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The efficiency of SMEs in Thai manufacturing: A stochastic frontier analysis

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ABSTRACT

This study examines the technical efficiency of Thai manufacturing SMEs and their firm-specific determinants utilising firm-level industrial census data for 1997 and 2007. Results from a stochastic frontier production function and technical inefficiency effects model reveal that Thai SMEs are overwhelmingly labour intensive with low average technical efficiency in both years. Results also indicate that firm size, firm age, skilled labour, location, type of firm ownership, government assistance, foreign investment and export activity are important firm-specific factors contributing to the technical efficiency of SMEs. Specific policies are warranted to improve Thai SMEs. These policy measures include: easier access to financial services, access to skilled labour, training of the workforce and entrepreneurs, addressing location and regional capacity inequities, encouraging foreign investment for operational synergies and export incentives for penetration in the world market.

1. Introduction

The importance of small and medium sized enterprises (SMEs) to economic and social development is increasingly recognised in the literature (Audretsch et al., 2009; Doern, 2009; Harvie, 2007; Hussain et al., 2009). SMEs contribute significantly to business numbers, output and economic growth, employment generation, exports, regional development, economic inclusion and empowerment and business opportunities. As subcontractors in the global value chains of multi-national enterprises, SMEs provide backward linkages for large firms through the supply of goods, services, information and knowledge (Audretsch et al., 2009; Doern, 2009; Harvie, 2007; OSMEP, 2003). An entrepreneurially vibrant, innovative and efficient SME sector can promote sustainable growth and development.

Thailand's SMEs have also played a pivotal role in the country's economic and social development (Office of Small and Medium Enterprises Promotion OSMEP, 2009). They constituted 99% of all enterprises in the country and contributed 73% of total employment during the period 1994[2] to 2009. They contributed 33% of total exports on average and approximately 38.8% of total GDP at current prices on average over the period 2000 to 2009 (OSMEP, 2009). Of total SMEs almost one-third were in the manufacturing sector over the period 1994 to 2009. Manufacturing SMEs employed around 27.1% of the private sector workforce on average over the period 1994 to 2009.[3] The contribution of manufacturing SMEs to total SME GDP was 28.7% over the period 1994–2009.

Despite their significance in the economy there is a dearth of evidence on the performance of Thailand's manufacturing SMEs. Hence the primary motivation of this study is to analyse the performance of Thai manufacturing SMEs[4] and investigate firm-specific factors that have influenced this performance. The issue is important since Thailand can no longer base its future economic growth on unskilled low cost labour. Thai firms must be dynamic, innovative and efficient if they are to flourish in a competitive and increasingly integrated regional and global economy.

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[2] Census data for Thai SMEs only started in 1994.

[3] The official definition of manufacturing SMEs in Thailand is based upon the number of employees or the value of fixed assets. An enterprise employing up to 50 workers, or having fixed assets, excluding land, not exceeding THB 50 million (approximately US$1.65 million) in the manufacturing sector is considered a small enterprise. An enterprise employing between 51–200 workers or fixed assets, excluding land, between THB 51–200 million (approximately US$1.68–6.6 million) is defined as a medium-sized enterprise in the manufacturing sector (OSMEP, 2003).

[4] The justification for focusing upon manufacturing SMEs is that there is substantially more data available for these SMEs in Thailand. In particular, detailed firm level industrial census data is produced every 10 years by the National Statistical Office of Thailand.

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The major aims of this study are: 1) to estimate and compare the level of technical efficiency performance of Thai manufacturing SMEs in the pre and post Asian Financial Crisis period using data for the years 1997 and 2007.[5] Estimation is performed by size of manufacturing SMEs, and by sub-manufacturing sectors of operation classified by the Standard International Trade Classification (SITC) Revision 4[6]; 2) to examine firm-specific factors that affect technical efficiency performance; and 3) identify plans and policies to improve the technical efficiency of Thailand's manufacturing SMEs.

The paper is structured as follows. Section 2 overviews the contribution of manufacturing SMEs to the economy. A brief literature review on approaches to measuring SME performance and results from empirical studies is presented in Section 3. The empirical methodology adopted in this study is presented in Section 4. Empirical results are presented in Section 5. Section 6 highlights key findings from this study and policy implications. Conclusions are presented in Section 7.

2. Overview — manufacturing SMEs and the Thai economy

SMEs in general have made and continue to make a significant contribution to the country's social and economic development (Brimble et al., 2002; Mephokee, 2003; Pholphirul and Biatasevi, 2012; Regnier, 2000). This contribution is multi-dimensional in nature: business numbers; employment, GDP and exports. This section conducts a brief overview of this contribution with a focus upon the period 1994–2009.[7] The hiatus of manufacturing SMEs in particular occurred in 1997 before the full effects of the Asian Financial Crisis (AFC) began to have an impact. They have not regained such a level of importance, although they still remain important in terms of their contribution to number of SME enterprises, employment, GDP and exports. They will remain important in the future but the extent of this will likely depend upon enhancing their efficiency and competitiveness.

2.1. SME business numbers: aggregate, sector and region

2.1.1. Aggregate

Table 1 shows that SME business numbers generally increased during the period 1994–2009 with the exception of the period immediately after the AFC (1997–98). Small enterprises (SEs) proved to be particularly fragile and less resilient to financial and economic turbulence, but subsequently recovered during the period 2002–2009, while medium sized (ME) and large enterprises (LE) also experienced some turbulence.[8] Business numbers in all categories of firm size increased even during the period of the Global Financial Crisis (GFC) (2007–2008) and subsequent global economic downturn (2008–2009). SME numbers remained remarkably buoyant during this period suggesting that they had become more financially resilient to regional and global crises and certainly in comparison to that of 1997–1998. SME numbers increased rapidly from 2002 to 2009, driven by the growth in SE numbers, mainly on the back of Government promotion policy during this period (see for example OSMEP, 2005; Sahakijpicharn, 2007).

2.1.2. Sector

Table 2 shows the dramatic decline in SME numbers in the manufacturing and service sectors in the immediate aftermath of the AFC, but their strong recovery thereafter. In 2003 the Office of the Board of Investment of Thailand promoted 675 projects involving SMEs, the total value of which amounted to US$3960 million (Mephokee, 2003; OSMEP, 2002). Of these projects, 573 involved manufacturing SMEs in such areas as raw steel, machines, car spare parts, mining, ceramics, electronic and electronic appliances, paper and plastic products, services and utilities (Sahakijpicharn, 2007). As a consequence of these projects and increased export growth by manufacturing sectors such as computers, automotive and auto parts, home appliances and electronics (Theingi, 2004), there was a dramatic increase in the number of SMEs in manufacturing until 2006.[9] With the onset of the GFC and subsequent global recession (2007–2009), however, SMEs in this sector have struggled and their numbers have steadily dwindled. Punyasavatsut (2007) argued that Thai manufacturing SMEs were not ready to face the rigours of international competition arising from the country's increased opening to foreign trade/investment and economic integration, more intense competition from lower labour cost countries in the region and poorer efficiency and competitiveness (Pholphirul and Biatasevi, 2009).

On the other hand SMEs in the services sector steadily increased in number from 2002–2009 with the exception of 2004. The service sector became the second most SME-dense sector, with the retail sector a close third. SMEs in the retail sector experienced a decline in numbers due to increased competition from the establishment of giant discount stores in Thailand such as Tesco Lotus, Carrefour, and Big C (OSMEP, 2002; Sahakijpicharn, 2007). This situation changed in 2006 with the newly established trade and repairs sector[10] classification which quickly became the most SME dense sector followed by services and manufacturing SMEs from 2007–2009.

2.1.3. Region

Table 3 shows the regional distribution of SME business numbers. Bangkok and vicinity areas were the most SME dense over the period 1994 to 2008, accounting for around 30% of total SMEs on average. This region is recognised as the country's major economic centre, and also containing many of Thailand's large businesses (OSMEP, 2008). This is followed by the North-eastern, Northern and Central regions respectively. Regional disparities in income and overall development are apparent in Thailand and this is likely to be reflected also in the performance of SMEs based across these regions. A major issue addressed in the empirical section of this paper.

2.2. SME contribution to employment — total, by sector and region

Table 4 presents total employment and employment by enterprise size from 1994 to 2009. It is clear that SMEs are a pivotal source of jobs in the economy. They contributed more than 73%, on average, of overall employment over the period 1994–2009, mostly in SEs (around two-thirds of total employment). Over the period 2004–2009 total employment in MEs increased slightly while that for LEs decreased. Employment in SEs noticeably increased, even during the period of the GFC and its economic aftermath. This fluctuating number and percentage contribution of SMEs to overall employment is likely to have been contributed to by an improvement in statistical collection methods during this period (OSMEP, 2003; Sahakijpicharn, 2007).

Table 5 shows employment by SMEs classified by sector during 1994 to 2009. The manufacturing, services and retail sectors[11] dominated SME employment. Numbers employed in the manufacturing and

[5] Data for the years 1997 and 2007 is chosen as these are based on industrial census data which is compiled by the Thai authorities every ten years, and contains the most comprehensive data available on Thai SMEs. Panel data cannot be constructed as the Thai government has not released firm identification codes for such data. Hence this study utilises the best available data on Thai manufacturing SMEs.

[6] The 1997 and 2007 industrial censuses comprise enterprises engaged in manufacturing activities which are classified by the International Standard Industrial Classification of all Economic Activities, ISIC: Revision 3. However, ISIC has 23 sub-manufacturing sectors in both industrial censuses. To keep the analysis tractable we adopt SITC Revision 4 which consists of only 10 sectors.

[7] Data collection of Thai SMEs only started in 1994.

[8] It should be noted that data collection on Thai SMEs was poor during this period and could account for the high variability in SME numbers from year to year. The volatility in SME numbers is likely to be also due to the way in which the National Statistical Office (NSO) of Thailand collected data on SMEs during the period 1994 to 2009.

[9] During 2004–2005 manufacturing had become the most SME dense sector accounting for almost 31% of total SMEs (see Table 2).

[10] Incorporating both the retail and wholesale sectors.

[11] The retail sector was included in the trade and repairs sector from 2006.

Table 1
Number and percentage of SMEs and enterprises by size, 1994–2009.

Enterprises	1994	1997	1999	2002	2003	2004	2005	2006	2007	2008	2009
SMEs	438,805	799,033	524,960	1,639,427	1,995,929	2,199,595	2,239,280	2,274,525	2,359,312	2,827,633	2,896,106
Small enterprises	432,967	767,766	515,664	1,630,015	1,989,394	2,189,966	2,229,353	2,264,734	2,347,531	2,815,560	2,884,041
Medium enterprises	5838	11,267	9296	9412	6535	9629	9927	9791	11,781	12,073	12,065
Large enterprise	3639	4168	4351	6103	10,599	4323	4444	4292	4324	4586	4653
Other enterprises	N/A	N/A	N/A	N/A	N/A	5989	5994	8240	6915	4158	N/A
Total	442,444	803,201	529,311	1,645,530	2,006,528	2,209,907	2,249,718	2,287,057	2,377,466	2,836,377	2,900,759
Percentage of all enterprises (%)											
SMEs	99.18	99.48	99.18	99.63	99.47	99.53	99.54	99.45	99.53	99.69	99.84
Small enterprises	97.86	95.59	97.42	99.06	99.15	99.1	99.09	99.02	98.74	99.27	99.42
Medium enterprises	1.32	1.4	1.76	0.57	0.33	0.44	0.44	0.43	0.5	0.43	0.42
Large enterprise	0.82	0.52	0.82	0.37	0.53	0.2	0.2	0.19	0.18	0.16	0.16
Other enterprises	N/A	N/A	N/A	N/A	N/A	0.27	0.27	0.36	0.29	0.15	N/A
Total	100	100	100	100	100	100	100	100	100	100	100

Sources: OSMEP (2001–2009).

Table 2
Number and percentage of SMEs Classified by Sector, 1994–2009.

Sectors	1994	1997	1999	2002	2003	2004	2005	2006	2007	2008	2009
Manufacturing	84,541	291,456	99,568	356,806	378,031	674,129	684,815	698,651	680,270	564,706	547,052
Wholesale	21,821	25,348	31,833	49,058	109,524	180,926	188,830	N/A	N/A	N/A	N/A
Retail	249,094	277,997	297,476	732,593	634,179	558,496	563,366	N/A	N/A	N/A	N/A
Service	83,349	204,232	96,083	500,970	627,772	561,797	577,663	636,626	709,841	946,812	975,552
Trade and repairs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	918,028	953,248	1,311,714	1,371,488
Other enterprises	N/A	N/A	N/A	N/A	246,423	224,247	224,606	21,220	15,953	4401	2014
Total	438,805	799,033	524,960	1,639,427	1,995,929	2,199,595	2,239,280	2,274,525	2,359,312	2,827,633	2,896,106
Percentage of enterprises											
Manufacturing	19.27	36.48	18.97	21.76	18.94	30.65	30.58	30.72	28.83	19.97	18.89
Wholesale	4.97	3.17	6.06	2.99	5.49	8.23	8.43	N/A	N/A	N/A	N/A
Retail	56.77	34.79	56.67	44.69	31.77	25.39	25.16	N/A	N/A	N/A	N/A
Service	18.99	25.56	18.3	30.56	31.45	25.54	25.8	27.99	30.09	33.48	33.68
Trade and repairs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	40.36	40.4	46.39	47.36
Other enterprises N/A	N/A	N/A	N/A	12.35	10.19	10.03	0.93	0.68	0.16	0.07	
Total	100	100	100	100	100	100	100	100	100	100	100

Sources: OSMEP (2001–2009)

service sectors began to increase from 2002 partly due to assistance from government support programmes such as the product development programme, the promotion of innovative SMEs programme, and the scientific and technological innovation programme (OSMEP, 2002). These were aimed at encouraging the establishment of new enterprises in the manufacturing and service sectors (OSMEP, 2003; Sahakijpicharn, 2007). By 2009 SMEs in the manufacturing, services and trade and repairs sectors contributed approximately one-third each of total SME employment. According to the OSMEP (2004), manufacturing and services SMEs were more labour-intensive than those in the retail and wholesale sectors. They had an average number employed of 4 workers for small enterprises and 200 and 109 workers for medium-sized enterprises in the manufacturing and service sectors, respectively.

From Table 5 it can be seen that the share of manufacturing employment in total SME employment increased rapidly from 24.9% in 2003 to 36.5% in 2004 and remained fairly stable until 2008, but in 2009 this share declined to 34.2%. As with the contribution to business numbers the hiatus of manufacturing SMEs to employment occurred just before the onset of the Asian financial crisis, when they contributed almost 46% of total SME employment or 35% of total employment in 1997. Subsequently, this contribution has declined, although remaining important at around 38–39% of total SME employment or 30% of total economy employment over the period 2005–2009[12] . On the other hand the share of the services and trade and repairs sectors steadily increased during this same period. The declining share of manufacturing SMEs could be a reflection of their poor efficiency and competitiveness performance which is the focus of this study.

2.2.1. Contribution of SMEs to Thailand's GDP

Table 6 shows the structure of Thailand's Gross Domestic Product (GDP) for the period 1999 to 2009. SME contribution to GDP, at current prices, was 38.8% over the period 1999–2009, with SEs accounting for 23.7% of this figure and MEs accounted for the remaining 15.1%. The SME share of GDP steadily declined after 2004, mainly due to that of a decline in the share from SEs. By 2009 SMEs contributed around 37.8% to overall GDP, with SEs contributing 25.4% of total GDP and MEs contributing 12.4%.

Table 6 also shows that the average annual real growth rate of SME output over the period 1999–2009 was approximately 3.9%. Comparing the average growth rate between 1999 and 2009 classified by size of enterprise (small and medium), the average annual real GDP growth rate of SEs was 3.6% while that of MEs was 4.5%. The average annual real growth rate of LEs was 4.5%. The real growth rate of SME output declined noticeably in 2009, by −2.4%, in the aftermath of the GFC, and was most notable for MEs (a −3.4% growth rate in 2009). LEs also experienced strong negative growth in output in 2009, while SEs appeared to demonstrate the most resilience to the global economic downturn.

