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Peter Warr

and

Archanun Kohpaiboon

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Arndt-Corden Department of Economics
Crawford School of Public Policy
ANU College of Asia and the Pacific

Explaining Thailand's Automotive Manufacturing Success*

Peter Warr
Australian National University, Canberra

and

Archanun Kohpaiboon
Thammasat University, Bangkok

Abstract

We argue that the success of Thailand's export-oriented automotive industry was based on three factors. First was the substantial public investment in productivity-raising port facilities and related infrastructure, beginning in the 1990s, that constituted the Eastern Seaboard economic corridor. The second was the exchange rate depreciation that accompanied the 1997-99 Asian Financial Crisis. Jointly, these two factors made manufacturing production for export more profitable. The third 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.

Key words: Automotive exports; final assembly; parts and components; Eastern Seaboard scheme; Thailand.

JEL codes: F14; L62; O18; O24.

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1. Introduction: Detroit of the East?

Thailand's export-oriented automotive industry is a celebrated economic success story. The production of motor vehicles and parts began in the 1960s and expanded from the early 1990s, catering solely for the highly protected domestic market. Production for export has been important only since 2000, but more than 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 two million units, making Thailand the world's 9th largest automotive producer. According to a 2013 report in *The Economist*, Thailand has become 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, 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. Within Japan these currency realignments and related labour market developments raised costs of production relative to the revenues from exports. American negotiators hoped that these cost pressures would induce at least some Japanese manufacturers to relocate to the Unites States. In the years following some did, but more often Asian locations outside Japan proved more attractive to Japanese manufacturers than relocation to the US. Low labour 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.

[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 estimate of total employment cited above is based on industry sources and implies that the automotive sector accounts for 4% of Thailand's manufacturing work force of 6.5 million.

In the case of automotive manufacturing for export, Thailand was very successful in attracting Japanese manufacturers, compared with neighbouring countries such as Malaysia, Indonesia and the Philippines (Doner *et al.* 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' characterisation, the final assembly operations occurring within Thailand are fully foreign-owned, with production and marketing decisions, together with most of the design and technical research, occurring in Japan. 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, following the 1997-98 Asian Financial Crisis (AFC), responsible for the relocation of foreign manufacturers to Thailand? Fifth, did the local content requirements in operation until their abolition in 1997 lay the foundation for the development of the Thai parts and components sub-sector, 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 growth of the automotive industry?

This study attempts to shed light on these and related questions. The prevailing literature has tended to attribute Thailand's automotive export performance to selective industry policy ('picking winners') on the part of the Thai government. In contrast, our hypothesis is that three sets of factors jointly facilitated Thailand's success in attracting footloose automotive production, leading to its export success. The first was a proactive set of infrastructure investments, beginning in the late 1980s and extending through the 1990s, known as the Eastern Seaboard Scheme, which created an economic corridor, designed to reduce costs within heavy industry in general, but not designed with

any specific industry in mind. The second factor was the exchange rate depreciation that followed the 1997-98 AFC, making manufacturing production for export more profitable. The third factor was two policy changes introduced by the Thai government shortly after and partly in response to the AFC. 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.

In this article, we first summarise, in Section 2, the recent history of the Thai automotive sector. In Section 3 we then describe the policy changes affecting this development. In Section 4 we draw upon industrial census data to analyse the relationships between Thai and foreign automotive producers. Section 5 concludes.

2. Development of the Thai automotive industry

The industry has passed through two distinct phases: an import substitution phase, followed by an export phase. During the import substitution phase, 1960 to 1997, the output of the automotive industry fluctuated with domestic demand**.** Output remained below 100,000 units per year until 1983 but expanded during the decade of economic boom from 1987 to 1996, when real GDP grew at almost 10% per year, stimulating domestic demand. Output reached just over half a million units in 1996, almost entirely for the domestic market. With the collapse of demand resulting from the AFC, output plummeted to just over one fourth of this level in 1998. Over the next two decades the policy changes and infrastructure investments described below produced a resurgence of output, reaching around 2 million units in 2015.[2] Figure 1 shows that the export share of this output grew dramatically from almost zero in 1997 to over 60% in 2015.

[2] Output surged temporarily in 2012 and 2013. An initiative of the populist government of Prime Minister Yingluck Shinawatra (2011-14) 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 two years, leading to total output of

[Figure 1 about here]

In 2014, automotive exports earned $US 33.6 billion, 16% of total merchandise exports and 19% of total manufactured goods exports. Table 1 shows that of this total, just over half was export of vehicles and the remainder parts and components. Total automotive imports were $US 13.5 billion, of which only 15% was vehicles and the remainder parts and components. 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 EU and Japan. 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 1 about here]

Value added derived from Thailand's automotive industry is summarised in Figure 2. From just over 5% of manufacturing value-added prior to the Asian Financial Crisis, 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 meaning one-ton pickups, currently represent 60% of Thailand's total vehicle output, as it did three decades earlier (Figure 3).

[Figure 2 about here]

[Figure 3 about here]

A striking feature of the Thai industry is revealed by Figure 4. The imported input content of vehicles produced in Thailand has declined steadily since the early 1990s. This decline was occurring already, prior to the abolition of local content requirements (LCRs) in 2000 and continued

2.5 million units. Output contracted correspondingly when the policy was abandoned following the military coup of May 2014.

thereafter until around 2005. The moderate increase since then is due to the high electronics content of vehicles, requiring more sophisticated imports. In 2014 the $US value of imported inputs per vehicle was only 55 per cent of its level in 2000 when local content requirements were abolished.

[Figure 4 about here]

Earlier studies confirm 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).

Finally, Figures 5 and 6 compare Thailand's automotive production and export performance with neighbouring 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 local content requirements 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 much less well than Thailand.

