THAILAND'S AUTOMOTIVE MANUFACTURING CORRIDOR

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ABSTRACT

Thailand's export-oriented automotive industry is a recognized economic success story. How did it happen and what lessons might other countries draw? This paper argues that the success of the industry was based on three factors. First was the substantial public investment in port facilities and related infrastructure, beginning in the 1990s, that constituted the Eastern Seaboard economic corridor. Second was the exchange rate depreciation that followed the 1997–1999 Asian Financial Crisis, making manufacturing production for export more profitable. The third factor was two key policy changes adopted by the Thai government shortly after the crisis, and partly in response to it: (a) abolition of restrictions on foreign ownership and (b) abolition of local content requirements. Neighboring countries, including Malaysia, Indonesia, and the Philippines, also experienced the crisis and were potential competitors in attracting foreign investment in automotive production for export. But they did not adopt these two key reforms.

Keywords: automotive exports, Eastern Seaboard scheme, final assembly, parts and components, Thailand

JEL codes: F14, L62, O18, O24

I. INTRODUCTION: DETROIT OF THE EAST?

Thailand's export-oriented automotive industry is a recognized economic success story. The production of motor vehicles and parts began in the 1960s and expanded from the early 1990s, but it catered primarily for the highly protected domestic market. Production for export has been important only since 2000, but roughly half of the industry's final output is now exported. Employment within Thailand's automotive sector—final assembly plus parts—now exceeds a quarter of a million workers.[1] In 2015 production exceeded 2 million units, making Thailand the world's ninth largest automotive producer. According to *The Economist,* Thailand is now the "Detroit of the East."

The opportunity for rapid development of this form of manufacturing production within middle-income countries like Thailand was stimulated in part by the Plaza Accord of 1985. The United States (US), Japan, and major Western European governments agreed on a steady appreciation of the Japanese yen, but also of the euro, relative to the US dollar. These currency realignments and related labor market developments raised costs of production within Japan relative to the revenues derived from Japanese exports. US negotiators hoped that these cost pressures would induce at least some Japanese manufacturers to relocate to the US. In the years following, some did, but in many instances, other Asian locations proved more attractive to Japanese manufacturers than relocation to the US. Low labor costs in Asia were a major part of this story, but not all of it. Competition was intense among Asian countries to attract internationally mobile Japanese manufacturing to their countries.

In the case of automotive manufacturing for export, Thailand was very successful in attracting Japanese manufacturers, compared with neighboring countries such as Malaysia, Indonesia, and the Philippines (Doner, Noble, and Ravenhill 2006). Why? In the literature on the apparent success of Thailand's automotive industry, the answers to several key questions are contested. First, is the Thai automotive sector really a success story? In contrast with the "Detroit of the East" characterization, the final assembly operations occurring within Thailand are fully foreign owned, with production and marketing decisions, together with much of the design and technical research, occurring in Japan and the US. Second, is the recent growth of the industry within Thailand a delayed consequence of earlier infant industry protection? Third, and more broadly, to what extent was prudent industry policy responsible for the success of the industry? Fourth, to what extent was the elimination of restrictions on foreign ownership of both final assembly and parts production responsible for the relocation of foreign manufacturers to Thailand? Fifth, did the local content requirements (LCRs) in operation until their abolition in 1997 lay the foundation for the development of the Thai parts and components subsector, or was the subsequent removal of these restrictions responsible? Sixth, did the export orientation of the industry since 2000 help or hinder the development of domestic linkages? Finally, to what extent did Thailand's infrastructure investments, concentrated in the Eastern Seaboard economic corridor, contribute to the success of the automotive industry?

This study attempts to shed light on these and related questions. It includes the following components:

(i) A review of the concept of economic corridors, including the Thai case study (section II);

[1] The Automotive Association, Industrial Federation of Thailand, reports total employment of the automotive sector as 530,000. This total apparently includes input supply industries like plastics that produce for many industries besides the automotive sector. This number of workers would constitute almost 10% of total manufacturing employment, about the same as its value-added share. Given the high capital intensity of the automotive sector, this seems improbable. The total employment cited above is based on industry sources and implies that the automotive sector accounts for 4% of Thailand's manufacturing workforce of 6.5 million.

(ii) A summary of the policies influencing Thailand's automotive industry (section III), including the Eastern Seaboard economic corridor;
(iii) A description of the development of the industry (section IV);
(iv) Analysis of Thailand's industrial census data for the available years: 1996, 2006, and 2012. These data make it possible to describe the evolution of the automotive sector across these years and to answer crucial questions about the transfer of technology from foreign to domestic parts manufacturers (section V);
(v) A general equilibrium analysis to estimate the impact that Thailand's infrastructure investments had on automotive production and exports and through this the effects on poverty incidence within Thailand (section VI);
(vi) Lessons drawn from the above analysis and a set of interviews with major automotive manufacturers, together with government officials, past and present, who were closely involved with the development of Thailand's automotive industry, conducted by the authors in June and July 2016 (section VII).

The central hypothesis of the study is that three sets of factors facilitated Thailand's success in attracting footloose automotive production. The first was a proactive set of infrastructure investments, beginning in the late 1980s, centered on the creation of a high-capacity deep water port. The new port, known as Laem Chabang, is located 75 kilometer southeast of Bangkok, and unlike the historic and highly congested Bangkok port, located upstream from the coast on the Chao Phraya River, it can accommodate large ocean-going container vessels. The Laem Chabang port is integrated with major investments in roads, electricity, and water supplies adjacent to the port and along the highway connected to the port. The port and the industrial area immediately adjacent to it might be considered a hub, but the highway system connected to it, with infrastructure investments in electricity and water located along this highway system created an economic corridor consisting of the outskirts of Bangkok itself and the seven provinces lying in a semicircle to the east and north of Bangkok, all linked to the Laem Chabang port.[2] This transport and infrastructure corridor facilitated the establishment and growth of final automotive assemblers. Crucially, this development occurred in conjunction with the establishment along the corridor of manufacturers of parts and components. The final assemblers were all foreign owned, mostly but not entirely Japanese. The parts and components manufacturers included both foreign firms (mainly Japanese) and many smaller Thai firms.

The second factor was policy changes introduced by the Thai government shortly after and partly in response to the disastrous Asian Financial Crisis (AFC) of 1997–1999. These changes (i) for the first time permitted unlimited foreign ownership of both final assemblers and parts and components manufacturers in the automotive sector and (ii) abolished Thailand's hitherto restrictive requirements on the local content of motor vehicles produced within Thailand. It is probably accurate to say that without the foreign exchange shortage produced by the Asian Financial Crisis, these policy changes would have been politically infeasible.

A third factor is noneconomic and difficult to quantify. For historical and cultural reasons, Thailand is an attractive and welcoming venue for Japanese firms. Their executives and their families emphasize that they enjoy living in Thailand, giving that country an advantage in attracting Japanese investment relative to most of its East Asian neighbors.

[2] The eight provinces constituting this corridor are Bangkok itself, Samut Prakan, Nonthaburi, Pathum Thani, Ayutthaya, Chon Buri, Rayong, and Chachoengsao. Within the corridor, industrial clusters can be identified, linking final manufacturers and parts suppliers. For example, a major cluster exists in Samut Prakan province, centered on Toyota, another in Ayutthaya, centered on Honda, and another in Rayong, centered on a commercial alliance between Ford and Mazda.

II. ECONOMIC CORRIDORS

The term economic corridor was coined by the Asian Development Bank in 1998 (Octaviano 2014). It refers to integrated networks of infrastructure, including but not confined to transport infrastructure. Brunner (2013) describes them as providing "connections between economic nodes or hubs, usually centered on urban landscapes," and notes that the term "trade corridor" is often used for the same phenomenon. Brunner points out that a broad range of infrastructure initiatives has been described within the category of economic corridors. A basic distinction is between corridors that cross international boundaries and those that do not (Srivastava 2011). When borders are crossed, economic corridors must address issues of customs control, agreements between countries on vehicle regulations and trade policy. The term *regional economic corridors* can be used to describe this cross-border case, compared with *national economic corridors*, the phenomenon described in this paper, which do not themselves cross international borders. National economic corridors may nevertheless be strongly related to international trade, by linking firms within a country to an international gateway such as a port or an airport.

Economic corridors are one of a range of development instruments designed to facilitate infrastructure development, trade, and economic growth. Others include growth triangles, growth areas, coastal corridors, and industrial zones. The essential feature of an economic corridor is that it facilitates economic development along the connection itself, including provision of electricity, telecommunications, and water supply grids. It does not simply provide a transport link between two distant end points, or hubs (Srivastava 2011). There is scope for a wide range of public–private partnerships to achieve this outcome, but public sector participation is generally required.

We argue in this paper that in the Thai context, the development of a national economic corridor adjacent to the capital of Bangkok was instrumental in the success of the export-oriented Thai automotive sector since 2000. In conjunction with other policy changes described below, the publicly provided transport linkages, electricity supply, and water supply facilities developed under the program known as the Eastern Seaboard Development Scheme facilitated the linkages between final manufacturers (mostly foreign) and parts and components suppliers operating with Thailand (both foreign and locally owned), and connected them to the international market. The publicly provided corridor facilitated the development of privately financed industrial estates along the corridor, within which both final assemblers and parts and components suppliers could locate profitably (Aveline-Dubach 2010).

III. THAILAND'S POLICY ENVIRONMENT FOR AUTOMOTIVE DEVELOPMENT

A. Trade Policy

The Thai government's trade policy toward the automotive industry has passed through two distinct phases: (i) an import substitution phase, lasting from the early 1960s to around 1997; and (ii) an export facilitation phase, from 1997 to the present. The major policy initiatives within these two phases are summarized in Tables 1 and 2, respectively.

Import substitution phase, 1960 to 1997

During the early 1960s, domestic motor vehicle assembly was encouraged as a substitute for imported fully assembled vehicles through a system of tariff rates that increased through the decade, supplemented by quantitative LCRs from 1974 onward. These LCRs were set at 45% in 1982 and increased to 54% in 1986. By the end of the 1980s, tariffs on completely built up (CBU) and completely

knocked down (CKD) passenger motor vehicles were 150% and 80%, respectively. The automotive sector was the most heavily protected component of the Thai economy. In addition, foreign manufacturers producing in Thailand were required to operate in joint ventures with domestic partners.

