A Comparative Study of Innovation Behaviour in Singapore's KIBS and Manufacturing Firms

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While most services innovation studies are concentrated on the OECD or EU countries, research on services innovation in the non-OECD context is still rare. This study investigates innovation behaviour of a certain group of services – knowledge-intensive business services (KIBS), compared with the manufacturing sector in Singapore. The main findings of this study are: (1) KIBS firms have higher innovating ratio than manufacturing firms, but innovating manufacturing firms are more likely to do R&D than innovating KIBS firms; (2) KIBS firms have higher human capital intensity, training spending intensity, innovation spending intensity, and R&D spending intensity than manufacturing firms; (3) KIBS firms and manufacturing firms have similar innovation objectives, although some delicate nuances do exist; (4) KIBS firms are less likely to have overseas partners for innovation collaboration than manufacturing firms; (5) there is a U pattern of innovation collaboration with geographic distance for both KIBS and manufacturing firms; (6) social capitals are important for KIBS firms' successful provision of innovation support to manufacturing clients; (7) the importance of spatial proximity varies over different phases of innovation support.

INTRODUCTION

It is well known that services account for about two-thirds of GDP in developed countries, and nearly half of GDP in developing countries. With the European Union as an example, the services sector accounted for 50 per cent of its GDP and 46 per cent of its total employment in 1970, but 67 per cent of its GDP and total employment in 1997 (including both market and non-market services). In the meantime, the share of manufacturing was decreasing [Eurostat, 1999].

Despite their economic importance, services were seen as innovation laggards until recently. Manufacturing was considered as the main source of technological

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innovation and hence the key drive for productivity growth, and not surprisingly innovation theory has been basically derived from the analysis of technological innovation in manufacturing. However, since the 1980s onwards a large number of serious scholars have studied innovation in services [e.g., Barras, 1986, 1990; Soete and Miozzo, 1989; Miles, 1993; Young, 1996; Gallouj and Weinstein, 1997; Sirilli and Evangelista, 1998]. In particular, most EU countries included many services sectors in the second round of the Community Innovation Survey (CIS-2) in 1997, while CIS-1 had been restricted to manufacturing in most member countries.

While most services innovation studies have been concentrated on the OECD or EU countries, research on services innovation in the non-OECD context is still rare, although some exceptions do exist, e.g., Chan, Go and Pine's [1998] survey of services innovation in Hong Kong. For Singapore where the manufacturing sector had traditionally been the key drive for rapid economic growth and technological catch-up, due attention has not been paid to services innovation given the fact that its share of services in GDP is at the same level of most OECD countries (66.4 per cent in 2000; see Table 1). Moreover, the 'total business hub' strategy of the Singapore government calls for a reappraisal of innovation in services to ensure that the services sector contributes to productivity growth of the Singapore economy by providing 'world-class' services. As a pilot exercise for a large-scale innovation survey in services, this study investigates innovation behaviour of a certain group of services – knowledge-intensive business services (KIBS), compared with the manufacturing sector in Singapore.

LITERATURE REVIEW

Innovation in Services

The traditional assertion that services contribute little to productivity growth was not seriously challenged before the 1990s [Miles, 2000]. However, recent analyses and

TABLE 1
SINGAPORE'S GDP AND EMPLOYMENT DISTRIBUTION BY SECTORS 1970–2000 (%)

Sectors	1970	1980	1990	1995	1996	1997	1998	1999	2000[c]
Share in GDP									
Manufacturing	20.2	28.1	28.0	26.3	25.4	24.5	23.1	24.4	25.9
Services	67.7	62.0	64.2	65.0	65.2	65.4	65.7	66.2	66.4
Others[a]	12.1	9.8	7.7	8.8	9.5	10.1	11.2	9.4	7.7
Total[b]	100	100	100	100	100	100	100	100	100
Share in employment									
Manufacturing	22.0	30.1	28.4	24.2	23.2	22.6	21.6	21.0	20.8
Services	66.4	60.7	61.7	67.8	69.5	69.5	70.5	71.1	65.5
Others[a]	11.6	9.2	9.9	7.9	7.3	7.9	7.9	7.9	13.7
Total[b]	100	100	100	100	100	100	100	100	100

[a]Including agriculture, mining, utilities, construction, and activities not adequately defined.
[b]Figures may not add up to 100 due to rounding.
[c]Employment data may not be comparable due to the adoption of new industrial classification 2000.
Source: Calculated from *Yearbook of Statistics Singapore* (various years), *and Economic Survey of Singapore* (various years).

empirical evidence show that services are actively engaged in innovation, and some of them are highly innovative:

- Services are active users and adopters of new technologies, especially ICT. The services sector is by far the main purchaser of ICT. ICT has enabled productivity improvements in many services, although official productivity estimates may obscure their impact because of measurement problems [OECD, 2000].
- Services can be the source of innovation in their own right. The European Union's CIS survey showed that service firms spent between 1.2 per cent and 4 per cent of their sales on innovation [OECD, 2000]. Many services have been found to be highly innovative, such as computing services and consulting services.
- Services do carry out R&D and can be the producer of technology. Taking the OECD countries as a whole, the share of business enterprise R&D (BERD) expenditure conducted by the services sector rose from less than 5 per cent of total BERD in 1980 to more than 15 per cent in 1995 (Figure 1). Based on R&D data of the OECD countries, Young [1996] identified three 'S&T intensive' service industries: R&D services, computer services and communication services. He also found a general growing propensity to perform R&D across service industries, even among 'non-S&T' based services.