[Figure 5 about here]

[Figure 6 about here]

3. Thailand's policy environment for automotive development

3.1 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 unable to receive large, ocean-going container ships directly, requiring trans-shipment of cargoes on 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 km. to the southeast of Bangkok, that came to be called the Eastern Seaboard Scheme, centred on the new port of Laem Chabang (Doner 1991). The scheme was connected by road to the large Map Ta Phut petro-chemical 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 (Banomyong 2010). It is notable that the planning documents of the time did not assume or anticipate that the resulting industrial development would take the form of export-oriented automotive production, though it was an obvious possibility. The new port was designed to support heavy industry in general, rather than any particular industry.

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 term 'economic corridor' refers to an integrated network of infrastructure, including but not confined to transport infrastructure, providing "connections between economic nodes or hubs" Brunner (2013). The 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 created an economic corridor consisting of

the outskirts of Bangkok itself and the seven additional provinces lying in a semi-circle to the east and north of Bangkok, all linked to the Laem Chabang port.[3] This transport and infrastructure corridor facilitated the growth of both final automotive assemblers and manufacturers of automotive parts. The final assemblers were all foreign-owned, mostly Japanese.[4] The parts and components manufacturers included both foreign firms (mainly Japanese) and many smaller Thai firms.

We argue in this paper that the development of this cost-reducing economic corridor 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 facilitated 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 enabled 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).

3.2 Trade policy

The Thai government's trade policy toward the automotive industry has passed through two distinct phases: an import substitution phase, lasting from the early 1960s to around 1997 and an export facilitation phase, from 1997 to the present. The major policy initiatives within these two phases are summarised in Tables 2 and 3, respectively.

Import substitution phase, 1960 to 1997

[3] The eight provinces constituting this corridor are Bangkok itself, Samut Prakarn, 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 Prakarn province, centered on Toyota, another in Ayutthaya, centered on Honda, and another in Rayong, centered on a commercial alliance between Ford and Mazda.

[4] Ford is the sole non-Japanese example, producing in a commercial alliance with the Japanese firm, Mazda.

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 local content requirements (LCRs) from 1974 onwards. 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 2 about here]

During the 1990s these high rates of protection were gradually reduced. Under the reform-oriented government of Anand Panyarachun (1991 to 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 WTO 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 1997-99 Asian Financial Crisis (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 local content requirements (LCR) 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. Only a few, efficient Thai parts producers survived. But many small Thai manufacturing firms, producing automotive parts for larger component systems emerged over the next few years.

The AFC contributed to the political feasibility of these liberalising reforms in two ways. First, by bankrupting about three-quarters of the domestic firms dependent on the pre-existing LCR policy it destroyed most of the political opposition to liberalisation (Doner 2009). Second, the crisis produced a severe balance of payments crisis at the macroeconomic level, leaving the government desperate to promote exports regardless of opposition from remaining domestic rent-seekers. The AFC was devastating for the Thai people, but it is ironic that without it these radical liberalisations may have been infeasible.[5]

[Table 3 about here]

It has been claimed that the earlier local content requirement (LCR) scheme encouraged the development of Thai parts producers and that this paid off during the export phase (Doner 2009; Natsuda and Thoburn 2013). This argument is difficult to reconcile with the huge turnover in Thai parts and components manufacturing that occurred from 2000 onwards. 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

[5] In Indonesia, this paradox of political economy is known as Sadli's Law, after the late Professor Mohammad Sadli: bad times often produce good policies; good times do the opposite.

that had developed under the LCR included many inefficient rent-seekers, very few of which survived the AFC, the abolition of the LCR scheme and the entry of fully foreign-owned parts producers. New, more efficient Thai firms later emerged, working closely with the new foreign-owned entrants, but this cannot reasonably be attributed to the earlier LCRs.

The large depreciation of the Thai currency resulting from the AFC made production for export more profitable. Both Indonesia and Malaysia experienced large currency depreciations at the same time as Thailand. But unlike Thailand they did not make the policy adjustments necessary to make export-oriented automotive production attractive. The large manufacturers were in Thailand already. To export, they needed to scale up their production, which they did, based on huge corporate investments in plant and equipment. Fully foreign-owned parts suppliers with close links to the major assemblers soon entered the country. Fortuitously, 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 co-existence of tariffs and exports

An issue raised in the literature is the apparent puzzle that despite the Thai automotive industry's export orientation since 2000, high tariffs on vehicle imports remain in place. Indeed, Thailand's automotive tariffs remain among the highest within ASEAN, averaging around 44% for vehicles and 10.4% for parts (Kohpaiboon 2015). Natsuda and Thoburn (2012) conclude from these observations that import substitution policies are consistent with export promotion. Our account is different.

To explain the coexistence of these two phenomena it is necessary to distinguish between (a) the types of vehicles produced within Thailand for export – small-to-medium sized, non-luxury passenger vehicles and one-ton pickups – and (b) 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. For brevity, we will refer to these two categories as

economy and luxury vehicles, respectively. They are imperfect substitutes in final demand, permitting their prices to move differentially.

Figure 7 depicts supply and demand for these two categories of vehicles, distinguishing between the situations roughly before and after 2000. Panel (a) depicts the market for economy vehicles. The pre-2000 situation is shown by the demand function D and supply function S^1. The world price is P^*. An *ad valorem* tariff rate of t leads to a domestic price of $P^*(1+t)$ and imports of M^1. There are no exports. Post-2000, infrastructure investments and the policy changes described above lead to large scale capital investments within the industry, with the intention of exporting, and the supply function shifts to S^2. Economy vehicles now become an export. Provided the domestic market is competitive, manufacturers will sell on the domestic market until the domestic price falls to P^*, beyond which they will sell on the export market. The tariff is a tax on imports and if these vehicles were actually imported, they would be subject to it. But because they are not imported, the tariff is irrelevant for them. Raising or lowering the rate of the tariff would have no effect on their domestic price.[6]

Panel (b) refers to luxury vehicles. Supply and demand pre-2000 are qualitatively similar to that described above for economy vehicles. But the investment-driven shift in the supply function that occurs in economy vehicles post-2000 does not occur because manufacturers do not see luxury vehicles as potentially profitable exports from Thailand. Post-2000, the decline in the domestic prices of economy vehicles induces some substitution in demand away from luxury vehicles and the demand function shifts from D^1 to D^2. Luxury vehicles remain net imports but the level of imports declines, abstracting from the very real effects of rising incomes. Post-2000, the tariff remains relevant for luxury vehicles, because raising or lowering the tariff rate would affect their domestic prices, but not for economy vehicles.

