THE REGIONAL MIGRATION STUDY GROUP

Manufacturing in the United States, Mexico, and Central America:

Implications for Competitiveness and Migration

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Wilson Center

MIGRATION POLICY INSTITUTE

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A primary goal of the Study Group is to develop and promote a longer-term vision of how to build a stronger social and economic foundation for these countries by enhancing the region's human-capital infrastructure. Building up the region's human capital — through education and workforce development reforms that gradually develop common standards in key sectors across the region — should create better economic opportunities for the region's citizens, creating an engine for growth in each country and strengthening regional competitiveness. Over time, success in this regard will mitigate today's concerns about the scope and "quality" aof regional migration while setting the stage for future regional migration to be more of a genuine choice, rather than a necessity. The manufacturing sector holds promise for all the countries of the region in terms of creating better formal-sector jobs and in generating positive economic spillovers, including increased regional competitiveness.

The Study Group's mission, membership, and research can be found at: www.migrationpolicy.org/regionalstudygroup.

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Executive Summary

This report examines trends in manufacturing — with a focus on advanced manufacturing — in Mexico, Guatemala, Honduras, El Salvador, and the United States. The manufacturing sector is a significant source of employment for people born in Mexico and Central America's Northern Triangle (Guatemala, Honduras, and El Salvador). Around 17 percent of the workforce in these four countries is employed in manufacturing,[1] and immigrants from these countries make up 8 percent (1.3 million people) of the US manufacturing workforce. Although these countries' manufacturing histories and contexts are quite different, the sectors are increasingly interdependent, and the prospect of moving up the manufacturing value chain by building human capital in each of these countries potentially holds great promise for improving both individual livelihoods and overall regional competitiveness.

The economies of Mexico, and to a lesser extent, Guatemala, Honduras, and El Salvador, have benefited from aggressive manufacturing-attraction strategies. At the same time, the achievements of the *maquiladora*[2] development strategy have masked important flaws that threaten to stymie the promise of even greater economic growth.

Proximity to the United States makes it possible for manufactured goods from Mexico, Guatemala, Honduras, and El Salvador to compete effectively against lower-wage regions in the world. Time to market is lower, as are many logistics and transportation costs. Multinational enterprises (MNEs) based in the United States are within two time zones of plants in these countries, supporting near-real-time communications between design and production facilities. But these factors also reduce these countries' leverage in securing spillover benefits that could be used to jump-start investment in research and development (R&D) and in endogenous supplier businesses. Whereas China, India, and other Asian manufacturing "tigers" represent gateways to new markets and can demand R&D and other innovation-related investment in production, Mexico, Guatemala, Honduras, and El Salvador have thus far only traded on their relationship to the United States.

The economies of Mexico, and to a lesser extent, Guatemala, Honduras, and El Salvador, have benefited from aggressive manufacturing-attraction strategies.

Looking forward, these countries need to achieve a second, post-*maquila* transformation. This would entail leveraging their existing manufacturing base and strong position in free trade by linking it with R&D and incremental and process innovation as a means of reaching new markets. Such changes are especially important for high-tech products in which advanced manufacturing techniques play a critical role.

As in the shift in focus from import substitution to exporting that these economies underwent in the 1960s and '70s, large-scale changes must occur. First, human-capital formation must be on a par with that of developed countries. This development goes well beyond education outcomes, as measured by the Organization for Economic Cooperation and Development (OECD) Programme for International Student Assessment (PISA) and other standardized means. The workforce must have the skills and proficiencies to compete with counterparts in advanced manufacturing regions such as northern Europe, Japan, and the United States. Credentialing standards, training systems, and outcome measures that are comparable

1 Authors' calculations using the data from national labor force surveys from International Labor Organization (ILO), "Labor Statistics Database (LABORSTA)," http://laborsta.ilo.org/.

2 A *maquiladora* (abbreviated *maquila*) is a manufacturing plant that imports and assembles duty-free components for export.

to those in industrialized economies will serve as the basis for attracting talent from outside the region as well as expanding employment options for homegrown talent.

Second, domestic business development policies and practices must be aligned to support innovation and the creation and growth of small and medium-sized business. Fundamental changes in intellectual property rights, business law, and business finance go hand in hand with changes in human-capital development.

In the United States — the world's leading manufacturer for more than a century — there is evidence that occupations in this sector are increasingly requiring higher skill levels. However, employment data and projected trends suggest that immigrants from the four sending countries of Mexico, Guatemala, Honduras, and El Salvador cannot compete for employment in higher-skilled manufacturing jobs, and so are not positioned to benefit from a manufacturing resurgence. Rather, they are employed in low-paying and/or disappearing jobs — jobs that don't generally offer skills training or provide pathways to long career ladders and that won't necessarily be around by the end of the current decade. This raises important questions regarding how employers and educators can best help to equip this significant segment of the manufacturing workforce with the tools to meet the sector's current and future labor needs.

This report lays out the case for a two-pronged strategy to address employment in advanced manufacturing in the United States, Mexico, and the countries of the Northern Triangle, with a focus on immigrants from these countries to the United States. One prong of the strategy is incorporating advanced manufacturing into domestic economic development initiatives. The other is integrating these immigrants into the manufacturing sector's skilled labor force.

The report begins by defining advanced manufacturing and its links to innovation. It then examines manufacturing and advanced manufacturing employment in the United States and in the sending countries, focusing on industrial changes in the former and missed opportunities in the latter. The report also offers a snapshot of employment in US manufacturing and the role of Latino immigrants in the sector. It concludes with recommendations regarding human-capital development in the United States.

I. Overview of Manufacturing in the United States

The importance of manufacturing to the US economy is equaled by its importance in the country's historical narrative. The United States has been the leading producer of manufactured goods for more than 100 years, currently producing nearly 18 percent of global manufactured products.[3] The sector has long sustained the country's economic growth, spurring constant innovation and knowledge generation. However, manufacturing has been declining as a share of gross domestic product (GDP) and employment. The sector now accounts for 12 percent of US GDP,[4] with the four largest subsectors — computers and electronics; chemicals; food, beverages, and tobacco; and petroleum and coal — making up 51 percent of total manufacturing GDP.[5]

At its highest point, in 1944, the total manufacturing employment share in the United States reached nearly 40 percent. However, increasingly challenged by its Asian competitors in the 1970s and '80s, the United States lost more than 40 percent of its manufacturing jobs between June 1979 and December

3 There is some disagreement as to whether the United States remains the world's top manufacturer, or whether it was superseded by China in 2010. See the Manufacturing Institute, *Facts about Manufacturing*, 9th edition (Washington, DC: the Manufacturing Institute, 2012): 47, www.themanufacturinginstitute.org/Research/Facts-About-Manufacturing/~/media/A9EEE900EAF04B2892177207D9FF23C9.ashx.

4 Michael Ettlinger and Kate Gordon, *The Importance and Promise of American Manufacturing* (Washington, DC: Center for American Progress, 2011), www.americanprogress.org/issues/labor/report/2011/04/07/9427/the-importance-and-promise-of-american-manufacturing/.

5 The Manufacturing Institute, *Facts about Manufacturing,* 12.

2009, with the worst losses coming in the first decade of the 21st century. Today, manufacturing employs 11 percent of the US private-sector workforce. Nationwide, immigrants from Mexico and Central America's Northern Triangle make up a little more than 6 percent of the total civilian workforce — but are overrepresented in manufacturing, where they are nearly 8 percent of all workers in the sector. In fact, manufacturing is the second-biggest employment source for all immigrants from these four countries, trailing only construction.[6]

Despite the long-run manufacturing employment losses, the industry remains vitally important to the US economy. Manufacturing is a source of high-wage jobs for workers at all skill and education levels, but is an especially important source of jobs for those who would otherwise earn the lowest wages.[7] In addition to production jobs, manufacturing ordinarily has a high "spillover" effect, indirectly creating millions of service jobs along the skills spectrum. (Production and service occupations include designers, engineers, machinists, assemblers, inspectors, sales representatives, and packagers, to name just a few roles.)

The "renaissance" of manufacturing is a topic of note in the media, and subject to debate among economists. Some manufacturers have "inshored," or relocated factories from Asia to the United States, citing rising labor costs in China and distance from R&D functions as drivers of their decision. Indeed, manufacturing's share of employment is up slightly from a low of 8.79 percent in November 2010.[8] However, the gains in manufacturing jobs from January 2010 to October 2012 — an increase of 500,000 jobs, or 4.4 percent from the trough[9] — though a positive sign for the industry, have not matched the job losses suffered during the previous decade. On the bright side, the gains have been mainly concentrated in durable goods manufacturing, which tends to be a more productive and thus higher-wage part of the industry. In fact, the top four export subsectors by value — transportation and aerospace equipment, computers and electronic products, chemicals, and nonelectrical machinery — accounted for nearly two-thirds of US manufactured exports in 2010,[10] and these key subsectors may have the potential to maintain or expand employment in the United States.

Despite the long-run manufacturing employment losses, the industry remains vitally important to the US economy.

Important to this analysis is an understanding of how the nature of manufacturing employment is changing along with advances in technology and the shift in production mix and location. Most US manufacturers report that they have redesigned and streamlined their production lines in the past five years and implemented more process automation. Skills requirements for workers are also evolving: manufacturers report that the top skill deficiency among employees is in problem solving, which is critical for workers to adapt to changing demands.[11] At the same time, the more that companies rely on smart machines and

6 Authors' analysis of American Community Survey (ACS) data, 2008-10.
7 Susan Helper, Timothy Kreuger, and Howard Wial, *Why Does Manufacturing Matter? Which Manufacturing Matters? A Policy Framework* (Washington, DC: Brookings Institution, 2012), www.brookings.edu/research/papers/2012/02/22-manufacturing-helper-krueger-wial.
8 Federal Reserve Bank of St. Louis, "FRED Economic Data," http://research.stlouisfed.org/fred2/graph/?g=eCo.
9 Bureau of Labor Statistics (BLS), "Employment, Hours, and Earnings from the Current Employment Statistics survey (National), Seasonally Adjusted," http://data.bls.gov/timeseries/CES3000000001.
10 US Department of Commerce, International Trade Administration, "U.S. Trade Overview," last updated June 24, 2011, www.trade.gov/mas/ian/build/groups/public/@tg_ian/documents/webcontent/tg_ian_002065.pdf.
11 Deloitte Development LLC and the Manufacturing Institute, *Boiling Point? The Skills Gap in US Manufacturing* (New York and Washington, DC: Deloitte Development LLC and the Manufacturing Institute, 2011), www.themanufacturinginstitute.org/~/media/A07730B2A798437D98501E798C2E13AA.ashx.

robots for production, the less important the domestic cost of labor becomes[12] — and the more important the quality of labor becomes.