Table 1: Thailand's Automotive Trade and Investment Policies: Import Substitution Phase, 1960–1997

1961	Industrial Investment Promotion Act provided incentives for the local assembly of automobiles.
1962	Revised Industrial Investment Promotion Act announced 50% reduction in tariffs on completely knocked down (CKD) kits: new rates, passenger cars 30%; pickups 20%; and trucks 10%.
1969	Ministry of Industry (MOI) set up Automotive Development Committee. 20% increase in tariffs on completely built up (CBU) vehicles: new rates, passenger cars 50%; pickups 40%; and trucks 30%.
1971	MOI restricted the number of locally assembled passenger car, pickups and trucks models. Announced local content requirement (LCR) measures to become effective in 1974: domestically assembled vehicles had to use locally produced parts to at least 25% of the total value of the vehicle.
1978	Banned CBU imports and increased import duty on CKD kits to 80%. Suspended approval of new assembly plants to reduce overcapacity. Tariffs of CBU passenger cars and CKD passenger cars were increased to 150% and 80%, respectively.
1982	LCR for all vehicles set at 45%.
1985	Mandatory local-content list imposed. Ban on imported CBU vehicles with engine capacity over 2,300 cubic centimeters lifted.
1986	LCR for passenger cars lifted to 54%. List for compulsory and noncompulsory parts introduced.
1989	Ceiling on production capacity of existing assembly plans lifted.
1990	Abolished restrictions on domestic production of series and models. Replaced quantitative import restriction (including the ban on imports of CBUs under 2.3 liters) on passenger cars with tariffs.
1991	Reduced tariffs on all types of CBUs and CKD kits: CBUs over 2.3 liters from 300% to 100%; CBUs under 2.3 liters from 180% to 60%; CKDs for cars, pickups, and vans from112% to 20%. Required use of locally produced diesel engines for one-ton pickup trucks.
1992	Exempted pickup trucks from excise tax.
1993	Ban on new assembly plants lifted.
1995	Reduced CKD tariffs from 20% to 2%.

Source: Based on Kohpaiboon (2015).

During the 1990s, these high rates of protection were gradually reduced. Under the reform-oriented government of Anand Panyarachun (1991–1992) tariff rates on all types of CBUs and CKD kits were reduced to one-third of their previous levels and all quantitative restrictions on vehicle imports were converted to tariffs. CKD tariffs were further reduced in 1995. In 1993, consistent with Thailand's commitments under the World Trade Organization Trade-Related Investment Measures (TRIMs) Agreement, it was announced that restrictions on foreign ownership of domestic automotive manufacturing would be removed by 1997, making Thailand the first developing country to do so. By the time of the Asian Financial Crisis in July 1997, Thailand's automotive sector remained almost entirely import substituting, but less heavily protected than it had been through the 1960s to the 1980s.

Export facilitation phase, 1997 to present

The capital outflows that caused the 1997–1999 AFC produced a foreign exchange emergency for Thailand, making it imperative that greatly increased levels of foreign investment be attracted. In the case of the automotive sector, this meant that the 1993 commitment to abolish restrictions on foreign

ownership of automotive manufacturers located in Thailand could not be postponed, despite desperate opposition from the Thai joint venture partners of foreign producers. Many of these local firms were heavily indebted and had little chance of avoiding bankruptcy.

A second crucial policy shift was the decision to abolish LCRs for domestically located final assemblers. This too was bad news for many Thai parts producers whose existence was owed to the LCR. The decision was announced in advance of its implementation in 2000 and in 1999, tariffs on CKD vehicles were raised from 20% to 35% to cushion against the impact on local parts producers. Despite this, Thai parts producers suddenly faced greatly increased competition both from imported parts and from foreign-owned parts producers who were now free to operate within Thailand. Many local parts producers were bankrupted by these events, combined with the effects of the crisis itself, with only a few, efficient Thai parts producers surviving. Many small Thai firms producing small automotive parts for larger component systems emerged over the next few years.

Table 2: Thailand's Automotive Trade and Investment Policies: Export Facilitation Phase, 1997–2015

1997	Abolished local ownership requirement on foreign-invested projects (announced 1993; implemented 1997).
1999	Raised tariffs on CKD vehicles from 20% to 30%–35% to cushion against the potential adverse impact of impending local content requirement abolition.
2000	Abolished local content requirement.
2003	Tariff preferences under the ASEAN Free Trade Agreement came into full effect: import duties applicable to intra-ASEAN trade down to 0%–5%.
2007	Launch of "Eco-car project Phase 1" by providing investment incentives for producing small passenger vehicles. The key investment incentive is low excise tax rate (17% as opposed to 30% for usual passenger vehicles). There were five carmakers approved including Toyota, Nissan, Mitsubishi, Suzuki, and Honda.
2014	Launch of "Eco-car project Phase 2." Another five firms were approved. They included Nissan, Toyota, Mitsubishi, Ford, and General Motors. Four more to be approved (Honda, Suzuki, MG, and Volkswagen).

ASEAN = Association of Southeast Asian Nations, CKD = completely knocked down.
Source: Based on Kohpaiboon (2015).

It has been claimed that the earlier LCR scheme encouraged the development of Thai parts producers and that this paid off during the export phase. This argument is difficult to reconcile with the huge turnover in Thai parts and components manufacturing that occurred from 2000 onward. The parts and components manufacturers that were important during the early phase of the export expansion were newly arrived, fully foreign owned, and closely linked to the major Japanese assemblers. The Thai firms that had developed under the LCR included many inefficient rent-seekers who did not survive the abolition of the scheme. New, more efficient Thai firms replaced them, along with foreign-owned entrants. The emergence of these firms could not reasonably be attributed to the LCR.

The large depreciation of the Thai currency resulting from the AFC crisis made production for export more profitable. Importantly, both Indonesia and Malaysia experienced large currency depreciations at the same time as Thailand. But they did not make the policy adjustments necessary to make export-oriented automotive production attractive. The changes in policy described above, particularly the abolition of restrictions on full foreign ownership of both final assemblers and parts producers and the abolition of LCRs, made Thailand an attractive location for export-oriented automotive production. The large manufacturers were in Thailand already. To export, they needed to scale up their production, which they did. Fully foreign-owned parts suppliers with close links to the major assemblers were now present in the country. Crucially, the infrastructure needed to support large

scale production for export, including the port facilities, roads connected to them, electricity, and water supplies, was already largely in place, in the form of the Eastern Seaboard scheme.

The turning point between these two phases of automotive policy was certainly the AFC, but the crisis itself was only partly the cause of the shift in policy. As described above, the seeds of reduced trade protectionism can be traced at least to 1991. The decision to allow full foreign ownership of automobile and parts manufacturing was made in 1993, even though its implementation was immediately postcrisis. The crisis played an important role in forcing a change in policy, but it would be incorrect to say that the crisis was the sole cause of the shift.

An issue raised in the literature is that despite the Thai automotive industry's export orientation since 1999, high tariffs on vehicle imports remain in place. Indeed, Thailand's automotive tariffs remain among the highest within the Association of Southeast Asian Nations (ASEAN), averaging around 44% for vehicles and 10.4% for parts (Kohpaiboon 2015). To explain the coexistence of these two phenomena, it is necessary to distinguish between (i) the types of vehicles produced within Thailand for export (small to medium sized, nonluxury passenger vehicles and one-ton pickups) and (ii) the larger, luxury passenger vehicles that are assembled within Thailand from imported CKD kits or imported as CBU vehicles for sale on the domestic market, but which are not exported. The two categories are imperfect substitutes in final demand, permitting their prices to move differentially. The tariff structure is directly relevant for the second category but is (almost) irrelevant for the first.

B. Infrastructure Policy: The Eastern Seaboard Economic Corridor

By the mid-1980s it was apparent that the Bangkok port was inadequate to support heavy manufacturing within Thailand. Not only was the port upstream on the Chao Phraya River and incapable of handling large, ocean-going container ships, requiring transshipment of cargoes to smaller vessels, but its road connection to industrial areas passed through Bangkok's notoriously congested traffic. Japanese expertise and financial support were important in designing a new port area, 75 kilometer to the southeast of Bangkok. This came to be called the Eastern Seaboard scheme, centered on the new port of Laem Chabang (Doner 1991). The scheme was connected by road to the large Map Ta Phut petrochemical complex, planned further to the south at Rayong and also served by a deep-water port. The intention was that the new port at Laem Chabang would accommodate ocean-going container vessels and thereby support the development of heavy manufacturing within Thailand, rather than just the garments, electronics, and other light manufacturing that was already important within the country (Banomyong 2010). It is notable that the planning documents of the time did not anticipate that the resulting industrial development would take the form of export-oriented automotive production, though it was an obvious potential candidate. The new port was intended to support heavy industry in general.

The port itself was accompanied by large-scale public investments in highways connected to the port and upgraded electricity, telecommunications, and water supplies along this highway system. The government also encouraged development of privately operated and financed industrial estates along the highway system connected to Laem Chabang port. Aside from a small publicly owned industrial estate adjacent to the port, the development of industrial estates was left to the private sector. These industrial estates were not confined to automotive-related production, but included the full range of Thailand's manufactured exports. Within these estates, their private operators provided local electricity connections to the public grid, made industrial land available for sale or lease and in many cases offered standard factory buildings for lease to foreign or domestic firms. The Laem Chabang port, together with the industrial area immediately adjacent to it, might be considered a hub; but the highway system connected to it, with infrastructure investments in electricity and water located along this highway

system, combined with subsequent private sector development of industrial estates utilizing this infrastructure, created what is now the Eastern Seaboard economic corridor.

C. Board of Investment Incentive Policy

Since the 1960s, Thailand's Board of Investment (BOI) has attempted to engineer the decentralization of manufacturing production away from the immediate vicinity of Bangkok. It has used a combination of fiscal incentives to encourage this. The incentive system in place until 2013 is summarized in Table 3. Zone 1 included the five provinces immediately adjacent to Bangkok, including Samut Prakan, where Toyota is located. Zone 2 consisted of nine provinces, including Chonburi and Ayutthaya, where Mitsubishi, Ford, Mazda, and Honda are located. Zone 3 included the remaining 62 of Thailand's 76 provinces, all more distant from Bangkok. No automotive producer has ever located in Zone 3. Although there was a rationale for encouraging firms to locate in Zone 3, resting on the lower incomes of the provinces concerned, poor infrastructure prevented it. The incentives offered were insufficient to overcome this drawback. The decentralization policy of the BOI was a failure.

