

# **Pattern of Innovation among Singaporean Manufacturing Firms**

*Assoc. Prof. Wong Poh-Kam*

*Director, Centre for Management of  
Innovation and Technopreneurship (CMIT),  
National University of Singapore (NUS)*

# OBJECTIVES

The objectives of this survey are

- to assess the current status of innovation among manufacturing companies in Singapore and benchmark it against those in OECD countries;
- to identify key problems and challenges faced by these companies in innovation.

## METHODS AND DATA ANALYSIS

- Data has been collected by postal survey, questionnaires sent out to CEOs of 1,876 companies.
- Before commencing the analysis, data entry has been tested for integrity using random checks as well as explorative statistical procedures (frequencies, ranges, cross tabulations etc.).
- Missing data as well as doubtful or contradictory responses have been clarified by telephone call-ups or in some cases removed from the sample.
- All relevant variables have been analysed with SPSS for Windows, versions 9 and 10. Statistical techniques used include frequency distributions, ANOVA<sup>1</sup> and correlation analysis.

## THE SAMPLE

- The following manufacturing clusters have been covered by this National Innovation Survey:
  - electronics
  - chemicals
  - precision and process engineering
  - transport engineering<sup>1</sup>
- Response rates differ only slightly between clusters, ranging from 21.6% for the chemicals cluster to 19.0% for electronics.

## THE SAMPLE

- The realised sample represents 97,000 employees. Total annual sales amount to S\$35 billion, while total fixed assets add up to S\$22 billion.
- Over half the responses were from the precision and process engineering companies. Chemicals companies contributed 18.6%, transport engineering 16.2% and electronics companies 10.8%.
- Almost two-thirds of the responses were from local companies
- To reduce sample bias, the data has been **weighted** throughout the analysis to represent the population in terms of industry structure and employment size class<sup>1</sup>.
- Unless otherwise stated, all totals given in this report have been **weighted** to represent the total population, i.e. the four manufacturing clusters under study.

**Intro-5** 1) Please refer to APPENDIX II for further details on weights and how they were computed.

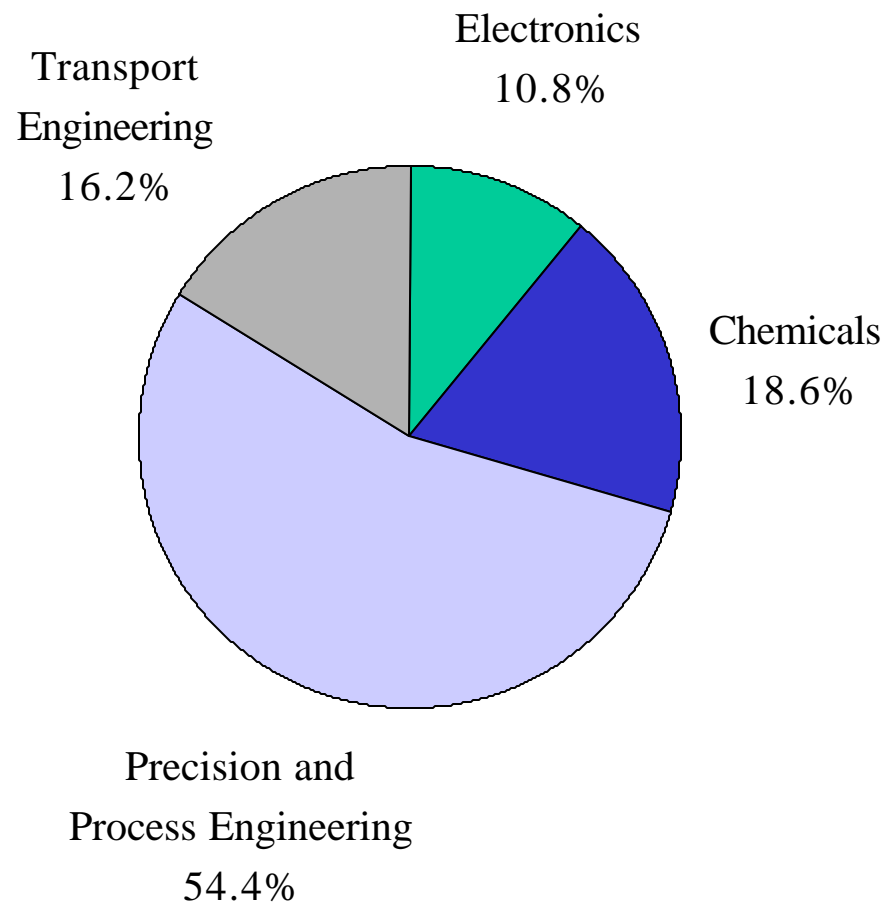
# POPULATION, SAMPLE AND RESPONSE RATE BY MANUFACTURING CLUSTER

	Electronics	Chemicals	Precision & Process Engineering	Transport Engineering	Total
<u>Population 1997<sup>1</sup></u>					
No. of establishments	261	502	1,616	352	2,731
Percentage	9.6 %	18.4 %	59.2 %	12.9 %	100.0 %
<u>Sample<sup>2</sup></u>					
No. of establishment	210	320	1,032	310	1,876
Percentage	11.2 %	17.1 %	55.0 %	16.5 %	100.0 %
<u>Valid responses<sup>3</sup></u>					
No. of establishments	40	69	202	60	371
Percentage	10.8%	18.6%	54.4%	16.2%	100.0 %
Share of sample (Response rate)	19.0 %	21.6 %	19.6 %	19.4 %	19.8 %
Share of population	15.3%	13.7%	12.5%	17.0%	13.6%

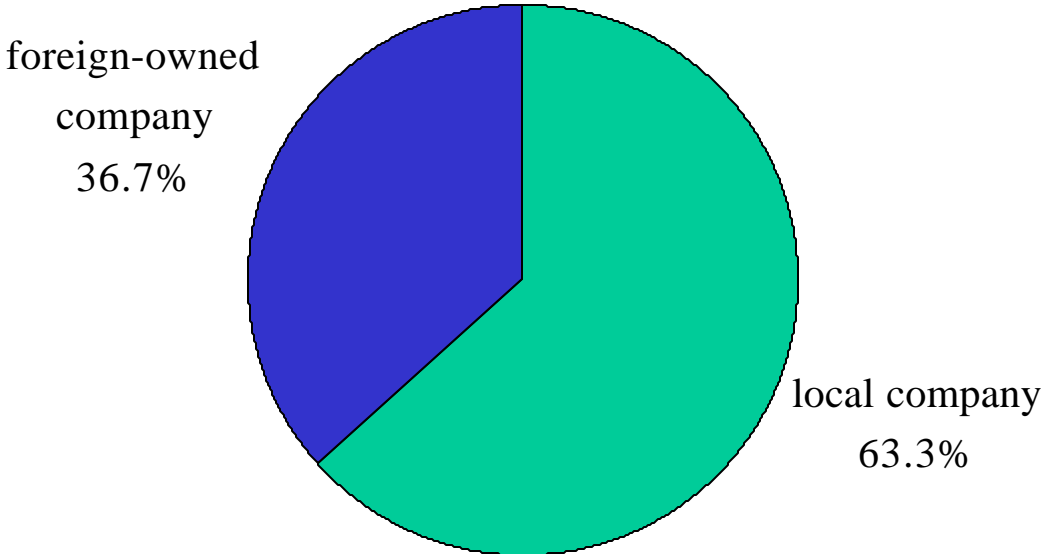
## Sources

- (1) Census of Industrial Production 1997 (*EDB* 1999)
- (2) *EDB* database; note that 4 cases could not be assigned.
- (3) *EDB/NUS-CMIT* National Innovation Survey Manufacturing; note that 3 cases could not be assigned.

## RESPONSES BY MANUFACTURING CLUSTER



# RESPONSES BY OWNERSHIP OF COMPANY



# DEFINING INNOVATION

## I. INNOVATING COMPANIES

- Following the OECD's 'Oslo Manual'<sup>1</sup>, companies are regarded as **innovating** if they have introduced to the market at least one of the following during the last three years:
  - a product new to the business or a substantially improved product (*product innovation*);
  - a new or substantially improved production process through new equipment or re-engineering (*process innovation*).

1) OECD, 1997: Oslo Manual. Proposed Guidelines for Collecting and Interpreting Technological Innovation Data. 2nd edition. Paris.

## DEFINING INNOVATION

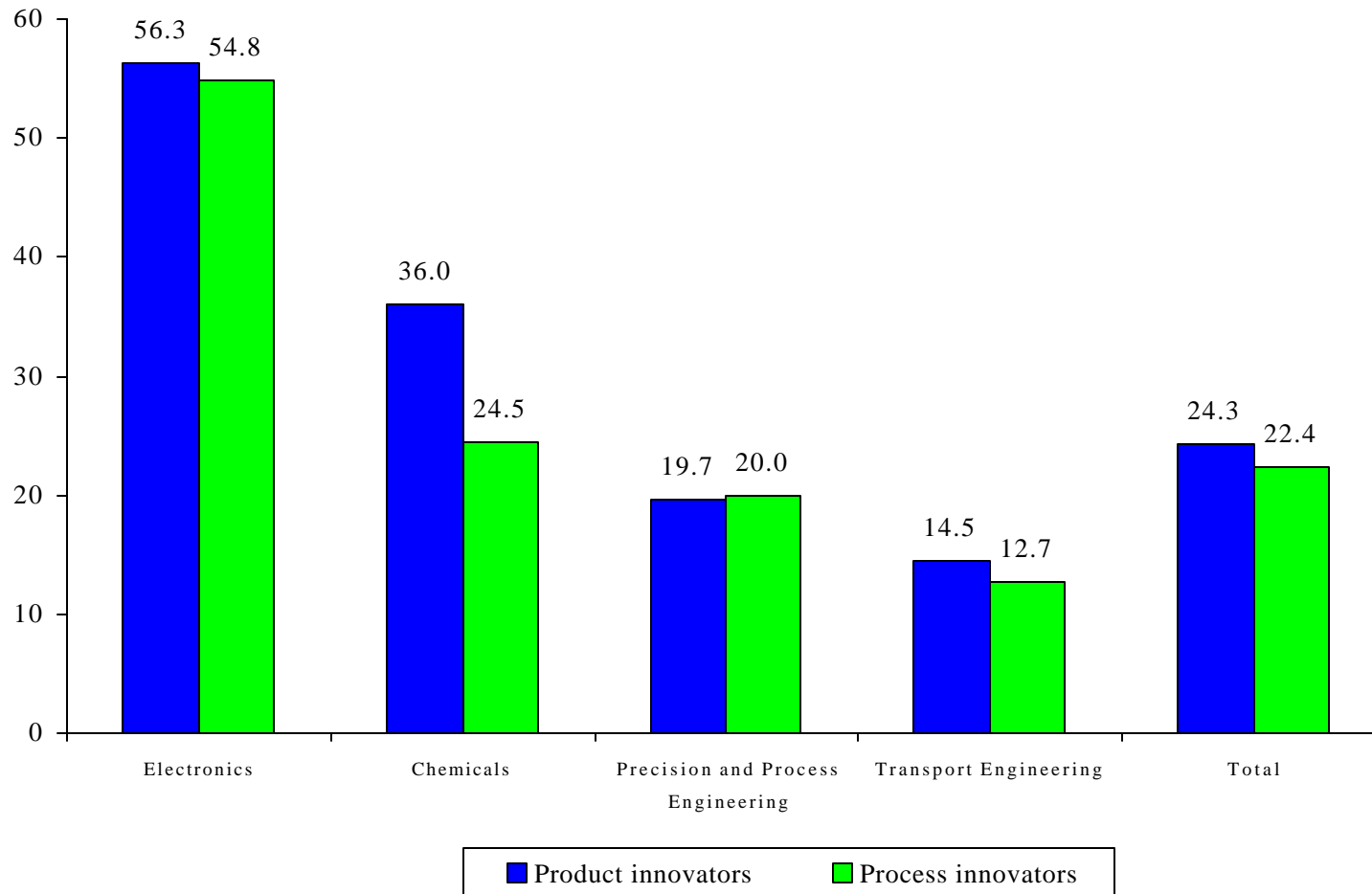
### II. INNOVATIVE COMPANIES

- Since the above definition does not tell anything about the commercial success of an innovation, a second distinction between innovative and non-innovative companies has been used widely throughout this report.
- A company is classified as **innovative** if it meets at least one of the following criteria:
  - 25% of sales accounted for by new or improved products introduced over the last three years;
  - 25% of production volume accounted for by new or improved processes introduced over the last three years.

