



Working Group on Development and Environment in the Americas

Discussion Paper Number 18

FDI Spillovers and Sustainable Industrial Development: Evidence from U.S. Firms in Mexico's Silicon Valley

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April 2008

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Introduction

Foreign direct investment has been studied for its impacts on development and its impacts on environment but rarely for both at the same time. Despite an occasional nod to the environment, development scholarship as a whole tends to focus on economic goals—growth, industry upgrading, or poverty alleviation. Environmental analysts, on the other hand, often take the economic benefits (or costs) of foreign direct investment (FDI) as a given and seek to uncover evidence of negative or positive externalities for the natural environment.

Using a case study methodology, this paper examines the impacts of FDI on sustainable industrial development—an integrated concept combining economic, environmental and social outcomes. We define sustainable industrial development as evolution along a three-dimensional path delineated by: 1) upgrading of the productive capacities of domestic firms; 2) employment creation, and 3) reduction of the ecological and health impacts of industrial growth and transformation.

For FDI to promote sustainable industrial development, transnational corporations (TNCs) must be linked to local firms, workers and consumers. In particular, they must generate--and host-country firms must absorb--two kinds of knowledge spillovers: technology and skills relevant to domestic industry upgrading; and technology and management practices that reduce the ecological footprint of industry. A widespread and dynamic process of industry upgrading, in turn, generates high employment. Without spillovers, especially to local small and medium sized firms (SMEs), the benefits of FDI tend to be narrowly concentrated in a few, usually urban, enclaves.

Our case study focuses on FDI inflows from U.S. firms into the information technology (IT) sector in Guadalajara, Mexico. Dubbed “Silicon Valley South”, Guadalajara attracted a host of U.S. IT firms after the signing of NAFTA in 1994. Expectations were raised that Mexico's second largest city would become a knowledge-intensive, high value-added, high employment cluster for the global information technology industry. Positive environmental externalities—cutting edge environmental technology, best practice environmental management, less toxic and chemical waste--were expected as part of the equation.

This paper examines whether FDI in the IT industry in Guadalajara generated spillovers for industry upgrading and the environment. Based on extensive interviews with company managers and government officials, as well as NGOs, we found that spillovers were meager to non-existent. The primary reason was that, rather than build local linkages, TNCs relied on foreign firms for manufacturing who, in turn sourced inputs from their global supply chains. Rather than upgrading, Mexican SME's went out of business, virtually obliterating Guadalajara's fledgling domestic IT manufacturing capacity. Lacking local linkages, many TNCs shifted production from

Guadalajara to China during the industry crisis in 2001, especially after China joined the WTO. Rather than a knowledge-intensive cluster, Guadalajara today is a low-value assembly and sub-assembly platform for computers and other electronics exported to the United States that is largely divorced from the domestic economy.

Few local business linkages limited the potential for environmental spillovers to local supply firms. Moreover, targeted at US markets, Mexican-based manufacturing has generally not been retooled to meet higher European (and Mexican) environmental standards for the IT industry. Some employment potential remains, but it is low compared to what a high-value cluster would have been able to generate and still has not recovered to pre-crisis levels.

The paper is in four parts. Part One presents defines and evaluates evidence that FDI generates spillovers in developing countries that promote industry upgrading and better environmental management. Part Two analyzes the particular challenges for sustainable industrial development posed by the global information technology (IT) industry. Part Three presents a case study of FDI spillovers in the IT sector in Guadalajara. The conclusion makes policy recommendations to increase FDI spillovers for sustainable industrial development in developing countries.

FDI Spillovers: Theory and Evidence

TNCs are considered to possess a “bundle of assets”—technology, technical and management expertise, links to global markets—that makes FDI more productive and more environmentally sustainable than domestic investment in developing countries. Because many of these special assets are a source of rents, TNCs work to keep them tightly in-house. Nonetheless, some knowledge “spills over” outside the firm.

Host-country knowledge spillovers from FDI can potentially be captured by:

- TNC subsidiaries;
- Other firms in the same industry as the TNC (horizontal spillovers);
- Downstream suppliers to the TNC (vertical spillovers);
- Firms in upstream market and other industries.

Except for TNC subsidiaries, whose access to knowledge is directly determined by their corporate parents, knowledge spillovers may occur in five ways:

Human capital: TNCs hire and train workers who can apply their technical and management knowledge in starting their own firms or in working for domestic firms in the same industry.

Demonstration effects: Domestic firms may adopt and produce technologies introduced by TNCs through imitation or reverse engineering. They may also adopt productivity-enhancing standards in relation to inputs, product quality, and environmental and labor management.

Competition effects: The presence of TNCs may exert pressure on domestic firms to adopt new technology or to utilize existing technology more efficiently.

Backward linkages: Domestic suppliers to TNCs may receive technical training to meet product specifications and global quality and environmental standards. If TNCs purchase a substantial volume of inputs locally, and/or if they help their local suppliers find additional export

markets, local suppliers may also capture economies of scale, thus increasing productivity and potentially ‘crowding in’ domestic investment.

Forward linkages: TNC-produced goods and services may enter into and increase the labor and resource efficiency of production processes of firms in upstream and other industries.

While the hope is that developing countries attract “quality” FDI which generates a “virtuous circle” of higher productivity, increasing skills, industry upgrading, and better environmental management, it is possible that TNCs will instead transfer out-of-date technologies and inefficient management practices which lock developing countries into dead-end, dirty, non-globally competitive growth paths. In addition, FDI may have *negative* spillovers—driving local firms out of business--leading to de-skilling, de-industrialization and loss of local jobs and livelihoods.

Spillovers for Industry Upgrading

Over the past thirty years, a large literature has emerged to determine empirically whether and in what circumstances FDI generates knowledge spillovers for industry upgrading (see for example Moran et al, 2005; Amsden and Chu, 2003, Lall and Urata, 2003; Aitken and Harrison, 1999; Blomstrom et al, 1999). Most statistical studies focus on *horizontal spillovers*—improved performance of domestic firms in the same industry as the TNCs. Using cross-sectional, industry level data in a single year, early studies found that industries with a higher concentration of FDI were more productive (Caves 1974; Blomstrom and Wolff 1994).

Later studies, using both industry and firm-level data, found far less optimistic results (Kokko 1996; Aitken and Harrison 1999; Smarzynska 2003). In a review of 40 studies spanning both developed and developing countries, a World Bank paper found that only 6 of the 40 studies found evidence of positive spillovers (Gorg and Greenway, 2003). *None* were in developing countries. Moreover, 6 of the 28 studies of developing and transition economies found evidence of *negative* spillovers.

