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Mexico's Economic Relationship with China: A Case Study of the PC Industry in Jalisco, Mexico.

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Mexico's Economic Relationship with China: A Case Study of the PC Industry in Jalisco, México[1].

Enrique Dussel Peters[2]

Resumen

Este documento ofrece una discusión detallada de las condiciones y desafíos actuales planteados por China en la cadena de valor agregado de la electrónica en México y específicamente en el segmento de las computadoras personales (PC) en Jalisco. Las entrevistas a nivel empresarial presentadas se realizaron desde 1994, pero más específicamente desde 2007. El análisis incluye el funcionamiento y las características de la industria electrónica en su contexto "glocal" y de su desarrollo desde los años 90. Considerando que la electrónica era uno de los casos más exitosos de la industrialización orientada a la exportación en México desde el finales de los 80´s, la base de las actividades iniciales de Jalisco ha desaparecido prácticamente desde 2007. Este proceso ha sido un resultado de la reestructuración global en la electrónica y de la crisis en este sector entre 2001 y 2003, pero particularmente se debe a la creciente competencia con Asia y China. Hoy, China provee más del 50% de las importaciones de los Estados Unidos mientras que la producción de PC en Jalisco es prácticamente nula. Las pocas firmas que substieron en el *cluster* de la electrónica tuvieron que reinventarse a través de cambios masivos en su organización interna, entrenamiento y nuevas relaciones intra e interfirma. Desde esta perspectiva, las lecciones de la experiencia de Jalisco en el segmento de PC y la electrónica reflejan el gran desafío que China ha planteado a los patrones de especialización en México en las últimas décadas y a la necesidad de una estrategia de largo plazo que pueda permitir la cooperación en algunos casos.

Palabras clave: industria de PC y electrónica en México y China; cadena de valor agregado en México y China.

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摘　要

本文详细讨论了中国对墨西哥电子加工产业的当前影响和挑战，尤其是对哈里斯科的个人计算机产业的影响。对于企业层面的分析始于 1994 年，但更为详尽的是自 2007 年以来的情况。文章分析了 20 世纪 90 年代在全球背景下电子工业的表现、特点及其发展状况。

自 20 世纪 80 年代后期开始 ,电子工业被认为是墨西哥出口导向工业中最为成功的例子之一，但 2007 以来，哈里斯科的最初的核心电子工业已消失殆尽。其原因在于全球电子产业重组以及 2001 至 2003 年期间该行业出现的危机，而更为重要的是来自亚洲和中国的竞争所致。目前，美国进口的 50%来自中国，而哈里斯科的个人计算机的生产实际为零。

在墨西哥电子加工行业仅存的几家企业，不得不通过改变内部组织形式、增加培训以及建立新型的“企业内部”和“企业之间”的关系等对自身进行再投资。哈里斯科个人计算机和电子工业发展的教训表明，中国在过去的几十年里对墨西哥专业化模式的形成巨大挑战，因此有必要制定一个长期战略，以便企业在某些情况下进行合作。

关键词： 个人计算机　电子产品　电子产品增值链 中国 墨西哥

Abstract

This paper provides a more detailed discussion of the current conditions and challenges posed by China in Mexico’s electronics value-added chain and specifically in the personal computer segment in Jalisco. Firm-level interviews have been carried out since 1994, but more specifically since 2007. The analysis includes the performance and characteristics of the electronics industry in its “glocal” context and its development since the 1990s.

Considering that electronics were one of the most successful cases of export-oriented industrialization in Mexico since the late 1980s, the core of Jalisco’s initial activities have practically disappeared since 2007. This process has been a result of global restructuring in electronics and the crisis in this sector during 2001–2003, but in particular it is due to increasing competition with Asia and China. Today, China supplies more than 50 % of US imports and PC production in Jalisco is practically zero.

The few firms left in the electronics cluster had to reinvent themselves through massive changes in their internal organization, training and new intrafirm and interfirm relationships. From this perspective, the lessons of Jalisco’s experience in PC and electronics reflect the great challenge that China has posed to Mexico’s specialization patterns in the last decades and the need for a long-term strategy which might allow for cooperation in some cases.

Keywords: PC industry and electronics in Mexico and China.

Contents

Introduction

This paper provides a more detailed discussion of the current conditions and challenges posed by China in Mexico's electronics value-added chain and specifically in the personal computer segment in Jalisco. A large part of this section is based on firm-level interviews carried out in July 2007 as well as research and firm-level interviews carried out since 1994. The paper is divided into three parts. The first section outlines the global industrial organization of the electronics industry, and particularly developments in the US. This section also includes the general performance of Mexico's electronics industry and PC segment. The second part analyzes the current situation in Jalisco's electronics industry in greater depth, based on the interviews' findings. The role of China is explicitly discussed in both parts. The final section presents the conclusions and policy proposals. This analysis includes the performance and characteristics of the electronics industry as a whole as well as its "g*local*" – global and local to Mexico and Jalisco – conditions; it was chosen this way because firms in Jalisco have specialized in telecommunications and in the PC sector. Nevertheless, the main focus of this paper is the China-Mexico relationship in the PC segment, and additional information is only included where necessary.

An Overview of the Electronics Industry: Mexico's Experience

The electronics value chain has undergone significant changes since the 1990s. In many cases it is closely linked to autoparts-automobiles and telecommunications, and several structures and tendencies have intensified since the 1990s, namely:[3]

– In addition to increasing capital intensity and thus reaching higher entry barriers in terms of capital and technology, the chain has drastically increased its segmentation into modules (Sturgeon 2002). The transfer of value chain segments and "*global knowledge networks*" (Ernst 2006b) has not only created new opportunities for particular territories to integrate into these segments but also increased the levels of competition. Traditional original equipment manufacturers[4] (OEM) such as International Business Machines (IBM) and Hewlett-Packard (HP), among others, have increasingly focused their manufacturing plants or production lines[5] – in the case of IBM almost exclusively – on core segments and increasingly on services. This process, however, is parallel to increased integration and more complex products – in both hardware and software – that generate rising entry barriers to newcomers.

– As a result, the role of OEMs, contract manufacturers[6] (CMs), assemblers, distributors, parts and components producers, centers of knowledge and Research & Development (R&D), among others, have changed substantially, a process a trend that is still observed today.[7]

– Since the 1990s, and increasingly since 2000, the entire electronics and PC chain has been devolving manufacturing and labor-intensive activities to lower tiers, i.e. since the 1990s from OEMs to CMs (HP, Siemens, Motorola, and IBM to Solectron, Flextronics and SCI-Sanmina, for example), and more recently from CMs to vendors and lower tiers and new active elements in the chain (to firms such as Arrow, Avnet and other firms that not only trade parts and components, but are also involved in an increasing number of processes within logistics, manufacturing, final configuration, transportation and others). From this perspective, the direct manufacturing and assembly process of parts and components for final commodities has left not only OEM firms since the 1990s but there has also been an increase in departure from CMs; i.e. the disintegration or fragmentation of these modules and segments has had significant geographical effects, particularly in manufacturing.

– The issue of upgrading and territorial endogeneity (Lall / Albaladejo / Zhang 2004; Bair / Dussel Peters 2006; Ernst 2006b; Mahoney et. al 2006; Sturgeon 2006) has generated new challenges in specific segments of electronics and in terms of the ability of firms and territories to integrate (or not) with these networks and processes. Territorial endogeneity[8] in these chains has to take into account the extreme dynamism of products and processes; in the case of

3 For an in-depth analysis of the industrial organization of the electronics industry, see: Borrus / Zysman (1998); Dedrick / Kraemer (1998); Lüthje (2004); Dussel Peters (2005a); Ernst (2006a); Lécuyer (2006).

4 OEMs refer to firms that provide the original product design and materials for assembly and manufacture. OEMs are directly responsible for the logistics required in all segments of the chain in order to sell a final product, including manufacturing and modifying products, making them commercially available, and providing the warranty (Dussel Peters / Palacios Lara 2004).

5 In many cases, concretely in the case of Jalisco, firms have not closed completely because of this process, but have rather transferred specific production lines as a result of intrafirm competition: new projects within firms compete at different sites and new products are produced and assembled according to the lowest prices in the already existing global sites or plants of the respective firms.

6 Contract manufacturers refer to firms that specialize in manufacturing components, products or services for OEMs, from assembly to shipping and other segments that can be outsourced (Dussel Peters / Palacios Lara 2004).