Table 3: Board of Investment Privileges, 1960–2013

Geographic Zone	Privileges
Zone 1: Five provinces surrounding Bangkok: Samut Prakan, Samut Sakorn, Nakorn Pathom, Nontaburi, and Pathum Thani.	• Reduction of 50% of import tariffs on machinery where the tariff is more than 10%. • Approved projects qualify for a 5-year exemption from import tariffs on raw materials and essential goods used in manufacturing exported products. • For projects inside industrial estates or promoted industrial zones, a 2-year exemption from corporate income tax for investments of more than B10 million in industrial zones or 3 years if the project succeeds in getting ISO 9000 or 14000 certification within 2 years of start-up.
Zone 2: Samut Songkhram, Ratchburi, Suphan Buri, Ang Thong, Ayutthaya, Saraburi, Nakhon Nayok, Chachoengsao, Chon Buri, and Map Ta Phut Industrial Estate.	• Reduction of 50% of import tariffs on machinery where the tariff is more than 10% or, for projects located within industrial estates or promoted industrial zones, exemption. • Approved projects qualify for a 5-year exemption from import tariffs on raw material and essential goods used in manufacturing exported products. • Three-year exemption from corporate income tax, or a 6-year exemption for projects inside industrial estates or promoted industrial zone with capital investment of more than B10 million in industrial zones or 7 years if the project succeeds in obtaining ISO 9000 or 14000 certification within 2 years of start-up.
Zone 3: All other areas.	• Approved projects qualify for a 5-year exemption from import tariffs on raw material and essential goods used in manufacturing exported products. • Reduction of 75% on import tariffs for 5 years on raw materials and essential goods that cannot be sourced in Thailand and are used in manufacturing for the domestic market, except that some provinces within Zone 3 are excluded. • Additional 25% capital allowance on the cost of infrastructure or construction costs over a period of up to 10 years. • Reduction of 50% of corporate income tax on profits for 5 years after the exemption period. • Twice the cost of electricity and water may be counted against revenue for 10 years from the date of first revenue. • Seven-year exemption from corporate income tax for projects with a capital investment of at least B10 million or 8 years if the project succeeds in obtaining ISO 9000 or 14000 certification within 2 years of start-up. • In addition, projects in some provinces in Zone 3 qualify for further incentives, such as a double allowance for the cost of transport in calculating corporate income.

Source: WTO. 2011. *Thailand: Trade Policy Review.* Geneva.

To some extent, the BOI incentive structure was at variance with the government's infrastructure policy. The Eastern Seaboard scheme was explicitly intended to concentrate scarce infrastructure resources along the southeastern corridor connected to the *Laem Chabang* port, all within

BOI's Zones 1 and 2. The purpose was to facilitate the development of manufacturing in this region. At the same time, the BOI was attempting, unsuccessfully, to encourage manufacturing firms to locate in the outer provinces of BOI's Zone 3, where wages were lower but which were less well endowed with public infrastructure. The Eastern Seaboard scheme assumed that workers would relocate to where the jobs could be found. The BOI incentives assumed that industry could be induced to locate to wherever the workers lived. The latter did not work and the decentralization objective was abandoned in 2013. The new incentive system, in place since then, is summarized in Table 4. BOI's new system is intended to encourage high technology, skill-intensive investments. It remains to be seen whether this strategy will be important for the future of the automotive industry, but past experience is not encouraging that the BOI incentives will have much effect on firms' decisions.

Table 4: Board of Investment Privileges, 2013 to present

Tax Incentives	Nontax Incentives
• Exemption/reduction of import duties on machinery. • Reduction of import duties for raw or essential materials. • Exemption of corporate income tax on the net profit and dividends derived from the promoted activity. • A 50% reduction of corporate income tax. • Double deduction from the costs of transportation, electricity, and water supply. • Additional 25% deduction of the cost of installation or construction of facilities. • Exemption of import duty on raw or essential materials imported for use in production for export.	• Permit for foreign nationals to enter Thailand for the purpose of studying investment opportunities. • Permit to bring into Thailand skilled workers and experts to work in investment promoted activities. • Permit to own land. • Permit to take out or remit money abroad in foreign currency.

Source: Board of Investment, Bangkok.

D. Labor Supply and Land Acquisition

Issues of labor supply and land acquisition have been constraints on the development of the Eastern Seaboard economic corridor. The availability of trained technicians and engineers requires public investment and this has been insufficient. Land acquisition is an additional problem. Generally, foreigners are not allowed to own land in Thailand. Nonetheless, they can enjoy full property rights over land (100% freehold ownership) in private industrial estates, whereas leasehold or joint ventures with local partners owning 51% of the operation is commonly required in other Asian countries. (Aveline-Dubach 2010, 178)

E. The Association of Southeast Asian Nations Industrial Cooperation Scheme

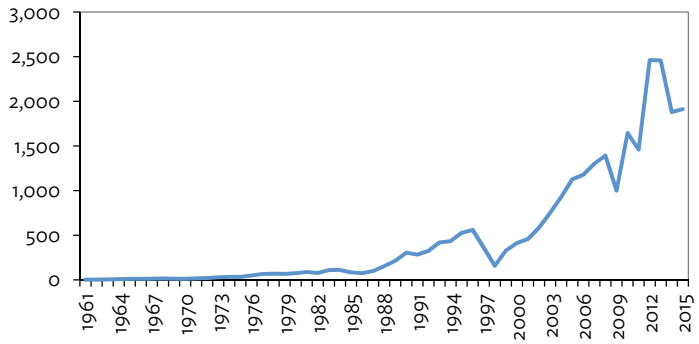
The ASEAN Industrial Cooperation Scheme is intended to encourage technology-based investments in ASEAN, and is open to any ASEAN-based company that is incorporated in and operating in an ASEAN country, with a minimum of 30% ASEAN equity. Perhaps surprisingly, the scheme has been used by only one automotive firm (Toyota) and its major supplier (Denso), both of which are fully foreign owned. Its impact on the development of the Thai automotive industry has been minor.

IV. DEVELOPMENT OF THE THAI AUTOMOTIVE INDUSTRY

During its import substitution phase, 1960–1997, the output of the automotive industry fluctuated with domestic demand (Figure 1). During the economic boom from 1987 to 1996, during which real gross

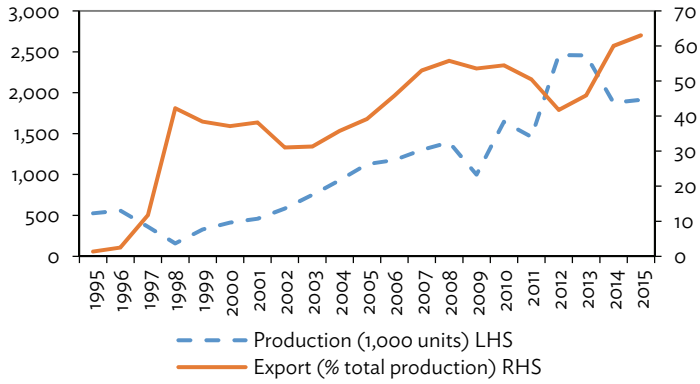
domestic product (GDP) grew at almost 10% per year (Warr 2005), the automotive industry expanded rapidly, reaching an output of roughly half a million units in 1996. With the collapse of demand resulting from the AFC, output plummeted to just over one-fifth of this level. Over the next decade and a half, the policy changes and infrastructure investments described above produced a resurgence of output, reaching around 2 million units in 2015.[3] Figure 2 shows that the export share of this output grew from almost zero in 1997 to over 60% in 2015. Over the 2 decades since the precrisis 1995 situation, annual sales to the domestic market grew from 0.5 million to 0.8 million units and exports expanded from near zero to 1.2 million units.

Figure 1: Thailand: Vehicle Production (1,000 units), 1960–2015



Sources: The Thai Automotive Industry Association; The Federation of Thai Industries; and Automotive Intelligence Unit, Thailand Automotive Institute, Bangkok.

Figure 2: Thailand: Export Share of Automotive Output, 1995–2015



LHS = left-hand side, RHS = right-hand side.
Sources: The Thai Automotive Industry Association; The Federation of Thai Industries; and Automotive Intelligence Unit, Thailand Automotive Institute, Bangkok.

[3] Output surged temporarily in 2012 and 2013. An initiative of the populist government of Prime Minister Yingluck Shinawatra (2011–2014) to provide households with tax rebates for the purchase of new passenger vehicles stimulated domestic demand by more than half a million units annually over the following 2 years, leading to total output of 2.5 million units. Output contracted correspondingly when a military coup in July 2014 led to the abandonment of the policy.

Thailand's international trade in automotive products is summarized in greater detail in Tables 5–8. In 2014, automotive exports earned $33.6 billion and comprised 16% of total merchandise exports and 19% of total manufactured goods exports. Of this total, just over half was export of vehicles and the remainder parts and components. Total automotive imports were $13.5 billion, of which only 15% was vehicles and the remainder parts and components. From Table 6, around a quarter of all vehicle exports were to other ASEAN countries (reflecting the 1992 ASEAN Free Trade Agreement) and a further quarter to Australia (reflecting the 2005 Thailand–Australia Free Trade Agreement). Perhaps surprisingly, other ASEAN countries are the largest source for Thailand's vehicle imports, followed by the European Union and Japan (Table 7). Other ASEAN countries are the main destination for parts and components exports, reflecting a deepening of global value chains, followed by Japan and the US (Table 8).