II. Overview of Manufacturing in Mexico and the Northern Triangle

Manufacturing in the study countries (Mexico, El Salvador, Honduras, Guatemala, and the United States) is primarily export focused and is the product of a significant economic development policy shift in the region from growth through import substitution to growth through exports. Mexico's *maquiladora* policy launched the change. This policy, begun in 1965 and adopted by the other countries in the 1970s, attracts foreign direct investment (FDI) by allowing producers and investors tax-free importation of raw materials and intermediate inputs which they process and/or assemble and then reexport, again tax-free, to the United States. This arrangement allows companies — largely US owned — to take advantage of lower production costs in the region, including lower wages. *Maquila* and similar duty- and tariff-free zone policies have been followed by fundamental, systemic changes in countries' export strategies, and by regional trade agreements such as the North America Free Trade Agreement (NAFTA) and the Central America/Dominican Republic Free Trade Agreement (CAFTA-DR); many bilateral trade agreements; and improvements in transportation, logistics, and marketing.

FDI has not brought the same positive spillover effects to the manufacturing sector in Mexico and the Northern Triangle that is seen in other emerging economies.

Manufacturing in the United States and the region are highly interdependent thanks to these policies and agreements. As of December 2011, there were 1.9 million jobs in export manufacturing in Mexico, accounting for around 3.9 percent of the employed population, or one in 25 jobs.[13] In 2011, nearly 80 percent of Mexico's manufactured exports went to the United States, with three industries accounting for more than 70 percent of trade: electrical and electronic equipment, vehicles, and machinery.[14] In other countries in the region, export manufacturing also contributes significantly to GDP. In El Salvador, for example, *maquila* manufacturing contributed 11 percent of the country's GDP in 2008.[15]

Despite significant changes in industrial and trade policy — and rapid growth in manufacturing output and exports — since the second half of the 20th century, FDI has not brought the same positive spillover effects to the manufacturing sector in Mexico and the Northern Triangle that is seen in other emerging economies, such as China and South Korea. Thus, we do not see the growth of domestic manufacturers that produce and export products of their own design and creation. In much of the Northern Triangle, manufactured exports are geared to the US and Central American markets, and so are mainly comprised of light assembly, apparel and textiles, and food processing.

12 Tyler Cowen, "What Export-Oriented America Means," *The American Interest*, May/June 2012, www.theamerican-interest.com/article.cfm?piece=1227.

13 Authors' calculations using data from Mexico's National Institute for Statistics and Geography (INEGI), "Estadística Mensual del Programa de la Industria Manufacturera, Maquiladora y de Servicios de Exportación," 2011, www.inegi.org.mx/est/contenidos/espanol/proyectos/INMEX/Informaci%C3%B3n_seleccionada_IMMEX.pdf.

14 Authors' calculations using data from the United Nations Commodity Trade Statistics database (UN COMTRADE), http://comtrade.un.org/.

15 *La Educación Superior en la Universidad Don Bosco* (Unpublished report, Universidad Don Bosco, El Salvador, August 2012, 5).

From 2003 through 2010, manufacturing exports from Latin America and the Caribbean grew by 70 percent, from $209 billion to $357 billion (see Table 1). Manufacturing exports from Mexico, the largest exporting country in the region, grew by 65 percent over the same period. El Salvador and Guatemala experienced greater rates of change, whereas Honduras showed only marginal improvements; unlike Mexico, Guatemala, and El Salvador, it did not achieve export values greater than the prerecession peak in 2008. This stagnation is likely due to the economic interruption imposed by the 2009 political crisis.

Table 1. Total Exports of Manufactured Products from Mexico and the Northern Triangle, (freight on board, millions of current dollars),[16] 2003-10

	2003	2004	2005	2006	2007	2008	2009	2010
El Salvador	716.4	883.4	952.6	1,078.7	1,190.7	1,432.3	1,224.5	2,087.5
Guatemala	1,062.7	1,223.2	1,345.6	1,115.5	1,716.2	2,001.7	1,683.2	2,009.1
Honduras	443.7	586.0	673.8	551.6	683.5	909.6	879.5	519.5
Mexico	134,634.2	250,993.4	165,005.8	189,128.0	204,017.6	212,236.0	172,393.4	222,648.2
Total	209,663.0	246,616.5	279,060.7	316,946.1	344,325.3	372,532.5	288,053.0	356,813.2

Source: Economic Commission for Latin America and the Caribbean (ECLAC), *Statistical Yearbook for Latin America and the Caribbean*, Table 2.2.2.4 (Santiago, Chile: ECLAC, 2011): 100, www.eclac.cl.

Trade in advanced technology products between the United States and Mexico and between the United States and the remainder of the South and Central American countries (excluding Brazil) consistently shows the United States as a net importer of these technology products. Overall, Mexico is the United States' second-most-important foreign source of advanced technology products behind China (which dwarfs Mexico).

Table 2. US Exports and Imports of Advanced Technology Products from Mexico, China, and All (millions of current dollars), 2006-11

	2006		2007		2008		2009		2010		2011	
	Exports	Imports	Exp.	Imp.	Exp.	Imp.	Exp.	Imp.	Exp.	Imp.	Exp.	Imp.
Mexico	18,650	30,881	17,240	38,631	19,585	40,326	20,601	39,748	27,227	48,733	31,914	47,782
China	17,633	72,727	20,342	88,015	17,363	91,392	17,202	89,674	21,444	115,631	20,133	129,488
Total	252,708	290,761	274,160	326,809	270,131	331,181	244,708	300,892	273,344	354,195	286,718	386,005

Source: US Department of Commerce, Census Bureau, various years.

Despite significant increases in the nominal value of exports of manufactured products, exports in manufactured goods in 2003-10 declined as a percentage of total exports for the region and specifically for Guatemala, Honduras, and Mexico. This relative decrease is likely due to a combination of factors, including increased manufacturing competition with China after its entry into the World Trade Organization (WTO) and the expiration of the agreement restricting trade on textiles and clothing; decreased US demand for manufactured goods due to the economic recession; and the "China Effect," or increased Chinese demand for commodities, leading to higher prices and thus a greater prominence of the primary sector in the export market. Nevertheless, manufactured products dominate the export markets for Mexico and El Salvador.

16 Includes chemicals and related products, manufactured goods classified chiefly by material (excluding division 68: nonferrous metals), machinery and transport equipment, and miscellaneous manufactured articles.

Table 3. Exports of Manufactured Products as Share of Total Exports from Mexico and the Northern Triangle (total value of export goods, freight on board), 2003-10

	2003	2004	2005	2006	2007	2008	2009	2010
El Salvador	57.1	59.9	57.5	56.4	54.7	54.7	53.0	62.0
Guatemala	40.3	41.8	39.8	34.9	37.9	37.2	33.7	34.7
Honduras	33.5	36.4	35.8	29.3	28.6	29.3	33.5	20.1
Mexico	81.4	79.8	77.0	75.7	75.0	72.9	75.1	74.7
Total	55.9	53.7	50.2	47.4	50.5	47.3	46.8	45.9

Source: ECLAC, *Statistical Yearbook for Latin America and the Caribbean*, Table 2.2.2.2, 98.

III. Understanding Advanced Manufacturing and its Potential

The term *advanced manufacturing* is used to indicate that the process uses some type of innovation — either in product design and function or in the production process itself. But the varying applications of the term *advanced* to products or processes leads to a wide range of results that do not necessarily produce the same effects across the entire "advanced" manufacturing workforce.

The US President's Council of Advisors on Science and Technology (PCAST) defines advanced manufacturing as a family of activities that "depend on the use and coordination of information, automation, computation, software, sensing, and networking, and/or . . . make use of cutting edge materials and emerging capabilities enabled by the physical and biological sciences, for example, nanotechnology, chemistry, and biology."[17] The US Department of Labor (DOL) Employment and Training Administration's definition focuses on the use of technology, processes, and demand for more skilled workers, but does not define advanced manufacturing in terms of industries or industry characteristics.[18] The Bureau of Labor Statistics (BLS) and the Census Bureau, on the other hand, have taken an industry-focused approach; the BLS defines 20 industries that lean heavily on employing science, technical, and engineering occupations,[19] and the Census has compiled a list of advanced technology products for purposes of foreign trade balance.[20]

To attract the advanced manufacturing that policymakers often assume will lead to positive spillovers, countries and localities may be tempted to use tax and similar incentives, but these strategies fail to account for complex underlying mechanisms. It is not a given that such strategies will greatly expand a regional economy in ways that improve workers' wages. Rather, complementary investments in local product and process innovations are critical to creating the spillover effects that are necessary for regional economic advancement.

In one sense, if a process is transportable and can be relocated through traditional industrial attraction strategies, production is probably so routinized and the work so commoditized that the activity will only require relatively unskilled workers. On the other hand, acts of creation — whether they are products,

17 President's Council of Advisors on Science and Technology (PCAST), *Report to the President on Ensuring American Leadership in Advanced Manufacturing* (Washington, DC: White House, Executive Office of the President, 2011): ii, www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-advanced-manufacturing- june2011.pdf.

18 US Department of Labor (DOL), Education and Training Agency, *Advanced Manufacturing Industry: Addressing the Workforce Challenges of America's Advanced Manufacturing Workforce* (Washington, DC: DOL, undated), www.doleta.gov/BRG/pdf/Advanced%20Manufacturing%20Report%2011.1.05.pdf.