7 See for example the case of Dell (Holzner 2006), which until very recently was considered a successful case of direct sales but had to change its business strategy significantly to sell through retailers.

8 The concept of territorial endogeneity refers to the issue of sites integrating into the world market under current specific globalization conditions (particularly considering global commodity chains and flexibilization or Fordism); i.e. territories have the option of either positively integrating into the world market with a high degree of endogeneity or with a high degree of polarization (for a full discussion, see: Dussel Peters 2000, Bair / Dussel Peters 2006).

semiconductors, for example, speed (at the same price) has doubled every 18 months over the last decade, in addition to innovation and creation of new commodities.

– Moreover, China has substantially changed the electronics chain globally since the end of the 1990s: it has become the largest exporter of information technology (IT) and electronics goods to the United States (US), and integrated a group of new Chinese firms such as Lenovo, Founder, TCL and Huawei, among others (Delgado Ramos 2006; Dussel Peters 2007; Zhong 2007) into these global networks. Since the end of the 1990s, China has become the main attractor of foreign investment in electronics and has created important new capabilities in assembly, parts and components and increasingly in R&D.[9] Recent developments in China have significantly changed the electronics landscape globally. There has been a process of acquisition, co-investments and partnerships involving both transnational corporations and Chinese firms. China's domestic market and Chinese firms have also been extremely dynamic, with the latter growing three times as fast as transnational firms, with net margins much lower than global margins.[10]

Two additional topics are relevant to understanding the recent performance of Jalisco's electronics and PC industry in relation to China: recent developments in the US and in Mexico and Jalisco.

In the case of the US at least three developments are significant. While its electronics industry has lost in terms of R&D and employment – from 1.25 % of the Gross Domestic Product (GDP) in 1985 to 0.8% in 2004 and more than 800,000 jobs lost in high-tech sectors – there has been a recovery in terms of employment since then. Some of the following topics are relevant to understanding the slow recovery in this sector:[11]

– In 2006 the high-tech sector amounted to 5.8 million, or 5.1 % of private sector employment, of which electronics manufacturing represented 23.5%, communication services 24.4 %, software 25.5 % and engineering and technological services 26.7 %. According to the American Electronics Association (AEA) (2007), employment in software and engineering and technological services has increased in the last years, while in manufacturing in general, but specifically in PCs and peripherals, jobs have been lost and are expected to continue doing so.

– High-tech sectors, including electronics, are not only relevant to R&D activities per se, but also because they generate employment with high wages: in 2005 wages in these sectors were US$ 75,500 on average, or 86 % above the private sector average. Particularly wages in PC manufacturing and peripheral equipment were 256 % and 235 % higher than the private sector average.

– According to this study, risk capital and R&D expenditure were the most relevant factors for developing high-tech sectors.

As discussed later in more detail, based on the interviews the high-tech sector in the US is expected to continue deepening outsourcing processes in general, especially in electronics manufacturing, but also in other tiers of the chain.[12]

Tables 1–3 show the dimension, dynamics, segmentation and competition of US-imports during 1990-2006. The main issues from these tables could be outlined as follows:

– China increased its share of total US imports from 2.25 % in 1990 to 31.03 % in 2006 with an Average Annual Growth Rate (AAGR) of 39.7% for the period, while Mexico's share increased from 6.53 % to 14.07 %. The period 2001–2006, however, has seen substantial changes in the dynamism of both countries, with an AAGR of 30.4 % and 4.7 % for China and Mexico respectively, Thus, both countries increased their share of total US-imports in 1990–2000, but Mexico's has fallen since 2001 (its peak year, with 16.1 %), whereas China substantially increased its exports to the US in the period 2001–2006 when electronics imports were less than in the earlier period.

– Given relatively small net margins of less than 3 % in the industry, as has already been discussed, effective tariff rates still play an important role in this chain. Table 1 shows that countries such as China paid an effective tariff rate of 0.48 % in 2006, and over 1 % during the 1990s, more than three times higher than Mexico. Only Japan paid a higher effective tariff rate than China on electronics imports to the US in 2006.

9 As part of the discussion and the current process in China, the latter has been able to upgrade "*incrementally*" in innovations (Ernst 2006b). For an analysis of China´s semiconductor industry, see: Stevenson-Yang / Zhang (2007).

10 Von Morgenstern / Xia (2006) stress that the net margin is around 2.5 % on average for the top 1,000 electronics companies in China. It is expected that by 2010 Chinese companies will hold around 80 % of China's high-tech market, up from 67 % in 2004.

11 For a detailed analysis of the electronics industry in the US, both generally and by state and subsector, see the AEA (2007).

12 As part of an ongoing discussion, authors such as Sanjaya Lall / Sturgeon, among others, have stressed that this process will have much wider impact in the case of transferring segments in the service sector (Sturgeon 2006).

– Table 2 describes the relevant segmentation within electronics and its corresponding dynamics. While electronics imports have been much more dynamic than total US imports – with an AAGR of 18.8 % and 8.7 % for 1990 and 2006, respectively – sectors such as telephone and telegraph apparatus, TVs and computers have been the sectors with the highest share of total imports in the sector. The latter accounts for more than 31.7 % of total imports of electronics in 2006 with an AAGR of 44.5 % during 1990–2006, while effective tariff rates are close to zero.

– Table 3 reflects China's impressive penetration of the US market in the PC segment:[13] with an AAGR of 138.7 % during 1990–2006 its share increased from 0.02 % to 45.5 %. Other countries such as Mexico, which competed with China and Japan at the end of the 1990s, have fallen substantially: the AAGR of Mexico during 2001–2006 was -6.2 %. With the exception of Malaysia, China has been the only major exporter to the US with a positive AAGR for that period. Contrary to other sectors, the tariff rate does not play an important role, as it has been zero since 2000.

In Mexico's case it is particularly relevant to stress that the PC sector was one of the most successful export sectors for 1990–2001, accounting for more than US$ 10 billion annually in some years.

Table 1: United States: Imports in electronics (main countries) (1990–2006)

	1990	1995	2000	2001	2005	2006	1990-2000	2001-2006	1990-2006
Value (US$ M)									
1 China	489,000	4,556	25,961	27,226	86,979	102,727	95,626	370,132	465,758
2 Mexico	1,421	6,462	35,092	36,962	40,219	46,576	135,591	232,558	368,150
3 Japan	8,080	20,751	47,434	35,733	31,650	30,665	277,829	190,415	468,244
4 Malaysia	454,000	3,721	17,044	17,682	27,517	29,372	76,531	137,129	213,659
5 Taiwan	1,233	3,690	19,583	17,424	16,272	18,329	87,247	100,956	188,203
Rest of world	10,082	24,337	106,034	94,026	103,819	103,417	495,750	588,330	1,084,080
Total	**21,758**	**63,518**	**251,148**	**229,053**	**306,456**	**331,085**	**1,168,574**	**1,619,521**	**2,788,095**
Share (percentage)									
1 China	2.25	7.17	10.34	11.89	28.38	31.03	8.18	22.85	16.71
2 Mexico	6.53	10.17	13.97	16.14	13.12	14.07	11.60	14.36	13.20
3 Japan	37.14	32.67	18.89	15.60	10.33	9.26	23.78	11.76	16.79
4 Malaysia	2.09	5.86	6.79	7.72	8.98	8.87	6.55	8.47	7.66
5 Taiwan	5.67	5.81	7.80	7.61	5.31	5.54	7.47	6.23	6.75
Rest of world	46.34	38.32	42.22	41.05	33.88	31.24	42.42	36.33	38.88
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Annual growth rate									
1 China	-	47.5	31.7	4.9	25.5	18.1	48.8	30.4	39.7
2 Mexico	-	14.1	28.7	5.3	3.0	15.8	37.8	4.7	24.4
3 Japan	-	21.5	13.8	-24.7	-1.5	-3.1	19.4	-3.0	8.7
4 Malaysia	-	21.7	29.8	3.7	23.5	6.7	43.7	10.7	29.8
5 Taiwan	-	27.0	23.9	-11.0	-1.4	12.6	31.9	1.0	18.4
Rest of world	-	141.4	335.7	-11.3	10.4	-0.4	26.5	1.9	15.7
Total	-	20.6	23.1	-8.8	8.8	8.0	27.7	7.6	18.5
Effective tariff rate (percentage)									
1 China	6.02	3.61	0.76	0.68	0.45	0.48	1.67	0.50	0.74
2 Mexico	4.36	0.46	0.12	0.12	0.16	0.10	0.39	0.14	0.24
3 Japan	4.33	3.25	0.76	0.81	0.99	0.84	1.98	0.92	1.55
4 Malaysia	1.25	0.89	0.30	0.28	0.20	0.17	0.63	0.23	0.37
5 Taiwan	4.60	2.37	0.27	0.22	0.38	0.43	1.15	0.30	0.70
Rest of world	4.14	2.67	0.39	0.39	0.45	0.45	1.18	0.42	0.77
Total	4.23	2.58	0.45	0.42	0.44	0.42	1.28	0.43	0.79
Effective tariff rate (US total = 100)									
1 China	142.3	139.8	170.5	160.6	102.4	114.7	130.3	115.0	93.5
2 Mexico	102.9	17.8	26.8	28.4	35.9	23.1	30.7	33.1	29.8
3 Japan	102.3	125.9	170.9	191.8	224.4	200.6	154.2	213.4	196.4
4 Malaysia	29.5	34.6	66.9	65.2	44.5	39.9	49.4	52.3	47.2
5 Taiwan	108.6	91.9	59.9	51.3	87.1	103.6	90.0	70.0	88.4
Rest of world	97.8	103.5	87.9	91.3	101.7	106.7	92.3	96.6	97.4
Total	100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Author's calculations based on USITC (1991-2007)