Table 7 presents the GDP of SMEs classified by economic activity during the period 1999 to 2009. The trade and maintenance sector contributed most to SME GDP with an annual average value of 32% of total SME output during the period 1999 to 2009, followed by private services (31.2%) and manufacturing (28%). By 2009 private services

[12] Latest figures (for 2009) indicate that manufacturing SMEs contributed 34.23% of SME employment, equivalent to 26.77% of total employment (OSMEP, 2009).

Table 3
Number and percentage of SMEs classified by region, 1994–2008.

Regions	1994	1997	1999	2002	2003	2004	2005	2006	2007	2008
Bangkok and vicinity	119,609	N/A	157,730	517,827	611,535	660,389	674,838	692,922	728,518	868,715
Central	82,673	N/A	85,795	202,411	203,585	186,516	190,061	195,970	198,620	298,548
Northern	81,168	N/A	76,640	298,124	300,490	386,232	387,585	395,611	400,126	479,154
North-Eastern	111,712	N/A	121,940	514,245	524,515	623,682	625,402	650,469	689,015	769,503
Southern	36,539	N/A	70,442	29,015	246,951	213,699	215,588	197,394	201,456	228,547
Eastern	5304	N/A	10,459	76,658	107,753	125,338	129,210	137,825	138,925	178,659
Unspecified 22	1800	N/A	1954	1147	1100	3739	16,596	4334	2652	4507
Total	438,805	N/A	524,960	1,639,427	1,995,929	2,199,595	2,239,280	2,274,525	2,359,312	2,827,633
Percentage of SMEs (%)										
Bangkok and vicinity	27.26	N/A	30.05	31.59	30.64	30.02	30.14	30.46	30.88	30.72
Central	18.84	N/A	16.34	12.35	10.20	8.48	8.49	8.62	8.42	10.56
Northern	18.50	N/A	14.60	18.18	15.06	17.56	17.31	17.39	16.96	16.95
North-Eastern	25.46	N/A	23.23	31.37	26.28	28.35	27.93	28.60	29.20	27.21
Southern	8.33	N/A	13.42	1.77	12.37	9.72	9.63	8.68	8.54	8.08
Eastern	1.21	N/A	1.99	4.68	5.40	5.70	5.77	6.06	5.89	6.32
Unspecified	0.41	N/A	0.37	0.07	0.06	0.17	0.74	0.19	0.11	0.16

Sources: OSMEP (2001–2008).

Table 4
Number and percentage of SME employment and enterprises by size, 1994–2009.

Enterprises	1994	1997	1999	2002	2003	2004	2005	2006	2007	2008	2009
SMEs	5,243,500	4,057,595	6,605,300	4,990,217	5,566,865	8,863,607	8,896,164	8,863,334	8,900,567	9,125,916	9,701,354
Small enterprises	4,700,000	3,619,670	5,718,600	4,444,532	5,012,216	7,454,493	7,482,561	7,524,936	7,550,269	7,715,458	8,262,128
Medium enterprises	543,500	437,925	886,700	545,685	554,649	1,409,114	1,413,603	1,338,398	1,350,298	1,410,458	1,439,226
Large enterprise	2,124,000	1,255,775	1,727,300	2,243,805	3,605,887	2,887,261	2,894,932	2,687,938	2,810,767	2,891,756	2,704,243
Total	7,367,500	5,313,370	8,332,600	7,234,022	9,172,752	12,000,000	12,000,000	11,551,272	11,711,334	12,000,000	12,405,597
Percentage of SMEs (%)											
SMEs	71.17	76.37	79.27	68.98	60.69	75.43	75.45	76.73	76	76.23	78.2
Small enterprises	63.79	68.12	68.63	61.44	54.64	63.44	63.46	65.14	64.5	64.2	66.6
Medium enterprises	7.38	8.24	10.64	7.54	6.05	11.99	11.99	11.59	11.52	11.73	11.6
Large enterprise	28.83	23.63	20.73	31.02	39.31	24.57	24.55	23.27	24	24.07	21.8

Sources: OSMEP (2001–2009).

contributed the highest SME GDP, accounting for 32% of total SME GDP, followed by manufacturing SMEs (30.4%) and trade and maintenance SMEs (29.9%). The average annual real output growth of all SMEs at constant prices was around 4.1% during 1999 to 2004, compared to 7% for Trade and Maintenance SMEs, 6.9% for manufacturing SMEs and 5.8% for private service SMEs. There was a general slowdown in the GDP growth of SMEs across these three sectors in 2005, arising from the Tsunami disaster in 2004, an increase in the oil price and by political uncertainty and violence in the south of Thailand (OSMEP, 2005; Sahakijpicharn, 2007). Most of the impetus for SME GDP growth from 2005 was generated from output growth in the manufacturing sector, however in 2009 manufacturing and trade and maintenance SME output growth experienced a decline with the deepening of the global economic recession in 2009.

2.2.2. SMEs and export activity 2000–2009

The Thai authorities do not compile statistics on the exports of SMEs by sector of activity. Table 8, however, shows the value and percentage of exports classified by size of enterprise during the period 2000 to 2009. LEs contributed, on average, 67% of total exports over the period 2000 to 2009, while the SME average contribution was 33% of total exports. The proportional contribution by SMEs to total exports remained fairly stable until 2002,[13] but experienced a sharp increase to 45.5% of total exports in 2003 due to high demand for manufactured products from Japan, USA and ASEAN, particularly for plastic products, electronic products, computer parts, vehicle and automotive parts (Dhanani and Scholtès, 2002; OSMEP, 2003), from flow on benefits from Thailand's closer economic integration with other economies in ASEAN, from its involvement with free trade agreements involving ASEAN–China FTA, ASEAN–India FTA, ASEAN–South Korea FTA, ASEAN–Australia–New Zealand FTA, Thailand–Australia FTA, Thailand–Peru FTA and Thailand–South Korea FTA, which all came into effect after 2002[14] (Chirathivat, 2007; Sally, 2007) as well as its membership of the WTO from 2001. By 2009, the share of total exports by SMEs was 30.6%[15] (see Table 9) with the largest export market for Thai SMEs being ASEAN, which accounted for 22% of the total export value of SMEs in 2009. The EU was the second largest export market, representing 14.5% of overall SME export value. The third ranked was the Japanese market which amounted to 9.7% of the total export value of SMEs.

The trend in SME exports indicated only a gradual increase during the period 2000–2009. Possible reasons for this are that Thai SMEs face specific barriers to exporting, they produce poor quality products and they lack competitiveness or proactive problems relative to large enterprises, experience inefficiencies, and a lack of competitiveness. This could be due to non-tariff barriers to trade (e.g. logistics, labelling, warehousing etc.). This problem is a typical problem faced by SMEs in other countries. Thai SMEs face intense competition from rapidly-developing regional economies such as China, India, Vietnam and Indonesia which have much lower labour costs. Thai SMEs are lagging in terms of upgrading their knowledge and skills, technology,

[13] Thailand joined the World Trade Organisation (WTO) in 2001.

[14] Thailand has been very active in establishing bilateral FTAs, and regional trade agreements in the Asia-Pacific region. Establishing bilateral FTAs has become the major trade policy priority in Thailand (Chirathivat, 2007; Sally, 2007).

[15] The percentage share of SME exports by value in total exports declined sharply in 2009, because of a strong Thai baht and a lack of international competitiveness (OSMEP, 2009).

Table 5
SME Employment by Number and Percentage, Classified by Sector, 1994–2009.

Sectors	1994	1997	1999	2002	2003	2004	2005	2006[1]	2007	2008	2009
Manufacturing	1,636,700	1,852,691	1,928,300	1,668,303	1,383,343	3,233,484[2]	3,420,120	3,452,699	3,501,167	3,541,587	3,320,409
Wholesale	190,226	183,063	623,460	256,643	355,630	935,702	846,162	N/A	N/A	N/A	N/A
Retail	1,644,274	1,033,116	1,848,240	1,563,221	1,200,070	1,395,029	1,365,054	N/A	N/A	N/A	N/A
Service	1,772,300	988,725	2,205,300	1,502,050	1,803,012	2,567,485	2,378,657	2,687,284	2,819,684	3,066,933	3,467,763
Trade and repairs[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,376,968	2,431,432	2,501,941	2,912,678
Unspecified[4]	N/A	N/A	N/A	N/A	824,810	731,907	886,171	346,383	148,284	15,455	N/A
Total	5,243,500	4,057,595	6,605,300	4,990,217	5,566,865	8,863,607	8,896,164	8,863,334	8,900,567	9,125,916	9,700,850
Percentage of SMEs (%)											
Manufacturing	31.21	45.66	29.19	33.43	24.85	36.48	38.44	38.95	39.33	38.8	34.23
Wholesale	3.62	4.51	9.44	5.14	6.39	10.56	9.51	N/A	N/A	N/A	N/A
Retail	31.35	25.46	27.98	31.33	21.56	15.74	15.34	N/A	N/A	N/A	N/A
Service	33.8	24.37	33.39	30.1	32.39	28.97	26.74	30.31	31.68	33.6	35.75
Trade and repairs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.81	27.31	27.42	30.02
Unspecified	N/A	N/A	N/A	N/A	14.82	8.26	9.96	3.9	1.67	0.18	N/A
Total	100	100	100	100	100	100	100	100	100	100	100

Notes: 1. In 2006, the trade and repair sector included the wholesale and retail sectors (the OSMEP, 2006). 2. The total numbers employed in the manufacturing sector in the period 1994 to 2003 are not complete, due to many manufacturing firms not reporting numbers employed. As a result, the number employed by the manufacturing sector during this period may be underestimated. In addition, the total numbers employed in this sector increased rapidly because of high domestic and foreign demand for Thai manufactured goods and a weak exchange rate (OSMEP, 2004). 3. The trade and repairs sector was introduced as a new classification in 2006 and included the wholesale and retail sectors. 4. OSMEP did not identify unspecified enterprises by sector.
Sources: OSMEP (2001–2009).

Table 6
Gross Domestic Product (GDP) Classified by Size of Enterprise, 1999–2009.

Items	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Gross domestic product (GDP) at current price (Thai Million Baht)											
Agriculture	435,507	444,143	468,456	510,877	579,460	654,810	706,285	836,077	967,091	1,054,175	1,052,564
Non-agriculture	4,201,572	4,479,120	4,665,380	4,940,977	5,359,602	5,848,677	6,397,943	6,980,397	7,501,542	8,050,783	7,998,151
Large enterprises	1,870,484	1,980,488	2,070,598	2,213,656	2,449,551	2,954,382	3,260,301	3,589,655	3,881,340	4,214,807	4,154,278
SMEs	1,811,905	1,946,224	2,020,128	2,115,316	2,263,574	2,598,657	2,816,641	3,041,895	3,236,634	3,446,589	3,417,861
SE	969,263	1,043,419	1,084,295	1,136,947	1,210,217	1,761,455	1,901,333	2,043,460	2,170,069	2,295,711	2,300,196
ME	842,642	902,825	935,833	978,369	1,053,357	837,202	915,307	998,435	1,066,564	1,150,877	1,117,665
Other enterprises	519,183	552,387	574,654	612,005	646,477	295,638	321,001	348,846	383,567	389,387	425,384
Total GDP	4,637,079	4,923,263	5,133,836	5,451,854	5,939,062	6,503,487	7,104,228	7,816,474	8,468,633	9,104,959	9,050,715
Gross domestic product (GDP) at current price (percentage)											
Agriculture	9.4	9	9.1	9.4	9.8	10.1	9.9	10.7	11.4	11.6	11.6
Non-agriculture	90.6	91	90.9	90.6	90.2	89.9	90.1	89.3	88.6	88.4	88.4
Large enterprises	40.3	40.2	40.3	40.6	41.2	45.4	45.9	45.9	45.8	46.3	45.9
SMEs	39.1	39.5	39.4	38.8	38.1	40	39.6	38.9	38.2	37.9	37.8
SE	20.9	21.2	21.1	20.9	20.4	27.1	26.8	26.1	25.6	25.2	25.4
ME	18.2	18.3	18.2	18	17.7	12.9	12.9	12.8	12.6	12.6	12.3
Other enterprises	11.2	11.2	11.2	11.2	10.9	4.5	4.5	4.5	4.5	4.34.7	
Total GDP	100	100	100	100	100	100	100	100	100	100	100
Real GDP growth rate at constant price (percentage)											
Agriculture	2.3	7.2	3.5	3	6.8	−2.4	−1.9	3.8	2.6	5	0.5
Non-agriculture	4.7	4.5	2	5.7	6.7	7.4	5.2	5.2	5.4	2.4–2.4	
Large enterprises	2.1	4.6	2.8	6.7	8.2	7.4	5.6	5.4	6	2.9–2.5	
SMEs[1]	4.6	4.3	1.7	4.5	5.5	7.6	4.9	5.5	4.9	1.9	−2.40
SE	2.1	4.6	1.9	4.5	5	6.9	4.7	5.4	4.7	1.7	−1.9
ME	7.4	4.1	1.6	4.5	6.1	9.1	5.2	5.5	5.3	2.3	−3.4
Other Enterprises	4	4.6	2.8	5.1	5	3.2	3.9	0	2.2	−1.1 N/A	
GDP	4.4	4.8	2.2	5.3	7.1	6.3	4.6	5.2	4.9	2.5	−2.3

Notes: 1. In 2009 the real output growth rate of SMEs was badly affected by the global financial and economic crisis in 2008.
Sources: OSMEP (2001–2009) and Sahakijpicharn (2007).

innovation and value-adding activities (Amornkitvikai et al., 2010; OECD, 2011). Consequently, this study is of particular importance as it will shed light on the source of these inefficiencies.

This sharp decline in the contribution of SMEs to overall exports is indicative of the increased difficulties being experienced by Thailand's SMEs in international markets, as they struggle to remain competitive in the face of intense competition from rapidly-developing regional economies such as China, India, Vietnam and Indonesia which have much lower labour costs. It is also a reflection of the poor performance of Thai SMEs in upgrading their knowledge and skills, technology, innovation and value-adding activities (Amornkitvikai et al., 2010; OECD, 2011).

2.2.3. SME policy context

The SME policy environment in Thailand is determined within the context of SME promotion plans. To date there have been three promotion plans since the Asian Financial Crisis, but only the first two of these are focused discussed here. The First SME Promotion Plan (2002–2006) [16] aimed to: enhance the efficiency and capacity of SMEs by means of creating a business environment in which they could prosper; improve firm efficiency and competitiveness; promote grassroots businesses to

[16] The first SME Promotion Plan is particularly pertinent in the context of the empirical analysis conducted in this paper.

Table 7
GDP of SMEs in Aggregate and Classified by Economic Activity, 1999–2009.

