Industrial Policy and the Domestic Content of Mexico's Maquila Exports: A long-run perspective

Juan Carlos Castillo[a], Gaaitzen J. de Vries[b]

[a]UNU Merit, Maastricht (castillo@merit.unu.edu)

[b]Groningen Growth and Development Centre, Faculty of Economics and Business, University of Groningen (g.j.de.vries@rug.nl)

Abstract

This paper studies the domestic value added content of exports by Mexico's maquiladora (export-processing) firms during the period from 1981 to 2006. Initially the government viewed maquiladoras as mere providers of employment. This view and subsequent industrial policies shifted with the increasing outward orientation of Mexico in the late 1980s. The government started to promote the sourcing of intermediates from upstream Mexican firms and the technological upgrading within maquiladora firms. We combine a recently released input-output table for maquiladora industries with detailed longitudinal data to study whether observed patterns are related to changes in industrial policy. Over time, productivity and the share of skilled workers in maquiladoras increased only modestly. A long-run decline in aggregate domestic value added embodied in maquila exports, from 31 percent in 1981 to 21 percent in 2006, is largely explained by the falling domestic content within electrical machinery product manufacturing. Changes in the domestic content of exports appear mainly related to internal and external shocks and not to changes in the regulatory environment.

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1. Introduction

Mexico's export-processing firms belong to one of the oldest and largest international production networks in the world. The first export-processing firms (officially known as maquiladoras de exportación) were established during the 1960s. Maquiladoras were allowed to import material and equipment without paying tariffs. In combination with low wages, it was very attractive for multinational enterprises to set up an export-processing subsidiary in Mexico. Employment in maquiladoras increased from 0.12 million in 1980 to 1.2 million in 2006. Maquiladoras account for about 20 percent of Mexican manufacturing value added and about half of the country's exports in 2006 (Bergin et al. 2009).

In the 1960s and 70s, the emergence of export-processing firms was not in line with import substitution industrialization, which aimed at building a domestic industry behind high tariff walls. The government saw maquiladoras as necessary providers of employment along its Northern border with the United States due to the end of the *bracero* guest-worker program for temporary work of Mexicans in the U.S. (mainly seasonal work in agriculture). Over time, however, policy makers increasingly realized that maquiladoras not only provide jobs, but are also important for generating foreign currency and for the development of domestic firms that deliver inputs to these maquiladoras. As a result, various policies were put in place during the 1990s to stimulate the technological development of maquiladoras and to increase incentives for sourcing inputs locally (SECOFI, 1994; SECOFI, 1998). These policies aimed to increase the domestic content of maquila production and the creation of good (skilled) jobs. Did these changes in industrial policy have their intended effects? Do we observe an increase in domestic value added contributions to export processing firms? Did productivity and the quality of jobs improve within maquiladoras over time?

This paper is the first to study long-term trends in the domestic content of Mexico's maquila exports. We combine a recently released input-output table for maquiladora industries with detailed longitudinal data on value added, gross exports, employment by skill type, and domestic and imported intermediate inputs to relate observed patterns to changes in industrial policy. Maquiladoras in Mexico predominantly export finished goods (Verhoogen, 2008). This contrasts to a 'typical' firm, which might produce intermediate inputs for use by other firms or sell goods in the local market (and sometimes also the foreign market). In contrast, a maquila firm assembles a good and sells it in the United States.[1] We study whether these maquiladoras upgrade their activities (reflected in an increasing skill content and/or rise in productivity), and increasingly source intermediate inputs locally, which could signal the success of industrial policies in stimulating the

[1] Most imports are from the U.S., and over 99.7 percent of sales were in the U.S (Utar and Torres Ruiz, 2013).

development of the domestic economy.

Despite various industrial policies, we find that the share of domestic value added in aggregate maquila exports fell from about 31 percent in 1981 to about 21 percent in 2006. However, the domestic content share varies substantially over time. The 1982 debt crisis and the 1994 Tequila crisis together with the run-up and adoption of the North American Free Trade Agreement (NAFTA) during the early 1990s coincide with declines in the domestic content. The emergence of China, especially after its entry to the WTO in 2001, appears related to a gradual decline in the domestic value added of aggregate maquila exports. A decomposition analysis suggests that this is partly driven by the demise of textile manufacturing that has a relatively high domestic value added content. However, the overall long-run decline in the aggregate domestic value added embodied in maquila exports, is largely explained by the falling domestic content within electrical machinery product manufacturing.

Research that studies the export composition of Mexico using gross exports, typically finds that the technology composition of Mexico's exports increased substantially, because it transformed from one based on raw materials to one dominated by medium- and high-technology manufactured products during the past decades (Sturgeon and Gereffi, 2009). This suggests learning and industrial upgrading is taking place in Mexico. However, one needs to know the value that is added in production by a country, rather than the gross output value of its exports, which is the approach taken in this paper. So far, most analysis of the domestic content embodied in exports and technology upgrading within maquiladoras has been limited to surveys and case studies. These studies provide a rich characterization of maquila firms, but it is unclear whether these findings can be generalized. We aim to provide a macro perspective to these case studies. Our paper is therefore most closely related to de la Cruz et al. (2011).[2] De la Cruz et al. (2011) measure the domestic content of maquila exports for the period from 2000 to 2006, and compare the domestic content of processing exports to that of China's export processing firms. We extend their analysis of Mexican maquiladoras by providing a more detailed and long-run perspective.

The remainder of the paper is organized as follows. In the next section, we give an overview of industrial policies for the maquila industry from its inception in the 1960s until the merging of the program in a broader framework in 2006. We argue that industrial policy has changed considerably as time progressed, but there is little evidence to guide us whether these policies had

[2] See also Johnson and Noguera (2012) who separate the value added content of non-maquila and maquila exports for the year 2004. They find that the domestic value added content of maquila exports is much lower compared to non-maquila exports. This paper focuses on changes in the share of domestic content of maquila exports over time.

their intended effects. In section 3, we describe the construction of the data and provide a descriptive analysis of changes in the use of domestic intermediate inputs by maquiladoras, as well as productivity growth and the use of skilled workers within maquiladoras. We also examine changes in the industry composition from 1981 onwards. Section 4 discusses the estimation of time series input-output tables and describes the method to measure the domestic value added content of exports. Section 5 presents empirical results; returns to a discussion of industrial policies related to changes in the share of domestic content in maquila exports; and provides a decomposition of the change in the aggregate domestic content share of exports. Section 6 provides concluding remarks.

