

9 Beyond the Silicon Valley consensus

Understanding the organizational challenges and opportunities for promoting innovation in Brazil¹

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1. Introduction

In the waning decades of the 20th century, economic policy came to be dominated by a neoliberal consensus built on standard economic theory, with reliance on the market as the motor of growth and development.² The key ideas are still influential in the design of economic policy, but the political support for those policy prescriptions has since dissolved.³ And a new agenda for development policy has emerged, which sits uneasily alongside the old, captured by the mantra: innovation, entrepreneurship, and the knowledge economy. The new agenda might be called the “Silicon Valley consensus.”⁴ The central idea is that growth and development are now driven by formal scientific and engineering knowledge embodied in new products, involving discontinuous technological changes. Such innovations are introduced into the marketplace by small, entrepreneurial firms and require a similarly trained labor force to bring them to market.⁵ The role of government in this new view is to create a set of institutions and cultivate an environment that fosters scientific and technical innovation and its rapid commercialization. This policy consensus, as well as the Washington consensus that preceded it, is generally linked to globalization and an open economy, creating competitive pressures that promote innovation even as those very technologies operate to enhance world trade.

But this approach to economic growth is not without its problems. It derives from the experience of relatively compact geographic areas whose economies developed spontaneously on their own. Other local economies that have tried to replicate this experience through deliberate public policy have had very, very limited success. The relevance of local development models for a national innovation policy is unclear. The models were moreover developed originally in the advanced, developed economies of Western Europe and the United States. And their relevance to middle-income countries, which have a large deficit in primary and secondary education and a significant portion of employment in traditional industries, is open to question. Indeed, Brexit in Great Britain and the election of Trump in the United States have called into question the political viability of the public policies that support these trends, even in the advanced developed economies where they originated.^{6,7}

In this chapter, we explore these issues through a case study of the Serviço Nacional de Aprendizagem Industrial (SENAI) and its initiative to support innovation in the country's manufacturing industry through the creation of the Institutos SENAI de Inovação (ISI). SENAI is a semiautonomous organization created in 1942, originally designed to support vocational training for Brazil's manufacturing industry.⁸ It is governed by industry associations at the state level but coordinated by a central department that provides general management and regulatory guidelines. SENAI is financed through a 1% payroll tax on manufacturing employment imposed by the federal government, the revenue from which is split between the state bodies and the national organization (85% and 15%).⁹ Additional revenue is generated by the provision of contracted services to industry and by tuition charged to students, or their sponsors, in its various training programs. The ISI initiative is part of SENAI's effort to broaden its mission from a narrow focus on education and training to the support of business services more broadly, and in this particular case, technology and innovation. The initiative is creating 25 centers spread across the country, each specializing in one technology and housed in the SENAI unit in which it is located but with a mission to serve business throughout the national territory. SENAI already supports 57 technological institutes that have a narrower focus and serve only the state in which they are located.

2. Research methodology

The study has four research components:

- 1 A series of exploratory interviews with key informants involved in the development of the ISI project and its current management
- 2 A survey conducted in 2014 and 2015 of the directors of all of the ISI centers in operation at that time
- 3 SENAI data covering all ISI projects, including sources of funding, project duration, and partnerships with other ISIs as well as with private industry and outside organizations
- 4 Case studies of two SENAI organizations: the Centro Integrado de Manufatura e Tecnologia (CIMATEC) in Bahia, and the Centro de Tecnologia da Indústria Química e Têxtil (CETIQT) in Rio de Janeiro

This chapter focuses on the two case studies. They were suggested in our first round of exploratory interviews by Luciano Coutinho, president of the Brazilian Development Bank (BNDES). BNDES, provided a substantial long-term loan that essentially underwrote the capital investment that the ISIs initially required. Coutinho was one of the early proponents of the project, and he mentioned these two organizations as models of the kind of institutions envisioned when the initiative was first proposed. As such, the ISI program reflects a combination of external and internal organizational models – one provided by the German Fraunhofer system and another developed internally by leading SENAI organizations.

But CIMATEC and CETIQT provide contrasting approaches to the problems that the ISIs were created to address. The two cases present a contrast between an organization focused on advanced technologies and relatively heavy industry (CIMATEC) and an organization focused on textiles and garments, the kind of traditional industry that we were concerned the ISI approach would neglect (CETIQT). Furthermore, they represent different sectorial focuses and institutional histories – the “new” and the “old” economy, respectively – making them relevant examples of whether and how the Silicon Valley consensus is being integrated in industries with different technological intensity.

The material upon which the studies are based was collected in six field-work trips to Brazil between 2015 and 2018 covering seven states. Overall, we conducted semistructured interviews and focus group discussions with 141 participants. Interviewees were selected from three broad groups: (1) key actors in the design and implementation of the older SENAI programs; (2) officials central to the creation and direction of the new ISIs; and (3) managers and executives in manufacturing firms that draw upon the services of SENAI, both in the acquisition and development of their skilled labor force and for technical aid and advice. In this context, particular attention has been devoted to the interaction between the traditional SENAI mission and the newer innovation thrust. The interviews explored a series of issues that emerged in the early parts of the study in the first exploratory interviews and in the formal survey of ISI directors, but they were open ended in the sense that they gave respondents the opportunity to express concerns of their own.