Case studies present a more optimistic, though still mixed, assessment. Amsden and Chu (2003) found that partnerships with TNCs in the 1960s and 1970s helped build globally competitive electronics firms in Taiwan. But Barclay (2003) found that substantial inflows of FDI in the 1990s failed to stimulate domestic development in the natural gas industry in Trinidad and Tobago (Barclay 2003). Ernst (2003) found that, despite large TNC investment in its electronics sector, “Malaysia has failed to develop a sufficiently diversified and deep industrial structure, to induce a critical mass of corporate investment in specialized skills and innovative capabilities” (p.4).

Given that TNCs seek to prevent knowledge leakages to competitors but want and need to transfer it to local suppliers, spillovers are more likely to be vertical than horizontal (Saagi 2002). A study of FDI in Lithuania, for example, found evidence of positive vertical spillovers in the manufacturing sector (Smarzynska 2003). Case studies, too, provide some support for vertical spillovers. In Mexico, FDI by the “big three” US car companies in the 1980s worked to upgrade technology and global competitiveness of auto supply firms (Moran, 1998). Singapore heavily depended on TNC investment to successfully develop a dense network of local supply firms in its electronics sector in the 1970s and 1980s (Wong 2003).

Other case studies, however, have found that TNCs generate few backward linkages or spillovers to local firms. In northern Mexico, one study found that despite twenty-five years of FDI,

Mexican material inputs accounted for less than 2 per cent of value added in *maquiladora* plants. Based on surveys with plant managers and corporate purchasing agents, the study found that TNC purchasing strategies favored imports over domestic firms (Brannon et al. 1994).

Generally, Latin American governments have adopted a passive policy approach to FDI, with the result that TNCs have few linkages with local firms. One recent study concluded (Ernst, 2005, p. 11):

economic opening in Argentina, Brazil and Mexico did not lead to export dynamism and had a disappointing impact on employment...only Mexico experienced an export surge in manufacturing production and employment during the second half of the 1990s, mainly due to the booming *maquiladora* sector. However, the *maquiladora* industry did not develop significant links with the rest of the economy. There was no upgrading of production even for the more sophisticated exports, since the import content of exports also rose significantly. Moreover, the *maquiladora* industry has declined significantly since 2000 thus reducing drastically formal job creation in Mexico.

The performance of FDI in Asia has been more mixed. Wong (2003) documents the positive role of FDI in the development of globally competitive high tech industries in Singapore. “About three-quarters of Singapore’s manufacturing output in recent years came from TNC’s...technology transfer was the major source of technological upgrading in Singapore, not indigenous research and development” (Wong, 2003, p. 194).

Unlike Latin American countries, Singapore adopted a pro-active approach that integrated FDI into an overall development strategy, with aggressive support for R&D, education, infrastructure investment, and science and technology policies. TNCs have also helped to promote industry upgrading in the IT sector in China and the automotive components sector in India (Dussell, 2005; Tewari, 2005). In both cases, government was highly pro-active towards both FDI and domestic SMEs.

As a whole, the evidence suggests that there is no assurance that FDI generates spillovers for industry upgrading. Central to the capture of spillovers is pro-active, coherent government industry policy.

Environmental spillovers: Theory and evidence

FDI potentially delivers three types of environmental spillovers for sustainable industrial development:

- *Clean technology transfer*: Transfer to TNC affiliates of production technologies which are less polluting and more input-efficient production than those used by domestic firms;
- *Technology leapfrogging*: Transfers of state-of-the-art production and pollution-control technologies;
- *Pollution halo*: Diffusion of best practice environmental management techniques to domestic firms, including suppliers.

Empirical studies have found a “mixed bag” in all three areas. A detailed case study of FDI in Chile’s mining sector in the 1970s and 1980s found that the two foreign-owned companies performed (far) better than domestic companies, largely due to cleaner technology (Lagos 1999). Using survey methodology, a study of TNCs in India’s manufacturing sector likewise found that foreign firms were less polluting than domestic firms (Ruud 2002). Using energy use per unit of output as a proxy for energy emissions, one World Bank study found that foreign ownership was associated with cleaner and lower levels of energy use in Mexico, Venezuela, and Cote d’Ivoire (Eskeland and Harrison 1997). In China, foreign investment in electricity generation was linked to improvements in energy efficiency and emission reduction (Blackman 1998, September).

Another group of World Bank researchers, however, found that foreign firms and plants performed no better than domestic companies in developing countries. Based on firm-level data in Mexico (manufacturing) and Asia (pulp and paper), the New Ideas in Pollution Regulation group found firm environmental performance to depend not on foreign ownership but on: 1) the scale of the plant (bigger is better); and 2) the strength of local regulation, both government and “informal” (Hettige et al 1996; Dasgupta et al. 1997). In addition, a study of the manufacturing sector in Korea found that domestic firms performed *better* than foreign-owned firms, a result the authors attributed to the sensitivity of Korean *chaebol* to public criticism (Aden 1999).

The concept of technology leapfrogging is that, through transfer by TNCs of the least polluting, state-of-the-art technology and management techniques, developing countries can move to the global production frontier. Besides upgrading industry, the reduction in the pollution-intensity production (and consumption) brings environmental benefits both locally, and, in the case of global pollutants such as carbon emissions, globally. For example, Gallagher (2004) found that steel production in Mexico is “cleaner” per unit of output, in terms of criteria air pollutants, than in the U.S.ⁱⁱ The primary reason is that FDI, as well as domestic investment in new plants, deployed newer and more environmentally benign mini-mill technology rather than more traditional and dirtier blast furnaces.

Other studies have found that TNCs transferred technologies and management practices that fell well short of best practice. A recent study of FDI by US auto companies in China, based on extensive interviews with plant managers at Ford, GM, and Jeep affiliates, found that U.S. firms transferred outdated automotive pollution-control technologies (Sims Gallagher, 2006). Rosenthal (2002) found that, in explorations for oil and natural gas off Sakhalin Island, Exxon openly flaunted Russian law requiring environmental review and zero water discharge. Case studies of FDI in the petroleum industry, including in Nigeria, Ecuador, Azerbaijan and Kazakhstan, found that TNCs operated with “double standards”--environmental and human rights practices that would be fined or prosecuted in their home countries (Leighton et al 2002)

What about diffusion of good environmental practice to local firms? TNCs can require that suppliers meet company-set standards and provide training to enable them to do so. Another channel is the demonstration effect; that is, domestic firms copy foreign firms or host country governments adopt TNC standards as local regulation. A third channel is industry collaboration to promote better environmental management in developing countries through self-regulation.