19 US Bureau of Labor Statistics, "High-Tech Employment," *Monthly Labor Review*, July 2005, www.bls.gov/opub/mlr/2005/07/art6full.pdf.

20 US Census Bureau, "Advanced Technology Product (ATP)," accessed January 12, 2013, www.census.gov/foreign-trade/reference/codes/atp/index.html.

services, or processes — are more likely to require the skilled touch of humans to have tangible results.

Rather, a key element that economic development authorities and policymakers might take into account when seeking to maximize positive spillovers is proximity. This factor has two important components: first, the access to a critical mass (or cluster) of human, physical, and financial resources; and second, the geographic or proximal relationship between invention and production or implementation. The link to human-capital development concerns is clear: shared resources and networks (including training networks) are needed to support robust innovation in the production process, typically accomplished by making small but continuous improvements to existing products, often in response to customer demand (this process is known in the industry as "incremental innovation").

Implications for the Region

The 2010 Global Manufacturing Competitiveness Index — a study drawing on a survey of 400 CEOs and senior manufacturing executives across the world — notes that "access to talented workers was the major driver of a country's competitiveness in attracting manufacturing, above the cost of labor and materials."[21]

This reality makes manufacturers from Mexico and the Northern Triangle vulnerable to other low-cost producers with deeper talent bases, especially if transportation and other costs are lowered. For example, the expansion of the Panama Canal is projected to reduce transportation costs for Asian producers by shortening overland routes as well as reducing the number of intermodal transfers (e.g., some shipments will go directly to truck instead of to rail and then truck). Other port-related transportation and logistics projects in Mexico, for example, may yield similar results.

A realistic goal for the smaller countries might be to advance gradually along the value-added continuum.

An advanced manufacturing strategy for these countries might therefore focus less on mass, low-cost, highly commoditized production (the result of innovations that characterize the tail end of the innovation continuum) and move up the innovation continuum to focus on improving existing processes and products as well as creating new ones. Realistically, such a transition would require economic and workforce development strategies that leverage FDI, including that in *maquiladoras*, to create greater spillovers in R&D and in incremental and process innovations. The classic *maquila* model dissociates production from process and incremental innovation, as well as the more fundamental novel-product and technology innovation. This model makes good sense if production is low cost and high volume or if innovation activities are not too far away, such as in the border regions of the United States.

Since the highest-value-added work in the industries central to bilateral trade flows in the region will likely continue to occur in the United States (and increasingly in Mexico), a realistic goal for the smaller countries might be to advance gradually along the value-added continuum. Strategies that allow countries to move into the additional stages of the manufacturing process, from R&D through process and incremental innovation, can support domestic development of higher-value-added, export-oriented manufacturing. If a fundamental shift does not occur in advanced manufacturing that is linked to process, and incremental and novel forms of innovation, manufacturers in the region will continue to rely on low-skilled workers,

21 PCAST, *Report to the President on Ensuring American Leadership in Advanced Manufacturing*. The report predicted that by 2015 the United States would slip in the competitiveness ranking, even though in 2007, prior to the economic crisis, wages for manufacturing workers in the United States were lower than the average in 16 other countries and Europe.

and the area's economies will not be able to achieve their productivity potential. These manufacturers will also continue to operate in labor markets that serve the informal sector in the region, in addition to drawing on low-skilled workers in US labor markets. Many labor migrants are drawn to the United States since they are able to earn more without incurring additional opportunity costs associated with training or with achieving more than a rudimentary education (although other costs such as travel, safety and security, and payments to migrant smugglers certainly pose formidable barriers to emigration).

IV. Productivity and Skills in Manufacturing

In the United States, manufacturing employment has historically included large percentages of both low- and mid-skilled workers. Using median wage as a proxy for skill, the low-skilled worker category includes service occupations as well as operators, fabricators, and laborers. The mid-skilled category consists of technical, sales, administrative, precision production, craft, and repair occupations.[22] In general, however, these occupations are declining as a percentage of the total, while high-skilled occupations — defined as those involving management and professional specialization — are increasing. Of course, the skills mix in demand varies by industry. Some subsectors remain particularly labor intensive, requiring large numbers of less-skilled production workers, while other, capital-intensive, subsectors employ a much higher proportion of mid- and high-skilled workers.

Productivity in US manufacturing increased at an average of 5.4 percent annually between 1997 and 2007, according to official statistics,[23] and there is evidence that manufacturing occupations in the United States are increasingly higher skilled.[24] But an often-overlooked possibility is that much of the apparent gains in productivity may be due to manufacturers' employing temporary workers, which reduces the labor input on the industry's balance sheet.[25]

Nevertheless, because of their high productivity levels, US manufacturing workers earn more than workers in other sectors, controlling for worker and job characteristics. In other words, in 2008-10, both genders and all racial/ethnic groups made more at all wage levels, at all levels of education attainment, and in all occupation groups. The exception is Hispanic workers, who earned 10 cents less per week in manufacturing than in nonmanufacturing industries — likely because of their concentration in the lowest-paying manufacturing sectors.[26] Durable goods manufacturing is generally the subsector with the highest productivity and wages. Hispanics are more heavily concentrated in nondurable goods manufacturing, particularly in food processing and textile and apparel manufacturing.

Although these nondurable manufacturing jobs are low wage by US standards, they pay relatively more for the same skills than in Mexico and Central America. There, manufacturing workers earned just above or just below the average for all workers (without controlling for other characteristics). In Mexico, Honduras, and El Salvador, manufacturing workers earned slightly less than the average, while in Guatemala, workers in manufacturing earned slightly more on average.[27]

While it is reasonable to conclude that higher skills will be demanded by advanced manufacturing (and advanced technology) businesses, the lines are not clearly drawn as to how and where these demands

22 Richard Deitz and James Orr, "A Leaner, More Skilled US Manufacturing Workforce," *Current Issues in Economics and Finance* 12, no. 2 (2006), www.newyorkfed.org/research/current_issues/ci12-2.pdf.
23 Helper, Kreuger, and Wial, *Why Does Manufacturing Matter?*
24 Deitz and Orr, "A Leaner, More Skilled US Manufacturing Workforce."
25 There is some debate as to how much productivity has increased in the sector. See Matthew Dey, Susan Houseman, and Anne Polivka, "Manufacturers' Outsourcing to Employment Services" (Working Paper No. 07-132, Upjohn Institute for Employment Research, Kalamazoo, MI, 2006), www.upjohninst.org/publications/wp/07-132.pdf.
26 Helper, Kreuger, and Wial, *Why Does Manufacturing Matter?*
27 Author's calculations using LABORSTA and household survey data from the National Statistics Institute of Honduras. Data are the most recent available: El Salvador, 2006; Guatemala, 2008; and Honduras, 2011. Honduras data are on income rather than salary.

will be manifested. No one quibbles with the assertion that a premium will be placed on the scientists and engineers who invent new products or spark the next series of innovations to current ideas. Few disagree that these new products will often require process innovations or at least a changeover from one process to another, and that such transitions will also demand highly skilled engineers, scientists, and production workers. But the actual production activities themselves may not require many skills beyond the basics — and this requirement is dictated in part by how quickly production becomes routinized. In other words, production workers employed by advanced manufacturers are not necessarily high skilled and do not necessarily receive high wages (to use an oft-cited example, consider the case of workers in iPhone assembly plants). Rather, skill level and wages will depend in part on the workers' role in product and process life cycles.

There is a growing sense that a push to attract, retain, and increase the number of advanced manufacturers in Mexico and the Northern Triangle will ultimately break the current pattern of low-wage, low-skill employment by improving the level of value creation, thereby increasing the demand for greater worker skills and supporting rising wages. The possible trap created by such an approach, however, is that, again, manufacturing labeled as "advanced" does not necessarily require high-skilled workers and may not result in high-wage jobs. These "outcomes" are related to the place of a given manufacturing facility in the innovation cycle of the parent enterprise. As regional economists have shown, even medium and high-tech manufacturing exports may not be associated with knowledge-intensive activities, and countries can export high-tech manufactured goods even if their technological capabilities are weak.[28]

A. Manufacturing Employment in Mexico and the Northern Triangle

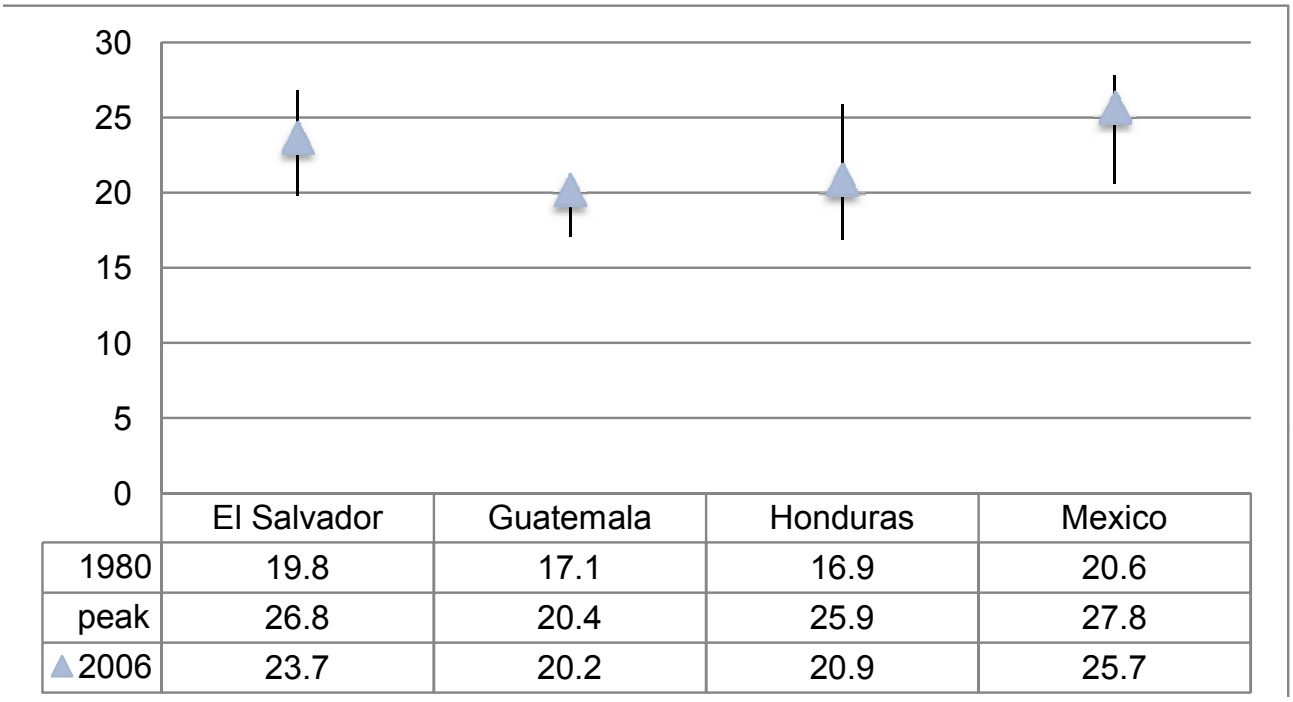
Below we describe the state of manufacturing employment in Mexico and the Northern Triangle, in order to understand what shifts and reforms will be needed. Since 1980 and at least through 2006, industrial employment has generally stagnated in Latin America as a percentage of total employment.[29] Overall, the industrial share[30] of the labor force rose from 22.7 percent in 1980 to 25.5 percent in 1985, and then dropped to 24.5 percent in 1990 and 21.6 percent in 2006. Industrial employment in these four countries grew more, on average, than in the greater Latin American region (see Figure 1).