## Overall Innovation Propensity

- Overall, 31.6% of manufacturing firms in Singapore were innovating, while a smaller percentage (15.2%) were innovative.
- The electronics cluster has the highest proportion of product and process innovators.
- More than half of the companies in the electronics cluster are innovators (56.3% for product innovation and 54.8% for process innovation).
- The transport engineering cluster has the lowest proportion of innovators. Only 14.5% of the companies within this cluster are product innovators and 12.7% are process innovators.

# PERCENTAGE OF INNOVATORS WITHIN AGGREGATE BRANCHES



## INNOVATION AND SALES GROWTH

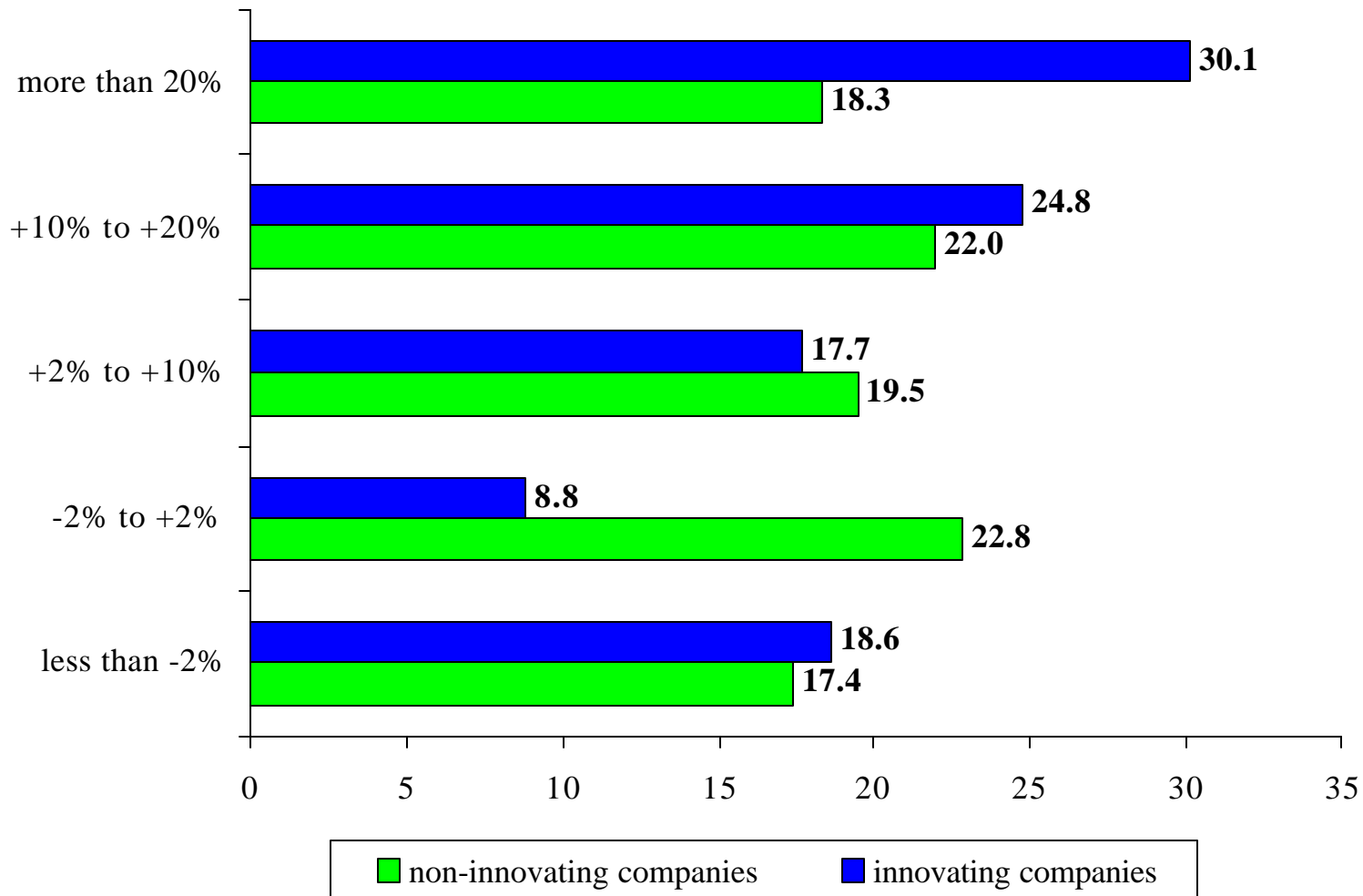
- Despite the economic crisis, companies' sales grew by 9.1% on average over 1996 to 1999
- Our data suggests that sales growth has been fastest in the electronics cluster, averaging 21% per year, followed by the chemicals sector at 17% per year. The engineering clusters reported average sales growth between 6% and 8%.
- Innovating companies grew more strongly than non-innovating companies, though this difference is not significant statistically due to high data variance.
- In contrast, innovative companies representing the successful innovators grew significantly faster than non-innovative companies, confirming the link between successful innovation and firm growth.

## AVERAGE ANNUAL SALES GROWTH

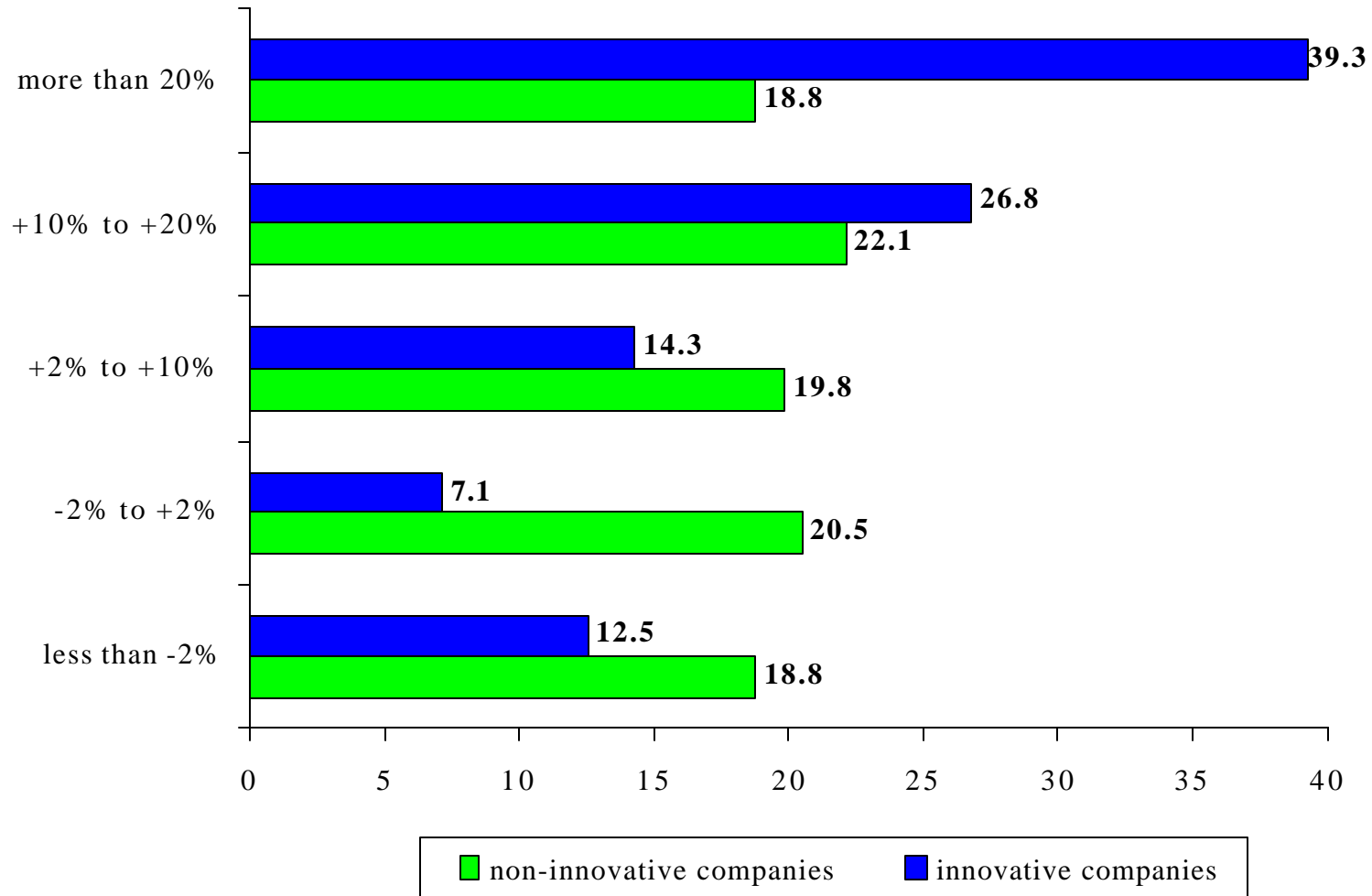
Sample subset	sales growth	
total	9.1%	
electronics	20.6%	+
chemicals	16.9%	
precision & process engineering	6.2%	
transport engineering	7.7%	
locally owned	8.7%	-
foreign owned	10.1%	
innovating	10.7%	-
non-innovating	8.4%	
innovative	15.0%	‡
non-innovative	8.0%	

- ‡ ANOVA: Difference is significant at 10% level.
- + ANOVA: Difference is significant at 5% level.
- ++ ANOVA: Difference is significant at 1% level.
- ANOVA: Difference is not significant at 5% level.