13 The PC segment refers to 71 10-digit items of the Harmonized Tariff System including PCs, peripherals and other related parts. For a discussion on the methodology, see Dussel Peters (2005a).

Table 2: United States imports in electronics by segment							
	1990	**2000**	**2001**	**2006**	**1990-2000**	**2001-2006**	**1990-2006**
Value (in US$ mbn)							
ET016 Office machines	811	1,783	1,654	1,740	14,761	9,506	24,267
ET017 Telephone and telegraph apparatus	1,002	29,094	24,163	51,279	89,707	213,503	303,210
ET018 Consumer electronics (except televisions)	2,032	21,197	18,527	25,283	110,488	132,956	243,444
ET019 Blank media	1,471	2,315	2,270	4,312	21,243	19,931	41,174
ET020 Pre-recorded media	13	1,234	1,105	1,163	4,710	7,401	12,111
ET021 Navigational instruments and remote control apparatus	492	1,466	1,598	3,614	9,234	14,369	23,603
ET022 Television receivers and video monitors	0	7,618	8,467	28,540	32,988	99,473	132,461
ET023 Radio and television broadcasting equipment	45	6,247	5,377	3,362	17,327	24,733	42,060
ET024 Electric sound and visual signaling apparatus	618	2,210	1,900	2,481	14,510	12,261	26,771
ET025 Electrical capacitors and resistors	680	3,412	2,034	2,305	17,200	11,422	28,621
ET026 Printed circuits	896	2,929	2,100	2,184	13,130	12,012	25,143
ET027 Circuit apparatus exceeding 1000V	123	355	316	407	2,210	1,901	4,111
ET208 Circuit apparatus not exceeding 1000V	321	6,574	5,029	6,947	26,422	33,982	60,405
ET029 Circuit apparatus assemblies	46	2,398	2,328	4,211	10,947	18,484	29,431
ET030 Parts of circuit apparatus	19	1,115	1,090	1,875	5,875	9,004	14,879
ET031 Cathode-ray tubes	88	627	637	326	5,553	3,410	8,962
ET032 Electron tubes other than CRTs	54	206	265	226	1,645	1,311	2,956
ET033 Semi-conductors and integrated circuits	960	38,540	28,764	25,454	164,380	151,037	315,417
ET034 Miscellaneous electrical equipment	190	2,795	2,154	1,818	10,913	14,945	25,858
ET035 Computers, peripherals and parts	275	67,804	71,722	99,491	297,089	496,310	793,399
ET036 Photographic film and paper	1,121	1,792	1,554	1,348	15,989	8,941	24,930
ET037 Optical fibers, optical fiber bundles and cables	62	1,236	1,005	505	3,202	2,546	5,748
ET038 Optical goods including ophthalmic goods	1,301	5,260	4,207	4,958	26,286	24,786	51,072
ET039 Photographic cameras and equipment	1,890	5,061	3,408	1,477	44,061	14,564	58,625
ET040 Medical goods	1,475	7,871	9,410	19,422	43,570	89,784	133,354
ET041 Watches and clocks	1,596	3,419	2,984	4,005	27,587	21,248	48,834
ET042 Drawing, drafting and calculating instruments	131	219	191	277	2,081	1,424	3,504
ET043 Measuring, testing and controlling instruments	2,205	10,772	10,776	14,763	61,220	74,202	135,422
Total imports from the United States	**19,917**	**235,545**	**215,034**	**313,772**	**1,094,327**	**1,525,447**	**2,619,774**

Table 2: United States imports in electronics by segment (cont.)							
	1990	**2000**	**2001**	**2006**	**1990-2000**	**2001-2006**	**1990-2006**
Share (percentage)							
ET016 Office machines	4.1	0.8	0.8	0.6	1.3	0.6	0.9
ET017 Telephone and telegraph apparatus	5.0	12.4	11.2	16.3	8.2	14.0	11.6
ET018 Consumer electronics (except televisions)	10.2	9.0	8.6	8.1	10.1	8.7	9.3
ET019 Blank media	7.4	1.0	1.1	1.4	1.9	1.3	1.6
ET020 Pre-recorded media	0.1	0.5	0.5	0.4	0.4	0.5	0.5
ET021 Navigational instruments and remote control apparatus	2.5	0.6	0.7	1.2	0.8	0.9	0.9
ET022 Television receivers and video monitors	0.0	3.2	3.9	9.1	3.0	6.5	5.1
ET023 Radio and television broadcasting equipment	0.2	2.7	2.5	1.1	1.6	1.6	1.6
ET024 Electric sound and visual signaling apparatus	3.1	0.9	0.9	0.8	1.3	0.8	1.0
ET025 Electrical capacitors and resistors	3.4	1.4	0.9	0.7	1.6	0.7	1.1
ET026 Printed circuits	4.5	1.2	1.0	0.7	1.2	0.8	1.0
ET027 Circuit apparatus exceeding 1000V	0.6	0.2	0.1	0.1	0.2	0.1	0.2
ET208 Circuit apparatus not exceeding 1000V	1.6	2.8	2.3	2.2	2.4	2.2	2.3
ET029 Circuit apparatus assemblies	0.2	1.0	1.1	1.3	1.0	1.2	1.1
ET030 Parts of circuit apparatus	0.1	0.5	0.5	0.6	0.5	0.6	0.6
ET031 Cathode-ray tubes	0.4	0.3	0.3	0.1	0.5	0.2	0.3
ET032 Electron tubes other than CRTs	0.3	0.1	0.1	0.1	0.2	0.1	0.1
ET033 Semi-conductors and integrated circuits	4.8	16.4	13.4	8.1	15.0	9.9	12.0
ET034 Miscellaneous electrical equipment	1.0	1.2	1.0	0.6	1.0	1.0	1.0
ET035 Computers, peripherals and parts	1.4	28.8	33.4	31.7	27.1	32.5	30.3
ET036 Photographic film and paper	5.6	0.8	0.7	0.4	1.5	0.6	1.0
ET037 Optical fibers, optical fiber bundles and cables	0.3	0.5	0.5	0.2	0.3	0.2	0.2
ET038 Optical goods including ophthalmic goods	6.5	2.2	2.0	1.6	2.4	1.6	1.9
ET039 Photographic cameras and equipment	9.5	2.1	1.6	0.5	4.0	1.0	2.2
ET040 Medical goods	7.4	3.3	4.4	6.2	4.0	5.9	5.1
ET041 Watches and clocks	8.0	1.5	1.4	1.3	2.5	1.4	1.9
ET042 Drawing, drafting and calculating instruments	0.7	0.1	0.1	0.1	0.2	0.1	0.1
ET043 Measuring, testing and controlling instruments	11.1	4.6	5.0	4.7	5.6	4.9	5.2
Total imports from the United States	**100.0**	**100.0**	**100**	**100.0**	**100.0**	**100.0**	**100.0**