28 Ramón Padilla-Pérez and Jorge Mario Martínez-Piva, "Export Growth, Foreign Direct Investment and Technological Capability Building under the Maquila Model: Winding Roads, Few Intersections," *Science and Public Policy* 36, no. 4 (2009): 301.

29 David Brady, Yunus Kaya, and Gary Gereffi, "Stagnating Industrial Employment in Latin America," *Work and Occupations* 38, no. 2 (2011): 180. The authors define Latin America as comprising Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela.

30 Industry includes mining and quarrying; manufacturing; electricity, gas, and water supply; and construction.

Figure 1. Industrial Employment Share for Mexico and Northern Triangle, 1980, Peak of Industrial Employment, and 2006



	El Salvador	Guatemala	Honduras	Mexico
1980	19.8	17.1	16.9	20.6
peak	26.8	20.4	25.9	27.8
▲2006	23.7	20.2	20.9	25.7

Source: David Brady, Yunus Kaya, and Gary Gereffi, "Stagnating Industrial Employment in Latin America," *Work and Occupations* 38, No. 2 (2011): 180, http://wox.sagepub.com/content/38/2/179.

It should be emphasized that there is no "optimal" proportion of industrial employment; rather, the GDP-maximizing mix depends on a country's specific resource allocations. In China, for example, the industrial sector employed around 18 percent of the workforce in 2005, while Germany's industrial sector employed around 30 percent of the workforce in 2009.

Overall employment in Mexico and the Northern Triangle is largely in services. Industry is more dominant than agriculture in Mexico; the two sectors are about equal in terms of overall employment in El Salvador. Agricultural employment remains dominant with respect to industry in Guatemala and Honduras.

Table 4. Structure of Total Employed Population in Mexico and Northern Triangle, by Sector of Economic Activity, 2000-10

	Agriculture			Industry			Services		
	2000	2005	2010	2000	2005	2010	2000	2005	2010
El Salvador	20.5	18.4	21.2	23.9	23.9	21.2	55.6	57.1	57.5
Guatemala	37.2	30.6	–	22.0	23.8	–	40.8	45.6	–
Honduras	34.0	35.1	36.2	22.4	22.0	19.0	43.6	42.9	44.8
Mexico	17.5	13.9	13.3	28.3	25.7	25.2	54.2	60.4	61.5

Note: Sectors are as defined by the International Standard Classification of All Economic Activities (ISIC), Rev. 2.
Source: ECLAC, *Statistical Yearbook for Latin America and the Caribbean*, Table 1.2.5, 42.

In all of these countries, the manufacturing sector employs approximately 16–17 percent of the workforce.

Table 5. Structure of Total Employed Population, Mexico and Northern Triangle, by Major Division of Economic Activity, Various Years

	Agriculture, hunting, forestry, and fishing	Mining and quarrying	Manufacturing	Electricity, gas, and water supply	Construction	Wholesale and retail trade, repair of motor vehicles, hotels and restaurants	Transport, storage, and communications	Financial intermediation, insurance, real estate, rental, and business services	Public administration, health, social, community, education, and household services	Other
El Salvador (2007)	18.0	0.2	16.7	0.4	6.1	29.8	4.3	4.7	19.8	0.0
Guatemala (2006)	33.2	0.1	15.9	0.2	6.6	22.8	3.0	3.3	14.7	0.2
Honduras (1999)	34.2	0.1	17.1	0.4	4.9	20.7	2.5	2.2	17.7	0.4
Mexico (2008)	13.1	0.4	16.5	0.5	8.3	29.2	4.6	5.9	20.7	0.8

Note: Sectors are as defined by the International Standard Classification of All Economic Activities (ISIC), Rev. 3.
Source: Authors' calculations using labor force survey data from International Labor Organization (ILO), "Labor Statistics Database (LABORSTA)," http://laborsta.ilo.org/.

In urban areas, the greatest concentration of workers, in terms of occupation, is in the production of goods.

Table 6. Structure of the Total Urban Employed Population, Mexico and Northern Triangle, by Occupational Group, 2010

	Occupations							
	Professional, technical, and related workers	Administrative and managerial workers	Clerical and related workers	Sales workers	Service workers	Agriculture, animal husbandry, and forestry workers; fishermen; hunters	Production and related workers, transport equipment operators, laborers	Workers not classifiable by occupation
El Salvador	15.0	1.5	6.5	21.8	20.0	7.5	27.8	–
Guatemala	14.3	8.5	5.4		19.61[31]	4.5	47.8	–
Honduras	16.2	13.4	5.1	10.3	17.8	7.1	28.9	1.2
Mexico	18.6	5.6	8.1	15.9	9.2	1.0	41.5	0.1

Note: Classifications are in accordance with ILO's International Standard Classification of Occupations (ISCO, 1968).31
Source: Authors' calculations using labor force survey data from ILO, "Labor Statistics Database (LABORSTA)," Table 1.2.11, 44.

31 Combination of occupations 4 and 5.

A recent study of OECD countries indicates that as production has increased in Mexico, manufacturing's share of employment has decreased about 6 percent over the 2000-09 period, while manufacturing wages rose in general. However, researchers also show that the opening of *maquilas* led to a higher proportion of low-skilled occupations overall (and a lower proportion of high- and mid-skilled occupations).[32] Furthermore, the increase in relatively high-wage export manufacturing jobs may have resulted in a higher school-dropout rate: one economist found that for every 20 new jobs, one student dropped out in 9th grade instead of continuing on through 12th grade — and that Mexicans who left school to work in export manufacturing would be earning more money if they had continued their studies.[33]

B. The Region's Immigrants in the US Workforce

US immigrants from Mexico, El Salvador, Honduras, and Guatemala compose a significant portion of the total civilian and manufacturing labor supply in the United States. They are especially prominent in the US Southwest, where immigrants from these countries make up 22 percent of manufacturing employees, but only 16 percent of total civilian employees (see Figure 2). For immigrants from these four countries, manufacturing is an important source of employment, especially in the north central United States, where more than one-quarter of these immigrants are employed within the sector.

As production has increased in Mexico, manufacturing's share of employment has decreased about 6 percent over the 2000-09 period.

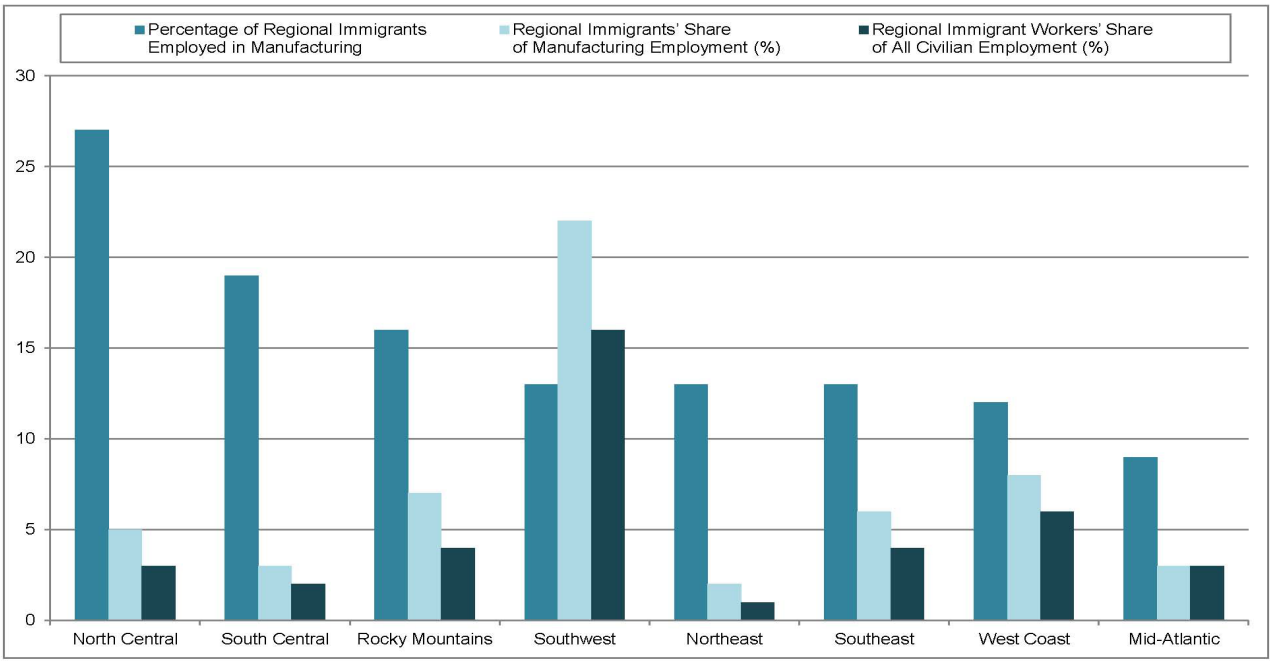
Immigrants from these four countries in manufacturing and production occupations are most heavily concentrated in jobs requiring little or no preparation or some preparation[34] — the two lowest job zone groups, as defined by the US O*NET. In the "little or no preparation" category, only some jobs require a high school or general educational development (GED) diploma, no related experience is required, and any needed training can be completed in a few days to a few months. The highest number and concentration of immigrants from Mexico and the Northern Triangle in this category is in food-processing occupations, where the median annual income for these immigrants ranged from $16,000 in the southeast to $24,000 in the Rockies and the northwest.