2. Industrial policy and Mexican maquiladoras: an overview

The maquiladora program was devised in the 1960s as an emergency program to cope with rising unemployment observed in the northern part of Mexico. Mexicans were pushed out of the United States due to end of the *bracero* guest-worker program in 1964. Initially, the maquila program was restrictive (Contreras, 2008). For example, firms were supposed to be located within 20 kilometers of the Mexican border; have a minimum national ownership of 51 percent; and they had the obligation of re-exporting their entire production. This restrictive legal framework was put in place, because the program was not in line with the Import Substitution Industrialization (ISI) policies prevailing in Mexico at the time. Providing tariff exemptions to manufacturing firms that are partly foreign owned was simply a policy contrary to the strategy of ISI. As a consequence of this ISI, the government of Mexico hardly implemented policies related to firms operating under the maquiladora program.

During the 1970s, several laws were passed that aimed to reduce unemployment, by permitting the creation of maquiladoras in coastal areas (in 1971), and soon thereafter for the entire Mexican territory (in 1972). Most maquiladoras remain along the Northern border of Mexico to avoid high transport costs. In addition, in 1977 a law was passed that allowed maquiladoras to be completely foreign owned (Urias, 1978). Few attempts were made to promote technological upgrading within maquilas and to increase the domestic content of production however. To the contrary, regulations implemented by the Mexican general Law on Foreign Investment in 1973, allowed the government to review and control the implementation of technologies in maquiladoras. Also, the government was able to prohibit any foreign firm or new plant from entry if it could harm

the national industry (González, 1990). These policies limited the possibility of industrial upgrading as it posed restrictions to the implementation of foreign technologies.

In the mid-1980s, as many Latin American countries (including Mexico) struggled with the debt crisis, Mexico's policies became more outward-oriented and various market-oriented reforms were implemented. A key policy change was Mexico joining the General Agreement on Tariffs and Trade (GATT) in 1985, which served as an initial push for domestic and international trade reforms during the upcoming years. Once this new economic model was established, major changes were seen in the legal framework for maquiladoras. The government recognized the potential of maquila firms as one of the drivers of the new export-led development in Mexico. According to new regulations that were passed in 1989 (see Government of Mexico, 1989), the maquiladora industry was now supposed to meet the following objectives: (1) to provide higher levels of employment; (2) to increase manufacturing exports and levels of foreign exchange; (3) to stimulate the development and transfer of knowledge and; (4) to promote investment in human capital through further integration with the local Mexican manufacturing industry.[3]

Various researchers have studied the effects of these new government objectives, but so far this has been restricted to selected sectors. For example, Wilson (1992) and Carrillo and Hualde (1997) study changes in the technology used in automotive and electronic manufacturing during the 1980s. They find that new technologies were typically introduced to obtain more precision, control and quality at labor-intensive activities. Hence, old machinery was replaced by technologically more sophisticated instruments that still needed a low qualified workforce to operate (Carrillo and Hualde, 1997). Also, more autonomous decision making was observed, but this remained restricted to issues such as recruitment and human resource management. Hardly ever did local managers participate in the selection of inputs or in the decision process of goods to be produced as most of the technical specifications came from abroad. Along the same lines, local management had little influence on investment, finance or production technology decisions (Wilson, 1992).

Output and employment expanded fast during the 1990s. And as we will describe below, the composition of output increasingly shifted towards the production of electronic and transport equipment goods. This growth was underpinned by legal changes that were in line with the liberalization of the economy. For instance, the new Law on Foreign Investment of 1990 represented a major relaxation of policies towards foreign direct investment relative to that of

[3] Also, maquiladoras were allowed to sell more of their produce in the Mexican market. However, INEGI (the national statistical office of Mexico) regularly carries out surveys, and consistently finds that maquiladoras sell less than 5% of their output domestically (Verhoogen, 2008).

1973, because it reduced uncertainty and allowed for long term planning of operations. This new regulation was thought to induce a change in current corporate strategies of foreign firms under the maquila program so that they could develop progressively more technologically complex activities in the country, moving away from the labor intensive ones (Carrillo, 2007). Along the same lines, import licensing continued to decline in importance and easier and faster administrative procedures were implemented.[4]

In 1994, the removal of trade and investment barriers in the North American Free Trade Agreement (NAFTA) gave rise to another boost of production by the maquila industry. This agreement increased the preferential access of maquiladoras to the US market due to the execution of the principles of national treatment and most-favored-nation (NAFTA Article 102). National treatment for goods means that once goods have been imported into any NAFTA member country, they will not be subject to tariff discrimination. Most-favored-nation treatment implied that the signatories of NAFTA have to extend trading benefits to each other equal to those accorded to any (that is, the most favoured) non-NAFTA country (Javorcik et al., 2008). In this context, non-NAFTA originated inputs had to pay Mexico's Most Favored Nation (MFN) tax, around 35 percent in 1994, while the intermediate goods originating in the NAFTA region could be imported free of duty. These new regulations created an important incentive for the production of parts and components in maquiladoras because the inputs eligible for the tariff exemption were not only those including pure NAFTA content, but also those from other regions that have been previously processed in Mexico.[5] In addition, with the NAFTA agreement, the benefits to maquila firms were extended to companies that supplied them goods and services thereby increasing the incentive for domestic firms to supply maquiladoras.

