The Indian Machine-Tool Industry
A Benchmarking Study

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This report sets out some benchmarking results on productivity and quality for CNC (computer numerically controlled) machine tools produced by leading Indian manufacturers. The study was carried out by Professor J. Sutton of the London School of Economics, with the assistance of Mr. G. Doshi, on behalf of the World Bank, during the period December 1999 to August 2000.

Executive Summary

1. This study relates to the production of two major product lines, CNC lathes and vertical machining centres. There are eight Indian manufacturers who produce significant volumes of such machines, and this study is confined to these eight firms.

2. The first half of the study deals with productivity. A comparison was made with a set of leading producers of similar machines in Japan, and in Taiwan. The main difficulty in making such comparisons lies in the fact that different firms produce a different mix of products, and the proportion of 'customized' versus ‘standard’ machines also differs across producers. To minimize such problems, the productivity comparisons presented here are based on the production of basic (2-axis, single spindle) CNC lathes of small or medium size (up to 12-15 kW spindle motor). In presenting the results, allowances are made where possible for differences in the customized/standardized mix, and in the size/complexity mix.

   The measure used is one of simple labour productivity (no. of machines produced per year per employee), ignoring differences in capital inputs.

3. The two main findings in respect of productivity are:

   (a) Differences among Indian firms are extremely large. A simple measure of labour productivity (no. of machines produced per man-year) shows a difference among Indian producers of a factor of more than 6.

   (b) The best level of productivity achieved by any Indian producer is somewhat less than half the minimum level achieved by the foreign firms surveyed.

   One implication of these findings is that it may be worth undertaking further comparisons among Indian firms, with a view to disseminating 'Indian best practice'.

   (c) The productivity gap between the leading Indian producer, and the foreign firms surveyed, is not as wide as the gap in wage rates, so that labour costs per machine are lower for the Indian producer. However, labour inputs constitute only a small part of total unit costs, so that the corresponding advantage to Indian producers in terms of unit production costs is small, and this small advantage is easily outweighed by even very minor shortcomings in quality.

4. Comparisons of quality between two machine tools are notoriously problematic, since it is usually the case that different machines are purchased with different uses in mind, so a 'fair' comparison is difficult. To minimize the difficulty, we identified 50 Indian users who operate an Indian CNC lathe or vertical machining centre side by side with a foreign equivalent machine, in the same production process. We inquired in considerable detail about the relative merits of each machine, both in terms of technical characteristics and in terms of service backup etc.

5. The main findings in respect of quality were:

(a) On technical performance, there was a small but significant quality gap in favour of the imported machine.

(b) On service characteristics, there was a small but significant gap in favour of the Indian machine.

(c) The most striking finding arose when we proceeded to pin down the source of this difference in service characteristics. Here, there are two key elements, the speed of response of service personnel when called, and the quality of service provided on arrival. Indian firms out-scored foreign rivals in terms of the speed of response when called, but - crucially - they scored less well than foreign firms in terms of the quality of the service provided on arrival. The small net quality advantage noted in point (b) above reflects the fact that the advantage of speedy response slightly outweighs the relative shortcoming in service quality.

The implication of these findings are that Indian producers already operate a sufficiently large service network, and the focus of improvement should lie, not in building up the size of this network, but in improving the calibre and training of service engineers.

1. Introduction

This study focuses on the production of CNC lathes and vertical machining centres by Indian machine-tool manufacturers. These two product lines are the two largest and most important categories of CNC machine tools made in India. Demand for these types of machine tool has been growing steadily within India and will become increasingly important over time. Future prospects for exports of machine tools from India will depend largely on CNC machines and these two types of machine are likely to play an important role in developing export markets. Machines of this kind are produced in significant quantities by only eight firms in India and it is on these firms that the study focuses.

In benchmarking the productivity of these Indian firms, the study uses a comparison with firms from Taiwan and Japan. Taiwanese producers offer an important point of comparison because, following liberalisation of the Indian industry in the early 1990s, they succeeded in capturing a substantial share of the Indian market for these products by offering machines of similar quality at significantly lower prices relative to domestic Indian firms. Over the past few years some Indian firms have made ground in recapturing the domestic market, but Indian firms differed widely in their ability to meet the more intense price competition of the late 1990s.

The Japanese firms, on the other hand, represent a high-price, high-quality competitor both on the Indian market and abroad, their focus being on more complex (multi-spindle, multi-axis) machines than the basic (single-spindle, 2-axis) machines which comprise more than 95% of demand for tools of this kind in the Indian market.

For the purpose of this study, comparisons were made with two of the leading Taiwanese producers and two of the leading Japanese producers. These producers were chosen with a view to providing the most appropriate point of comparison with the Indian firms.

The most striking difference between these foreign firms and their Indian counterparts relates to the scale of production. This difference is illustrated in Figure 1 which shows the range of annual output levels for CNC lathes across producers by country. Only one firm in India achieves a volume of output that is comparable to the lowest levels encountered among leading producers in Taiwan or Japan. Comparisons of this kind must always be qualified by reference to the distinction between the production of standarized machines and the production of customized machines. All Indian producers offer predominantly customized machines. Both Taiwanese firms offer standarized machines only. One of the Japanese firms offers standardized machines only, while the other produces a half and half mix of standardized and customized machines.

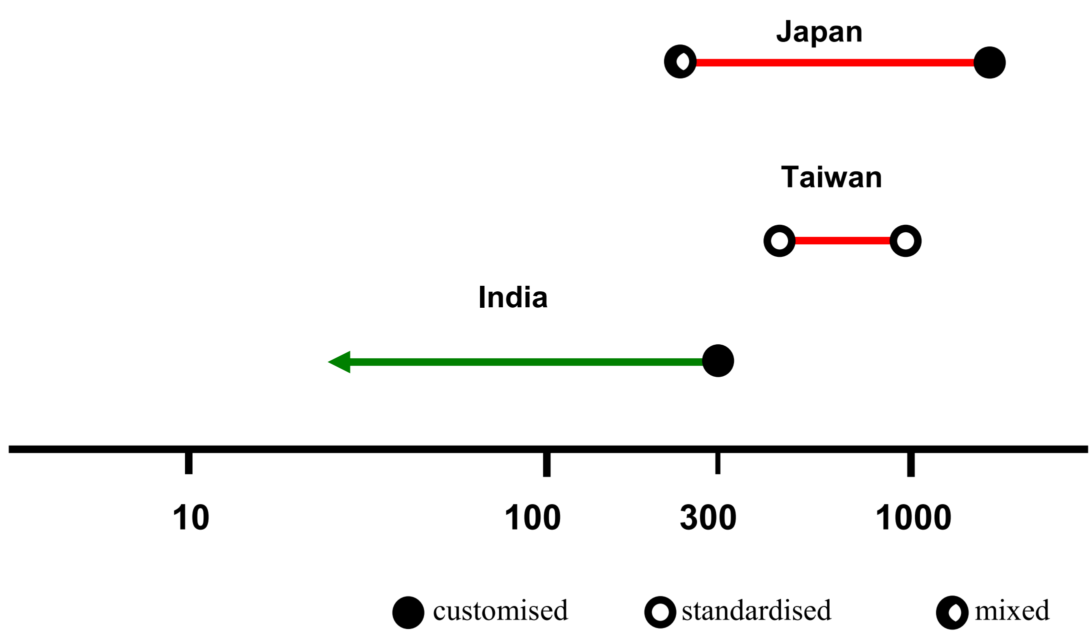

Figure 1. Annual output of CNC lathes by leading producers.

