8].

[13] J. L. Leyva Montiel, private communication, January 2023.

making ([49], [40], [4][14] Building on this work, but taking a different path, I examined the logistical dimension of the prototype. According to Hockenberry et. al., efficiency-based management strategies—like those cultivated at *CTS*— carry a logistical imagination that builds on forms of representations, aesthetics, and performative practice that grapple with supply chains globalization [37]. This logistical imagination responds to new understandings of economic space beyond geographical parameters and into its value-adding possibilities [37]. Offshore outsourcing practices—such as those at the heart of IBM, *CTS,* and in contract manufacturing at large—are an instance of this logistical imagination [83]. The strategy was twofold. By setting manufacturing operations in Mexico, IBM minimized the after-production costs of catering to the Mexican and Latin American markets. By outsourcing semiconductor design to *CTS* it produced value out of circulation because technology prototyping was cheaper in Mexico than the US. In the same way, by selling their designs in the US, while maintaining operations in Mexico, *CTS* engineers produced value out of circulation.

As *CTS* increasingly outsourced its services to the cluster rather than IBM in the US, the research center's organizational forms built directly on computing supply chains, another site of logistical imagination. A special economic zone (SEZ) for technology assembly, the Jalisco's IT cluster occupied an important place in the global computing industry and was directly affected by changes in its organization [36]. *CTS's* drastic changes in business models responded to these global changes. For example, the creation of *PADTS* and the research center's reorientation towards training occurred during the burst of the 2001 dot.com bubble. This global financial crisis led to the restructuration of the global computing industry around China as the main site for computing industry manufacture [20]. To adapt to these global transformations, contract manufacturing companies in the Jalisco IT cluster reoriented their services towards production logistics and outsourced the management of assembly shopfloors to *agencias de subcontractación* (subcontracting agencies). [73], [78].

CTS's logistical calculations put Mexico on the map of technology innovation. The center's experimental business models during the nineties led it to compete—and win—in the global market against other US-based technology design firms. This international recognition sustained Mexican government's innovation narratives and legitimized changes on its protectionist national development strategies. Ultimately it contributed to IBM's broader change agenda seeking to establish a non-protectionist alternative model of development to that suggested by ECLAC.

[14] These authors have explored the connection between innovation and supply chains [49] and/or value chains [40]. However, their focus is not in examining the logistical and spatial dimension of these innovation practices.

4. Innovation Backside: Remaking Labor in the Mexican Silicon Valley

Part of *CEREAL*'s archives, *Turno Extra: Vida Laboral en Jalisco* (1998 – 2003) was a bi-monthly bulletin that gathered tech assembly workers' concerns, ideas, and reflections. Published in August of 1998, its second issue is titled: "Workers, the Majority Absent at the Table: The Mexican Labor Law Reform Debate" [82]. Inside, it warns about an upcoming labor reform in the country, one which could be used to fulfill foreign companies' need for making more profit at the expense of workers' rights. Although the proposed reform was to be discussed in congress later in the year, Government officials and domestic and foreign companies had already held several private meetings on the subject. Workers, important stakeholders in this matter, had been left out of these early negotiations.

On the next page, a note explained that ongoing state apparatuses' modernization and internationalization processes in Mexico had led to the proliferation of subcontracting labor practices via *agencias de subcontractación* [78], [82]. Commonly known as *"agencias,"* these short-term labor hiring firms served the goals of the lean firm and factory. As another issue of *Turno Extra* from 2000 reads: "A client requests a very large order, and the company must deliver it on a certain date. The company recruits many workers [via *agencias*] to fulfil the order. Once the workers fulfilled the order, the project is closed and they are fired" [50].

Popularized during the nineties in Silicon Valley, contract manufacturing, a version of the lean factory [19], [71], is a modular form of organizing production that decouples design from manufacturing [52, p. 231], [74]. By the late nineties, this form of mass production integrated a wide array of productive functions related to circuit boards and hardware assembly, including product engineering, component design, logistics, after-sales, and repair services [52]. Through their continuing acquisitions of manufacturing facilities, contract manufacturing companies have articulated transnational production networks that connected national and global markets [52, p. 236].

In the Jalisco IT cluster, contract manufacturing companies worked with *agencias* and the Mexican Government to achieve the labor flexibility that federal labor legislation hindered [23], [5]. A labor reform in Mexico implied amending the constitution. Furthermore, updating workers' collective contracts to foreign companies' new flexible labor demands—a key aspect of the reform— implied a substantial political cost for the Mexican government. *Agencias* transformed labor in Mexico years before the official reform, which occurred only in 2012 during Calderon's presidential tenure [73], [31]. Operating outside of the law but sanctioned by the government, *agencias* established a second, more flexible labor regime than that experienced by planta workers or workers under the collective contracts stipulated in Mexican Federal labor law [5], [30].