As a result of this changing economic environment in Mexico, maquiladoras started to introduce more technologically complex procedures. Buitelaar and Padilla (2000) argue that modern management systems were more commonly seen in maquiladoras, such as total quality control, just in time delivery, elaborate operation manuals as well as norms regarding

[4] At the same time, other export promoting programs for the manufacturing industry were implemented. In 1990, the "Programas de Importación Temporal para Producir Articulos de Exportación" (PITEX) came into effect with the intention of permitting firms to import intermediate inputs and machinery free of duty as long as 30% of their total sales were exported. The difference between the firms under PITEX and the maquiladora program lies in the fact that the industries under the latter program were exempted to a bigger amount of taxes. Similarly, unlike maquiladoras, PITEX firms were mainly located in the interior of Mexico as most of their production was destined for domestic consumption (de la Cruz et al., 2011).

[5] As of 2001, only North American inputs were exempted from tariffs. In order not to lose competitiveness, policy makers implemented a new program called "Sectoral Programmes" (PROSECs) that provided tax exemption to the import of a specific percentage of inputs not produced in North America across selected industries.

organizational culture and labor discipline. In addition, they find that more skilled workers were employed and they observe an increase in local R&D centers. However, these results are based on a case study and it remains to be seen whether technological upgrading is a general pattern.

A large contraction of output and employment in the maquiladora industry occurred during the early 2000s. This was in part due to the 2001 recession of the US economy with the collapse of the dot-come bubble, and in part due to the industrial emergence of China and its entry to the WTO in 2001. China's emergence has had a profound negative effect on maquiladoras. The reason for this negative effect is often sought in the similarity of the composition of US imports from Chinese and Mexican producers (Dussel Peters, 2005; Gallagher et al., 2008).

In light of increasing competition, the government of Mexico implemented more changes in the legal framework that aimed to induce an increasing number of maquiladoras to exit low-tech, labor intensive industries and evolve toward higher value added, technology intensive sectors (Sargent and Mathews, 2008). During the early 2000s, the government provided substantial tax incentives to maquiladora firms that engaged in research and development activities (R&D) and created a fund to promote Mexico's software industry (Ruiz Durán et al., 2005). State governments, industry chambers, and universities were also involved in the upgrading efforts. The branch of Mexico's largest private university system in Guadalajara established institutes designed to accelerate the development of design engineering centers, software development firms, and technology intensive startups in the city's cluster of electronics firms. The government in Mexico was especially interested in attracting new companies engaged in applied research, product and process development, product testing, and high-tech manufacturing in five industries; biotechnology, mechatronics, information technology, health, and nanotechnology (Sargent and Mathews, 2008).

In a nutshell, Mexico's industrial policy towards maquiladoras gradually shifted from viewing them as mere providers of employment towards promoting the sourcing of intermediates from upstream domestic firms and technological upgrading within maquiladora firms. In the next section we discuss the dataset to that will be used to analyze whether these policy changes had their intended effects.

3. Database construction and descriptive statistics for maquila industries

The dataset for detailed maquiladora manufacturing industries consists of longitudinal information on output (gross output and value added), gross exports, as well intermediate inputs and employment distinguished by production and non-production workers. This data is derived from

various publications by the statistical office (INEGI 1991, 2001, 2005). The data presented in these publications are based on the monthly statistical surveys for the maquiladora industry as well as the five-yearly economic census. The monthly sample survey of the maquiladora industry collects detailed information on the business operations of maquilas. The setup of the survey has not changed much during the period analyzed, and the economic census is a full census of economic activity that underpins this monthly survey. Data from 1990 to 2006 can be readily obtained from the national statistical office's website (www.inegi.org.mx), but to trace the development further back and to obtain more industry detail, we collected and digitized hard copies of various reports (notably INEGI 1991, 2001). Detailed industry data following Mexico's industry classification is matched to two digit industries in the International Standard Industrial Classification 3.1.[6]

After 2006, the maquiladora program was merged with another program that offers duty relief for temporary imports, the PITEX program (Programas de Importación Temporal para Producir Articulos de Exportación). As a result, the statistical office no longer updates information for maquiladoras. Information that includes the maquiladoras and other firms is reported in the monthly statistical report of the IMMEX program from 2006 onwards (Industria Manufacturera, Maquiladora, y de Servicio de Exportación). Since it is not possible to distinguish maquiladora firms in these reports, our time series stop in 2006. Also, from 2006 onwards specific policies for maquiladoras are no longer designed. Since we focus on the domestic content of maquila exports in this paper, we consider the period 1981 to 2006.[7]

Columns (1) – (4) of table 1 show gross output shares by industry for 1981, 1990, 2000, and 2006. Note that gross output equals exports for maquiladoras since we assume that everything produced is subsequently exported (this is further discussed in section 4). Changes in gross output shares reflect changes in the industry composition. Textile products, electronics, and transport equipment account for the majority of gross output, with the assembly of electronic goods by itself accounting for over halve of the gross production value.[8]

During the 1980s, transport equipment and miscellaneous manufacturing (including furniture, jewelry, musical instruments, sports goods and toy production) grew substantially faster as compared to other sectors such as textiles and electronics. The opposite pattern is observed for

[6] Our analysis starts in 1981 as we were unable to obtain industry level data further back. The Maquiladora program started in the 1960s, but it only started to boom with the increasing outward orientation of Mexico during the late 1980s (Feenstra and Hanson, 1996). We believe the time period included in this paper captures the most important periods in the history of the Maquiladora program.

[7] Note that we will measure direct and indirect domestic value added embodied in exports. Therefore a proper analysis that would update our work requires an input-output table for firms participating in the IMMEX program.

[8] "Business services" includes activities such as "professional services", "leisure services" and "other services". These services are provided by some maquiladoras (INEGI, 2010).

the 1990s. After 2000 we observe a sharp drop in the relative importance of textile manufacturing. This drop might be related to the entry of China to the WTO in 2001 and the end of the Multi-Fiber Agreement in 2004 that eliminated import quotas for textile products. Mexican textile firms faced relatively tough competition from Chinese firms thereafter. These import competition effects in the US market are likely to differ across industries, for example due to quality differences and transport costs, but also firm size within industries (Iacovone et al., 2013).