Table 5: Thailand: International Trade of the Automotive Industry, 1999–2014

	Total Exports	Share of Total Exports (%)		Total Imports	Share of Total Imports (%)		Trade Balance
	($ million)	Vehicles	Auto Parts	($ million)	Vehicles	Auto Parts	($ million)
1999	3,018	42.5	57.5	2,446	22.8	77.2	572
2000	3,744	44.1	55.9	3,378	15.4	84.6	366
2001	3,884	49.5	50.5	3,281	11.4	88.6	602
2002	4,325	45.5	54.5	3,741	11.0	89.0	584
2003	5,683	46.7	53.3	4,789	12.8	87.2	895
2004	7,732	47.6	52.4	5,516	12.0	88.0	2,216
2005	10,529	49.4	50.6	6,266	12.7	87.3	4,263
2006	13,118	50.7	49.3	6,458	12.0	88.0	6,660
2007	16,521	49.8	50.2	7,481	13.5	86.5	9,040
2008	20,709	52.1	47.9	9,324	16.4	83.6	11,385
2009	15,639	49.3	50.7	7,490	15.9	84.1	8,149
2010	24,332	53.3	46.7	12,115	15.1	84.9	12,217
2011	25,547	46.2	53.8	13,593	14.9	85.1	11,954
2012	31,106	52.8	47.2	18,831	14.9	85.1	12,275
2013	33,180	52.7	47.3	17,427	13.1	86.9	15,752
2014	33,593	51.1	48.9	13,495	14.4	85.6	20,098

Source: Authors' compilation from UN Comtrade database, using the WITS (World Integrated Trade Solutions) website. http://wits.worldbank.org/

Value added derived from Thailand's automotive industry is summarized in Figure 3. From just over 5% of manufacturing value added prior to the AFC, this value-added share had doubled to 10% by 2014. The industry's employment share within manufacturing is estimated at roughly 4%, the difference between this and its value-added share reflecting the high capital intensity of the automotive sector. Commercial vehicles, primarily one-ton pickups, represent about 60% of Thailand's total vehicle output (Figure 4). This share has declined steadily from around 70% in the early 1990s, replaced by passenger vehicles.

Table 6: Thailand: Composition and Destination of Vehicle Exports, 2002–2003 and 2013–2014

(share of vehicle exports by value, %)

	ASEAN 10	Japan	PRC	Republic of Korea	Australia	New Zealand	India	US	EU 15	Total Value ($ million)
2002–2003										
Tractors	82.4	0.6	0.1	0.2	2.5	0.4	0.1	1.2	2.0	22
Buses	43.9	0.4	0.9	0.0	0.1	0.0	0.0	0.0	7.3	5
Passenger vehicles	50.5	7.7	0.9	0.0	14.9	2.1	0.0	0.0	9.4	1,150
Commercial vehicles	6.9	0.2	0.0	0.0	23.5	3.2	0.0	0.0	32.8	2,198
All vehicles	22.3	2.7	0.3	0.0	20.4	2.8	0.0	0.0	24.6	3,374
2013–2014										
Tractors	80.5	0.3	0.1	0.1	0.9	0.1	5.4	11.1	0.1	256
Buses	84.4	0.2	0.5	0.1	0.0	0.0	1.5	0.1	0.4	30
Passenger vehicles	36.3	6.0	0.4	0.0	21.3	1.6	0.0	2.8	3.2	6,575
Commercial vehicles	15.0	0.1	0.0	0.0	24.0	3.6	0.0	0.0	4.6	10,469
All vehicles	24.1	2.4	0.2	0.0	22.6	2.8	0.1	1.2	4.0	17,330

ASEAN = Association of Southeast Asian Nations, EU = European Union, PRC = People's Republic of China, US = United States.
Note: The definitions (HS codes) of tractors, buses, passenger vehicles, and commercial vehicles are HS 8701, 8702, 8703, and 8704, respectively.
Source: Authors' compilation from UN Comtrade database, using the WITS (World Integrated Trade Solutions) website. http://wits.worldbank.org/

Table 7: Thailand: Composition and Destination of Completely Built Up Vehicle Imports, 2002–2003 and 2013–2014
(share of vehicle exports by value, %)

	ASEAN 10	Japan	PRC	Republic of Korea	Australia	New Zealand	India	US	EU 15	Total Value ($ million)
2002–2003										
Tractors	0.5	52.7	2.3	0.6	0.1	0.3	1.1	1.8	31.8	127
Buses	0.0	76.7	0.2	5.1	0.0	0.0	0.0	0.2	11.6	123
Passenger vehicles	50.3	22.9	0.1	1.1	0.3	0.0	0.0	1.8	23.1	324
Commercial vehicles	2.5	55.7	1.3	10.5	0.3	0.0	0.0	6.6	19.3	48
All vehicles	26.5	42.2	0.6	2.5	0.1	0.1	0.2	1.8	22.3	621
2013–2014										
Tractors	1.1	43.1	14.8	6.0	0.0	0.1	8.0	2.1	15.8	290
Buses	11.1	34.4	14.5	21.2	0.0	0.0	1.2	0.0	16.2	243
Passenger vehicles	42.7	20.4	0.9	0.6	0.1	0.0	0.1	2.0	31.2	1,328
Commercial vehicles	44.7	25.1	6.7	1.3	0.1	0.0	7.5	0.7	9.0	250
All vehicles	33.6	25.7	5.1	3.8	0.1	0.0	2.1	1.6	24.8	2,112

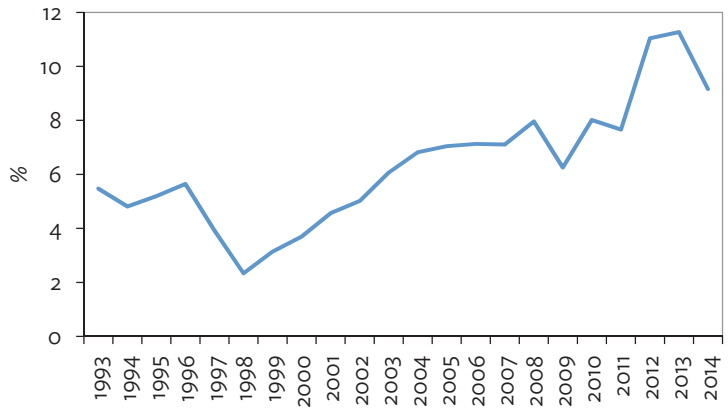
ASEAN = Association of Southeast Asian Nations, EU = European Union, PRC = People's Republic of China, US = United States.
Note: The definitions (HS codes) of tractors, buses, passenger vehicles, and commercial vehicles are HS 8701, 8702, 8703, and 8704, respectively.
Source: Authors' compilation from UN Comtrade database, using the WITS (World Integrated Trade Solutions) website. http://wits.worldbank.org/

Table 8: Trade Pattern for Automotive Parts, 2002–2014

	Exports		Imports	
	2002–2005	2013–2014	2002–2003	2013–2014
Value ($ million)	3,693	16,057	4,457	13,349
Composition (%)				
ASEAN10	29.4	31.1	13.5	13.1
Indonesia	7.8	10.7	3.2	5.4
Malaysia	9.3	9.2	3.0	1.8
Philippines	3.0	2.9	5.1	3.6
PRC	2.7	3.5	3.2	12.7
Hong Kong, China	3.5	1.1	0.4	0.1
Japan	17.4	10.9	63.5	52.0
Republic of Korea	1.8	0.8	1.6	2.5
Australia	2.7	3.5	0.5	0.4
Oceania	2.9	3.8	0.5	0.4
India	3.0	4.5	0.5	2.1
US	13.6	10.3	2.5	3.6
EU 15	8.7	6.6	10.9	9.2

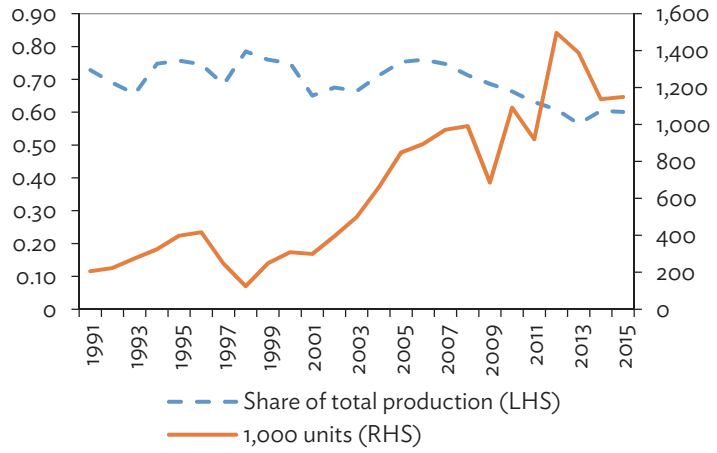
ASEAN = Association of Southeast Asian Nations, EU = European Union, PRC = People's Republic of China, US = United States.
Source: Authors' compilation from UN Comtrade database, using the WITS (World Integrated Trade Solutions) website. http://wits.worldbank.org/

Figure 3: Thailand: Automotive Sector Value-Added Share of Total Manufacturing, 1993–2014
(%)



Source: National Economic and Social Development Board, Bangkok.

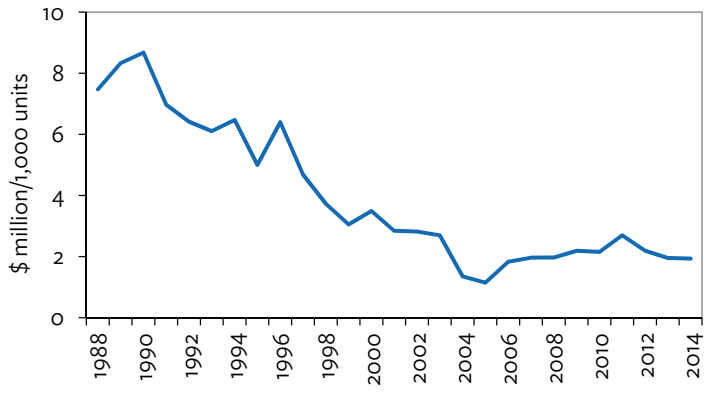
Figure 4: Thailand: Commercial Vehicle Production and Share of Total Vehicle Production, 1991–2015



LHS = left-hand side, RHS = right-hand side.
Sources: The Thai Automotive Industry Association; The Federation of Thai Industries; and Automotive Intelligence Unit, Thailand Automotive Institute, Bangkok.