Items	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP of SMEs by economic activities at current price (Thai Million Baht)											
SMEs	1,811,905	1,946,224	2,020,128	2,115,316	2,263,574	2,598,657	2,816,641	3,041,895	3,236,634	3,446,589	3,417,861
Mining	44,389	57,263	61,928	66,960	26,921	31,636	40,159	46,545	49,902	57,073	54,686
Manufacturing	412,995	469,673	495,964	534,534	682,640	755,130	830,247	921,924	992,617	1,101,480	1,039,030
Construction	122,142	110,431	113,093	120,835	146,830	164,043	184,051	197,448	205,471	212,283	201,654
Trade and maintenance	676,642	717,509	725,271	734,680	722,551	783,347	841,407	889,518	937,861	981,979	1,021,940
Private services	534,038	561,848	590,345	623,117	781,905	857,892	913,893	975,561	1,043,155	1,085,581	1,093,715
Electric, gas and water supply	21,699	29,520	33,527	35,190	6262	6610	6882	7900	7628	8190	10,254
Share of GDP SMEs by economic activities at current price (percentage)											
SMEs	39.1	39.5	39.4	38.8	38.1	40	39.6	38.9	38.2	37.9	37.76
Mining	2.5	2.9	3.1	3.2	1.1	1.2	1.4	1.5	1.5	1.7	1.6
Manufacturing	22.8	24.1	24.6	25.3	28.8	29.1	29.5	30.3	30.7	32	30.4
Construction	6.7	5.7	5.6	5.7	6.2	6.3	6.5	6.5	6.3	6.2	5.9
Trade and maintenance	37.3	36.9	35.8	34.6	30.5	30.1	29.9	29.2	29	28.5	29.9
Private services	29.5	28.9	29.2	29.5	33	33	32.4	32.2	32.2	31.5	32
Electric, gas and water supply	1.2	1.5	1.7	1.7	0.3	0.3	0.2	0.3	0.2	0.2	0.3
GDP growth rate of SMEs at constant price (percentage)											
SMEs	4.6	4.3	1.7	4.5	5.5	7.6	4.9	5.5	4.9	1.9	−2.4
Mining	1	1.2	1.2	1.2	−4.6	9.5	9	4.2	3.5	2.3	N/A
Manufacturing	8.9	9.5	9.7	10.2	11.3	10.1	5.2	5.9	6.2	3.9	−5.1
Construction	2.6	2.2	2.2	2.2	0.8	5.5	5.7	4.3	1.6	−4.7	N/A
Trade and maintenance	14.6	14.6	14.1	13.5	1.7	4.5	4.4	3.9	5.5	1.9	−2.1
Private services	11.5	11.4	4.4	4.1	2.3	8.3	4.7	6.5	3.7	0.9	N/A
Electric, gas and water supply	0.5	0.6	0.7	0.7	0.4	1.7	5.3	4.8	5	4.3	N/A

Sources: OSMEP (2001–2009).

Table 8
Value and percentage of exports classified by size of enterprise, 2000–2009.

Enterprises	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Exports (Thai Million Baht)										
Large Enterprises	1,208,000	1,217,000	1,954,000	1,816,000	2,611,085	3,060,290	3,448,181	3,634,414	4,042,799	3,610,713
SMEs	755,500	793,760	1,209,303	1,516,971	1,235,139	1,291,858	1,456,083	1,575,971	1,691,145	1,589,200
Total	1,963,500	2,010,760	3,163,303	3,332,971	3,846,224	4,352,148	4,904,264	5,210,385	5,733,944	5,199,912
Percentage of exports (%)										
Large enterprises	61.52	60.52	61.77	54.48	67.89	70.32	70.30	69.75	70.50	69.44
SMEs	38.48	39.48	38.23	45.52	32.11	29.68	29.70	30.24	29.50	30.56
Total	100	100	100	100	100	100	100	100	100	100

Sources: OSMEP (2001–2009).

facilitate income distribution and prosperity in regional economies. The specific objectives of the plan is summarised in Table 10, as well as outcomes and perceived problems by the government. The plan incorporated seven strategies: 1) managerial and technological upgrading; 2) human resource development; 3) expanding markets; 4) strengthening financial capabilities; 5) improving the business environment; 6) cultivating microenterprises and grassroots community business; and 7) establishing comprehensive linkages between enterprises (SMEs and large enterprises). To achieve the objective of the plan the Thaksin government focused upon investment promotion, financial assistance to SMEs, and the provision of technical and management consultancy services.[17] During this period Thailand's SME policy was more interventionist in nature and also involved the targeting of certain sectors (e.g. food processing, the fashion industries, automotive parts, electrical and electronics components) (Punyasavatsut, 2007).

The Second SME Promotion Plan (2007–2011) aimed to enable SMEs that would grow with continuity, strength, and sustainability in terms of knowledge and skills. Consistent with the first plan, the second plan aimed to achieve three economic targets: raise the share of SMEs in GDP to 42%; achieve higher SME export shares than total export growth; increase the total factor productivity of SMEs by an average 3% annually, including a minimum of 5% labour productivity growth per annum. The second plan targeted sectors such as auto and electronic parts, software, logistics, healthcare, education, tourism related industry, health foods, and rubber products. Measures specifically targeting manufacturing SMEs included: 1) improving product quality; 2) establishing business incubator centres in regional and local areas; 3) establishing trade fairs; 4) setting up exhibition centres for SME products throughout the country; 5) improving logistics or distribution channels; and 6) establishing industrial clustering and networks.

3. Literature review

Numerous approaches exist to measure SME performance, including those based on financial performance, output growth, employment generation, exporting and firm growth (Bartlett, 2004; Chen et al., 2007; Kimura and Kiyota, 2007; Liedholm, 2002; Nguyen, 2001; Park et al., 2009; Phan, 2004; Regnier, 2000; Rosa and Scott, 1999; Serrasqueiro, 2008; Tambunan, 2008). Added to these are studies utilising the concept of economic efficiency, including technical and allocative efficiencies (Arunsawadiwong, 2007; Assaf, 2007; Coelli et al., 2005; Farrell, 1957; Herrero and Pascoe, 2002; Murillo-Zamorano, 2004). Allocative efficiency measures the reduction in cost when a firm uses optimal combinations of inputs. Technical efficiency occurs when the maximum quantity of output

[17] See Punyasavatsut (2007) for a detailed discussion of these policy measures.

Table 9
Value and percent of SME exports classified by countries, 2003–2009.

Countries	2003	2005	2006	2007	2008	2009
SME Exports (Thai Million Baht)						
ASEAN	315,442	269,944	302,959	363,706	361,032	349,624
EU	44,498	186,648	201,368	222,422	228,434	230,434
USA	205,028	220,585	221,130	188,927	181,435	147,001
Japan	281,986	151,576	159,231	160,766	181,798	154,311
China	89,363	102,736	138,921	120,688	113,976	133,652
Hong Kong	90,573	64,801	66,612	98,672	124,565	143,982
Middle East	N/A	72,367	88,509	97,359	103,464	N/A
Australia	17,668	29,143	47,978	48,842	68,222	77,712
South Asia	N/A	35,761	39,824	45,550	48,432	N/A
Switzerland	N/A	12,234	15,368	26,631	46,230	90,584
Republic of Korea	13,755	23,235	23,516	26,120	39,916	N/A
Taiwan	N/A	26,803	26,419	29,609	30,779	N/A
South Africa	N/A	10,621	11,492	12,665	15,674	N/A
Canada	N/A	14,727	15,697	15,722	15,521	N/A
Unspecified Countries	458,658	70,676	97,058	118,294	131,669	261,900
Total	1,516,971	1,291,858	1,456,083	1,575,971	1,691,145	1,589,200
Percentage of Total SME Exports (%)						
ASEAN	20.79	20.90	20.81	23.08	21.35	22.00
EU	2.93	14.45	13.83	14.11	13.51	14.50
USA	13.52	17.08	15.19	11.99	10.73	9.25
Japan	18.59	11.73	10.94	10.20	10.75	9.71
China	5.89	7.95	9.54	7.66	6.74	8.41
Hong Kong	5.97	5.02	4.57	6.26	7.37	9.06
Middle East	N/A	5.60	6.08	6.18	6.12	N/A
Australia	1.16	2.26	3.30	3.10	4.03	4.89
South Asia	N/A	2.77	2.73	2.89	2.86	N/A
Switzerland	N/A	0.95	1.06	1.69	2.73	5.70
Republic of Korea	0.91	1.80	1.62	1.66	2.36	N/A
Taiwan	N/A	2.07	1.81	1.88	1.82	N/A
South Africa	N/A	0.82	0.79	0.80	0.93	N/A
Canada	N/A	1.14	1.08	1.00	0.92	N/A
Unspecified countries	30.24	5.47	6.67	7.51	7.79	16.48
Total	100	100	100	100	100	100

Sources: OSMEP (2003–2009).

is produced for a given set of inputs (output-oriented technical efficiency) or when the minimum quantity of inputs are used to produce a given output level (input-oriented technical efficiency). Firm output is typically measured in terms of units or value added, while inputs consist of resources such as labour and capital A firm is technically efficient if it produces maximum output, for a given technology, from a given amount of inputs, thereby operating on its production efficiency frontier (Coelli et al., 2005). It is technically inefficient when it is located beneath this frontier. This study employs the concept of technical efficiency to measure the performance of Thai manufacturing SMEs and to identify key factors contributing to the technical efficiency/inefficiency of these firms.

The two most commonly-used techniques for estimating technical efficiency and a production efficiency frontier, are the Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) approaches (Coelli, 1996a,1996b; Coelli et al., 2005; Mortimer, 2002). DEA is a non-parametric approach that involves the use of a linear programming method to construct a production efficiency frontier to measure technical inefficiency (Assaf, 2007; Coelli, 1996b; Coelli et al., 2005; Cooper et al., 2006; Kontodimopoulos et al., 2010; Lee, 2011, 2013). DEA does not require a priori assumptions concerning the specific form of the production function (Assaf, 2007; Coelli, 1996b; Coelli et al., 2005; Cooper et al., 2006; Kontodimopoulos et al., 2010; Lee, 2011, 2013). The best practice production function is estimated empirically from observed inputs and outputs. DEA does not identify the difference between technical inefficiency and random error. By utilising linear programming methods to measure technical efficiency it produces no standard errors, with deviations from a frontier treated as being entirely due to technical inefficiency, leaving no provision for random shocks of any type (Admassie and Matambalya, 2002; Arunsawadiwong, 2007; Assaf, 2007; Coelli et al., 2005; Cooper et al., 2006; Lee, 2011; Murillo-Zamorano, 2004; Vu, 2003; Zahid and Mokhtar, 2007).

SFA, on the other hand, is a parametric approach where the form of the production function is assumed to be known or is estimated statistically.[18] SFA also allows other parameters of the production technology to be explored. The advantages of this approach are that hypotheses can be tested with statistical rigour and that relationships between inputs and outputs follow known functional forms. Modelling the production function in the context of SFA is consistent with production function theory (Coelli et al., 2005; Le and Harvie, 2010; Major, 2008) and is frequently employed because of its superior conceptual treatment of noise. SFA allows not only just for the measurement of inefficiency, but also acknowledges the fact that random shocks outside the control of the firm can influence the level of output (Coelli, 1996a; Coelli et al., 2005; Cooper et al., 2006; O'Donnell et al., 2009; Wadud, 2003). The important concept behind SFA is that the error term can be decomposed into two components: the first error component is assumed to follow a symmetric distribution (the standard error), and the other component reflects inefficiency and is assumed to follow common distributions, including half-normal, truncated and exponential distributions. As a consequence the SFA-based model yields technical efficiency that is free from distortion and statistical noise inherent in the deterministic DEA model.

A number of firm specific factors have been identified in the literature as impacting upon the efficiency of SMEs, manufacturing SMEs and firms in the manufacturing sector more generally. These are summarised in Table 11 and include: firm location; firm age; firm size; ICT; proportion of skilled labour; adoption of ICT; financial assistance received; government support; type of ownership; and export activity.[19] Firm size has been found to be statistically significant in a number of empirical studies

[18] Discussed in greater detail in the following section of the paper.
[19] The variables used are generally determined by the focus of the study, the judgment of the researcher and data availability.

Table 10
Results of the first SME promotion plan for 2002–2006.

Targets of the plan	Results	Problems and limitations from the government point of view
1. GDP share of SMEs to reach 50% in 2006	• 38.9% per year on average	• The GDP of SMEs in the manufacturing and service sectors increased gradually, while the trade sector decreased.
2. Increasing employment by SMEs at an average of 180,000 people annually	• Employment increased by about 354,533 workers per year during 2000–2006.	• SMEs are labour intensive enterprises. • Inadequate skilled labour. • Job opportunities and working environment were insufficient for SMEs.
3. Boosting the value of SME exports by 6% per year	• 9% per year	• Most SME exports were in primary and labour intensive products. • Lack of product differentiation. • Weak marketing infrastructure.
4. Increasing new entrepreneurs by 50,000 per year	• 44,551 entrepreneurs per year	• New SMEs required government support due to market failures and policy biases.
5. Enhancing and promoting target groups of SMEs, such as enterprises with existing high potential and good record. Increasing groups[1] of SMEs by 10% per year and to reach 6300 groups in 2006	1602 groups per year	• SMEs needed to focus upon knowledge and quality. • SMEs required a strong integration of business networking.

Notes: 1 SMEs that have a 3–5 star OTOP rating.
Sources: (OSMEP, 2007b).

Table 11
Firm-specific factors impacting upon the efficiency of SMEs and other sectors identified in the literature.

Authors/years	Countries	Sector/firm size	Approach	Firm location	Firm age	Firm size	Skilled labour	ICT	Financial support	Government support	Ownership type	Exporting
Hallberg (2000)	N/A	SMEs	N/A	X	X	✓	X	✓	X	✓	X	X
Yang (2006)	Korea	SMEs	DEA	✓	X	✓	X	X	X	✓	X	✓
Li and Hu (2002)	Taiwan	SMEs	Multi-logit model	✓	X	X	X	X	✓	X	X	X
Mini and Rodriguez (2000)	Philippines	Manufacturing	SFA	X	X	✓	X	X	X	✓	X	X
Park et al. (2009)	Korea	Manufacturing Industry	N/A	X	✓	✓	X	X	X	X	X	✓
Krasachat (2000)	Thailand	Small Farms	DEA	✓	X	✓	X	X	X	✓	X	X
Batra and Tan (2003)	Six countries	SMEs	SFA	X	✓	✓	✓	✓	✓	✓	X	✓
Lundvall and Battese (2000)	Kenya	Small Manufacturing Firms	SFA	X	✓	✓	X	X	X	X	X	X
Wiboonchutikula (2002)	Thailand	SMEs	TFP	X	X	✓	X	X	X	X	X	X
Tran et al. (2008)	Vietnam	Manufacturing SMEs	SFA	✓	✓	✓	✓	X	✓	✓	X	X
Charoenrat et al. (2013)	Thailand	Manufacturing SMEs	SFA	✓	✓	✓	✓	X	X	✓	✓	✓
Charoenrat and Harvie (2013)	Thailand	Manufacturing SMEs	SFA/DEA	✓	✓	✓	✓	X	X	✓	✓	✓
Admassie and Matambalya (2002)	Tanzania	SMEs	SFA	X	✓	✓	✓	X	✓	✓	X	X
Vu (2003)	Vietnam	Manufacturing SMEs	SFA	✓	X	X	✓	X	X	X	X	X
Snodgrass and Biggs (1995)	East Asia	SMEs	N/A	X	X	✓	X	X	X	X	X	X

Notes: X refers to variables not included in the study, ✓ variables that were found to be statistically significant.
SFA — stochastic frontier analysis, DEA — data envelopment analysis, TFP — total factor productivity.
Source: Various.

(Admassie and Matambalya, 2002; Batra and Tan, 2003; Charoenrat and Harvie, 2013; Charoenrat et al., 2013; Krasachat, 2000; Li and Hu, 2002; Lundvall and Battese, 2000; Mini and Rodriguez, 2000; Park et al., 2009; Snodgrass and Biggs, 1995; Tran et al., 2008; Wiboonchutikula, 2002; Yang, 2006), as is firm age (Admassie and Matambalya, 2002; Batra and Tan, 2003; Charoenrat and Harvie, 2013; Charoenrat et al., 2013; Lundvall and Battese, 2000; Park et al., 2009; and Tran et al., 2008), firm location (Charoenrat and Harvie, 2013; Charoenrat et al., 2013; Krasachat, 2000; Li and Hu, 2002; Tran et al., 2008; Vu, 2003; Yang, 2006), government support (Admassie and Matambalya, 2002; Batra and Tan, 2003; Charoenrat and Harvie, 2013; Charoenrat et al., 2013; Krasachat, 2000; Mini and Rodriguez, 2000; Tran et al., 2008; Yang, 2006), and skilled labour (Admassie and Matambalya, 2002; Batra and Tan, 2003; Charoenrat and Harvie, 2013; Charoenrat et al., 2013; Tran et al., 2008; and Vu, 2003). Financial support has also been found to be important in some studies (Admassie and Matambalya, 2002; Batra and Tan, 2003; Li and Hu, 2002; Tran et al., 2008), as well as ICT adoption (Batra and Tan, 2003), ownership type (Charoenrat et al., 2013; Charoenrat and Harvie, 2013) and export activity (Charoenrat et al., 2013).