Table 2: United States imports in electronics by segment (cont.)							
	1990	**2000**	**2001**	**2006**	**1990-2000**	**2001-2006**	**1990-2006**
Annual growth rate							
ET016 Office machines		7.3	-7.2	4.1	8.2	1.0	4.9
ET017 Telephone and telegraph apparatus		61.6	-16.9	10.9	40.0	16.2	27.9
ET018 Consumer electronics (except televisions)		20.9	-12.6	1.9	26.4	6.4	17.1
ET019 Blank media		8.5	-1.9	5.7	4.6	13.7	7.0
ET020 Pre-recorded media		13.0	-10.4	-15.6	58.2	1.0	32.7
ET021 Navigational instruments and remote control apparatus		21.5	9.0	24.1	11.5	17.7	13.3
ET022 Television receivers and video monitors		15.2	11.1	27.5		27.5	31.1
ET023 Radio and television broadcasting equipment		46.0	-13.9	-1.1	63.6	-9.0	30.9
ET024 Electric sound and visual signaling apparatus		9.9	-14.0	7.3	13.6	5.5	9.1
ET025 Electrical capacitors and resistors		52.0	-40.4	19.4	17.5	2.5	7.9
ET026 Printed circuits		92.5	-28.3	5.3	12.6	0.8	5.7
ET027 Circuit apparatus exceeding 1000V		42.7	-11.0	10.8	11.2	5.2	7.8
ET208 Circuit apparatus not exceeding 1000V		21.9	-23.5	7.6	35.2	6.7	21.2
ET029 Circuit apparatus assemblies		18.1	-2.9	14.4	48.3	12.6	32.5
ET030 Parts of circuit apparatus		19.2	-2.2	15.0	50.5	11.5	33.3
ET031 Cathode-ray tubes		-12.9	1.5	-40.4	21.7	-12.5	8.5
ET032 Electron tubes other than CRTs		13.8	28.7	13.8	14.4	-3.1	9.4
ET033 Semi-conductors and integrated circuits		26.6	-25.4	5.2	44.7	-2.4	22.7
ET034 Miscellaneous electrical equipment		26.1	-22.9	-42.2	30.8	-3.3	15.2
ET035 Computers, peripherals and parts		11.8	5.8	9.2	73.5	6.8	44.5
ET036 Photographic film and paper		6.8	-13.3	-10.7	4.8	-2.8	1.2
ET037 Optical fibers, optical fiber bundles and cables		87.7	-18.7	37.4	35.0	-12.8	14.1
ET038 Optical goods including ophthalmic goods		45.4	-20.0	11.1	15.0	3.3	8.7
ET039 Photographic cameras and equipment		-8.9	-32.7	-17.7	10.4	-15.4	-1.5
ET040 Medical goods		19.7	19.6	7.2	18.2	15.6	17.5
ET041 Watches and clocks		6.7	-12.7	3.3	7.9	6.1	5.9
ET042 Drawing, drafting and calculating instruments		-21.4	-12.6	-12.2	5.3	7.7	4.8
ET043 Measuring, testing and controlling instruments		21.9	0.0	7.5	17.2	6.5	12.6
Total imports from the United States		**23.0**	**-8.7**	**8.7**	**28.0**	**7.9**	**18.8**

Table 2: United States imports in electronics by segment (cont.)							
	1990	**2000**	**2001**	**2006**	**1990-2000**	**2001-2006**	**1990-2006**
Effective tariff rate (percentage)							
ET016 Office machines	3.51	0.62	0.59	0.88	2.10	0.80	1.59
ET017 Telephone and telegraph apparatus	3.64	0.01	0.02	0.01	1.27	0.01	0.38
ET018 Consumer electronics (except televisions)	4.37	1.04	1.01	0.82	2.00	0.89	1.39
ET019 Blank media	4.19	0.00	0.00	0.00	2.21	0.00	1.14
ET020 Pre-recorded media	4.02	0.24	0.22	0.19	0.37	0.21	0.27
ET021 Navigational instruments and remote control apparatus	1.88	0.62	0.53	0.34	1.24	0.42	0.74
ET022 Television receivers and video monitors		0.96	0.91	1.25	1.02	1.37	1.28
ET023 Radio and television broadcasting equipment	3.94	0.65	0.65	1.32	1.23	0.87	1.02
ET024 Electric sound and visual signaling apparatus	2.43	0.44	0.45	0.52	1.31	0.50	0.94
ET025 Electrical capacitors and resistors	8.52	0.01	0.01	0.00	4.05	0.00	2.43
ET026 Printed circuits	2.12	0.00	0.00	0.00	1.99	0.00	1.04
ET027 Circuit apparatus exceeding 1000V	5.44	1.53	1.51	1.61	3.13	1.63	2.44
ET208 Circuit apparatus not exceeding 1000V	5.32	1.20	1.19	1.23	1.99	1.23	1.56
ET029 Circuit apparatus assemblies	4.56	1.39	1.34	1.53	2.09	1.39	1.65
ET030 Parts of circuit apparatus	5.18	2.79	2.50	2.38	3.43	2.13	2.64
ET031 Cathode-ray tubes	4.24	2.63	2.39	0.65	4.51	2.14	3.61
ET032 Electron tubes other than CRTs	4.94	2.24	2.07	2.87	2.57	2.46	2.52
ET033 Semi-conductors and integrated circuits	0.25	0.00	0.00	0.00	0.02	0.00	0.01
ET034 Miscellaneous electrical equipment	4.36	1.27	1.46	1.17	1.48	1.44	1.46
ET035 Computers, peripherals and parts	0.75	0.00	0.00	0.00	0.21	0.00	0.08
ET036 Photographic film and paper	3.90	2.84	2.49	2.58	3.29	2.56	3.03
ET037 Optical fibers, optical fiber bundles and cables	7.64	2.71	2.76	1.16	3.77	2.12	3.04
ET038 Optical goods including ophthalmic goods	7.74	2.46	2.51	2.55	4.74	2.53	3.67
ET039 Photographic cameras and equipment	4.15	1.07	0.90	0.97	2.44	0.89	2.06
ET040 Medical goods	5.92	0.08	0.07	0.07	2.00	0.06	0.70
ET041 Watches and clocks	9.19	5.23	5.52	4.59	6.36	5.06	5.81
ET042 Drawing, drafting and calculating instruments	5.20	4.23	4.16	3.77	5.99	3.94	5.16
ET043 Measuring, testing and controlling instruments	3.97	0.76	0.71	0.77	1.92	0.75	1.28
Total imports from the United States	**4.62**	**0.48**	**0.45**	**0.44**	**1.37**	**0.46**	**0.84**

Source: Author's calculations based on USITC (1991-2007)