Changes in the relative size of sectors carry important implications for the composition of maquila exports and subsequently also for the domestic value added content of exports. In column (5) we report the share of domestic intermediate inputs in total intermediate inputs in 2006. The share of domestic intermediates varies substantially across industries. Food processing manufacturing is sourcing a lot of inputs domestically (37.9 percent in 2006) as fresh produce typically requires immediate processing. However, most inputs in the more technologically advanced electronics manufacturing sector are sourced from abroad. The domestic share is only 6.8 percent in 2006. The share of domestic inputs directly used in production reflects the direct domestic content of maquila exports. Hence, the relative decline of textile manufacturing with a high share of domestically produced intermediates and the relative expansion of electronics and transport equipment manufacturing with a low domestic content after 2000 suggests that the domestic content in aggregate exports declined. We will examine this more formally in section 5.

Table 1. Descriptive statistics, size and domestic input use maquiladora industries

	Gross output shares				Domestic intermediate use shares
	1981	1990	2000	2006	2006
	(1)	(2)	(3)	(4)	(5)
Food, Beverages and Tobacco	1.9	1.1	0.4	0.8	37.9
Textiles and Textile Products	15.5	7.4	12.0	7.4	16.0
Leather, Leather and Footwear	1.0	1.0	0.6	0.3	16.0
Pulp, Paper, Printing and Publishing	1.5	3.6	2.0	1.9	17.7
Chemicals and Chemical Products	-	0.3	0.2	0.2	35.1
Rubber and Plastics	2.3	1.6	2.2	3.1	22.9
Other Non-Metallic Minerals	0.4	0.6	0.7	1.9	10.5
Basic Metals and Fabricated Metal	2.4	3.1	3.1	3.2	21.4
Machinery	1.8	2.0	1.8	2.3	17.3
Electronics	55.3	45.9	52.9	53.0	6.8
Transport Equipment	11.4	22.5	16.5	17.2	14.2
Miscellaneous manufacturing	2.3	9.7	6.1	6.9	10.1
Business services	4.2	1.3	1.5	1.8	24.5
Total	100.0	100.0	100.0	100.0	10.9

Notes: Columns (1) – (4) show gross output shares in current prices by industry. Column (5) shows the share of domestic intermediate inputs in total intermediate inputs. Total refers to total maquila industries. Wood and Products of Wood and Cork is included in Pulp, Paper, Printing and Publishing manufacturing. *Sources*: INEGI (1991, 2001, 2005) and others, see text.

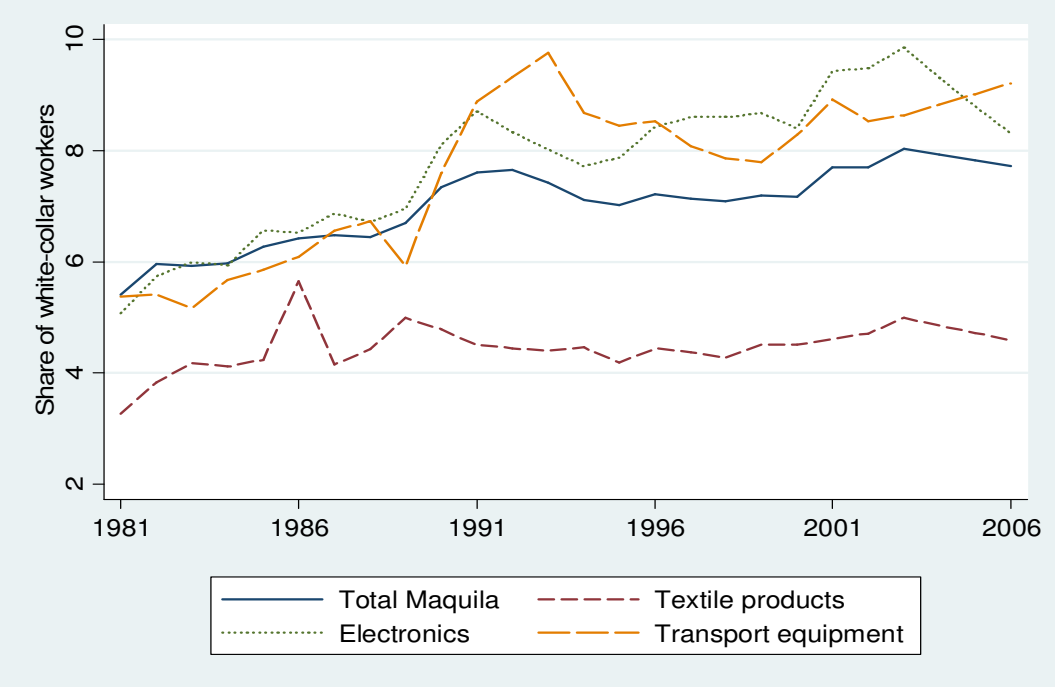
Figure 1 shows various indicators of technological development within maquila manufacturing industries. The top panel shows productivity growth for total manufacturing and the three largest sectors (textile, electronics, and transport equipment manufacturing). We divided real value added by persons engaged to measure labor productivity. Based on growth rates of labor productivity an index is constructed, which equals 1 in 1981. The overall trend suggests that productivity hardly improved during the period considered. In the final year, the index is slightly above 1, which suggests that long-term growth has been positive in the industries considered, but modest.

The dataset we constructed distinguishes between production workers and non-production

workers. Production workers mainly undertake manual tasks, whereas non-production workers mainly undertake managerial and administrative tasks (the so-called blue and white collar workers). The bottom panel of figure 1 shows the share of non-production workers in total persons engaged, which in a way reflects the quality of jobs. The figure reveals that more technology intensive sectors such as electronics and transport equipment manufacturing have a higher share of non-production workers compared to textile manufacturing. A slightly upward trend, though from low initial levels, can be observed.

Overall, however, the modest positive trend in labor productivity and the small increase in non-production workers suggest that technological development in the maquiladora industry has not advanced at a high pace. In the next sections we will study whether the domestic content of exports has increased. We first outline the input-output table and the method to determine the domestic content based on this table before turning to the empirical analysis.