A study of TNCs in the chemical industry in Latin America found that US companies played a leading role in diffusing the Responsible Care program to domestic companies in Mexico and Brazil (Garcia-Johnson 2000). Developed in the early 1980s in Canada by the chemical industry in response to the Bhopal disaster, the program aims to raise industry self-regulation beyond

mandatory government standards in the areas of environmental impact, employee health and safety, facility security, and product stewardship.ⁱⁱⁱ

A volume of case studies in Latin America found evidence that better environmental management practices were diffused through FDI, including through supply chains (Gentry 1998). One example was the cooperation of the US company Chiquita Brands International in the Better Banana Project. Started by the Rainforest Alliance, the Project uses NGO monitors to certify that growers meet strict environmental and social standards in the areas of toxic chemical use, pollution, water and soil conservation, and worker health and safety (Rainforest Alliance 2000).

In India's manufacturing sector, however, Ruud (2002) found no evidence that TNCs diffused better environmental management practices to local partners, suppliers or consumers. While TNC affiliates were cleaner than domestic firms, they apparently operate as "islands of environmental excellence in a sea of dirt" (Ruud 2002). He concludes that local norms and institutions are central in determining TNC practice and that "FDI inflows do not automatically create a general improvement in environmental performance" (Ruud, 2002, p. 116).

The Global IT Industry: Challenges to Sustainable Industrial Development

Foreign direct investment in the IT industry is very attractive to developing countries. Beyond benefits common to all FDI, such as jobs and foreign exchange, high tech FDI offers the promise of industry upgrading: new technology, new skills, and a link with the world's fastest-growing industry. Moreover, IT promises a "clean and green" alternative compared to traditional smokestack industries. There are formidable barriers, however, to upgrading industry in the IT sector, and significant health and environmental hazards to address.

Challenges for Domestic Industry Upgrading

The global IT industry is structured in three layers which function as a global production network. At the top are the global "flagships"—companies like HP, Dell, IBM—who bring brand name, global marketing, and design capacities to the network and who earn the highest profits. Next are the contract manufacturers (CMs)—large firms like Flextronics, Jabil Circuit, and SCI-Sanmina—who assemble components into a variety of electronic products under contract to global flagships and who increasingly are also undertaking design functions.^{iv} The CMs purchase inputs from components suppliers, themselves ranging from large firms with substantial manufacturing capacities to small SMEs and mom-and-pop outfits. CMs and suppliers operate on low to razor-thin margins.

The global IT industry is highly concentrated, creating barriers to entry for would-be flagships, CMs, and even higher-level suppliers. Nurtured by highly pro-active industry policies, only a handful of developing countries—China, Taiwan, Korea, India—have emerged as major players, "The domination of the United States and Asia in electronics," argues Amsden, "makes it very difficult for newcomers to enter this field" (Amsden 2004). Even in East Asia, it is not clear that important producers like Malaysia and Singapore will be able to meet the challenge of continuous upgrading in the face of the intense competitive dynamics of the industry itself, as well as new competition from China and India (Ernst 2003; Wong 2003).

The primary route for developing countries trying to build a local IT industry is to attract FDI in low-wage export platforms for low- and semi-skilled manufacturing and assembly operations. The plants are owned and operated by foreign CMs and higher tier suppliers and, in the main, products are exported to markets in US, Europe or Japan. Production is highly standardized but the hope is that knowledge spillovers and TNC procurements will nurture the emergence of a local supply base. ^v

While the promise is palpable, there are four pitfalls. First, competition for IT investment is intense, both among developing (and developed) countries and municipalities. Many developing countries simply do not have the requisite infrastructure, skills, and large domestic markets to successfully attract high-tech FDI in the first place. Trying can impose opportunity costs.

Second, intense cost pressures inside the industry undermine the sustainability of low-wage, assembly work. CMs tend to rapidly relocate operations to lower-cost locations when global conditions change. Even China, which successfully leverages its cheap labor and domestic market access to build a burgeoning CM industry, is vulnerable. Asked by one of the authors how much of his company's southern China operations would relocate if land and infrastructure subsidies were withdrawn, the head of Asia operations for Flextronics responded "about 50 percent." Where to? Vietnam.

A third pitfall is that there is little skill acquisition and hence few human capital spillovers in assembly work. Because an initial level of training is required, assembly workers have been called "semi-skilled". But there is no chance to get further training and little opportunity for workers to innovate on-the-job. Organized into work groups, workers undertake highly standardized and repetitive tasks. Indeed, global standardization and uniformity of work procedures is a defining feature of CMs, who "offer a uniform interface for flagships seeking global one-stop-shopping for manufacturing services" (Luthje 2003 p. 9).

Fourth, FDI by foreign IT firms may not generate sufficient knowledge spillovers to promote technological upgrading of local firms seeking to become suppliers. Unlike licensing arrangements with TNCs, FDI does not necessarily or directly transfer technology. Besides human capital, spillovers are indirectly captured through backward and forward linkages. But CMs draw inputs from a global supply chain and may have few backward linkages to local firms. Moreover, a neo-liberal "hands off" policy framework inhibits governments from helping local firms develop capacities to become suppliers.

A substantial level of infrastructure, manufacturing and innovation capabilities is required to garner TNC interest in sourcing from domestic suppliers. Few developing countries have such "absorptive capacities". Indeed, the focus of the UNIDO report quoted above is precisely "to determine why many developing countries are unable to use new industrial technologies efficiently" (UNIDO, 2002 p. 10). The answer, in a nutshell, is the lack of institutions to nurture local skill acquisition and manufacturing capabilities.

Spillovers will also be scarce if forward linkages are weak. But a single-minded focus on production-for-export inhibits the growth of a domestic market for IT goods and the benefits of IT domestic diffusion, including the spur to product innovation. The lack of a strong domestic market, in turn, makes it more likely that flagships and CMs will be footloose—and less likely that they will be willing to partner with local governments and firms to transfer technology and know-how.

Environmental Challenges

Given its “clean and green” image, the IT sector is often a low priority for regulation or monitoring in developing countries. Regulation, however, is important on two counts: 1) there are significant health and environmental problems associated with IT manufacturing and assembly; 2) global environmental standards for IT products are rising rapidly.

The IT industry poses risks to occupational and community health stemming from the highly toxic chemicals used in production and assembly. At the center of all IT products is a microchip—a highly manufactured silicon wafer on which hundreds or even thousands of transistors have been etched. Beyond water and energy, microchip fabrication requires an intensive use of a wide variety of solvents, acid solutions and alcohol. A survey by the US EPA in 1995 listed thirty-one categories of chemicals used in photolithography alone, one of the last stages of manufacturing (Mazurek, 1999 p 52).

While somewhat less chemical-intensive, the component manufacturing and assembly parts of the IT global production network expose workers to some of the same hazardous substances, including solvents. Moreover, they pose new occupational health risks in the form of exposure to lead and formaldehyde. Assembly involves plating copper and soldering components to the plates with lead and tin. The copper plating process emits formaldehyde while the soldering process produces lead “solder dross” that is highly contaminating, especially if its ends up in local waterways (Kuehr 2003).