Table 3: United States: Imports of PCs, peripherals										
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Value (US$ M)										
1 China	0	0	0	0	326	491	2,580	3,777	4,889	6,541
2 Malaysia	0	0	3	9	181	217	3,015	3,410	3,225	3,895
3 Mexico	0	0	0	0	242	215	2,168	3,578	4,237	5,755
4 Japan	132	109	107	127	2,162	2,365	11,788	13,487	12,395	12,808
5 Singapore	2	0	6	10	455	560	10,400	11,108	10,614	9,920
Rest of world	143	142	143	213	2,662	3,435	17,182	21,277	21,753	24,600
Total	**277**	**252**	**260**	**360**	**6,028**	**7,282**	**47,134**	**56,636**	**57,113**	**63,518**
Share (percentage)										
1 China	0.02	0.01	0.07	0.03	5.42	6.74	5.47	6.67	8.56	10.30
2 Malaysia	0.00	0.07	1.32	2.51	3.01	2.98	6.40	6.02	5.65	6.13
3 Mexico	0.01	0.06	0.04	0.09	4.01	2.95	4.60	6.32	7.42	9.06
4 Japan	47.66	43.35	41.16	35.32	35.86	32.48	25.01	23.81	21.70	20.16
5 Singapore	0.80	0.19	2.18	2.77	7.54	7.69	22.07	19.61	18.58	15.62
Rest of world	51.52	56.32	55.22	59.27	44.16	47.17	36.45	37.57	38.09	38.73
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Annual growth rate										
1 China	-	-53.28	853.22	-37.95	281,606.09	50.34	425.65	46.39	29.45	33.78
2 Malaysia	-	-	1,858.48	162.84	1,906.13	19.66	1,290.91	13.08	-5.41	20.76
3 Mexico	-	383.49	-27.52	194.10	72,973.20	-11.31	910.35	65.05	18.41	35.84
4 Japan	-	-17.36	-2.13	18.88	1,601.15	9.39	398.48	14.41	-8.10	3.34
5 Singapore	-	-78.42	1,089.57	75.94	4,454.38	23.24	1,756.69	6.80	-4.44	-6.54
Rest of world	-	-0.66	1.04	48.72	1,148.23	29.01	400.26	23.83	2.24	13.09
Total	**-**	**-9.14**	**3.06**	**38.54**	**1,575.32**	**20.79**	**547.28**	**20.16**	**0.84**	**11.21**
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**1990-2000**	**2001-2006**	**1990-2006**
Value (USUS$ M)										
1 China	8,956	10,550	14,953	22,167	34,019	40,369	46,614	27,560	168,673	196,233
2 Malaysia	4,925	7,342	9,084	9,982	11,171	12,657	14,598	18,880	64,835	83,715
3 Mexico	7,171	10,352	8,914	7,646	7,795	7,164	7,053	23,366	48,925	72,290
4 Japan	13,539	10,176	8,730	6,986	6,810	6,555	6,649	69,019	45,904	114,923
5 Singapore	8,668	7,901	7,631	7,323	7,080	6,348	6,074	51,743	42,356	94,099
Rest of world	27,813	28,178	26,539	23,102	22,663	21,159	21,464	119,363	143,105	262,468
Total	71,071	74,499	75,852	77,206	89,539	94,251	102,452	309,930	513,798	823,728
Share (percentage)										
1 China	12.60	14.16	19.71	28.71	37.99	42.83	45.50	8.89	32.83	23.82
2 Malaysia	6.93	9.86	11.98	12.93	12.48	13.43	14.25	6.09	12.62	10.16
3 Mexico	10.09	13.90	11.75	9.90	8.71	7.60	6.88	7.54	9.52	8.78
4 Japan	19.05	13.66	11.51	9.05	7.61	6.95	6.49	22.27	8.93	13.95
5 Singapore	12.20	10.61	10.06	9.48	7.91	6.73	5.93	16.70	8.24	11.42
Rest of world	39.13	37.82	34.99	29.92	25.31	22.45	20.95	38.51	27.85	31.86
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Annual growth rate										
1 China	36.93	17.79	41.74	48.25	53.47	18.67	15.47	241.16	28.10	138.71
2 Malaysia	26.44	49.09	23.73	9.88	11.91	13.30	15.34	-	12.14	112.82
3 Mexico	24.60	44.37	-13.89	-14.23	1.95	-8.10	-1.54	242.67	-6.20	115.70
4 Japan	5.71	-24.84	-14.21	-19.98	-2.51	-3.75	1.43	58.87	-6.85	27.75
5 Singapore	-12.63	-8.84	-3.42	-4.04	-3.31	-10.35	-4.31	128.74	-4.29	64.04
Rest of world	13.06	1.31	-5.82	-12.95	-1.90	-6.63	1.44	69.41	-4.44	36.79
Total	11.89	4.82	1.82	1.79	15.97	5.26	8.70	74.13	5.45	44.70
Source: Author, based on United States merchandise imports (1991-2007)										

Table 4 shows some of the main features of Mexico's electronics sector, namely:

– The sector accounted for its highest share in GDP in 2000 – with 4.38 % – and has fallen since then to levels below 4 % of Mexico's GDP. In terms of employment, however, the sector lost more than 25 % during 2000–2004. Today it accounts for almost 0.9 % of Mexico's total formal employment.

– Although the gap has narrowed since the 1990s, jobs in electronics pay higher wages than in the rest of the Mexican economy. This gap was over 50 % in the 1990s and still remains at 40 % above Mexico's average wage since 2000.

– Historically labor productivity in electronics has been much higher than in the rest of the Mexican economy. Since 2000, a strong restructuring process with substantial job losses has led to labor productivity in electronics more than six times higher than in the rest of the economy.

– In the period 1988–2004, electronics was one of the most successful trade cases, particularly up to 2000. Today it accounts for almost 20 % of Mexico's imports and exports and its respective share has fallen since 2000.

– Rather surprisingly – but consistent with the structure of temporary imports for re-exportation (Dussel Peters 2008a) – electronics generates a significant trade deficit for Mexico. It accounted for a ratio of trade balance/GDP of over 15 % in some years in the 1990s but this has fallen to levels below 10 % with the crisis since 2000. From this point of view, electronics reflects a similar structure to the most dynamic processes of Mexico's export orientation, i.e. a need for massive imports of parts and components in order to export finished products.

The previously mentioned "*crisis*" in Mexico's manufacturing, electronics and PC sectors is still continuing in 2007 in terms of employment, although exports and GDP have been relatively stable since 2004 after a strong fall in 2001–2003. In April 2007 employment in manufacturing, electronics and PCs still only reached 90.6 %, 93.6 % and 91.5 % of the level seen at the start of North American Free Trade Agreement (NAFTA) (January of 1994) and 85.8 %, 78.5 % and 36.1 % compared to the peak levels in November of 2000, respectively. In other words one of the most successful sectors in integrating with the US economy since NAFTA in terms of trade and productivity has not only failed to generate employment, but has expelled labor power.

Table 4: Selected economic variables of Mexico's electronics sector (1988–2004)

	1988	1989	1990	1991	1992	1993	1994	1995
GDP electronics (1988=100)	100.00	112.79	137.17	135.54	139.65	152.07	207.67	271.74
GDP total (1988=100)	100.00	105.06	111.09	116.51	121.40	123.90	130.64	123.38
GDP electronics (total = 100)	1.55	1.65	1.70	1.52	1.43	1.44	1.72	2.93
Employment in electronics	158,870	163,563	172,512	175,675	176,097	183,609	192,065	196,707
Employment in electronics (1988=100)	100.00	102.95	108.59	110.58	110.84	115.57	120.89	123.82
Employment in total economy (1988=100)	100.00	102.88	107.84	111.03	112.84	114.11	117.02	113.62
Employment in electronics (total=100)	0.66	0.66	0.66	0.66	0.65	0.67	0.68	0.72
Wages per worker in electronics (total=100)	155.00	168.10	164.66	152.94	141.81	131.28	131.87	140.44
Labor productivity in electronics (1988=100)	100.00	109.55	126.32	122.57	125.99	131.58	171.78	219.47
Labor productivity in electronics (total=100)	178.30	191.28	218.64	208.26	208.80	216.07	274.34	360.36
Including maquiladora industry								
Imports in electronics (1988=100)	100	110.33	137.72	150.72	172.38	179.35	244.80	292.54
Imports, total (1988=100)	100.00	117.92	140.29	165.74	202.74	207.95	257.61	222.67
Imports in electronics (total=100)	14.33	14.40	14.43	13.95	13.19	13.36	13.87	18.08
Imports / GDP, electronics (percentage)	88.04	88.23	89.18	97.00	103.85	98.79	98.18	93.79
Imports / GDP, total (percentage)	9.52	10.12	10.47	10.54	11.28	10.68	12.17	15.20
Exports in electronics (1988=100)	100.00	110.84	132.97	130.65	135.76	145.94	210.15	310.73
Exports, total (1988=100)	100.00	104.37	111.47	118.82	126.53	138.76	166.46	219.28
Exports in electronics (total=100)	11.62	12.71	12.85	13.39	13.49	13.51	14.78	15.65
Exports / GDP in electronics (percentage)	75.00	75.37	74.36	76.38	76.06	76.35	77.52	86.67
Exports / GDP, total (percentage)	10.00	9.80	9.81	8.64	8.08	8.16	9.02	16.24
Trade balance / GDP, electronics (percentage)	-13.03	-12.86	-14.82	-20.62	-27.80	-22.44	-20.65	-7.12
Trade balance / GDP, total (percentage)	0.48	-0.32	-0.67	-1.89	-3.20	-2.52	-3.15	1.03