Figure 1. Productivity growth and share of non-production workers, 1988-2004



Notes: The first panel shows productivity growth, which is based on the growth in real value added divided by persons engaged (the index equals 1 in 1981). The second panel shows the percentage share of non-production (white-collar) workers in total persons engaged. *Sources*: INEGI (1991, 2001, 2005) and others, see text.

Our preferred method (explained in the next section) to measure the direct and indirect domestic input content embodied in maquila exports requires an input-output table. INEGI recently released such a table for the maquila industry for the year 2003 (INEGI, 2010). Although total economy input-output tables are available for Mexico as well, the use of such tables would introduce a bias in the measured domestic content if the sourcing structure differs across maquiladora and non-maquiladora exporting firms. Dietzenbacher et al. (2012) show how this sourcing structure differs between processing and non-processing firms in China. We follow their approach because the sourcing structure is likely to differ for processing and non-processing firms in Mexico as well.

The maquiladora input-output table is constructed on the basis of a Supply and Use Table (SUT) at basic prices and additional assumptions concerning technology. To transform the SUT in an industry by industry Input Output Table (IOT), we use the so-called "fixed product-sales structure" assumption stating that each product has its own specific sales structure irrespective of the industry where it is produced. The sales structure assumption refers to the proportions of the output of the product in which it is sold to the respective intermediate and final users. This assumption is most widely used, not only because it is more realistic than its alternatives, but also

because it requires a relative simple mechanical procedure. Furthermore, it does not generate any negatives in the IOT that would require manual rebalancing (see Millar and Blair (2009) for further discussion).

In constructing the maquila SUT, INEGI relies on various internally and externally available statistical sources. The main source for production data is the Monthly Statistical Report for the Maquiladora Industry (EMIME in Spanish) undertaken by INEGI. This information is combined with the Foreign Trade Database prepared by the Central Bank of Mexico (BANXICO), which contains information on imported intermediate consumption. Trade margins (the difference between products valued at producer and purchasers' prices) are estimated from the 2004 Commercial Census. Gross value-added is the sum of the wage bill, net taxes on subsidies from production and the gross operating surplus. The "National Survey of Employment for 2003" prepared by INEGI in conjunction with EMIME was the underlying source of information for these data. For further details on the methods and sources, see INEGI (2010).

4. Methodology to measure the domestic content of exports over time

This section is divided in two parts. First, we outline a methodology to measure the domestic content of maquila exports. Second, we discuss a GRAS procedure to estimate time series input-output tables based on the expanded IOT for Mexico.

4.1 Measuring the domestic content of maquila exports

In measuring the domestic content of maquila exports, we will closely follow the approach in Dietzenbacher et al. (2012) and Yang et al. (2013), which itself is an adaptation to the methodology proposed in Hummels et al. (2001).[9] The main difference between the methodology in this paper and that in Dietzenbacher et al. (2012) is that we do not distinguish between industries producing for domestic use and industries producing non-processing exports. In our approach, these two are combined. We do not have enough information to separate these, and our focus is on the domestic content of maquila exports for which we do not need this distinction. In addition, we slightly alter the methodological exposition, because we aim to measure the domestic content of exports and not vertical specialization trade as in Dietzenbacher et al. (2012).

Consider n industries and let the matrix $\mathbf{Z}$ denote domestic inter-industry flows from industry i to industry j. The vector of exports is denoted by $\mathbf{e}$, the final demand vector by $\mathbf{f}$, the

[9] In fact, the methodology in Hummels et al. (2001) is a classic approach adopted from the development economics literature that used to measure the domestic content of exports (see e.g. Chenery et al., 1986).

vector of value added by **v**, the vector of industry gross outputs by **x**, and let **M** denote the import use matrix with a typical element m_{ij} the imports of industry *i* by industry *j*.

The domestic and imported intermediate input flows for both domestic and maquila industries can be depicted in an adaptation of the ordinary input-output table, see table 2. The framework is similar to an interregional Input-Output table, with two regions. In this table, the matrix $\mathbf{Z}^{DD}$ gives domestic industry deliveries to other domestic industries, whereas $\mathbf{Z}^{DP}$ gives domestic inter-industry flows to maquila industries. Likewise, the vector $\mathbf{v}^{D}$ gives value added generated in domestic industries whereas $\mathbf{v}^{P}$ gives value added in maquila (export-processing) industries.

Note that in the final use block shown in table 2, maquila firms are assumed not to deliver output for final demand ($\mathbf{f}^{P} = 0$). INEGI (the national statistical office of Mexico) regularly carries out surveys, and consistently finds that maquiladoras sell less than 5% of their output domestically (Verhoogen, 2008). In fact, some of these minor domestic sales of maquiladoras will end up as intermediate inputs for domestic firms (which would be in the matrix $\mathbf{Z}^{PD}$, also set to zero). We are unable to take these intermediate transactions into account and this will result in a bias in our estimates. However, given the typically low value of these transactions we presume this bias will not be large.

We therefore assume that everything is exported, so gross output of maquila firms equals gross exports. This is consistent with procedures at the statistical office INEGI, who give the estimates for the maquiladora industries that are compatible with the Mexican Balance of Payments. In the Mexican BOP, gross output equals gross exports and imported intermediate inputs equals the total value of maquila imports such that the difference is the maquiladora trade balance.

Table 2. Expanded input-output table for Mexico

	Intermediate use		Final use		
	D	*P*	*FD*	*EXP*	*TOT*
D	$\mathbf{Z}^{DD}$	$\mathbf{Z}^{DP}$	$\mathbf{f}^{D}$	$\mathbf{e}^{D}$	$\mathbf{x}^{D}$
P	0	0	0	$\mathbf{e}^{P}$	$\mathbf{x}^{P}$
IMP	$\mathbf{M}^{D}$	$\mathbf{M}^{P}$	$\mathbf{f}^{M}$	0	$\mathbf{x}^{M}$
VA	$(\mathbf{v}^{D})'$	$(\mathbf{v}^{P})'$			
TOT	$(\mathbf{x}^{D})'$	$(\mathbf{x}^{P})'$			

Notes: D = industries producing for domestic use; P = maquila industries (export processing); FD = final demand; EXP = exports; TOT = gross industry outputs (and total imports in the column TOT); IMP = imports; and VA = value added.

