Creating Good Jobs in Regulated Labor Markets: Lessons in Skill Formation and Urbanization from Brazil's Shipbuilding Industry

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ABSTRACT

Drawing on the case of a shipyard in Pernambuco, Brazil, this paper examines the problem of skill formation and retention in tight labor markets during times of rapid industrial growth and urbanization. Brazil, like many large emerging economies, has experienced resurgent industrial growth in the past decade, moving into higher skill and higher value-added activities at a rapid pace. This growth has placed fresh demands on the labor market for new skills and capabilities among workers that traditional institutions have been unable to meet. The persistent inability of certain firms to fill openings for highly skilled labor has led to a variety of responses by the private and public sectors, including international labor recruitment, the intensification of internal training systems and the expansion of public and quasi-public vocational training organizations. Despite these challenges, the shipbuilding industry has succeeded in creating a large cadre of skilled, mid-tech workers in record time. Using data from interviews, fieldwork and archival research this paper explores the establishment of a set of innovative practices and vocational training institutions for welders and assembly workers which have permitted the shipyard to realize an extremely rapid speed-to-production and create a broadly skilled workforce virtually from scratch. Most notably, the shipyard has been able to retain most of the workers it has trained in spite of tight labor market conditions. This paper will show how successful training and retention in tight labor markets increasingly requires labor practices that create linkages between circles of skill formation at the workplace, socially situated perceptions of loyalty and status, and the social embedding of workers as citizens within the local community.

During the last three decades, large emerging economies throughout the world have engaged in deep restructuring in pursuit of economic modernization and growth. Even as liberalization has promoted foreign and domestic investment in high-value and knowledge-intensive activities, particularly in the services sector, growth during the 1990s and 2000s has produced disappointingly few jobs. Investment and growth has occurred largely in sectors with relatively low employment elasticities (need citation here) and has been spatially concentrated in already-leading regions.1 This has exacerbated spatial disparities leaving policy makers with the conundrum of finding ways to prevent lagging regions from falling farther behind, even as diseconomies of congestion undermine productivity and labor-saving technologies dampen job growth in the established metropolitan economies. Even as formal job growth has been slow, the size of the working age population entering the labor market in many low and middle-income economies has continued to soar. Creating good jobs in this era of rising inequality and deep technological change is a central challenge facing economic planners in many emerging economies. How and under what conditions can regions and localities create decent jobs that can not only absorb the large numbers of the low and mid-skilled entrants into the labor market, but also provide avenues of upward mobility for workers displaced by trade and technical restructuring? This challenge is deepened by the ostensible decline of manufacturing, particularly labor-intensive manufacturing, that once provided pathways to the middle class for generations of low skilled workers (Rodrik, 2016; McMillan and Rodrik 2015).

This paper draws on a case that seems to have bucked this trend to an extent – providing thousands of good paying blue collar jobs in a mid-tech industry that took root and came to flourish in one of the poorest regions of Brazil's Northeast – to investigate what lessons it may provide to other economies struggling with these dilemmas globally. We present evidence from the rapid growth and turnaround of the shipbuilding industry in the Northeast Brazilian state of Pernambuco

[1] See Martins and Severino 2014 for evidence on the Brazilian case.

between 2003 and 2013, a period when it grew from producing 0 ships to 8 carriers, developed an ecosystem of supporting businesses and institutions, and built a strong local blue collar workforce with career ladders and avenues of upward mobility where none existed before. The shipbuilding industry in Pernambuco is of practical and theoretical interest for a number of reasons. First, the industry is both labor- and capital-intensive and, given the complexity and size of modern shipbuilding, demands a strong cadre of shop-floor workers as well as robust project management capabilities. Second, the industry has strong backward linkages and positive externalities to a range of supplier industries such as steelmaking, mechanical parts and structural subsystems, high-tech instrumentation and engineering services that can not only help embed broad-based industrial growth in place, but create a cascading set of jobs in related sectors and sub-sectors. Third, in the context of the Brazilian shipbuilding industry's collapse during the 1980s and 90s -- after a period of dynamism in the 1960s and 70s, no large vessels were produced anywhere in Brazil since the 1990s (and the last vessel built before 2007 took over ten years to complete) -- this case presents an example of industrial rejuvenation and revitalization. In an era of declining fortunes of manufacturing, this is story of an industrial turnaround that is worth learning from. Fourth, this case represents successful industrial decentralization – where a relatively successful hub of a mature manufacturing sector with significant economies of scale took root in a completely new region, away from the traditional base of the sector around Rio de Janeiro. In the context of rising spatial inequality, then, this successful incubation of shipbuilding in the lagging northeast is an example of the opposite – of more equitable spatial development or, at least, the mitigation of some existing spatial disparities. Fifth, this case is interesting and important from the perspective of job creation and occupational deepening and the creation of a strong blue collar workforce from scratch. Finally, even as Pernambuco's shipbuilding industry is itself privately owned and operated, its expansion would have been unimaginable if not for the implementation of an innovative suite of industrial

policies on the part of the Brazilian state2, not only at federal level in terms of legislative rules and regulations, but also through the coming together of a web of public, parastatal and private institutions at the local level to help build a capable workforce. Of central importance were the various subnational actors and agencies, public and private, involved in vocational training and skill formation.

This case is also an example of the importance of learning lessons from "successes" that are somehow banished or obscured from vision by subsequent crises and ostensible failure. For example, Petrobras and its attendant networks, is the poster child of the current crisis of governance that has gripped Brazil. Since 2014, corruption scandals and the economic recession brought down the shipbuilding industry as well as the petro-chemical complex, through stasis in the front and back end sourcing segments of shipyards like Suape. This led to a decline in orders and with it mass layoffs. This current crisis, however, does not take away from the dramatic growth and workforce development success of the sector during its rise and sustained expansion over a decade between 2003 and 2013. Indeed, as we show later in the paper the developments in Suape's shipyards led to a lasting occupational change in the region's workforce. The rise of skills in a range of blue-collar categories such as welders, pipefitters, electricians, and so on has led to a shift in Pernambuco's skills profile. Despite the down turn in some sectors, these skills have stayed in the region, and after a period of struggle, have begun to draw in other industries and sectors, including home grown small and mid-sized enterprises.