Table 4: Selected economic variables of Mexico's electronics sector (1988-2004) (cont.)								
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2003**	**2004**
GDP electronics (1988=100)	359.89	462.38	571.36	692.31	895.25	849.00	874.53	1031.36
GDP total (1988=100)	131.45	141.89	150.86	158.50	171.29	169.78	174.30	183.23
GDP electronics (total = 100)	3.24	3.64	3.99	4.12	4.38	3.97	3.69	3.92
Employment in electronics	226,000	270,756	305,080	330,907	384,248	346,140	280,790	286,592
Employment in electronics (1988=100)	142.25	170.43	192.03	208.29	241.86	217.88	176.74	180.39
Employment in total economy (1988=100)	117.45	121.92	127.28	130.30	132.98	132.23	131.72	133.69
Employment in electronics (total=100)	0.80	0.92	1.00	1.06	1.20	1.09	0.89	0.89
Wages per worker in electronics (total=100)	142.03	139.97	140.66	139.82	138.72	144.48	140.90	136.80
Labor productivity in electronics (1988=100)	252.99	271.31	297.54	332.38	370.15	389.67	494.81	571.73
Labor productivity in electronics (total=100)	403.05	415.69	447.57	487.22	512.40	541.12	666.75	743.81
Including maquiladora industry								
Imports in electronics (1988=100)	412.97	538.25	649.41	801.35	1059.39	1003.55	1029.07	1251.81
Imports, total (1988=100)	277.34	343.93	404.99	463.28	563.89	553.92	565.20	634.13
Imports in electronics (total=100)	19.48	21.02	20.80	22.05	23.55	22.12	20.76	21.80
Imports / GDP, electronics (percentage)	101.04	100.09	97.80	99.55	102.99	97.86	98.95	105.38
Imports / GDP, total (percentage)	16.81	17.34	18.75	18.59	19.15	17.57	17.59	18.93
Exports in electronics (1988=100)	426.22	524.41	633.74	787.28	1032.05	992.27	1055.84	1256.67
Exports, total (1988=100)	264.52	297.23	334.86	380.29	444.76	432.58	453.35	507.42
Exports in electronics (total=100)	16.14	18.08	19.46	20.49	21.92	22.18	20.76	21.32
Exports / GDP in electronics (percentage)	87.23	83.82	83.06	86.10	88.48	89.80	93.03	95.41
Exports / GDP, total (percentage)	17.52	16.88	17.02	17.31	17.68	16.08	16.53	17.53
Trade balance / GDP, electronics (percentage)	-13.81	-16.27	-14.74	-13.45	-14.52	-8.06	-5.92	-9.97
Trade balance / GDP, total (percentage)	0.71	-0.46	-1.74	-1.29	-1.47	-1.49	-1.05	-1.40
Source: Author, based on INEGI (SCN) a: Refers to branch 54 (Electronic equipment)								

The Electronics and PC Industries in Jalisco

In the last ten years a number of studies have analyzed the performance, opportunities and challenges of Jalisco's electronics and PC industries.[14] Some key features highlighted in these studies are that:

– Foreign direct investment (FDI) has been the main – practically the only – engine of growth of the chain since its beginnings in the 1970s.

– A relatively small number of firms (both OEMs and CMs) led the growth of Jalisco's electronics cluster, particularly HP, Motorola, Siemens and IBM, as well as others such as SCI-Systems, Solectron, Jabil, and Flextronics. According to official information (CADELEC 2007a) the cluster is currently made up of 12 OEMs including ATR, Pegasus, IBM, Hitachi, Kodak, BDT, Intel, Technicolor, Siemens-VDO, among others; 13 CMs such as Flextronics, Yamaver, Solectron, Jabil, Sanmina-SCI, Foxconn, Telect, USI, Loganmex and Benchmark Electronics; 31 design centers including Freescale, Jabil, Flextronics, Mixbaal, Mexikor, Resser, CTS/CINVESTAV and Intel GDC; and more than 300 specialized suppliers.

– In 2001–2002 the cluster faced a serious crisis as a result of the processes and products it was specializing in, competition from Asia and the sector's global difficulties.

– In spite of these tendencies there has been little research on developments after the crisis of 2001–2003/2004.

Independently of this performance there has been an ongoing debate since the mid-1990s, over the degree of territorial endogeneity of the cluster in terms of its integration with local and national firms, diffusion of technology, territorial absorption capabilities and the scale and quality of employment, particularly regarding the supplying tiers of the cluster.[15]

Two recent trends have been established as a result of research carried out in 2007 (see Table 5; CADELEC 2007a, 2007b):

– It holds almost two thirds of Jalisco's exports and more than 50 % of Jalisco's FDI; in addition, employment presented a 30.6 % AAGR during 1996–2000.[16]

– There is a clear division into two periods: a) 1990-2000, the "*boom period*" of the cluster, and b) 2001-2006, which includes a profound crisis during 2001-2003/2004 and a recovery since then. In terms of employment and exports, electronics accounted for 89.5 % in 2006 and peaked at 121 % in 2000. As a result, productivity per worker has surged and in 2006 it was at 135.2 % of its 2000 level.

In this context, what have been the most relevant findings of the interviews conducted in July 2007, especially considering the relationship with China in the PCs industry?[17]

– Jalisco's electronics cluster is going through a substantial change that has not yet been sufficiently analyzed by Cadena Productiva de la Electrónica (CADELEC), or by the local and federal governments or researchers. The main change, in contrast to the 1994-2000 boom period and the later crisis, is that its recovery has included substantial new sectors and firms that did not exist earlier: firms in medical appliances, aeronautics, multimedia, movies and software. Firms such as Tata, Hydra Technologies de México, Metacube, Wipro, Infosys, Freescale and CTS/CINVESTAV and more than 150 software firms (CADELEC 2007c) are today – together with previously existing hardware firms – creating a new boom (Chávez 2007) in terms of employment, investment, new technology and performance. While the sector has to be examined in much greater depth in the future in terms of FDI, employment, productivity, territorial absorption capabilities and transfer of knowledge, it is undoubtedly the case that these firms, in addition to changes in the more traditional *"hardware"* firms, have substantially changed the situation of Guadalajara's electronics cluster: services, design, call centers, development of systems, software in general and logistics are reshaping it in contrast to the period at the start of the boom of 1994-2000 (Dussel Peters 1999).

14 For detailed analyses, see: Dussel Peters 1999, 2005a; Palacios Lara 2001; Woo 2001; Rivera Vargas 2002; Dussel Peters, Palacios Lara and Woo Gómez 2003; Partida Rocha and Moreno Badajós 2004; Padilla 2005; Dussel Peters, Galindo, Loría and Mortimore 2007; CADELEC 2007a, 2007b, among others.

15 Jalisco has also been one of the most successful cases in Mexico in terms of institutional cooperation among local and federal, private and public institutions to promote the cluster. For an analysis, see: COECYT 2007; Dussel Peters, Galindo, Loría and Mortimore 2007.

16 The concentration of electronics exports was considerable in 2007: just six firms accounted for over 90 % of electronics exports (according to one interviewed institution), similar to levels in the second half of the 1990s (Dussel Peters 1999).

17 Twelve interviews were conducted in Jalisco from July 16th to July 18th, 2007, including eight with OEMs and CMs,. In the last ten years more than 100 firms, in many cases the same firms have been interviewed.

– A major transformation that has taken place within electronics firms since the end of the 1990s – and has probably not been sufficiently examined so far – has transformed them from regional (within NAFTA) and international firms into global firms. Whereas in the late 1990s in many of them (as highlighted by two of the interviewed firms), different international plants still competed for specific projects, in recent years they have become truly global, i.e. their respective plants have specialized in specific products and processes such as logistics, product tracking, global programming and shipping. This is important in terms of understanding the relative stabilization of the 2001-2003 crisis in Jalisco and the creation of new conditions of competition within firms between Jalisco (and Mexico) and China.

– The latter issue is important to understanding the reconfiguration of the cluster in terms of FDI and jobs, as discussed earlier, since employment and exports for 2000-2007 are not comparable in many cases: before 2000 most jobs were in manufacture on production lines and, while this is still true for many, if not most, thousands of new jobs in these new firms represent qualitatively different jobs and technological levels, i.e. "one job is not equal to another job" if comparing 1994 with 2007.