## AVERAGE ANNUAL SALES GROWTH DURING THE LAST THREE YEARS (Percentage)



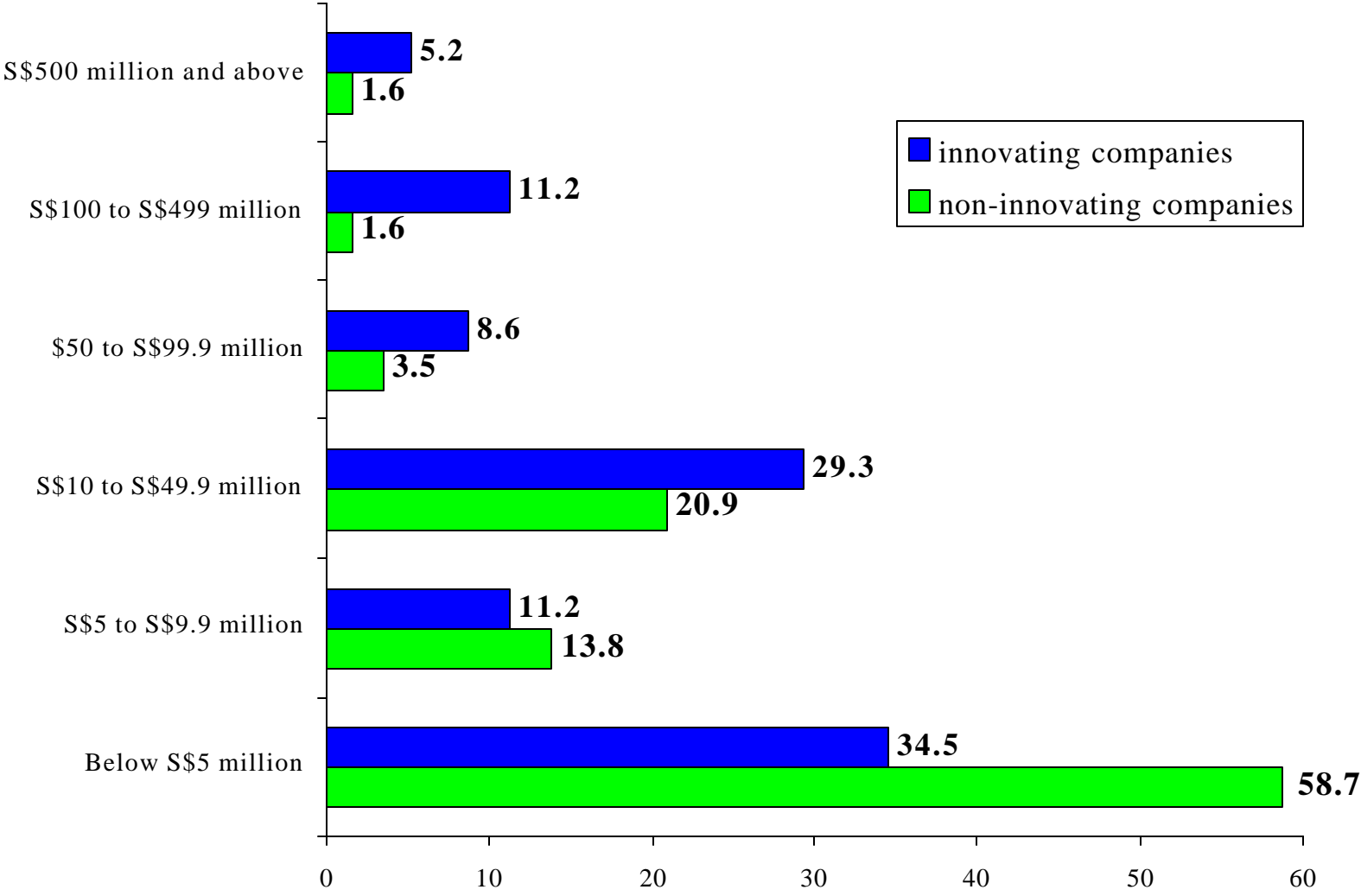
## AVERAGE ANNUAL SALES GROWTH DURING THE LAST THREE YEARS (Percentage)



## **INNOVATION AND FIRM SIZE I: SALES VOLUME**

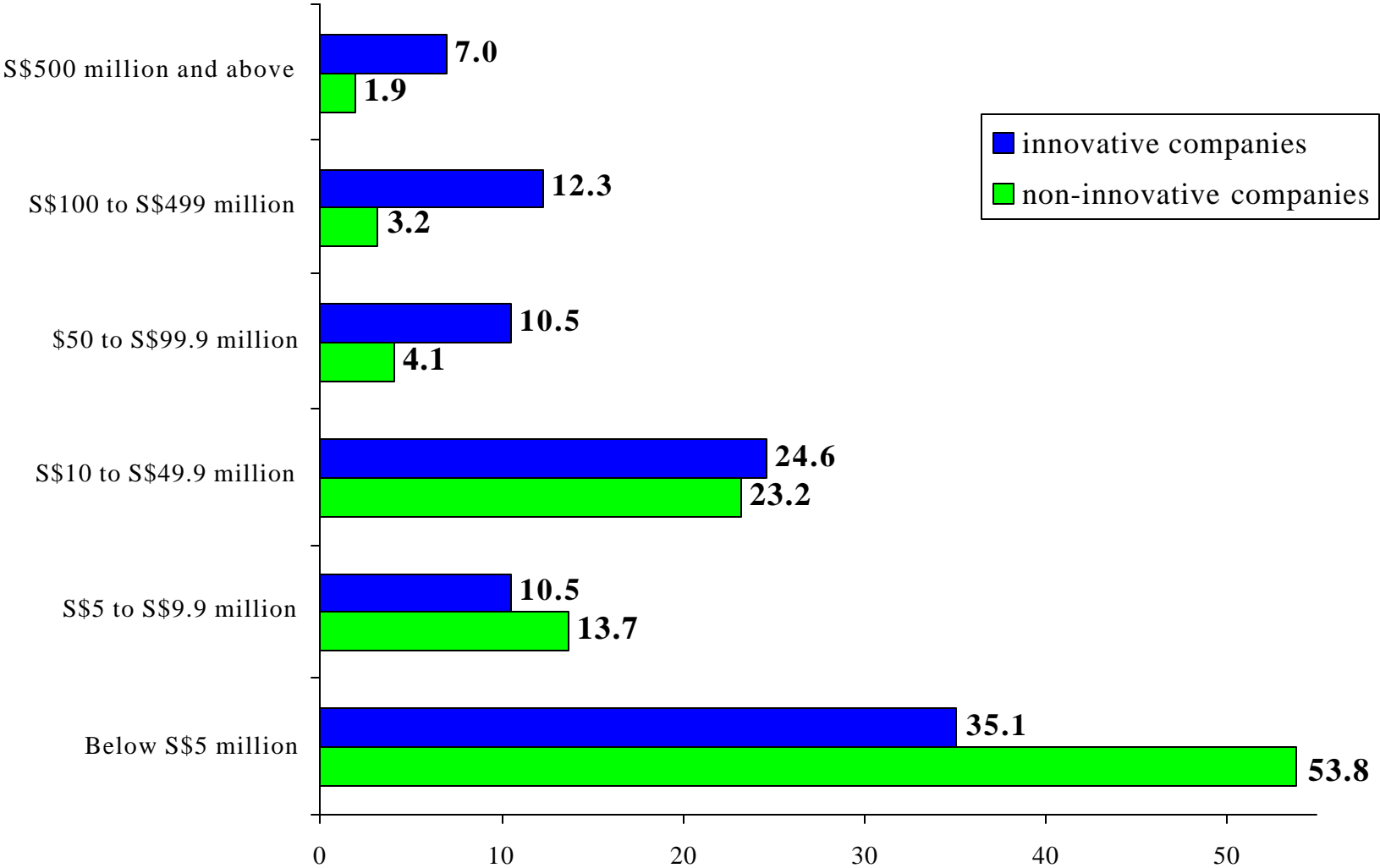
- Sales volume is positively related to innovation.
- The share of both innovating and innovative companies increases with sales volume, being above average for companies with sales of more than S\$ 10 million.
- Only about one third of innovating and innovative companies, and about one quarter of R&D performers, reported sales below S\$ 5 million, compared to well above one half of non-innovating companies

# TOTAL ANNUAL SALES FOR LATEST FISCAL YEAR (Percentage)

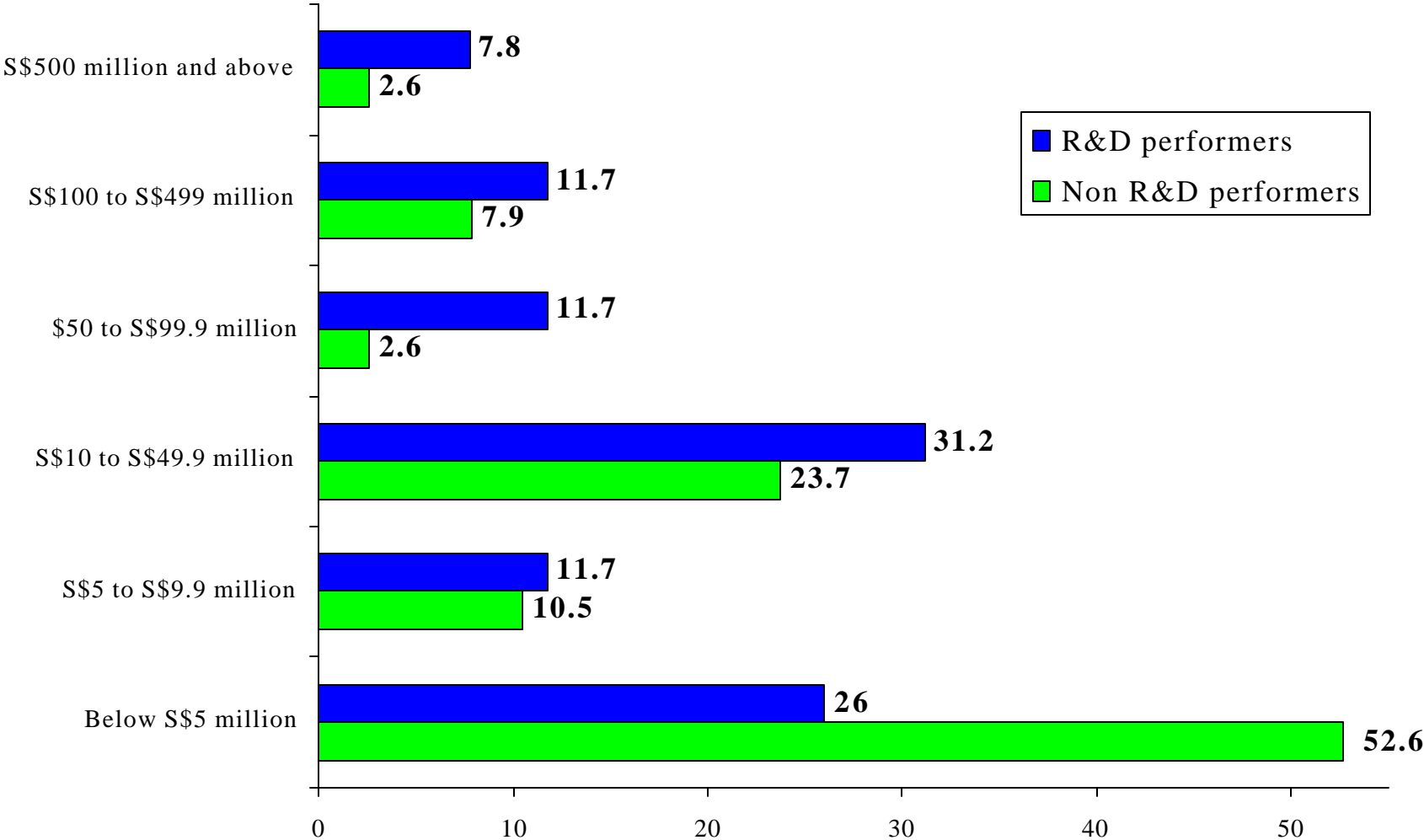


■ innovating companies  
■ non-innovating companies

# TOTAL ANNUAL SALES FOR LATEST FISCAL YEAR (Percentage)



# TOTAL ANNUAL SALES FOR LATEST FISCAL YEAR (Percentage)



## INNOVATION AND EMPLOYMENT GROWTH

- Despite the economic crisis, employment in our sample has grown by 5% from 1996 to 1999.
- Our data suggests that employment has increased the most in the electronics sector (by 6% per year), while the other clusters have all grown by 5% per year.
- These increases in employment are largely owed to local companies which have expanded their staff by 6% annually, compared by 3% for the foreign companies.
- Innovative and R&D performing companies have grown faster in terms of employment than companies not engaging in such activities. However, innovating companies have not. This confirms that new products and processes actually need to penetrate the market to benefit the labour market.