[6] Within Thailand, new vehicle sales are subject to high rates of excise tax, which raise the domestic prices of all vehicles. But an excise tax is distinct from a tariff, a tax on imports.

[Figure 7 about here]

The reported co-existence of high rates of tariff protection and exports is misleading, conflating two distinct commodity categories. The imported category for which the tariff is relevant (luxury vehicles) is not exported. The exported category (economy vehicles) is not imported and is unaffected by the tariff.

Some industry observers have suggested that Thailand's automotive industry is oligopolistic with regard to the domestic market. If so, the high import tariffs on economy vehicles could support that market structure by allowing Thai producers to exercise price discrimination between domestic and export markets.[7] The price discrimination argument requires that Thai manufacturers collude to restrict domestic sales, because otherwise competition for the more lucrative domestic market would result in diversion of sales from export to the domestic market, eroding the price differential.

Price discrimination requires a tariff on imports of economy vehicles, because imports from elsewhere or re-import of vehicles exported from Thailand would otherwise destroy the price differential. It is clear that the existing tariff rates are well in excess of the levels required to achieve this outcome, a phenomenon known as 'water in the tariff'. It follows that even large percentage changes in tariff rates, upwards or downwards, would have no effect on the domestic price of economy vehicles.

3.3 One-ton pickups: a national product champion?

[7] Evidence exists for a price differential between the domestic Thai market and the export market for economy vehicles. Hill and Kohpaiboon (2016) report such comparisons for four economy models exported from Thailand to Australia. Thai prices were higher by 42% (Toyota Camry), 31% (Toyota Yaris), 25% (Honda Civic) and 31% (Honda Jazz). These differences must be interpreted in the light of Thailand's 30% vehicle excise tax, Australia's 5% tariff, value-added taxes in the two countries (7% in Thailand and 10% in Australia) and transport costs between Thailand and Australia. It is not clear whether a significant price differential remains after allowing for these cost differences. This matter may be clarified by further research.

A feature of the Thai automotive sector is the high proportion of commercial vehicles, especially one-ton pickups, in its output, as summarised in Figure 3 above.[8] Pickups also represent a large share of automotive exports. To explain these observations, Natsuda and Thoburn (2013) postulate a form of industry policy they call "*product champion* (picking a winning type of vehicle)".[9] The authors contrast this with the Malaysian policy of creating a national champion *firm*. Unlike Malaysia, Thailand has not attempted to establish a national brand automotive producer. The incentive used to encourage production of one-ton pickups in Thailand is said to be a lower rate of excise tax on one-ton pickups than on passenger vehicles (Natsuda and Thoburn 2013, p. 414).[10]

Pickups do attract a lower rate of domestic excise tax than other vehicles and this fact means that domestic demand for pickups is encouraged relative to other vehicles. But exports are exempt from excise taxes. Differences in excise tax rates accordingly provide no incentive to export one type of vehicle versus another. Yet one-ton pickups were the first vehicles exported from Thailand, as Natsuda and Thoburn point out, and constitute a higher proportion of Thailand's automotive exports than their share of the global market. Differences in domestic excise tax rates cannot be the explanation. Moreover, the excise tax policy dates to 1988, but as Figure 3 shows, one-ton pickups were already dominant in the output of the Thai automotive sector prior to that, at around 60 per cent of output, and despite some fluctuations driven by domestic demand, this proportion barely changed over the following three decades.[11]

Some, but not all, Japanese automakers have chosen to concentrate their global production of pickups within Thailand, for strategic reasons of their own. So far as the domestic market was

[8] This is true of some (Toyota, Isuzu, Nissan and Mitsubishi) but not all of the major Japanese producers operating in Thailand.
[9] Natsuda and Thorburn (2013, p. 413). Emphasis in original. For similar arguments, see also Doner (2009, pp. 240 and 254) and Doner and Wad (2014, p. 675).
[10] Natsuda and Thoburn also state the existence of "tax concessions, such as low corporate tax, for attracting investors into national product champion production." (p. 414) According to the present authors' enquiries, this is incorrect. Corporate tax rates do not discriminate between automotive producers who produce one-ton pickups and those who do not.
[11] The main exception was due to the temporary collapse in domestic demand for these vehicles during and immediately following the 1997-98 AFC.

concerned, Thailand's domestic tax policies supported that outcome, mainly to benefit farmers and small businesses, both heavy users of these vehicles. But this was not industry policy, attemping to pick winners, and it had no bearing on export decisions. The 'national product champion' story seems to be a myth.

3.4 Board of Investment incentive policy

Since the 1960s Thailand's Board of Investment has attempted to encourage the decentralisation of manufacturing production away from the immediate vicinity of Bangkok. It defined three zones. Zone 1 included the five provinces immediately adjacent to Bangkok, including Samut Prakan, where Toyota is located. Zone 2 consisted of nine adjacent provinces, including Chonburi and Ayuthaya, where Mitsubishi, Ford, Mazda and Honda are located. Zone 3 was the remaining 62 of Thailand's 76 provinces, all more distant from Bangkok. Until 2013 the BOI used a combination of fiscal incentives to encourage relocation to outer provinces, especially to Zone 3. 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 household incomes of the provinces concerned, poor infrastructure prevented it. The incentives offered were insufficient to overcome this drawback. The decentralisation policy failed.

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 latter did not work and the decentralization objective was abandoned in 2013. 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.

3.5 Labour supply and land acquisition

Issues of labour 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 per cent freehold ownership) within private industrial estates, whereas leasehold or joint ventures with local partners owning 51 per cent of the operation is commonly required in other Asian countries. (Aveline-Dubach, 2010: p.178)

3.6 The ASEAN Industrial Cooperation Scheme

The ASEAN Industrial Cooperation Scheme (AICO) 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 percent 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 apparently been minor.