A striking feature of the Thai industry is revealed by Figure 5. The input content of vehicles produced in Thailand has declined steadily since the early 1990s. This was occurring already, prior to the abolition of the LCRs in 2000, and the decline did not abate until around 2005. The moderate increase since then is due to the high electronics content of vehicles, requiring more sophisticated imports. The abolition of LCRs was attractive to final assemblers. The lesson is that export-oriented manufacturers will attempt to source their parts locally when they can. But they do not want to be compelled to do so.

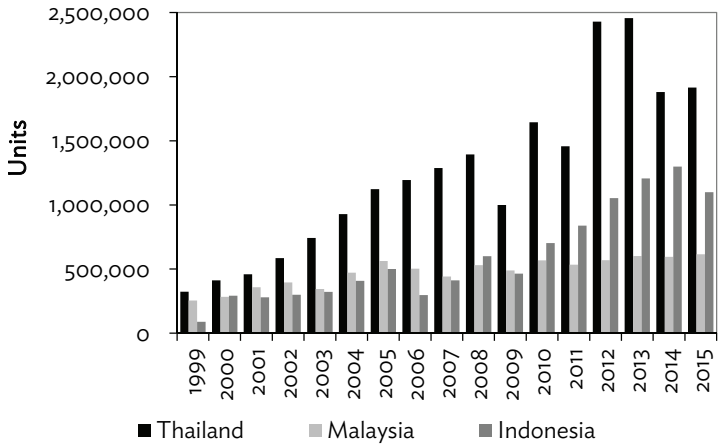
Figure 5: Value of Imported Parts per Locally Assembled Vehicle



Sources: Authors' calculations, based on official data sources. The import value of parts data are drawn from UN Comtrade and vehicle production data are from the The Thai Automotive Industry Association; The Federation of Thai Industries; and Automotive Intelligence Unit, Thailand Automotive Institute, Bangkok.

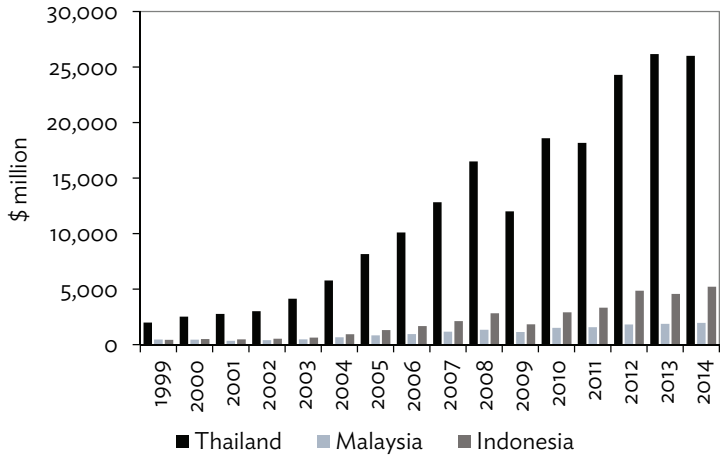
Finally, Figures 6 and 7 compare Thailand's automotive production and export performance with neighboring Malaysia and Indonesia. The main difference between these countries was in policy. Malaysia and Indonesia were both committed to national car policies. Foreign ownership was restricted and LCRs were enforced, as they were in Thailand prior to 1997. In 1999, Thailand's vehicle output was only slightly larger than Malaysia's, but by 2015, it was more than triple Malaysia's. The comparison is even more dramatic in the case of exports. Malaysia's automotive exports have grown only marginally compared with Thailand's. Indonesia has performed better than Malaysia in both respects, but still less well than Thailand.

Figure 6: Automobile Production in Thailand, Malaysia, and Indonesia, 1999–2014



Source: Authors' compilation from UN Comtrade database, using the WITS (World Integrated Trade Solution) website. http://wits.worldbank.org/

Figure 7: Thailand, Malaysia, and Indonesia: Export Value of Automobiles



Source: Authors' compilation from UN Comtrade database, using the WITS (World Integrated Trade Solution) website. http://wits.worldbank.org/

Past studies indicate that the development of the automotive industry has produced spillover benefits to other industries, such as plastics, metallic industries (such as casting and forging) through backward linkages from carmakers to local suppliers (Kohpaiboon 2007).

V. ANALYSIS OF THE INDUSTRIAL CENSUS

Thailand's industrial census is available for the years 1997, 2007, and 2012, containing data relating to 1996, 2006, and 2011, respectively, and the surveys will subsequently be referred to by the latter years, indicating the years of data collection. The data contained in these surveys relate to plant level, rather than firm-level observations. Firm identification is not recorded systematically, so conversion of the data into panel format is not possible. The industries of interest in this study are ISIC 3410 "Manufacture of motor vehicles" and ISIC 3430 "Manufacture of parts and accessories for motor vehicles and their engines." Although the data are intended to cover all firms producing in these industries, the actual response rate has varied widely across years. This was particularly important in the case of the 2011 census, which was severely disrupted by flooding in central Thailand. Many firms did not respond. For example, the data indicate that the number of large final assembly plants declined substantially from 2006 to 2011. In fact, no such firm left the industry, but many did not respond the survey. For this reason, the comparison between the 1996 and 2006 surveys is the most reliable.

A. Descriptive Summary

Table 9 summarizes the responses to the three censuses. Vehicle assembly includes two quite different kinds of firms: large, multinational car manufacturers engaging in significant manufacturing within Thailand and producing within very large plants; and small, Thai-owned assemblers producing for niche markets within Thailand. The latter include firms assembling buses and certain types of trailer trucks using imported new or used engines and these firms undertake very little actual manufacturing activity within Thailand.

The large, foreign-owned vehicle assemblers are each linked to numerous parts suppliers, that tend to be small to medium sized and include both foreign and domestically owned firms. New parts supplier plants tend to locate in the area surrounding car assembly plants. For example, the number of part supplier plants located in Samut Prakan province increased from 56 in 1996 to 122 and 144 plants in 2006 and 2011, respectively. These parts suppliers have been crucial to the development of the Thai automotive sector and Table 10 provides further summary details on them. Table 11 does the same for final assembly plants. For the purposes of these two tables, all firms containing any foreign ownership are classified as "foreign owned." The category "Thai owned" therefore means a firm that has no foreign ownership. Among parts suppliers (Table 10), domestically owned firms are smaller and more labor intensive, as measured by output per worker. Turnover among firms is higher among the Thai-owned input suppliers. This is indicated by the average age of plants responding to the surveys in the 3 years covered. In 1996, the average age of Thai-owned plants exceeded the average age of foreign-owned plants, but by 2011 this difference had been reversed. Over the 5 years between 2006 and 2011 the average age of foreign-owned input suppliers increased by roughly 5 years, but the average age of Thai-owned suppliers increased by only half as much, even though the number of Thai firms increased only marginally. Many Thai firms had left the industry to be replaced by others. Tables 10 and 11 reveal the vast difference in sample coverage among these three censuses, especially for foreign carmakers, which are a central interest in our analysis.

Table 9: Number of Plants by Sales Volume, 1996, 2006, and 2011

	1996		2006		2011	
	No. of Plants	% of Total	No. of Plants	% of Total	No. of Plants	% of Total
Panel A: Automotive assembly						
More than 10,000 million baht	9	18.4	10	18.2	5	11.4
1,000–10,000 million baht	9	18.4	1	1.8	4	9.1
100–1,000 million baht	2	4.1	9	16.4	11	25.0
10–100 million baht	13	26.5	17	30.9	17	38.6
1–10 million baht	16	32.7	9	16.4	7	15.9
Less than 1 million baht	0	0.0	9	16.4	0	0.0
Total	49		55		44	
Panel B: Automotive parts						
More than 10,000 million baht	0	0.0	1	0.2	1	0.2
1,000–10,000 million baht	10	4.9	58	11.6	52	11.0
100–1,000 million baht	64	31.5	126	25.3	139	29.4
10–100 million baht	95	46.8	172	34.5	144	30.5
1–10 million baht	34	16.7	99	19.9	101	21.4
Less than 1 million baht	0	0.0	42	8.4	35	7.4
Total	203		498		472	
Panel C: Total automotive						
More than 10,000 million baht	9	3.6	11	2.0	6	1.2
1,000–10,000 million baht	19	7.5	59	10.7	56	10.9
100–1,000 million baht	66	26.2	135	24.4	150	29.1
10–100 million baht	108	42.9	189	34.2	161	31.2
1–10 million baht	50	19.8	108	19.5	108	20.9
Less than 1 million baht	0	0.0	51	9.2	35	6.8
Total	252		553		516	

Source: Authors' compilation from National Statistical Office, *Industrial Census*, 1997, 2007, and 2012.

Table 10: Automotive Parts Supplier Plants in the Industrial Census

	Ownership	1996	2006	2011
Number of plants	Foreign owned	59	133	94
	Thai owned	144	365	378
Average age of plant (years)	Foreign owned	7.3	11.6	16.4
	Thai owned	11.1	13.1	15.6
Average output (million baht per plant)	Foreign owned	453.3	1,225.1	941.7
	Thai owned	169.4	213	362.7
Average employment (workers per plant)	Foreign owned	210.0	322.2	386.5
	Thai owned	136.8	114.5	143.9

Source: Authors' compilation from National Statistical Office, *Industrial Census*, 1997, 2007, and 2012.