## INNOVATION AND EMPLOYMENT GROWTH

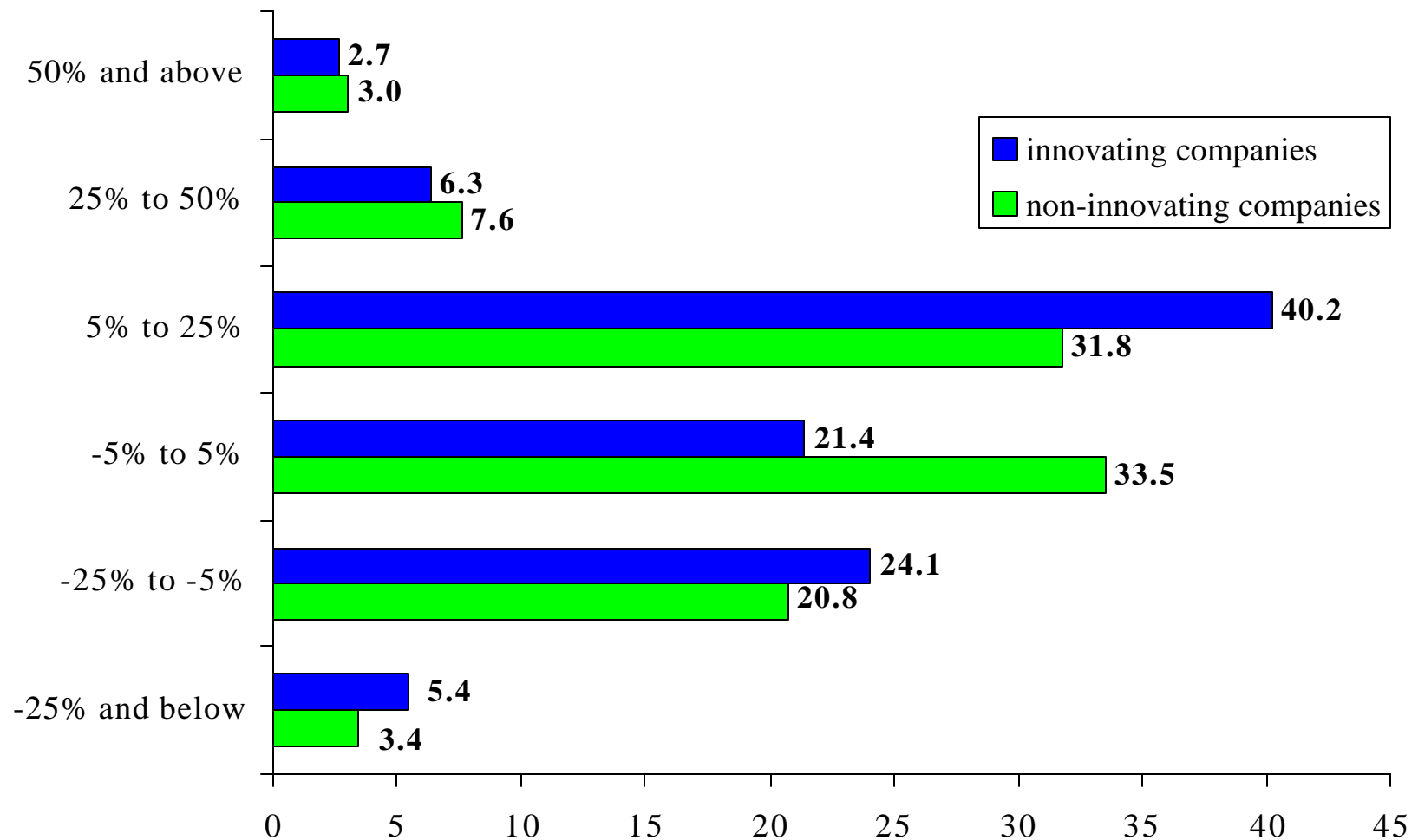
- These increases in employment are largely owed to local companies which have expanded their staff by almost 8% annually while foreign companies have actually shed some staff. The latter is due to layoffs by Japanese companies which North American and European Companies could not compensate for.
- As for sales growth, innovating, innovative and R&D performing companies have grown faster in terms of employment than companies not engaging in such activities.
- This difference is largest and statistically significant for innovative companies, confirming that new products and processes actually need to penetrate the market to benefit the labour market.

## AVERAGE ANNUAL EMPLOYMENT GROWTH

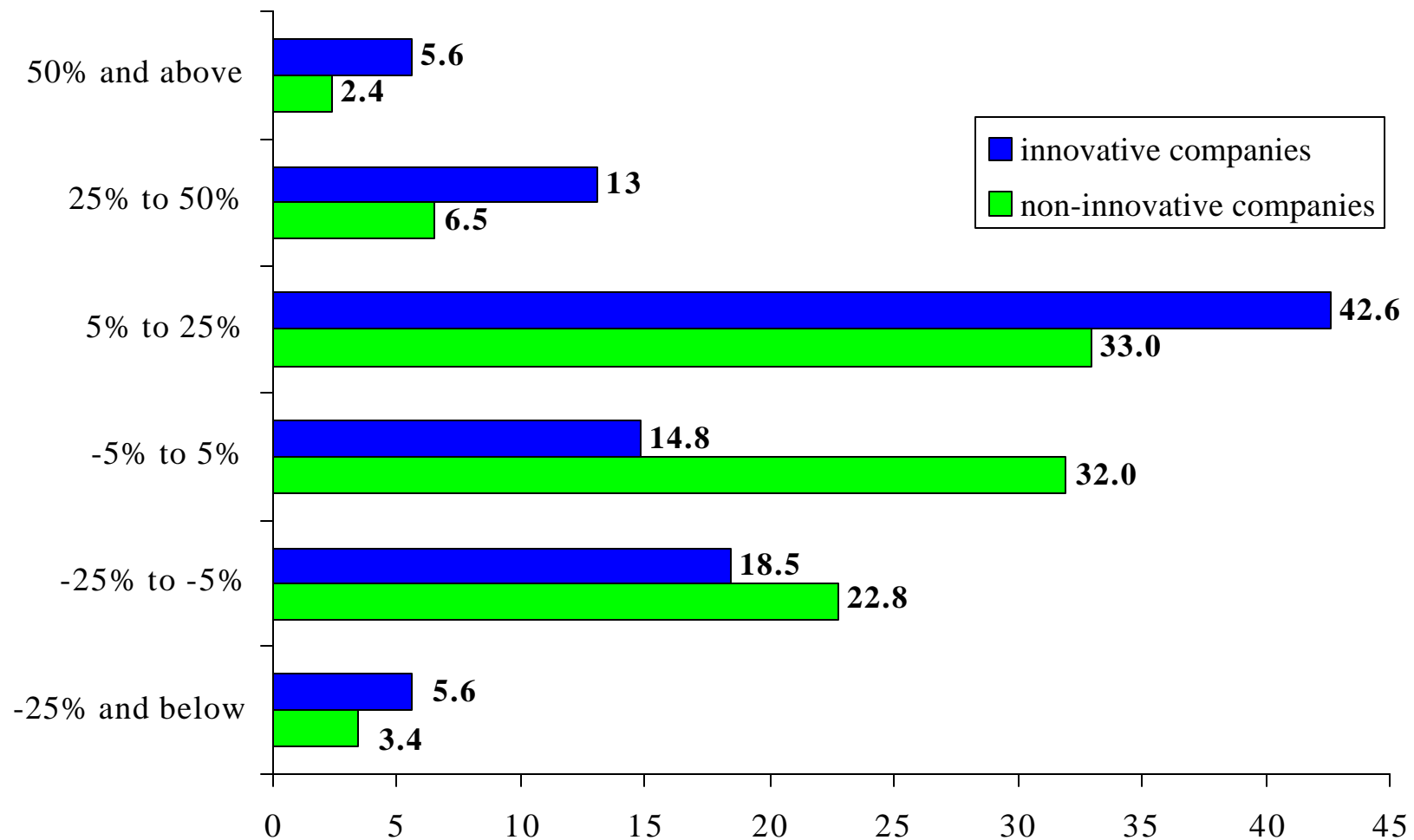
Sample subset	Employment growth	
total	5.2%	
electronics	6.3%	-
chemicals	5.4%	
precision & process engineering	5.1%	
transport engineering	5.1%	
locally owned	6.2%	-
foreign owned	3.4%	
innovating	4.3%	-
non-innovating	5.7%	
innovative	8.8%	-
non-innovative	4.6%	
R&D performers	4.8%	-
Non-R&D performers	2.7%	

- ANOVA: Difference is not significant at 5% level.