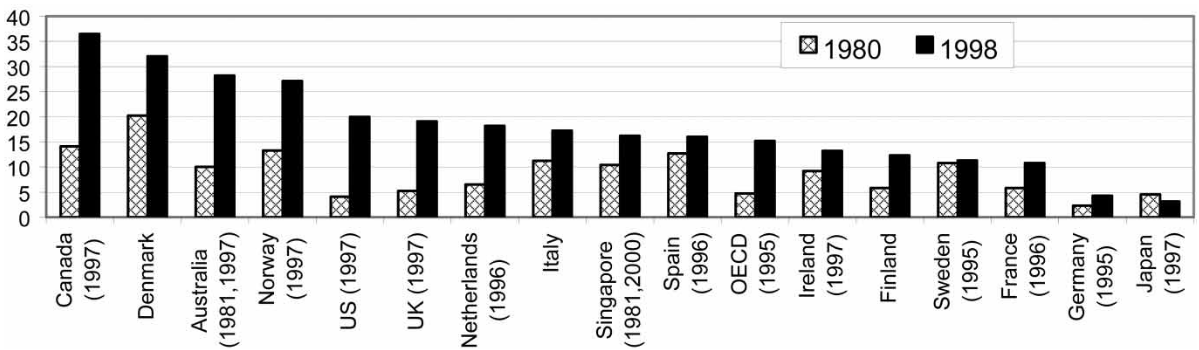
On the one hand, innovation is becoming increasingly decisive for competitiveness and performance of services, as it is already in the case of manufacturing. On the other hand, many services are increasingly recognised as an important component in innovation systems. For example, den Hertog [2000] illustrated that KIBS are critical for facilitating innovation across economy, and thus take an important role of innovation agent in national innovation systems.

Knowledge-Intensive Business Services

In the late 1990s, there have been significant research efforts directed to a particular group of services – knowledge-intensive business services (KIBS). KIBS constitute one important characteristic of the rise of the knowledge-based economy [Muller and Zenker, 2001], and is one of the most dynamic components of the services sector in most industrialised countries [Strambach, 2001].

Miles et al. [1995: 18] defined KIBS as services that involve 'economic activities which are intended to result in the creation, accumulation or dissemination of knowledge'. Another general definition is from Muller [2001: 2]: 'KIBS can be described as firms performing, mainly for other firms, services encompassing a high intellectual value-added'. Based on Miles et al. [1995] extensive discussion of KIBS, den Hertog [2000: 505] provided a more comprehensive definition: 'private companies or organisations who rely heavily on professional knowledge, i.e., knowledge or expertise related to a specific (technical) discipline or (technical) functional domain to supply intermediate products and services that are knowledge based'. The working definitions of KIBS vary considerably in the literature. Following Miles et al. [1995] and den Hertog [2000], we include three major KIBS sectors in

FIGURE 1
SHARE OF SERVICES IN BUSINESS R&D EXPENDITURE IN SINGAPORE AND SELECTED OECD COUNTRIES



Source: STI Outlook (OECD, 2001).

our study: IT and related services, business and management consulting, and engineering and technical services (see appendix 1 for a detailed decomposition).

KIBS may be or may not be technology intensive.[1] What is important is that the definition of KIBS provides a platform to study a group of services which are very actively integrated into innovation systems by joint knowledge development with their clients, and which consequently create considerable positive externalities and possibly accelerate knowledge intensification across the economy. KIBS firms' innovation efforts extend far beyond their internal organisation to the service relationship and directly into the domain of service clients by providing competence enhancing knowledge services to their clients, i.e., to 'foster knowledge development elsewhere in the economy' [Miles et al., 1995: 25]. The SI4S project further summarised three functions of KIBS in innovation systems [e.g., Hauknes, 1998: 54]: (1) KIBS as facilitator of innovation when a KIBS firm supports a client firm in its innovation process, but the innovation at hand does not originate from this KIBS firm; (2) KIBS as carrier of innovation when a KIBS firm plays a role in transferring existing innovations from one firm or industry to the client firm or industry. However, the innovation at hand does not originate from this particular KIBS firm; (3) KIBS as source of innovation when a KIBS firm plays a major role in initiating and developing innovations in the client firm.

Three Approaches to Study Services Innovation

Several peculiarities of services compared to manufacturing are often recalled in the literature to shape services innovation. Summarising works of Miles [1993], Sirilli and Evangelista [1998], and Hipp, Tether and Miles [2000], a common but not necessarily comprehensive list of these peculiarities includes (1) low levels of capital equipment; (2) non-continuous production and limited role of economies of scale; (3) co-terminality (or interactivity, co-production) of service production and consumption in time and space, which implies difficulties in distinguishing between product and process innovation, and the importance of client in services innovation; (4) high information intensity or intangibility of service products; (5) the key role of human capital because most service production is heavily dependent on specialised knowledge and skills of individual employees; (6) the critical role of organisational factors in determining service firms' competitiveness due to the intangible nature of most services. Nevertheless, it must be said that these peculiarities do not apply to all services given the highly diverse nature of the services sector.