In empirical studies specifically for Thailand using either DEA or SFA techniques firm size in particular (Charoenrat and Harvie, 2013; Charoenrat et al., 2013; Krasachat, 2000; Wiboonchutikula, 2002), firm location (Charoenrat and Harvie, 2013; Charoenrat et al., 2013; and Krasachat, 2000) and government support (Charoenrat and Harvie, 2013; Charoenrat et al., 2013; Krasachat, 2000) appeared to be important. In addition, access to skilled labour and firm age[20] were also found to be important in the studies by Charoenrat et al. (2013) and Charoenrat and Harvie (2013). In this study we adopt all of the potential technical efficiency explanatory variables listed in Table 10 with the exception of ICT adoption and final assistance. The former is due to a lack of data while

[20] Equivalent to a so called learning by doing effect.

the latter has been incorporated under the broader heading of government assistance.

The methodology used in this study is discussed in the following section.

4. Methodology

A firm's performance can be measured by its technical and allocative efficiencies. Technical efficiency can be estimated using either data envelopment analysis (DEA) or stochastic frontier analysis (SFA). We adopt SFA because of its numerous advantages over alternative methods. SFA is a parametric approach where the form of the production function is assumed to be known and estimated statistically. Other advantages of SFA are that hypotheses can be tested with statistical rigour, and relationships between inputs and outputs follow known functional forms. SFA can simultaneously estimate a stochastic production model and technical inefficiency effects model.

4.1. The analytical model

A two stage approach is adopted in this study. In the first stage firm technical efficiency scores are estimated for the sample of SMEs using a stochastic frontier analysis (SFA),[21] a parametric approach, where the form of the production function showing the relationship between inputs and output is assumed to be known (Alvarez and Crespi, 2003; Battese and Coelli, 1992; Kumbhakar and Lovell, 2000). A Cobb–Douglas production function is the most commonly used functional form for SFA and is the form adopted in this study. In the second stage the estimated technical efficiency scores are regressed against hypothesised explanatory variables (Admassie and Matambalya, 2002; Alvarez and Crespi, 2003; Coelli et al., 2005; Battese and Coelli, 1992; Battese and Coelli, 1995; Amornkitvikai and Harvie, 2011; Kim, 2003; Kumbhakar and Lovell, 2000).

4.1.1. First stage

A two input factor and one output Cobb–Douglas production function in logarithmic form utilising cross-sectional data can be expressed as follows:

$$\ln Y_i = \beta_0 + \beta_1 \ln(K_i) + \beta_2 \ln(L_i) + (V_i - U_i) \qquad (1)$$
$$i = 1, \ldots, N,$$

where:

Y_i = value added of firm i;
K_i = the net value of fixed assets of firm i;
L_i = the total number of employees of firm i;
V_i = a random error term for firm i, and is assumed to be an independently and identically distributed normal random variable with zero mean and variance $V_i : iidN(0, \sigma_V^2)$ independently distributed of U_i; and
U_i = a non-negative random variable for firm i, accounting for technical inefficiency in the production function and is assumed to be independently distributed such that U_i is defined by the truncation of the normal distribution with mean μ_1 and variance σ_u^2

V_i and U_i are also assumed to be independently distributed for all firms ($i = 1, 2, \ldots, N$) (Battese and Coelli, 1995; Coelli, 1996a; Coelli et al., 2005; Tran et al., 2008). If U_i is equal to zero the firm is defined as being totally technically efficient and is at its maximum output level given the inputs used. If U_i is greater than zero the firm is defined as being technically inefficient (Coelli, 1996a; Kumbhakar and Lovell, 2000; Tran et al., 2008).

The subscript i refers to firms, β_0 represents the intercept term, β_1 represents the coefficient estimates of capital input and β_2 represents the coefficient estimates of labour input.

4.1.2. Second stage

There is no single theory that guides selection of variables to be used in regression analysis of possible causes of inefficiency of the production units (SMEs) under investigation. The standard practice is to draw from the literature, emphasising potentially important local characteristics of factors while being mindful of constraints imposed by data availability. In this context the following explanatory variables are emphasised in this study for the sample of Thai SMEs: firm size (resource based hypothesis), firm age (learning by doing hypothesis), skilled labour (knowledge and skill intensity), urban or rural location (agglomeration effects), regional location (capturing differences in regional economic structure and industry clusters), firm ownership type (private, state, co-operative and foreign), export intensity (self-selection hypothesis) and recipient of government assistance (financial dependence).

Hence, potential firm specific-factors that could influence technical efficiency can be modelled in an inefficiency functional form as follows,[22] [23]

$$\begin{aligned}\mu_i = {} & \delta_0 + \delta_1 \mathrm{Size}_i + \delta_2 \mathrm{Age}_i + \delta_3 \mathrm{Skill}_1 + \delta_4 \mathrm{Location}_i + \delta_5 \mathrm{Bangkok}_i + \\ & \delta_6 \mathrm{Central}_i + \delta_7 \mathrm{Northern}_i + \delta_8 \mathrm{North\text{-}eastern}_i + \delta_9 \mathrm{Individual}_i + \\ & \delta_{10} \mathrm{Juristic}_i + \delta_{11} \mathrm{Limited}_i + \delta_{12} \mathrm{State}_i + \delta_{13} \mathrm{Co\text{-}operative}_i + \\ & \delta_{14} \mathrm{Foreign}_i + \delta_{15} \mathrm{Export}_i + \delta_{16} \mathrm{Government\ assistance}_i\end{aligned} \qquad (2)$$

where:

$Size_i = 1$ for small enterprises employing up to 50 workers; $= 0$ for medium enterprises employing between 51–200 workers;
Age_i = age of firm i, represented by operating years;
$Skill_i$ = skilled labour of firm i, represented by the ratio of skilled workers to total workers;
$Location_i = 1$ if firm i is located in a municipal area[24]; $= 0$ otherwise;
$Bangkok_i$[25] $= 1$ if firm i is located in Bangkok; $= 0$ otherwise;
$Central_i = 1$ if firm i is located in the Central region; $= 0$ otherwise;
$Nothern_i = 1$ if firm i is located in the Northern region; $= 0$ otherwise;
$Nother\text{ - }eastern_i = 1$ if firm i is located in the North-eastern region; $= 0$ otherwise;
$Individual_i = 1$ if firm i is an individual proprietor; $= 0$ otherwise;

[21] A software package which is most commonly used in the estimation of stochastic production frontiers in the literature is FRONTIER 4.1 developed by Coelli (1996) and is also used in this study.

[22] See, for example, Battese and Coelli, 1995; Coelli, 1996a; Admassie and Matambalya, 2002; Alvarez and Crespi, 2003; Coelli et al., 2005; Tran et al., 2008; Charoenrat et al., 2013.

[23] Eq. (2) includes potential explanatory variables for manufacturing SME technical inefficiency as identified from the literature and existing empirical studies, see Table 11 above, elaborating upon the potential importance of firm location and regional industry clustering (municipal versus non municipal, and by region) for the case of Thai manufacturing SMEs.

[24] A municipal area is classified in this study as a town or city. Hence, the dummy variable takes a value of 1 for SMEs located in an urban area (town or city) and zero for SMEs located in a rural area covering the entire nation. The 1997 and 2007 industrial censuses included all manufacturing SMEs located in urban or rural areas for all regions of Thailand (NSO, 2011a, 2011b).

[25] The National Research Council of Thailand (ONRCT, 2012) divides Thailand into six geographical regions consisting of (1). The Bangkok area, (2). Central and Vicinity regions, (3) Northern region, (4). North-eastern region, (5). Eastern region and (6) the Southern region. The National Statistics Office of Thailand (NSO, 2011a, 2011b), however, included the Eastern region in the Central and Vicinity regions in the 1997 and 2007 industrial censuses, which is the source of data used in this study. In order to avoid problems relating to multi-collinearity (or the "dummy trap") the Southern region is used as the reference category for the other regional dummy variables. Hence only four regional dummy variables are employed in the model, these being for: (1) the Bangkok area, (2) Central and Vicinity regions, (3) Northern region, and (4) the North-eastern region as shown in Eq. (2).

Jurish partnership$_i$ = 1 if firm i is a juristic partnership; = 0 otherwise;
Limited$_i$ = 1 if firm i is a limited liability company; = 0 otherwise;
State$_i$ = 1 if firm i is a state-owned enterprise; = 0 otherwise;
Cooperative$_1$ = 1 if firm i is a cooperative, = 0 otherwise;
Foreign$_i$ = 1 if firm i has foreign investment[26]; = 0, otherwise;
Export$_i$ = 1 if firm i exports more than 50% of its total sales revenue, = 0 otherwise;
Government assistants$_i$ = 1 if firm i obtains privileges from the BOI[27];
= 0 otherwise;
δ_i = a vector of unknown parameters to be estimated.

The coefficients of the stochastic frontier production function and technical inefficiency effects model can be estimated utilising the maximum likelihood method. The maximum likelihood function is defined in terms of the variance parameters as follows (Battese and Corra, 1977; Coelli et al., 2005):

$$\sigma^2 \equiv \sigma_v^2 + \sigma_u^2 \text{ and } \gamma \equiv \sigma_u^2/\sigma^2 \tag{3}$$

where:

σ_v^2 = a random error variance;
σ_u^2 = a technical inefficiency effects variance.

γ represents the share of technical inefficiency in the overall residual variance. If the value of γ is close to zero deviations from the frontier are largely attributable to noise, whereas a value close to unity indicates that deviations from the frontier are largely attributable to technical inefficiency (Coelli et al., 2005; Tran et al., 2008).

4.2. Hypotheses tests

We estimate the stochastic frontier production function and technical inefficiency effects model to test three hypotheses: 1) absence of technical inefficiency effects; 2) absence of stochastic inefficiency effects; 3) insignificance of joint inefficiency variables. These tests are conducted by utilising the generalised likelihood-ratio (LR) test which can be expressed as:

$$\lambda = -2\{\log[L(H_0)] - \log[L(H_1)]\} \tag{4}$$

where: $\log[L(H_0)]$ and $\log[L(H_1)]$ are the values of a log-likelihood function for the stochastic frontier model under the null hypothesis (H_0) and the alternative hypothesis (H_1). The LR test statistic has an asymptotic chi-square distribution with parameters equal to the number of restricted parameters imposed under the null hypothesis (H_0), except hypotheses (1) and (2) which contain a mixture of a chi-square distribution (Kodde and Palm, 1986). Hypotheses (1) and (2) involve the restriction that λ is equal to zero which defines a value on the boundary of the parameter space.

4.3. Data and variables

We use firm-level data from industrial censuses for 1997 and 2007 compiled by the National Statistical Office (NSO) of Thailand[28] (NSO, 2011a, 2011b). The total number of Thai manufacturing SMEs included in the 1997 and 2007 industrial censuses is 22,685 and 56,441 respectively.

The key variables utilised for the first stage are output value added (Y), labour input (L) and capital input (K). Output (Y) is defined as the value of gross output minus intermediate consumption. Labour input (L) includes the number of workers in the enterprise, including the owner or partner, unpaid workers, skilled and unskilled labour. Capital input (K) is measured by the net value of fixed assets less depreciation at the end of the year. Value added (Y) of firms is deflated by the Producer Price Index (PPI) of manufactured products and capital (K) of firms is deflated by the PPI of capital equipment. The year 2000 is taken as the base year.

The key variables utilised for the second stage and also obtained from the census data: firm size, firm age, skilled labour as a proportion of the firm's workforce, location, ownership type, export activity and government assistance. The Thai authorities do not provide comprehensive data on manufacturing SMEs by SITC and region. However data obtained from the 1997 and 2007 industrial censuses can be used as an alternative source. Some 22,685 manufacturing SMEs were surveyed in 1997 and 56,441 manufacturing SMEs in 2007 (NSO, 2011a, 2011b). Summary statistics for the variables used in the analysis by SITC code are contained in Table 12.

Given the use of location (or region) as an influencing variable on manufacturing SME technical efficiency in this study, it is useful to identify if there are specific clusters of manufacturing SMEs (by SITC) across the various regions and the importance of each SITC for exports. Table 13 shows the importance of the various manufacturing SMEs by SITC categories. SITC 6, SITC 0 and SITC 8 are the most important in terms of overall SME numbers, with SITC 1 the least important. The table also shows that there does appear to be evidence of clustering by SITC.[29] In 1997 SME manufacturing firms in SITC 0 (Food) were more heavily clustered or concentrated in the Central and vicinities region, those in SITC 1 (Beverages and Tobacco) are spread more evenly across regions but marginally more prevalent in the North-eastern region, those in SITC 2 (crude materials), SITC 5 (chemicals) and SITC 6 (manufactured goods) were more heavily concentrated in the Central region, in particular, followed by Bangkok, SITC 7 (machinery) and SITC 8 (miscellaneous) were more concentrated in Bangkok, in particular, and the Central region. In 2007, manufacturing SMEs in the SITC 0 category were more heavily concentrated in the Central, Northern and North-eastern regions, SITC 1 SMEs in the Northern region, SITC 2 SMEs in the Central, Northern and North-eastern regions, SITC 5 SMEs in the Central and Bangkok regions, SITC 6 SMEs in the Central and North-eastern regions, SITC 7 SMEs in the Central and Bangkok regions and SITC 8 SMEs more widely spread across the Central, Bangkok, Northern and North-eastern regions. Comparing 1997 with 2007 the industrial census data suggests that the predominance of manufacturing SMEs in Bangkok remained in SITC 8, SITC 6, SITC 5 and SITC 7. For the Central region manufacturing SME predominance remained in SITC 6, SITC 0, SITC 5 and more recently SITC 8 rather than SITC 7. SME predominance in the Northern, North-eastern and Southern regions remained largely unchanged in SITC 6, SITC 0, SITC 8 and SITC 2.

Data derived from industrial census data for 1997 and 2007 can also be used to identify the export intensity of SMEs in the various SITC

[26] With respect to the foreign investment dummy variable, a dummy variable for foreign investment takes the value 1 if a firm has some form of foreign ownership or involvement and 0 otherwise. A number of studies have found that a firm having cooperation with a foreign partner can benefit from superior technology, management style, managerial knowledge, good corporate governance and other performance improving business practices (Kimura and Kiyota, 2007; Phan, 2004). The Thai Foreign Business Act 1999 allows foreign investors to own up to 49% of a firm's total shares.

[27] Government assistance/privileges come in the form of financial support (i.e. credit assistance, income tax exemption or reduction, and duty privileges) and non-financial support (i.e., managerial, technical and training assistance).

[28] This data source is the best and most extensive available for manufacturing SMEs in Thailand, and is compiled on the basis of recommendations from the United Nations that countries should conduct such a census every 10 years. In intervening years less exhaustive and data rich manufacturing surveys are conducted but data from these are not utilised in this study. As mentioned previously panel data cannot be constructed because the Thai government has not yet released firm identification codes for such data.

[29] Based upon industrial census data for 1997 and 2007.

Table 12
Summary statistics for sub manufacturing sectors by SITC, 1997 and 2007.