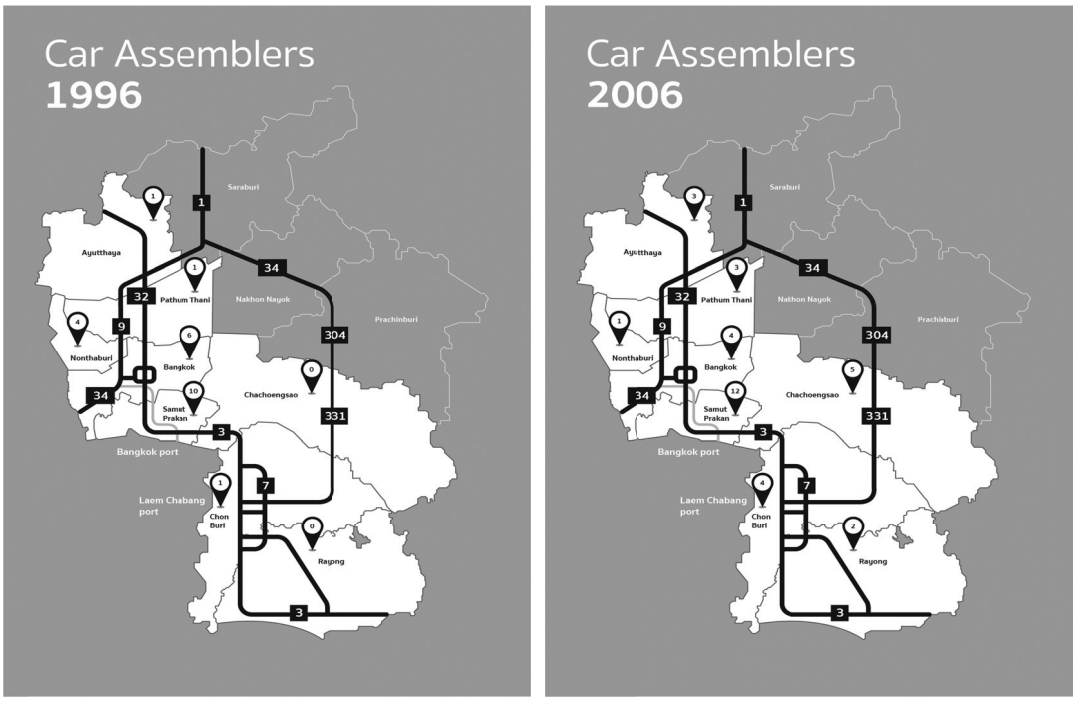
Table 11: Automotive Final Assembly Plants in the Industrial Census

	Ownership	1996	2006	2011
Number of plants	Foreign owned	15	16	5
	Thai owned	34	39	39
Average age of plant (years)	Foreign owned	13.8	24.8	30.4
	Thai owned	10.9	11.2	16.7
Average output (million baht per plant)	Foreign owned	19,840	14,870	40,075
	Thai owned	389	3,057	2,207
Average employment (workers per plant)	Foreign owned	1,501	651.8	1,582
	Thai owned	134.8	165.5	310.6

Source: Authors' compilation from National Statistical Office, *Industrial Census*, 1997, 2007, and 2012.

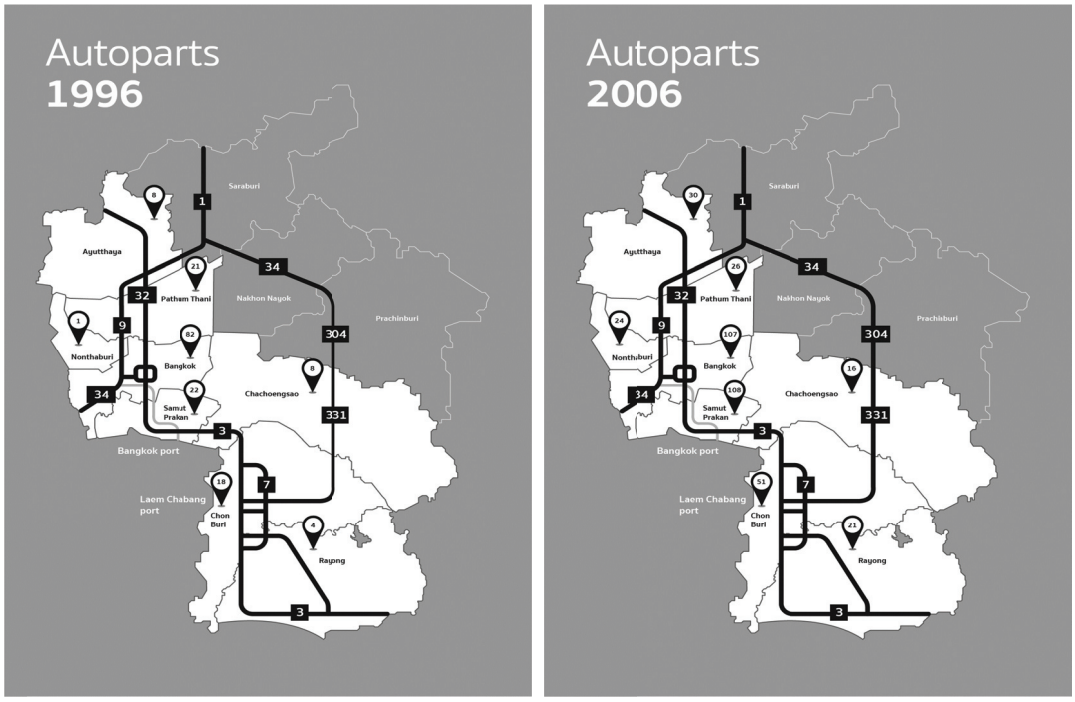
Drawing on the industrial census data, Figures 8 and 9 summarize the changes in the location of the final assembly and auto parts industries over the decade between 1996 and 2006. The census data for 2011 are not used for this purpose, because as noted above flooding in 2011 greatly reduced the census response rate for that year and this reduced the usefulness of the data for the current purpose. In the figures, firm numbers are indicated with white balloons with arrows pointing downward. Major highways are indicated in black with black rectangles showing highway numbers in white against the black background. The figures show that assemblers and parts suppliers have located along the highway system connected to the Laem Chabang port. Parts suppliers have tended to locate close to the final assemblers.

Figure 8: Location of Automotive Assembly Industry, 1996 and 2006



Source: Authors' construction using data from National Statistical Office, *Industrial Census*, 1997 and 2007.

Figure 9: Location of Automotive Parts Industry, 1996 and 2006



Source: Authors' construction using data from National Statistical Office, *Industrial Census*, 1997 and 2007.

B. Econometric Analysis

The comparison between foreign-owned and domestically owned input suppliers is important for understanding the development of the Thai automotive industry. These linkages are studied econometrically below, by pooling the data for the two rounds of the census 1996 and 2006. For the reasons explained above, 2011 data were considered unreliable and were not used. Dummy variables were used to indicate the year of the survey. The following questions will be addressed in relation to auto parts producers.

(i) Is there a differential in output per firm between foreign and domestic producers? If so, has this differential changed over time?
(ii) Is the capital–labor ratio higher for foreign firms than domestic firms? If so, has this differential changed over time?
(iii) Is value added per worker higher among foreign than domestic firms? If so, has this differential changed over time?

For the purposes of these regressions, all nominal money values were converted to real values using price deflators at the 4-digit ISIC level. In each of the three simple regression equations estimated, the variable of interest is the dependent variable, expressed in natural logarithms. The independent variables include a foreign ownership dummy, to detect any influence ownership might have, denoted for below. Intercept and slope year dummies are used to capture the year of observation. The intercept dummy variable for 2006 is denoted $D06$ and the slope dummy variable for the interaction variables between foreign ownership and the year of observation, is denoted $F \times D06$. Numbers in parentheses

below estimated coefficients are *t*-statistics. The superscripts *, **, and *** indicate that the null hypothesis that the true coefficient is zero is rejected at the 90%, 95%, and 99% confidence levels, respectively. *F*-tests relate to the joint null hypothesis that all coefficients are zero.

Question 1: Plant output, measured as real value of sales, Q

$$\ln Q = 3.61 + 1.40F - 1.05D06 + 1.69\ F \times D06 \quad (1)$$
$$(18.86)^{***}\ (3.95)^{***}\ (-4.65)^{***}\ \ (3.98)^{**}$$
R^2 = 0.223; *F*-stat. = 67.8; number of observations = 701.

In equation (1) the dummy variable for foreign ownership is positive and significant. Foreign firms tend to be larger than domestic firms. The interaction effect variables for the year 2006 is positive and significant, indicating that the output difference between foreign and domestic firms increased over time.

Question 2: Capital intensity, measured as capital stock per worker, K/L

$$\ln(K/L) = -1.70 + 1.43F - 0.58D06 - 0.22\ F \times D06 \quad (2)$$
$$(-10.76)^{***}\ (4.90)^{***}\ (-0.31)\qquad (-0.62)$$
R^2 = 0.08; *F*-stat. = 21.66; number of observations = 701.

Equation (2) indicates that foreign firms are more capital intensive than domestic firms and that the difference is significant. There was no significant decline in this difference over time.

Question 3: Labor productivity, measured as value added per worker, VA/L

$$\ln(VA/L) = 2.74 + 0.15\ln(K/L) + 0.98F - 0.46D06 + 1.63\ F \times D06 \quad (3)$$
$$(15.58)^{***}\ (3.86)^{***}\qquad\qquad (3.18)^{***}\ \ (-2.39)^{**}\ \ (4.51)^{***}$$
R^2 = 0.244; *F*-stat. = 57.22; number of observations = 698.

Equation (3) controls for capital intensity (K/L), to ask whether foreign firms are more productive than domestic firms. The coefficient on the foreign ownership dummy is positive and significant, so the answer is yes. Moreover, although average value added per worker declined over time, the interaction effect variable for 2006 is positive and significant, indicating that the difference between the productivity of foreign and domestic parts suppliers increased over time.

The above findings do not support the notion that the entry of foreign input suppliers after 1997 had positive spillover effects on domestic suppliers. The differential between the two groups in output per firm, capital intensity, and labor productivity was significant in each case and did not decline over time. Did the long period of LCRs prior to 1997 have lasting effects on the productivity of the domestic input suppliers, relative to foreign suppliers? The above findings indicate that the answer is no.

C. Productivity Effect of Improved Public Infrastructure

Beginning with the development of the Laem Chabang port, the Thai government invested in infrastructure upgrades in the eight provinces close to the Eastern Seaboard scheme (Bangkok, Samut Prakan, Nonthaburi, Pathum Thani, Ayutthaya, Chon Buri, Rayong, and Chachoengsao), with the objective of improving the investment climate for manufacturing firms, including but not solely automotive final assemblers and parts suppliers. These infrastructure upgrades consisted of investments

in improved roads, industrial capacity electricity supplies, water supplies, and telecommunications. Infrastructure upgrades in the other 68 provinces were significantly less extensive. If they were successful, the infrastructure investments should have raised labor productivity relative to those areas not receiving similarly favorable treatment. The Industrial Census data can be used to investigate whether the intended effect was achieved. We calculate labor productivity inside and outside the improved infrastructure regions. This is done for each of the 3 years of the Industrial Census and for both foreign and local firms.