32 Raymundo Miguel Campos-Vazquez and Jose Antonio Rodriguez-Lopez, "Trade and Occupational Employment in Mexico since NAFTA" (Working Paper No. 129, OECD Trade Policy, OECD Publishing, Paris, 2011), www.oecd-ilibrary.org/trade/trade-and-occupational-employment-in-mexico-since-nafta_5kg3nh5q7p5k-en.

33 David Atkin, "Endogenous Skill Acquisition and Export Manufacturing in Mexico" (unpublished working paper, Department of Economics, Yale University, July 2012), www.econ.yale.edu/~da334/Endogenous_Skill_Acquisition_Mexico.pdf.

34 See Appendices, Table A-1.

Figure 2. Employment of Mexican, Guatemalan, Honduran, and Salvadoran Immigrants by US Region, 2009



Notes: *Southwest*: Texas, Arizona, New Mexico, and California; *Northeast*: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont; *Mid-Atlantic*: Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania, Virginia, West Virginia; *Southeast*: Florida, Georgia, North Carolina, South Carolina; *North Central:* Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin; *South Central:* Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Tennessee; *Rocky Mountains/Plains:* Colorado, Kansas, Montana, Nebraska, North Dakota, Oklahoma, South Dakota, and Wyoming; *West Coast:* Alaska, Hawaii, Idaho, Nevada, Oregon, Utah, and Washington. *Source*: Census Bureau, American Community Survey (ACS) three-year estimates, 2008-10.

Regional workers in manufacturing do not generally earn what is considered to be a family-sustaining wage.

The "some preparation" category generally requires a high school or GED diploma, some previous work-related skills, knowledge, or experience, and a few months to a year of training. For immigrants from Mexico and the Northern Triangle countries, the most common occupations in this category are assemblers and fabricators; metal workers and plastic workers; workers in textile, apparel, and furnishings occupations; woodworkers; first-line supervisors of production and operating workers; and workers in miscellaneous production occupations. During the 2008-10 period, median incomes for these immigrants in textile, apparel, and furnishing occupations (generally the lowest paid in the category) ranged from $15,000 in the Southwest to $19,500 in the Southeast. Incomes for metal and plastic workers (generally the highest paid) ranged from $23,000 in the South Central region to $28,500 in the West.[35]

As we have shown, regional workers in manufacturing do not generally earn what is considered to be

35 Authors' analysis of Census Bureau American Community Survey (ACS) data, 2008-10.

a family-sustaining wage.[36] Additionally, the medium-term employment outlook for these immigrants appears mixed. Overall jobs for metal workers and plastic workers are projected to increase by 139,300 or 7.9 percent through 2020, while assembly and fabrication jobs are projected to increase by 88,000 or 5.4 percent during the same period.[37] But in general, immigrants from Mexico and the Northern Triangle appear to be more highly concentrated in specific industries where employment is projected to decline by the end of the decade. Traditional (nonadvanced) textiles and apparel manufacturing will see continued employment declines, following a long-term trend in this industry. Job declines are projected in industries manufacturing resin, synthetic rubber, and fibers and filaments; paint, coating, and adhesives; and electrical lighting and other electrical equipment and components. All are advanced manufacturing industries in which immigrants from these four sending countries are overrepresented.

These projected trends suggest that immigrants from Mexico and the Northern Triangle are not competitive for securing employment in high-skilled, advanced manufacturing jobs, and are not currently positioned to benefit from a manufacturing resurgence, if one is indeed occurring. In other words, these immigrants are employed in low-paying and/or disappearing jobs — jobs that don't generally offer skills training or provide pathways to long career ladders and that won't necessarily be around by the end of the current decade. The question is — if the economic trends and employment projections bear out — to what extent will these existing workers be able to transfer their skills to other manufacturing industries, or upgrade their skills and climb the jobs ladder within their current industries? Of course, these concerns hold not just for Mexican and Central American immigrants, but for all lower-skilled manufacturing workers. However, as immigrants from these four countries are largely limited in English proficiency and have lower education levels than the native-born as well as other foreign-born groups, they face additional barriers to finding good, lasting jobs.

Projected trends suggest that immigrants from Mexico and the Northern Triangle are not competitive for securing employment in high-skilled, advanced manufacturing jobs.

It is also unlikely that individuals from these countries are gaining the competencies required for higher-skilled jobs in advanced manufacturing in their home countries. In 2006 there were more than 450,000 students enrolled in full-time undergraduate engineering degree programs in Mexico,[38] compared to around 370,000 in the United States.[39] But because few Mexican educational institutions are linked to dynamic, innovating, private-sector firms, many of these students are studying outdated material and using obsolete technology, practices that will not prepare them to find good jobs.[40] Furthermore, just 340 engineering doctorate degrees were awarded in Mexico in 2008 — 0.5 percent of the world total. Nor are Mexicans keeping up with their Asian counterparts in earning science and engineering doctorates abroad. In 2010 just 169 doctoral degrees in all science and engineering fields were awarded to Mexican temporary visa holders at US universities.[41]

36 We use the definition developed by the Economic Policy Institute (EPI). According to EPI's definition, a worker's income must be at least 60 percent of the median national household income, or about $30,000 in 2010 (when the median was roughly $50,000). See Algernon Austin, "Getting Good Jobs to People of Color" (Briefing Paper 3250, Economic Policy Institute, 2009), www.epi.org/publication/getting_good_jobs_to_people_of_color/.

37 DOL, "Occupational Outlook Handbook, 2012-13 Edition, Assemblers and Fabricators," www.bls.gov/ooh/production/assemblers-and-fabricators.htm.

38 Asociación Nacional de Universidades e Instituciones de Educación Superior (ANUIES), Mexico, www.anuies.mx/.

39 American Association of Engineering Societies, Engineering Workforce Commission, "Engineering and Technology Enrollments: Fall 2010 Survey," www.ewc-online.org/data/enrollments_data.asp; Michael Gibbons, *Engineering by the Numbers* (Washington, DC: American Society for Engineering Education, 2009), www.asee.org/papers-and-publications/publications/college-profiles/2009-profile-engineering-statistics.pdf.

40 Organization for Economic Cooperation and Development (OECD), *OECD Reviews of Regional Innovation: 15 Mexican States* (Paris: OECD, 2009), 152.

41 National Science Foundation (NSF), National Institute of Health (NIH), US Department of Education (ED), US Department

V. Manufacturing Performance in Mexico and Central America

A. *Findings from the Organization for Economic Cooperation and Development*

OECD territorial reviews benchmark the economic performance of one region against others and provide an in-depth analysis of underlying mechanisms responsible for historic and current conditions. These reviews may encompass countries that are not members of the OECD — in this case, El Salvador, Guatemala, and Honduras. Of the findings relevant to the Mexico and the Northern Triangle, one is that while manufacturing offers great opportunities for economic growth, significant barriers have caused the industry to underperform as a driver of rising incomes and reduced income inequality. These barriers include legal and institutional obstacles to formal business and capital formation, persistently low education quality, little innovation and investment in R&D, poor coordination of public resources intended for economic development, and poor coordination between manufacturers and higher education institutions.

Guatemala, Honduras, and El Salvador have been characterized by low-value-added industry and been less successful than Mexico in creating and capitalizing on spillovers from FDI.

As a result, the full value of FDI has not been achieved in Mexico and the Northern Triangle countries, since positive indirect effects, such as increased development of related services, have been limited. Manufacturing inputs are often imported (an institutional component of the *maquila* model) rather than produced by local businesses. Consequently, there are few linkages between export-oriented firms and domestic small and medium enterprises. Product and process innovation occurs in the United States and other places operated by foreign multinationals, and so local patent applicants are often foreign, while Latin American applicants at US and European Patent Offices are scarce in R&D-intensive sectors. There is limited networking or cooperation between firms, impeding process standardization and improvements in output quality. Further, there are also limited linkages in both quantity and quality between manufacturing operations and local higher educational institutions, even in Mexico City, which has one of the highest concentrations of universities and research institutions in the region.[42] The situation has led to a "brain drain" of talent from even the more-advanced areas. This exodus of talent can be seen on both sides of the US-Mexico border, in areas like the El Paso–Ciudad Juárez "border-plex."[43] Ultimately, across the region, these factors have led to a lack of dynamically functioning industry clusters; those in Monterrey and Guanajuato are the exception, not the rule.

In general, Guatemala, Honduras, and El Salvador have been characterized by low-value-added industry and been less successful than Mexico in creating and capitalizing on spillovers from FDI, and in linking large export manufacturers to small and medium-sized local firms. While El Salvador and Guatemala have made strides in light manufacturing, and Honduras has attracted electronics *maquilas*, further success has been stymied by the overall poor business environment and low quality of labor supply. This low quality is a result of the fact that the region's primary and secondary education systems face major challenges:

of Agriculture (USDA), National Endowment for the Humanities (NEH), and National Aeronautics and Space Administration (NASA), "2010 Survey of Earned Doctorates: Top 10 Countries/Economies of Origin of Temporary Visa Holders Earning Doctorates at U.S. Colleges and Universities Ranked by Total Number of U.S. Doctorates Awarded: 2000–10," www.nsf.gov/statistics/doctorates/, "Doctorate Recipients from United States Universities: 2010 Data Tables," Table 26.