Years	1997							2007						
Variables	SITC 0	SITC 1	SITC 2	SITC 5	SITC 6	SITC 7	SITC 8	SITC 0	SITC 1	SITC 2	SITC 5	SITC 6	SITC 7	SITC 8
Firm size:														
Small (% of total)	84.66	92.57	78.00	69.75	82.07	77.87	81.33	93.02	96.32	88.61	74.92	90.84	76.44	87.85
Medium (% of total)	15.34	7.43	21.93	30.25	17.93	22.13	18.67	6.98	3.68	11.39	25.08	9.16	23.56	12.15
Firm age (years, mean)	10	8	7	7	6	6	6	9	6	8	10	8	10	8
Skilled workers:														
Skilled workers (% of total)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	54.64	59.83	61.91	80.76	73.10	88.95	72.28
Unskilled workers (% of total)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	45.36	40.17	38.09	19.24	26.90	11.05	27.72
Firm location:														
Municipal area (% total)	36.70	30.48	50.88	53.02	43.63	61.26	78.27	38.73	38.58	29.86	46.02	38.17	57.17	59.54
Non-municipal area (% total)	63.30	69.52	49.12	46.98	56.37	38.74	21.73	61.27	61.42	70.14	53.98	61.83	42.83	40.46
Location by region:														
Bangkok (% of total)	12.47	10.59	40.55	42.12	17.93	47.87	68.30	3.79	2.95	10.94	23.22	9.42	21.97	26.81
Central (% of total)	42.46	19.14	34.48	43.48	40.52	39.85	16.53	30.16	23.80	27.13	47.94	35.15	56.81	27.16
Northern (% of total)	16.51	26.77	9.92	2.18	10.84	4.40	6.65	22.95	40.40	22.76	7.18	16.26	6.73	18.21
North-eastern (% of total)	15.66	34.94	4.25	2.22	10.69	4.73	4.65	27.32	16.09	25.76	13.39	29.46	7.89	19.60
Southern (% of total)	12.89	8.55	10.80	10.00	20.01	3.15	3.86	15.79	16.77	13.41	8.28	9.70	6.60	8.22
Ownership type:														
Individual (% of total)	30.58	49.63	22.40	9.15	31.91	19.84	32.11	64.21	63.46	45.42	17.79	51.16	33.56	52.15
Partnership (% of total)	29.21	23.05	25.51	18.61	25.11	23.59	19.55	5.85	13.88	7.47	9.75	7.86	9.74	7.27
Limited (% of total)	36.44	27.32	51.01	66.95	41.58	56.43	47.13	13.32	9.63	22.81	56.26	22.97	56.50	28.42
Government (% of total)	0.13	0	0.27	0	0.18	0.14	0.23	0.16	0.23	0.28	0.14	0.12	0	0.43
Cooperative (% of total)	1.07	0	0.13	3.15	0.11	0	0.11	0.41	1.70	0.09	2.32	0.04	0	0.14
Unspecified (% of total)	2.57	0	0.67	2.14	1.12	0	0.86	16.06	11.10	23.94	13.74	17.86	0.21	11.59
Shared ownership:														
Foreign ownership	4.95	1.30	4.59	13.51	5.38	10.63	6.29	0.89	0.28	1.26	7.59	2.18	10.95	2.52
Thai ownership	95.05	98.70	95.41	86.49	94.62	89.37	93.71	99.11	99.72	98.74	92.41	97.82	89.05	97.48
Export intensity:														
Exporting SMEs (% of total)	13.36	3.72	10.20	22.62	8.48	15.54	20.75	3.49	1.36	5.53	14.40	3.91	15.18	8.85
Domestic SMEs (% of total)	86.64	96.28	89.80	77.38	91.52	84.46	79.25	96.51	98.64	94.47	85.60	96.09	84.82	91.15
Government assistance:														
Received government assistance (% of total)	3.62	2.60	3.51	9.89	2.81	6.84	3.41	3.06	1.19	4.99	12.87	2.08	13.72	6.71
Did not receive government assistance (% of total)	96.38	97.40	96.49	90.11	97.19	93.16	96.59	96.94	98.81	95.01	87.13	97.92	86.28	93.29

Note: Foreign ownership, the Thai Foreign Business Act 1999 allows foreign investors to own up to 49% of a firm's total shares. Government assistance, if a firm obtains promotional privileges from the Board of Investment (BOI).
Source: National Statistical Office (NSO, 2011a, 2011b).

Table 13
Number and regional concentration of manufacturing SMEs by SITC and Region.

Years	1997							2007						
Category	SITC 0	SITC 1	SITC 2	SITC 5	SITC 6	SITC 7	SITC 8	SITC 0	SITC 1	SITC 2	SITC 5	SITC 6	SITC 7	SITC 8
Bangkok area	383	57	601	1082	1989	1337	3801	458	53	504	1122	1653	855	3122
Central & vicinity regions	1304	103	511	1117	2687	1113	920	3643	419	1250	2317	6166	2211	3163
Northern region	507	144	147	56	719	123	370	2772	713	1049	347	2853	262	2121
North-eastern region	481	188	63	57	709	132	259	3300	284	1187	647	5167	307	2283
Southern region	395	46	159	257	527	88	215	1907	296	618	400	1702	257	957
Total	3070	538	1481	2569	6631	2793	5565	12,080	1765	4608	4833	17,541	3892	11,646

Source: National Statistical Office (NSO, 2011a, 2011b).

categories. From Table 14 it can be derived that the most export intensive SITC categories[30] in 2007 were SITC 7, SITC 5 and SITC 8, the same as for 1997.

5. Empirical results

5.1. Hypotheses test results

Table 15 presents results for hypotheses tests for the size of manufacturing SMEs (small and medium) in the period 1997 and 2007. The first null hypothesis (H_0) tests for the absence of technical inefficiency in the model. It is rejected at the 1% level of significance for the size of manufacturing SMEs in both 1997 and 2007, as specified by Eqs. (1) and (2). The second null hypothesis (H_0), that technical inefficiency effects are not stochastic, is also rejected at the 1% level of significance, implying that the technical inefficiency effects model is applicable for size of manufacturing SMEs in both 1997 and 2007, given by Eqs. (1) and (2). The last null hypothesis (H_0) specifies that all estimated parameters of the explanatory variables in the technical inefficiency effects model are equal to zero. The null hypothesis is strongly rejected at the 1% level of significance for the size of manufacturing SMEs in 1997 and 2007.

Table 16 summarises the results for a number of null hypotheses relating to sub-manufacturing sectors in the period 1997 and 2007. The

[30] Defined as the ratio of exporting SMEs in an SITC category to the total number of SMEs in an SITC category (domestic plus export active SMEs).

Table 14
Number of manufacturing SMEs classified by SITC, and by domestic and exporting activity.

Year	1997		2007	
Categories	Domestic SMEs	Exporting SMEs	Domestic SMEs	Exporting SMEs
SITC 0: Food	2660	410	11,658	422
SITC 1: Beverages	518	20	1741	24
SITC 2: Crude materials	1330	151	4353	255
SITC 5: Chemicals	1988	581	4137	696
SITC 6: Manufactured goods	6069	562	16,856	685
SITC 7: Machinery	2359	434	3301	591
SITC 8: Miscellaneous	4410	1155	10,615	1031
Total	19,334	3313	52,661	3704

Source: National Statistical Office (NSO, 2011a, 2011b)

first null hypothesis (H_0) tests whether technical inefficiency effects are absent from the model. This hypothesis is rejected at the 1% level of significance for all sub-manufacturing sectors in the period 1997 and 2007. The second null hypothesis (H_0), that technical inefficiency effects are not stochastic, is also rejected at the 1% level of significance for all sub-manufacturing sectors in 1997 and 2007. The last null hypothesis (H_0) specifying that all estimated parameters of the explanatory variables in the technical inefficiency effects model are equal to zero, is rejected at the 1% level of significance for all sub-manufacturing sectors in 1997 and 2007.

5.2. Estimation results for input elasticities, gamma parameters and technical efficiency (first stage)

Maximum likelihood estimates (MLE) of the parameters of the stochastic frontier and technical inefficiency effects models (Eqs. (1) and (2)) are estimated simultaneously using the computer program Frontier Version 4.1 developed by Coelli (1996b). The estimation technique is a three-step procedure. In step 1 ordinary least squares (OLS) is applied to obtain unbiased estimates of the parameters of the production function. In step two the OLS estimates are used as starting values to estimate the final maximum likelihood model. The value of the likelihood function is estimated through a grid-search of γ between 0 and 1 given the values of the βs derived by OLS. Finally, an iterative Davidon–Fletcher–Powell algorithm calculates the final parameter estimates, using the values of the $\beta's$ from the OLS and the value of γ from the intermediate step as starting values. The estimated results are reported in Tables 17 and 18, and a summary of average technical efficiency by: SME size, SITC category and overall for 1997 and 2007 is shown in Table 19.

Table 17 presents the results for the size of manufacturing SMEs (small and medium) in 1997 and 2007. For 1997 both capital (β_1) and labour (β_2) inputs have positive coefficients and are significant at the 1% level. Medium sized SMEs exhibit marginal increasing returns to scale as the sum of the estimated input coefficients is greater than unity (1.07). By contrast, small SMEs operate under constant returns to scale. While input elasticities differ between small and medium sized firms the elasticities of labour (β_2) in the stochastic production functions are much higher than that for capital (β_1). From Table 15 the elasticities of labour (β_2) in small and medium sized firms are equal to 0.825 and 0.724, respectively, indicating that small firms are particularly labour dependent in their production. The elasticities of capital (β_1) in small and medium sized SMEs are 0.194 and 0.343, respectively. Indicating that medium sized firms are more dependent on capital input that small firms in their production. The high labour elasticity (β_2) indicates that both small and medium sized SMEs are labour dependent in production. The low elasticity of capital (β_1) reveals that capital has a low share in small and medium sized firm production in 1997 (see Table 14). Further, the inefficiency parameter (γ) for small and medium sized firms are equal to 0.803 and 0.756 in 1997, respectively, indicating a high degree of technical inefficiency in production for both sizes of enterprise.

Table 17 also shows the results of estimation by size of manufacturing SME in 2007. For small firms the elasticities of capital (β_1) and labour (β_2), are 0.219 and 1.042 respectively and are significant at the 1% level. These are higher than the coefficients for 1997, indicating that inputs of both capital and labour contributed more to production in 2007. Small firms now exhibit increasing returns to scale in production as the sum of the input coefficient exceeds unity (1.26). The estimated γ for small SMEs is 0.65 indicating a high degree of technical inefficiency. For medium sized firms the elasticities of capital (β_1) and labour (β_2) are 0.307 and 0.653, respectively, and are significant at the 1% level, and are both lower compared to 1997. Unlike small firms, additional output from additional inputs in medium sized firms appears to have declined in 2007. Medium sized firms now tended to operate under constant returns to scale in production. Their estimated γ is 0.770 implying high technical inefficiency amongst medium sized firms. However, irrespective of the size of manufacturing SME, the contribution of labour in the production function is higher than capital, indicating labour dependence in production. For medium sized firms both the labour and capital input contribution to output declined in 2007 compared to 1997, while for small firms it increased and most notably for labour input.

Table 15
Statistics for hypothesis tests of the stochastic frontier model and technical inefficiency effects model by size of manufacturing SMEs (small and medium).

Years	1997		2007	
	Small enterprises	Medium enterprises	Small enterprises	Medium enterprises
(1) Null hypothesis	No technical inefficiency effects ($H_0 : \gamma = \delta_0 = \delta_1 = \cdots = \delta_{14} = 0$)		No technical inefficiency effects ($H_0 : \gamma = \delta_0 = \delta_1 = \cdots = \delta_{15} = 0$)	
LR statistics	3886.51	441.62	18,120.21	2073.68
Critical value	31.35*		32.77*	
Decision	Reject H_0	Reject H_0	Reject H_0	Reject H_0
(2) Null hypothesis	No stochastic inefficiency ($H_0 : \gamma = 0$)		No stochastic inefficiency ($H_0 : \gamma = 0$)	
LR statistics	711.14	69.96	2132.77	328.23
Critical value	5.41*		5.41*	
Decision	Reject H_0	Reject H_0	Reject H_0	Reject H_0
(3) Null hypothesis	No joint inefficiency variables ($H_0 : \delta_1 = \delta_2 = \cdots = \delta_{14} = 0$)[1]		No joint inefficiency variables ($H_0 : \delta_1 = \delta_2 = \cdots = \delta_{15} = 0$)	
LR statistics	2651.95	287.22	15,011.08	1416.28
Critical value	29.14		30.58	
Decision	Reject H_0	Reject H_0	Reject H_0	Reject H_0

Note: 1. In 1997 small and medium sized enterprises have 14 explanatory variables, whereas there are 15 explanatory variables in 2007.
All critical values of the test statistic are presented at the 1% level of significance and obtained from a chi-square distribution, except those indicated by * which contain a mixture of a chi-square distribution obtained from Table 1 of Kodde and Palm (1986).

Table 16
Statistics for hypothesis tests of the stochastic frontier model and technical inefficiency effects model by standard international trade classification (SITC), revision 4.

Years	1997								2007							
	SITC 0	SITC 1	SITC 2	SITC 3[1]	SITC 5	SITC 6	SITC 7	SITC 8	SITC 0	SITC 1	SITC 2	SITC 3	SITC 5	SITC 6	SITC 7	SITC 8
(1) Null hypothesis	No technical inefficiency effects ($H_0 : \gamma = \delta_0 = \delta_1 = \cdots = \delta_{15} = 0$)								No technical inefficiency effects ($H_0 : \gamma = \delta_0 = \delta_1 = \cdots = \delta_{16} = 0$)							
LR statistics	386.19	202.61	223.69	N/A	371.79	1239.25	343.49	1247.41	3294.20	327.76	2090.87	N/A	2719.65	5416.55	945.22	5702.39
Critical value	32.77*								37.17*							
Decision	Reject H0	Reject H0	Reject H0	N/A	Reject H0	Reject H0	Reject H0	Reject H0	Reject H0	Reject H0	Reject H0	N/A	Reject H0	Reject H0	Reject H0	Reject H0
(2) Null hypothesis	No stochastic inefficiency ($H_0 : \gamma = 0$)								No stochastic inefficiency ($H_0 : \gamma = 0$)							
LR statistics	42.49	50.82	40.74	N/A	52.26	207.56	118.53	174.34	418.42	44.89	248.00	N/A	346.08	463.13	68.44	762.02
Critical value	5.41*								5.41*							
Decision	Reject H0	Reject H0	Reject H0	N/A	Reject H0	Reject H0	Reject H0	Reject H0	Reject H0	Reject H0	Reject H0	N/A	Reject H0	Reject H0	Reject H0	Reject H0
(3) Null hypothesis	No joint inefficiency variables ($H_0 : \delta_1 = \delta_2 = \cdots = \delta_{15} = 0$)[2]								No joint inefficiency variables ($H_0 : \delta_1 = \delta_2 = \cdots = \delta_{16} = 0$)							
LR statistics	285.96	170.51	146.04	N/A	272.55	830.27	150.43	930.85	2652.63	247.24	1792.19	N/A	2159.52	4684.05	797.10	4641.08
Critical value	30.58								32							
Decision	Reject H0	Reject H0	Reject H0	N/A	Reject H0	Reject H0	Reject H0	Reject H0	Reject H0	Reject H0	Reject H0	N/A	Reject H0	Reject H0	Reject H0	Reject H0

Note: 1. The estimation of SITC 3: Mineral fuels, lubricants and related materials in 1997 and 2007 failed to produce significant results.
2. In 1997 all sub-manufacturing sectors have 15 explanatory variables, whereas there are 16 explanatory variables in 2007.
All critical values of the test statistic are presented at the 1% level of significance, obtained from a chi-square distribution, except those indicated by *, which contain a mixture of a chi-square distribution, obtained from Table 1 of Kodde and Palm (1986) . SITC 0: Food and live animals, SITC 1: Beverages and tobacco, SITC 2: Crude materials, inedible, except fuels, SITC 3: Mineral fuels, lubricants and related materials, SITC 5: Chemicals and related products, SITC 6: Manufactured goods classified by material, SITC 7: Machinery and transport equipment, SITC 8: Miscellaneous manufactured articles.