Table 12 performs these calculations for final assemblers. The Industrial Census records no foreign final assemblers outside the improved infrastructure region (the above eight provinces) in 1996 and 2011, so for foreign final assemblers the "Inside/Outside" comparison can be made only for 2006. The "Inside" mean for that year is more than three times the "Outside" mean. For local firms, the "Inside" mean is at least twice the "Outside" mean in each of the 3 years. Table 13 performs similar calculations for parts suppliers. The means of labor productivity are again higher "Inside" than "Outside," except for foreign firms in 1996 and 2011, where the "Outside" means are higher.

Table 12: Labor Productivity and Infrastructure: Final Assemblers Inside and Outside Upgraded Regions

		Foreign		Local	
		Inside	Outside	Inside	Outside
1996	Average	3.26	n.a.	0.36	0.16
		(2.88)	(n.a.)	(0.32)	(0.16)
	SD	1.94	n.a.	0.31	0.08
		(2.05)	(n.a.)	(0.31)	(0.09)
	Number	14	n.a.	7	25
		(15)	(n.a.)	(8)	(26)
2006	Average	2.55	0.74	1.06	0.24
		(14.34)	(0.74)	(3.40)	(0.24)
	SD	2.19	0.23	1.37	0.31
		(36.26)	(0.23)	(8.57)	(0.31)
	Number	12	2	18	18
		(14)	(2)	(20)	(18)
2012	Average	5.03	n.a.	2.06	0.47
		(4.16)	(n.a.)	(2.86)	(0.47)
	SD	3.04	n.a.	1.63	0.27
		(3.27)	(n.a.)	(6.83)	(0.27)
	Number	4	n.a.	7	17
		(5)	(n.a.)	(22)	(17)

SD = standard deviation.

Notes: Labor productivity means value added in million baht per worker. n.a. means no firms recorded in data. Numbers not in parentheses refer to the sample excluding outliers. Outliers are defined as firms with recorded labor productivity greater than five times or less that one-fifth of the mean value. Numbers in parentheses refer to the full sample. "Inside" means factories located in the eight provinces with improved infrastructure: Bangkok, Samut Prakan, Nonthaburi, Pathum Thani, Ayutthaya, Chon Buri, Rayong, and Chachoengsao. "Outside" means firms located in any of the other 68 provinces.

Source: Authors' calculations using data from National Statistical Office, *Industrial Census*, 1997, 2007, and 2012.

Table 13: Labor Productivity and Infrastructure: Parts Suppliers Inside and Outside Upgraded Regions

		Foreign Firms		Local Firms	
		Inside	Outside	Inside	Outside
1996	Average	0.81	0.88	0.32	0.16
		(0.66)	(0.56)	(0.34)	(0.16)
	SD	0.72	0.71	0.21	0.12
		(0.74)	(0.74)	(0.65)	(0.18)
	Number	14	5	95	26
		(15)	(8)	(113)	(31)
2006	Average	1.58	0.74	1.06	0.24
		(1.45)	(0.74)	(3.4)	(0.24)
	SD	2.19	0.23	1.37	0.31
		(36.26)	(0.23)	(8.57)	(0.31)
	Number	12	2	18	18
		(14)	(2)	(20)	(18)
2011	Average	1.06	1.26	0.62	0.57
		(1.17)	(1.13)	(0.63)	(0.52)
	SD	1.12	0.58	0.58	0.49
		(1.64)	(0.68)	(0.90)	(0.86)
	Number	77	8	238	66
		(85)	(9)	(289)	(89)

SD = standard deviation.
Notes: Labor productivity means value added in million baht per worker. Numbers not in parentheses refer to the sample excluding outliers. Outliers are defined as firms with recorded labor productivity greater than five times or less that one-fifth of the mean value. Numbers in parentheses refer to the full sample. "Inside" means factories located in the eight provinces with improved infrastructure: Bangkok, Samut Prakan, Nonthaburi, Pathum Thani, Ayutthaya, Chon Buri, Rayong, and Chachoengsao. "Outside" means firms located in any of the other 68 provinces.
Source: Authors' calculations using data from National Statistical Office, *Industrial Census*, 1997, 2007, and 2012.

Recalling that the Industrial Census is in fact a sample survey of only some firms, rather than a true census of all firms, it makes sense to ask whether these differences in the sample-based mean estimates of labor productivity are statistically significant. This is done in Table 14. The analysis assumes that the sample is an unbiased random sample from the overall population of relevant firms. The null hypothesis is that true labor productivity for the full population is the same inside and outside the improved infrastructure regions. The alternative hypothesis is that "Inside" productivity is higher. Can the null hypothesis be rejected in favor of the alternative hypothesis? This can be tested by calculating the *t*-statistic for the estimated mean difference and comparing it with the critical values from a one-tail *t*-test.[4]

The final column of Table 14 summarizes the results. As explained above, comparisons cannot be made for foreign final assemblers for 1996 and 2011, because of the absence of "Outside" firms in the sample. For foreign assemblers in 2006, labor productivity is significantly higher "Inside" than "Outside." This is also true for local final assemblers in all 3 years. Among parts suppliers, productivity is higher for foreign firms "Inside" than "Outside" in 2006, but not significantly different in the other 2 years. For local firms, "Inside" productivity is significantly higher in 1996 and 2006 but not significantly different in 2012. For the reasons discussed above, the 2012 Industrial Census (2011 data) is considered less reliable than that for the previous two rounds. Discounting those results, the conclusion is that the public investments

[4] The *t*-test is one tailed because the alternative hypothesis is that labor productivity is higher inside than outside the improved infrastructure region, not just that it is different, which would correspond to a two-tailed test.

in infrastructure significantly raised labor productivity among both final assemblers and parts suppliers and for both foreign and local firms.

Table 14: Test That Firm Labor Productivity Is Raised by Upgraded Public Infrastructure

		Sample Means		One-Tailed *t*-test				
	Year	Inside	Outside	*t* (10%)	*t* (5%)	*t* (1%)	*t* est.	Result
Final Assemblers								
Foreign	1996	3.26	n.a.					-
Foreign	2006	2.55	0.74	1.36	1.80	2.72	2.77	**
Foreign	2011	5.03	n.a.					-
Local	1996	0.36	0.16	1.44	1.94	3.14	1.69	*
Local	2006	1.06	0.24	1.44	1.94	3.14	2.48	**
Local	2011	2.06	0.47	1.33	1.73	2.55	2.57	**
Parts Suppliers								
Foreign	1996	0.81	0.88	1.48	2.02	3.37	0.20	n.s.
Foreign	2006	1.58	0.85	1.33	1.74	2.57	3.16	***
Foreign	2011	1.06	1.26	1.35	1.77	2.65	0.83	n.s.
Local	1996	0.26	0.15	1.30	1.67	2.38	3.45	***
Local	2006	0.50	0.29	1.28	1.65	2.33	5.62	***
Local	2011	0.62	0.57	1.29	1.66	2.36	0.70	n.s.

Notes: The analysis tests the null hypothesis that the true population means are the same inside and outside the improved infrastructure areas. The alternative hypothesis is that the true means are *higher inside*. As in Tables 12 and 13, n.a. means no firms recorded in data. M1 and M2 are the sample means inside and outside the upgraded infrastructure regions, respectively, as shown in Tables 12 and 13. The columns *t* (*p*) are the critical t-values for significance in a one-tailed *t*-test at the level *p*, where *p* = 10%, 5%, and 1%, respectively. The column *t* est. is the computed *t*-statistic for the difference between sample means using the sample data shown in Tables 12 and 13. In the column Result: - means that no test result can be provided because the sample data in Tables 12 and 13 are incomplete; *, **, and *** mean that the null hypothesis that the difference is zero is rejected at the 90%, 95%, and 99% confidence levels, respectively, in favor of the alternative hypothesis that labor productivity is *higher* in the improved infrastructure region; and n.s. means that the null hypothesis cannot be rejected at these significance levels.
Source: Authors' calculations using data from National Statistical Office, *Industrial Census*, 1997, 2007, and 2012.

VI. GENERAL EQUILIBRIUM MODELING

By drawing on an existing general equilibrium model of the Thai economy, known as *JamlongThai*, we shall analyze the effect of reducing automotive firms' costs through infrastructure improvement. The purpose is to ascertain the effect that the infrastructure development described above had on automotive output, exports, and employment. In addition, it will be possible to analyze the effect that these industry outcomes have on poverty incidence within Thailand. The goal of this analysis is to determine the magnitude of the contribution that infrastructure improvements have had on the performance of the automotive sector and, through this, the degree to which they have contributed to the substantial reduction in poverty incidence that has occurred in Thailand over recent decades.

A. The Model

The *JamlongThai* model is a 65-sector general equilibrium model with a highly disaggregated household structure. This disaggregation of households permits the model to produce estimates of the effects that economic shocks have on poverty incidence within Thailand. The model is documented in Warr (2010).

B. The Shocks

Based on interviews with industry representatives, it is estimated that infrastructure improvements reduced the costs of export-oriented firms by around 15%. The database of the *JamlongThai* model relates to 2007 and so it incorporates the impact of the cost-reducing infrastructure investments that had occurred prior to that date. The purpose of the simulations is to estimate the unobserved counterfactual in which these cost reductions did *not* occur. The estimated impact of the cost reductions is thus the difference between the observed value of variables and the simulated counterfactual value of these variables in which the cost reductions had not happened. That is, we simulate the effect of taking away the cost reductions. The shock is thus a 15% *increase* in industry costs, occurring through a *reduction* in productivity. The estimation is done at two levels. First, the productivity reduction applies only to final vehicle assemblers (Simulation A). Second, it applies to all automotive firms, including parts and components firms (Simulation B).

C. Model Closure

Since the real expenditure of each household is the basis for the calculation of poverty incidence, the macroeconomic closure must be made compatible with both this measure and with the single-period horizon of the model. This is done by ensuring that the full economic effects of the shocks to be introduced are channeled into current-period household expenditures and do not "leak" in other directions, with real-world intertemporal welfare implications not captured by the welfare measure. To prevent these kinds of welfare leakages from occurring, the simulations are conducted with balanced trade (exogenous balance on current account), fixed real government spending and real investment demand for each good, and a fixed government budget deficit in nominal terms. The latter is achieved by endogenous across-the-board adjustments to the value-added tax rate—Thailand's most important source of government revenue—so as to maintain the base level of the budgetary deficit. The combined effect of these features of the closure is that the full effects of changes in policy are channeled into household consumption and not into effects that the single-period focus of the model fails to capture.