4. Analysis of the Industrial Census

Thailand's industrial census is available for the years 1997, 2007 and 2012, containing data collected in 1996, 2006 and 2011, respectively. The surveys will subsequently be referred to by the latter years, indicating the years of data collection, rather than the years of census publication. The data

contained in these surveys relates 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.[12]

4.1 Descriptive summary

Table 4 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 trailer trucks using imported new or used engines and these firms undertake very little actual manufacturing activity within Thailand.

[Table 4 about here]

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 Prakarn province increased from 56 in 1996 to

[12] A longer, working paper version of this paper (Warr and Kohpaiboon, 2017, available online) contains detailed maps showing the location of final assembly and autoparts firms within the economic corridor in 1996 and 2006, based on the Industrial Census data.

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 5 provides further summary details on them. Table 6 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, domestically-owned firms are smaller and more labour-intensive, as measured by output per worker.

[Table 5 about here]

[Table 6 about here]

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 three 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 five years between 2006 and 2011 the average age of foreign-owned input suppliers increased by roughly five 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 5 and 6 reveal the vast difference in sample coverage among these three censuses, especially for foreign car makers, which are a central interest in our analysis.

4.2. 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.

1. Is there a differential in output per firm between foreign and domestic producers? If so, has this differential changed over time?
2. Is the capital / labour ratio higher for foreign firms than domestic firms? If so, has this differential changed over time?
3. 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 *F* 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

$$\ln Q = 3.61 + 1.40F - 1.05D06 + 1.69\, F \times D06$$

(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

$$\ln(K/L) = -1.70 + 1.43F - 0.58D06 - 0.22\,F \times D06 \qquad (2)$$

(-10.76)*** (4.90)*** (-0.31) (-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: Labour productivity, measured as value-added per worker, VA/L

$$\ln(VA/L) = 2.74 + 0.15\ln(K/L) + 0.98F - 0.46D06 + 1.63\,F \times D06 \qquad (3)$$

(15.58)*** (3.86)*** (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 labour productivity was significant in each case and did not decline over time. Did the long period of local content requirements 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.

4.3 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 Prakarn, 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 labour 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 labour productivity inside and outside the improved infrastructure regions. This is done for each of the three years of the Industrial Census and for both foreign and local firms.

Table 7 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 three years. Table 8 performs similar calculations for parts suppliers. The means of labour productivity are again higher 'Inside' than 'Outside', except for foreign firms in 1996 and 2011, where the 'Outside' means are higher.

[Table 7 about here]

[Table 8 about here]

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 labour productivity are statistically significant. This is done in Table 9. The analysis assumes that the sample is an unbiased random sample from the overall population of relevant firms. The null hypothesis is that true labour productivity for the full population is the same inside and outside the improved infrastructure regions. The alternative hypothesis is that 'Inside' productivity is higher. 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.[13]

The final column of Table 9 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 labour productivity is significantly higher 'Inside' than 'Outside'. This is also true for local final assemblers in all three years. Among parts suppliers, productivity is higher for foreign firms 'Inside' than 'Outside' in 2006, but not significantly different in the other two 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 that for the previous two rounds. Discounting those results, the conclusion is that the public investments in infrastructure significantly raised labour productivity among both final assemblers and parts suppliers and for both foreign and local firms.

[Table 9 about here]

5. Conclusions: Explaining the Thai experience

The impressive growth of Thailand's export-oriented automotive industry – both final vehicles and parts – has generated hundreds of thousands of manufacturing jobs that would not otherwise have existed. The industry developed within an automotive manufacturing corridor based on massive public infrastructure investments in the 1990s, known as the Eastern Seaboard scheme. The

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

investment was far-sighted but risky. It had a happy ending, but things could have been otherwise. It eventually generated large benefits for Thailand, but only after the disastrous 1997-98 Asian Financial Crisis, combined with crucial policy changes within Thailand, made automotive production for export profitable.

The key policy changes were abandonment of (a) restrictions on foreign ownership and (b) local content requirements. The infrastructure development and policy reforms were jointly necessary for the export success. Without the policy reforms, the huge public infrastructure investments would have been under-utilised because they required a scale of heavy industry production possible only through exports. But without the cost-reducing effects of the improved infrastructure, the policy reforms would not have attracted large scale export-oriented investment. Development of the infrastructure supporting an efficient export gateway (Laem Chabang port and the associated Eastern Seaboard corridor) was crucial, but this infrastructure development was not automotive industry-specific and the growth of the automotive sector was not anticipated by the planners concerned.

Neighbouring 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 (a) they did not invest similarly in cost-reducing infrastructure improvements[14] and (b) they did not adopt comparable policy reforms. These policy missteps among its competitors clearly contributed to Thailand's success.

Thailand's Board of Investment (BOI) had attempted for decades to use fiscal incentives to encourage manufacturers to locate in economically disadvantaged regions of the country. The BOI policy assumed 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 policy failed and

[14] On Malaysia, see the detailed account in Athukorala and Nayaranan (2018).

was abandoned in 2013. The lesson for other countries is that manufacturing firms cannot readily be induced to locate in regions preferred by governments, but where infrastructure facilities are sub-standard, even when seemingly generous tax incentives are offered as inducements.

Thailand avoided the failed 'national car' policies of some of its neighbours, 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 liberalised input supplies by abolishing local content requirements, becoming an export platform, paradoxically facilitating higher, not lower, local content, even *per vehicle*. In addition, the volume of production was much higher than it otherwise would have been. The lesson for other countries is that local content schemes can be strongly counterproductive. Following the relaxation of restrictions on foreign entry of input suppliers (1997), MNE 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 local content requirements facilitated the development of export-oriented automotive production.

Thailand cannot (yet) be considered the 'Detroit of the East' because its automotive industry remains largely foreign-owned, foreign-managed and dependent on design, engineering development and technical research occurring mainly in Japan. The export success of the industry reflects the Thai government's impressive institutional capacity in physical infrastructure development. But the industry also reflects a lack of capacity in human resource development. The limited availability of skilled workers remains a major industry problem and a constraint on deepening its domestic design and engineering content. Thailand will not become the 'Detroit of the East' until this changes.