– Acknowledging the above process, in terms of employment and FDI the more traditional electronics firms – OEM, CMs and the rest of the tier related to hardware – still represent at least 85 % of employment in the cluster, according to our calculations. It is important not to overestimate the new activities that have been generated recently and the previously described boom. What have been the main changes and issues for the cluster since the crisis of 2001-2003? Several issues emerged during the interviews:

– With the exception of one firm, the core of Jalisco's electronics industry up until 2000 (i.e. PCs in a broader sense, including personal computers, laptops and peripherals) has shifted and disappeared from Jalisco. Firms such as IBM, HP, Solectron, Jabil, among others, have transferred their production lines on a major scale to Asia and particularly to China.[18]

Table 5: Electronics in Jalisco: Selected variables (1996-2006)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	1996 -2000	2001 - 2006
Total exports	5,045	6,508	7,757	12,274	14,702	15,661	16,248	14,365	14,766	15,966	18,545	-	-
Electronics exports	3,500	5,200	6,400	9,030	9,860	10,529	9,976	7,872	10,250	10,500	11,933	-	-
FDI electronics	370	377	742	611	472	311	228	209	63	147	375	-	-
Electronics employment	26,336	46,100	52,528	65,684	76,666	48,028	47,813	45,877	51,601	60,890	68,605	-	-
IMSS	14,631	25,611	29,182	36,491	42,592	26,682	26,563	25,487	28,667	33,828	38,443	-	-
Subcontracted	11,705	20,489	23,346	29,193	34,074	21,346	21,250	20,390	22,934	27,062	30,162	-	-
Electronics exports (percentage over total)	69.38	79.90	82.51	73.57	67.07	67.23	61.40	54.80	69.42	65.76	64.35	73.43	63.90
Electronics employment (IMSS/ total)	55.56	55.56	55.56	55.56	55.56	55.56	55.56	55.56	55.56	55.56	56.04	55.56	55.66
Total exports (growth rate)	-	29.0	19.2	58.2	19.8	6.5	3.7	-11.6	2.8	8.1	16.2	30.7	3.4
Electronics exports (growth rate)	-	48.6	23.1	41.1	9.2	6.8	-5.3	-21.1	30.2	2.4	13.6	29.6	2.5
FDI electronics (growth rate)	-	1.9	96.8	-17.7	-22.7	-34.1	-26.7	-8.3	-69.9	133.3	155.1	6.3	3.8
Electronics employment (growth rate)	-	75.0	13.9	25.0	16.7	-37.4	-0.4	-4.0	12.5	18.0	12.7	30.6	7.4

Source: Author, based on Cadelec (2007c)

18 Dussel Peters 2005a and Palacios Lara 2004, among others, provide a detailed discussion of projects, processes and firms in Jalisco that transferred to China during 2001-2003, losing around US$500 M in investments and more than 45,000 jobs in the electronics industry during that period in Jalisco alone.

– This fact reflects dramatic changes in the cluster over a rather short period of time (since 2001) in terms of changes within firms (for example for the major OEMs and CMs), the disappearance of others (such as On Semiconductors/ Motorola and Hitachi in 2007–2008), and the emergence of new firms and sectors mentioned above.

– Probably the most significant evidence of change within firms, known in the cluster as a shift from high-volume to high-value, is in the number of products that firms use and produce. According to one major CM, in the period 2002–2004 the number of active assemblies and active components increased from 242 and 8,277 to 3,684 and 40,810, respectively. Another major vendor of electronic parts and semiconductors stressed a change from less than 400 products to more than 4,000 between 2001 and 2007. In addition, a second major CM established in Jalisco grew from less than 10 mass-produced products to 100 products produced in parallel today, as well as tripling the number of clients. These trends highlight the profound changes that have taken place within the firms that were able to survive the process since 2001: massive reorganization of plant-level organization from assembly line production to modules that allow each worker to produce the full final product, thus permitting an extreme degree of flexibility[19]; significant massive learning processes in handling more parts and components in terms of logistics (a topic discussed later in terms of vendors), and a real diversification of processes, products, and also of clients.

– What concrete results have there been in the PC industry in Jalisco since 2001? In a broad sense, the PC industry has been the basis of the cluster since the 1990s, as has already been examined; but these products have practically disappeared today. In 2007 only one Asian firm assembled 20,000-30,000 PCs for a major OEM, and another Chinese firm assembled PCs in Ciudad Juárez. Interestingly, both Asian firms – one Chinese and one Taiwanese – import "*vanilla*" PCs[20] from China and allow for the final configuration in Mexico. As stressed by one of these firms, it is expected that these processes, including imports of parts and components, configuration, testing and delivery to its client in Jalisco, will continue. As a result of changing conditions compared to 1994 – NAFTA and the homogenization of tariffs and Mexico's increasing overvaluation – as well as the overall superiority of China, the PC sector does not have a future in Jalisco with the exception of the existing volumes, processes and firms, i.e. on a very minor scale and only for the final configuration to be sold in the US. Even in the case of the Taiwanese firm in Jalisco it is interesting to note that the number of orders or specific configurations has increased by more than 200 % during 2003–2007, indicating that increasing flexibility is also important in this case. According to another major OEM, Jalisco's presence in the PC sector might also increase in the next two years, particularly in BTO (build-to-order) and CTO (configure-to-order) processes.

– What role has China played in this process since 2001? In general terms, Asia and China profoundly questioned Mexico's NAFTA integration process in electronics, which was based on the assembly of imported parts and components by cheap labor power. In addition to specialization in commodities – the previously mentioned vanillas – other conjunctural issues such as low tariffs and undervaluation of the peso were significant (especially in 1994–1995). When China joined the World Trade Organization (WTO) in 2001 it not only offered cheaper labor power and better production conditions than Mexico but also a battery of instruments to attract FDI (Dussel Peters 2005b)[21] and a significant domestic market, in contrast to most of Latin America and Mexico. Also as a result of China's increasing global presence, all the firms in the chain required presence in China because of global pressures and its massively increasing domestic market. Thus, China emerged as a major manufacturer and exporter as a result of its accession to the WTO, major endogenous efforts to attract FDI and produce parts and components in China (for example semiconductors on a major scale), and the strategic decision of major OEMs and CMs to benefit from China's incentives and domestic market. As a result, China has been, without doubt, a considerable challenge for Jalisco's electronics cluster since 2001. In these terms, what were some of the relevant opinions of the interviewed firms?

– China has been an important player, but not the only one – Malaysia, Korea, Thailand and Hungary, among others, are also significant and not that well-known, according to the specific segment – in explaining the crisis of 2001–2003; and China was still, in 2007, a major pressure on operations and plants in Jalisco.[22]

– Developments within Mexico and Jalisco are at least as important as China's presence in understanding the 2001–2003 crisis. The real exchange rate in Mexico became overvalued. Firms in the sector grew accustomed to massive orders from a small number of clients. There was practically no domestic (local or national) integration and little upgrading in the sector. Thus the main problems of competitiveness in the electronics sector in Jalisco were both external and endogenous.

19 Another major CM outlined that these changes allowed for incoming orders in the morning, thus defining the number of workers in specific modules and shipping the products to the US the same afternoon, i.e. substantial investments in the form of plants and training needed for these extreme levels of flexibility.

20 Refers to standardized products without any specific features that allow for the final configuration of the PC according to the client's requirements.

21 These topics came up in several interviews: specific instruments developed by the central government in China, but particularly incentives developed by cities and local governments for attracting FDI in electronics, among other sectors, that were considered to be high-tech.

22 Table 14 only includes the top five PC exporters of to the US, but Singapore, Korea, Philippines, Thailand and Hungary are the 6th to 9th most important exporters to the US.

– While practically all the firms established in Jalisco – from OEMs to Original Design Manufacturers (ODMs), CMs and the rest of the tiers, with the exception of smaller domestic and local firms – transferred and closed PC related production lines and products, from PCs to laptops, printers and peripherals linked to these products, to China. A small number of these products and processes have returned to Mexico since 2004–2005.

– The latter development (according to the firm interviews) is the result of a learning process within firms. On the one hand, China has been proven to have severe difficulties in aspects such as delivery on time, supply of specialized labor (such as middle and high-level engineers) and other aspects such as customs and corruption in several segments of the chain. Logistics and distribution problems have also increased skepticism, particularly over quality. The increased volume of imports and exports have, in many cases, resulted in a worsening of the price and quality of services in customs, ports, airports and delivery time, while increasing labor costs also diminished enthusiasm in these firms and contributed to problems with the quality of the final goods.[23]

– As a result, a new configuration has arisen (and is still developing) in electronics production for the North American market. While China is specializing in vanilla products and mass-production, Mexico and Jalisco are increasingly specializing in two segments: in the final configuration of both goods and services and in segments with high value-added that require rapid delivery to the market. As a result, delivery time to market, transport costs[24] and proximity to suppliers and customers are the key factors in most of Jalisco's recent specialization in electronics.