The initial interviews together with the survey of ISI directors revealed a series of tensions inherent in the organizational design. We then used the case studies along with the project data to explore ways in which those tensions might be moderated or resolved. The remainder of the chapter is organized accordingly.

3. The underlying tensions

The central tension that emerged in the study is between technologically advanced industry on the one hand, and traditional or legacy industries on the other. This tension, but also the incentive to resolve it, has been augmented by the way in which technological change has increasingly blurred traditional industry lines and technical boundaries.¹⁰ But this is not, strictly speaking, a finding of the research, but rather a product of the design of the study itself. That conflict aside, the basic tensions as they emerged in the interviews are twofold.

First is a tension between the ISI’s mandate to serve the nation as a whole and to support industry in all parts of the country, and the governance structure of SENAI, which is decentralized at the state level. Despite the fact that each ISI is intended to be the national reference in its area of technological expertise, they remain under the supervision of the local SENAIs in the states where they

are located. Furthermore, ISIs depend on this local infrastructure for administrative and in some cases financial support.

The second tension derives from the fact that ISIs are organized around specific technologies, while the economy is structured around industries. The tension here is exacerbated by SENAI's decentralized governance structure, in which local industry associations represent the main constituency of SENAI's at the state level.

Other tensions include:

- *Education vs. technological services and innovation*: the tensions between the traditional educational mission of SENAI and the new orientation towards technology and innovation.
- *ISI-ISI cooperation vs. competition*: the tension between ISIs' imperative to become financially sustainable and the need to develop innovation expertise. The former has increased competition among ISIs for clients, while the latter requires cooperation since most innovation derives from a combination of several of the technologies that define the ISIs and thus requires the sharing of expertise among them.
- *ISI-IST cooperation vs. competition*: the tension among the activities associated with SENAI's expanded mission, in particular between the innovation institutes and the technology institutes. ISIs' innovation-related activities are intended to create new markets and technologies, which imply a longer timeline for financial sustainability and higher initial investment. ISTs cater to existing local markets providing technological services and therefore have an advantage in achieving a stable business model faster.

4. The case studies

The case studies suggest different approaches to managing these tensions – CIMATEC because it is an integrated organization that combines a variety of technical competencies in a single location, and CETIQT because it is organized around a single industry rather than a technology and because it reports directly to a national directorate and is thus not tied to a single region with its parochial interests and concerns.

CIMATEC

Overview

CIMATEC is the oldest of the institutions that have grown up within SENAI to strengthen the innovative capacity of the manufacturing sector, and as noted, it served as a reference point in the design of the ISI program due to its growth and performance developing R&D projects. It is not, strictly speaking, an ISI itself, but contains within it three ISI institutes (automation, logistics, and conformation and bonding of materials).¹¹ It has worked in collaboration with

high-tech firms to create several very high-profile innovative products and services. These include the supercomputer Yemoja, the second-most powerful of its kind in Latin America, now housed within CIMATEC in the Supercomputing Center for Industrial Innovation, which constitutes a kind of separate profit center, and the FlatFish, an autonomous underwater vehicle for visual inspection of oil and gas operations in deep waters.¹² The FlatFish initiative is currently being implemented in partnership with the oil company Shell, the Brazilian Agency for Industrial Research and Innovation (EMPBRAPII), and the German Research Center for Artificial Intelligence (DFKI) from Germany. CIMATEC is located in Salvador in the state of Bahia, but most of its projects come from partners outside the state (principally from São Paulo).

Strikingly, none of the tensions that pervaded the interviews in other parts of the ISI network and were prominent in the formal survey of ISI directors were apparent in the interviews in CIMATEC itself. There was one major exception: a tension between CIMATEC's orientation towards advanced technologies, and the demand for services and education by local firms, most of which come from traditional sectors. We will return to this issue shortly, but in the context of the ISI program itself, the questions that stand out are: how did CIMATEC manage to escape conflicts that other ISI centers have struggled to resolve, and what lessons does its success suggest for the rest of the ISI network?

The answer to the first of these questions appears to lie in the fact that CIMATEC is an integrated organization. It is composed of a series of conceptually and organizationally distinct units, but the different units work together in an apparently smooth and harmonious way. From our interviews, it became apparent that the professionals working in these units share a common understanding of what CIMATEC is about, although individual respondents described it in terms that reflect their different positions within the organization as well as their own individual histories within SENAI. In a sense, these collective statements reflected a strong company ethos (the "company," however, was CIMATEC, not SENAI).