2. Productivity Comparisons

The productivity comparisons discussed in this section are simple comparisons of labour productivity. In other words, they represent an attempt to ask the question: how many machines are produced per year per employee? In interpreting such figures. it is important to bear in mind that a high score in terms of labour productivity will probably reflect inter alia the use of more capital intensive methods of production. Indeed, the higher wages prevailing in Taiwan and Japan make it economically worthwhile for manufacturers to use a much higher proportion of machining centres in their production plants than do their Indian counterparts. At the extreme, the Japanese plants employ quite heavily automated techniques of production. A second point that should be borne in mind in examining these figures is that the productivity ratios should be considered in tandem with the relative wage rates in the three countries. For shop floor manpower, this ratio is approximately 1:6:15 for India:Taiwan:Japan.

In making this comparison, plants were selected in which CNC lathes were the main product line. Where other lines were produced in the same plant, an approximate attribution of manpower was made between CNC lathes and other products. A correction was made to allow for differences in the extent to which different plants buy in components rather than manufacture them on site. The standard plant to which these numbers apply is one in which:

- all castings are bought in
- all CNC controls and electrical equipment are bought in
- all sheet metal parts are bought in
- mechanical components are produced in house[1]
- all machining and assembly operations and all fitting of electrical equipment and CNC controls are carried out in house

[1] In the case of one Taiwanese producer a substantial proportion of components are bought in (see Figure 2) and this has not been corrected for in drawing the figure.

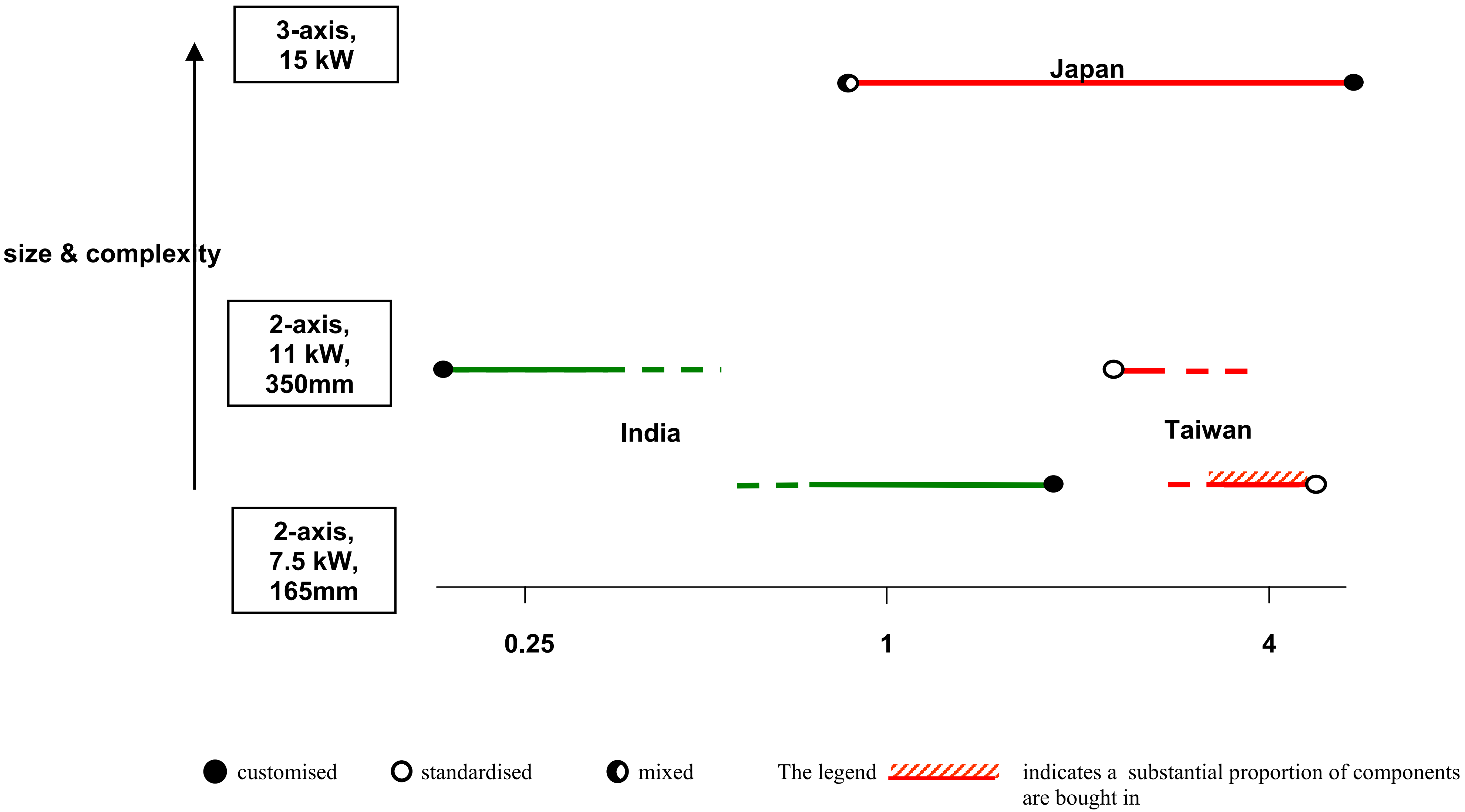

Figure 2. A comparison of gross labour productivity in the production of CNC lathes.

The productivity figures represent the number of machines per year produced at the plant in an average year during the late 1990s divided by the total manpower associated with that plant including both direct and indirect labour. All design staff and all sales and service staff are excluded. All managerial and supervisory staff are included.

With these observations in mind, the productivity comparisons can be read from Figure 2. It will be seen from the figure that the Indian and Taiwanese firms both produce basic two-axis, single-spindle machines and these come in two size categories, small (7.5kW spindle motor, 165 mm chuck) and medium (11kW, 350mm). In interpreting the figure it might be expected that production volumes per man of the smaller type should be expected to be about double that of the medium type in a plant of equal productivity, but this ratio is a crude estimate and should be applied cautiously. If we accept this crude estimate for the appropriate correction factor, then the range between the maximum of 2 (smaller machines) and the minimum of 0.15 (medium machines) indicates a corrected ratio between the maximum and minimum productivity levels of $2/2 \div 0.15 = 6\frac{2}{3}$.