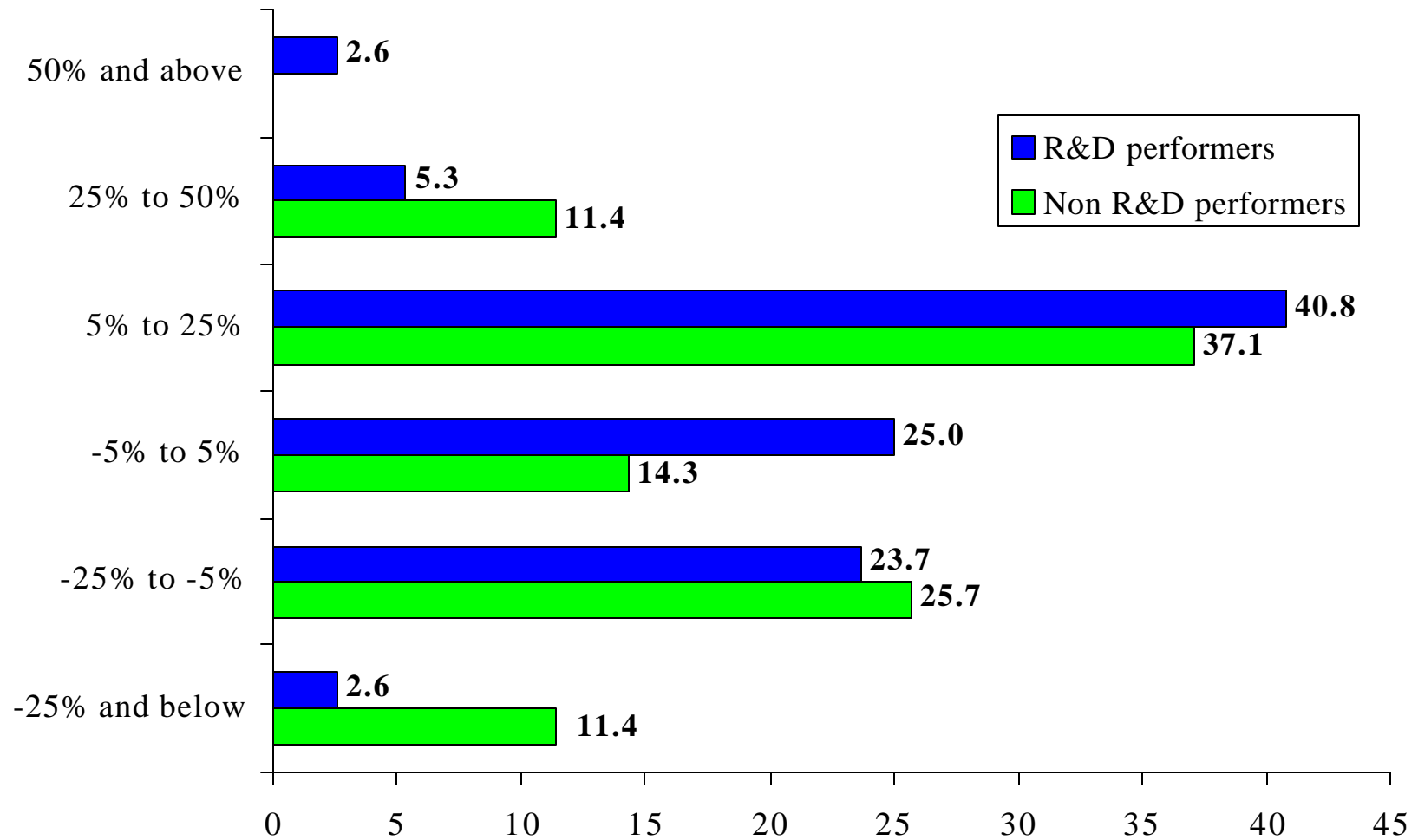
# AVERAGE ANNUAL EMPLOYMENT GROWTH, 1996-1999 INNOVATING VS NON-INNOVATING COMPANIES (Percentage)



# AVERAGE ANNUAL EMPLOYMENT GROWTH, 1996-1999 INNOVATIVE VS NON-INNOVATIVE COMPANIES (Percentage)



# AVERAGE ANNUAL EMPLOYMENT GROWTH, 1996-1999 BY R&D PERFORMANCE (Percentage)



## INNOVATION AND TRAINING

- On average, companies in our sample spend around 2.6% of their payroll on training, with values ranging from nil to 29%.
- Almost one quarter of firms do not engage in training at all. The majority of companies spend up to 5% of their payroll on training, while only 10% reported training intensities of more than 5%.
- Training intensity is highest in the electronics and chemicals clusters and below average for transport engineering firms.
- Our data suggest a clear link between innovation and training, especially between successful innovation and training: Training intensity is much higher for innovating, innovative and R&D performing companies, the distinction being particularly pronounced and statistically significant for innovative as opposed to non-innovative firms.

# TRAINING INTENSITY<sup>1</sup> FOR SELECTED CATEGORIES

Sample subset	training intensity	
total	2.56	
electronics	2.87	-
chemicals	2.82	
precision & process engineering	2.62	
transport engineering	1.92	
locally owned	2.63	-
foreign owned	2.42	
innovating	2.94	-
non-innovating	2.38	
innovative	3.67	+
non-innovative	2.36	
R&D performing	3.23	-
non-R&D performing	2.23	

- + ANOVA: Difference is significant at 5% level.
- ++ ANOVA: Difference is significant at 1% level.
- +++ ANOVA: Difference is significant at 0.1% level.
- ANOVA: Difference is not significant at 5% level.

## INNOVATION AND INTERNATIONALISATION

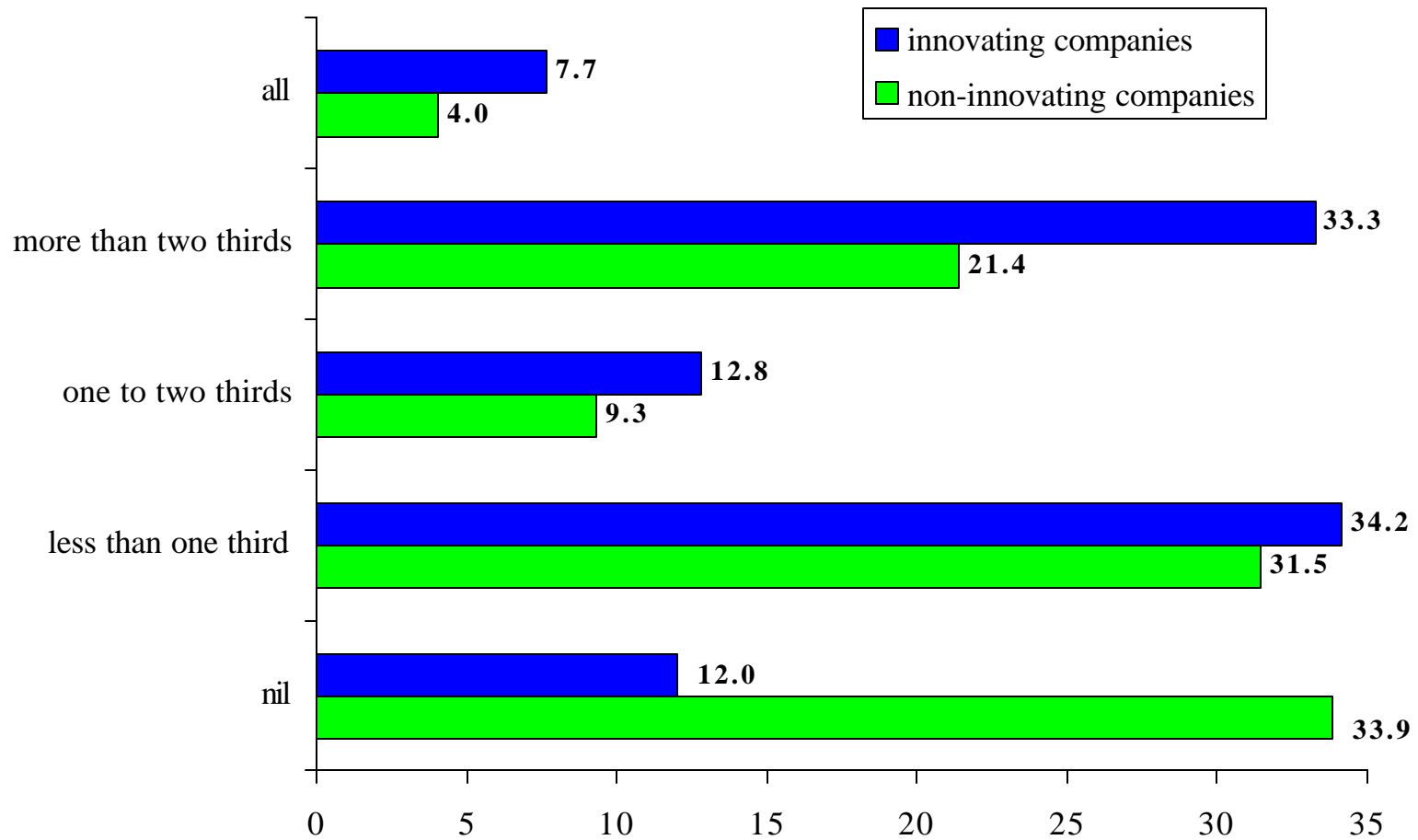
- 37% of all sales are accounted for by the domestic market, while 63% of sales are for export.
- The electronics cluster is the most internationalised sector, selling 62% of shares abroad followed by the transport engineering and chemicals sector at 44%.
- Foreign owned companies are naturally more internationalised than local firms.
- Companies engaging in innovation are more oriented towards international markets than non-innovation companies, the mean export shares for innovating, innovative and R&D performing firms being significantly higher than for non-innovation companies.

## EXPORT SHARE<sup>1</sup> AT COMPANY LEVEL FOR SELECTED CATEGORIES

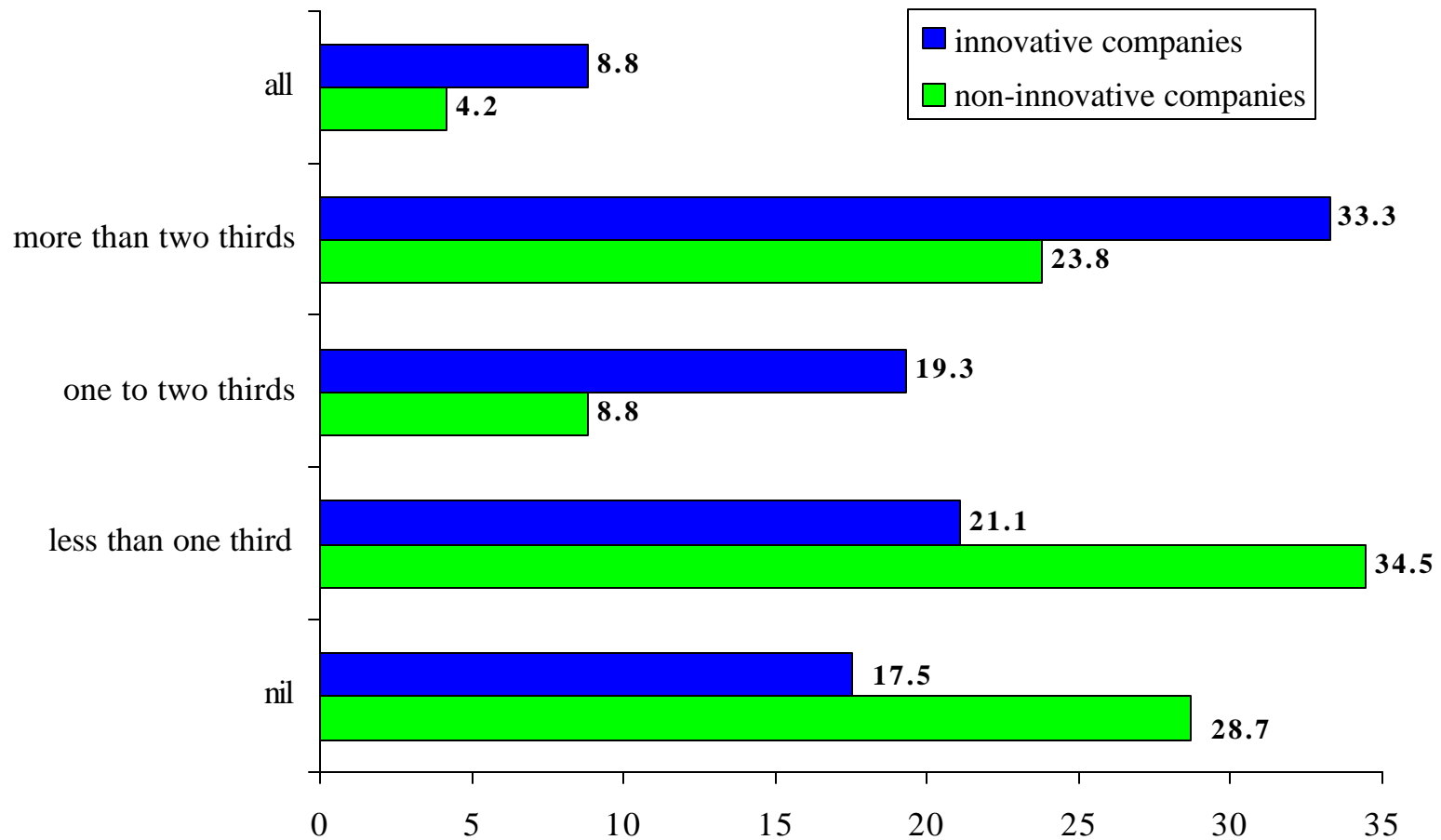
Sample subset	share of exports	
total	36.7%	
electronics	62.1%	+++
chemicals	43.5%	
precision & process engineering	30.0%	
transport engineering	44.9%	
locally owned	24.3%	+++
foreign owned	62.5%	
innovating	48.5%	+++
non-innovating	31.1%	
innovative	52.3%	+++
non-innovative	33.8%	
R&D performing	54.0%	+
non-R&D performing	38.9%	

- + ANOVA: Difference is significant at 5% level.
- ++ ANOVA: Difference is significant at 1% level.
- +++ ANOVA: Difference is significant at 0.1% level.
- ANOVA: Difference is not significant at 5% level.