Throughout the case, we found that success was not rooted in the public or private sector alone, but rather in newly constructed networks of problem-solving that interpenetrate the state, the

[2] The adoption of developmental policies favoring shipbuilding as a component of a national industrialization strategy is not unique to Brazil. Such policies were pursued by Japan and South Korea during industrialization in the 1970s and more recently by China (Amsden, 1989; Kubota, 2013).

firm and civil society. The shipbuilding industry grew successfully in Suape not only as a result of key regulatory innovations and federal investments, but also through pulling together a set of critical alliances with a variety of public and private institutions to create and build a workforce, adopt strategies to upskill and retain this workforce, and build avenues of upward mobility. While institutions of training and skill formation are central to this story, so is the role of area-based strategies linked to urbanization and urban amenities that undercut the challenges of retention. In spite of the employer's and industry's overall downturn in recent years, it is the success of strategies to promote training and retention that has led to the stickiness of the workforce in the region. We highlight three interdependent pieces of the case: 1) the firm and its institutional relationships with public and private organizations to enable the shipyard's construction and the local recruitment and upskilling of a workforce; 2) the firm's internal efforts to consolidate and diffuse skills throughout the enterprise, focusing especially on the role and position of mentors; 3) activities to embed and retain workers locally through investments in housing, amenities and other urban services. Across each of these pieces, we will emphasize the central importance of micro-institutional relationships in driving industrial growth and creating secure jobs in a place without a history of either.

Origins and Antecedents: The resurgence and decentralization of the Brazilian shipbuilding industry

The Brazilian petrochemical complex has grown rapidly during the last 15 years, driven by the expansion of Petrobras, Brazil's semi-publicly owned petroleum company, generating a sharp increase in demand within supplying industries. Among the key industries which have seen growth in demand is the naval construction industry, which includes shipbuilding and as well as the construction of drilling platforms and drillships. Even the large-scale shipbuilding industry in Brazil had essentially collapsed during the 1980s and 90s, Petrobras initiated a number of procurement programs which targeted domestic suppliers, beginning with 1999's Programa de Renovação da

Frota de Apoio Maritimo (Prorefam; Program of Renovation of the Maritime Support Fleet). This program called for the procurement of relatively unsophisticated support vessels, primarily from shipyards in the State of Rio de Janeiro that remained from the industry's old heyday in the 1970s.

By 2005, Petrobras's continued growth required the acquisition of larger and more complex petroleum transport vessels (classified as Panamax, Aframax and Suezmax) as well as natural gas carriers, leading to the creation of the Programa de Modernização e Expansão da Frota da Transpetro (Promef; Program of Modernization and Expansion of the Transpetro Fleet). In the wake of the discovery of the massive pre-sal oil fields off the coast of Southeast Brazil, it became clear that Petrobras would require an even larger fleet as well as numerous drill ships and drilling platforms, leading to the renewal and expansion of Promef in 2008 and again in 2010. These procurement contracts were primarily managed through Transpetro, the logistics subsidiary of Petrobras, and a separate semi-private company (a majority of the shares were owned by Petrobras) called Sete Brasil.

All told, Petrobras's procurement schedule called for the construction of 316 vessels and drilling assets, representing a value of R$ 135 billion by 2020 (Dores et al, 2012; Neto 2014). All of these were to be procured domestically, in concordance with Law 9,432, passed in 1997, which regulates cabotage and grants preference at ports to transport ships that have Brazilian flags and were constructed in Brazil.[3] Furthermore, beginning in 2007 the naval construction industry was identified as a strategic sector within the Programa de Aceleração de Crescimento (PAC; Growth Acceleration Plan), as well as the Plano de Desenvolvimento Produtivo (PDP; Productive Development Plan) of 2008 and the Plano Brasil Maior (PBM; Bigger Brazil Plan). These industrial policies, respectively, set goals with respect to local content (70% by value), representation of Brazilian firms among parts suppliers, and increases in the productivity of Brazilian shipyards and

[3] Law 9,432/1997 is analogous to, though slightly less strict than, the USA Jones Act.

the share of Brazilian engineers employed in the sector (Pires et al, 2014). Even though purchasing ships on the world market from China or South Korea would be lest costly to Petrobras, the Lula administration justified the introduction of industrial policy measures because of the tax revenues, salaries and employment that the shipbuilding industry would create (Silva, 2007).

Adding private contracts from domestic and foreign buyers, by 2010 the shipbuilding industry association SINAVAL predicted the construction of 430 large vessels in Brazil by 2015; this estimate, which was widely viewed as credible at the time, would entail an expansion of employment in the national shipbuilding sector from less than 5,000 in 2000 to approximately 100,000 (SINAVAL 2011). Nevertheless, relevant skills and project management capabilities had been decimated during the industry's nadir in the 1990s, and those shipyards which remained lacked the production technologies characteristic of the modern global industry, which had advanced several generations since the last time that Brazil was a player in the global industry. Thus, Brazil would require the construction of several new modern shipyards as well as the insertion of several thousand workers into the industry every year.

The financing of new shipyard construction was provided by the federal government, through BNDES, the national development bank (Pires et al 2014). In contrast to the industrial policies of the 1950s through the 1970s, which tended to concentrate industry in the relatively wealthy states of Southeastern Brazil (Baer 2014), the revitalization of the shipbuilding in the 2000s entailed a decentralization of the industry, such that the construction of the largest and most important of the new shipyards would occur in the Northeast, the poorest and least industrialized part of Brazil. In light of the massive agglomeration economies that characterize shipbuilding, why were the recent investments decentralized? The key to understanding this difference in the spatiality of industrial policies is the political context. Older industrial policies that regulated and financed the shipbuilding industry were implemented in the context of a bureaucratic-authoritarian dictatorship

whose elites' networks were based in the Southeast (Rio de Janeiro remained Brazil's capital until 1960). In contrast, more recent industrial policy efforts have been implemented in a context of constitutional democracy (Gomes and Pires 2014). On a formal level, Brazil's democratic constitution, ratified in 1988, called for the decentralization of federal policies and programs. Decentralization also followed a political rationality: in order to govern, Lula's Workers' Party (PT) depended on coalition partners in the legislature as well as the cooperation of state governors from other parties who represented various states and political parties (see Pires et al 2014, p. 90-93). Thus, new shipyards would be constructed in the Northeastern, Southeastern and Southern regions of the country. Pernambuco would receive four of these shipyards, including the largest: Estaleiro Atlântico Sul (EAS).

To address challenge of preparing a large number of workers for employment in the modern shipbuilding industry, the federal government introduced the Programa de Mobilização da Industria Nacional Petróleo e Gas Natural (Prominp; English: Petroleum and Natural Gas Industry Mobilization Program), which was formed in 2003 by the Ministry of Mining and Energy[4]. Prominp would coordinate closely with Petrobras and its suppliers (including those in the shipbuilding industry) as well as relevant organizations involved in human capital formation to enable compliance with federal local content policies and promote global competitiveness with respect to the private market. The key organizations involved in preparing a pipeline of workers for the shipbuilding industry are the private network of vocational training schools known as Sistema-S, which is managed by peak industry association Confederação Nacional da Industria (CNI; National Industry

[4] This program is overseen by a Directive Committee consisting of the Ministry of Mining and Energy; the Ministry of Development, Industry and Trade; the semi-public Petrobras oil company; the Banco Nacional de Desenvolvimento Econômico e Social (BNDES; English: National Economic and Social Development Bank); and two industry associations representing the petrochemical industry. Additionally, eight industry and professional organizations are represented on the Executive Committee.