The figures for Taiwan which relate to standard machines are 2.6 (medium machines) and 5 (smaller machines) respectively. In the latter case, a high proportion of components are bought in. If, once again, we use the crude correction factor of 2 for machine size, then the ratio between the lowest Taiwanese score and the highest Indian score is a factor of $2.6 \div (2/2) = 2.6$. This ratio should be compared to the corresponding ratio in wage rates; a comparison between the hourly rate paid to qualified machinists in the two countries suggests a wage ratio of about 6:1 for Taiwan relative to India at current exchange rates. This implies that wage costs per machine produced are higher in the lowest-scoring Taiwanese firm, in comparison with the highest scoring Indian firm by a factor of $6 \div 2.6 = 2.3$.

The figure also shows productivity figures for Japan. In interpreting these it should be borne in mind that the mix of production in these plants is heavily weighted towards more complex machines, so that the median product by value would be a three-axis, 15 kW machine[2]. It is difficult for engineers to agree upon an appropriate correction factor in relating these figures to figures for a producer of basic machines.

[2] The figures for Japan are 1 (customized machines) and 5.5 (half and half mix of customized and standardized machines).

2.2 The Design Function and the Sales and Service Function

In making the above comparisons two categories of staff were excluded: design staff and sales and service staff. Figure 3 shows a comparison across countries of the size of the design team employed at the firm as a percentage of total employment at the firm and in terms of absolute numbers. It is clear from Figure 3a that Indian firms on average devote a somewhat smaller proportion of total manpower to design but the smaller size of the Indian firms means that the absolute numbers of design staff are very much lower (Figure 3b). Figure 4 illustrates a similar comparison for the size of the sales and service manpower.

2.3 Interim Conclusions

The main findings in respect of productivity and the use of manpower are:

(a) Differences among Indian firms are extremely large. A simple measure of crude labour productivity (no. of machines produced per man-year, corrected for machine size) shows a difference among Indian producers of a factor of more than 6.

(b) The best level of crude labour productivity achieved by any Indian producer is somewhat less than half the minimum achieved among Taiwanese producers.

(c) The productivity gap between the leading Indian producer and the foreign firms surveyed is not as wide as the gap in wage rates, so that labour costs per machine are lower for the most productive Indian producers than for comparable Taiwanese producers.

(d) In respect of the design function, the absolute size of design teams is small in comparison to foreign companies but this largely reflects the smaller scale of the Indian producers.

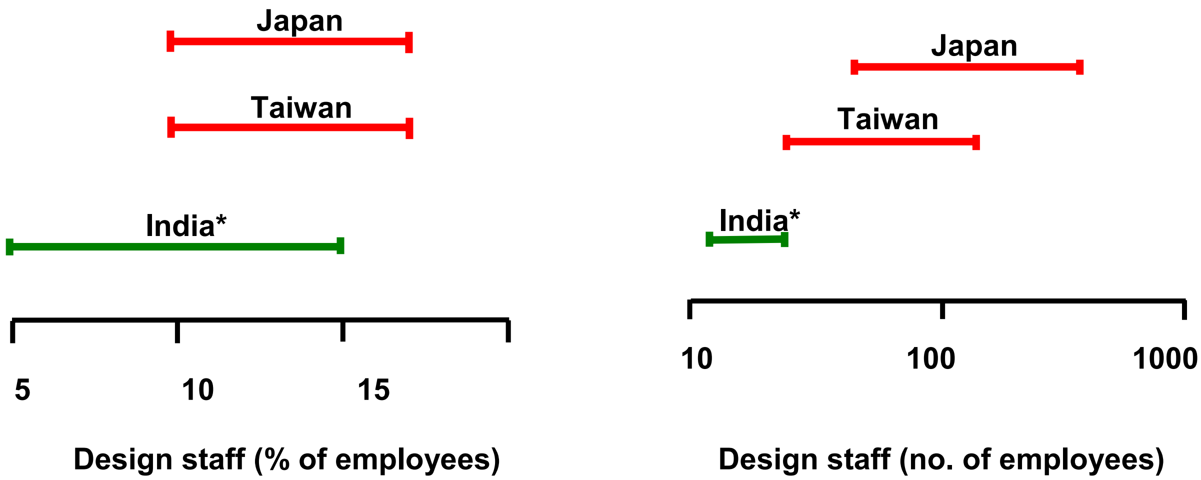

Figure 3. The size of design teams as a proportion of total firm employment (Panel a) and in terms of the number of employees (Panel b).
*For India the HMT company is excluded from this comparison.

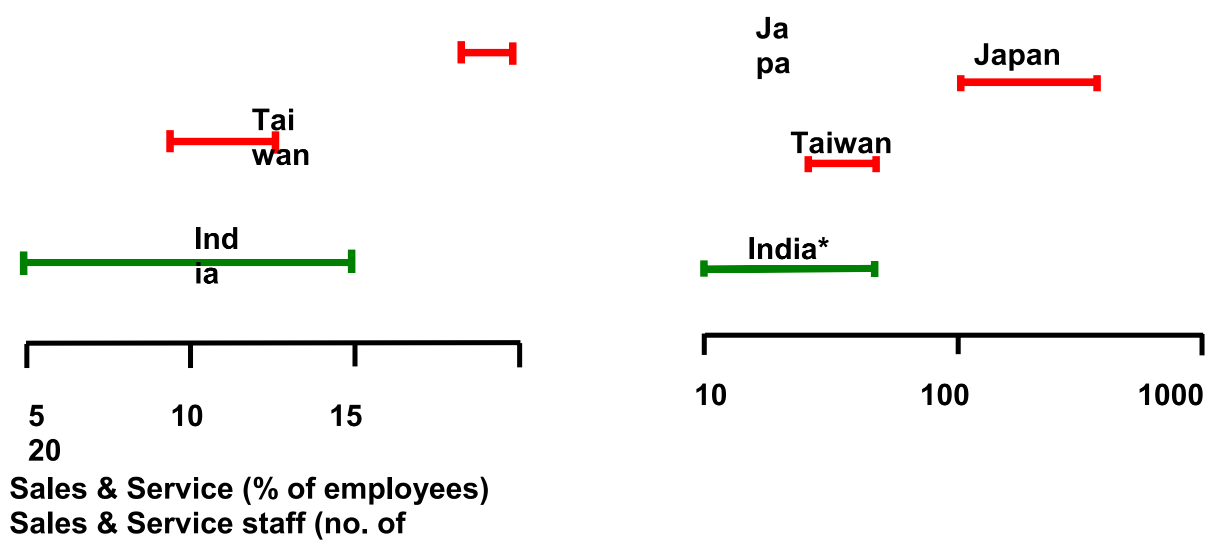

Figure 4. Sales and service manpower as a proportion of total firm employment (Panel a) and in terms of the number of employees (Panel b).
*For India the HMT company is excluded from this comparison.