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Table 1. Thailand: Automotive trade and investment policies - Import substitution phase, 1960 to 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 CKD kits: new rates, passenger cars 30%; pick-ups 20%; and trucks 10%.
1969	Ministry of Industry set up Automotive Development Committee (ADC). 20% increase in tariffs on CBU vehicles: new rates, passenger cars 50%; pick-ups 40%; and trucks 30%.
1971	MOI restricted the number of locally assembled passenger car, pick-ups 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 completely knocked down (CKD) kits to 80%. Suspended approval of new assembly plants to reduce over capacity. Tariffs of CBU passenger cars and CKD passenger cars were increased to 150% and 80% respectively.
1982	LCR requirement for all vehicles set at 45%.
1985	Mandatory local-content list imposed. Ban on imported CBU vehicles with engine capacity over 2,300cc lifted.
1986	LCR for passenger cars lifted to 54%. List for compulsory and non-compulsory 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 1-ton pickup trucks.
1992	Exempted pick-up trucks from exercise tax.
1993	Ban on new assembly plants lifted.
1995	Reduced CKD tariffs from 20% to 2%.

Notes: CKD means completely knocked-down; CBU means completely built-up; LCR means local content requirement.
Source: Based on Kohpaiboon (2015).

Table 2. Thailand: Automotive trade and investment policies - Export facilitation phase, 1997 to 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 LCR 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 5 carmakers approved including Toyota, Nissan, Mitsubishi, Suzuki and Honda.
2014	Launch of 'Eco-car project Phase 2'. Another 5 firms were approved. They included Nissan, Toyota, Mitsubishi, Ford and General Motors. 4 more to be approved (Honda, Suzuki, MG and Volkswagen).

Notes: CKD means completely knocked-down; CBU means completely built-up.
Source: Based on Kohpaiboon (2015).

Table 3. Thailand: International trade of the automotive industry, 1999–2014

	Total exports (US$m)	Share of total exports (%)		Total imports (US$m)	Share of total imports (%)		Trade balance (US$m)
		Vehicles	Auto parts		Vehicles	Auto parts	
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	89	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	88	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	88	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/).

Table 4. Thailand: Number of automotive plants by sales volume, 1996, 2006 and 2011

	1996		2006		2011	
	No. Plants	% of total	No. Plants	% of total	No. 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' compilations from National Statistical Office, *Industrial Census*, 1997, 2007 and 2012.

Table 5. Thailand: 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' compilations from National Statistical Office, *Industrial Census*, 1997, 2007 and 2012.

Table 6. Thailand: 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' compilations from National Statistical Office, *Industrial Census*, 1997, 2007 and 2012.

Table 7. Thailand: Automotive final assemblers inside and outside upgraded regions - labour productivity and infrastructure

		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)
2011	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)

Notes: Labour 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 labour 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 Prakarn, 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 8. Thailand: Automotive parts suppliers inside and outside upgraded regions - labour productivity and infrastructure

		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)

Notes: Labour productivity means annual turnover 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 labour 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 Prakarn, 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.

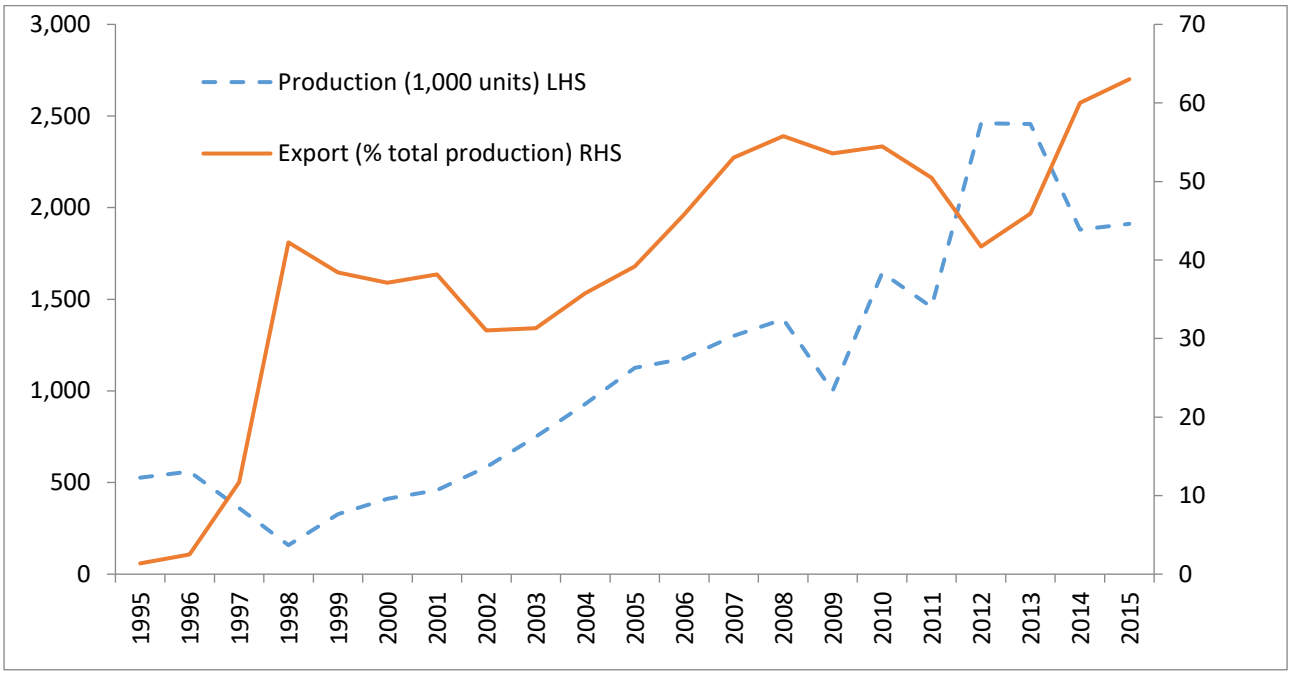
Table 9. Thailand: Test that firm labour productivity is raised by upgraded public infrastructure

	Year	Sample means		One-tailed *t*-test				
		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	1.691	*
Local	2006	1.06	0.24	1.44	1.94	3.14	2.477	**
Local	2011	2.06	0.47	1.33	1.73	2.55	2.566	**
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	3.161	***
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	3.448	***
Local	2006	0.5	0.29	1.28	1.65	2.33	5.623	***
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 labour productivity is *higher* in the improved infrastructure region; and n.s. means that the null hypothesis cannot be rejected at these significance levels.