Regarding the peculiarities of service activities, to what extent that the methodology established in manufacturing innovation studies can be used in services innovation analysis is debatable in the literature. Three approaches have been discussed in the literature: demarcation, assimilation and synthesis [Tether et al., 2001]. The demarcation approach suggests that services innovation is so distinctive that brand new models and instruments are needed to address the peculiarities of services. This approach is scarcely practised and is not necessary given the evidence of 'convergence' and 'intertwining' between manufacturing and services [Miles, 1993].

The assimilation approach assumes innovation in services is basically similar to innovation in manufacturing, and it can be analysed under the framework of manufacturing innovation with minor adjustments. This approach has been widely adopted in many studies [e.g., Brouwer and Kleinknecht, 1995; Sirilli and Evangelista, 1998; and notably the CIS-2 survey] which apply manufacturing innovation survey instruments [e.g., the revised 'Oslo Manual', OECD-EUROSTAT, 1997] directly without major adaptation. Although it makes close comparison possible, this approach is subject to at least four limitations. First, it is usually is biased towards technological innovation by excluding organisational innovation (nevertheless, organisational innovation is also important for manufacturing firms). According to McKinsey's [1992] report, it is organisational change rather than technical innovation that has the most positive influence on productivity in services. Second, it does not pay sufficient attention to the fact that services innovation appears to draw less on formal R&D than manufacturing innovation, and the management of services innovation often has an *ad hoc* nature [Sundbo, 1997]. Third, the co-terminality between service production and consumption implies difficulties to distinguish product innovation and process innovation which are widely used in manufacturing innovation research. Fourth, relating to co-terminality again, the close interaction between service provider and client indicates the importance of service relationship in services innovation. Gallouj and Weinstein [1997] have stressed that the service provider-client relationship is a major influence on innovation in services. As Miles [2000] pointed out, the service relationship as a site of innovation has been poorly addressed by current services innovation studies.

The synthesis approach goes beyond simply stressing similarities and differences between manufacturing and services. On the one hand, services innovation studies can benefit from the established conceptual and methodological frameworks in manufacturing innovation studies. On the other hand, services innovation studies can help correct the inadequacies of the mainstream innovation research by looking into various aspects and/or peculiarities of services innovation, and thus contribute to our understating of innovation processes in general [Miles, 2000; Tether et al., 2001].

Our study takes the synthesis approach. Besides comparing innovation behaviour between KIBS and manufacturing where data are comparable, we also take into account the peculiarities of services, especially KIBS' role of innovation agent in innovation systems and their innovation support to manufacturing clients.

DATA AND METHODS

Development of the Services Sector and KIBS in Singapore

While labour-intensive manufacturing was largely responsible for the early take-off of economic growth in Singapore in the first decade after political independence in 1965, the sustained high economic growth performance in the subsequent two decades was propelled by rapid technological upgrading of manufacturing. In addition, the development of Singapore into an increasingly important business, finance, transport and communication services hub in the Asia-Pacific region provided additional momentum of growth [Wong, 2001]. Table 1 shows that manufacturing and services were two engines for economic growth in Singapore. In the year 2000, the share of services in Singapore's GDP was 66.4 per cent which is on par with major OECD countries. A slow but steady growth of services share in both GDP and employment is also observed over the last two decades, except that the adoption of new industrial classification may make the year 2000 employment data not comparable. The share of services in Business Expenditure on R&D (BERD) in Singapore is now on par with the average level of the OECD countries (Figure 1). Meanwhile, we must bear in mind that these conventional R&D survey may not capture small-scale and often informal R&D activities in numerous service firms.

KIBS actually cover a wide range of services, and there has been no uniform operationalisation of KIBS in the literature. Particularly the working definition based on industrial classification may miss the emerging activities which can be regarded as KIBS across industries [Miles et al., 1995]. Based on our rather restrictive KIBS operationalisation, we construct a rough picture of the evolution of KIBS in Singapore over the 1990s (Table 2). Steady growth of KIBS in Singapore is observed. Share of KIBS employment in the services sector increased from 12.9 per cent in 1990 to 17.3 per cent in 1999, and correspondingly share of KIBS value added increased from 9.4 per cent to 13.8 per cent. In particular, strong growth is found for IT and related services.

Survey Methodology

Data for this study were drawn from two national innovation surveys in Singapore in 1999, one focusing on manufacturing and the other on KIBS. The manufacturing survey was conducted in collaboration with the Economic Development Board (EDB) of Singapore, while the KIBS survey was conducted through a university research centre. The sampling frame for the manufacturing survey was constructed from the Census of Industrial Production (CIP) database maintained by the EDB of Singapore. This database covers all firms in Singapore's major manufacturing industries except for the smallest ones (less than five employees). Since there was no available comprehensive list for KIBS firms, a variety of business directories were used to construct the KIBS list.[2] The KIBS sample did not have the lower limit of employment and was randomly selected from the population.

Structured survey questionnaires were sent to the CEOs of 1872 manufacturing and 3728 KIBS firms (two-thirds of the manufacturing population, and half of the KIBS population respectively, both excluding closures and non-traceable relocations). The manufacturing survey covered four major manufacturing sectors – electronics, chemicals, precision and process engineering and transport engineering. The KIBS survey covered three KIBS sectors – IT and related services, business and management consulting, and engineering and technical services. A total of 371 valid responses from manufacturing and 181 valid responses from KIBS were achieved at the end of the surveys, yielding response rate of 19.8 per cent for manufacturing and 4.9 per cent for KIBS. The response rate for KIBS was considerably lower than the typical range of 12 per cent and 10 per cent for mail surveys targeted at senior executives [Hambrick, Geletkanyca and Fredrickson, 1993]. Nevertheless, for both surveys, we found no systematic sample bias in terms of industry distribution, but foreign firms and large firms had a slightly higher response rate in both surveys.