A newer but possibly even greater hazard is the widespread use of brominated flame retardants, such as the compound polybrominated diphenyl ether (PBDE). Workers routinely add brominated flame retardants to a wide variety of IT goods, including circuit boards and plastics in computer cabinets, to reduce flammability. The compounds are bio-accumulative and are rapidly rising in human breast milk in North America. While toxicology studies are still being undertaken, there is evidence that exposure is linked to thyroid hormone disruption, neuro-developmental deficits, and possibly cancer (Kuehr, 2003).

A second environmental challenge of the IT industry is end-of-life product management. When consumers have finished with a computer—often replacing it with a newer, faster version—a computer becomes waste. In landfills, chemicals and other hazardous substances inside a computer—lead, arsenic, selenium, brominated flame retardants, antimony trioxide, cadmium, chromium, cobalt, mercury—leach into land and water. In the US, about 70 percent of the heavy metals found in landfills, including mercury and cadmium, comes from electronic products. In 2001, California and Massachusetts banned CRTs from municipal landfills (BAN and SVTC, 2002).

In an effort to reduce landfill hazards, the US EPA and municipal governments have promoted computer recycling. A vibrant e-recycling industry has sprung up in the US. About 11 percent of US e-waste is recycled. However, about 80 percent of the e-waste sent to recyclers is exported to Asia, nine-tenths of it to China, where computers are pulled apart by hand, useful components sold, and the rest thrown into landfills, waste dumps or just the nearest piece of empty land (ibid. 2002).^{vi}

With its witches brew of lead, heavy metals and toxic chemicals, the production and disposal of IT products pose hazards to workers and the environment wherever they occur. But there are extra hazards in developing countries stemming from lack of waste management infrastructure

and regulatory oversight. The scarce resources of environment ministries prioritize “dirtier” industries, leaving IT firms to self-regulate.

Occupational health standards in particular tend to be sketchy or non-existent in developing countries. In Thailand in the early 1990s, for example, four workers at a Seagate disk drive facility died after a pattern of fatigue and fainting. A study by the country’s most prominent occupational health doctor found that some 200 plant employees had blood levels that suggested chronic lead poisoning, perhaps aggravated by exposure to solvents (Foran 2001).

Even a relatively well-off industrializing country like Taiwan has suffered the effects of toxic chemical use. In a study of the Hsinchu Science-Based Industrial Park, the heart of Taiwan’s high-tech industry, the Taiwan Environmental Action Network found a shocking pattern of neglect of risks to human health and the environment, starting from the 1960s and continuing through to 2001. The legacy of Taiwan’s spectacularly successful high-tech development is a cohort of former employees with a high rate of rare cancers, and a severe and widespread problem of freshwater and coastal chemical pollution (Shang et al 2001).

Rising EU Standards: Globalization or Bifurcation?

Environmental regulation is important not only to protect workers and the public but as part of industry policy. With public concern mounting, national and municipal authorities in Europe, Japan and the United States, as well as companies themselves, are undertaking a wide range of regulatory and voluntary initiatives to reduce chemical hazards and electronic waste and to improve energy and resource efficiency.

The European Union, however, has gone the farthest towards “raising the bar” in terms of environmental regulation of the IT industry, as well as hazardous chemicals in general. A signatory to Annex One of the Basel Convention, which prohibits the export of hazardous waste from developed countries, EU regulation is focused on reducing the amount of waste entering, produced, and stored in Europe.

Along with new sweeping regulation of chemicals, two EU directives have changed the rules for IT market access in Europe:

- **Restriction on Hazardous Substances (ROHS)** The RoHS Directive, which went into effect on July 1, 2006, bans the placing on the EU market of new electrical and electronic equipment containing more than agreed levels of lead, cadmium, mercury, hexavalent chromium, and the flame retardants polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE).
- **Directive on Waste from Electrical and Electronic Equipment (WEEE).** Adopted in the Spring of 2003, WEEE sets criteria for the collection, treatment, recycling and recovery of waste electrical and electronic equipment and makes producers responsible for financing most of these activities (producer responsibility).

Other large electronic markets, notably the United States and Japan, have not adopted such laws, at least not yet, giving rise to the possibility that global standards will bifurcate by end market. While there is mounting concern about landfill contamination from e-waste, the United States is not a signatory to Annex One of the Basel Convention. Indeed, the US EPA views the export of e-waste to Asia as part of its industrial waste management strategy (BAN and SVTC, 2002).

On the other hand, TNCs may find it too costly to design products and processes around multiple standards, suggesting that globally harmonized standards might be in the making. The state of California, for example, has enacted its own version of ROHS, and the US EPA is working with chemical manufacturers to phase out the most toxic of the brominated flame retardants (Pohl 2004).

Full global harmonization may be in the cards in the future. In the short to medium term, however, IT markets will bifurcate along the lines of higher EU versus lower US environmental and health standards. Japan, which was the first country to pass a law requiring recycling of domestic e-products, is likely to be in between. Developing countries—and the TNCs that invest in them--will need to strategically align their environmental management policies with their export markets. If they choose markets with lower standards, they may be at risk of being squeezed out if and when standards are globally harmonized.

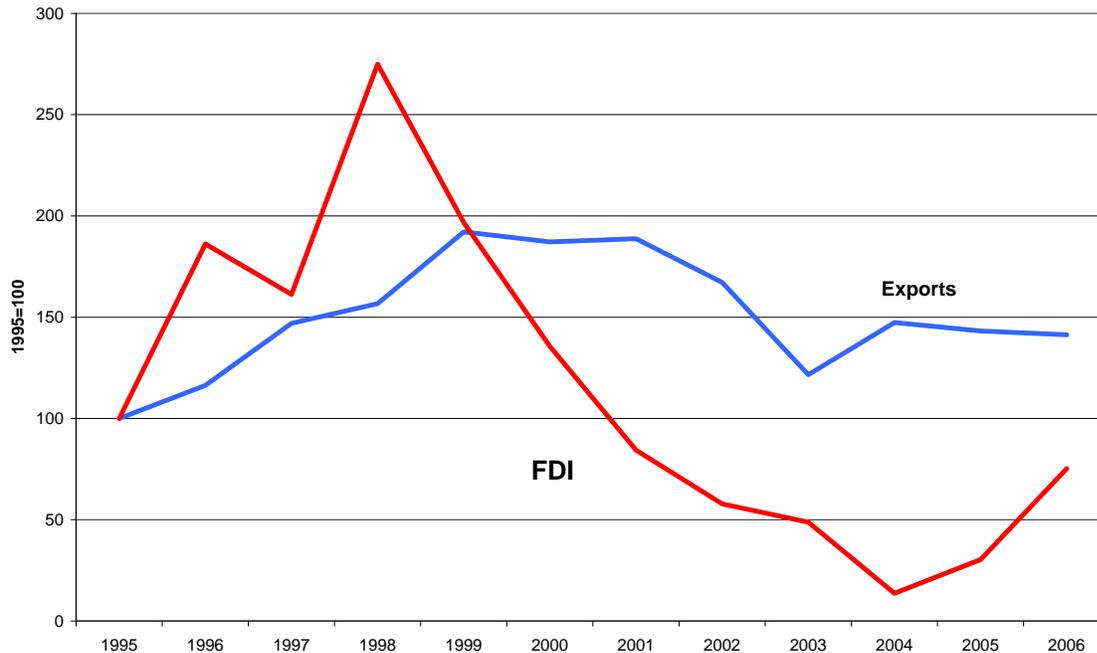
Mexico's Silicon Valley: Missing Spillovers, Missed Opportunity