CIMATEC operational characteristics

Ironically, the coherence of the organization makes it relatively easy to identify its separate components. CIMATEC divides its activities in two main areas: technology/innovation and education. Each of these areas is managed by a specific director with a separate budget, but the organizational structure is designed to facilitate collaboration between them. The technology/innovation area is responsible for providing technological services and developing applied research. A services unit in this area provides support to firms seeking CIMATEC's help to perform tasks such as water quality tests required by federal environmental legislation, energy efficiency assessments of machinery and buildings, and technical consulting on optimization of production processes.¹³ The three ISIs located within CIMATEC are fully harmonized with CIMATEC organizational structure, so in practice they do not have distinct

operational roles. Education, service provision, and technological innovation are tasks performed by the organization as a whole. This is, in fact, in line with CIMATEC's fundamental principle of representing an *integrated campus*, where research in different fields overlaps in terms of location, implementation, and content.

The work is organized not around technologies or organizational components but around projects, which thus constitute the key operational units. They are managed by a Project Management Office (PMO), which relies on a secondary administrative layer structured according to competencies. There are currently 33 competencies, each of which is an autonomous organizational unit specialized in one knowledge area, such as advanced manufacturing, energy and environmental sustainability, and automation and robotics.¹⁴ The size of each competency – in terms of number of staff and complexity of its infrastructure – varies according to the demand for services, though most of them have a dedicated team and manager.

The PMO relies on a team of professionals with deep industry knowledge (often retirees) to work on business development, using their expertise and personal contacts to bring new projects and funding. When a new initiative starts, the PMO usually pulls resources (staff and infrastructure) from several different competencies. When this is the case, the project manager and the relevant competencies' leaders collaborate to allocate people and resources appropriately. When the project is complete, the professionals return to their original assignment – or dedicate time to teaching – until a new project requires their services. This structure provides great flexibility for managers to organize work that is inherently multidisciplinary.

But it is the relationship between technology and educational activities that makes CIMATEC particularly interesting, especially in terms of its strategy to integrate SENAI's traditional manpower development mission with its new innovation agenda. There are four types of educational programs: basic vocational training (short-duration courses that prepare workers for jobs in construction, carpentry, electrical work, etc.); a post high-school advanced vocational degree (a two-year program regulated by the Ministry of Education); an undergraduate program (mostly focused on engineering courses in nine specialties); and a postgraduate program offering high-level master's, MBA, and PhD degrees in fields such as computer modeling and technology, innovation, and management.¹⁵

There are at least two elements that distinguish these programs from similar ones offered in conventional universities in Bahia. First, in each of these programs there is an effort to use projects as a pedagogical tool, building on SENAI's close relationship with local industry. CIMATEC has formalized this principle through the adoption of a methodology called TheoPrax, elaborated in the 1990s by the Fraunhofer Institute of Technology in Germany.¹⁶ Through this method students are expected first to identify problems of concern to local industry, then to develop projects that address these problems, and, finally, to provide a solution. Although there are several ways in which this project

orientation is embedded in the actual curriculum – from specific assignments to year-long collaborations – most courses, irrespective of the degree or skill levels, were designed to foster a problem-solving mindset among those participating in the program.

Second, roughly 50% of all faculty teaching at CIMATEC at the undergraduate and graduate level are also involved as team members in the research projects of the technology/innovation division. During the interviews, the education staff pointed out that the organizational culture is not yet fully embedded in the teaching staff, some of whom still see their role along more traditional lines (teaching exclusively). However, CIMATEC leaders have started to transform expectations about professors' involvement in research into workplace policy. One example is the new system in which individual faculty members are assigned to competency units, and from there are seconded to project teams close to their areas of expertise. The goal is to have at least one professor participating in every project. Another factor that has contributed to the development of the ethos of organizational integration, according to the respondents, is the gradual hiring of younger professors who are more familiar or at least open to performing a flexible role within CIMATEC.

CIMATEC operational challenges and the role of communities of practice in resolving them

The CIMATEC model has not, however, worked well in support of traditional (or legacy) industries. Indeed, it has led to a revolt in FIEB, the governing body of SENAI Bahia: the long-time president was defeated by an insurgent candidate demanding the resources be diverted from Salvador and reallocated to the support of traditional industries in the interior of the state. This episode was obviously of great interest to us, given our concern with potential conflict between technically *avant garde* sectors and traditional industry. Several supporters of the defeated regime attributed the insurgency to parochial partisan conflicts and personal relations that were only incidentally related to policy disputes, an interpretation that has become less plausible as similar political reactions have gained momentum in North America and Europe.

The CIMATEC administration did not, however, dismiss the insurgency in this way but sought rather to develop a substantive response, even after the insurgent candidate died in office and was succeeded by a more moderate leader. It actually did reallocate resources to a program in the hinterland and seems to have engaged in a serious internal discussion about what form the program that those resources would support should take. The discussion, however, did not lead to a program that had organic connections to the other components of CIMATEC. Even the components of the new program taken on its own terms had an ad hoc flavor without a unifying philosophy. The closest the CIMATEC leadership came to identifying a component of the Salvador program that could be devolved to the hinterland was in software development, and even that did not prove to be viable – not surprising given the

notorious difficulty of partitioning software projects into separable tasks.¹⁷ The program components we observed when we visited the projects were very traditional vocational programs, some involving substantial investment in machinery that, not coincidentally, were highly visible but had no organic connection to industry.