TABLE 2
SHARE OF KIBS EMPLOYMENT AND VALUE ADDED IN THE SERVICES SECTOR (%)

	1990	1991	1992	1993	1994[b]	1995	1996	1997	1998	1999
Share in employment										
KIBS	12.9	13.6	13.5	14.0	15.1	16.2	15.2	15.8	15.9	17.3
IT and related services in KIBS	14.2	14.5	15.1	16.1	16.3	16.4	18.5	18.9	20.0	23.8
Business and management consulting in KIBS	54.7	54.9	55.6	52.9	53.9	54.9	53.6	51.4	49.4	50.6
Engineering and technical services in KIBS	31.1	30.6	29.2	31.0	29.9	28.8	27.9	29.7	30.6	25.7
Total[a]	100	100	100	100	100	100	100	100	100	100
Share in value added										
KIBS	9.4	9.6	9.9	10.0	10.8	11.6	11.0	12.3	12.9	13.8
IT and related services in KIBS	13.5	16.0	17.8	17.7	18.4	19.0	20.6	20.9	21.6	23.4
Business and management consulting in KIBS	57.4	56.6	54.4	54.2	53.7	53.2	52.0	52.6	52.3	53.3
Engineering and technical services in KIBS	29.2	27.4	27.8	28.2	28.0	27.7	27.4	26.5	26.1	23.3
Total[a]	100	100	100	100	100	100	100	100	100	100

[a]Figures may not add up to 100 due to rounding.
[b]Year 1994 data not available, based on interpolation.
Source: Calculated from *Economic Surveys Series* (various years).

The manufacturing survey adopted the definition of the OECD ‘Oslo Manual’ [OECD-EUROSTAT, 1997] wherever applicable. For the KIBS survey, while many variables common to the manufacturing survey were adopted to maintain certain compatibility, some adaptations were also made. Several methodological issues for the KIBS survey are worth noting here.

First, the distinction between product and process innovation was kept, but organisational innovation was not included. Close interaction between production and consumption (co-terminality) is thought to cause difficulties in distinguishing between product and process innovation. However, Sirilli and Evangelista [1998] found that only a quarter of the innovating service firms in their Italian survey were unable to distinguish between product and process innovation. Hipp, Tether and Miles [2000], and Preissl [2000] also found that in empirical investigations the distinction between product and process innovation was reasonably robust, but it was difficult to maintain a clear distinction between process and organisational innovation in services.

Second, Miles et al. [1995] introduced ‘delivery innovation’ as a specific category of innovation besides the conventional product and process innovation to describe innovation at the service provider–client interface. But it has been rarely used in empirical investigations, and sometimes, it was embedded in process innovation. For example, in Sirilli and Evangelista’s [1998: 898] study, process innovation was defined as ‘adoption of a production or a delivery method which is new from a technological point of view’. Similarly, in the CIS-2 [Tether et al., 2001: 17] study, process innovation was defined as ‘new or significantly improved methods to produce or deliver services’. The present study also did not distinguish delivery innovation from process innovation.

Third, since services innovation may draw less on technological knowledge, following Brouwer and Kleinknecht [1995], and Hipp, Tether and Miles [2000], we dropped the term ‘technological’ from the definition of innovation in the KIBS survey. This may inflate innovation activities in the KIBS survey.

Fourth, to address the importance of service provider-client interaction in services innovation and the specific characteristics of the innovation process of KIBS firms, several additional questions about KIBS firms’ innovation support to manufacturing clients were asked.

RESULTS

Comparison between KIBS and Manufacturing

Given the increasing convergence between services and manufacturing, innovations in manufacturing and in services do not necessarily have to be sharply demarcated [Miles, 2000]. Nevertheless, because of the traditional emphasis on innovation in manufacturing, there have not been many empirical studies on the pattern of innovation in the services sector, particularly in the newly industrialised economies (NIEs). As such, it is important to compare the pattern of innovation in KIBS vs. manufacturing firms.

As can be seen from Table 3, KIBS firms seem to have higher innovating ratio than manufacturing firms ($\chi^2 = 16.588$, $p = 0.000$), with IT and related services sector in KIBS on par with electronics in manufacturing. Overall, there are no substantial differences in gross R&D ratio ($\chi^2 = .098$, $p = 0.754$), i.e., manufacturing firms and KIBS firms have the same propensity to do R&D. However, innovating manufacturing firms are more likely to do R&D compared to innovating KIBS firms ($\chi^2 = 15.033$, $p = 0.000$). This is consistent with the argument that services innovation draws less on R&D compared to manufacturing. Significant differences are also found at the more detailed sectoral level: (1) electronics and IT and related services have the highest innovating ratio respectively ($\chi^2 = 29.613$, $p = 0.000$ for the manufacturing sample; $\chi^2 = 15.841$, $p = 0.000$ for the KIBS sample); (2) electronics and IT and related services tend to have higher gross R&D ratio respectively ($\chi^2 = 35.669$, $p = 0.000$ for the manufacturing sample; $\chi^2 = 10.960$, $p = 0.004$ for the KIBS sample). Given firms are innovating, there are no substantial differences in R&D ratio within the two samples.