42 OECD, *OECD Territorial Reviews: Mexico City* (Paris: OECD Publishing, 2004): 14, www.oecd.org/centrodemexico/publicaciones/36635112.pdf.

43 OECD, *Higher Education in Regional and City Development: The Paso del Norte Region, Mexico and the United States* (Paris: OECD Publishing, 2010): 50, www.oecd.org/mexico/45820961.pdf.

high dropout rates, poor infrastructure, and limited resources. To increase the quality and supply of higher education in these countries, OECD recommends harmonizing diplomas, creating accreditation mechanisms and other regulations to facilitate multicountry educational consortia, and furthering the transition from a vocational model centered on the public sector by better matching education and training to the needs of private-sector firms.

It should be noted that there are some positive findings from the OECD's reviews, as well as from other studies. In the Mexican state of Chihuahua, where the four main manufacturing clusters (automotive, electrical, electronics, and IT) add higher value than other Mexican states, there are 10 technical institutions that supply area manufacturers with at least 1,000 graduates annually. R&D centers have appeared in the region since the mid-1990s, and more recently global companies have established design and engineering centers in the state. Chihuahua has spearheaded a promising government-academia-industry partnership — a "triple helix" collaboration — under which the partners have developed a range of resources and training institutions. These include an industry-academia liaison council that helps match supply and demand for high-skilled labor in selected industries (Consejo de Vinculación Académico-Productiva, COVAP), and a sector-based skilled workforce training initiative that also provides process improvements in small businesses (Centro de Entrenamiento en Alta Tecnología, CENALTEC). Initiatives such as these allow human-capital development to be localized and responsive to the needs of the state's industries.[44] However, challenges remain in connecting foreign-financed plants to Chihuahua's small and medium firms. And despite upper secondary educational attainment levels being better than the Mexican average, they remain significantly below the OECD average, and are particularly low in rural areas.

B. Other Findings on R&D and FDI

Additional research on whether Mexico and the Northern Triangle countries have achieved significant spillover effects from FDI is consistent with the OECD findings. One study comparing the MNE spillovers in developing Asian and Latin American countries notes that FDI is more closely associated with skills formation than with domestic investment, although this pattern is not uniform.[45] In general, some plants operated by MNEs are passive, do not invest in human resources development, and provide little training; other MNE plants provide training that responds to their own requirements; and a third group is "proactive," and provides training because they realize the competitive advantage of human resources development.

Other findings on the relationship between education and technology are mixed: in Mexico, the higher the R&D investment, the higher the human resources investment, suggesting a complementarity between these two variables that is also positively correlated with firm economic performance. Firms may also substitute educated workers for training. The determinants appear to be skilled labor turnover and local supply of vocational students and professionals.[46]

In general, these countries participate in the most labor-intensive activities of the production process; therefore, "exports of medium- and high-technology goods have not been supported by strong technological capabilities, but by MNEs that keep knowledge-intensive activities in their home countries or in other developed countries."[47] To counter this situation, the countries could increase their efforts to develop domestic technological capabilities in order to attract knowledge-intensive activities.[48]

Additionally, in the case of Mexico, FDI policies that were implemented to resolve fiscal crises in the 1980s

44 Ibid, 22. See also OECD, *OECD Territorial Review: Chihuahua, Mexico* (Paris: OECD Publishing, 2012), www.oecd.org/mexico/oecdterritorialreviewschihuahuamexico.htm.

45 Alfonso Mercado, "MNE Spillover in Developing Asian and Latin American Countries: Trends and Policies," *OECD Journal: General Papers* 2008/1, www.oecd-ilibrary.org/economics/mne-spillovers-in-developing-asian-and-latin-american-countries_gen_papers-v2008-art7-en;jsessionid=pic8t4lxl39i.epsilon.

46 Ibid, 16.

47 Ibid, 312.

48 Ibid.

may have had the unintended consequence of undermining a homegrown high-tech sector. During the 1970s, foreign firms were invited to invest in Mexican computer production through joint ventures. Foreign producers were also required to invest in Mexican R&D and science, technology, engineering, and mathematics (STEM) training centers. This policy was supported by new Mexican institutions that embedded foreign high-tech producers within the domestic economy. Recurring balance-of-payments and currency crises, and large debts to foreign banks, helped prompt a shift in development policies away from import substitution and toward export creation. The result was that support for an endogenous high-tech sector was largely lost.[49]

C. Opportunities for Advanced Manufacturing

Despite structural weaknesses and the historical inability to create business linkages and spillovers, the opportunities for Mexico, El Salvador, Guatemala, and Honduras in advanced manufacturing are great. Mexico, in particular, is well positioned to sell goods manufactured in the country by virtue of its 11 free trade agreements with 43 countries. Both domestic and foreign manufacturers in Mexico have free-trade access to more countries than any other in the world. The Mexico Consulting Group[50] in Chicago cites three sectors in which Mexico is especially strong:

- ***Automotive.*** This sector accounted for 3.2 percent of GDP and 16.4 percent of all exports. Most production is located in the northern and central parts of the country. Volkswagen, Honda, and Mazda will be opening three new plants in Guanajuato in the next two years, employing around 9,500 people.
- ***Aerospace.*** Investments here cover design; engineering; manufacturing; maintenance, repair, and operations (MRO); and education as well as parts produced for most major commercial aircraft companies. The majority of structural components for Bombardier's Learjet 85 are being fabricated in Queretaro and full production is expected by 2013. In 2010 Mexico was the sixth-largest recipient of aerospace R&D in the world and the twelfth-largest exporter of aerospace equipment. In 2011, 286 companies employed around 31,000 people in 17 states across the country.[51]
- ***Medical devices.*** Medical device exports reached $5.8 billion in 2010, with concentrations in tubular metal needles and suture needles, surgery and dental instruments, therapy equipment, respiratory equipment, orthopedic products, and gauze and bandages. Most production is centered on the state of Baja, California.

VI. The Role of Standards, Credentials, and Certification

A. Quality Standards and Business Performance

American manufacturing underwent a major transformation during the 1980s as a result of an increasing emphasis on quality and performance. This transformation was driven by the development of international standards (e.g., International Organization for Standardization, ISO) as production operations spread across the globe, with different parts manufactured in different areas of the world. These international standards were also driven by new product-specific performance requirements imposed by manufacturers (e.g., on automotive suppliers) and through various "best practices" initiatives such as the Baldrige Excellence pro-

49 Mark Z. Taylor, "Toward an International Relations Theory of National Innovation Rates," *Security Studies* 21, no.1 (2010): 113–52.

50 Ralph Biederman, "IMMEX, Manufacturing and Investment Opportunities," (presentation to the US-Mexico Chamber of Commerce, Detroit, February 29, 2012), www.usmcocma.org/file.php?id=376.

51 Federación Mexicana de la Industria Aeroespacial (FEMIA), "FEMIA," http://femia.com.mx/themes/femia/ppt/femia_presentacion_tipo_eng.pdf.

grams.[52] While the adoption of standards has not been required by the US government (although many have been supported directly or indirectly), internationally recognized certifications are often needed for a business to operate within a given industry cluster. Manufacturers routinely require that their suppliers be certified in a specific ISO classification. While this certification provides firms with added assurances that the parts they receive will meet their expectations, the requirements may create significant barriers to entry for new businesses wishing to compete on the market, since the certification process can be costly and lengthy. As specifications and tolerances increase — which is to be expected in advanced manufacturing and high-technology industries — institutional credentialing looms large as a barrier to entry.

If the US experience is a guide to the challenges in meeting ISO and other institutional credentials, it is unreasonable to expect small and medium businesses in the region to have the resources to achieve the necessary certifications. Virtually all certifications are obtained through a comprehensive set of initiatives that touch on all aspects of business operations and all levels of the workforce. For example, a common quality initiative — statistical process control — requires that each machine operator be schooled in how to measure the performance of the machine that he or she is operating, how to chart this performance, how to recognize when the machine may become out of tolerance, and how to diagnose and fix the problem before it arises. This training then must be incorporated into a companywide quality assurance program that meets the expectations of the company's customers.

To promote the seamless transfer of knowledge and talent, conventions for communicating ideas and establishing credentials are needed.

The adoption of new manufacturing practices by business has been assisted and often subsidized by state and federal agencies[53] and by various industry and trade association initiatives. While these efforts have not been targeted solely to advanced manufacturing, adoption and implementation of internationally accepted standards is basically required of all businesses within advanced manufacturing. Although supply chains do not necessarily cross borders, advanced technology products compete internationally, so common standards are *de facto* universal.

B. Credentials and Skills Standards

To promote the seamless transfer of knowledge and talent, conventions for communicating ideas and establishing credentials are needed. These conventions are by and large informal or are linked to academic achievement. A few advanced technology or advanced manufacturing industries will require some professional-level workers to be licensed — for example, some nuclear engineers within a firm may be required to be licensed if blueprints for a device to be used in a nuclear facility require the signature of a professional engineer. In most cases, formal credentials and certifications serve as indicators of proficiency and are used to screen potential applicants for positions. But, more informal ways of demonstrating proficiency may be accepted within emerging fields. Since many innovation clusters are highly localized, the challenge for anyone entering the cluster is to understand local conventions and to translate their own experiences and achievements to local standards. Innovation clusters operating in nodes within a country or even globally need to be linked together in order to support both the transfer of knowledge and ideas

52 This is a national education program that is part of the National Institute of Standards and Technology at the US Department of Commerce. It develops and disseminates evaluation criteria, and promotes performance excellence and the learning and sharing of successful performance practices, principles, and strategies.

53 These include state training and business development initiatives and the Manufacturing Extension Partnership operated under the auspices of the National Institute of Standards and Technology at the US Department of Commerce.

as well as to establish new norms that support the movement of talent. In other words, an innovation cluster in advanced manufacturing cannot grow in isolation but must be part of the larger universe of clusters operating in the same industry.