Confederation), the public Institutos Federais (Federal Institutes), the public university system, and the private employers themselves who provide in-house training.

Creating and sustaining vocational training institutions is notoriously difficult to achieve, particularly in contexts of skills shortages. As is widely know, the problem is one of poaching and free-riding. While all firms within a labor market benefit from a plentiful supply of skilled workers, any individual firm faces the incentive to "free ride" – that is, to shirk investments in vocational training and instead "poach" trained workers from other firms which have provided training to their own workers. This phenomenon, in which the returns to investments in training made by one firm are accrued to another firm via recruitment, is generally referred to as a "poaching externality," and it exists due to the presence of a class of skills termed "transferable skills," which, in contrast to firm-specific skills, are of value to multiple firms within a given labor market (Stevens 1996, Acemoglu and Pischke 1999).

Thus, when private firms provide training, there are three parties that realize the returns to these investments: the training firm, the worker and external firms. When a firm is led to believe that some of the benefits of its training may be poached by other firms, that firm will, following microeconomic logic, under-invest in training. By this argument, the conclusion is that firms will only invest in firm-specific skills, i.e. those that are of value to only that particular firm, and that workers will themselves invest in general skills that are of value to multiple employers (Becker 1964). Within this framework, then, the main constraint limiting workers' accumulation of new skills is the lack of access to capital for investment in general skills training. The main point here is that firms under-invest in broadly applicable skills out of fear of poaching, but workers are not always able to finance individual investments in training and education.

The following section will describe the innovative set of institutional arrangements that EAS and external training organizations, both public and private, put into action in order to rapidly train

up thousands of blue-collar workers for employment in the shipyard. Efforts to decentralize an industry, especially one requiring huge agglomerations of capital and labor and characterized by the mastery of uncodified technologies (see Amsden, 1989 p. 277), do not always succeed. So the accomplishments described below are especially noteworthy in light of the historical lack of a shipbuilding industry, and of an industrial culture more generally, in the Suape region.

Product demand and capability formation at the firm-level

Estaleiro Atlântico Sul incorporated as a privately owned firm in 2005 through a partnership between the private Brazilian investment groups Carmargo Corrêa and Quiroz Galvão, in order to capture some of the investments planned by the Promef program. After a competitive bidding process, EAS won contracts to construct 22 of the 49 transport and drilling vessels commissioned by Transpetro as part of the Promef program, one drilling platform for Sete Brasil, and two very large crude carriers (VLCCs) for the Brazilian subsidiary of Norway's national oil transport company Noroil, comprising a total value of more than R$ 7 billion. It had aUpon beginning operations in 2009 EAS would be the largest, most modern and most efficient shipbuilder in the Southern Hemisphere, with an area of 1.5 million square meters, capacity to process 160,000 tonnes of steel a year, and the capability to build the largest categories of carrier vessels (up to 500,000 deadweight tonnes). At peak employment in 2013 employed 11,000 workers, roughly 7,000 directly and another 4,000 on contract. As of 2016, EAS had delivered seven vessels to Transpetro and one drilling platform to Petrobras.

This section will focus on the firm-level strategies (which sometimes arose at the suggestion of state-based program administrators in Transpetro and Prominp) that EAS pursued in order to absorb modern production technologies and successfully build a workforce with the capabilities to use them. These include building foreign partnerships with leading global shipbuilders from Asia and constructing alliances with local private and public training organizations in order to recruit and

train thousands of blue-collar workers. Though the firm faced multiple challenges, relationships among the firm, foreign partners, federal program administrators, local public and private organizations, and workers and their organizations drove the creation of a large industrial workforce in Suape, transforming the region from a reliance on (largely informal) work in the sugar cane fields to one of the most important manufacturing poles in Brazil today.

Foreign Technology Partnerships

In 2008, Samsung Heavy Industries (SHI) purchased a 10% equity share of EAS and became a technology partner in the venture. Such international partnerships were encouraged by Prominp administrators as a means of absorbing the latest shipbuilding technologies and were common among the shipyards that supply Petrobras. Even though EAS ownership was initially reluctant to take on SHI, the soon realized that the shipyard would have trouble attaining global competitiveness without an international partner to facilitate the transfer of technologies that are critical to modern shipbuilding processes. Transpetro viewed this partnership as crucial, because EAS was to be the first (and remains the only) Brazilian shipyard to use the "fourth generation" shipbuilding technologies characteristic of the world's leading shipyards in Korea, Japan and China, whereby production is organized in modules according steps in the construction process, allowing work to proceed in parallel on multiple vessels. By comparison, Rio de Janeiro's shipyards still use second- and third-generation production technologies from the 1980s, in which production is organized by vessel and ships are produced in series. Compared to the other new shipyards, however, Samsung's 10% stake (later reduced to 6%) was relatively small (Neto 2014). Under the agreement, SHI would supply US$29 million worth of technical and design support, provide knowledge on safety management and procurement strategies, and assist with worker training for shipbuilding techniques (Samsung 2008). The deal also included the option to outsource some production from South Korea to the Brazilian shipyard (Jornal do Comércio 2008).

By 2012, however, Samsung had grown frustrated with the shipyard's performance and its own limited ability to influence management. EAS had delayed the delivery of its first vessel to Transpetro and risked losing contracts for other vessels. Observers speculated that the shipyards' plans to scale up production so rapidly were too ambitious (Goés and Nogueira 2012). Consequently, Samsung withdrew its investments from the shipyard. Dismayed at these events – and heavily invested in the success of EAS – Transpetro and Prominp assisted in bringing on board a trio of Japanese shipbuilding and engineering firms – IHI, JCG and Japan Marine United – through a special-purpose investment vehicle called Japan EAS Investimento. The Japanese firms had initially invested a 25% stake (R$ 207 million), later increasing this to 33%. Until the explosion of the *Lava Jato* scandal that froze the accounts of EAS's buyers, Transpetro and Sete Brazil, and led to the departure of Japan EAS Investimento from the venture in 2016, the firm improved its performance and maintained its contracts.