(e) In spite of the smaller scale of Indian producers, the size of sales and service teams compares quite well with those of Taiwanese producers but is substantially smaller than those of Japanese producers.

2.4 Implications: Productivity and Unit Costs

In order to put the above findings into perspective, it is necessary to link the crude measure of labour productivity reported above with the firm's unit cost of production. For the firms in this survey, the cost of (bought-in) CNC controls, ball-screws and bearings, and electrical components, amounts on average to about 55% of unit cost. The breakdown of other costs elements varies substantially across firms; however, for the typical Indian producer, the pattern is roughly 15% wage costs, 15% other bought-in components (castings, sheet metal) and 15% on ancillary costs including energy costs. The implications of this are most clearly seen by considering the impact on a firm's unit cost of production, and so on its price, of a doubling of labour productivity. Given that in-house wage costs account for only 15% of unit costs, the cost (and price) advantage accruing to a firm that doubles its level of labour productivity amounts to a reduction of only 7½%. Price differences of this order are easily outweighed by fairly modest advantages in relative quality levels. In the second part of the study, we turn to a comparison of various quality measures.

3. Quality Comparisons

Comparisons of quality between two machine tools are notoriously problematic, since it is usually the case that different machines are purchased with different uses in mind, so a ‘fair’ comparison is difficult. To minimize the difficulty, we identified 50 Indian users who operate an Indian CNC lathe or vertical machining centre side by side with a foreign equivalent machine, in the same production process.

The Indian machine tools included in these comparisons together with the foreign comparison machines are shown in Tables 1 and 2. In all cases, the firm was asked to specify the price it paid for each machine (including import duty on foreign machines), but in many cases, this information was not supplied. In the case of 56 matched pairs of machines, the prices of both machines were reported. For these cases, the ratio of the price of the Indian machine to that of the foreign machine had a mean value of 0.81. In 25% of cases, the cost of the Indian machine exceeded that of the foreign machine, while in 33% of cases, the price of the Indian machine was less than 60% of the price of the matched foreign machine.

In order to get a preliminary summary comparison, each user firm was asked to rate its general satisfaction with each machine on a scale of 1 to 5. Figure 5 shows the difference in the score obtained by the two machines. A positive difference indicates that the Indian machine is regarded as better. (In this and subsequent figures we adopt the convention that scores favourable to the Indian machine are shown in green, while those favourable to the foreign machine are shown in red.) It is clear from Figure 5 that the most commonly reported result involves a 1-point disadvantage for the Indian machine. We attempt to pinpoint the source of this disadvantage in what follows.

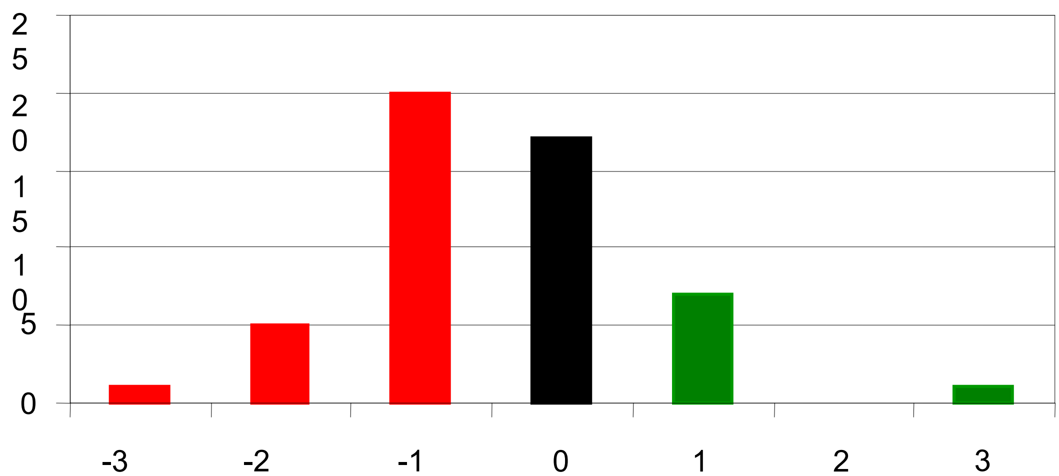

Figure 5. Difference in general satisfaction with machine (1-5 rating) (Indian-Foreign). In this and subsequent figures, outcomes favourable to the Indian machine are shown in green, and those favourable to the foreign machine are shown in red.

ACE Designers (LT2- LT25, LCXT16)
HMT (STC15, 25)
Kirloskar (WSC 15 - 18, MKU8)
Lakshmi (Pilatus, SL3, LAL2, LSL2,3b, AL II)
PMT

Durga (25E)
Feeler (FTC280)
Goodway (GCL 2L)
Ikegai (RU40 LL, TUR20, 25)
Monfort (RNC 4, 10171)
Mori Seki (AL2)
Murata (ISCP II, WSC 15)

Nakamura Tome (TMC20)
Takamaz (X-15)
Takisawa (TC10, 20, EX106)
Wasino (L3J3, 5)
Yamazaki Mazak (QT6G, 15)
Yong Chin Supermax (TC26)

Table 1. Quality comparisons for CNC lathes. The Indian manufacturers and models are shown in the upper panel and the foreign comparison machines in the lower panel.

ACE Manufacturing Systems (MCV 320, 320M)
BFW (Max Pro V 400)
HMT (VMC8, 1200)
Lakshmi (LMV-Junior)
Kirloskar (V40)
PAL (VA40, 50)

Bridgeport (VMC600/22, 460)
Chiron (12W/12S, Fz 12 WM)
Daewoo (V400, 800)
Feeler (800)
Hartford (VMC 850)
Leadwell (MCO P, MCV 610)

Makino (V55)
NTC (NV45)
STAMA (MC 325)
Takisawa (V40)
Yamazaki Mazak (FJV-20, V515)

Table 2. Quality comparisons for vertical machining centres. The Indian manufacturers and models are shown in the upper panel and the foreign comparison machines in the lower panel.

We asked users to identify, without prompting or suggesting categories, the points where they felt the foreign machine, or the Indian machine, was better. The foreign machine was rated better on three counts by a substantial number of users:

Reliability	(cited by 21 of 50 users)
Accuracy	(20)
Productivity	(13)

Other factors mentioned by more than five users were documentation, workmanship and maintainability.

Users identify three points on which the Indian machine was better:

Service	(cited by 28 of 50 users)
Price	(20)
Spares	(19)

No other factor was named by more than five users.

These results suggest that the foreign machines score better on "machine-related" factors, while the Indian machines score better on "service-related" factors.