Table 4 shows that KIBS firms have much higher human capital intensity ($F = 832.082$, $p = 0.000$) and training spending intensity ($F = 31.220$, $p = 0.000$) than manufacturing firms. This is consistent with the importance of human capital in KIBS, because the main competitiveness of KIBS firms is professional skills and

TABLE 3
SHARE OF INNOVATING FIRMS AND R&D PERFORMING FIRMS IN MANUFACTURING VS KIBS

	Innovating firms[a]	N	Innovating ratio	Doing R&D	R&D ratio relative to all firms	R&D ratio relative to innovating firms
Manufacturing	145	371	39.1%	101	27.2%	69.7%
Electronics	30	40	75.0%	24	60.0%	80.0%
Chemicals	32	69	46.4%	26	37.7%	81.3%
Precision and process engineering	66	202	32.7%	42	20.8%	63.6%
Transport engineering	17	60	28.3%	9	15.0%	52.9%
Chi-square test for manufacturing			29.613 ($p = 0.000$)		35.669 ($p = 0.000$)	7.824 ($p = 0.050$)
KIBS	104	181	57.5%	47	26.0%	45.2%
IT and related services	41	55	74.5%	23	41.8%	56.1%
Business and management consulting	36	58	62.1%	13	22.4%	36.1%
Engineering and technical services	27	68	39.7%	11	16.2%	40.7%
Chi-square test for KIBS			15.841 ($p = 0.000$)		10.960 ($p = 0.004$)	3.383 ($p = 0.184$)
Chi-square test for manufacturing vs KIBS			16.588 ($p = 0.000$)		0.098 ($p = 0.754$)	15.033 ($p = 0.000$)

[a]Firms were regarded as innovating if they had introduced product innovation and/or process innovation over the last three years.

TABLE 4
HUMAN CAPITAL INTENSITY, TRAINING SPENDING, INNOVATION SPENDING, AND R&D SPENDING INTENSITY (MEAN SCORES)

	Human capital intensity[a]	Training spending intensity[b]	Innovation spending intensity[c]	R&D spending intensity[d]
Manufacturing	22.15	2.68	8.02	2.53
Electronics	27.49	2.63	7.83	5.48
Chemicals	27.49	2.71	7.70	1.95
Precision and process engineering	20.15	2.85	9.28	1.79
Transport Engineering	19.10	2.11	4.24	1.26
ANOVA for manufacturing	F = 4.741 (p = 0.003)	F = 0.325 (p = 0.807)	F = 0.871 (p = 0.458)	F = 2.996 (p = 0.033)
KIBS	78.17	6.00	19.04	7.14
IT and related services	83.21	6.37	22.40	12.74
Business and management consulting	81.12	5.19	18.64	3.74
Engineering and technical services	71.57	6.37	14.23	3.39
ANOVA for KIBS	F = 3.418 (p = 0.035)	F = .339 (p = 0.713)	F = 1.368 (p = 0.260)	F = 7.351 (p = 0.001)
ANOVA for manufacturing vs KIBS	F = 832.082 (p = 0.000)	F = 31.220 (p = 0.000)	F = 29.368 (P = 0.000)	F = 14.229 (p = 0.000)

[a]Percentage of university graduates and diploma holders in total employment.
[b]Expenditure on training as a percentage of payroll.
[c]Total expenditure on innovation activities in Singapore as a percentage of total sales (for innovating firms). Innovation activities include: (1) R&D; (2) acquisition of R&D services; (3) acquisition of machinery, equipment and software linked to product and process innovation; (4) licensing of external technology linked to product and process innovation; (5) industrial design, market research and marketing expense for product innovation; (6) training directly linked to innovations. Adoption of e-commence applications was added in the KIBS survey as an additional type of innovation activity.
[d]R&D spending in Singapore as a percentage of total sales (for innovating firms).

knowledge, which are embedded in the expertise of their staff [Miles et al., 1995; Larsen, 2001]. Although service firms are said to be less likely to engage in R&D than manufacturing firms of comparable size, innovating KIBS firms in our sample have significantly higher R&D spending intensity than their manufacturing counterparts (F = 14.229, p = 0.000), with IT service firms scoring more than twice of electronics firms. Innovating KIBS firms also put proportionally more effort into other innovation activities than R&D. This is reflected in the significantly higher innovation spending intensity of KIBS firms than manufacturing firms (F = 29.368, p = 0.000). Within the manufacturing sample and the KIBS sample, a heterogeneous pattern is found for human capital intensity (F = 4.471, p = 0.003 for the manufacturing sample; F = 3.418, p = 0.035 for the KIBS sample) and R&D spending intensity (F = 2.996, p = 0.033 for the manufacturing sample; F = 7.351, p = 0.001 for the KIBS sample). Substantial differences are not found at the more detailed sectoral level for training spending intensity and innovation spending intensity.

The relative rankings of innovation objectives between KIBS and manufacturing firms are shown in Table 5. While both KIBS and manufacturing firms stress improving quality and new market creation as the most important objectives for investing in innovation, KIBS firms seem to lay more stress on 'improve work conditions for employees', but less on 'reduce labour cost/production cost' and 'reduce materials consumption' compared to manufacturing firms. This is consistent with the fact of higher human capital intensity in KIBS. Despite these observed differences, the Spearman rank correlation (0.78, significant at 0.01 level) indicates that the overall orderings of innovation objectives are actually quite similar between KIBS and manufacturing firms.