Fuelled by liberalization, Guadalajara's small but promising IT industry boomed after the signing of NAFTA. Between 1994 and 2000, FDI in the electronics sector grew by five times (reaching \$742 million) and the value of exports quadrupled to \$20 billion (though not as robustly in real terms, as shown in Table 1). An influx of global flagships expanded or newly located in Guadalajara, including Hewlett Packard, IBM, Intel, Lucent Technologies and NEC. They were soon followed by CMs, including Flextronics, Solectron, Jabil Circuit and SCI-Sanmina. "High-Tech Jobs Transfer to Mexico with Surprising Speed," proclaimed the *Wall Street Journal* in an article dated April 9, 1998. To the Journal's surprise, Guadalajara had become home to a booming IT assembly industry that exported \$7.7 billion worth of IT products in 1998 and seemed poised to become the IT manufacturing hub of North America.

It was a short-lived triumph. Between 2000 and 2003, the global flagships shut down all but sales and service operations of computers and peripherals in Guadalajara, relocating to China or elsewhere in East Asia. Exports dropped by 60 percent, FDI fell by 123 percent, and 60,000 jobs were lost. By 2000, the cover of *MexicoNow*, a leading Mexican business magazine, bemoaned "Rescuing Mexico's Electronics Industry." The global firms have indeed recouped since 2003 through fairly impressive industrial upgrading from "hard" to "soft" tooling that entails greater worker skill, but such upgrading operates in a virtually complete enclave that has few connections to the domestic economy.

What happened to the promise of "Silicon South"? While fingers can be pointed toward a variety of government and market failures, the central problem can be summed up as the failure to capture FDI spillovers.

Jalisco: Electronics Exports and FDI



Source: author's calculations (1993 pesos) based on CADELEC, 2007

Enclave Economy

Linked to TNCs, firms in Guadalajara built up substantial electronics manufacturing capacities under Mexico's import substitution industrialization (ISI) policies from the 1940s to the 1980s. By the early 1990s, close to fifty local firms were involved in electronics manufacturing, including CM assemblers, suggesting great promise for the emergence of an industry cluster with strong local linkages between TNCs and local suppliers (Wilson, 1992; Shaiken, 1990). According to Wilson (*ibid.*, p. 120), it was just a matter of the government playing a nurturing role in capturing TNC spillovers:

The Mexican government can increase the local linkages not only of the locally owned *maquiladoras* but also of some of the foreign-owned *maquiladoras*. In Guadalajara, the sector of locally owned producers and the sector of foreign owned electronics producers show particular potential.

In the event, government support did not materialize. Under the liberalization regime, the old ISI-type industry policies were rapidly dismantled. Little in the way of contemporary industry policy, which seeks to correct market failures, was put in its place. New approaches to industry policy aim squarely to help build local firm capacities, including to integrate into global TNC value chains. Policies include technical and business management training programs for local firms and workers; support for R&D to develop local niche markets; promotion of TNC-university partnerships to expand value-added; the creation of science and technology parks; and the provision of credit to domestic firms.

Table 2**IT Plant Closings--Whole or Partly Owned Mexican Firms**

<i>Firm</i>	<i>Ownership (percent)</i>	<i>Activity</i>
Cumex Electronics	50/50 Mex-US	CM of PCBs
Mitel	51/49 Mex-Canada	Telephone Components
Phoenix International	50/50 Mex-US	Plastic Injection
Encitel	100 Mex	CM of PCBs
Info Spacio	100 Mex	CM of printers
Logix Computers	100 Mex	Design and manufacturer of PCs
Mixel	100 Mex	CM of PCBs
Unisys	100 Mex	CM of computers and peripherals
Electron	100 Mex	Design and manufacturer of PCs
Scale Computers	100 Mex	Design and manufacturer of PCs
Advanced Electronics	100 Mex	Design and Manufacturer of PCBs
Compuworld	100 Mex	CM of hard drives
Microtron	100 Mex	Buffers and Carton Packages

Source: Rivera Vargas (2002); Gallagher and Zarsky (2007)

Moreover, Mexican trade and monetary policies actively undermined TNC spillovers to local firms. The PITEX program allows companies to import inputs duty-free as long as more than 65 percent of the finished product is exported (Dussel, 2003). Not only does PITEX encourage TNCs to source from foreign suppliers, thus cutting off the potential for backward linkages; in its tilt towards exports, it reduces the scope for forward linkages through sales in domestic markets (Dussel et al., 2003, 2004).

The capacity for Mexican firms to absorb spillovers was also constricted by macro-economic policies—high interest rates and an over-valued peso—to support NAFTA and keep inflation at bay. The over-valued peso provided an additional incentive for CMs to source components globally rather than locally. High interests not only contributed to peso over-valuation but also choked off domestic investment. Foreign firms, including in the IT sector, had access to internal company sources of finance and global capital markets. Domestic firms did not (Dussel et al., 2003, 2004).

The unsupportive policy environment for SMEs in Mexico was exacerbated by restructuring processes within the global IT industry. In the late 1980s, the global flagships began to outsource manufacturing functions, a trend that accelerated in the 1990s. Increasingly, they turned towards the “top five” CMs—Solectron, Flextronics, Sanmina-SCI, Celestica, and Jabil Circuit. Between 1995 and 2004, the “top five”—all US firms—grew by a roaring compound annual growth rate of 24 percent and in 2004, accounted for just over half of world production by the top 100 CMs (Sturgeon, 2006). In June, 2007, Flextronics, now based in Singapore, bought its California-based rival, Solectron, creating a company that operates in 35 countries with a combined workforce of 200,000 and expected annual net revenues of \$30 billion (Taylor, 2007).

In the mid-1990s, there was a small window of opportunity for Mexican CMs to take advantage of the flagships' shift to outsourcing, in the same way that firms in Taiwan had upgraded domestic industry by contracting with global flagships two decades earlier. Many Taiwanese firms are now among the leading global CMs, while others have grown into global flagships (Amsden and Chu 2003).