Preparing a workforce from scratch

In order to actually begin operations as the Southern Hemisphere's largest shipbuilder, EAS needed to prepare workers for a variety of jobs, including welders, assemblypersons, electricians, painters, naval plumbers, coppersmiths, engineers, designers and managers. Pernambuco, however, has relatively little experience in modern industrial production, compared with São Paulo, Rio de Janeiro and the other states in the Southeast and South; professionals prepared to work in the shipbuilding industry were virtually non-existent in Pernambuco. In 2003, the economy of the five administrative districts that comprise the Suape region was reliant upon sugar cane harvesting and tobacco processing; there were few workers qualified to work in a modern industrial setting (IBGE – See Tables 1 and 2 in Appendix 1.)

In spite of these challenges, EAS had maintained a commitment to hire a predominately (80%) local workforce. To accomplish this goal, the shipyard invested R$16 million in training

programs between 2008 and 2010, the years when it was scaling up operations. The federal government played an important role in inducing these investments through conditions attached to BNDES loans, according to which EAS must direct 1% of the total project investment (R$670 million) towards works deemed to be tied to social responsibility, such as schools, worker training programs and infrastructure upgrading.

EAS also formed partnerships with the state and local governments to carry out worker recruitment, and with local public and private vocational training organizations and municipal schools to undertake skill formation. Among the vocational training organizations, Senai (which is privately managed by CNI) focused on preparing production workers such as welders, pipefitters, painters, and so on, while the publicly owned federal institutes focused on providing training and apprenticeships in narrower and more specialized occupations, such as engineering, metal-mechanics and naval design. EAS worked closely with these organizations to integrate its own in-house training programs, producing a trajectory of skill upgrading that workers might follow. These partnerships drew together a network of actors that not only inserted workers – in particular, those previously employed in the informal sector as well as young people entering the labor market for the first time – into EAS's internal labor market but also facilitated the broader transformation the economic structure of the Suape region by preparing workers for employment in other shipyards that would soon come online as well as in other industries such as construction, petrochemicals, and metal-mechanics. The majority of the apprentices who participate in Senai's technical training programs are between the ages of 14 (the youngest age at which one can legally enter an apprenticeship contract in Brazil) and 21 (Jornal do Commercio 2010).

The management of these training programs and the process through which this network of organizations came together serve as an important source of lessons for two further reasons. First, due to rapid growth throughout the country the Brazilian labor market at the time was particularly

tight, making retention of skilled workers difficult, especially given Brazil's notoriously high rate of labor turnover (Noronha, 2006; DIEESE, 2014). Second, after the onset of recession in 2014, this network of organizations would become instrumental in stabilizing the local labor market, serving as a key resource for workers who were laid off and searching for similar work in other firms or as entrepreneurs.

The key occupational categories that EAS required were technical: welders, pipefitters, painters, and electricians. In order to impart these skills, EAS pursued a two-prong strategy: 1) forming a partnership with Senai to supply remedial education and external training in transferable skills and 2) creating its own internal training system through the Engeniero C. E. Vasconcelos Training Center. These apparently distinct strategies were not entirely separate; Senai would come to play an important role in providing curriculum materials and training services used in EAS's internal programs.

Through these various programs, a relatively straightforward and direct training pathway emerged for workers seeking employment at EAS. To explain the system, we will focus on specifically on the training of welders, who comprise the largest share of employees in the shipbuilding workforce. First, individuals would receive three or more months of remedial education, focusing on mathematics and literacy, through Senai or Sesi. Those who passed this course would then become eligible to register for Senai's basic welding class, which also lasts three months. This course, though it incorporates some practical training, remains primarily theoretical; graduates are not yet ready to be placed directly on the production line (Murillo 2010). Finally, those individuals who show the most promise are offered employment at EAS and, if they accept, receive a second round of training at the shipyard itself, through the Training Center and through on-the-job training. Financing is divided among EAS and Sistema-S (the parent organization of Senai), so that the only financial risk faced by workers is foregone wages time spent in classes and on

homework. EAS's contributions to training costs are not insubstantial, amounting on average to R$3,748 per student each month (SUPORT-BA 2011). This is about 50% more than the combined contributions of CNI and the federal and state governments, which amounted to R$2,550 per trainee, and more than twice the starting-level wage (Jornal do Comércio 2015). Organizing this system required the construction of a set of relationships between the shipyard, local government, and Sistema-S.

Beginning in 2007, EAS formed a partnership with the five administrative districts[5] in Suape in order to lobby for increased funding from Sistema-S to support the Senai training center in the municipality of Cabo de Santo Agostinho. The school received R$26 million from the central office of Sistema-S to modernize its facilities and programs (Murillo 2010). In crafting the curricula for these programs, Senai coordinators consulted not only with EAS but also with other area employers in order to ensure that the content of its courses would be adequate to their needs. In 2009, when EAS's hiring reached its peak, the shipyard was the largest consumer of workers trained at Senai (2,075, or 74% of all trainees in welding and pipefitting), the newly modernized facility was a public good that benefited other local employers by providing remedial education and skills training in a variety of occupations, such as plumbing, brass work and carpentry (Senai, 2009). Even as EAS's demand for new workers slowed down after 2011, Senai would continue training workers apace, in order to to satisfy the labor demand of the still-growing shipbuilding industry (two other shipyards began operations in 2012) as well as to provide workers for two major regional infrastructure projects: the construction of a railroad and the transposition of the São Francisco River.

Senai also assisted with EAS's recruitment efforts, hosting recruiting workshops in their various offices throughout the Suape region in partnership with the shipyard and the state Departments of Labor and of Education. The goal of these workshops was the recruitment of 2,000

[5]Ipojuca, Cabo de Santo Agostinho, Jaboatão dos Guararapes, Moreno, and Escada

industrial workers who would then receive training (via Senai) and be incorporated into EAS workforce. The integration of the remedial education, recruitment, and training programs offered by Senai with EAS' own personnel system reduces costs for the shipyard in a number of ways. It not only defrays some of the direct training costs but also cuts down recruitment-related search costs. In addition, these courses help workers without exposure to manufacturing work (even indirectly, e.g. through family members) to adjust into the culture and rhythms of heavy industry. Furthermore, the input of employers like EAS into the structure of training curricula is an important factor in reducing risk and uncertainty in the recruitment process, helping to ensure a good fit for workers. Indeed, four out of five workers hired by EAS have passed through Sistema-S courses at the Cabo de Santo Agustino facility (Senai 2009b).

For the internal training aspect of its Human Resources strategy, EAS initially relied on two sources of skilled and experienced workers to provide firm-specific training to new workers. First, there was a pool of skilled welders with experience in shipbuilding in Rio de Janeiro, the old center of Brazilian shipbuilding. EAS tapped into this group of workers by recruiting some to come to Pernambuco to provide training and also by sending some workers from Suape to Rio de Janeiro to be trained in the city's vocational training schools. However the trainers from Rio lacked direct experience with the modern, fourth-generation technologies used at EAS. The second strategy was to leverage the partnership with Samsung by importing skilled welders from the Korean shipyard to provide theoretical (classroom) and practical (on-the-job) instruction. Even though this approach was actually cheaper for EAS (the Korean trainers remained on Samsung's payroll), it proved unsuccessful for the most part because of the language barrier. Since linguistic communication was impossible, the Brazilians could only watch and try to emulate what the Koreans were doing; it was impossible to convey information in real time. How EAS overcame the problem of securing and embedding a supervisory workforce will be taken up in the following section.