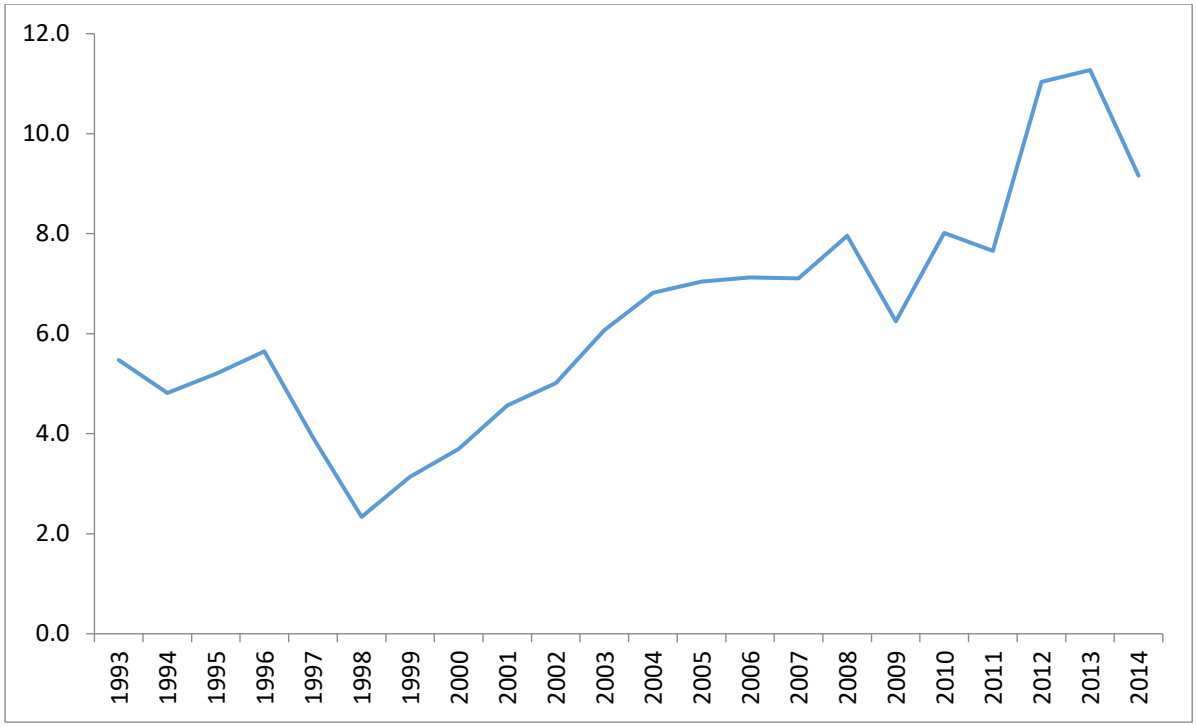
Source: Authors' calculations using data from National Statistical Office, *Industrial Census*, 1997, 2007 and 2012.

Figure 1. Thailand: Automotive output and export share, 1995 to 2015



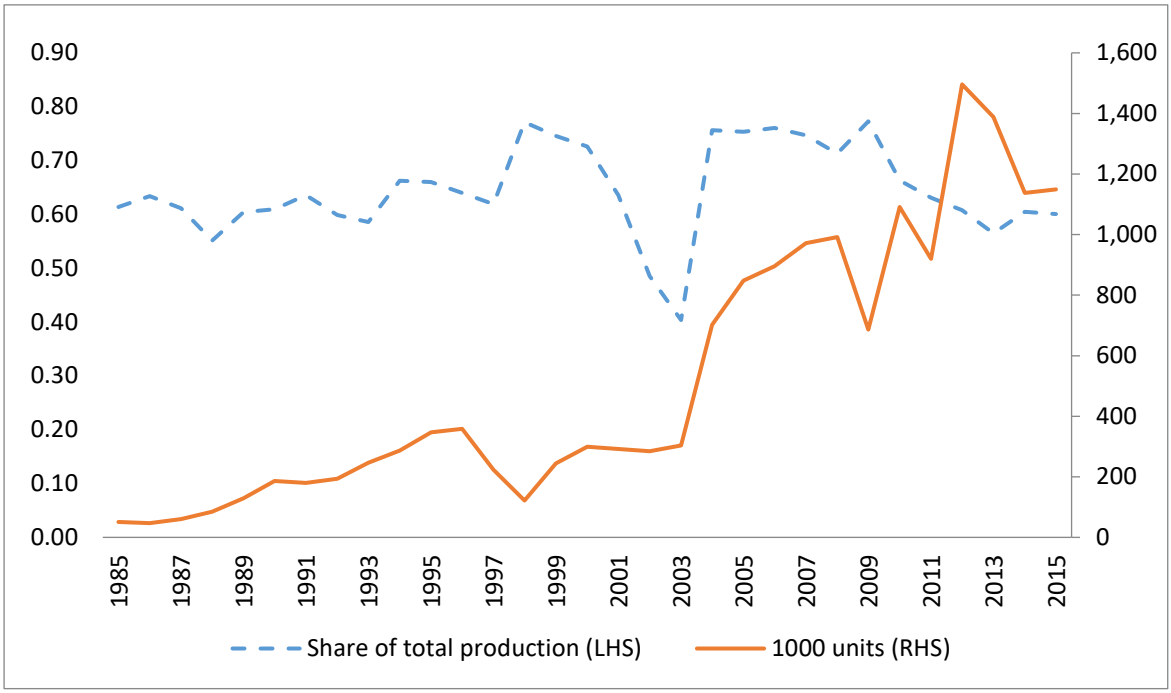
Source: Authors' calculations using data from Automotive Association, Industrial Federation of Thailand and Automotive Intelligence Unit, Bangkok.