To seize the opportunity, Guadalajara-based firms would have had to expand their production scale significantly, which entails large sunk costs. But SMEs had no access to credit. Between 1994 and 2003, total domestic credit as a percentage of Mexican GDP fell by 66 percent, the result of high interest rates and a dysfunctional financial system. Even more dramatically, credit to firms nose dived by almost 84 percent. In a survey of Mexican firms, the Bank of Mexico learned that an astonishing 82 percent were not able to access credit between 1998 and 2003. The majority were squeezed out by high interest rates, while the rest were simply rejected (UNIDO 2005). With access to internal sources of finance, as well as global capital markets, TNCs were exempted from the credit squeeze (Gallagher and Zarsky, 2007).

Rather than explore the potential to contract with and help build capacities of Mexican CMs, the global flagships invited the "top five" to co-locate in Guadalajara. By the mid 1990s, US-based CM giants Jabil Circuit, Sanmina-SCI, Flextronics, and Solectron (along with NatSteel from Singapore) had established plants in Guadalajara and conducted virtually all of the manufacturing for HP and IBM and the other flagships (Sturgeon, 2002).

Mexican CMs like Unisys had relied on local suppliers for up to 18 percent of their inputs. The "top five" CMs, on the other hand, have extensive global supply networks. Today, local firms supply a very limited range of CM inputs—cardboard boxes and shipping labels, cables and wires, and disposal services. Over 95 percent of components used in CM assembly are imported (Gallagher and Zarsky, 2007).

The result of the "double whammy"—changes in global industry strategy and Mexican policy—was the virtual wipe-out of the local IT industry, including manufacturers, assemblers and suppliers. Between 1985 and 1997, the number of indigenous electronics firms in Guadalajara declined by 71 percent (Rivera Vargas, 2002). And 13 of the 25 indigenous electronics firms that were still in existence at the end of 1997 had been closed by 2005 (Gallagher and Zarsky, 2007). Thirteen of the twenty-five domestic firms still in existence at the end of 1997 had gone out of business by 2004. As one study (Rivera-Vargas 2002, p. 171) concluded:

In the case of Guadalajara, what foreign investment has done is, first, to sweep away entrepreneurial capacity by pushing the endogenous electronics and computer industry out of the market. Second, foreign investment may limit the process of building scientific and technological capacities in the host country by demanding major emphasis in operational and manufacturing capabilities in detriment to the electronic design orientation.

From 2000-2002, the global flagships abandoned Guadalajara, relocating to China and other East Asian locations. There were two driving forces. First, the industry suffered a crisis of over-capacity and stock prices fell dramatically. Second, China acceded to the WTO. Mexico had based its competitive advantage on the combination of geographical proximity to US markets and low wages relative to the US. But manufacturing wages in Mexico averaged \$2.40 per hour in 2005, compared to 95 cents in China. Moreover, China offered both a well-developed local supplier base and a large and growing domestic IT market.

What remains in Guadalajara today is an IT enclave dominated by foreign CMs using imported inputs to assemble products for export to the US. There is still some employment potential: about 41,000 were employed in seven assembly plants in Guadalajara in June, 2006, compared to 47,000 before the crisis (Sturgeon, 2006). Indeed, the foreign CMs have recovered to become the “just in time” assembly floor favorites for communication switches, internet firewalls and other more sophisticated and labor intensive products headed for the United States. However, the dynamism that infused hopes of a high-growth, knowledge-intensive IT industry cluster that included spillovers to the domestic economy had evaporated. Without a significant change either in market conditions or government policies—or both—it is unlikely that Mexico will recapture it.

Environmental Spillovers: Missing Links, Missing Waste

As in most developing countries, Mexico’s capacities for the regulation of industry are thin and the IT industry is not a high priority. On the contrary, the Mexican government had expectations of positive environmental spillovers from FDI. With the exception of broad rules applicable to all industries, such as the requirement to dispose of hazardous wastes and sulfur dioxide emissions off-site, the IT industry in Guadalajara blossomed in the 1990s largely in a regulatory void. How did the IT industry fare in terms of delivering the three types of environmental spillovers identified above, viz, clean technology transfer, technology leapfrogging, and pollution halo?

Clean technology and best practice

Circuit board assembly operations based in Guadalajara use a considerable amount of lead in attaching components to copper plates. Moreover, the copper plating process emits formaldehyde and brominated flame retardants. The on-site handling and storage of lead and the transport and “disposal” of hazardous wastes are important environmental and health management issues not only for workers but also for local communities (Kuehr 2003).

An industry-wide regulation requires firms taking part in the *maquiladora* and PITEX programs to return toxic waste of production processes to their countries of origin. Since US companies dominate in the high tech sector, this means shipping toxic waste across the border. IT production generates liquid wastes and scrap, comprised of solid waste and hazardous waste. The Mexican environmental agency PROFEPA certified one firm, Environmental Electronics Recycling, to take and separate the scrap from IT manufacturing sites. The solid waste is sent to Japan, while the hazardous waste is sent to a treatment plant in Nuevo Leon or to the United States. Permits are needed for every transaction along the chain. Despite its limited monitoring capacity, PROFEPA uncovered a significant amount of fraud, including forged permits by unauthorized waste haulers (PROFEPA 2003).

How much of the hazardous electronic waste actually makes it to Nueva Leon or the United States? Separate data for the electronics industry is not available. One study found that, of the 60,000 tons of reported waste that required special handling generated in 1996, 60% was returned to country of origin and 12% was kept in known locations in Mexico. However, the whereabouts of 26% of the waste was unknown (ECLAC 2003). Moreover, many firms do not report hazardous waste generation.

All five of the global flagships we interviewed in Guadalajara said that, during the period when they were conducting manufacturing or assembly operations in Guadalajara, they sent waste back to the US through certified waste handlers. However, none filed notices of hazardous waste return with Mexican authorities (TCPS 2004). All had in place an environmental management system (EMS) and environmental professionals on staff. All were ISO 14,001 certified and some went beyond ISO to create their own EMS.

Facility-level data are not available. However, given different corporate cultures and policies, it is likely that environmental performance varied. HP, for example, is a recognized leader in global corporate social responsibility (CSR), while IBM, which has been sued by US workers claiming occupation-related illness, has a more mixed reputation. Lucent Technologies built a state-of-the-art facility in Guadalajara which employed 12,000 workers at its peak and was the first facility in Mexico designed to have zero effluents. They also installed an innovative wave soldering process, which replaced manual soldering and facilitated capture and recycling of solder dross. Unfortunately, Lucent's state-of-the-art facility went bust--a victim of the technology stock crash in the early 2000s (Gallagher and Zarsky, 2007).

Like the flagships, few hard data are available about the environmental performance of CMs in Guadalajara, either in the period under study or today. All generate significant amounts of solder dross, lead and tin. All have an EMS and an EHS unit, one has applied for Responsible Care certification and another is certified to ISO 18,000. Like the flagships, CMs claim they sent hazardous waste back to the US through certified disposal services. However, only one—SCI-Sanmina--filed notices of hazardous waste return to Mexican authorities (TCPS 2004).