Logically, certain other factors must fall into place in order for this networked growth to succeed. Local education and training institutions, especially those in higher education, must align their curricula and programs with those of other higher education institutions linked to similar clusters. This linkage can be accommodated through common institutional accreditation and other standardization initiatives. As a recent OECD territorial review on Mesoamerica points out, the inability of higher educational institutions to work from a common accreditation framework is inhibiting their ability to support domestically driven development. On a more global scale, higher education institutions supporting the development of an industry such as aerospace in these countries must be aligned with their counterparts in other parts of the world. At a minimum, their innovations will be more readily accepted, and under the best of circumstances, viewed as leading edge. This alignment builds greater agglomerations; although some talent will leave, new talent will be attracted to such clusters. Institutional linkages are particularly relevant to Mexico, in which aerospace manufacturing is growing rapidly.[54]

Coincidental to the development of institutional standards and credentials for businesses is the development of occupational skills standards for workers. Traditional occupational classification systems that describe organized occupations by function and task gave way in the 1990s to systems that also take into account the knowledge, skills, and aptitudes (KSAs) and proficiencies associated with each given occupation. In addition, new distinctions clarify whether a given knowledge, skill, or aptitude is basic, cross-functional, or specific to an occupation. In real life, careers can follow varied pathways, especially where basic and cross-functional skills are common to multiple occupations. New occupational taxonomies have emerged, such as O*Net in the United States, that describe each occupation according to its associated KSAs and support cross-walking across occupations along any dimension.

Industry groups, supported by a national effort through DOL in the 1990s and by state councils throughout the country, developed and adopted skills standards and occupational pathways. Such pathways track the progression of workers' foundational skills as they become more specialized. For example, the national metalworking industry developed learning and operational standards for various levels of machinists, from basic machine operation to highly specialized operations on a specific machine used in connection with a specific set of materials. The aim for these and other standards is to provide training institutions with clear guidance on industry expectations, to provide employers with a reliable mechanism for determining the qualifications of prospective workers, and to improve overall industry performance and quality by setting expectations of workforce quality and performance.

The classification efforts started in the early 1990s eventually foundered, however, for several reasons.[55] First, the process for determining and setting standards became highly centralized and rigid. It often took years to agree to a set of standards and it was not unusual for standards to be out of date upon their adoption. Second, the standards were often too narrowly focused in their definitions of occupations. As occupations changed rapidly, especially in advanced manufacturing and in the production of high-tech products, the standards could not keep up. Although much of this change was due to the addition of new skills, these skills often existed in other occupations and were not totally new and invented. Nonetheless, training institutions would often teach to the wrong outcome. Third, although many occupational standards initiatives were industry driven, employers often discouraged their workers from achieving a credential by, for example, hiring before the completion of training (i.e., once they knew enough to do the job) or dropping training assistance short of completion. Some employers expressed fears that a creden-

54 The country ranked seventh in 2010 as an aerospace supplier to the United States, ahead of all other Latin American countries ($724 million, or 2.56 percent of total value).

55 See Jeff King, "Dilemmas of Design: Education Versus Qualification in the US Vocational System," in *Work and Education in America: The Art of Integration*, eds. Antje Barabasch and Felix Rauner (Dordrecht, the Netherlands: UNESCO-UNEVOC Book Series v. 15, Springer, 2012); and David Boesel, "Governing VET in the United States: Localization Versus Centralization," in *Work and Education in America: The Art of Integration*, eds. Antje Barabasch and Felix Rauner (Dordrecht, the Netherlands: UNESCO-UNEVOC Book Series v. 15, Springer, 2012).

tial would do more than qualify a worker for the job at hand — it might qualify her to do other jobs at other businesses. Such added mobility would give workers their opportunity to seek higher pay and better working conditions.[56]

While employer reluctance remains a barrier to universal adoption of skills standards, the National Association of Manufacturers (NAM), through the Manufacturing Institute, is developing and now pilot-testing the NAM-endorsed Manufacturing Skills Certification System. Cited by President Obama in 2011 as a national solution to the skills gap in manufacturing and part of the Skills for America's Future Initiative, this is a nationally portable, industry-recognized, cross-sector, stackable credential system that validates the skills and competencies needed for entry-level manufacturing positions. NAM's credentialing partners in the Skills Certification System are ACT, the American Welding Society, the Manufacturing Skills Standards Council, the National Institute of Metalworking Skills, and the Society of Manufacturing Engineers.[57] The skills address personal effectiveness (punctuality, readiness to work, ability to work in teams), essential academic skills (in reading, writing, math, and using and locating information), core manufacturing competencies (safety, quality assurance, continuous improvement), and key technical skills (for the production line, welding, machining, metal forming, and operation of computer-controlled machines or robots). The certifications are aligned to secondary and postsecondary programs and can serve as pathways to employment or degrees. All certifications are validated and accredited by industry-trusted third-party organizations.[58]

The traditional maquila structure does not put special demands on the development of a highly skilled workforce, but the creation of spillover business requires it.

There are several noteworthy differences between earlier efforts and this new initiative. First, the current initiative conceives of training and certifications as "stackable" — in other words they can be mixed and matched to fit changing occupational demands — forming the basis for more technical, content-specific skills. Second, NAM is the umbrella for a collection of industry- and process-specific organizations that will oversee the development and continued improvement of skills within their purview. Third, NAM is leaving the implementation of these systems to individual states (or statewide organizations) which are tasked with making the connections between education and training systems and employers. In comparison to education in Mexico and the Northern Triangle, US education is governed entirely by the states and, by local school authorities at the primary and secondary levels and often at the level of technical or community colleges.

Separate and apart from these broad initiatives, businesses often impose their own workforce credential standards, either by adopting certifications associated with the operation of specific equipment (e.g., Cisco systems certification, Microsoft certification), or as a result of informal industry standards. These credentials are often used to screen applicants, but they may also be part of a concerted effort to improve performance and standardized operations.

56 Robert I. Lerman, Signe-Mary McKernan, and Stephanie Riegg, *Employer-Provided Training and Public Policy* (Washington, DC: Urban Institute, 1999), www.urban.org/publications/1000247.html.
57 Manufacturing Institute, www.themanufacturinginstitute.org.
58 Ibid.

C. *Implications for Advanced Manufacturing Development and for Immigration*

Although the movement to use workforce credentials in the manufacturing sector coincided with the development and adoption of institutional credentials such as ISO certification, progress on the former has lagged. Nevertheless, there has been movement toward greater use of credentials in the United States, as secondary and postsecondary institutions have formally incorporated them into their curricula and as similar measures in Europe have matured more rapidly. Apprenticeships — both registered and unregistered — have traditionally served as the training pathway in manufacturing; those who completed a registered apprenticeship received an industry-issued nationally recognized credential, but adoption of apprenticeship programs is far from universal within the sector. The acceptance of such credentials is most likely in operations where individuals are required to exercise greater skill and analytical abilities, and use higher levels of mathematics and reading. These activities are found in businesses that are innovating, such as those involved in advanced manufacturing and high-technology products. As we have discussed before, not all functions within advanced manufacturing require skilled workers — especially if production has become routine and highly automated. But functions that are tied to the act of innovation and its early implementation will require the services of skilled workers.

Distance to market is both a friend and enemy to the economies of Mexico and the Northern Triangle.

In addition to serving as the place where innovation occurs, if these countries wish to move into the sphere of originating advanced manufacturing and high-technology products, they will need a workforce that is capable of producing these items or adopting new processes as they are developed. The traditional *maquila* structure does not put special demands on the development of a highly skilled workforce, but the creation of spillover business requires it. A labor market characterized by low education attainment rates and poor training structures is severely constrained in supporting the creation and development of advanced manufacturing businesses.

Labor emigrants coming to the United States from areas that are not developing systems similar to those promoted by NAM will face dimmer prospects if NAM or similar systems are more universally adopted in the United States. US community colleges are already showing a willingness to adopt some form of stackable credentials, evidenced by their strong response to a 2009 grant solicitation by the Employment and Training Administration for demonstration projects in this vein. Given that the early development of such credential systems will continue along the lines of states and even within metropolitan areas, immigrants will have to navigate a maze of unpublished, somewhat-informal requirements in order to qualify for even entry-level jobs. This challenge will be made worse if nothing in their background can be cross-walked easily to the United States, much less to state or local contexts. As a result, immigrants will continue to be relegated to positions that continue to require few, if any credentials, essentially locking them out of more advanced skilled positions in advanced manufacturing and other industries.

In sum, the challenge that Mexico, Honduras, El Salvador, and Guatemala face in pursuing advanced manufacturing is twofold with respect to skills credentials. First, they must consider adopting standards that are similar to those of their major markets. Since the United States continues to be the dominant market for goods produced by the region, they should consider the NAM-endorsed Manufacturing Skills Certification System.

Second, in adopting and implementing systems that support skills certifications that are recognized in

other markets, these countries are also paving the way for some of their workers to emigrate to those markets. This is especially true where there are already well-established pathways to manufacturing employment in the United States. On the other hand, a failure to train the workforce to meet international standards will result in those who do emigrate being relegated to unskilled work since they cannot qualify for anything else.

VII. Looking Forward

The economies of Mexico, and to a lesser extent, Guatemala, Honduras, and El Salvador, have benefited from aggressive manufacturing attraction strategies. The *maquiladora* was the key element in the transformation from an import-substitution manufacturing economy to one that emphasized exports — in particular to the burgeoning, almost insatiable, US market. This change came at a time of great economic challenges for Mexico and was critical to righting its economic ship. NAFTA, CAFTA-DR, and subsequent free trade agreements have further cemented this strategy and positioned Mexico and the Northern Triangle to attract FDI in manufacturing as well as services. At the same time, the great achievements of the *maquila* development strategy have masked important constraints on the potential for even greater economic growth — growth that might improve median incomes across the region and reduce income inequalities. The most important factor to address is improving the spillover opportunities from FDI.