How does one understand CIMATEC, the integrated character of its operation in Salvador, the way in which it escapes the tensions evident among the other ISIs, and its failure to extend that integration to the traditional industries in the rest of the state? Our own research in the management of innovation at the IPC leads us to understand the CIMATEC experience in terms of what we have called interpretative communities or communities of practice.¹⁸ These are groups of people coming from different backgrounds with different technical expertise and experience who share a common language and enough of the same perspective that they can communicate with each other and work together on a common project, but at the same time are sufficiently different that they can learn from each other. Such communities emerge through discussion, debate, and repeated interactions around common projects over time in a free environment in which people are not inhibited from expressing their ideas and opinions by the fear that their ideas will be stolen, and for this reason such communities need to be fostered in an environment protected from competition until enough of a shared culture has developed to avoid misunderstanding and distrust.

CIMATEC can be understood as a complex of such communities that overlap and interact with each other. But the formation and maintenance of CIMATEC as a community of practice depends on intense, frequent, and direct interaction among people who ultimately constitute the "community." The components of the rest of the ISI network, however, are deliberately spread out over the whole of the national territory, and each of the ISIs is specialized in a given technology. In this way, they are isolated from each other both geographically and intellectually.

The kind of communities that grow up naturally within CIMATEC would have to be created in the rest of the ISI network in other ways. SENAI National Department (DN) has tried to do this by bringing the directors together to meet with each other regularly and exchange ideas and experiences and by the creation of monetary incentives for two or more ISIs to partner with each other in creating projects for their business clients. Our own review of the SENAI data indicate that the kind of repeat partnership that might indicate the emergence of a community of practice is occurring primarily among ISIs in close physical proximity to each other, an observation consistent with the CIMATEC experience but not conducive to technological innovation in the way that patterns of collaboration around technology or industry would be likely.

Our interviews suggest that one of the reasons why these other patterns of collaboration have failed to develop is that the DN has orchestrated contacts primarily among the local SENAI units at the state level and ISI directors

who are in direct competition with each other for clients, and hence reluctant to engage in free interaction with each other for fear of jeopardizing their client base. The competition has been intensified by an emphasis in the meetings on a discussion of clients, actual and potential, and even more so by the creation of monetary incentives to reward collaboration. Our own studies of the management of research and development in other contexts suggest the DN would be better advised to promote contacts among the researchers rather than the managers, and to do so around intellectual (or technological) themes through seminars and colloquia focused on technical rather than business issues.

The difficulty of creating communities of practice in this way, however, raises serious questions about innovation and the institutions that promote it as they spread out over the whole of a national territory, especially one as vast as that of Brazil, or whether they should be concentrated in relatively closed enclaves. Indeed, the very term “Silicon Valley consensus” seems to imply an enclave strategy. The fact that the model has been used to support a development strategy so broadly – not just in Brazil and other middle-income countries, incidentally, but in communities throughout the United States – seems to belie the very term. The DN has now hired an experienced consultant who is experimenting with different approaches to the development of communities of practice in the ISI network that address the limitations of efforts thus far. He has not, however, attempted to address the problem of extending the CIMATEC model to traditional industries.

CETIQT and the traditional industry

If neither CIMATEC nor the ISI model is supportive of traditional industry, what kind of program would it be? For an answer to that question we turned initially to CETIQT. In a number of respects, it appears well suited to address this problem. In contrast to CIMATEC and the ISIs, it is dedicated to an industry (in this case, textile and garments) as opposed to a technology, and it reports directly to the DN, thus escaping the tension between its national mission and the narrow geographic interests of the state organizations in which the other projects are embedded. Historically, moreover, CETIQT has been the acknowledged leader of the textile and garment industry and has provided the managers and engineering talent for its development. The industry today is largely populated by its graduates. But in many ways, history has passed CETIQT by. The industry, which was once centered in the Brazilian Southeast, close to the CETIQT campus and dormitories, has moved out and dispersed to other parts of the country. Major centers are now found in Santa Catarina, in the South, and in several cities in the Northeast; local universities and state-level SENAI in these areas have developed programs to train manpower and service the industry. Further, the neighborhood where CETIQT’s campus is located has changed substantially in ways that make it difficult to attract students and faculty to the campus.

The DN has responded to this challenge gradually, but particularly in the last year, when a new director with enhanced authority was appointed, reforms have picked up speed. A new organizational structure has been imposed, inspired in part by the CIMATEC experience, and a decision has been made to move the old campus to a new one at a location where interaction with other research and educational institutions is easier. Finally, CETIQT is making a determined effort to build its comparative advantage by complementing the work of regional SENAI units rather than establishing a relationship of direct competition with them.

Meanwhile, however, what has emerged in our own attempt to understand the context in which the new leadership is operating is that the answer probably lies in a model of innovation and economic efficiency very different from that which guided the ISI project and the Silicon Valley consensus about development among policymakers more broadly, from which that model derives.