In addition to EMS, the majority of the plants—both flagships and CMs from the U.S.—use relatively less energy and water. This is due to the plant vintage of the firms. Virtually all of the plants were constructed since 1994. Energy and water use are very much part of the core production processes of IT firms that newer plants by nature are cleaner than older ones. However, when pollution is a function of end-of-pipe technologies it is not clear that a new plant will automatically be relatively less pollution intensive (Gallagher, 2007). Guadalajara IT firms use formaldehyde, solder dross, and Polybrominated diphenyl ether (PBDE)—end of pipe process pollutants which are less regulated and hardly inspected in Mexico. Based on our interviews with workers and representative groups these pollutants are rife in Guadalajara (Partida, 2006).

Given the difficulty in wielding the “stick” of inspections and fines, PROFEPA devised an innovative, facility-based, voluntary “carrot”-based certification approach to improve environmental performance in manufacturing industries—the *Industria Limpia* (clean industry) program. To obtain certification, firms must sign up, undergo an environmental audit and negotiate an action plan with PROFEPA. To stay in the program, firms must quantifiably demonstrate every three months that they remain in compliance with their plan goals. All firms must register on-site hazardous wastes with PROFEPA. The only IT firms that signed up, however, are SCI-Sanmina, IBM, HP and Motorola. Only SCI-Sanmina completed the process all the way to certification.

One shortcoming of the *Industria Limpia* certification is in the area of occupational health and safety. In May, 2004, there was a toxic explosion at SCI-Sanmina just a few months after it was certified. The 400 people working on the shift were evacuated for an hour and 39 employees were taken to the hospital for respiratory or nervous system problems (Zamora, 2004). Another is

that it doesn't exactly fit into the plans of the TNCs. The "prize" of *Industria Limpia* is what amounts to an eco-label so your products can be sought after by green consumers in Mexico. Given that the majority of IT (virtually all) of production is sent to the United States, there is little incentive to go for the prize.

Occupational health and safety lags in all Mexican CMs. In one plant visited by the authors, the smell of solvents on the assembly floor was so over-powering that we had to leave after a few minutes. All CMs conduct blood tests for lead and urine to test for solvents at least twice a year. One firm uses the American Council of Government Industrial Hygienists standards that establish threshold limit values based on permissible exposure standards based on exposures of 8 hrs/day, 40 hours/week and 20 years of working.

Given that CMs favor temporary, usually 6-month contracts, benchmarking to such standards means that the companies simply avoid rather than grapple with the issue of worker health risk due to chemical exposure. For example, according to interviews with workers carried out by the UK-based Catholic Agency for Overseas Development, women workers are subjected to regular and intrusive questioning to determine if they are pregnant. If they are pregnant, they are subject to immediate job termination. The short term contracts disqualify them from maternity benefits (CAFOD 2004).

Generally, the picture that emerges is that TNC environmental performance was uneven. Some, like Lucent, clearly transferred clean technology and best practice. In the main, however, there is little evidence of environmental spillovers generated by clean technology transfer or best practice management.

Pollution Halo

Beyond the transfer of clean technology and good management to their own affiliates, TNCs can generate environmental spillovers to domestic firms through demonstration effects and requirements on local suppliers. Given the absence of local competitors, the primary channel for environmental spillovers in Guadalajara is the supply chain.

HP currently has a strong supply chain policy. Established in 2002, its Supply Chain Social and Environmental Responsibility (SER) Policy commits the company to "[working] with suppliers to ensure they operate in a socially and environmentally responsible manner." In 2004, in conjunction with Dell and IBM, HP took the lead in bringing together a coalition of eight flagship and CM firms that created and launched an Electronics Industry Code of Conduct. The Code outlines broad management standards for the electronics supply chain in the areas of labor rights, health and safety, and environment (Hewlett Packard, 2004).

The implementation of HP's policy, however, may have missed Guadalajara. An EHS manager for HP in Guadalajara told us that "HP's theory is to keep costs down...and for that reason we do not make demands on suppliers" (HP, 2003). One SME supplier confirmed that none of their flagship clients, including HP, had ever imposed any environmental requirements. However, HP Mexico was part of a small business group formed in 1993 to promote best practice, including ISO 14,001, among manufacturing firms in Guadalajara.

Lucent created an industry association of flagships to develop local suppliers and improve their environmental performance. Lucent also participated in and contributed funds towards a World Bank project in 1997 and 1998 which aimed to train SMEs in environmental management.

However, the project's success was mixed. In some cases, the mentoring foreign firms themselves did not have an EMS, reducing their capacity to positively influence and work with their suppliers (World Bank 1998).

The policies and good will of at least some of the flagships suggest that “pollution halo” environmental spillovers, at least theoretically, were on offer in Guadalajara. In the event, the lack of local business linkages mitigated against their capture. The flagships contracted with the CMs, who sourced almost nothing locally. Even if the CMs had imposed environmental requirements on suppliers—which they did not in the early 2000s—there would have been few spillovers to SMEs in Guadalajara.

Technology Upgrading

In the face of rising EU standards, the key question for all IT production sites throughout the world is whether TNCs and domestic firms are upgrading technological and management capacities to serve high-standard EU markets or the lower-standard US market. Mexican IT assembly is geared overwhelmingly to the US market.

TNCs involved in electronics assembly in Mexico—at least along the northern border—have generally been slow to introduce innovations that reduce the toxic substances used in production and embodied in products (ECLAC, 2002). The problem is that there are no incentives to upgrade. On one hand, there are no national environmental standards for the IT industry in Mexico. On the other hand, Mexico-based TNCs export overwhelmingly to the US market.

In Guadalajara, we found little evidence that IT firms are retrofitting their production operations in anticipation of the new European laws. Of all the firms we interviewed, only Solectron is working towards compliance with the EU's Restriction on Hazardous Substances (RoHS). The explanation given was that the vast majority of exports from the Jalisco plants are headed for the US, which is showing no signs of creating such a law. Some firms noted that their subsidiaries in Ireland and Hungary are already RoHS compliant because those branches of their operations export into the European market.

In the absence of national or global regulatory pressures, TNCs can—and apparently do—tailor their environmental technology and performance to particular markets. The lack of environmental upgrading in Guadalajara suggests that the IT sector will remain locked into the US market—and locked out of higher-standard markets like the EU (ECLAC, 2003).