Contract manufacturing companies also outsourced the management of their tech-assembly workers to a*gencias* in order to focus on more profitable aspect of their business, such as production

logistics. By 2001, seven out of every ten companies in Jalisco recruited their manufacturing labor force via these *agencias*, which managed about 60,000 workers each year [60]. One of them was Nicolás, a tech-assembling worker from Zapopan, Jalisco. He started working at IBM in 1998 as a quality inspector via the *agencia,* Temporary Work. A year later, in 1999, he was fired due to personnel cuts. Soon after, another *agencia,* hired him for the same project. After eight months, he was again fired without any severance. In 2000, he started working at Flextronics where he was finally hired as a long-term or *planta* worker. However, after two year, Nicolás was fired again due to personnel cuts [14].

Nicolás's account of his time in the IT industry shows how innovation discourses ultimately remade labor in the Mexican Silicon Valley [79]. *Agencia* workers experienced a very precarious labor regime since they had no protection against the industry's efficiency-based lean organization. Nicolás's contracts were only three to eight months long and required constant renewal. Furthermore, *agencias* often reduced his shifts and switched his job position and schedule to prevent him from becoming a long-term worker. [14]. In time, these short-term work features seeped into long-term work regimes such as those protected by contracts gained from collective bargaining processes. For example, even when Nicolas' entered the collective contract, Flextronics fired him due to personnel cuts.

Historians of science and technology have examined how computer modularity precludes not only the components' technical organization, but any conflicts involved in their development, for example, these labor rights struggles [70], [56], [65]. Along, the same lines, feminist and postcolonial STS scholars have highlighted how the division of labor within the computing industry and the conflicts resulting from this division, reproduce existing divisions between race, gender, and geography [49], [56].[15]

Suchman and Bishop's [79, p. 327] critical approach to innovation takes it as naturalizing a cultural imaginary that places the individual actor—whether they are a research center like *CTS*, engineers, or tech-assembly workers on shopfloors—in a sort of "survival mode;" where the burden of change (or survival) falls on the individual. As *CEREAL's* archives attest, the proliferation of *agencias* and other temporary regimes of labor remade work in the Jalisco IT cluster and turn the labor market in a fight for survival. This eventually turned outsourcing into a site of political struggle in Mexico [31]. Companies overcame workers' resistance by controlling unions and preventing workers' organizing. For example, companies often fired workers they considered troublemakers or harassed them into quitting. Managers threatened workers with black listing so neither they nor their families could work in the cluster [14]. In that sense, despite remaking labor in the cluster, innovation discourses in Mexico only reproduced old anti-union strategies. Discourses and performances of innovation within *CTS* and the broader Jalisco

[15] Due in part to the uneven distribution of the benefits and costs of innovation for its stakeholders [79].

IT cluster ended up reinforcing long-lasting and conservative power relations and geographies of production.

Conclusions

In this article, I have argued that *CTS,* a site of innovation, is also a conservative project. The early story of this research center materially connects—via policy reform, situated practices, and computing circuits—entrepreneurial tropes of lean management, tech-assembling workers' precarity in Mexico, and the ever-changing operations of computing supply chains. Initially a strategy for industrialization within a protectionist development model, in 1985 *CTS* became part of Mexico's innovation efforts focused on internationalization. Throughout the nineties, its operations sustained innovation discourses, contributing to maintaining IBM's advantage in the computing market and remaking labor in the Jalisco IT cluster. However, these innovation and change agendas ultimately reproduced old anti-union managerial strategies and power relations. IBM was pivotal in introducing organizational practices that ensured these technological trajectories developed in Mexico.

The advantageous position of the Jalisco IT cluster in the computing supply chain and its symbiotic relations to this research center emphasizes the logistical dimension of *CTS's* prototypes while revealing the inherent logistical dimension of prototyping more broadly [15]. By circulating their designs and prototypes, *CTS* engineers produced value out of supply chains. In the same way, *CTS's* relations to the cluster developed an understanding of supply chain operations among its engineers, in other words, a logistical imagination.

Ultimately, innovation in the Jalisco IT cluster operated within a cultural imaginary that placed the cluster's members in "survival mode." The benefits and costs of such a competitive environment were unevenly redistributed across its participants (research centers, workers, companies, and business associations, among others). Such uneven distribution of risk and opportunity reproduced and reinforced existing divisions in Mexico based on class, race, and geographical location. As *CEREAL's* archives attest, while Mexico's and IBM's change agendas contributed to *CTS'*s success and vice versa, they remade tech assemblers' working conditions in the cluster for the worse. In the years following the dot-com bubble bursting and the cluster's reorganization (2001-2004), tech assembly workers' situation only became more precarious.

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