In terms of the dominant models of growth and development, the garments and textiles industry in Brazil is something of a paradox. Brazil is one of the very few countries in the world that has managed to retain within its borders the whole of the value chain from fiber to finished garments.¹⁹ Elsewhere in the world, where garment production survives, it does so through exports; the industry in Brazil is almost entirely domestic, with minimal reliance on imports or exports – exports represent just 6% of the sector's annual revenue in 2015 of US\$39 billion, and imports in the same year were below US\$5 billion.²⁰ Outsiders viewing the industry through the lenses of standard development models dismiss the industry's survival as a product of protectionism; it is in fact often used as an example of the distortions of Brazilian development policy. And indeed the industry is highly protected, not only by tariffs but also by administrative regulations that make it very hard for foreigners to navigate the domestic market. WTO data from 2014 puts Brazil as imposing the sixth-highest average tariff on textiles in the world (23%),²¹ and the tenth-highest average tariff on garments (35%).²²

The protections are justified by the importance of the employment opportunities the industry provides and the environmental and labor standards that have successfully forestalled the conditions in other parts of the world, most notably the horrendous industrial accidents and the literally thousands of worker fatalities that have accompanied the export boom in Southeast Asia. The politics of protection and the limits that it places on globalization, moreover, have begun to look very different in the light of Trump's victory in the United States and Brexit in England and the protectionist policies with which they appealed to the electorate. But the real paradox of the textile and garments industry in Brazil is that despite the level of protection and in defiance of the conventional wisdom about its impact, the industry has been quite dynamic, and it is that dynamism that suggests an alternative model of innovation and development. That dynamism and the traces of an alternative developmental model are suggested by two companies that we visited as part of this study.

The case of Cia. Hering

Cia. Hering is an old-line company founded in 1880, with headquarters in Blumenau in the state of Santa Catarina but with production now concentrated in the states of Goiás (since 1997) and Rio Grande do Norte (since 2000).²³ With 7,000 employees, a retail network of 821 stores, and market value of US\$1.25 billion (2014), Cia. Hering is one of the 100 largest companies in Brazil.^{24,25} As noted, the company attracted our attention because of its dynamism. This also characterizes other firms we visited, but in some ways, Cia. Hering stood out due to its unique business strategy and the way it has been supported by public policy and SENAI.

The company has historically focused on the production of textiles and garments, also working as a subcontractor for branded clothing companies in the 1980s and 1990s until establishing its own retail network in 1993.²⁶ At about this time, a combination of an acute economic crisis and the broad liberalization of the Brazilian markets changed the structure of competition in the country.²⁷ Cia. Hering survived this period of macroeconomic instability by implementing a production strategy based on the decentralization of production through subcontracting to small firms, a strategy that the garment industry uses throughout the world.²⁸ The parallels are particularly strong to the evolution of the garment industry in northern Italy in the late 1960s and early 1970s.²⁹

Whereas most brands in Europe and North America contract established firms,³⁰ Cia. Hering sought to develop its own subcontractors and to exercise much tighter control over them than was typical in the industry. Part of the reason for this is that in Brazil, the manufacturer is responsible for its subcontractors' adherence to mandated labor and environmental regulations and must pay fines if its subcontractors are found to be in violation of the law.^{31,32} Another important factor was the establishment of the Sistema Integrado de Pagamento de Impostos e Contribuições das Microempresas e Empresas de Pequeno Porte (SIMPLES).³³ This government regulation was put in place in 1996 and then expanded in 2006 (SIMPLES Nacional)³⁴ and 2017 (Programa Bem Mais SIMPLES).³⁵ It simplified and reduced taxation on small firms, creating an incentive to large companies like Cia. Hering to lower production costs via outsourcing. Participation in the program is also contingent on adherence to labor regulations, so to avoid compliance problems, the company exercises a great deal of control over its suppliers.

The process through which Cia. Hering developed its subcontractors had several different variants. A network was initially created around the company's headquarters in Blumenau by sponsoring spin-offs led by their own employees, to whom Cia. Hering provided capital and machinery. Because the employees already had experience as part of the company, their firms were integrated easily into the existing production process. One important element in this transition was the fact that Cia. Hering maintained control of its core capabilities in high-value-added stages of production including clothing design, textiles

manufacturing, and complex garment production. Outsourcing firms were responsible, at least initially, for simpler tasks, such as assembling the pre-cut pieces.

This basic division of labor was maintained when the company moved part of its production to Anápolis in the state of Goiás in the late 1990s. This was virgin territory for the garment industry as there were neither firms nor manpower with experience in garment production. The company recruited entrepreneurs with no previous business experience, again providing capital and equipment but training them in production and managerial practices. Today, although Cia. Hering has expanded its operations in Goiás to four garment centers and one logistics unit, most of them still have their work restricted to the simplest stages of production. Complex pieces are produced by Cia. Hering itself or by some of its older subcontractors in Santa Catarina, most of which upgraded their technological capabilities over time.