The direct requirements for domestic input *i* per unit of output *j* are given by $\mathbf{A^{DD}} = \mathbf{Z^{DD}}\,(\widehat{\boldsymbol{x^D}})^{-1}$ for domestic industries (with typical element $a_{ij}^{DD} = z_{ij}^{DD}/x_j^D$) and $\mathbf{A^{DP}} = \mathbf{Z^{DP}}\,(\widehat{\boldsymbol{x^P}})^{-1}$ for maquila industries.[10] Likewise, direct requirements for imported inputs are given by $\mathbf{B^D} = \mathbf{M^D}\,(\widehat{\boldsymbol{x^D}})^{-1}$ for domestic industries (with typical element $b_{ij}^{D} = m_{ij}^{D}/x_j^{D}$) and $\mathbf{B^P} = \mathbf{M^P}\,(\widehat{\boldsymbol{x^P}})^{-1}$ for maquila industries.

Production typically requires domestic and imported inputs. However, these inputs in turn also require domestic and imported inputs. The latter effects are indirect effects. The size of these indirect effects depends on the interrelatedness of production across industries and countries. To include both direct and indirect effects in an analysis of the domestic content of exports, we calculate the total effect using the Leontief inverse $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$ (Leontief, 1936), where **I** is the identity matrix, a diagonal matrix of ones. The partitioned form of the Leontief inverse can be written as follows

$$\boldsymbol{L} = \left(\begin{bmatrix} \boldsymbol{I} & 0 \\ 0 & \boldsymbol{I} \end{bmatrix} - \begin{bmatrix} \boldsymbol{A^{DD}} & \boldsymbol{A^{DP}} \\ 0 & 0 \end{bmatrix}\right)^{-1} = \begin{bmatrix} \boldsymbol{L^{DD}} & \boldsymbol{L^{DP}} \\ 0 & \boldsymbol{I} \end{bmatrix}$$

These can be used to calculate the domestic content of maquila exports. The total domestic content of aggregate exports is one minus a weighted average of the corresponding import multipliers, using maquila exports as weights, given by

$$DCE = 1 - \frac{\left(\boldsymbol{u'B^D L^{DP}} + \boldsymbol{u'B^P}\right)'\boldsymbol{e^P}}{\boldsymbol{u'e^P}}, \qquad (1)$$

where **u** is a summation vector consisting of ones, and a prime (e.g. **u**') indicates transposition. We will use equation (1) to calculate the Domestic Content of maquila Exports (DCE). In order to do so, we need a time series of the expanded input-output table as shown in table 2. The next subsection describes the estimation of time series expanded input-output tables.

[10] The circumflex indicates a diagonal matrix, in this case with the vector **x** on the main diagonal.

4.2. Construction of time series extended IOTs.

We use the Generalized RAS (G-RAS) procedure to estimate time series of the extended input-output table shown in table 2. The G-RAS method is developed in Junius and Oosterhaven (2003) and we apply the improved algorithm described in Lenzen et al. (2007).

Basically, the G-RAS procedure requires a benchmark input-output table, the domestic and maquila table for 2003 in our case, and row and columns sums for all years for which we would like to estimate IOTs. G-RAS estimates new IO matrices for all years under the constraints of the row and column sums as close as possible to the benchmark table. We implement this approach for the domestic and imported intermediate use blocks of the maquila and the domestic table (so for $\mathbf{Z}^{DD}$, $\mathbf{Z}^{DP}$, $\mathbf{M}^{D}$, and $\mathbf{M}^{P}$). That way we estimate a time series of domestic and imported intermediate use blocks from 1981 onwards.

While this approach allows us to project IOTs for non-benchmark years, an important limitation that we face is the absence of benchmark tables for earlier years. Our approach takes into account differences in the overall structure of the maquila and domestic industries, but if intermediates sourcing structures change substantially over time, these changes are not necessarily well accounted for.

5. The domestic content of maquila exports

In this section we describe the evolution of Mexico's value added contribution to maquila exports for the period from 1981 to 2006. In section 5.1 we document aggregate and industry trends. Subsequently we examine in section 5.2 whether changes in the aggregate trend are driven by changes within industries or by changes in the industry composition.