Table 6 presents the geographic pattern of innovation collaboration across different regions: local (Singapore), regional (ASEAN), and international (Asia + North America + EU). In the local context, it seems that manufacturing firms collaborate more with R&D institutes/universities in Singapore for innovation ($\chi^2 = 31.423$, $p = 0.000$). This means KIBS firms are less well integrated into public knowledge infrastructures compared to manufacturing firms. However, KIBS firms are more likely to collaborate with local competitors ($\chi^2 = 18.656$, $p = 0.000$). A possible reason is the smaller size of KIBS firms (24 vs 560 of mean employment in our study) and thus less emphasis on market power compared to manufacturing firms. In the regional context, there are no substantial differences in the propensity to collaborate with ASEAN firms/institutions between manufacturing firms and KIBS firms. In the international context, it seems that manufacturing firms are more likely to have overseas partners for innovation collaboration than KIBS firms, especially in terms of customers ($\chi^2 = 27.469$, $p = 0.000$), suppliers ($\chi^2 = 16.330$, $p = 0.000$), parent/associate companies ($\chi^2 = 29.782$, $p = 0.000$), and R&D institutes/universities ($\chi^2 = 18.344$, $p = 0.000$). This could be well related to KIBS firms' lower level of internationalisation, e.g., innovating manufacturing firms in our sample have an average of 36.7 per cent share of turnover from Asia + North America + EU compared to 16.4 per cent of innovating KIBS firms.

TABLE 5
INNOVATION OBJECTIVES

	Mean for KIBS firms[a]	Ranking in manufacturing firms
Improve service quality/product quality	3.39	2
Open up new markets	3.30	1
Extending service range/product range	3.12	4
Improve internal business process flexibility/production flexibility	2.57	6
Improve work conditions for employees	2.48	9
Reduce labour cost/production cost	2.38	3
Replace services/products being phased out	2.23	7
Fulfil regulations and standards	2.18	8
Reduce materials consumption	1.61	5
Reduce environmental effects	1.57	10
Reduce energy consumption	1.52	11

[a]From 0 = not important to 4 = very important (for innovating firms).

TABLE 6
GEOGRAPHIC PATTERN OF INNOVATION COLLABORATION[a,c]

	Singapore		ASEAN[b]		Asia + North America + EU	
	KIBS	Manufacturing	KIBS	Manufacturing	KIBS	Manufacturing
Customers, buyers	63.1%	66.7%	22.3%	38.6%	33.0%**	67.4%**
Suppliers	60.4%	58.5%	21.8%	17.8%	35.6%**	62.2%**
Parent/associate companies overseas	–	–	5.0%	11.4%	35.0%**	71.5%**
R&D institutes/universities	33.0%**	69.5%**	4.0%	3.0%	22.0%**	49.3%**
Business service providers	39.6%	34.5%	11.9%	4.3%	19.8%	22.4%
Technical service providers	49.0%	51.6%	11.0%	4.9%	22.0%	36.9%
Competitors	37.8%**	12.6%**	11.2%	4.2%	16.3%	13.4%

[a]Percentage of firms that have innovation collaboration partners across regions (for innovating firms).
[b]Association of South East Asian Nations, including Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam.
[c]Chi-square test, $^{**}p < 0.001$, $^{*}p < 0.01$.

It is worth noting that there is a U pattern of innovation collaboration with geographic distance (Figures 2 and 3). This is in contrast with many innovation geography studies that shown innovation collaboration increase with spatial proximity. For example, Fischer, Revilla Diez and Snickars [2001] found that firms in three metropolitans, Vienna, Barcelona and Stockholm, often relied more on local linkages, less on international linkages for innovation collaboration, with regional (the EU) linkages in between. Our results cannot be solely explained by the geographical distribution of turnover. For example, innovating KIBS firms have nearly the same turnover share from ASEAN and Asia + North America + EU (15.1 per cent and 16.4 per cent respectively). We suggest three additional reasons for the U pattern: (1) the EU itself is a source of advanced technologies with sophisticated customers and suppliers, but other ASEAN member countries are all developing countries with rather weak technological capabilities, hence it is less meaningful for Singapore firms to build innovation linkages regionally; (2) the high presence of MNCs from three major advanced economies (Japan, North America and the EU) in Singapore[3] implies that foreign firms in our sample may have close relationship with their home countries.[4] Here we assume 'Asia' is largely referred to Japan given the close economic linkage between Japan and Singapore and the heavy presence of Japanese companies in Singapore; (3) compared to ASEAN, EU is a more mature common market which is conducive to cross-border innovation collaboration and technology exchange.