D. Results

Table 15 summarizes the estimated macroeconomic effects of the two sets of negative productivity shocks. Taking the case of real GDP first, Simulation A estimates the impact at –0.144%. This means that in the absence of the 15% productivity gain in final assembly only, real GDP would have been 0.144% lower. Simulation B, the more realistic, indicates that in the absence of the productivity gain in the whole automotive sector—including parts as well as assembly—real GDP would have been 0.9% lower. Putting this differently, it is estimated that the 15% productivity gain in the automotive sector raised the level of annual real GDP in Thailand by just under 1%. It is important to recognize that this is a permanent increase in the level of GDP per annum and not just a temporary 1-year increase in the level of GDP.

Focusing on Simulation B, the cost reductions led to an increase in the level of skilled real wages of 1.15% and an increase in unskilled real wages of 0.75%. The high skill intensity of the automotive sector explains the differential in wage effects. These wage effects occurred through an increase in the demand for labor resulting from the automotive output increases summarized in Table 16. In the absence of the productivity gains, output would have been lower, producer and consumer prices would have been higher, exports would have been lower, imports higher, and domestic consumption of automobiles would have been considerably lower.

Table 15: Simulated Macroeconomic Effects
(% change, unless stated)

	Simulation A: Final Assembly Only	Simulation B: Final Assembly Plus Parts
Real GDP	−0.144	−0.907
Real household consumption	−0.487	−1.537
GDP Price Index	−0.504	−0.428
Consumer Price Index	−0.446	−0.667
Wages: Paid skilled	−0.542	−1.147
Paid unskilled	−0.361	−0.749
Unpaid skilled	−2.206	−5.071
Unpaid unskilled	−0.600	−1.021
Average capital rental	−0.734	−1.601
Output of petroleum	−1.303	−1.254
Government revenue	−0.624	−0.820
Government expenditure	−0.500	−0.992
Government budget balance (million baht)	−923.848	871.308

GDP = gross domestic product.
Source: Authors' calculations, using the *JamlongThai* model of the Thai economy.

Table 16: Simulated Effects on Automotive Sector
(percentage point change)

	Simulation A: Final Assembly Only	Simulation B: Final Assembly Plus Parts
Output	−8.17	−24.92
Producer price	5.92	25.33
Consumer price	3.29	14.53
Domestic consumption	−20.05	−39.30
Export	−12.56	−46.22
Import	4.52	14.46

Source: Authors' calculations, using the *JamlongThai* model of the Thai economy.

The estimated effects on poverty incidence are shown in Table 17. Without the increases in automotive productivity, poverty incidence would have been higher, especially in urban areas. Relative to the massive reductions in poverty incidence that have occurred in Thailand, these estimated impacts are significant, but small. Holding the real value of the poverty line constant, between 1986 and 2014, poverty incidence in Thailand declined from 67% to 11% of the total population. This remarkable achievement implies that over 28 years, the incidence of poverty declined by 56% of the population, an average rate of decline of 2% of the population per year. The estimates in Table 13 mean that the reductions in automotive costs (Simulation B) reduced poverty incidence by an estimated 0.2% of the population. In a population of 60 million people, this means 0.12 million, or 120,000 people moving from levels of real consumption below to levels above the poverty line. This number includes both poverty reduction among those directly employed in automotive parts and assembly firms, and those receiving remittances from these workers. Productivity-raising infrastructure investments enabled the automotive sector to contribute to poverty reduction in Thailand, but this was not in itself a major driver of the huge reductions in poverty incidence that have occurred. It is important that these calculations do not measure the total poverty-reducing effects of the infrastructure investments described, but only those that operated via the automotive sector. The full effects would certainly be larger.

Table 17: Simulated Effects on Poverty Incidence (Headcount Measure)
(percentage point change)

	Simulation A: Final Assembly Only	Simulation B: Final Assembly Plus Parts
National	0.02	0.18
Urban	0.03	0.32
Rural	0.02	0.17
Regional:		
Bangkok and southeast	0.59	1.77
Central	0.01	0.06
North	0.01	0.05
Northeast	0.06	0.27
South	0.01	0.05

Notes: Positive numbers in the table mean increases in the simulated level of poverty incidence. Changes in poverty incidence are reported above as the difference between the simulated level of poverty incidence (postshock) and the initial level (preshock), both expressed in percentage form. For example, in 2007 (the year of the model's database) the initial (preshock) level of poverty incidence for the total population was 14.36%. In Simulation B, the reported change in national poverty incidence above is 0.18 percentage points, meaning that the simulated level (postshock) is 14.36 + 0.18 = 14.54%. That is, it is estimated that without the effect of the productivity enhancing effect that infrastructure investments had on the automotive industry, in 2007 poverty incidence would have been 0.18 percentage points higher, at 14.58% of the population.
Source: Authors' calculations, using the *JamlongThai* model of the Thai economy.

VII. CONCLUSIONS

A. Lessons from the Thai Experience

Thailand's automotive sector is not really the "Detroit of the East" because the industry is largely foreign owned. Nevertheless, growth of the automotive sector generated hundreds of thousands of manufacturing jobs that would not otherwise have existed. Thailand's automotive manufacturing corridor involved substantial public investment in infrastructure. The investment was risky. It eventually generated large benefits for Thailand, but only after the 1997–1999 AFC, combined with policy changes in Thailand, made automotive production for export profitable. This included export of both final vehicles, on the one hand, and parts and components on the other. The key policy changes were abandonment of (i) restrictions on foreign ownership and (ii) local content requirements. Without these policy changes within Thailand, the huge public infrastructure investments represented by the Eastern Seaboard scheme might not have been productive.

Neighboring countries, including Malaysia, Indonesia, and the Philippines, were potential competitors in attracting foreign investment in automotive production for export. But they did not share similarly in the automotive export boom because they did not adopt these two key reforms. These policy missteps among its competitors clearly contributed to Thailand's success. The decision to reorient policy on the automotive sector (late 1980s to early 1990s) coincided with the decisions of major manufacturers to relocate their production internationally to lower cost venues. It was not a coincidence in that financial support and intellectual inputs from Japanese sources played an important role. Development of the infrastructure supporting an efficient export gateway (Laem Chabang port and the associated Eastern Seaboard corridor) was a necessary condition for this to happen because the existing port facilities could not have supported an export-oriented automotive sector. Nevertheless, this infrastructure development was not automotive industry specific and the growth of the automotive sector was not anticipated by the planners concerned.

Thailand's BOI had attempted for decades to use fiscal incentives to encourage manufacturers to locate in economically disadvantaged regions of the country. The assumption was that firms could be encouraged to locate wherever the workers lived. The Eastern Seaboard scheme assumed instead that workers would move to wherever the jobs could be created most efficiently. The Eastern Seaboard scheme eventually worked, but the BOI scheme failed and was abandoned in 2013. The lesson for other countries is that manufacturing firms cannot readily be induced to locate to regions preferred by governments, but where infrastructure facilities are substandard.

Thailand avoided the failed "national car" policies of some of its neighbors, permitting full foreign ownership of vehicle manufacturing, but it did not eliminate its high rates of protection of final vehicles. It is argued in this study that these tariffs were largely irrelevant to the development of the export-oriented component of the automotive industry. Thailand liberalized input supplies, by abolishing LCRs, becoming an export platform, ironically facilitating higher, not lower, local content. The lesson for other countries is that local content schemes can be counterproductive. Manufacturers are strongly averse to restrictions on their decisions on input procurement. Following the relaxation of restrictions on foreign entry of input suppliers (1997), multinational enterprise final assemblers often preferred domestically located, but foreign, tier-1 input suppliers. Not many of the existing indigenous input suppliers survived this period, but those that did mainly became tier-2 suppliers. The evidence does not support the claim that earlier LCRs facilitated the development of export-oriented automotive production.

Finally, the cost-reducing effects of infrastructure investments contributed greatly to the expansion of the Thai automotive sector, leading to a small but significant contribution to poverty reduction within Thailand.

B. What Is Next for the Automotive Industry?

The main constraint on the expansion and upgrading of the Thai automotive industry continues to be the bottleneck of skilled labor supply. This applies to both carmakers and parts suppliers. Upgraded vocational training and increased investment in the training of engineers are required.

In June 2016, the Thai government announced an extension of the existing economic corridor concept, with a new scheme called the Eastern Economic Corridor to be located in the provinces of Rayong, Chachoengsao, and Chon Buri, expanding the existing Eastern Seaboard scheme (see Changsorn 2016). The scheme is to be focused on foreign investors and includes 10 targeted industries, including next-generation automotive production. New infrastructure is to be provided and incentives are to include allowing foreign investors to open foreign currency accounts and keep their incomes in foreign currencies, instead of having to convert them into baht. The detailed implementation of the scheme is yet to be announced.

It seems likely that the global automotive industry will move toward the use of electricity as in-car fuel. This will raise challenges for both assemblers and parts suppliers. Foreign-based assemblers are already moving in this direction, but parts suppliers will face major adjustment issues. Not all parts currently produced will be required and many new types of parts will be needed. The technology required to innovate, the information and communication technology, management, and marketing will all be costly. These costs may be reduced by government investment in new forms of infrastructure, scientific equipment, and especially the training of technicians and scientists, all of which are undersupplied in Thailand, even without the rapid technological changes that seem imminent.

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Thailand's Automotive Manufacturing Corridor

The economic success of Thailand's export-oriented automotive industry was based on three factors: public investment in port facilities and related infrastructure, beginning in the 1990s, resulting in the Eastern Seaboard economic corridor; the exchange rate depreciation that followed the 1997–1999 Asian Financial Crisis; and two key policy changes. Restrictions on foreign ownership were abolished in 1997 and local content requirements were dropped in 2000. Neighboring countries, including Malaysia, Indonesia, and the Philippines, also experienced the crisis and were potential competitors in attracting foreign investment in automotive production for export. But they did not adopt these two key reforms.

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