Distance to market is both a friend and enemy to the economies of Mexico and the Northern Triangle. Their proximity to the United States makes it possible for these countries to compete effectively on manufactured goods against lower-wage regions in the world. Time to market is lower, as are many logistics and transportation costs. MNEs based in the United States are within two time zones of plants in these countries, supporting near-real-time communications between design and production facilities. But these factors also reduce these countries' leverage in securing spillover benefits that could be used to jump-start investment in R&D and in endogenous supplier businesses. Whereas China, India, and other Asian manufacturing "tigers" represent gateways to new markets and can demand R&D and other innovation-related investment in production, Mexico, Guatemala, Honduras, and El Salvador have largely only traded on their relationship to the United States thus far.

Human-capital development must be on a par with that of advanced economies.

Looking forward, Mexico and the Northern Triangle countries need to achieve a second transformation. This change entails leveraging their existing manufacturing base and strong position in free trade by linking it with R&D and incremental and process innovation as a means of reaching new markets. Such efforts are especially important for advanced technology products where advanced manufacturing plays a critical role.

As in the first transformation from import substitution to exports, large-scale changes must occur. First, human-capital development must be on a par with that of advanced economies. Mexico, Honduras, El Salvador, and Guatemala are all below the OECD mean in education and other critical human-capital measures. While Mexico is the only OECD country among those mentioned, the operation of the global economy dictates that OECD and non-OECD countries are held to the same standards. And such standards go well beyond education outcomes, as measured by OECD's PISA and other means. The workforce must have the skills and proficiencies to compete with counterparts in advanced manufacturing regions such

as northern Europe, Japan, and the United States. This demand, in turn, requires adoption of credentialing standards, training systems, and outcome measures that are *comparable to and can be cross-walked* with those of other advanced manufacturing regions. We note that this is not a recommendation for the wholesale adoption of a European or US standard; the reality is that culture and context are important. What counts is performance, not whether a foreign structure is imposed on a region. At the same time, comparability is important for foreign investors to gauge workforce quality. It is also important as a basis for attracting talent from outside the region as well as expanding employment options for homegrown talent.

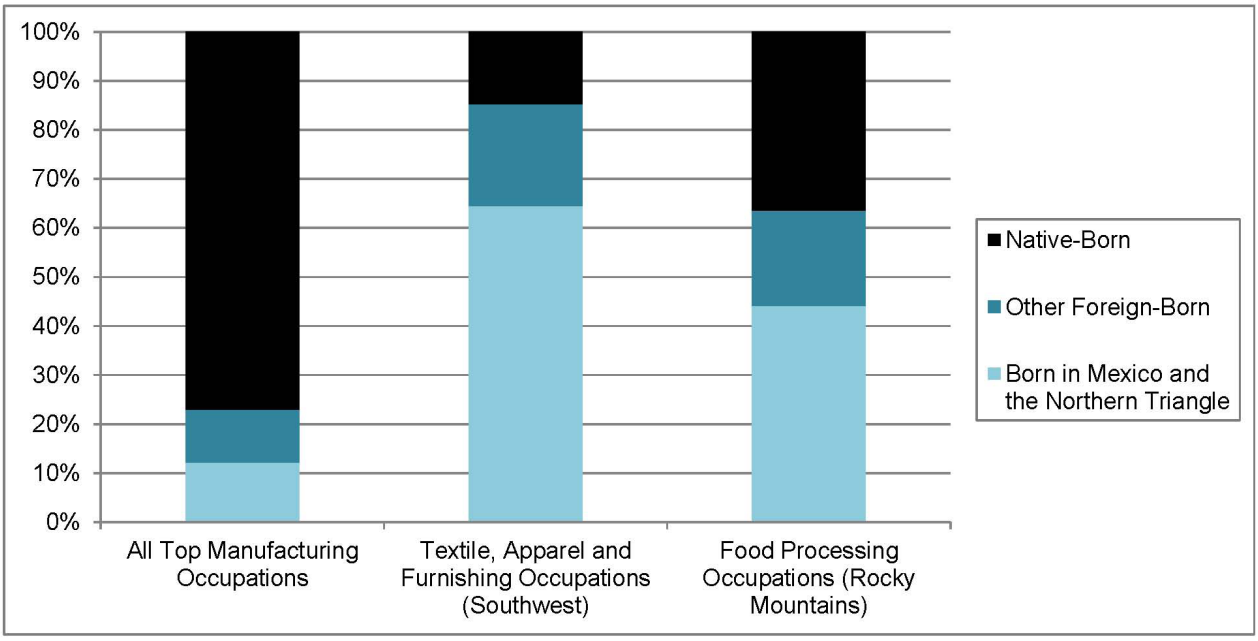
As the OECD study of the Paso del Norte region shows, the best and the brightest are already leaving because they have few options within the region. It may seem counterintuitive that making credentials seamless within an international context will improve the likelihood of retaining these individuals. In the absence of a concurrent policy focused on innovation, this is probably right. But a strategy linking innovation with the attainment of internationally recognized credentials would help the region compete within international labor markets for talent. It also might encourage high achievers seeking opportunities elsewhere to return in order to start and expand their own businesses, or simply enjoy the fruits of a diversifying economy.

The best and the brightest are already leaving because they have few options within the region.

Domestic business development policies and practices must be aligned to support innovation and small and medium-size business creation and growth. While specific recommendations fall outside the scope of this paper, fundamental changes in intellectual property rights, business law, and business finance go hand in hand with changes in human-capital development. Such factors are the basis for innovation economies that serve to retain and attract both creators and producers.

Appendices

Figure A-1. Immigrants from Mexico and the Northern Triangle as Percentage of Workers in Selected Manufacturing Occupations, 2009



Source: Authors' analysis of Census Bureau American Community Survey data, 2008-10.

Table A-1. Top Occupations of Mexican and Central American Immigrants Employed in Manufacturing, by US Region, 2008-10

US Region	Top Five Occupations of Mexican and Central American Immigrants (O*Net Job zone) [59]
Southwest	Miscellaneous production occupations (some preparation) Metal workers and plastic workers (some preparation) Assemblers and fabricators (some preparation) Textile, apparel, and furnishings occupations (some preparation) Food-processing occupations (little or no preparation)
Northeast	Miscellaneous production occupations Assemblers and fabricators Metal workers and plastic workers Textile, apparel, and furnishings occupations First-line supervisors of production and operating workers (some preparation)

59 O*Net Job Zone groups for production and manufacturing occupations are as follows. Medium preparation: industrial production managers, printing occupations, plant and system operators; some preparation: first-line supervisors of production and operating workers, assemblers and fabricators, metal workers and plastic workers, textile and apparel and furnishings occupations, woodworkers, and miscellaneous production occupations; little or no preparation: food-processing occupations.

Mid-Atlantic	Miscellaneous production occupations Assemblers and fabricators Food-processing occupations Metal workers and plastic workers Textile, apparel, and furnishings occupations
Southeast	Miscellaneous production occupations Textile, apparel, and furnishings occupations Assemblers and fabricators Food-processing occupations Metal workers and plastic workers
North Central	Miscellaneous production occupations Metal workers and plastic workers Assemblers and fabricators Food-processing occupations First-line supervisors of production and operating workers
South Central	Miscellaneous production occupations Food-processing occupations Metal workers and plastic workers Assemblers and fabricators Textile, apparel, and furnishings occupations
Rocky Mountains and Plains	Food-processing occupations Miscellaneous production occupations Metal workers and plastic workers Assemblers and fabricators First-line supervisors of production and operating workers
West Coast	Miscellaneous production occupations Food-processing occupations Assemblers and fabricators Metal workers and plastic workers First-line supervisors of production and operating workers

Source: Authors' analysis of Census Bureau American Community Survey data, 2008-10.

Glossary

ACS: American Community Survey
ANUIES: Mexico's National Association of Universities and Institutions of Higher Education (Asociación Nacional de Universidades e Instituciones de Educación Superior)
BLS: Bureau of Labor Statistics
Border-plex: The greater cross-border metropolitan area comprising El Paso, Texas; Ciudad Juarez, Chihuahua; and southern New Mexico (e.g., Las Cruces)
CAFTA-DR: The Dominican Republic/Central America Free Trade Agreement (between the United States and Costa Rica, the Dominican Republic, El Salvador, Guatemala, Honduras, and Nicaragua)
CENALTEC: High-Technology Training Center, Chihuahua (Centro de Entrenamiento en Alta Tecnología)
Cluster: A geographic concentration of interconnected businesses, suppliers, and associated institutions in a particular field
COVAP: Industry-Academia Liaison Council, Chihuahua (Consejo de Vinculación Académico-Productiva)
DOL: US Department of Labor
ECLAC: Economic Commission for Latin America and the Caribbean
EPI: Economic Policy Institute
f.o.b.: freight on board
FDI: foreign direct investment
FEMIA: The Mexican Aerospace Industry Federation (Federación Mexicana de la Industria Aeroespacial)
GDP: gross domestic product
GED: General Educational Development
ILO: International Labor Organization
Incremental innovation: The process of making small but continuous improvements to existing products, often in response to customer demand
INEGI: Mexico's National Institute of Statistics and Geography (Instituto Nacional de Estadística y Geografía)
ISCO: International Standard Classification of Occupations
ISIC: International Standard Classification
ISO: International Organization for Standardization
IT: Information technology
KSAs: knowledge, skills, aptitudes
Maquiladora; maquila: A manufacturing plant that imports and assembles duty-free components for export
MNE: multinational enterprise
MRO: maintenance, repair, and operations
NAFTA: North American Free Trade Agreement (between the United States, Canada, and Mexico)
NAM: National Association of Manufacturers
Northern Triangle: A region comprising the Central American countries of El Salvador, Guatemala and Honduras
NSF: National Science Foundation
OECD: Organization for Economic Cooperation and Development
OEM: original equipment manufacturer
PCAST: US President's Council of Advisors on Science and Technology
PISA: Programme for International Student Assessment, an international study that evaluates education systems worldwide every three years by assessing 15-year-olds' competencies in reading, mathematics, and science
Programa IMMEX: Mexico's manufacturing industry, duty-free import and export services program (Industria Manufacturera, Maquiladora y de Servicios de Exportación)
R&D: research and development
RMSG: Regional Migration Study Group
STEM: science, technology, engineering, and mathematics
UN COMTRADE: United Nations Commodity Trade Statistics database
WTO: World Trade Organization

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