The company followed the same operational pattern in a third wave of expansion to Natal and other cities in the state of Rio Grande do Norte. In this instance, however, it found a region where a traditional garment industry already existed, making it easier to recruit experienced firms to become subcontractors. Cia. Hering's experience in Rio Grande do Norte also created unique spillover effects that did not exist in Goiás, as other companies in the sector emulated its business strategy, enlarging even further the number of subcontractors operating in the state.³⁶

In all three waves of expansion, Cia. Hering worked with SENAI to recruit and provide training to its own staff and subcontractors. But in each of them, SENAI's role was somewhat different, or at least the concerns of the managers with whom we talked varied substantially across the three regions. In Blumenau, SENAI staff tended to be concerned with the education of textile engineers and managers. They were seeking to work with local universities to revise its educational offerings and, to summarize a long discussion, broaden the training of higher level manpower so their skills would be relevant in other industries as well. They worked with CIMATEC in Bahia to develop a new pedagogical strategy, which in a way seems to undercut the strict dichotomy between advanced technology and traditional industries.

In Anápolis, however, SENAI has partnered with the company to support two different audiences. The first was the contingent of garment workers that was recruited by Cia. Hering without prior industry experience. Working within its own factories rather than in SENAI schools, the company organized customized training sessions on both hard and soft skills, from technical sewing practices to appropriate behavior in the workplace. The second audience consisted of new subcontractors – *façôdes*. With this group, SENAI was much more focused on training managers in the specific skills associated with managing a business and worked closely with Cia. Hering to develop strategies that allowed these new entrepreneurs to comply with the applicable labor, technical, and environmental legal requirements.

In Rio Grande do Norte, SENAI took on yet a different role in supporting Cia. Hering and other firms in the garment sector. Although it did, as it had in Goiás, contribute with the training of skilled personnel, most of its work was directed towards *facções* independent from the larger contracting firms. This has been especially true in the economic crisis that, beginning in the early 2010s, forced many garment companies to curtail their operations. In the absence of large buyers, smaller local firms were able to draw on their considerable industry experience to develop new products and find new markets, a pattern that is again reminiscent of northern Italy in the 1970s, through which Italy emerged as the leading center of high fashion in the world garment industry. SENAI's role in this process consisted mostly of providing consulting services in areas such as production optimization and business management.

The case of CEDRO

CEDRO is an old-line textile company, founded 145 years ago as a family company but now publicly held. The family continues to hold a controlling share, but it is a large and dispersed family, and the company is professionally managed. It presently specializes in denim. It produces a limited number of different denim fabrics, which it sells to jeans manufacturers exclusively in Brazil, where it currently holds approximately 30% of the market. But the company has been producing denim for only the last 25 years. Previously it produced work clothing and cotton prints. It gradually reduced these other product lines as its denim business expanded, but never entirely eliminated them.

The move into denim was an important innovation for the company. It occurred at a time when denim jeans were just becoming dominant in men's apparel throughout the world. The company was not by any means a world leader in this development, but it followed the emerging trend closely. At the same time, denim jeans were becoming a fashion item, and for the company, the move into denim constituted a move also into the fashion business – a move that denim producers and jeans manufacturers were making throughout the world but that older companies in other parts of the world (especially Levi-Strauss in the United States, which had dominated the market with a product that had not changed in more than 100 years) had trouble negotiating.

In this sense, the move to denim was not only an innovation in itself, but one that committed the company to a business that, unlike the case with work clothing, involved continual change. The change in the denim industry in this period has involved not just the accommodation of style and fashion but continual updates in product and process technology as well – fashion in jeans is driven by technical development in finishing, where the garment is washed and abraded to produce a variety of different effects. The finishing process places enormous stress on the underlying textile material, which must then be redesigned to survive. At the same time, the decomposition of the material leads, in the finishing process, to new effects in the look and feel of the garment, which

then themselves become the focus of fashion. These changes have been further complicated by the introduction of new fibers – most recently stretch fibers – that alter the fit of the garment as well as the hand (or feel) of the material.

The innovations in this chain have been (and are being) developed abroad in advanced industrial countries, especially in Italy and Japan. The company does not compete directly in these markets, nor does it try to develop totally new products itself. But it actively “shops” throughout the world, follows these developments closely, and seeks to identify those that are likely to be most “interesting” for the Brazilian market (Brazil, for example, is a warm climate that does not have a cold winter season; it favors tighter, form-fitting fabrics). It then reverse-engineers the new products in order to figure out how they are made – not only how the look and feel of the cloth are produced but also how the cloth needs to be constructed so that the finishing process produces the effects that have become, or are likely to become, fashionable. Hence, while the company is not engaging in what you might call “world class” or “first in the world” innovation, it is continually changing and adapting its product and is committed to maintaining a research and development organization that enables it to do so.

The company also has a deliberate, highly disciplined approach to process innovation, three elements of which are notable. First, it sees itself as basically a mass production company pursuing economies of scale. It thus limits the number of different fabrics it produces, which puts a premium on selecting the right designs from its worldwide shopping trips. Second, the company CEO feels that he belongs to a generation of managers whom he characterized as among the best in the world. The guiding principles for this generation are the principles of Japanese management; he stressed the importance of drawing the rank-and-file workforce into a critical examination of the production processes on an ongoing basis and emphasized the number of suggestions for improvements that the rank-and-file labor force produce.