3.1 Machine-related factors

We began by asking firms to rate machine reliability on a 1 to 5 scale. The difference in ratings shown in Figure 6 indicates that the most common response involves a difference of 1 point in favour of the foreign machine. In order focus specifically on down time, we asked for a figure for each machine for the number of hours lost due to breakdown in the past year and we expressed this as a ratio of the number of hours booked. From Figure 7 it is clear that the most commonly reported result shows no difference in hours lost. The weakness in the scores for Indian machines can be traced to the fact that a small number of machines of each category show substantial losses and the number of Indian machines showing such losses is somewhat higher than the number for the foreign machines, but this difference is not large.

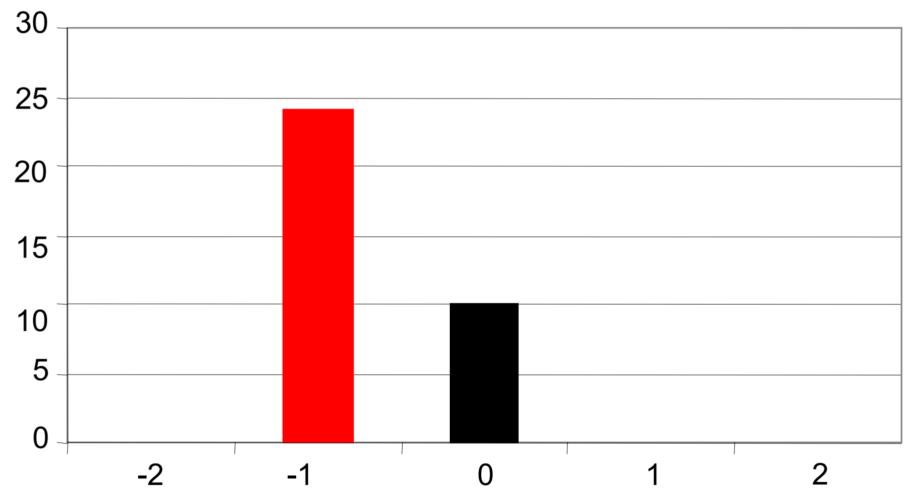

Figure 6. Difference in scores on machine reliability on a 1 to 5 scale.

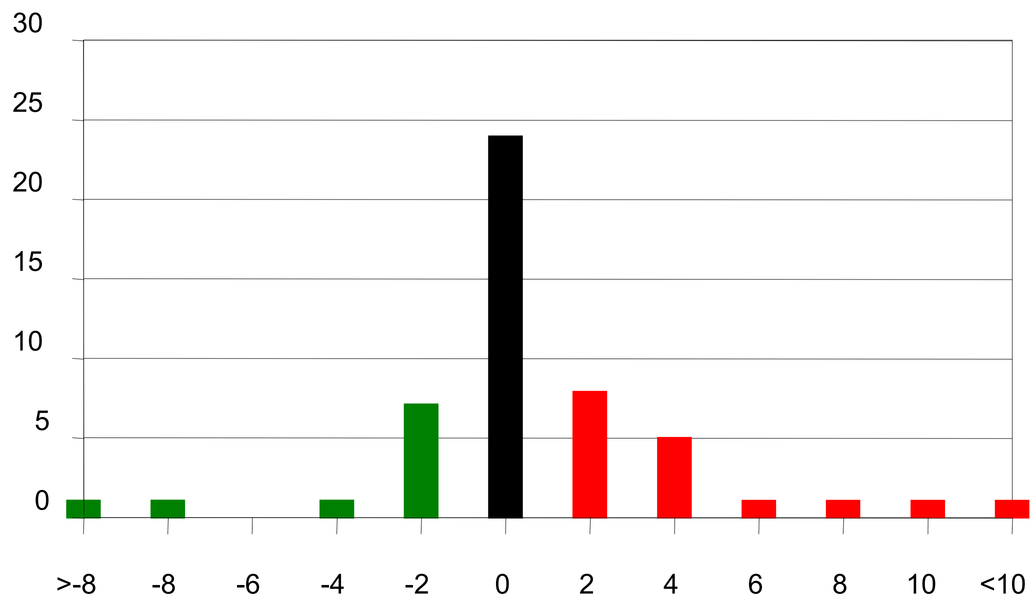

Figure 7. Difference in % lost hours due to breakdown/no of machine hours booked. (Indian-Foreign)

User firms also reported their ratings for accuracy and ease of maintenance. Here the score difference in both cases shows a somewhat weaker performance for the Indian machines.

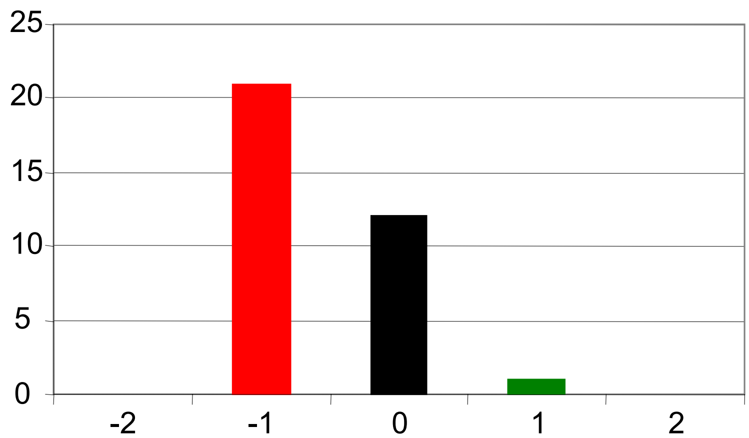

Figure 8. Difference in rating for accuracy.

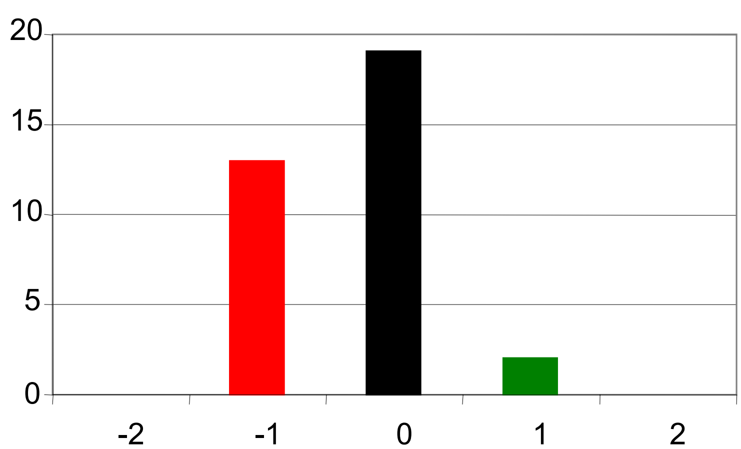

Figure 9. Difference in rating for ease of maintenance.