Table 18 exhibits the results for sub-manufacturing sectors classified by SITC Revision 4 in 1997 and 2007. In 1997 the estimated coefficients of capital (β_1) and labour (β_2) are both positive and significant at the 1% level in all sub-manufacturing sectors. The input elasticities of capital (β_1) and labour (β_2) reveal modest increasing returns to scale in production in all sub-manufacturing sectors, and strong increasing returns to scale in SITC 1. Input elasticities varied in all sub-manufacturing sectors in 1997 but the elasticities of labour (β_2) in the stochastic production functions are noticeably higher than capital (β_1) for all sub-manufacturing sectors. From Table 18 the elasticities of labour (β_2) range between 0.733 in SITC 0 to 0.917 in SITC 7, while the elasticities of capital (β_1) range from 0.160 in SITC 7 to 0.382 in SITC 1. The high values of labour elasticity signify that all sub-manufacturing sectors remained highly labour dependent in production, and particularly SITC 7, SITC 2, SITC 8 and SITC 6. The low capital elasticity value indicates that capital input is of lower significance in production. For the γ parameter, its value ranges from 0.519 in SITC 8 to 0.941 in SITC 7 with the exception of SITC 1. This indicates that the technical inefficiency effects are important in SITC 0, SITC 2, SITC 5, SITC 6, SITC 7 and SITC 8. However, the value of γ in SITC 7 was only 0.126.

In 2007 all sub-manufacturing sectors had positive signs for both capital (β_1) and labour (β_2) and were significant at the 1% level. All sub-manufacturing sectors operated under increasing returns to scale in production, and the significance of this increased for all sub sectors in comparison to 1997 with the exception of SITC 7. Table 18 reveals that the elasticities of labour (β_2) are noticeably greater than that of capital (β_1) and that this dependence on labour input in production increased in 2007 compared to 1997 with the exception of SITC 7. This is consistent with Thailand being stuck in a middle income trap[31] with SMEs in most manufacturing sub sectors being dependent on less expensive labour input with low capital investment and predominantly involved in low value adding activities, putting these SMEs in a weaker competitive position. The contribution of capital input to output declined in 2007 compared to 1997 for all sub manufacturing sectors with the exception of SITC 5 and SITC 7, where it increased and in SITC 8 where it remained stagnant. Limited investment in capital and low dependence on capital input in production is likely to have limited higher value adding activities to SITC 5 and SITC 7. The elasticities of labour (β_2) varied between 0.812 in SITC 5 and 1.060 in SITC 0, while the capital (β_1) elasticities range from 0.168 in SITC 8 to 0.316 in SITC 1. High labour elasticity indicates that all sub-manufacturing sectors remained heavily labour input dependent in their production and increasingly so compared to 1997. The low value of capital elasticity shows that capital input was less important in production in all sub-manufacturing sectors in 2007. Furthermore, the estimated γ ranges from 0.190 in SITC 7 to 0.754 in SITC 2. The major exceptions to these trends are SITC 5 and in particular SITC 7. Given the nature of these sub sectors, relatively more capital intensive, capital input is likely to be important in expanding production. In the case of SITC 7 there appears to be a distinct movement in 2007 towards relatively more capital dependent forms of production compared to that of 1997.[32]

5.2.1. Average technical efficiency of Thai manufacturing SMEs

Table 19 presents and compares the average technical efficiency of manufacturing SMEs by size and SITC in 1997 and 2007. The mean technical efficiency in six SME categories, including small SMEs, SITC 0, SITC 2, SITC 6, SITC 7 and SITC 8 decreased in 2007 compared to 1997, the exceptions being medium sized SMEs, SITC 1 and SITC 5. Only medium sized SMEs achieved an improvement in technical efficiency. The overall simple average technical efficiency for SMEs ranges from 57% in 1997 to 50% in 2007, indicating a deterioration of technical efficiency of Thai manufacturing SMEs. Thai manufacturing SMEs experienced a high

[31] A middle-income trap is generally defined as an economic development situation in which a country has attained a certain income (due to given advantages such as cheap labour and natural resources) but gets stuck at that level without graduating towards high-income status. These countries find themselves unable to compete further in export markets with lower-cost producers elsewhere (the so-called "nutcracker effect") and lack the innovation necessary for achieving higher value added production.

[32] This is consistent with the middle income trap. Production remains heavily dependent in all sub manufacturing sectors on labour input, and a lack of investment in the capital stock and in improving human capital is constraining the contribution of capital input to production. Consequently, as labour costs rise relative to other countries in the region competitiveness in these activities will decline while the country remains unable to compete in more capital intensive sectors due to a lack of investment in these.

Table 17
Maximum likelihood estimates for parameters of the stochastic frontier model and technical inefficiency effects model by size of manufacturing SMEs (small and medium).

Years	1997		2007	
Variables	Small enterprises	Medium enterprises	Small enterprises	Medium enterprises
Number of observations	18,214	4471	49,835	6606
	Coefficients	Coefficients	Coefficients	Coefficients
Stochastic frontier model				
Constant	6.453***	5.219***	5.407***	5.956***
	(0.054)	(0.159)	(0.039)	(0.144)
Capital	0.194***	0.343***	0.219***	0.307***
	(0.004)	(0.011)	(0.003)	(0.007)
Labour	0.825***	0.724***	1.042***	0.653***
	(0.012)	(0.032)	(0.007)	(0.028)
Technical inefficiency effects model				
Constant	2.761***	3.523***	2.586***	1.719***
	(0.142)	(0.386)	(0.045)	(0.214)
Firm size (dummy)	N/A	N/A	N/A	N/A
Firm age (years)	0.001	−0.064***	−0.002*	−0.023***
	(0.003)	(0.013)	(0.001)	(0.004)
Skilled labour1[1] (ratio)	N/A	N/A	−0.854***	0.411***
			(0.026)	(0.111)
Municipality (dummy)	−0.774***	0.402***	−0.385***	0.090
	(0.099)	(0.134)	(0.025)	(0.103)
Bangkok area (dummy)	−2.893***	−3.425***	−2.343***	−2.055***
	(0.281)	(0.773)	(0.193)	(0.518)
Central & vicinity regions (dummy)	−0.157*	0.021	0.009	−0.425**
	(0.091)	(0.189)	(0.037)	(0.207)
Northern region (dummy)	−0.335***	0.377*	0.641***	2.330***
	(0.104)	(0.230)	(0.035)	(0.212)
North-eastern region (dummy)	0.358***	0.684***	0.389***	−0.129
	(0.121)	(0.246)	(0.033)	(0.195)
Individual proprietor (dummy)	−2.594***	−3.300***	−1.245***	−1.584***
	(0.180)	(0.536)	(0.034)	(0.196)
Juristic partnership (dummy)	−5.000***	−4.110***	−2.960***	−3.429***
	(0.355)	(0.574)	(0.101)	(0.300)
Limited & public limitedcompany (dummy)	−5.959***	−5.114***	−4.469***	−4.545***
	(0.434)	(0.763)	(0.191)	(0.356)
Government & state enterprises (dummy)	−3.191***	−1.736***	0.009	1.383***
	(0.711)	(0.469)	(0.198)	(0.242)
Cooperatives (dummy)	−2.069***	−15.257***	−1.901***	−0.727*
	(0.224)	(4.129)	(0.163)	(0.443)
Foreign investment (dummy)	−0.854**	−1.176***	−0.258	−0.951***
	(0.396)	(0.281)	(0.396)	(0.217)
Exports (dummy)	−1.020***	−0.226**	−0.621**	−0.194
	(0.177)	(0.106)	(0.264)	(0.333)
Government assistance (BOI) (dummy)	0.228	−0.397**	−0.353	−1.270***
	(0.210)	(0.168)	(0.327)	(0.369)
Variance parameters				
Sigma-squared	3.581***	3.142***	1.782***	2.664***
	(0.255)	(0.517)	(0.031)	(0.237)
Gamma	0.803***	0.756***	0.652***	0.770***
	(0.014)	(0.042)	(0.007)	(0.022)
Log-likelihood Function	−26,595.03	−6483.26	−73,972.99	−8800.36
Mean technical efficiency	0.58	0.62	0.42	0.65
Returns to scale	1.02	1.07	1.26	0.96

Note: 1. The National Statistics Office of Thailand did not compile statistics on skilled labour in the 1997 industrial census.
Standard errors are in brackets; *, ** and *** indicate that the coefficients are statistically significant at 10%, 5% and 1%, respectively.

level of technical inefficiency in their production process in both 1997 and 2007, and it appeared to have deteriorated further in 2007.

5.3. Estimation results from the technical inefficiency effects model (second stage)

Tables 17 and 18 also summarise the estimated results from the technical inefficiency effects model. Negative coefficient signs indicate technical efficiency.

5.3.1. Firm-specific factors contributing to technical inefficiency

5.3.1.1. Firm size. From Tables 17 and 18, for 1997, the estimated coefficients for firm size have negative and significant signs for only two categories — SITC 0 at the 1% level and SITC 7 at the 5% level. In 2007 the estimates of coefficients for firm size contain significant negative signs in SITC 0, SITC 1, SITC 6 and SITC 8. Thus, small sized SMEs were more technically efficient than medium sized SMEs in both 1997 and 2007 in these categories. While economies of scale expanded for SMEs in the SITC 0, SITC 1, SITC 6 and SITC 8 sub sectors in 2007, from an efficiency perspective there were advantages from remaining small possibly from the importance of adaptability and flexibility to changes in the market. For these sectors remaining small contained advantages. This result is consistent with other studies which show that firm size can have a negative association with technical efficiency (Battese and Coelli, 1992; Coelli et al., 2005; Tran et al., 2008). Small firms have greater flexibility in adjusting inputs in their production, resulting in less costly adjustments to business environment and economic shocks.

Small firms contribute to industry dynamics through their high entry and exit rates. They adapt quickly to changes in an economy and can also easily cooperate with other firms when required (Alvarez and Crespi, 2003; Le and Harvie, 2010; Yang and Chen, 2009). Manufacturing sectors in which such characteristics are desirable are conducive to smaller sized enterprises.

5.3.1.2. Firm age. Empirical studies suggest that the impact of firm age on technical efficiency is ambiguous. (Alvarez and Crespi, 2003; Audretsch et al., 2009; Biggs, 2002) find that firm age can have a positive effect on technical efficiency where learning by doing and accumulated knowledge effects are important sources of firm competitiveness and efficiency. Batra and Tan (2003) and Tran et al. (2008), however, find that firm age can also be negatively correlated with technical efficiency. Older firms may have more experience but technology lock-in and possession of older machinery, equipment, office appliances and software may be a handicap, while younger firms are aggressive and vigorous in the market having access to modern plant, equipment and technology (Tran et al., 2008).

As shown in Tables **17** and **18** the coefficients for firm age in 1997 are negative and significant, indicating a positive impact on SME efficiency, for four categories — SITC 6, SITC 5, SITC 8 and medium sized SMEs, while there is a positive and significant coefficient for SITC 1. In 2007 estimates of coefficients for firm age are negative and significant for both small and medium sized firms, SITC 0 and SITC 5. Estimated coefficients for SITC 2 and SITC 6 in 2007 are positive and statistically significant. Firm age appears to be positively correlated with technical efficiency for medium sized firms and only for small firms in 2007. However for both size of firms the estimated coefficients are small indicating that firm longevity is no guarantee of achieving high technical efficiency. In terms of sub sectors, only for SITC 0 and SITC 5 does firm age (experience) matter in 2007 for improved technical efficiency, while for SITC 2 and SITC 6 it has the opposite effect. The size of this effect on technical efficiency, however, is very small. For all other sectors firm longevity and experience is not statistically significantly correlated with firm technical efficiency. Technology lock-in and accumulated experience is not guaranteed to increase efficiency.

5.3.1.3. Skilled labour. From Tables 17 and 18 it can be seen that in 2007 estimated coefficients for skilled labour, as represented by the ratio of skilled labour to total workers, are negative and highly significant for small firms, SITC 0, SITC 1, SITC 2, SITC 5, SITC 6, SITC 7 and SITC 8, the only exception being medium sized firms where the coefficient is positive and significant. Overall, a high ratio of skilled labour in a firm is positively correlated with technical efficiency. Hence it is imperative to update the education and training system to ensure that there is an adequate pool of skilled workers to meet the needs of the business community including that of manufacturing SMEs. The positive result for medium sized enterprises is puzzling, but could be due to a lack of investment in new capital and technology required to make the employment of additional skilled workers more effective and efficient.

5.3.1.4. Location. A number of studies have found a statistically significant relationship between firm location and efficiency performance (Charoenrat and Harvie, 2013; Charoenrat et al., 2013; Krasachat, 2000; Li and Hu, 2002; Tran et al., 2008; Vu, 2003; Yang, 2006). To address this issue focus is placed on identifying the significance of location on the efficiency of manufacturing SMEs from two perspectives — location in a municipality (urban sector) and location by region.

5.3.1.4.1. Municipality. Location in a municipality has the potential to benefit SME production efficiency from agglomeration, knowledge spill-over, availability of skilled labour, closeness to customers, access to business services and improved physical infrastructure effects. The results presented in Tables 17 and 18 show that in 1997 the dummy variable for municipality had statistically significant negative coefficients for small firms, SITC 1 and SITC 8. However, the estimated coefficients for medium sized SMEs and SITC 7 exhibit a positive coefficient, and they are highly significant. In 2007 the municipality dummy variable coefficient has a negative sign in all categories, but is only statistically significant for SITC 0, SITC 2, SITC 6 and SITC 8. The estimated coefficient for medium sized SMEs in 2007 remained positive but was now not significant. Hence the results for location in a municipality are mixed but appear to become more important and significant in 2007 for certain sub sectors, particularly those requiring proximity to major markets and customers and best able to take advantage of being in an urban location. Such a location can provide important technical efficiency gains. The results also appear to suggest problems in locating in a non-urban area in Thailand for SMEs in many SITC sectors due to factors such as poor infrastructure, weak support institutions, limited spill-over benefits, smaller markets and difficulty in obtaining necessary resources such as labour and physical infrastructure.

5.3.1.5. Regional location. A discussion of the estimated empirical results for each regional dummy variable with respect to the reference category (the Southern region) is now discussed. The Bangkok area is recognised as the economic epicentre of the country and the empirical results confirm that location in this area is positively and significantly correlated with the technical efficiency of manufacturing SMEs, both small and medium, and for all sub manufacturing sectors with the exception of SITC 1 and SITC 5 in 1997. However, the coefficients for SITC 1 and SITC 5 are not statistically significant. The estimated coefficients for location in Bangkok are negative for all categories, indicating higher technical efficiency (or lower technical inefficiency) relative to SMEs in equivalent categories in the Southern region. In 2007 the estimated dummy variable coefficients for Bangkok are sizeable, statistically significant and have negative signs in all categories, indicating that location in Bangkok carries with it technical efficiency advantages for all categories of SMEs. Thus, the negative dummy variable coefficients in 1997 and 2007 specify that location in the Bangkok area is positively and significantly associated with a better technical efficiency performance compared to their equivalents in the Southern region. Closer analysis suggests that the gap between the technical efficiency of SMEs in Bangkok relative to their equivalents in the Southern region in 2007 compared to 1997, increased for SITC 0, SITC 1, SITC 5 and SITC 8 but for SITC 2, SITC 6, SITC 7, small and medium sized SMEs the gap declined but remained statistically significant. This was most notable for SITC 7. This suggests that Southern region SMEs in these categories improved their technical efficiency relative to those in Bangkok, but still lagged behind.

Results for the Central and vicinity region in 1997 and 2007 are mixed. In 1997 the estimated coefficients for this dummy variable indicate negative signs for small firms, SITC 0, SITC 2 and SITC 8, and positive signs for medium sized SMEs, SITC 1, SITC 5, SITC 6 and SITC 7. Only four of these are statistically significant — small SMEs, SITC 5, SITC 6 and SITC 8. Central and vicinity area SMEs were more technically efficient in SITC 8 and for overall small businesses while those in SITC 5 and SITC 6 were less technically efficient compared to their equivalents in the Southern region. In 2007 only the coefficient estimates for medium sized SMEs at the 5% level and SMEs in SITC 1 at the 10% level are statistically significant. Hence the relative efficiency of medium sized enterprises improved but that of small firms deteriorated. These are the only two categories of SMEs that we can statistically conclude have higher levels of technical efficiency compared to their equivalents in the Southern region in 2007. The SITC 5 and SITC 6 categories, however, had statistically significant lower technical efficiency compared to the same category of SMEs in the Southern region in 1997 but this difference had become statistically insignificant in 2007. So a relative improvement in Central and Vicinity region SMEs in these categories is likely to have occurred putting them on a par with their equivalents in the Southern region. On the other hand SMEs in SITC 8 in the Central and vicinity regions were more technically efficient in 1997 but this difference became insignificant in 2007, suggesting a relative deterioration which put them on a

Table 18
Maximum likelihood estimates for parameters of the stochastic frontier model and technical inefficiency effects model by standard international trade classification (SITC), revision 4.