Figure 2. Thailand: Automotive sector value added share of total manufacturing, 1993–2014 (per cent)



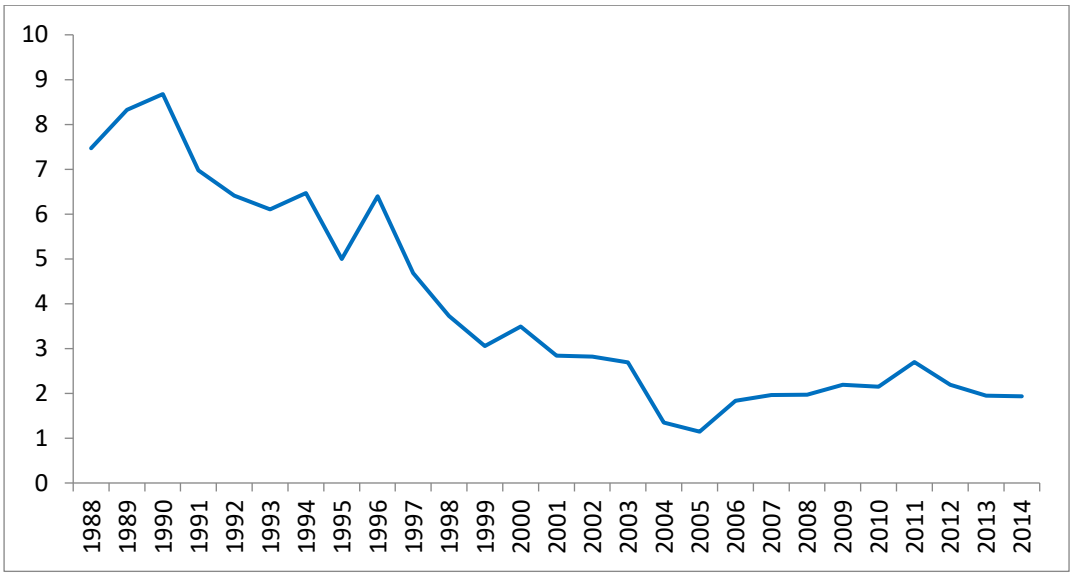
Source: Authors' calculations using data from National Economic and Social Development Board, Bangkok.

Figure 3. Thailand: One-ton pickup production and share of vehicle production, 1985 - 2015



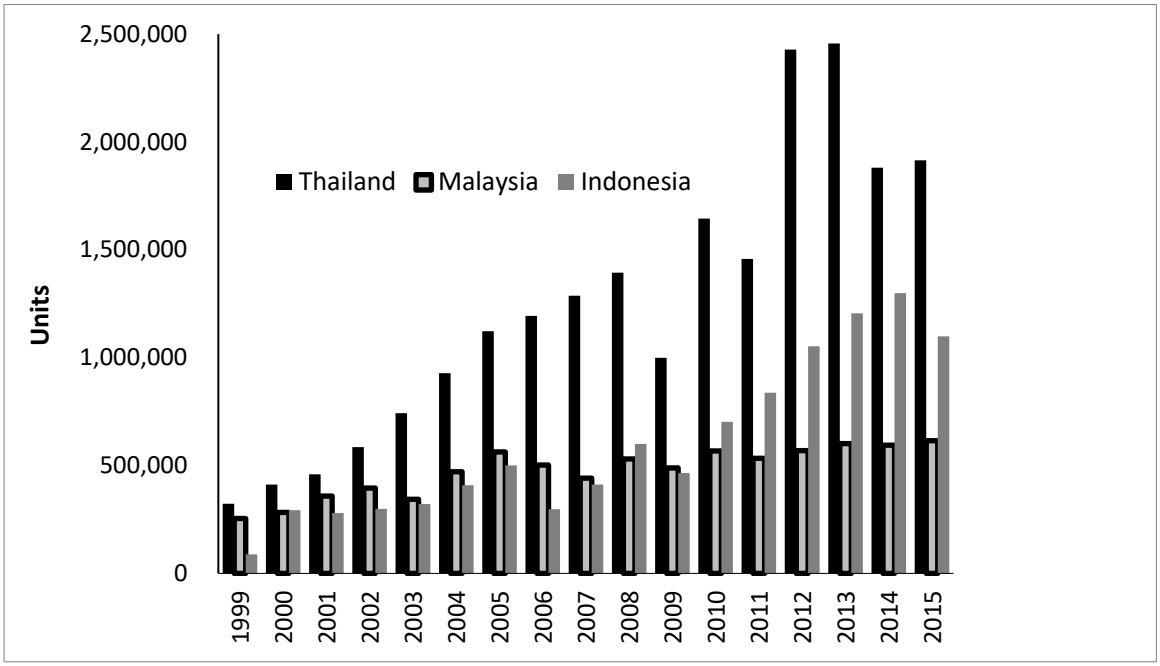
Source: Authors' calculations using data from National Economic and Social Development Board, Bangkok.