In order to pin down differences in machine characteristics in detail, we provided firms with a list of specific questions. In Table 3, we show the set of questions on which Indian machines achieved lower scores. In Table 4, we show the remaining questions from our list; on these questions the Indian and foreign machines scored about equally well.

Indian machines achieved slightly lower scores on the following questions:	
Are higher spindle speeds required?	[53% versus 34% said "yes"]
Is higher motor power required?	[39% versus 22% said "yes"]
Are higher feed rates required?	[49% versus 32% said "yes"]
Is higher rigidity required?	[55% versus 32% said "yes"]
Is shorter tool change time required?	[59% versus 30% said "yes"]
Is the machine easy to maintain?	[59% versus 76% said "yes"]
Is material removal rate adequate?	[24% versus 36% said "yes"]
Is accuracy retained over an adequate number of years?	[55% versus 78% said "yes"]

Table 3. Sources of satisfaction and dissatisfaction. The figures in square brackets show the percentage of our respondents who answered yes in respect of the Indian machine versus the percentage who answered yes in respect of the foreign machine.

Indian and Foreign machines scored about equally well on the following questions:	
Is shorter pallet change time required?	[57% versus 60% said “yes”]
Is the coolant flow adequate?	[73% versus 74% said “yes”]
Is in-process inspection provided wherever necessary?	[41% versus 50% said "yes”]

Table 4. Sources of satisfaction and dissatisfaction (continued).

3.2 Service-related factors

While the results reported above indicate that Indian machines score relatively well on service-related factors, a more detailed set of questions suggests a more complex picture. In Figure 10, we show the difference in rating for the speed of service backup response and also for the availability of spare parts. On both these elements the Indian machines achieved substantially higher scores. However, as Figure 11 illustrates, the Indian machines achieve substantially lower scores on the adequacy of service backup and the knowledge of service personnel.

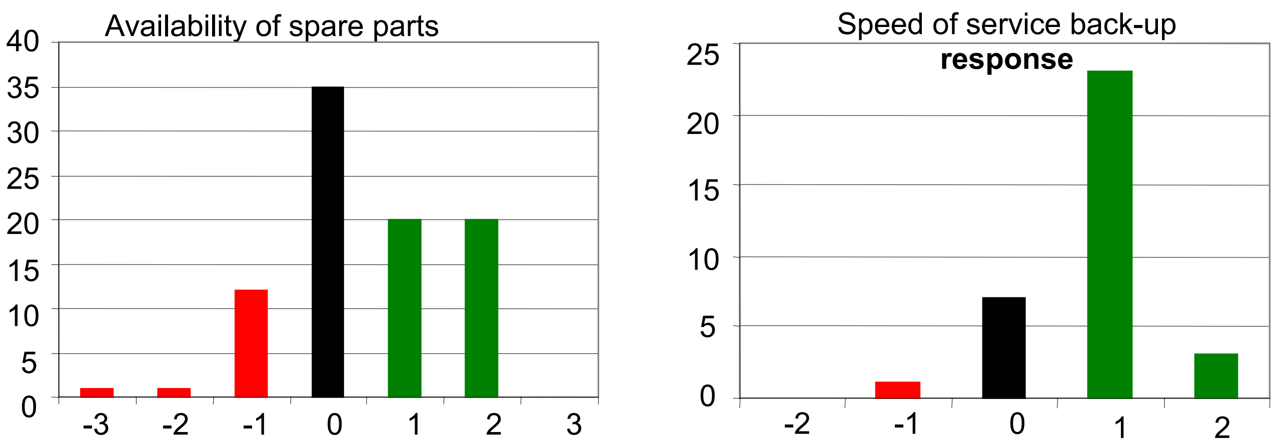

Figure 10. Difference in rating on after-sales service (1-5 scale, Indian score minus Foreign score).

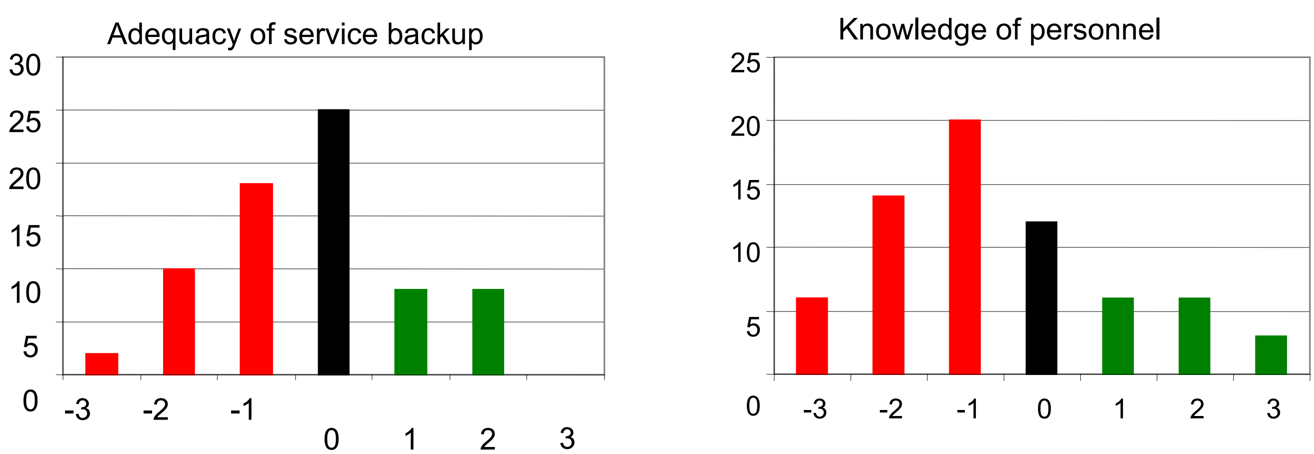

Figure 11. Difference in rating on after-sales service (continued).

3.2 Pre-sales service, training and documentation

Indian machines score slightly better than foreign machines on pre-sales service (Figure 12). On training, there is little difference in scores between Indian and foreign machines (Figure 13). On documentation, the Indian machines achieved higher scores on average than the foreign machines in the areas of programming, diagnostics and machine operation (Figure 14). There is little difference in the quality of documentation between Indian and foreign machines in respect of maintenance, servicing and spare parts listing (Figure 15)

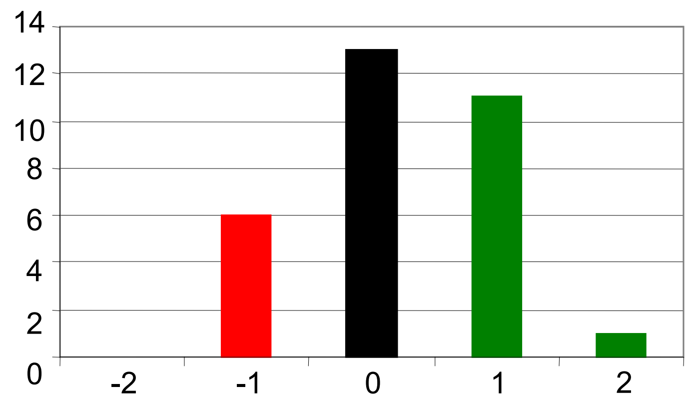

Figure 12. Difference in rating on pre-sales service.