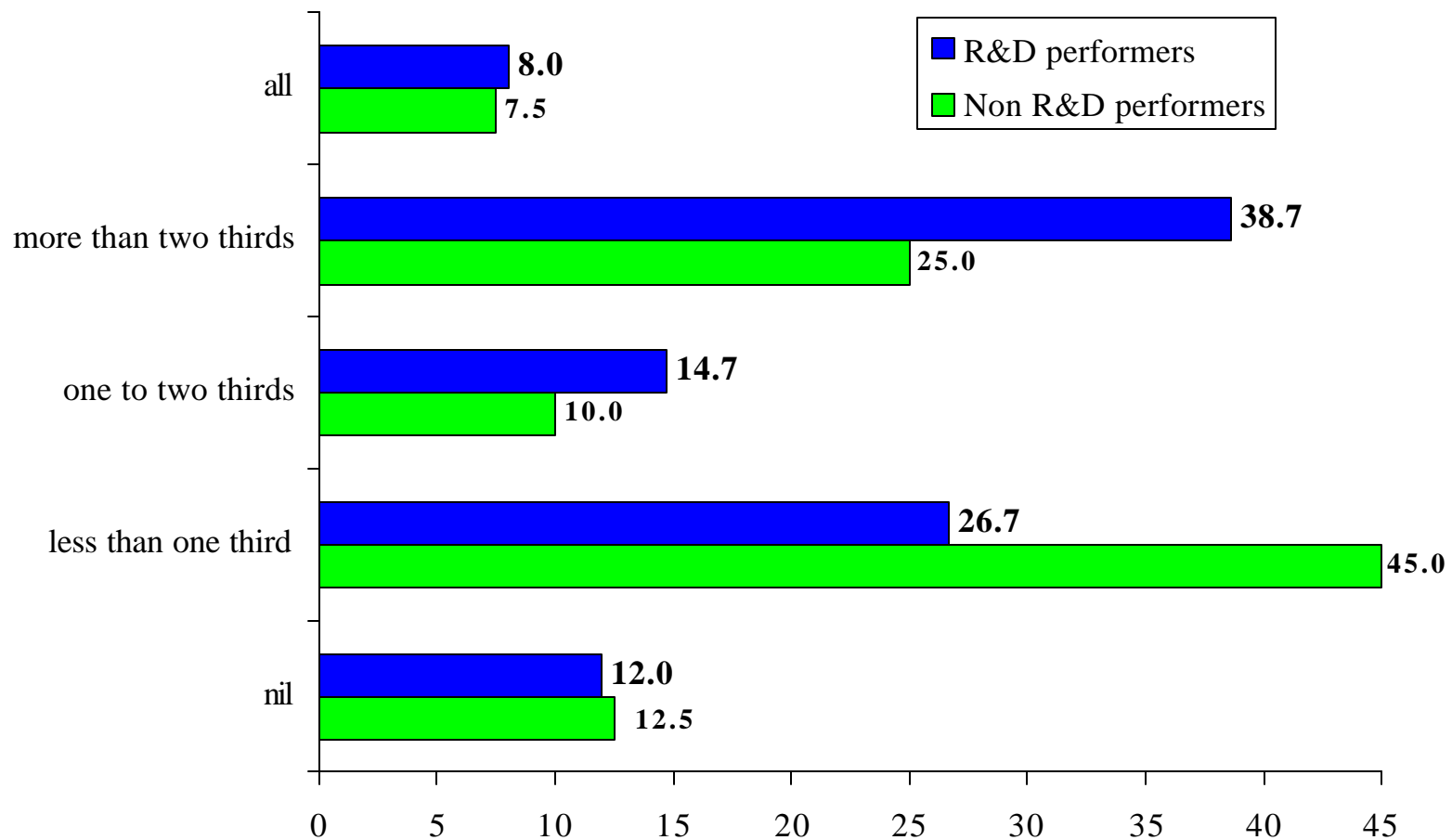
# EXPORT SHARE<sup>1</sup> AT COMPANY LEVEL INNOVATING VS NON-INNOVATING COMPANIES (Percentage)



# EXPORT SHARE<sup>1</sup> AT COMPANY LEVEL INNOVATIVE VS NON-INNOVATIVE COMPANIES (Percentage)



## EXPORT SHARE<sup>1</sup> AT COMPANY LEVEL AND R&D PERFORMANCE (Percentage)



## SPIN-OUTS

- 11.6% of companies reported to know of at least one firm started up by ex-employees during the last three years. The majority of these (89%) reported one or two spin-outs only.
- In relative terms, the precision and process engineering as well as the chemicals cluster are the most conducive breeding grounds for new ventures started by ex-employees.
- Also, foreign companies have a slightly higher spin-out rate than local firms.
- Companies engaging in innovation activity are more likely to spin out new ventures on average.

## SPIN-OUT INTENSITY<sup>1</sup> FOR SELECTED CATEGORIES

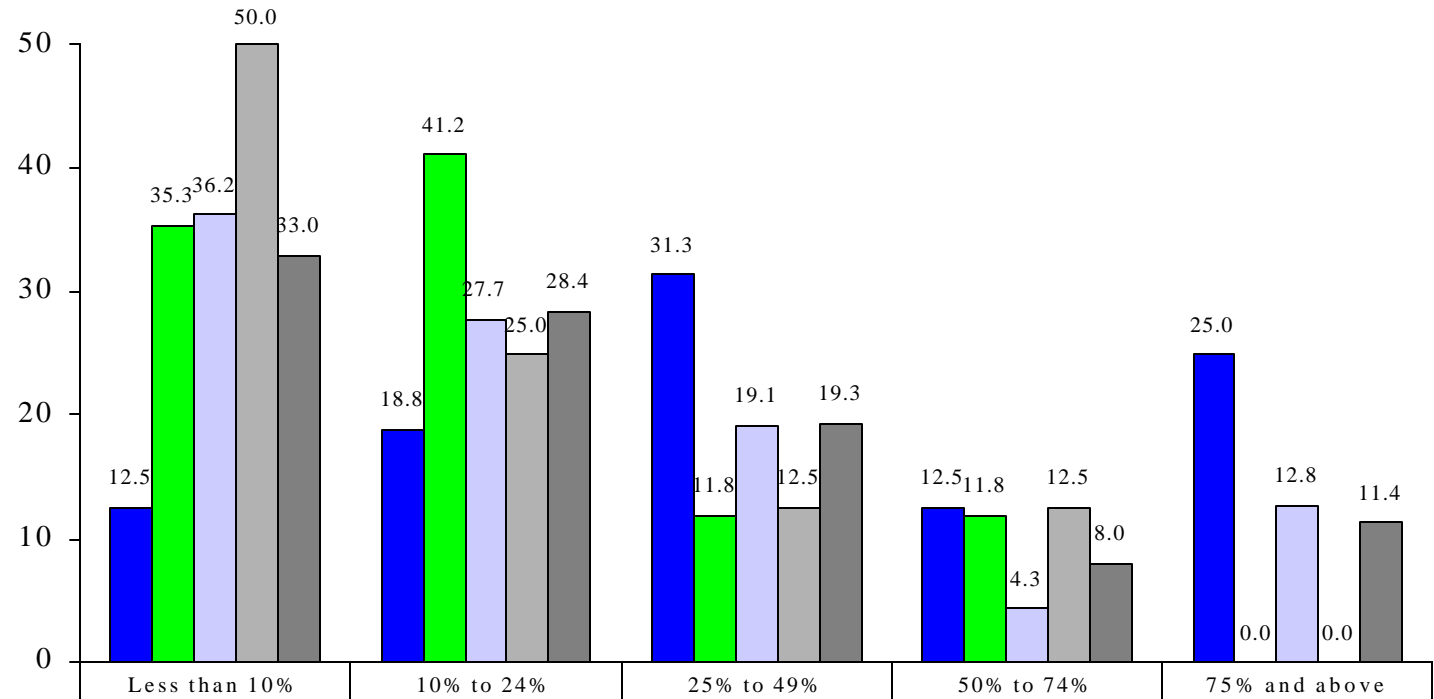
Sample subset	Percentage of companies
Total	11.6%
<u>Cluster</u>	
Electronics	6.5%
Chemicals	14.0%
Precision & process engineering	13.7%
Transport engineering	3.6%
<u>Ownership</u>	
Local	9.1%
Foreign	12.9%
<u>Number of employees</u>	
1-9	11.9%
10-19	19.0%
20-49	9.5%
50-99	8.1%
100-499	10.2%
500+	23.1%
<u>Innovation</u>	
Innovating	17.9%
Non-Innovating	8.7%
Innovative	16.1%
Non-Innovative	10.8%

1) Percentage of companies reporting start-ups by ex-employees during the last three years.