5.1 The domestic content of maquila exports: aggregate and industry trends

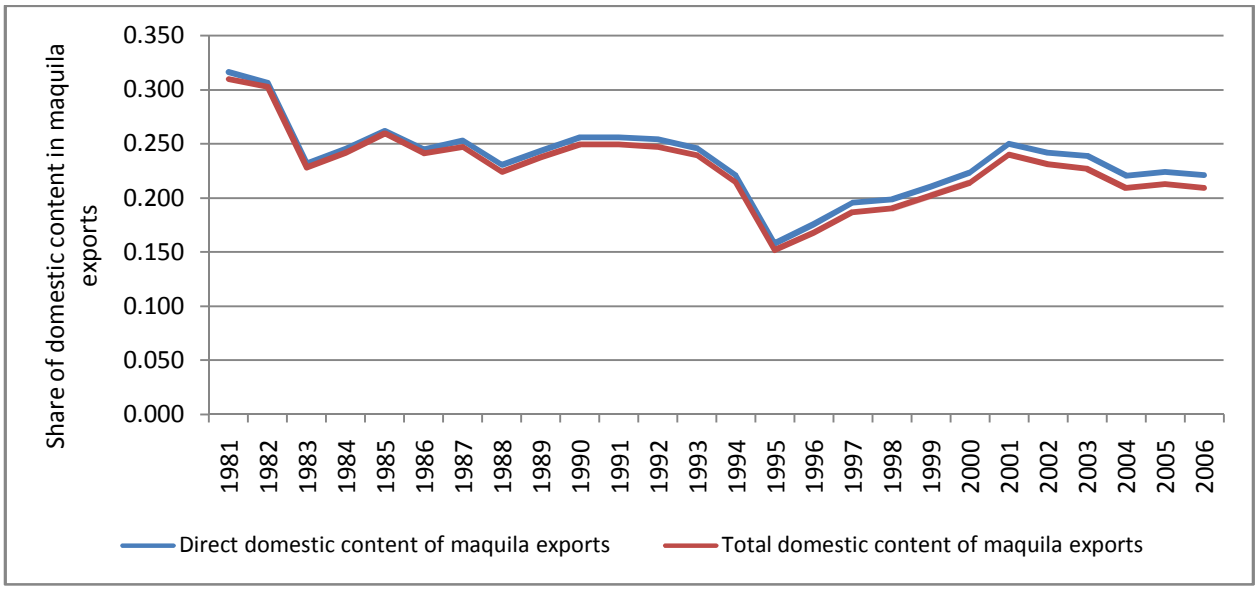
The share of domestic content in aggregate exports is shown in figure 2. We use the extended input-output tables and equation (1) for the years from 1981 to 2006. The figure reports the direct domestic content (obtained by ignoring the first part in the nominator of equation 1) and the total domestic content. The latter incorporates indirect effects, because for the production of domestic intermediates also imported inputs are used, although the difference is small. The small difference between direct and total domestic content is consistent with estimates for China presented in Yang et al. (2013). In 1981, the domestic content share in Mexico's maquila exports was about 31 percent. In 2006 this share has fallen to 21 percent. This suggests that local sourcing has not increased substantially.

Buitelaar and Perez (2000) use detailed firm-level studies to explain why local firms supply so few inputs to maquiladoras. They argue that part of the low domestic content embodied in maquila exports relates to the regulatory environment that did not stimulate the development of a local supplier network until the increasing outward orientation in the late 1980s. However, other factors are also at work that relate to the persistent low domestic content, even after the policy changes that stimulated local sourcing. These other factors include transnational corporate strategies that did not consider local procurement to be important, and U.S. import tariffs on Mexican intermediates embodied in maquila exports. Supply side constraints also affect the domestic content of exports. For example, local firms have to pass very strict and time-consuming processes of certification and quality control before they can provide multi-national firms with inputs. In addition, the quality and technology of inputs demanded by maquiladoras is typically quite high and often subject to change; maquiladoras demand low prices for the inputs they use (comparable to recent practices in the sourcing structure by WalMart in Mexico, see Javorcik et al. (2008)); and demand predictable delivery times.

The domestic content varied substantially over time. In particular, the 1982 debt crisis and the 1994 Tequila crisis coincide with a substantial drop in domestic value added embodied in maquila output.[11] After the 1982 debt crisis there does not seem to be a recovery, but after the 1994 crisis the domestic content recovered to levels observed before the crisis. The increasing value added content during the second half of the 1990s is consistent with the case study findings presented by Buitelaar and Perez (2000). Indeed, the abolition of U.S. duties on Mexican intermediate inputs with the 1994 NAFTA agreements might have had a positive effect on domestic sourcing by maquiladoras, although the 1985 GATT agreement appears unrelated to a substantial change in domestic value added. After 2001 we observe that the domestic content share again starts to decrease. Overall, these results suggest that the effects of industrial policy are probably limited. Indeed, overall patterns appear mainly due to internal and external shocks, such as the 1982 and 1994 crisis, and not to changes in the regulatory environment.

[11] These findings seem at odds with currency devaluation, which one would expect to result in a decrease of imported intermediates. However, other effects may dominate. For example, credit constraints or increased uncertainty may affect domestic sources, and changes in industry composition of exports may also affect these outcomes. If industries with lower domestic value added content expand, the overall effect is a decrease in domestic content of aggregate maquila exports.

Figure 2. The domestic content of aggregate maquila exports



Notes: authors' calculations using time series of the extended input-output table and equation (1).

In table 3 we further explore the domestic content of exports at the industry level. These results are obtained by replacing the vector **e** in equation (1) by a diagonal matrix with the vector **e** on the main diagonal. The findings suggest that the domestic content differs substantially across sectors. In particular, the domestic content is low in electronics manufacturing (14 percent in 2006) as compared to textiles manufacturing (31 percent) and in particular food processing manufacturing (44 percent). These findings suggest that the domestic content is higher in less technology intensive sectors. In comparison to the estimates presented in Yang et al. (2013), our findings suggest that the domestic content of Mexico's export processing firms is lower compared to those in China.

The time series results suggest that in some industries the domestic content increased, for example in textile manufacturing from 28 to 31 percent. While in other industries the share fell, for example in electrical machinery product manufacturing from 25 to 14 percent. Combining changes in the domestic content with the changes in export (or gross output) shares as in table 1, we examine whether the aggregate patterns observed in figure 2 are related to changes within industries or a result of changes in the product composition. The decomposition and results are discussed next.

Table 3. Domestic content of maquila exports, industry results

	1981	1990	2000	2006
Food, Beverages and Tobacco	0.27	0.64	0.62	0.44
Textiles and Textile Products	0.28	0.27	0.31	0.31
Leather, Leather and Footwear	0.44	0.38	0.27	0.28
Pulp, Paper, Printing and Publishing	0.56	0.28	0.36	0.31
Chemicals and Chemical Products	-	0.47	0.43	0.46
Rubber and Plastics	0.37	0.37	0.36	0.35
Other Non-Metallic Minerals	0.48	0.44	0.33	0.18
Basic Metals and Fabricated Metal	0.31	0.27	0.31	0.30
Machinery	0.37	0.26	0.25	0.26
Electronics	0.25	0.20	0.16	0.14
Transport Equipment	0.33	0.27	0.21	0.27
Miscellaneous manufacturing	0.35	0.28	0.24	0.25
Business services	0.91	0.52	0.42	0.41

Notes: authors' calculations using time series of the extended input-output table and equation (1).