International Recruitment and an Innovative On-the-Job Training System

Even as EAS managed to articulate a reliable training pathway across multiple programs to prepare new welders for its workforce, the company still ran up against the problem of limited access to welders with several years of experience. The question of experience is important not only because veteran workers are frequently used to train new hires. Experienced workers are also important for productivity because they tend to be better problem solvers and can complete tasks more quickly[6]. Given the historical lack of a local shipbuilding industry in the Northeast and the tight labor market for shipbuilding workers across Brazil, EAS had trouble identifying a large pool of experienced workers who might serve as team leaders.

The shipyard attempted a couple of solutions that ultimately did not work out. Initially, EAS initiated a program with Senai and Petrobras to bring up team leaders from within the firm's existing workforce Within this partnership, EAS provided the facilities and funding for the training, while Petrobras supplies the training curricula and educational materials, which had been drafted as part of Prominp. The central Senai office for Pernambuco supplied instructors and actually implemented the program. However the lack of long-term experience and exposure to fourth generation shipbuilding technologies within the internal workforce hampered this effort. As indicated above, bringing in experienced production workers from Samsung's shipyard in Korea was not an effective solution because of challenges posed by the language barrier. In the end, the company came upon an unlikely resource: skilled Japanese-Brazilians working in Japan.

In 1990, hindered by an aging workforce and a shortage of workers willing to do certain

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[6] This was a much larger problem in Pernambuco than for the shipyards in Rio de Janeiro, where most of the welders already had several years of work experience. A coordinator for PROMINP explained how the question of experience tied in with training issues: "But training people [in Rio de Janeiro], it's easier[than at EAS]. 'OK, I need another 100 welders. I'll contract 100, and they'll be trained by my 1000 workers that I already have here.' "

types of manual labor,[7] Japan reformed its migration laws in order to facilitate the immigration of workers to fill positions in factories, shipyards and construction sites. The law targeted the descendents (up to the third generation) of Japanese emigrants in the interest of promoting cultural harmony. Given high rates of Japanese migration to Brazil during the early part of the 20th Century, Brazil was especially targeted as a source of unskilled and semi-skilled workers. By coincidence, the Brazilian economy in the early 1990's was characterized by extreme hyperinflation, which made the relative macroeconomic stability of Japan (which was only just entering a prolonged period of stagnation) rather attractive to many Japanese-Brazilians. Additionally, wages in Japan were significantly higher than in Brazil, even for jobs that required little qualification. A large number of Japanese-Brazilian families responded to the call, and by 2010 an estimated 280,000 Brazilian nationals had moved to Japan (Gaspari 2010). These individuals were known as *dekasegi* in Japan or *dekassegui* in Brazil.[8]

At the time, global restructuring had recast the push-pull factors shaping workers' decisions to migrate or not. While Brazil escaped the recession of 2007-2010 relatively unscathed, Japan faced contracting exports and rising unemployment. In fact, as a partial solution to the unemployment problem, the Japanese government instituted a pay-to-go program to incentivize non-Japanese citizens to return to their home countries by offering the equivalent of US$3,000 per adult and US$2,000 per dependent to families willing to leave the country and not seek re-entry within three years. Since most dekassegui workers, as non-citizens, were ineligible for the job protection and unemployment benefits enjoyed by Japanese nationals, the Japanese-Brazilian population in Japan

[7] These jobs, including welding positions in shipbuilding and construction, are known in Japan as "3K" jobs because they are kitsui (difficult), kitanai (dirty) and kiken (dangerous).
[8]出稼ぎ(dekasegi)means "leaving to work." It describes, from the Japanese perspective, the ethnically Japanese individuals who left Japan to work in Brazil (and other countries) early in the 20th Century. It is therefore sometimes perceived as a pejorative term by Japanese-Brazilians who identify as culturally Brazilian.

was especially hard-hit by the recession. In addition, their opportunities for upward mobility were limited due to linguistic factors, discrimination, non-citizenship and other reasons. Consequently, for a number of Japanese-Brazilian families living in Japan, return to Brazil was an attractive option around 2010 (Mackie, 2010).

Against this backdrop, four dekasseguis who returned from Japan sought employment at EAS in July, 2009. Given their experience as welders in Japan, the shipyard was willing to hire them. By November of the same year, the shipyard was in need of additional experienced welders to assist with training and to serve as team leaders and mentors. Recalling the four recently hired welders with experience in Japan, the Human Resources coordinator at EAS decided to attempt recruiting more dekasseguis. The company began advertising vacancies on the Portuguese-language television channel in Japan and placed recruiting ads on the internet.

In December, the Human Resources coordinator booked a plane ticket to Tokyo and spent ten days in Hamamatsu, Japan, a hub of heavy manufacturing and the home to one of the highest concentrations of dekasseguis. During this time, she interviewed candidates and made presentations about EAS and Pernambuco to dekassegui community groups. EAS' recruitment efforts benefited, as an unintended consequence, from publicity provided through the Portuguese-language media in Japan once the shipyard initiated operations in 2009. One worker recalls the first time that he heard about EAS on the Portuguese-language television channel in Japan: "I saw on television that they were building the biggest shipyard in the Southern hemisphere here. Even [then-President] Lula was filmed." (quoted in Estaleiro Atlântico Sul 2010). So, by the time that EAS began actively targeting workers for recruitment from Japan, the existence of the company was already familiar to many of these individuals. Indeed, a spokesperson from the shipyard mentioned that in some cases welders from Japan themselves "entered into contact saying that there had been a lot of discussion in the

Brazilian community in Japan about the construction of a large shipyard. In this sense, informal communication helped us out a lot."

In February, 2010, fifty dekasseguis arrived in Ipojuca to begin work at EAS as welders. By March, the number had risen to 122, and the shipyard decided to attempt hiring a total of 200 dekasseguis in this capacity. The majority of the welders had received training in Japan and held certifications from the Japanese Welding Engineering Society (JWES). Many had worked in the Japanese shipbuilding industry, some for more than a decade. Therefore, they were experienced with the best practices of modern, fourth generation shipyards, unlike welders working in the Rio de Janeiro, EAS's other source of experienced welders. Given that these workers were either Brazilian citizens or held dual Japanese-Brazilian citizenship, the repatriation process did not require that EAS go through the time-consuming process of securing work visas, which takes at least three months and sometimes as long as a year (Rocha 2011). Recruitment of dekasseguis, then, proved to be a flexible solution to the shipyard's workforce issues.