There is little data and few studies on the environmental performance of TNCs in Mexico's IT Sector. A World Bank study that analyzed the determinants of environmental compliance in Mexican manufacturing as a whole found that foreign firms were no more likely to be in compliance than domestic firms (Dasgupta 2000). In 2002, the UN Economic Commission for Latin America and the Caribbean conducted a survey of 298 electronics firms on Mexico's northern border with the US. The study found some signs that environmental compliance was improving. About two-thirds of the companies in their large sample—over three quarters of which were foreign—had an environmental unit. Over half said they had raised the level of environmental protection in the preceding three years.

However, the report identified what it calls a foreign firm “double standard” by showing that the country source of FDI had no influence on the environmental policy or performance of the plant. Only half of the companies had an “active” environmental policy, defined as environmental

management measures complemented by technologies to mitigate contaminant emissions from the plants. Moreover, only half had even limited supervision of Mexican applicable environmental laws, which are much lower than norms in other countries with electronic assembly industries, such as the Philippines.

The report cautioned that this low level of performance would create barriers for Mexican products in markets with high environmental requirements, such as the European Union. Comparing Mexico with the Philippines, it concluded that, overall, the Mexican electronics industry is being left behind in the speed and scope of environmental policy, especially in terms of production processes and product life cycle (ECLAC 2003).

Capturing FDI Spillovers: Lessons for Policy

FDI in the high tech sector in Guadalajara offered initial promise of spillovers for sustainable industrial development. Some of the world's best companies in terms of environmental performance invested in Guadalajara. One built a state-of-the-art plant that met the world's highest standards at the time. A number banded together to develop both the supply capabilities and environmental management skills of local firms.

But the capture of significant spillovers was stymied by three factors. First was the Mexican government's failure to match FDI inflows with adequate environmental regulatory infrastructure. As a result, there was no local incentive to eco-innovate--and a significant amount of unaccounted-for hazardous IT waste is likely buried somewhere in the Mexican countryside.

The second obstacle was the evolution of the IT sector into an enclave economy, the result of both government and market failures. With no domestic competitors, there were no direct demonstration effects on local firms. With a bias towards foreign contract manufacturers and few local suppliers, there were few spillovers via backward linkages either for industry upgrading or environmental management.

The third obstacle was the lock-in of IT production for export to the US market. With its lagging environmental standards, the US offered no incentive for Guadalajara-based firms to leapfrog to the global technology frontier. While being in the US backyard keeps assembly operations viable, it provides little incentive to move up the value chain.

The experience of Guadalajara offers four policy lessons about how governments may increase the benefits of FDI for sustainable industrial development.

1. Capturing spillovers requires explicit linkage policies which integrate FDI in an overarching development strategy.

The literature demonstrates unambiguously that positive FDI spillovers are not automatic and that, in developing countries, FDI is as likely to deliver negative spillovers—the hollowing and crowding out of domestic firms—as positive ones. Moreover, in the instances when FDI has generated positive spillovers, it has been the result of deliberate public policies geared toward encouraging TNCs to supply them and increasing the capacities of domestic firms to absorb them. Put another way, the literature shows that it is not the quantity of FDI but the integration of FDI into a coherent, strategic set of development policies that matters.

Ignoring this insight, Mexico's leaders in the 1990s adopted a passive approach in which the overarching objective was to increase the quantity of FDI inflows. Treating FDI as an end rather than as a means grew out of what we call the "maquila mindset" --a perception of Mexico's role as simply a low-wage, low tax and tariff, export-oriented manufacturing base for North American TNCs. The strategy permeated the entire manufacturing sector. In the IT industry, there was little vision or investment in building local knowledge assets or upgrading local industrial capabilities. Without significant local knowledge assets, TNCs tend to transfer their low skill, low technology operations and rely on global suppliers than help to develop a local supply base. Mexico's experience shows clearly that treating FDI as an end in itself rather than as part of an overarching development strategy is more likely to generate enclaves than broad-based growth.

2. *Relying on low wages alone to attract FDI leaves developing countries vulnerable to pull-out by TNCs.*

Mexico's primary objective in attracting FDI inflows was to increase employment and income, as well as to help balance the capital account. Low wages were central to achieving this goal. Given that FDI inflows increased dramatically, the strategy may appear to have been successful. However, TNCs pulled out rapidly when demand contracted in the US and when China joined the WTO. The lesson is clear: an FDI enclave built around low wages rather than local knowledge assets and domestic markets is vulnerable to the emergence of even lower-cost producers. Only geographical proximity to the US and NAFTA preferences sustain Guadalajara's assembly operations.

3. *Garnering environmental spillovers requires explicit attention to environmental policy.*

Mexico, like other developing countries, considered IT investment to be "clean and green" and made environmental oversight a low priority. But significant environmental and occupational health problems are associated with IT production, problems the TNCs are still struggling to address. Moreover, the expectation that TNCs will transfer "best practice" was not borne out in Mexico. As a result, Mexican-based firms are not equipped to meet the new, high environmental standards of the European Union and will be locked out of that market. The lesson is that, like knowledge spillovers, there is nothing automatic about environmental spillovers from FDI. Pro-active government policy is needed to generate and to capture environmental spillovers.

4. *The benefits of FDI in IT manufacturing are limited for late industrializing countries.*

Barriers to entry in the global IT industry, even at the level of third tier suppliers, suggest that it will be very difficult for developing countries to gain a foothold in the global IT industry in the absence of strong government policy and simultaneous changes in TNC strategic interests. Without such policies, large TNC firms are bound to crowd out domestic firms with global supply chains and generate few knowledge spillovers to the local economy.

Even with pro-active industry policies, however, it may not be possible for late industrializing countries with relatively small domestic markets to enter the global IT industry except as assembly and semi-skilled manufacturing platforms for CMs. Without significant local knowledge assets, TNCs are unlikely to transfer proprietary technology. Rather, technology and skills transfer will be low-end and, as argued above, vulnerable to relocation to cheaper production sites.

In the short term, the employment potential of FDI in the IT sector might be substantial, though again, in the medium to long term, low wage producers are vulnerable to footloose TNCs.

Revenue potential, however, will be limited because of fierce global wage competition and the tax breaks developing countries offer to attract TNCs.

Taken together, these factors suggest that the benefits of attracting IT investment may be limited in developing countries. To promote sustainable industrial development, governments should look to industries that better suit local productive assets and capacities, domestic market potential and development objectives.

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ⁱⁱ Criteria air pollutants are non-toxic air pollutants such as nitrogen oxide (NO_x), sulfur oxide (SO_x), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), volatile organic compounds (VOC), all particulates, and carbon monoxide.

ⁱⁱⁱ For more information see <http://www.responsiblecare-us.com>. See also information from the International Council of Chemical Associations <http://www.icca-chem.org/>.

^{iv} Also called Electronic Manufacturing Services (EMS) companies.

^v A domestically-based IT industry can also help to locally diffuse IT products, with large benefits for productivity and poverty alleviation (UNDP 2001).

^{vi} Production of micro-chips is also energy-intensive. See Mazurek 1999.