## **NEW / IMPROVED PRODUCTS AS A PERCENTAGE OF TOTAL ANNUAL SALES**

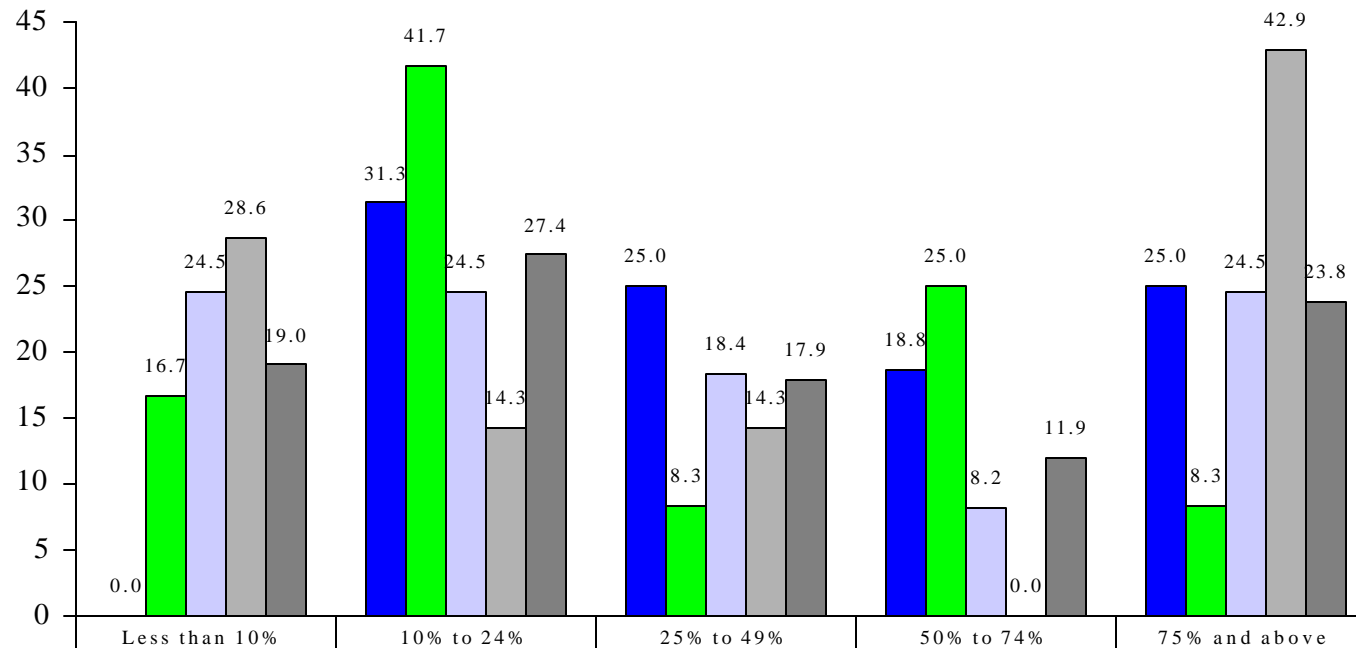
- In total, more than half of the innovating companies (61.4%) obtained less than one-quarter of their sales from new/improved products. This is also true for each of the individual clusters with the exception of the electronics cluster.
- Only 11.4% of the companies derive at least 75% of their sales from new/improved products.
- In total, close to half of the innovating companies (46.4%) produced less than 25% of their production volume using new/improved products.
- 23.8% of the companies produced at least three-quarters of their production volume using new/improved processes. The transport engineering sector stands out in this regard, with a corresponding figure of 42.9%.

# NEW / IMPROVED PRODUCTS AS A PERCENTAGE OF TOTAL ANNUAL SALES



■ Electronics	12.5	18.8	31.3	12.5	25.0
■ Chemicals	35.3	41.2	11.8	11.8	0.0
■ Precision and Process Engineering	36.2	27.7	19.1	4.3	12.8
■ Transport Engineering	50.0	25.0	12.5	12.5	0.0
■ Total	33.0	28.4	19.3	8.0	11.4

# PERCENTAGE OF PRODUCTION VOLUME USING NEW / IMPROVED PROCESS METHODS

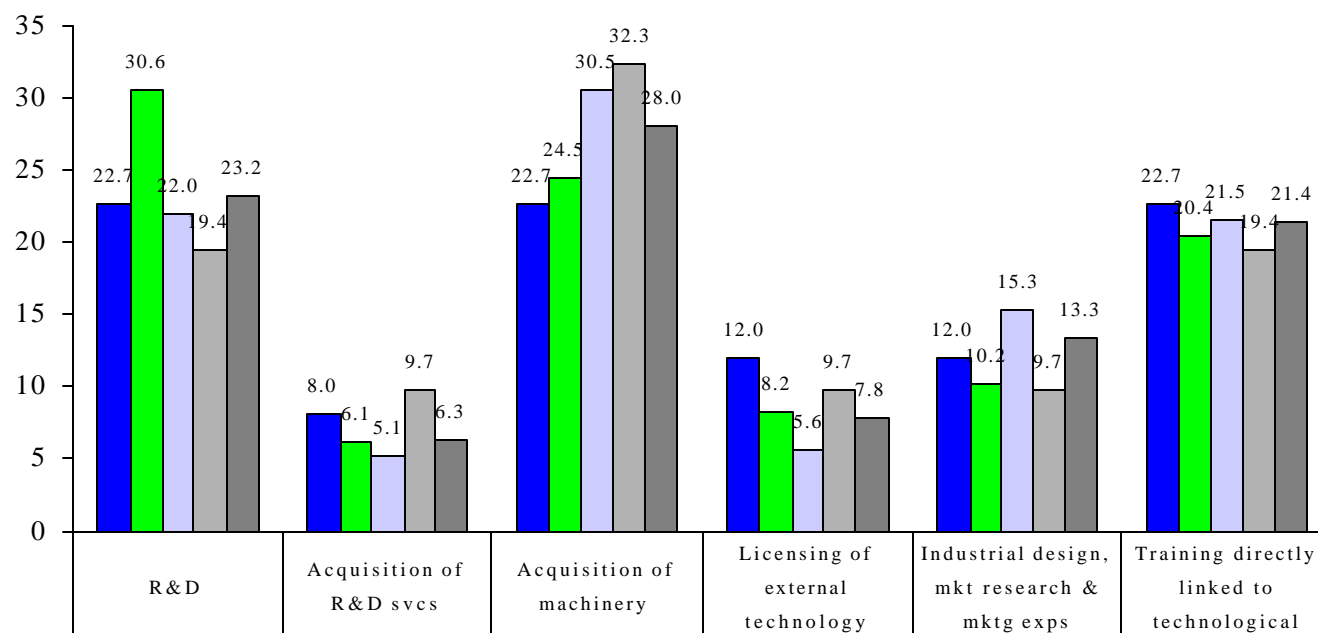


■ Electronics	0.0	31.3	25.0	18.8	25.0
■ Chemicals	16.7	41.7	8.3	25.0	8.3
■ Precision and Process Engineering	24.5	24.5	18.4	8.2	24.5
■ Transport Engineering	28.6	14.3	14.3	0.0	42.9
■ Total	19.0	27.4	17.9	11.9	23.8

## INNOVATION ACTIVITIES AND INTENSITIES

- The most common innovation activity is acquisition of machinery, equipment and software linked to product & process innovation (28.0%), followed by R&D (23.2%).
- R&D is particularly favoured in the chemicals sector (30.6%), while engineering sectors favour acquisition of machinery, equipment and software linked to product & process innovation (32.3% for transport engineering and 30.5% for precision and process engineering).
- The least common innovating activity is acquisition of R&D services, which was conducted by only 6.3% of the innovating companies.

## ACTIVITIES ENGAGED BY COMPANIES (Percentage)



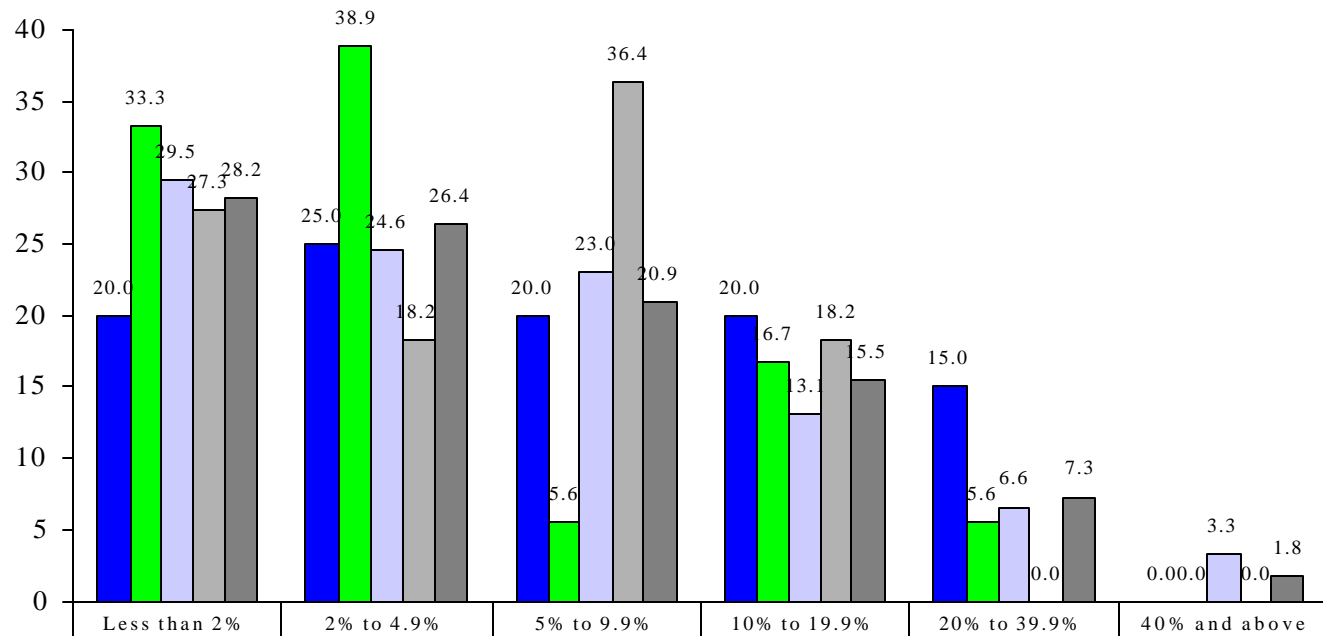
■ Electronics	22.7	8.0	22.7	12.0	12.0	22.7
■ Chemicals	30.6	6.1	24.5	8.2	10.2	20.4
■ Precision and Process Engineering	22.0	5.1	30.5	5.6	15.3	21.5
■ Transport Engineering	19.4	9.7	32.3	9.7	9.7	19.4
■ Total	23.2	6.3	28.0	7.8	13.3	21.4

## INNOVATION AND R&D INTENSITIES AMONG INNOVATING COMPANIES

- The majority of innovators (75.5%) spend less than 10% of their total sales revenue on innovation
- Conversely, only 1.8% of the innovators had an innovation intensity of 40% or more; all of these companies were found in the precision and process engineering sector<sup>1</sup>
- Similarly, more than 80% of the innovators spent less than 5% of their sales revenue on R&D activities.
- The 4.2% of innovating companies who spent at least one-fifth of their revenue on R&D were in the electronics and precision and process engineering sectors.