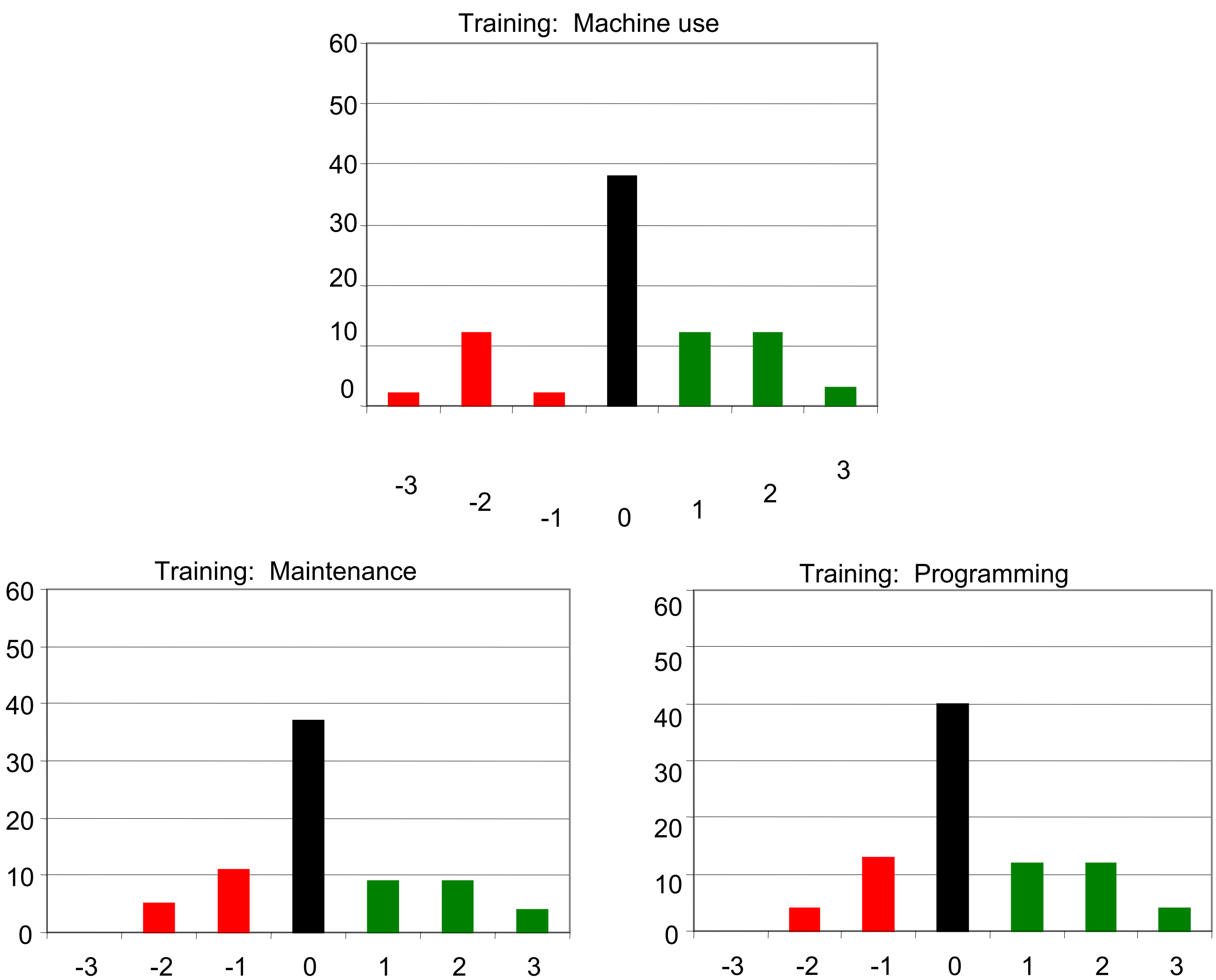

Figure 13. Difference in ratings in respect of training.