Years	1997							2007						
Variable	SITC 0	SITC 1	SITC 2	SITC 5	SITC 6	SITC 7	SITC 8	SITC 0	SITC 1	SITC 2	SITC 5	SITC 6	SITC 7	SITC 8
Number of observations	3070	538	1481	2569	6631	2793	5565	12,080	1765	4608	4833	17,541	3892	11,646
	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients
Stochastic frontier model														
Constant	5.362***	3.755***	6.168***	6.378***	6.143***	6.657***	7.146***	4.610***	4.249***	5.757***	5.770***	5.703***	6.657***	6.311***
	(0.152)	(0.312)	(0.223)	(0.197)	(0.086)	(0.099)	(0.117)	(0.058)	(0.154)	(0.108)	(0.095)	(0.059)	(0.141)	(0.069)
Capital	0.322***	0.382***	0.210***	0.236***	0.214***	0.160***	0.168***	0.266***	0.316***	0.197***	0.271***	0.206***	0.170***	0.168***
	(0.014)	(0.031)	(0.020)	(0.015)	(0.008)	(0.010)	(0.008)	(0.006)	(0.017)	(0.009)	(0.008)	(0.005)	(0.012)	(0.005)
Labour	0.733***	0.815***	0.887***	0.785***	0.833***	0.917***	0.854***	1.060***	0.928***	0.995***	0.812***	0.994***	0.857***	0.923***
	(0.034)	(0.077)	(0.042)	(0.035)	(0.018)	(0.022)	(0.019)	(0.014)	(0.035)	(0.022)	(0.021)	(0.010)	(0.024)	(0.014)
Technical inefficiency effects model														
Constant	4.153***	−0.438	2.919***	2.219***	3.823***	−6.795***	3.715***	3.076***	3.280***	2.568***	2.492***	2.406***	3.297***	3.757***
	(0.389)	(0.643)	(0.949)	(0.326)	(0.280)	(1.720)	(0.226)	(0.172)	(0.332)	(0.256)	(0.245)	(0.125)	(0.384)	(0.139)
Firm size (dummy)	−1.168***	0.497	0.955	−0.237	−0.143	−0.776**	−0.117	−0.500***	−1.783***	−0.029	0.104	−0.217**	0.005	−0.765***
	(0.392)	(0.319)	(0.596)	(0.270)	(0.170)	(0.314)	(0.137)	(0.162)	(0.329)	(0.218)	(0.184)	(0.095)	(0.126)	(0.125)
Firm age (years)	−0.005	0.018***	−0.009	−0.027**	−0.023***	−0.003	−0.012***	−0.025***	−0.001	0.007*	−0.029***	0.004**	−0.000	−0.000
	(0.007)	(0.007)	(0.014)	(0.013)	(0.007)	(0.009)	(0.004)	(0.003)	(0.010)	(0.004)	(0.006)	(0.001)	(0.002)	(0.002)
Skilled labour (ratio)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	−0.979***	−1.210***	−1.388***	−0.717***	−0.630***	−0.655***	−0.869***
								(0.083)	(0.207)	(0.109)	(0.122)	(0.033)	(0.091)	(0.055)
Municipality (dummy)	0.208	−0.576**	0.420	−0.423	−0.011	0.706***	−0.378***	−0.543***	−0.235	−0.384***	−0.162	−0.250***	−0.039	−0.384***
	(0.168)	(0.233)	(0.367)	(0.299)	(0.094)	(0.186)	(0.103)	(0.069)	(0.149)	(0.105)	(0.130)	(0.029)	(0.054)	(0.042)
Bangkok (dummy)	−1.032**	−0.673	−3.626**	0.328	−3.700***	−10.168***	−0.986***	−4.279***	−3.569***	−3.156***	−1.764***	−1.123***	−0.725***	−1.957***
	(0.465)	(0.509)	(1.787)	(0.467)	(0.707)	(2.328)	(0.150)	(0.423)	(1.182)	(0.580)	(0.291)	(0.153)	(0.118)	(0.184)
Central & vicinity regions (dummy)	−0.243	0.255	−0.336	0.675*	0.315**	0.328	−0.502***	−0.134	−0.437*	0.198	−0.035	0.092	−0.119	−0.066
	(0.202)	(0.366)	(0.279)	(0.408)	(0.130)	(0.298)	(0.121)	(0.101)	(0.265)	(0.144)	(0.188)	(0.059)	(0.082)	(0.075)
Northern region (dummy)	0.044	0.162	−0.812*	1.014**	−0.543***	−2.143***	−0.467***	0.687***	0.250	0.794***	1.946***	0.668***	0.265***	0.404***
	(0.215)	(0.295)	(0.463)	(0.489)	(0.175)	(0.713)	(0.130)	(0.086)	(0.195)	(0.138)	(0.183)	(0.062)	(0.098)	(0.071)

(continued on next page)

Table 18 *(continued)*

Years	1997							2007						
Variable	SITC 0	SITC 1	SITC 2	SITC 5	SITC 6	SITC 7	SITC 8	SITC 0	SITC 1	SITC 2	SITC 5	SITC 6	SITC 7	SITC 8
Number of observations	3070	538	1481	2569	6631	2793	5565	12,080	1765	4608	4833	17,541	3892	11,646
	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients
North-eastern region (dummy)	−0.128	1.225***	0.376	0.761	−0.265*	−2.767***	−0.695***	−0.047	0.265	0.873***	0.538***	0.569***	0.550***	0.218***
	(0.235)	(0.288)	(0.415)	(0.559)	(0.144)	(0.873)	(0.151)	(0.091)	(0.233)	(0.137)	(0.172)	(0.061)	(0.098)	(0.070)
Individual proprietor (dummy)	−3.146***	0.658	−3.381***	−1.137**	−3.650***	1.514***	−1.354***	−1.950***	−1.352***	−0.962***	−0.906***	−0.763***	−1.291***	−1.031***
	(0.601)	(0.531)	(1.015)	(0.470)	(0.402)	(0.547)	(0.188)	(0.074)	(0.191)	(0.087)	(0.125)	(0.038)	(0.363)	(0.055)
Juristic partnership (dummy)	−5.194***	−0.752	−4.410***	−1.905***	−5.251***	−1.539**	−2.141***	−5.861***	−1.622***	−3.305***	−3.428***	−2.090***	−2.169***	−2.625***
	(1.117)	(0.539)	(1.293)	(0.559)	(0.590)	(0.681)	(0.233)	(0.454)	(0.263)	(0.314)	(0.277)	(0.104)	(0.378)	(0.154)
Limited & public limited company (dummy)	−5.538***	−0.345	−5.368***	−2.367***	−6.458***	−2.838***	−2.551***	−5.982***	−3.817***	−4.716***	−4.349***	−2.885***	−2.807***	−3.711***
	(1.262)	(0.545)	(1.608)	(0.635)	(0.766)	(0.831)	(0.251)	(0.259)	(0.599)	(0.408)	(0.252)	(0.156)	(0.396)	(0.178)
Government & state enterprises (dummy)	−4.321***	0[1]	−4.655	0	−3.433***	−3.932***	−0.021	−0.994	−2.574**	2.096***	−2.495**	0.688**	0	0.682***
	(1.187)	(1)	(3.741)	(1)	(0.835)	(1.224)	(0.389)	(0.921)	(1.112)	(0.428)	(0.990)	(0.301)	(1)	(0.224)
Cooperatives (dummy)	−5.958***	0	−0.186	0.306	−1.761**	0	−3.514***	−2.025***	−0.193	0.237	−3.583***	0.001	0	−0.352
	(2.100)	(1)	(1.402)	(0.276)	(0.801)	(1)	(1.352)	(0.426)	(0.327)	(0.998)	(0.472)	(0.470)	(1)	(0.369)
Foreign investment (dummy)	−0.080	−1.271	−0.837	−0.501	−3.801***	−2.745***	0.058	0.473	−1.004	−3.299***	−3.803***	−1.437*	0.460**	0.176
	(0.726)	(1.008)	(0.671)	(0.341)	(0.854)	(0.594)	(0.206)	(0.975)	(1.068)	(0.854)	(1.145)	(0.856)	(0.196)	(0.322)
Exports (dummy)	−1.243**	−0.105	0.641	−0.545*	−0.336*	0.715***	−0.168	0.100	1.274	−1.182*	−2.142***	−0.322	−0.585	−0.505*
	(0.550)	(0.430)	(0.416)	(0.287)	(0.186)	(0.253)	(0.117)	(0.694)	(1.308)	(0.721)	(0.747)	(0.328)	(0.431)	(0.291)
Government assistance (BOI) (dummy)	−0.430	0.530	0.374	−0.422	0.228	−1.045**	−0.290	0.665	−3.463*	0.829	0.231	−0.182	−1.911	−0.116
	(0.471)	(0.389)	(0.500)	(0.388)	(0.298)	(0.452)	(0.237)	(0.795)	(1.886)	(0.734)	(0.774)	(0.394)	(2.653)	(0.341)
Variance parameters														
Sigma-squared	2.875***	1.040***	3.053***	1.701***	3.324***	8.824***	1.122***	2.341***	1.780***	2.162***	2.352***	1.295***	0.954***	1.593***
	(0.550)	(0.091)	(1.030)	(0.305)	(0.430)	(1.923)	(0.087)	(0.055)	(0.111)	(0.091)	(0.073)	(0.027)	(0.042)	(0.048)
Gamma	0.630***	0.126	0.743***	0.556***	0.776***	0.941***	0.519***	0.648***	0.671***	0.754***	0.748***	0.522***	0.190***	0.702***
	(0.074)	(0.148)	(0.086)	(0.087)	(0.029)	(0.013)	(0.037)	(0.011)	(0.024)	(0.014)	(0.009)	(0.018)	(0.074)	(0.011)
Log-likelihood function	−4862.96	−746.03	−2202.91	−3721.19	−9819.93	−3733.74	−7274.33	−18,794.07	−2452.07	−7100.19	−6810.46	−25,027.20	−5243.74	−16,295.76
Mean technical efficiency	0.58	0.54	0.59	0.55	0.57	0.63	0.53	0.48	0.54	0.36	0.55	0.39	0.59	0.42
Returns to scale	1.05	1.20	1.10	1.02	1.05	1.08	0.98	1.33	1.24	1.19	1.08	1.2	1.10	1.09

Note: 1. The estimated coefficients and standard errors shown for government & state enterprises and cooperatives for SITC 1, SITC 5 and SITC 7 in 1997 and SITC 7 in 2007 are all insignificant due to the very small number of observations in these categories.

Standard errors are in brackets; *, ** and *** indicate that the coefficients are statistically significant at 10%, 5% and 1%, respectively. SITC 0: Food and live animals, SITC 1: Beverages and tobacco, SITC 2: Crude materials, inedible, except fuels, SITC 5: Chemicals and related products, SITC 6: Manufactured goods classified by material, SITC 7: Machinery and transport equipment, SITC 8: Miscellaneous manufactured articles.

Table 19
Simple average technical efficiency of Thai manufacturing SMEs.

Years	1997	2007
Categories	The simple average technical efficiency	The simple average technical efficiency
Small enterprises	0.58	0.42
Medium enterprises	0.62	0.65
SITC 0	0.58	0.48
SITC 1	0.54	0.54
SITC 2	0.59	0.36
SITC 5	0.55	0.55
SITC 6	0.57	0.39
SITC 7	0.63	0.59
SITC 8	0.53	0.42
The overall simple average technical efficiency	0.57	0.50

Note: SITC 0: Food and live animals, SITC 1: Beverages and tobacco, SITC 2: Crude materials, inedible, except fuels, SITC 5: Chemicals and related products, n.e.s., SITC 6: Manufactured goods classified chiefly by material, SITC 7: Machinery and transport equipment, SITC 8: Miscellaneous manufactured articles.

par with their Southern region equivalents in terms of technical efficiency.

The Northern and North-eastern regions, by contrast, appear to have experienced a significant deterioration in technical efficiency across virtually all SITC categories relative to their equivalents in the Southern region. In 1997 estimates of the coefficients for the Northern region dummy variable indicate higher technical efficiency for small SMEs, SITC 2, SITC 6, SITC 7 and SITC 8 relative to those in the Southern region. However, lower technical efficiency is found for medium sized SMEs and SITC 5. By 2007 the estimated coefficients for all categories of SMEs in the Northern region had positive signs indicating lower technical efficiency (higher technical inefficiency) compared to their equivalents in the Southern region. Comparing the 1997 results with those for 2007 indicates a major deterioration in the efficiency of SMEs across all categories in the Northern region relative to their equivalents in the Southern region.

In 1997 estimates of the coefficients for the North-eastern region dummy variable indicate that SMEs in SITC 6, SITC 7 and SITC 8 were more technically efficient than their equivalents in the Southern region. Lower technical efficiency, however, is apparent for categories SITC 1, small and medium sized SMEs compared to that of Southern region based SMEs in these categories. There are no statistically significant differences in the technical efficiency performance of SMEs in SITC 0, SITC 2 and SITC 5 between the North-eastern and Southern region SMEs. By 2007, however, the estimated coefficients for the North-eastern region dummy variable indicate significantly lower technical efficiency compared to Southern region equivalents in six categories, including small SMEs, SITC 2, SITC 5, SITC 6, SITC 7 and SITC 8. No statistically significant difference in the technical efficiency performance of SMEs in the SITC 0, SITC 1 and medium sized enterprises categories was found between the North-eastern and Southern regions. A comparison of the coefficients obtained for 1997 with those for 2007 indicates a statistically significant deterioration in the technical efficiency performance of SMEs in SITC 2, SITC 5, SITC 6, SITC 7 and SITC 8 located in the North-eastern region compared to those located in the Southern region. There is no statistically significant difference in the technical efficiency performance in 1997 and 2007 between the two regions for SMEs in SITC 0. A relative improvement is possible for SITC 1 as the statistically significant inferior technical efficiency performance in 1997 becomes insignificant in 2007. There was virtually no change in the relative performance of overall small firms in the two regions. Small firms in the North-eastern region remain more technically inefficient than those in the Southern region. However the relative performance of medium sized enterprises appears to have improved. From being statistically significantly more technically inefficient in 1997 to there being no statistically significant difference between their performance in 2007.

5.3.2. Type of ownership

5.3.2.1. Private. Coefficient estimates for individual proprietor ownership in 1997 are negative and highly significant for seven categories comprising small and medium sized firms, SITC 0, SITC 2, SITC 5, SITC 6 and SITC 8, but it is positive and significant for SITC 7. In 2007 the estimated coefficients for individual proprietor ownership in all SME categories are negative and statistically significant but their size is smaller, which is indicative of a smaller positive impact of this SME form of ownership on technical efficiency. However, this form of ownership is significantly positively correlated with SME efficiency performance.

Estimated coefficients for juristic partnerships in 1997 and 2007 are all negative and significant with the exception of SITC 1 in 1997, which is statistically insignificant. These results signify that juristic partnership ownership has a positive correlation with manufacturing SME technical efficiency and that this was generally larger in 2007. Such partnerships bring more finance, management experience and expertise into the operation of SMEs in comparison to that of individual ownership, and this is reflected in higher coefficient values.