Upon incorporation into the shipyard's workforce, these dekasseguis were valuable to EAS not simply for their skill. They were typically assigned to leadership positions within work teams and served as mentors to new recruits. For this additional responsibility, they received a higher salary. Though the dekasseguis that were repatriated to work at EAS earned significantly less in pay than they could expect to have received in Japan. The median wage for shipbuilders in Japan is US$25 per hour, while in Brazil the figure is US$8 (Boas 2007). In Pernambuco, the median wage is around US$6 per hour (Camarotto 2010). However cost of living is much lower in Pernambuco than Hamamatsu, and team leaders received subsidized housing through EAS.

The dekasseguis' experience in Japan is beneficial to EAS not only for the high level of skills training that it carries; they had become familiar with Japanese quality control practices. One

worker explained that he tried to impart to trainees aspects of the industrial culture that he learned in Japan: "the work ethic is more important than the technique" (Estado de São Paulo 2010). And according to a spokesperson for EAS, "They brought an accumulated, functional knowledge. The profile of these workers fits perfectly with the level of welder that we were looking for" because of the discipline and knowledge of routine industrial practices that they brought. Dekassegui workers, then, unlike their experience in Japan, were not relegated to the periphery of the firm but instead enjoyed important, central positions that conferred status and pay beyond what their less experienced co-workers earned. Furthermore, their central position within the organization of the firm allowed them to play a more significant role as facilitators of knowledge-transfer (Williams 2007).

This strategy of repatriating dekasseguis to work as skilled welders within the EAS organization is important for a number of reasons. First, through providing a source of experienced mentors with skill certifications and several years of experience, it addressed the problem of dealing with an unskilled and inexperienced labor force by effectively facilitating human capital transfer within internal training systems, while remaining responsive to the shipyard's short-term labor needs. Recalling that firms requiring human capital are traditionally thought to have the option to "make or buy" (Miles and Snow 1984), this case presents a hybrid solution. The firm both recruits skilled workers from the outside (buying human capital) and strategically places these workers in central positions within work teams in order to facilitate skills transference to local workers (generating human capital). Second, EAS's experience demonstrates that linguistic considerations are an extremely important factor in the success of this sort of hybrid strategy for human capital formation. The recruitment of Portuguese-speaking, Japanese-Brazilian workers allowed EAS to bypass the communication problems that commonly derail such programs, as exemplified by company's attempts to use Korean workers from Samsung. Mentors could therefore explain not only the

technical aspects related to basic skill acquisition but also the "feel" of the work, and convey knowledge regarding the systematized routines of employment in a modern shipyard that they had learned in Japan. The central position of these individuals within work teams, in turn, maximized the effectiveness of this knowledge transfer (Williams 2007). As one dekassegui worker at EAS mentioned, "Beyond just our training as welders, we brought from Japan knowledge about technology and a lot of life experience. Without all of this, I certainly wouldn't be here" (quoted in Nippo-Brazil 2010b).

As for the Japanese government, the pay-to-go scheme has helped to relieve a glut in the labor supply. In addition to this passive policy, that the Japanese Ministry of Foreign Affairs has expressed some interest in more active labor market policies to coordinate emigration policy with the Brazilian government. A Japanese consul in Brazil announced at a meeting of the Chamber of Commerce of Rio Grande interest in building closer and tighter relations with other shipyards in Brazil as the industry scaled up, building on the serendipitous success of EAS's experience (Agora 2011).

Employer-based and Urban Amenities: Embedding Workers Locally

It has been noted that circumstances can compel firms to provide employees with general skills when labor market imperfections are present, for example when a monopsony employer dominates a local economy (Acemoglu and Pischke 1999, Thelen 2004). Can the existence of these training institutions simply be ascribed to the firm's labor market power? It is true that EAS is – by far – currently the largest employer of welders in the region, especially in the shipbuilding industry, so its monopsonistic power likely explains at least some of the shipyard's willingness to generously invest in its employees' general skills. Indeed, wages for welders at EAS – roughly US$6 per hour (Camarotto 2010) are below the national median wage for welders of approximately US$8 (Boas 2007), lending some credence to the market power explanation.

But the firm has been clearly aware that market power will not last forever, and indeed it was already whittled away by the entry of other medium and large firms by 2012 or even earlier. Within Suape, several developments generated strong demand for trained welders, including the construction of the Abreu e Lima refinery (2007-14), the opening of the Vard Promar shipyard in 2013, and the state-supported coalescing of a metal fabrication cluster. A number of other projects in the metropolitan region and beyond – the installation of a new auto cluster north of Recife, the transposition of the São Fernando River, and the construction of the Transnordestina Railroad connecting Suape to the Pecém Port in Ceará – threaten to siphon off workers to places outside of Suape. As the Brazilian labor market is known for high levels of turnover (Noronha, 2006; DIEESE, 2014), EAS's investment in skill might seem precarious, given the risks posed by poaching externalities and the substantial costs described above associated with building up a labor force from scratch.

In light of these risks, the shipyard has made attempts to secure the loyalty of workers and supervisors by finding ways to confer status upon them and by investing in urban amenities, in an effort to embed them socially within the firm, and spatially within Suape. EAS has thus instituted measures targeted at the levels of both the individual worker as well as the community as a whole. These measures constitute social upgrading, since they enhance the livelihood of workers as well as their families and communities. To the extent that they induce higher retention rates, they also represent sources of economic upgrading to the firm by reducing training and search costs associated with high turnover.

In terms of individually targeted benefits, EAS workers receive a mix of perks, including medical and dental insurance and free bus transportation to and from work, which are relatively generous by regional standards. Such "perks" are especially meaningful, since most of the workers at EAS had been working in the informal sector as sugar cane harvesters, domestic servants or

fishermen before seeking employment in the shipbuilding industry. One worker, whom the firm identified as one of its most productive, explained, "cutting cane, I worked more and earned less – some R$250 per fortnight. And now I have this health plan which is very good for my family" (quoted in Camarotto 2010). Workers also receive career-planning services, which provide information on opportunities for upward mobility. For example, the company has explicit career ladders that allow workers who begin constructing piers to become surveyors, or welders to become team leaders and, eventually, supervisors (Senai 2009a). These career ladders are formally folded into the internal training system through the firm's Training Center.