Innovation Support to Manufacturing Clients

To investigate the innovation agent role of KIBS, we asked KIBS firms whether they supported four types of innovation activities in manufacturing clients: product

FIGURE 2
GEOGRAPHIC PATTERN OF INNOVATION COLLABORATION FOR KIBS FIRMS

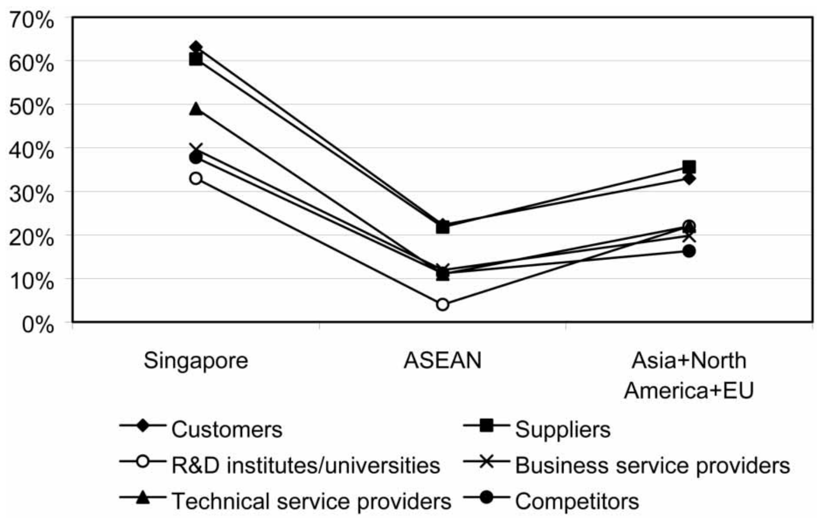
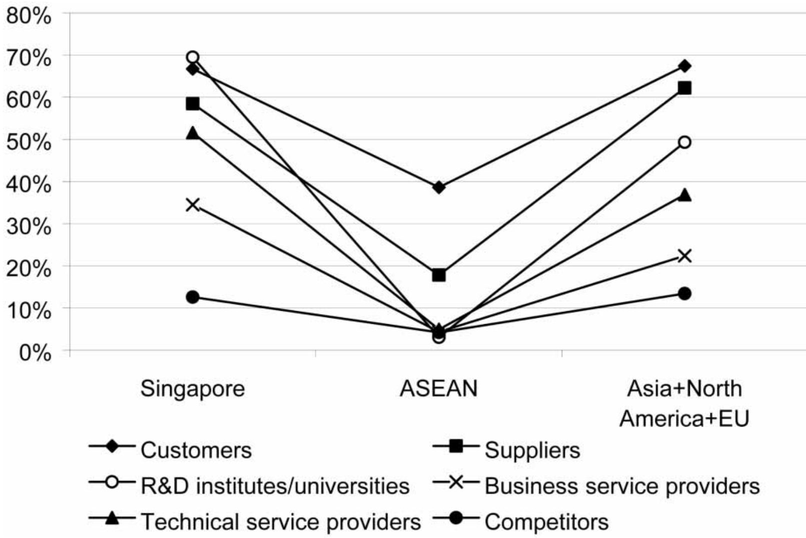


FIGURE 3
GEOGRAPHIC PATTERN OF INNOVATION COLLABORATION FOR MANUFACTURING FIRMS



innovation, process innovation, organisational innovation and market development.[5] Sixty-three KIBS firms reported that they provided at least one type of innovation support to manufacturing clients over the last three years. We examine what are the important factors for successful provision of innovation support.

Among these 63 KIBS firms, 47.5 per cent regard 'frequent personal contact', and 50.8 per cent regard 'good knowledge of clients industry' as important factors for the successful provision of innovation support to manufacturing clients. Although 'location close to the client' seems not to be important (21.3 per cent), most of KIBS firms' manufacturing clients are indeed located in Singapore and the nearby ASEAN region – 90.2 per cent and 58.3 per cent of these 63 KIBS firms have manufacturing clients for innovation support in Singapore and ASEAN respectively, followed by Asia (46.8 per cent), North America (32.3 per cent) and Europe (27.4 per cent).

The above results indicate that social capitals, such as shared language/jargon, overlapping knowledge structure and personal connections are critical for KIBS firms' successful innovation support to manufacturing clients. Following this logic, spatial proximity may be necessary to develop such social capitals, but its importance may vary over different phases of innovation support.

Although ICT is reducing the barriers of distance in service production, physical proximity may still be necessary for knowledge interaction between KIBS firms and their clients. Héraud [2000: 4] has explained this paradox:

> To a certain extent, the trend of de-materialisation and the development of the techniques of communication should help the creative networks to get rid of

> distance; but at the same time it appears that complex cognitive processes need not only large flows of codified scientific and technical information, but also a lot of tacit knowledge for using and interfacing that information. Then proximity does matter, since building common tacit knowledge implies close contacts, at least at the beginning.

Table 7 further shows the relative importance of spatial proximity over different phases in product and process innovation support. For product innovation support, spatial proximity is most frequently cited as important for 'market analysis' and 'idea generation/feasibility assessment'. For process innovation support, spatial proximity is of greatest importance for 'diagnosis of process problems' and 'process-related training of employees'. It thus appears that spatial proximity is important for the early phases of product innovation support, but for both early and late phases of process innovation support.

DISCUSSION

The main findings of this study are: (1) KIBS firms have higher innovating ratio than manufacturing firms, but innovating manufacturing firms are more likely to do R&D than innovating KIBS firms; (2) KIBS firms have higher human capital intensity, training spending intensity, innovation spending intensity, and R&D spending intensity than manufacturing firms; (3) KIBS firms and manufacturing firms have similar innovation objectives, although some delicate nuances do exist; (4) KIBS firms are less likely to have overseas partners for innovation collaboration than manufacturing firms; (5) there is a U pattern of innovation collaboration with geographic distance for both KIBS and manufacturing firms; (6) social capitals are important for KIBS firms' successful provision of innovation support to manufacturing clients; (7) the importance of spatial proximity varies over different phases of innovation support.