– To understand Jalisco's profound restructuring since 2001–2003 it is important to understand the new role and weight of global vendors and distribution centers – firms such a Arrows, Avnet and, to a certain extent, Federal Express – that have substantially increased their activities in Jalisco. Their core business is buying products from producers for CMs and OEMs as a result of their ability in creating economies of scale and achieving lower prices. These firms, however, have increased their share in total sales in the electronics cluster in Jalisco from less than 1 %–2 % in 2001 to around 10 %–12 % in 2007. The increasing presence of these firms is a result of two tendencies: a) the increasing complexity of handling more parts, components and products by OEMs and CMs – and thus the importance of logistics – as has been discussed; b) the fact that these firms specialize not only strictly in trading commodities but also increasingly in processes that were historically typical of CMs,[25] for example simple programming of semiconductors and storage functions; and c) as was the case in the period prior to the crisis beginning in 1994 (Dussel Peters 1999), despite recent restructuring, the weakest segment of Jalisco's electronics clusters is still its domestic (local and national) suppliers. Highlighting the new engines of growth in the cluster, the lack of domestic supply was considered by several of the interviewed firms as the main limitation of the current cluster; one of the interviewed firms spoke of a "*ship without anchor*". Today, the challenges for domestic integration are much greater than in the past: if domestic integration was difficult in previous mass-production processes, the tasks today are even more complex, and firms below the CM-tiers had the greatest difficulty in adjusting to the crisis. The challenges regarding the shift to low volume-high value require massive investments in logistics, knowledge, training and sharing information with clients regarding future products and processes. On the other hand, the potential benefits of including suppliers for the analyzed CMs and vendors are substantial, particularly considering the high degree of complexity and requirements of new products and processes in Jalisco.

– From this perspective, what are the main possibilities for Jalisco's electronics cluster in the medium term? According to the interviews there is a general consensus that the new engines of growth will continue increasing their share in terms of high quality employment – at least higher than in the period based on assembly line employment – and potential integration with the local economy. Second, there are possibilities for OEMs and CMs and the rest of the hardware tier, in products that are competitive with Asia and China in terms of delivery time and transportation costs (such as servers and racks, for example). In terms of exports and employment this segment will still be the main segment, but with a falling share in the next years. Third, products that are either at the start of their lifecycle, and thus require fast delivery and also rapid interaction with the OEM and the possibility of sending personnel from the US,[26] or those with a short lifecycle with a high profitability over a few weeks.[27] And, fourth, Mexico can become one of the main – if not the major – recipients of huge transfers of electronics plants from the US, as discussed in the previous section.[28]

23 One of the interviewed firms highlighted the importance of hidden costs in China, including time zones; travel costs and transportation costs for specific projects – concretely for personnel flying between China and the US – were above 10 % of the project estimates and resulted in non-profiting projects.

24 The issue of transportation costs in the NAFTA region, and compared to other regions and specifically with China, is of great relevance. For a detailed analysis, see Dussel Peters (2008b).

25 According to one of these firms, the concept of services supplied by these firms has changed significantly in the last years and they have also upgraded to programming centers in terms of logistics, services and commodities.

26 One of the interviewed firms – related to electronics and autoparts – explained the important benefit of geographic proximity and working in a similar time-zone (contrary to China and Asia): communication and fast exchange would have otherwise been extremely difficult with Asia. The person in charge of this new production line – in several cases – had had to stay awake throughout the night in earlier projects to be in touch with counterparts in Asia.

27 Specific products such as games and gadgets related to festivities or other events such as the Super Bowl, in which OEMs and clients have to react quickly at short notice, are examples of these short-notice, highly profitable products that cannot be made in Asia and China as a result of the long time taken to begin projects, according to these firms.

28 One of the interviewed CMs stressed that in the near future more then 100 US electronics plants will be transferred, either to Asia or to other sites globally.

The learning process of the crisis and the recovery since then is clear: firms and local and national institutions have to go beyond manufacturing processes with small margins and diversify in terms of suppliers and especially clients. This has happened in some cases, for example a major interviewed CM increased its clients from 4 in 2001 to 18 in 2007. Diversification of products and processes has also been significant, as discussed above for particular firms. Other topics such as security are relevant to transaction costs.[29] The high rotation of workers – up to 3 % monthly, according to several of the interviewed firms – still acts as an important disincentive to training in the region.

Nevertheless, two issues are most critical for the future of the cluster. First, the lack of domestic suppliers; this is practically disregarded at present, with the exception of CADELEC and Consejo Estatal de Ciencia y Tecnología de Jalisco (COECYT). The topic is, however, fundamental according to the interviewed firms. Second, and related to the first issue, private and public firms, as well as education institutions, have to increase their investments in Jalisco. While a significant shift has taken place in Jalisco's cluster, great challenges have appeared. These include the lack of engineers, with new firms such as Tata requiring more than 500 engineers and not finding them in the region, and a lack of incentives compared to Asia and particularly China. At a national level, according to the interviewed firms and institutions, it is necessary to improve infrastructure and gain advantages against Long Beach because it is saturated and transport costs might account for more than 10 % of the cost of the final good. National incentive programs such as Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional (CINVESTAV), Programa para el Desarrollo de la Industria del Software (PROSOFT) and COECYT have been important and successful, but require more resources and specialized personnel.

Conclusions and Policy Proposals

Electronics and PC exports from Mexico to the US were one of the most successful cases of export-oriented industrialization in Mexico, particularly in the region of Jalisco, known as the Silicon Valley of the South. The core of the region's initial activities – PCs, including laptops, peripherals and other related products – had practically disappeared by 2007. The restructuring process of the electronics cluster started with its crisis in 2001–2003 and there has been further reorganization since. As discussed in detail, Asia, and particularly China, played a significant role in reshaping the global electronics chain and especially the assembly segments. After less than five years, today China supplies almost 50 % of US imports, and PC production in Jalisco is practically zero – with the exception of one Asian firm. With another Chinese exception in Ciudad Juárez, PC production and exports have been practically eliminated from Mexico in less than five years. The competition between the two countries in this specific sector could not be clearer.

The profound questioning of Mexico's export orientation and the crisis in this particular chain have been particularly fruitful in terms of experience and learning processes in Jalisco and its electronics chain, although not at a national level so far. In Jalisco most of the surviving firms in the cluster, after dramatic cuts in employment, exports and sales over several years, had to invest and reinvent themselves through reorganization of plants, massive training, new investment in R&D and by attracting new firms in sectors which are linked to electronics but go far beyond traditional hardware. While there is no guarantee that Jalisco's path will be sustainable in the medium term, it clearly shows the need for *"coompetition"* in terms of the cooperation of the public, private and educational sectors in Jalisco and the generation of new incentives and specific programs for the sector, as well as cooperation with medium and high-level educational institutions. In addition, many production lines and firms have returned from China to Jalisco. Lack of distribution and logistics capacity, corruption, increasing labor costs, training and the need not to *"put all the eggs in one basket"* (i.e. failure to diversify the manufacturing sources) have made Mexico and Jalisco attractive once more after several years.

Nevertheless, the electronics cluster, with practically no PC activities today or in the foreseeable future, is by no means guaranteed success. The overvaluation of the exchange rate, China's fast and rather successful upgrading process in many of the segments of the chain and its economies of scale, but also the lack of a domestic supplier system and preparation in Jalisco for the new growth engines will make it difficult to repeat the boom period of 1994-2000. Today, public and private institutions related to the old and new segments in Jalisco are clearly not interested in specific lessons from the crisis of the PC sector in 2001-2003 and prefer to focus on the new and more fashionable booming sectors, as in occurred 1994-2000.

In addition to the general conclusions about the economic and trade relationship between China and Mexico that have already been established, the electronics and PC cluster in Jalisco and its competition and restructuring allow for more concrete conclusions. On the one hand, it indicates the impressive advantages of China's production and export platforms compared to those of Mexico and Jalisco. In a rather brief period of time Jalisco's PC segment has disappeared almost completely, while at the firm level and particularly the institutional level, learning processes have been weak. This is of concern for the future of the new cluster in Jalisco and forthcoming experiences with China.

29 Several of the interviewed firms complained that major exported goods to the US had to be guarded and this was an unnecessary cost for the firm.

On the other hand, Jalisco's telecommunication and electronics clusters have been able to reconstruct and shift towards new activities, although not necessarily as a result of public or private strategies, but rather through the cluster's existing experience with global firms – OEMs and CMs – and microlevel restructuring. These experiences have been outstanding in terms of time, costs, training, defining new intrafirm and interfirm relationships, and finding advantages both at the intra- and interfirm levels compared with Asia and China. These experiences, without a doubt, require deepening and extension to other sectors in the future in order to generalize from the experience into overall policies.

In general terms, Jalisco's PC experience deepens the knowledge of China's profound impact on Mexico's specialization patterns in the last 20 years and the need for a long-term strategy which might allow for cooperation in some cases – as is the current case in this cluster – and competition. The latter has been the main characteristic of the bilateral relationship in this segment.

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