In order to maintain job quality and retain employees, the shipyard has also incorporated aspects of high performance work systems into its production operations. Alongside the metalworkers union, which represents all workers in the firm (though, by Brazilian law, has no say over shop floor matters), EAS has created a Work Improvement Group, which represents EAS employees and enjoys an open-door policy with top management, thus allowing workers to exercise voice over the production process. Additionally, the company holds regular contests for workers, for example to see who can weld the greatest number of rolls of wire within a given amount of time. The "champion" receives new welding equipment, an LCD television set and a raise of around R$50 per month. Thus, the firm makes an effort to recognize honor the work contribution of its employees by attaching status and recognition to craftsmanship.

Beyond such benefits that are tied to the worker-employer link, EAS has made significant and analytically relevant social investments in the community, effectively expanding the employment relationship beyond a simple economic transaction and towards a broader social bond. In key respects the firm does not keep an arms-length distance with respect to its workers and their families; instead, through investments in local amenities, such as educational facilities and transportation infrastructure, it maintains a responsive and almost paternalistic affiliation with its

employees and the community within which it is situated. For example the shipyard has invested R$74 million in a housing development for its workers, which includes a bicycle path, an elementary school, childcare facilities and a health clinic (EAS 2010b). The firm has made investments in several other local educational facilities, including financing the construction and payroll, as well as other operational costs, of the Santo André School, which offers remedial education and job training through the staff of Sesi, an affiliate of Senai. EAS also renovated an old slaughterhouse in the municipality of Ipojuca to function as an education center specializing in remedial education for local residents who did not complete formal schooling. The shipyard covered the operational costs of the school, which has a capacity of 600 students, for two years before turning its financing and management over to the state's education department.

These investments build important social links between the firm and the community within which it is embedded. As one Prominp coordinator put it, "they are grateful for the shipyard, the shipyard changed their lives. It's not easy for another shipyard to go and say, 'come work for me.' No. 'I used to work out in the sun cutting sugar cane, having a very tough life. I didn't know how to read. And now I'm working here, I have this salary each month, I have this house now.' So, it's a relationship with the local community." In other words, the way that EAS has inserted itself in the community as the supplier of key signifiers of social status (decent housing, upward mobility via education and training, formal employment status, pension and insurance benefits) enhances loyalty; through this mechanism, the firm reduces the threat of poaching. The fact that many of these investments were made as part of the BNDES-mandated social responsibility program does not detract from the success; indeed, it speaks to the policy benefits of such loan conditionalities.

Such investments serve to embed employees within the place by providing communal amenities, beyond the wages and contractual benefits at the level of the employment relationship, and thus influence workers' loyalty. Inasmuch as such investments reduce the probability that an

individual worker will migrate to a higher-wage region, the firm enjoys benefits from such investments in local infrastructure and the housing stock. In fact, since these amenities represent a sunk cost to EAS, they also serve to embed the firm within the local place.

Persistence and a Slow Transformation

The investments in shipbuilding facilities, training institutions and urban amenities described in the preceding section have contributed to a remarkable transformation in the structure of industry and the local labor market in Suape. Though shipbuilding was non-existent in the Suape in 2003 – and indeed in the entire state of Pernambuco – by 2013 it directly contributed more than 10,000 jobs (9.3% of formal jobs) to the region. Whereas the region had formerly been dominated by informal agricultural labor[9] and logistics activities, the construction of EAS has led a tripling of manufacturing employment and a transformation in the occupational structure of Suape. As one can see from the location quotients in Table 2, by 2008 (shortly after EAS began operation), specializations were apparent in core shipbuilding occupations such as welders, steel assembly workers, boilermakers, and the construction trades. These specializations continued to deepen through 2013 and were accompanied by growing concentrations of associated and supporting occupations in engineering and metalwork. Meanwhile, agricultural employment, which had previously constituted the core specialization of Suape, is now not especially prevalent in the region compared to the country as a whole.

Furthermore, the expansion of shipbuilding has led to the development of backward linkages in supporting industries, drawing in in other suppliers of manufacturing and services inputs, such as machinery and equipment manufacturing and engineering services (see Table 1). These supporting industries have in turn come to constitute a metal-mechanical cluster, whose members

[9] Informal employment is not represented in IBGE statistics, and hence its magnitude is unknowable. The main informal activities in this region are sugarcane cutting, fishing, and domestic work.

have organized a statewide association, SIMMEPE (Sindicato das Indústrias Metalúrgicas, Mecânicas e de Material Elétrico do Estado de Pernambuco) and which is based in Suape. Additionally, in 2009, another major shipyard, Vard Promar, which specializes in smaller support vessels and natural gas carriers, was established with foreign investment from Norway. Vard chose to locate in the region due to the presence of a skilled workforce and has even redirected work from its other Brazilian shipyard in Rio de Janeiro to Suape due to the Pernambucan shipyard's higher productivity.

As recession has descended upon Suape and the rest of Brazil in the wake of the ongoing scandal at Petrobras and Sete Brazil, SIMMEPE has coordinated with state and federal officials to mitigate its long-term impact on workers and employers, such as organizing training programs for workers at the shipyards and local metalworking firms in order to raise productivity, and identifying export opportunities for local firms wishing to take advantage of the declining value of the real. The entry of additional manufacturing employers has also softened the impact of the recession on workers. For example, when Petrobras suspended orders for large petroleum carriers with EAS, the local metalworking union and the state government facilitated the transition of laid-off welders into jobs at Vard and in other local employers (SDEP, 2016). Anecdotal evidence and journalistic accounts indicate that laid-off workers have also put their skills to use as entrepreneurs in small manufacturing ventures which complete outsourced tasks for the shipyards and metalworking firms, or in the service sector (Jornal de Comércio 2015).

Conclusions: Creating skills from the ground up, and embedding them in place

This case study provides an example of a successful, area-based initiative for localized skill formation and retention. Within five years of incorporation, EAS oversaw a trained workforce of nearly 5,000 individuals, in spite of a series of challenges including the lack of a competitive national shipbuilding industry, a tight labor market context and, significantly, the fact that many of the firm's

production workers had no previous ties to the formal labor market or to manufacturing work in general.

In this paper, we have highlighted how a constellation of public and firm-based investments in skill-forming institutions and other local amenities were introduced in such a way that enabled the creation of new skills and embedded these within the local labor market. On the public side, local governments successfully collectively lobbied Sistema-S and the national government in order to attract training investments. This achievement is not insignificant in a region where many municipalities believe that their competitive advantage lies not in skill but in cheap labor (Tendler 2002). Top-down public support through BNDES, Prominp and PAC were also important in providing resources for new local training systems and in guiding private investments through local procurement clauses and social responsibility requirements. On the private side, EAS organized an effective internal training program that built off the Senai curriculum, instituted human resources policies with an eye towards worker retention and made investments in local amenities; such investments in housing and infrastructure reduce the firm's rate of turnover, thus cutting down on hiring costs. Finally, these actions by public and private actors bore fruit thanks to the effective and well-respected training programs managed by the private Sistema-S vocational training network.