Third, the company buys equipment around the world, presumably in an attempt to keep up with improvements and innovation. As a result, a wide variety of different makes and models are in operation on the plant floor at any time. This creates a maintenance problem, potentially requiring an enormous spare parts inventory. The vendors are responsible for maintenance in the first two years; afterwards the company itself maintains the equipment. But the inventory requirements are reduced by the capacity of the internal maintenance workers to produce the spare parts on their own. The strategy again suggests the innovative capacity of the company – although what is at stake here is not first-in-the-world innovation, but the ability to draw quickly on process innovations developed elsewhere in the world.

A final word is in order about the role of this company and the textile industry more generally with regard to the way in which the textile and garment industry is financed. Because the whole of the garment-textile supply chain is located in Brazil, stretching from cotton fiber production through the finished garments, the country is in a position to define and pursue an industrial

policy for the industry as a whole. Textile companies are in a key position here; because of their size relative to firms at other points in the supply chain and because they are extremely capital intensive and have access to funds that are not available to smaller producers, they are in a position to lead the industry and to provide financing to their customers (and in fact to their suppliers as well). Whether or not they choose to do so thus becomes a key factor in the evolution of the industry.

Implications of the traditional industry case studies

These two company vignettes underscore the point with which we started out: the textile and garment industry is quite innovative. These particular companies are innovative on two different levels. They are innovative in their long-term business strategies, but they are also innovative in the short term, generating new products and adjusting their production processes. Both firms completely changed their business strategy over the course of the last 20–25 years: Cia. Hering by decentralizing its production system, CEDRO by focusing on denim. For both firms as well, their new business strategies commit them to continual innovations in product and process. This, as we suggest earlier, flies in the face of the conventional wisdom – that protectionism leads to stagnation – and in this sense, it defies the conventional wisdom of the Washington consensus.

But in some ways more important than the fact that these two companies are innovative is that the innovative process of the companies follows a model very different from that of the Silicon Valley consensus, which undergirds the ISI. This is so in several respects. First, the innovations do not depend on being at the forefront of science or engineering but rather represent adaptation of innovations in technology and management originating elsewhere. They thus do not depend on university collaboration – indeed because they are basically derivative, they are not the kind of innovation that would attract the attention of university researchers. By the same token, the “innovativeness” of these firms is not captured by the measures usually used to gauge the innovativeness of a country (or of an industry). Patents, academic citations, and licensing agreements are largely irrelevant to the success of these firms.

Second, the innovations do depend on high-level managers and engineers to work out the business processes that the firms have adopted or to understand the technological developments that they find abroad and then to adapt these developments to the Brazilian context. In this sense, the strategies require a system of advanced higher education to produce the skilled manpower to carry them out. But they also draw heavily on the kind of craft skill that their labor forces develop on the job in the process of production or through much more conventional vocational preparation. Third, their relationship to their suppliers and customers is hierarchical. They do not constitute a community of practice in the way in which the firms and workers associated with CIMATEC do, or in the way in which we have suggested the ISIs need to cultivate.

Fourth, they draw on much more conventional sources of capital to support their own endeavors than the Silicon Valley consensus prescribes. Both of these firms are publically traded and financed through the capital market. Cia. Hering actually supplies capital to its *façção*. Other lead firms in the textile industry support much of the value chain in this way, although CEDRO has deliberately decided not to do so. Bank loans and commercial paper are other important sources of capital. For smaller firms in the supply chains, the *façções* of Hering, and the customers of CEDRO, family capital is also important. What is not important is venture or angel capital or private equity. Similarly, innovation in this industry is less risky than innovation in advanced technology; it does not involve totally new products with which the consumer has no experience in a market that is impossible to estimate accurately. Rather, it involves standard business risks. Given the wide fluctuations of the Brazilian economy, these are not trivial, but they are of a very different sort than we associate with innovation in the Silicon Valley model.

By the same token, the small firms in the textile garment supply chain, CEDRO's denim customers, and Hering's *façções* are independent businesses, but their owners do not match the image of the Schumpeterian entrepreneur cultivated in Silicon Valley. We have not fleshed out the role of government policy in the dynamics of these firms, but it too is clearly different from the kinds of innovation policies prescribed by the Silicon Valley consensus. The firms operate behind a set of government tariff barriers. They are constrained by a panoply of regulations that provide additional protection from foreign firms but also impose obligations on the firms that channel and constrain their business processes in ways that protect worker welfare and the environment.

SENAI has provided a lot of the skill training but also managerial training, especially for Cia. Hering, and has adapted this training to the several very different locations to which the company has decentralized business operations. But it is a traditional SENAI function and could not be said to involve significant innovation in SENAI's mission and mode of operation. ABIT, the textile and garment business association, has been active in organizing business trips to review practices abroad and also in organizing in-house seminars to expose its members to developments in the industry in different parts of the world. But both CEDRO and Cia. Hering (as well as the other firms we visited) actively work to keep abreast of foreign developments on their own initiative through teams of managers and engineers who travel regularly throughout the world.