The coefficients for limited and public limited companies in 1997 and 2007 are negative for all categories and significant at the 1% level, except for SITC 1 in 1997 which is also negative but insignificant. Limited and public limited owned SMEs, with the exception of SITC 1 in 1997, are strongly and positively correlated technical efficiency in virtually all SME categories. The size of the coefficients suggests that this form of ownership has an important impact on SME efficiency and is stronger than that of individual or partnership form of ownership. Greater access to finance, managerial expertise and investment are likely to be important factors in this for this type of ownership.

5.3.2.2. Government and state ownership. The coefficients for government and state ownership in 1997 are negative and significant for small and medium sized firms, SITC 0, SITC 6 and SITC 7. In 2007 the coefficients for government and state enterprises are negative and significant in SITC 1 and SITC 5. However, there are positive and significant coefficients for medium sized SMEs, SITC 2, and SITC 8. A positive and significant coefficient exists for SITC 6. There is an overall deterioration in the technical efficiency performance of government and state owned enterprises in 2007 compared to that of 1997, irrespective of firm size and occurs across a number of sub manufacturing sectors. These developments could be explained as being as a result of privatisation of such enterprises in general and in the various sub sectors, with the most efficient and profitable sold off and the least efficient and profitable remaining in government or state ownership. The only sectors in which government ownership of SMEs remained positively correlated with technical efficiency in 2007 is in the SITC 1 and SITC 5 sub sectors.

5.3.2.3. Cooperative ownership. In 1997 the results for the estimated coefficients for cooperative ownership indicate negative and significant coefficients for five manufacturing SME categories — small and medium sized SMEs, SITC 0, SITC 6 and SITC 8. Cooperative ownership was particularly effective in improving SME technical efficiency in the SITC 0 and SITC 8 sub sectors and for medium sized firms By 2007 the impact of cooperative ownership on SME technical efficiency deteriorated somewhat, but still remained significant for small and medium sized firms and in particular for SMEs in the SITC 0 and SITC 5 sub sectors. The SITC 0 (food and live animals) sector is not surprising but for SITC 5 (chemicals) it is more difficult to explain. These results indicate that in certain manufacturing sub sectors cooperative ownership can improve SME technical efficiency.

5.3.2.4. Foreign investment/ownership. One important means by which SME technical efficiency can be improved is by encouraging foreign

ownership. Many studies have found that foreign investment (via foreign ownership) has a positive correlation with technical efficiency (Li and Hu, 2002; Park et al., 2009; Yang, 2006). A firm that has cooperation or ownership with a foreign partner or owner can benefit from access to superior technology, managerial knowledge and good corporate governance (Bottasso and Sembenelli, 2004; Goldar et al., 2004). In 1997 the results concerning the dummy variable for foreign investment are negative in four categories — small firms, medium sized firms, SITC 6 and SITC 7. In 2007 the coefficients for foreign investment are negative in four categories, including medium sized SMEs, SITC 2, SITC 5, and SITC 6. However, there is an unexpected positive sign for SITC 7 (machinery and transport equipment) and it is statistically significant. Many of the SMEs in this subsector are likely to be suppliers to the motor vehicle industry in Thailand. The results for medium sized firms is not surprising with foreign investors more likely to be interested in investing in or establishing medium sized rather than small SMEs.

5.3.3. Exports

Many empirical studies have also found that exporting has a positive association with technical efficiency (Granér and Isaksson, 2009; Kim, 2003; Rankin, 2001). In 1997 the coefficients for the export dummy are negative in five categories, comprising small and medium sized SMEs, SITC 0, SITC 5 and SITC 6 and positive for only one category — SITC 7. In 2007 the estimated coefficients for exports are negative and statistically significant for small SMEs, SITC 2, SITC 5 and SITC 8. Thus, we conclude that there is generally a positive relationship between exporting and technical efficiency.

5.3.4. Government assistance

In 1997 the estimated coefficients for government assistance on technical efficiency are negative and significant at the 5% level only for medium sized SMEs and SITC 7. In 2007 estimates of the coefficients for government assistance are negative for only two categories — medium sized SMEs and SITC 1. These results indicate that government assistance has a positive and significant correlation with the technical efficiency of only medium sized enterprises and SITC 1. Otherwise it has no statistically significant correlation with other categories of SMEs in Thailand. This result is consistent with a number of empirical studies (Granér and Isaksson, 2009; Kim, 2003).

6. Key findings and policy implications

6.1. Key findings

The technical efficiency performance of most Thai manufacturing SMEs deteriorated in the post crisis period, with the exception of medium sized firms which improved and SMEs in SITC 1 and SITC 5 which remained unchanged (see Table 7). Manufacturing SMEs remain heavily dependent on labour input and labour intensive technology in production. This is consistent with the problems identified by government as shown in Table 10. Much of this labour input remains unskilled and engaged in low value adding activities, which intensified in a number of sub manufacturing sectors in the post crisis period. Again this is consistent with the findings shown in Table 10. The low dependence on capital input suggests as lack of capital investment that will restrict higher value adding activity and the production of differentiated quality output that is capable of competing in international markets.

Skilled labour had a significant and positive correlation with the technical efficiency of all categories of manufacturing SMEs in 2007 (post crisis period). This shows the importance of continually upgrading the knowledge and skills of the workforce in manufacturing SMEs through the provision of appropriate educational and training opportunities. Without access to a skilled workforce improvement in the technical efficiency of Thai SMEs will be difficult to achieve, making it difficult to engage in higher knowledge, innovative and higher value adding activities and the country will remain in its middle income trap. Greater provision of skilled workers must occur in conjunction with enhanced capital and upgraded technology usage by SMEs. This is again consistent with the findings shown in Table 10.

The importance of firm size (small versus medium) for technical inefficiency is variable across SME categories and across the pre and post crisis periods. In aggregate, small firms were less technically efficient in 1997 and 2007 and the gap had increased. Small firms in sub manufacturing sectors SITC 0, SITC 1, SITC 6 and SITC 8 in 2007 were found to be more technically efficient than medium sized firm, reflecting industry characteristics and the importance of flexibility and adaptability to meet changing market needs and operating in sectors with limited economies of scale (Le and Harvie, 2010; Tran et al., 2008; Vu, 2003). Targeted financial and other assistance to small SMEs and start-up firms in manufacturing sub sectors SITC 0, SITC 1, SITC 6 and SITC 8 has the potential to improve SME technical efficiency. This is consistent with the findings shown in Table 10.

The importance of firm age on technical efficiency is mixed. Longevity does not guarantee improved technical efficiency. The major exception to this being SITC 5. The effects of firm age on technical efficiency, however, appear to be small even if found to be statistically significant. In Thailand's increasingly open and rapidly changing economy and sectors, firm age and experience with technology lock-in may actually impact negatively upon technical efficiency. This is most likely to be the case in those sectors where technology, market demand, products and production processes change rapidly. In these circumstances continual updating of knowledge and technology as well as encouragement of new market entrants and start-ups could be key policy strategies. Addressing market failures and policy biases as alluded to in Table 10 will be important in this context.

In general, location in an urban centre, or municipality, comes with advantages for manufacturing SMEs in the form of: better physical and social (network) infrastructure, knowledge spill-overs, better access to skilled workers, better access to business support services, including finance, and proximity to markets and business opportunities. However, those SMEs in non-municipal areas are at an efficiency and competitive disadvantage, which can exacerbate the urban–rural income and development divide. It can also exacerbate the divide across regions. Location in Bangkok is found to be particularly significant and positively correlated with the technical efficiency of all SME categories. The technical efficiency performance of SMEs located in the Northern and North-eastern provinces suggest considerable regional disadvantage, and particularly after the Asian Financial Crisis, with the Central and Southern regions appearing to have fared better although lagging well behind Bangkok.

All types of manufacturing SME ownership can contribute to improving all categories of manufacturing SME technical efficiency. The public and limited company type of ownership has the strongest correlation with the technical efficiency of all SME categories, based on the estimated coefficients, in both the pre and post financial crisis periods. The juristic partnership form of ownership has the second largest estimated coefficients in relation to SME technical efficiency, and this increased in importance for many SME categories in the post crisis period. Individual ownership has the third largest estimated coefficients for impact on SME technical efficiency in both the pre and post financial crisis periods. However the relative impact of this form of ownership on technical efficiency in general weakened in the post crisis period. The contribution of government and state ownership to SME technical efficiency deteriorated in the post crisis period with the exception of SMEs in SITC 1, SITC 5 and SITC 6. This may be due to the privatisation of the most profitable and efficient firms, with the least profitable and most inefficient firms remaining in public ownership. The cooperative type of ownership, while limited in terms of scope, has the potential to make a significant contribution to the technical efficiency of SMEs in certain categories, specifically SITC 0 and SITC 5.

The correlation between foreign investment (ownership) and SME technical efficiency in the post crisis period is quite focused on that of

medium sized firms and SMEs operating in SITC 2, SITC 5 and SITC 6. Targeting foreign investment into such key sectors may be the best way to enhance the technical efficiency of foreign investment and ownership.

The results for exporting and SME technical efficiency are also mixed. In the post crisis period exporting is positively and significantly correlated to the technical efficiency of only small firms and SMEs in SITC 2, SITC 8 and, in particular, SITC 5. There appears to be particular benefits to firm technical efficiency from exporting activity by SMEs in SITC 5. There is a potential link between foreign ownership of SMEs in SITC 5, export activity by firms in this category and the beneficial effects of these on the technical efficiency of SMEs in SITC 5.

A correlation between government assistance and SME technical efficiency across most SME categories is limited. The only clear and significant correlations were found for medium sized firms and those SMEs operating in SITC 1. This suggests that government assistance during this period was largely ineffective, or biased towards medium sized enterprises and SMEs in specific SITC codes.

6.2. Policy implications

This results presented in this study suggest that the government's first SME promotion plan (OSMEP, 2007a, 2007b), covering the period 2002–2006, aimed at improving the efficiency and capacity of SMEs was largely ineffective as their technical efficiency generally deteriorated. Policy needed to focus more on the following. First, upgrading the skills of the workforce through improved education and training facilities to ensure that labour skills are appropriate and meet contemporary business needs. Second, this must be done in conjunction with more investment in the capital stock and upgrading technology. These two developments need to go hand in hand so as to facilitate and encourage more knowledge, skill intensive, innovative and higher value adding activity by the country's SMEs. This will also facilitate higher quality and differentiated products that will be more competitive in the domestic and international marketplace. This is a key challenge which the country faces otherwise it will remain confined to its middle income trap and is consistent with Second SME Promotion Plan (2007–2011) objectives of improving product quality, expanding SME export shares, increasing SME productivity and efficiency and labour productivity.

Third, policy should give more emphasis to highlighting and addressing factors behind regional and urban–rural inequity in the technical efficiency performance of SME. This is likely to include the need to: invest more in local physical infrastructure, improve local logistics and distribution channels, encourage and support local SME networks and value chains, promote local SME products through trade fairs and the establishment of exhibition centres for SME products domestically and internationally, encourage technology upgrading, establish business incubator centres in regional and local areas, establish and build upon existing local and regional industrial clusters, encourage the adoption of e-commerce through improved access to information and communications technology, improve local business support services, enhance the skills and capabilities of the local workforce and entrepreneurs through the provision of relevant local education and training facilities, encourage business start-ups in sectors of competitive advantage and establish special economic zones.

Fourth, policy should encourage all forms of entrepreneurial activity and SME ownership, however the public and public limited type of ownership is worthy of emphasis given the results obtained from this study. Increased public and limited ownership can only be achieved, however, if SMEs have greater access to stock markets. This can be prohibitively expensive for smaller SMEs in particular. Reducing the costs of this type of ownership should be addressed. This type of ownership has the potential to unlock greater access to finance and other resources for medium sized SMEs in particular, facilitating their access to capital, technology and skilled labour, and enable them to achieve faster growth, benefit from economies of scale and scope and improve their technical efficiency. Encouraging the juristic and individual types of ownership is more prevalent for small SMEs. Policy should ensure that start-up costs are reduced and that adequate funding is available for new firm start-ups and entrepreneurs. In this context the establishment of venture capital markets would be important for start-ups in knowledge intensive and IT sectors. Establishing dedicated financial institutions catering primarily to the needs of SMEs can also play a critical role here.

Fifth, encouraging cooperative ownership of SMEs in rural sector and regional areas in targeted types of activity could also be beneficial for SME technical efficiency.

Sixth, foreign ownership has the potential to improve SME technical efficiency as it can promote technological upgrading, managerial skills and knowledge, promote good corporate governance and enable access to foreign markets (OSMEP, 2007a). The results from this study indicate that for it to be most effective a targeted approach, by means of incentives, should be adopted, with a focus on medium sized SMEs and SMEs operating in SITC 2, SITC 5 and SITC 6, in particular, and away from SMEs in SITC 7. Not all SMEs in all categories necessarily benefit from foreign investment in terms of improved technical efficiency. The Second SME Promotion Plan targeted sectors such as auto and electronic parts, software, logistics, healthcare, education, tourism related industry, health foods, and rubber products. Encouraging foreign investment in these sectors is consistent with the findings of this study.

Seventh, the empirical results suggest that policy should encourage export activity by small firms and particularly those in SITC 5. Export activity is generally not positively correlated with improved SME technical efficiency, and is likely to reflect the fact that many export active SMEs primarily export labour intensive and low value adding products. Policy should help identify export market opportunities for existing products while encouraging the export of higher value adding and more differentiated products.

Finally, on the basis of the findings from this study existing policy measures and government assistance have clearly failed in terms of contributing to a broad based improvement in the technical efficiency of SMEs, with the exception of medium sized SMEs and those in SITC 1. Existing policy measures need to be reviewed and weaknesses addressed to achieve more broad based and inclusive benefits to a broader range of domestic SMEs.

7. Conclusions

This paper has conducted a comprehensive review of the technical efficiency performance of Thai manufacturing SMEs. Its findings are important as manufacturing SMEs remain vital to future growth and employment generation in Thailand. A disturbing result from the study is the deterioration in the technical efficiency of manufacturing SMEs in the post crisis period. Despite concerns arising from the financial and economic crisis of 1997–98 and attempts to bring about a sustainable improvement in SME performance. All categories of SMEs, with the exception of medium sized SMEs, have experienced a decline in technical efficiency and in some categories the decline is alarming. Manufacturing SMEs remain predominantly labour intensive, and focused on low-skill, low value adding activities. Thailand must move away from production based on low labour cost to that based on innovation, knowledge and skill intensive activities. Firm longevity and experience in certain sectors will not guarantee future success in Thailand's contemporary economic environment. Adaptability and flexibility to rapidly changing market circumstances and less focus on technology lock-in will be critical.

To date Government policy measures have largely failed to address the issue of improving SME technical efficiency and competitiveness. Policy emphasis should be on enhancing SME capabilities and capacity, by improving labour force and entrepreneurial quality and upgrading the capital stock and technology. Addressing the growing disparity between SME technical efficiency in Bangkok and other key regions in the country is also important. SMEs will continue to play a critical role

in contributing to inclusive and broad based economic growth in the country and are a logical focus of policy in addressing regional disparities. This will require policy measures aimed at improving regional physical and social infrastructure, labour force skills, business support services, local products and value chains and take up of electronic commerce. Public and limited ownership of SMEs offers greater access to finance for existing SMEs but is only a viable option if the cost of stock market listing can be reduced. The development of venture capital markets should also be a focus of policy to facilitate access to finance for knowledge and innovation intensive start up small firm. Government and state ownership should be carefully reviewed, while cooperative ownership should be encouraged in well identified activities in the rural sector. Policies should be developed to encourage foreign direct investment in SMEs in well targeted sub manufacturing sectors. Export activity should be encouraged through policy support in well targeted sectors rather than more generally. Existing government assistance towards SMEs has largely failed in improving the technical efficiency of SMEs with the exception of medium sized SMEs and SMEs in narrow areas of industrial activity. Overall, policy focus needs to be continually re-evaluated, and this study has provided comprehensive data based evidence upon which to identify and develop effective future SME policy measures.

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