This arrangement has two notable characteristics. First, the resultant training path, which spans both general and firm-specific skill formation, is sandwiched between top-down and bottom-up investments. Whereas top-down investments provided the large-scale resources for programming and facilities upgrading, bottom-up collective action strategies and investments in local amenities served to provide the conditions under which new skills could be retained locally. Second, the organization of the resulting path to skill formation was partially internal to the firm and partially external to the firm, yet training organizations across the public-private divide cooperated in aligning programs. This pathway provides both transportable and firm-specific skills to workers, and

it successfully provided the critical link between skill provision and job placement, thanks to partnership between Sistema-S and EAS.

It may appear on one level that the success of the vocational training arrangements is attributable to the tight labor market for welders and other semi-skilled workers. With such demand for skills, how can training programs fail to place so many graduates into well remunerated jobs? Given the threat of poaching and the historically high levels of turnover in the Brazilian labor market, however, it is clear that the training and human resources arrangements in Suape were successful *in spite of* the tight labor market. Indeed, the wage for welders in Suape is 75% of the national median wage. While purchasing power parity calculations reduce the effective wage gap, the absence of high levels of poaching is notable. In fact, when poaching externalities are high enough that firms investing in training cannot realize a return on their investments – that is, when there is an insufficiently credible commitment of trained workers to the training firm – vocational training institutions are liable to collapse (Thelen 2004). In the EAS case, the loyalty secured through human resources initiatives and investments social amenities serves as an important source of credible commitment which supports the retention of skill both within the firm and within the local labor market. In this sense, it is important to stress that area-based initiatives and investments, both private and public, were critical to worker retention. When workers might realize higher absolute wages in other regions, the decision to stay with a particular firm or to remain in a particular labor market is contingent upon other, "soft" incentives: job quality, opportunities for upward mobility and local public goods such as schools, housing, infrastructure and natural or cultural amenities.

Before closing, we should point out that the ultimate success of this arrangement will be tested once the EAS' contracts with Transpetro and Petrobras have been filled and the firm must compete globally with other shipyards for orders. These firms have chosen to source from EAS not because it is a globally competitive shipyard but because they are state enterprises with a political

mandate to support national economic development. Nevertheless, the ability of EAS and other firms in the region, such as Vard, to compete with shipbuilders in East Asia will depend critically on both the firms' and the Suape region's ability to upgrade and retain local workers.

Table 1: Employment, establishments and wages by industry

		Suape			Pernambuco			Brazil		
		2003	2008	2013	2003	2008	2013	2003	2008	2013
All formal sector	Total employment	35505	53392	115067	962176	1308771	1758482	29543974	39441503	48948433
	Number of establishments	1345	1894	3059	55750	70561	97243	2211772	2713319	3386727
	Average wage	679	840	1333	681	789	978	925	1031	1190
Manufacturing	Total employment	11999	17721	32791	124241	190007	226886	5153487	6905074	7900136
	Number of establishments	147	173	268	5507	6581	9385	225020	263419	316616
	Average wage	734	899	1469	594	636	853	926	1026	1179
Shipbuilding	Total employment	0	1501	10684	1	1508	10755	14394	26970	52892
	Number of establishments	0	1	3	1	4	7	248	207	266
	Average wage	0	1623	2006	231	1618	1998	1244	1446	1781
Supporting industries										
Machinery manufacturing	Total employment	24	588	2177	1369	3006	5502	243192	357425	428140
	Number of establishments	3	4	13	98	104	151	9323	11610	13780
	Average wage	2304	1257	1703	1048	987	1273	1343	1477	1628
Engineering services	Total employment	0	48	6019	4068	4110	17387	101772	145958	245021
	Number of establishments	0	2	13	188	145	247	8297	6371	9066
	Average wage	0	3762	1689	971	1080	1471	1236	1437	1654

Source: Rais, Dataviva

Notes: All wages are monthly figures

Table 2: Employment and wages by occupation

		Suape			Occupational LQ, % national avg. wage		
		2003	2008	2013	2003	2008	2013
All formal employment	Total employment	35505	53392	115067	-	-	-
	Average wage	679	840	1333	73%	81%	112%
Specialized production workers	Total employment	6231	14291	49317	0.9	1.3	2.1
	Average wage	690	713	1140	106%	97%	133%
Welders	Total employment	247	565	3815	1.9	2.4	7.1
	Average wage	801	980	1582	90%	93%	134%
Production line worker	Total employment	957	2112	2760	1.6	2.1	1.2
	Average wage	848	527	653	160%	90%	99%
Steel structural assembly workers	Total employment	72	192	2653	1.4	1.9	11.2
	Average wage	531	703	1166	86%	95%	134%
Metal equipment painters	Total employment	44	76	1569	0.7	0.8	7.2
	Average wage	568	661	1221	76%	73%	120%
Boiler workers	Total employment	94	227	1482	1.0	1.4	4.3
	Average wage	835	876	1290	106%	95%	125%
Plumbers	Total employment	71	116	3449	1.1	1.1	12.9
	Average wage	741	1078	1490	88%	112%	137%
Civil engineering assistants	Total employment	605	2345	7141	1.1	2.3	3.1
	Average wage	395	447	596	96%	95%	104%
Construction workers	Total employment	47	330	3540	0.5	1.7	7.2
	Average wage	504	525	1153	83%	74%	132%
Construction supervisors	Total employment	88	301	1212	1.1	2.3	3.6
	Average wage	1154	1637	2749	106%	117%	158%
Skilled workers/tradespeople	Total employment	4429	4584	11727	1.1	0.8	0.9
	Average wage	859	1261	2103	77%	99%	148%
Electricians/Electrical engineers	Total employment	61	183	579	1.0	1.8	2.4
	Average wage	1612	1720	3098	88%	90%	151%
Professionals	Total employment	1678	4360	7571	0.5	0.8	0.6
	Average wage	1717	1224	2654	91%	57%	109%
Production engineers	Total employment	32	82	324	1.8	2.3	3.4
	Average wage	3055	4447	5998	81%	105%	130%
Mechanical engineers	Total employment	20	28	240	1.0	0.8	3.0
	Average wage	7016	7170	9066	144%	122%	137%
Administrative workers	Total employment	4279	7158	13108	0.6	0.7	0.6
	Average wage	711	826	1109	80%	88%	108%
Production Trainers	Total employment	176	463	1189	1.4	2.1	2.2
	Average wage	774	1351	1513	103%	169%	169%
Agricultural workers	Total employment	8422	5667	5638	5.2	2.7	1.6
	Average wage	270	365	505	68%	73%	78%

Source: IBGE Rais

Notes: All wages are monthly figures, LQs are taken w/r/t national employment