There is nothing like the ISI, or for that matter EMBRAPPII, promoting technology in the industry. Some of the advanced technologies associated with industry 4.0 appear likely to facilitate the business models that these firms have developed. Three-D printing is particularly applicable to the way in which CEDRO manages the mix of equipment from different vendors and the inventory of spare parts that this would seem to require, and IT development should facilitate the management of Hering's decentralized production structure. But both of these enterprises are so conscious of technological developments in

their fields that they are likely to find out about these technologies on their own, and ABIT is very active in keeping abreast of developments like these that are potentially significant for the industry. In any case, the innovations associated with industry 4.0, useful though they might be, are marginal to the dynamism that seems to characterize the industry.

5. Conclusions

The research reported here is still in progress, and any conclusions drawn at this stage are necessarily tentative and provisional. The generality of the results is moreover potentially limited by the dependence of the research on particular cases that, however deliberately and self-consciously selected, may not be broadly representative. But at the very least, they point towards a more critical view of innovation and the framework through which innovation policy is being conceived and promoted, not just in Brazil but in the international community of economic policy experts. One can accept the starting point of the current discourse about innovation – that a dynamic economy needs to continually develop new products and new ways of producing them if it is to grow and expand over the long run. But the debate about what is required to do this has been dominated by a particular view of innovation and how it is achieved, a view for which we have used here as a short-hand term “the Silicon Valley consensus.”

The case studies suggest that there is at least one other pattern of innovation, a pattern characteristic of the textile and garment industry (and possibly of so-called legacy industries more broadly), with very different welfare and distributional implications and requiring different institutional supports. The Silicon Valley model offers only limited employment opportunities and concentrates those opportunities in jobs for highly educated engineers and managers in a limited number of geographic centers. In contrast, the textile and garment model seems to spread out employment geographically, which provides a more balanced distribution of jobs across different levels of education and training, and in general is employment preserving. The political significance of these differences is underscored in the present research by the revolt against CIMATEC in the governing body of SENAI Bahia, and the pressure that revolt exerted to divert resources to traditional industry and to the geographic hinterland of the state. This episode takes on broader significance in the light of the reaction against globalization signaled by Trump’s victory in the U.S. elections and by Brexit in England.

But for policy itself, as opposed to the political debate that surrounds it, the difference in the institutional supports required by the two approaches may be more significant than the distributional consequences. The Silicon Valley model points towards advanced research for industrial development, whereas the textile and garment industry draws much more heavily on SENAI in its traditional role in education and training. The ISI program has placed SENAI at the institutional intersection between these two approaches, and it will ultimately be

called upon either to choose between them or to figure out how to combine them in a politically viable way.

One of the most significant aspects of the current research is the opportunity to look over SENAI's shoulder as it attempts to do so. Two issues that have emerged in this process deserve more attention than we have been able to devote here. One is the role of protection in the textile and garment industry; the dynamism that we observed flies in the face of the conventional wisdom about the way in which protectionism stifles innovation. Is our finding robust and, if so, what does it imply about the innovation process and what are its implications for trade policy in other industries? The second issue that emerged is the role of communities of practice – the ability to create them deliberately, and to overcome the extreme geographic concentration of activity and the accompanying economic prosperity that it entails. CIMATEC is, after all, one of the very few cases in which an advanced innovation hub has been created deliberately through public policy. And while CIMATEC itself has been unable to replicate this achievement across a geographically dispersed network, that is exactly what SENAI DN is attempting to do, and its success would fundamentally change the implications of the Silicon Valley model for the distribution of social welfare and go a long way towards the reconciliation of political and institutional conflict between the different innovation models that SENAI must try to achieve.

Notes

- 1 The research reported here is one component of a larger project housed in the Industrial Performance Center at MIT and organized at the request of SENAI to support its efforts to promote Brazilian innovation. The other components of the IPC research focus on the broader innovation ecosystem of the country.
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- 9 Brazil (1944) Decreto-Lei N° 6.246, De 5 De Fevereiro De 1944. Available at: www.planalto.gov.br/ccivil_03/decreto-lei/1937-1946/Del6246.htm.
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- 17 Brooks Jr, F. P. (1995). *The Mythical Man-Month: Essays on Software Engineering, Anniversary Edition, 2/E*. Pearson Education India.
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- 31 For example, the Súmula nº 331 from the Superior Labor Tribunal established in 2011 attributes responsibility to contracting firms for illegal labor practices of subcontractors. Available at: www3.tst.jus.br/jurisprudencia/Sumulas_com_indice/Sumulas_Ind_301_350.html.
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- 32 In spite of existing regulations, there are still a number of initiatives from the private and public sectors trying to improve the conditions of workers in the textile and garment industries and to reduce the level of informality that still represents a challenge for the sector. One recent example can be found in this recent project promoted by the United Nations: <https://nacoesunidas.org/setor-textil-certifica-empresas-para-eliminar-trabalho-escravo-de-cadeias-produtivas/>.
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