Figure 4. Thailand: Value of imported parts per locally assembled vehicle ($ million/1000 units)



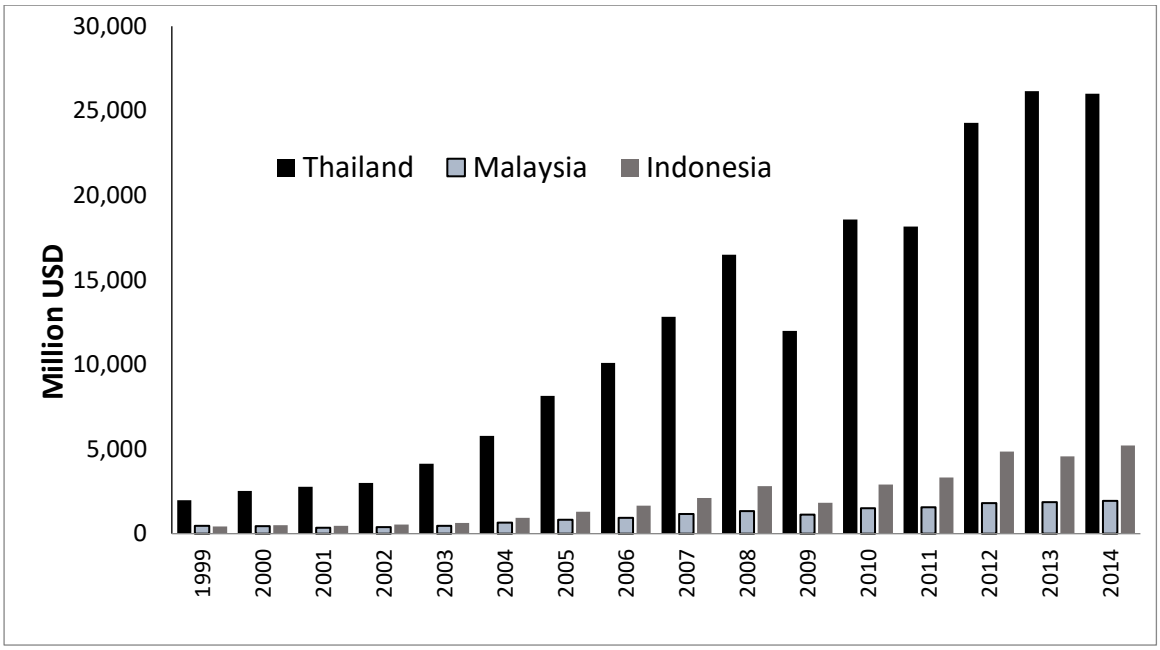
Source: Authors' calculations, based on: imports - UN Comtrade; vehicle production - Automotive Association and Industrial Federation of Thailand, Automotive Intelligence Unit, Bangkok.

Figure 5. Automobile Production in Thailand, Malaysia, and Indonesia: 1999-2014 (units)



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

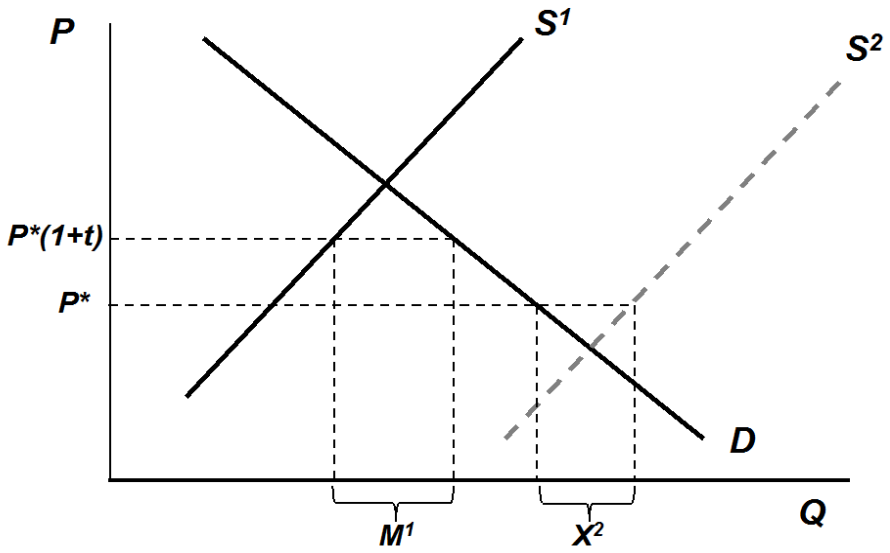
Figure 6. Thailand, Malaysia and Indonesia: Export Value of Automobiles (million USD)



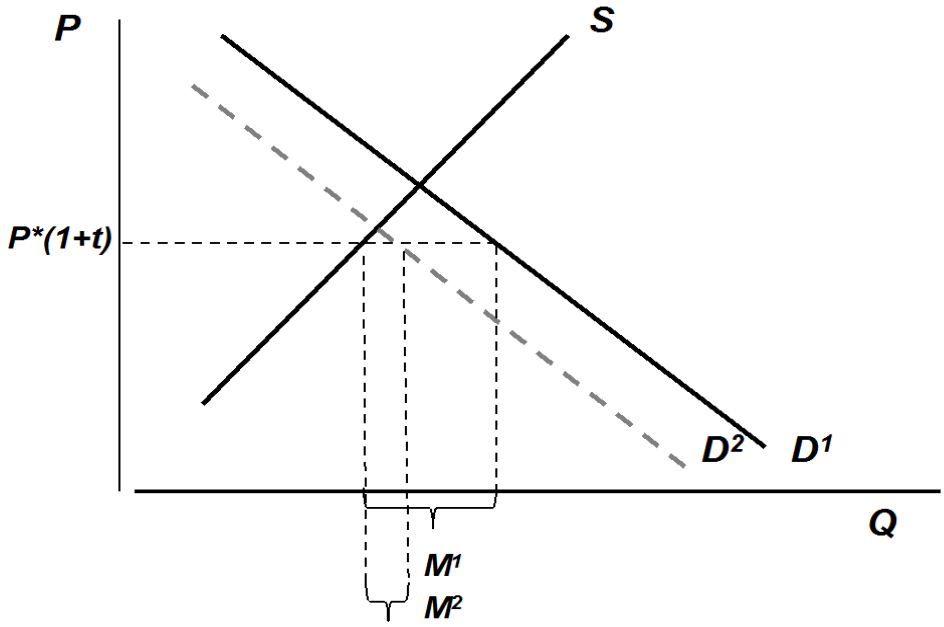
Source: Authors' compilation from UN Comtrade database, using the WITS (World Integrated Trade Solution) website (http://wits.worldbank.org/).

Figure 7. The two phases of the Thai automotive industry:

(a) Economy vehicles



(b) Luxury vehicles



Source: Authors' construction.