Notwithstanding the small sample size, this study highlights a number of implications for public policy as well as innovation management. First, we recommend public policy makers to pay more attention to policies to support and promote innovation in services, especially the KIBS sector. Current public policies on promoting innovation are more geared towards manufacturing industries, especially in many NIEs where the manufacturing sector had traditionally been the key drive for rapid economic growth. A recent study in the UK showed that innovating manufacturing enterprises were approximately five times more likely to participate in government innovation support programs than their counterparts in services [Green, Howells and Miles, 2001]. This result is echoed in our sample in that manufacturing firms are twice more likely to receive government support for innovation than KIBS firms.

Second, we recommend policy makers to take a holistic, interactive system view of innovation policy. KIBS contribute to the overall national innovation intensity – KIBS firms are found to invest more aggressively in innovation, and exhibit higher human capital intensity, training spending intensity and innovation spending

TABLE 7
THE IMPORTANCE OF SPATIAL PROXIMITY TO CLIENT FOR INNOVATION SUPPORT[a]

Phase	Product innovation support	Percentage of KIBS firms reporting spatial proximity is particularly important[b]	Process innovation support	Percentage of KIBS firms reporting spatial proximity is particularly important[c]
1	Market analysis	51.9%	Diagnosis of process problems	42.9%
2	Idea generation and feasibility assessment	44.4%	Idea generation and feasibility assessment	34.1%
3	Front-end development	26.5%	Font-end development	18.9%
4	Development and design	30.5%	Development and design	21.9%
5	Manufacturing process development and planning	20.6%	Organisational re-design	20.0%
6	Market introduction	29.4%	Process implementation and testing	35.0%
7	IPR licensing and protection	6.7%	Training of employees	44.4%
Overall	For any phase in product innovation support	71.0%	For any phase in process innovation support	75.5%

[a]Firms can tick three phases as ‘particularly important’ at most.
[b]Among KIBS firms providing product innovation support to manufacturing clients (N = 46).
[c]Among KIBS firms providing process innovation support to manufacturing clients (N = 54).

intensity, than manufacturing firms. Moreover, KIBS play important bridging roles in knowledge generation and diffusion through knowledge interaction with their clients. Our results confirm Strambach's [2001] description of the contribution of KIBS to national and regional competitiveness: (1) direct effects resulting from their own innovative activities of KIBS firms, and (2) indirect effects of positive feedbacks that expand their clients' innovation capabilities through the use of their services. These two types of effects are highly interdependent. It is not enough to examine innovation policies for manufacturing and services in isolation from one another; instead, policy makers need to focus on how to promote interactive learning and knowledge transfer between the two.

Third, our results are highly consistent with the interactive learning theory. Den Hertog [2000] suggested that KIBS operate as catalysts to promote a fusion between generic explicit knowledge dispersed in the economy and more tacit knowledge located in the firms or sectors they service. Innovation support to manufacturing clients is a process of knowledge interaction. This knowledge interaction between KIBS and manufacturing firms is a complex learning and reframing process where trust and shared understanding should be constructed through rich communication. This study shows that social capitals and spatial proximity are important for successful innovation support to manufacturing clients. This finding suggests that the management of KIBS provider–client relationship is critical to achieve the learning objectives for both parties.

NOTES

1. Miles et al. [1995: 29–30] distinguished between P-KIBS and T-KIBS. P-KIBS are 'traditional professional services, liable to be intensive users of new technology' (such as marketing/advertising services, business and management consulting services, legal and accounting services and so on). T-KIBS are 'related to emerging technologies and technological challenges' (such as IT related services, engineering services, R&D consulting services and so on).
2. Including *Singapore Business Services* (a directory by the Trade Development Board), *Singapore Information Technology Federation Membership Directory* (online), *Times Business Directory of Singapore* (online), 1998 list from the then National Computer Board, *1998 Kompass Singapore Directory, Singapore Industrial and Commercial Directory*, and so on.
3. Singapore has the highest inward foreign direct investment (FDI) per capita in the world.
4. However, the U pattern of innovation collaboration with geographic distance remains for local firms alone (both KIBS and manufacturing). This means that local firms, like foreign MNCs in Singapore, tend to source knowledge from advanced economies.
5. Since KIBS firms' own innovation and innovation support to manufacturing clients can be highly interdependent, to prevent possible ambiguities in answering the questionnaire, we reminded respondents at the beginning of the innovation support section: 'This section is about innovations introduced by your manufacturing clients. Please do not refer to innovation in your own enterprise any longer!'

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APPENDIX 1#

OPERATIONALISATION OF KIBS ACCORDING TO SINGAPORE STANDARD INDUSTRY CLASSIFICATION (SSIC)

IT AND RELATED SERVICES

721 IT consultancy
722 IT development
723 IT services
724 Maintenance and repair of office, accounting and computing machinery
729 Other IT and related services

BUSINESS AND MANAGEMENT CONSULTING

7411 Legal activities
7412 Accounting, book-keeping and auditing activities; tax consultancy
7413 Market research and public opinion polling
7414 Business and management consultancy activities
7430 Advertising activities

ENGINEERING AND TECHNICAL SERVICES

7421 Architectural and land survey activities
7422 Engineering activities
7423 Technical testing and analysis services
7424 Industrial design activities
731 Research and experimental development on natural science and engineering