5.2 The domestic content of maquila exports: decomposition

To decompose the aggregate change in domestic export content, we apply a 'within' and 'between' decomposition, which can be written in the current context as follows

$$DCE_{t+1} - DCE_t = \sum_i \left(\left(\left(DCE_{i,t+1} - DCE_{i,t} \right) \left(\frac{\omega_{i,t+1} + \omega_{i,t}}{2} \right) \right) + \left(\left(\omega_{i,t+1} - \omega_{i,t} \right) \left(\frac{DCE_{i,t+1} + DCE_{i,t}}{2} \right) \right) \right), \quad (2)$$

where $DCE_{i,t}$ is the domestic content of exports by industry *i* in year *t*, and $\omega_{i,t}$ is industry *i*'s share in total exports at time *t*. The industry contribution in equation (2) is split into two terms. The first term gives the industry contribution due to changes in the industry level DCE share (within), and the second term gives the contribution due to changes in the industry-level export share (between).

The results from this decomposition are given in table 4. The contributions from the three main maquila sectors, namely textiles, electrical machinery, and transport equipment are shown. The other sectors are grouped. The decomposition suggests that changes in the aggregate domestic content are mainly accounted for by changes within industries. The substantial drop in the domestic content of electronics manufacturing accounts for almost two thirds of the aggregate

change in domestic content. The dominance of within-industry effects is confirmed from decompositions using different time periods.

Table 4. Sources of change in domestic value added of maquila exports, 1981 to 2006.

	Share of domestic content in exports		Contribution of (in percent):		
	1981	2006	Change in industry DCE intensity	Change in industry share in overall exports	Total
Total maquiladora	**0.31**	**0.21**			
Textile products	0.28	0.31	-2.6	23.8	
Electrical machinery products	0.25	0.14	61.7	4.4	
Transport equipment products	0.33	0.27	8.0	-17.1	
Other			27.7	-6.0	
			94.8	5.2	100

Notes: authors' calculations using equation (2).

In table 5 we do the same decomposition, but for the period from 2001 to 2006. This period coincides with the demise of textile maquiladora activities due to the strong competition from China after its entry to the WTO in 2001 and the end of the Multi-Fibre Arrangements in 2004. The effect of the shrinking share of textile manufacturing output (it fell from 13 percent in 2001 to 7 percent in 2006) is clearly borne out by the decomposition results. About 51 percent of the fall in the domestic content between 2001 and 2006 is accounted for by textile manufacturing. Interestingly, changes within industry still explain most of the change in the domestic content of exports. The 'within' explanation of changes in the aggregate content is the dominant explanation, also if we consider different time periods. Again, electronic manufacturing accounts for the majority of the within-industry decline in the domestic content of exports.

Table 5. Sources of change in domestic value added of maquila exports, 2001 to 2006.

	Share of domestic content in exports		Contribution of (in percent):		
	2001	2006	Change in industry DCE intensity	Change in industry share in overall exports	Total
Total maquiladora	**0.24**	**0.21**			
Textile products	0.35	0.31	13.2	51.3	
Electrical machinery products	0.24	0.27	68.7	-8.2	
Transport equipment products	0.18	0.14	-18.9	-3.3	
Other			26.6	-29.4	
			89.6	10.4	100

6. Concluding remarks

This paper studied the domestic content of maquila industries. It has taken a long-run macro perspective in order to relate changes in industrial policies to changes in the domestic content of maquila exports. Initially the government viewed maquiladoras as mere providers of jobs. This view and subsequent industrial policies shifted with the increasing outward orientation of Mexico in the late 1980s. We combined a recently released input-output table for maquiladora industries with detailed longitudinal data on output and inputs to study whether observed patterns are related to changes in industrial policy. We find substantial differences in the domestic value added content of exports across industries and over time. The domestic content is typically higher in labor-intensive goods manufacturers, such as textiles, compared to capital-intensive industries such as transport and electronic goods manufacturing. Over time, productivity and the share of skilled workers in maquiladoras improved only modestly. A long-run decline in aggregate domestic value added embodied in maquila exports, from 31 percent in 1981 to 21 percent in 2006, is largely explained by the falling domestic content in electrical machinery product manufacturing. Overall, these findings suggest that even if industrial policies had an effect for specific firms, these are not observed in the aggregate as the domestic content fell.

This paper is the first to study long-term trends in the domestic content of Mexico's maquila exports. So far, most analysis of domestic content and technology upgrading within maquiladoras

are limited to case studies. We provide a macro perspective to these case studies. A clear limitation in this approach is that we are unable to causally link industrial policy to the domestic content of exports. Typically, detailed micro studies are better able to isolate effects of particular policies. However, our findings suggest even if some detailed micro studies may find that industry-specific policies have been successful (Jordaan, 2011), overall these policies did not have their intended effects as productivity levels and the use of skilled workers in maquila industries hardly improved. Also, we do not find a systematic tendency of increased domestic sourcing of inputs.

Various policy measures might be considered to increase the local content of maquiladoras production. We discuss some here, but refer the interested reader to Brannon et al. (1994) and Verhoogen (2012) for further discussion. In particular, the government might seek to strengthen engineering and design capacities. Typically these activities generate much higher value added compared to the provision of standard inputs such as boxes and packaging materials. Also, the Mexican government might stimulate decentralized decision making at maquiladora establishments and engaging them with local suppliers. Typically, if maquiladoras source inputs locally, they have a strong incentive to improve the quality of the goods sourced (Brannon et al., 1994). Also, government officials might actively encourage joint ventures to increase technology spillovers.

Future work may aim to incorporate the maquila tables in a larger cross-country table. For example, the recently released World Input-Output Tables (see Timmer et al., 2014) can be extended to allow for firm heterogeneity, in this case distinguishing between maquila and non-maquila production. Such a distinction allows the analysis of value added embodied in exports to be extended to compare the domestic content of non-maquila with maquila exports. In addition, it allows the analysis of production networks tracing value added along the global value chain. This paper provides the necessary building blocks to carry this type of research forwards.

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