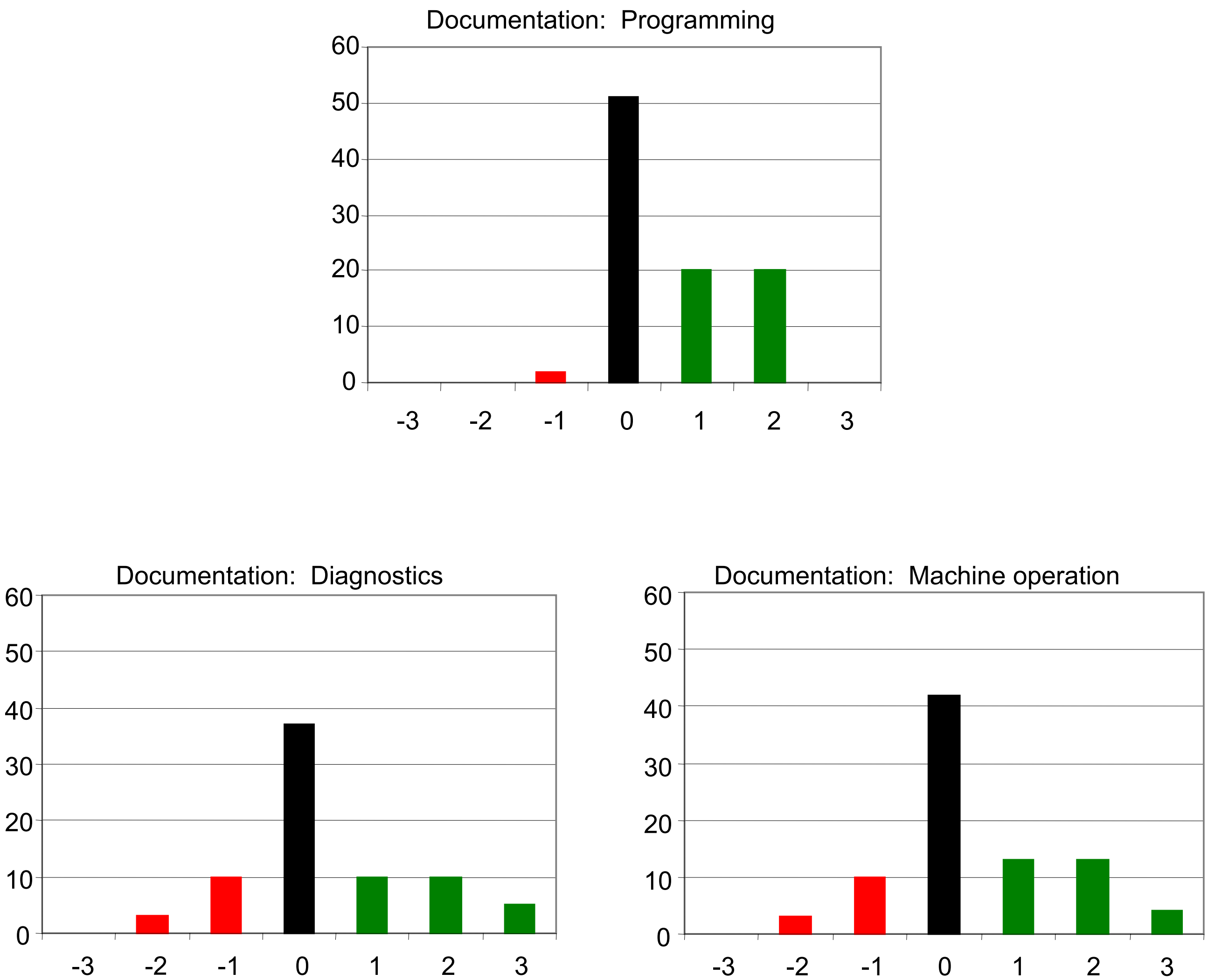

Figure 14. Difference in ratings in respect of documentation: programming, diagnostics, machine operation.

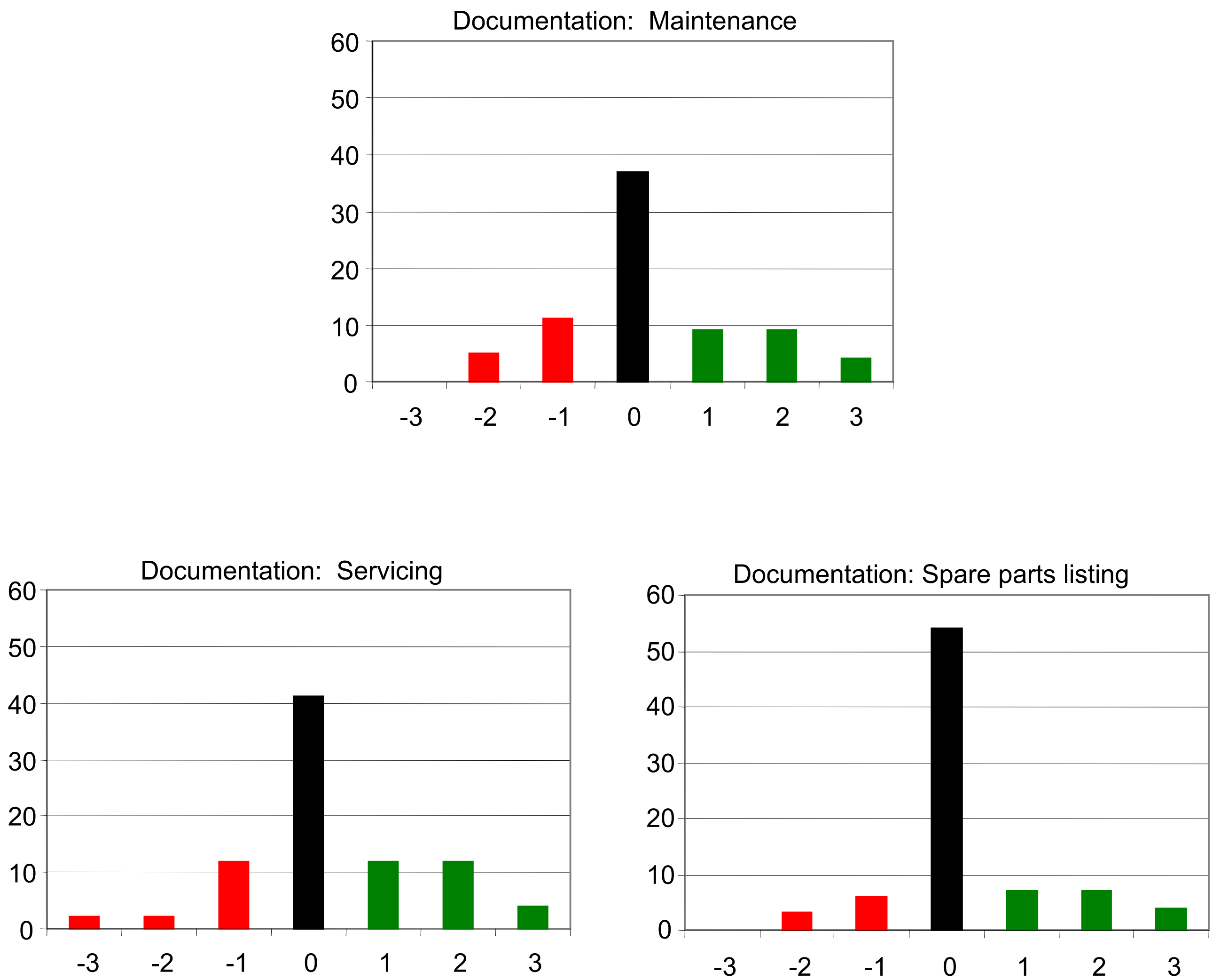

Figure 15. Difference in ratings in respect of documentation: maintenance, servicing, spare parts listing.

4. Conclusions

1 The range of productivity across Indian producers is very wide, and the highest level attained in India is not very far below those of some Taiwanese competitors. This implies that benchmarking against best Indian practice may be a good strategy for many firms in the industry.

2 The productivity gap between the leading Indian producer and world class levels is not as wide as the gap in wage rates; labour costs per machine produced are below Taiwanese levels.

3 Only 15% or so of total unit cost consists of in-house wage costs, so even a doubling of productivity would support a price cut of about 7½%. Such a price advantage can be wiped out be even very small quality failings.

4 An important contributory factor to shortcomings both in productivity and quality lies in the low output volumes of Indian firms.

5 The more important priority in improving performance lies in quality, rather than productivity. Many of the problems in machine quality are of a kind that require both design improvements and a tight control of production processes. Here, low volumes are a problem, as it is difficult to implement and sustain improvements in production practice without a continuous flow of production.

6 Recent experience of Taiwanese (and other foreign) competition has shown that many Indian customers are highly price-sensitive. Cutting prices may solve the volume problem for some individual firms, but the net effect of such developments will lie in

a rise in industry concentration (a fall in the number of Indian producers), whether by way of merger, consolidation or exit.

7 While Indian machines enjoy an overall advantage on service-related factors, they under-perform foreign machines in terms of the knowledgability of service personnel. This suggests that efforts should be focussed, not on increasing the number of service personnel, but on improvements in the training of service engineers.