<sup>1</sup> One chemicals company in our sample also reported an innovation intensity of 40% or more, but it does not appear in the analysis because the weight ascribed to it was relatively small

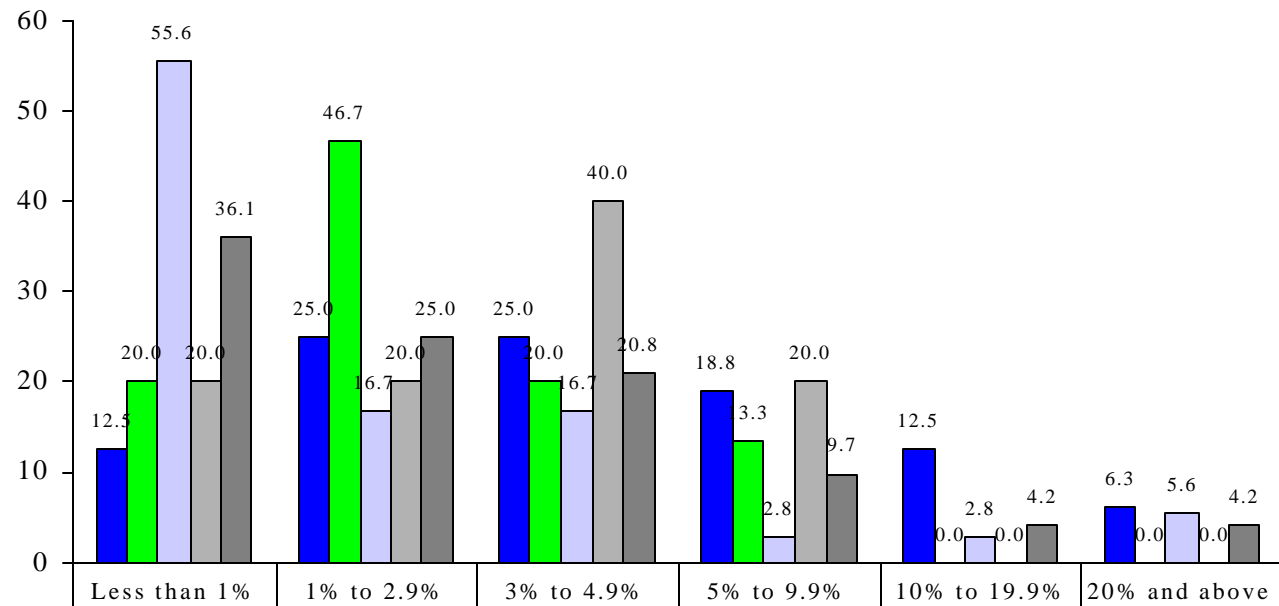
# INNOVATION INTENSITY<sup>1</sup>



■ Electronics	20.0	25.0	20.0	20.0	15.0	0.0
■ Chemicals	33.3	38.9	5.6	16.7	5.6	0.0
■ Precision and Process Engineering	29.5	24.6	23.0	13.1	6.6	3.3
■ Transport Engineering	27.3	18.2	36.4	18.2	0.0	0.0
■ Total	28.2	26.4	20.9	15.5	7.3	1.8

<sup>1</sup> Total expenditure on innovation as a percentage of total sales

# R&D INTENSITY<sup>1</sup>



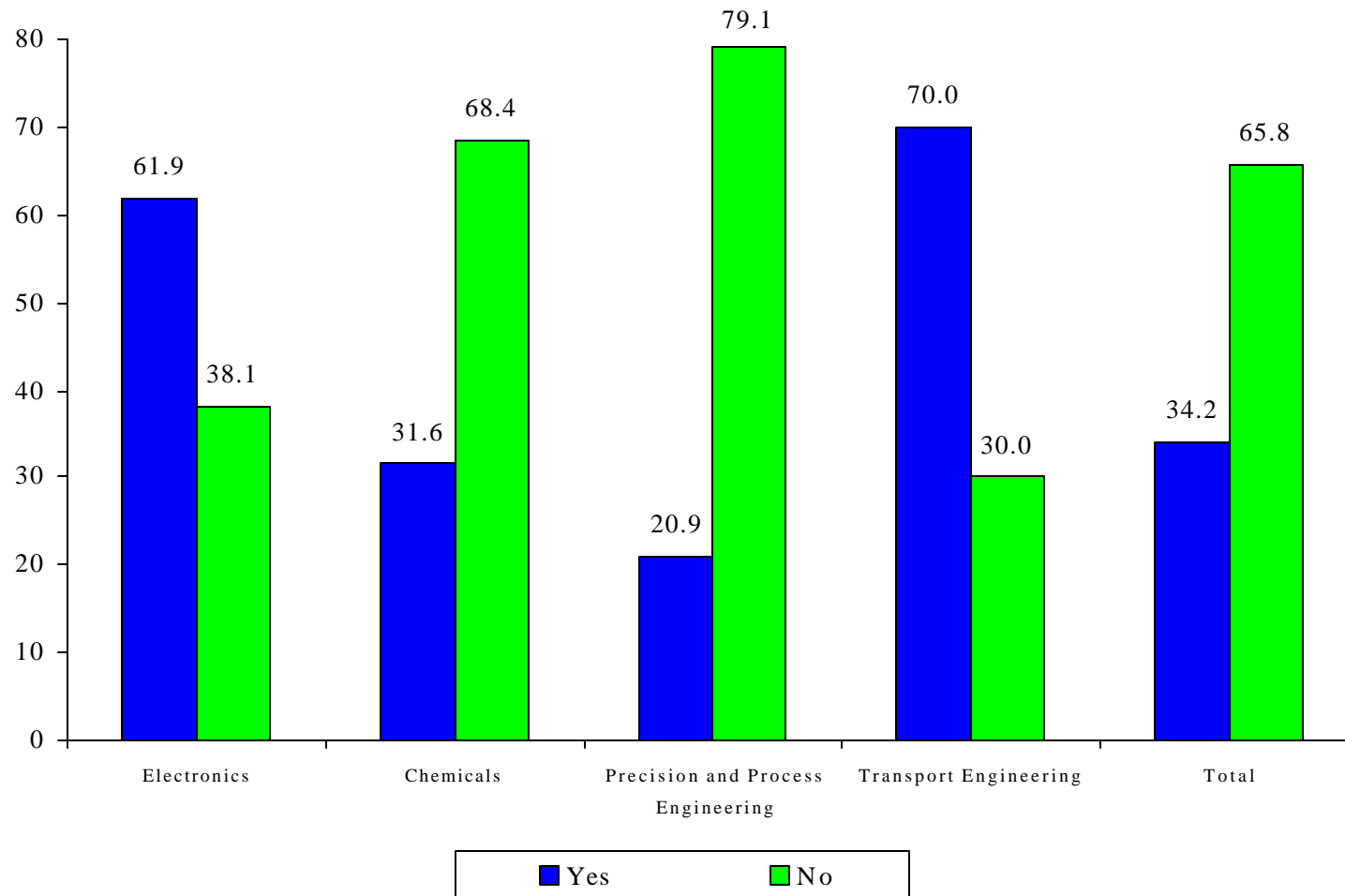
	Less than 1%	1% to 2.9%	3% to 4.9%	5% to 9.9%	10% to 19.9%	20% and above
■ Electronics	12.5	25.0	25.0	18.8	12.5	6.3
■ Chemicals	20.0	46.7	20.0	13.3	0.0	0.0
■ Precision and Process Engineering	55.6	16.7	16.7	2.8	2.8	5.6
■ Transport Engineering	20.0	20.0	40.0	20.0	0.0	0.0
■ Total	36.1	25.0	20.8	9.7	4.2	4.2

<sup>1</sup> R&D expenditure as a percentage of total sales

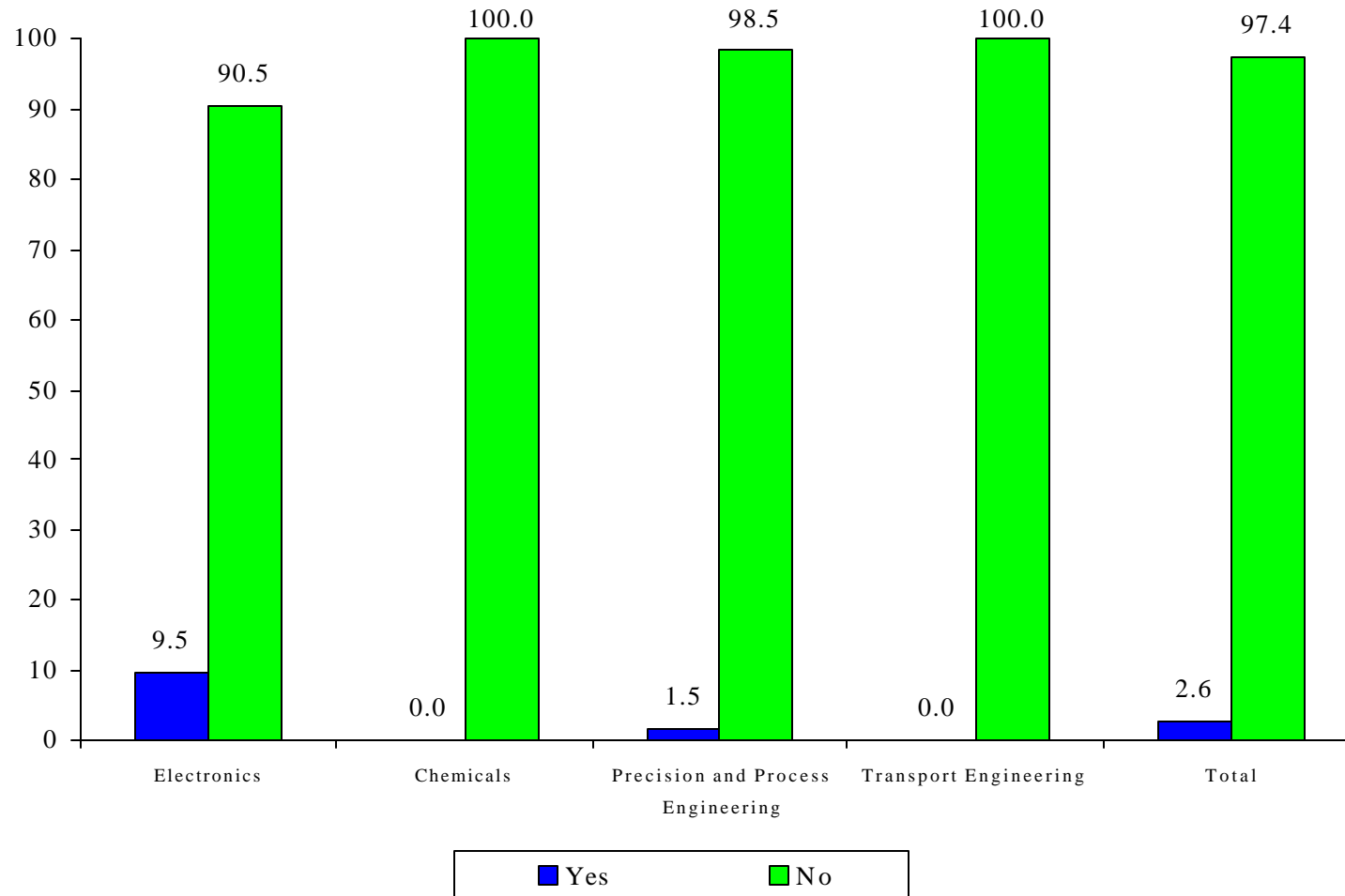
## **FINANCIAL SUPPORT OVER THE LAST 3 YEARS**

- About one-third (34.2%) of the innovating companies received government assistance or support in their innovation activities over the last 3 years.
- Innovators in the transport engineering and electronics clusters report a higher than average rate of government assistance, 70.0% and 61.9% respectively
- The overwhelming majority of the innovators (97.4%) have not receive any venture capital or business angel investment over the last 3 years.

## GOVERNMENT ASSISTANCE / SUPPORT FOR INNOVATION PROJECTS (Percentage)



## VENTURE CAPITAL OR BUSINESS ANGEL INVESTMENT (Percentage)

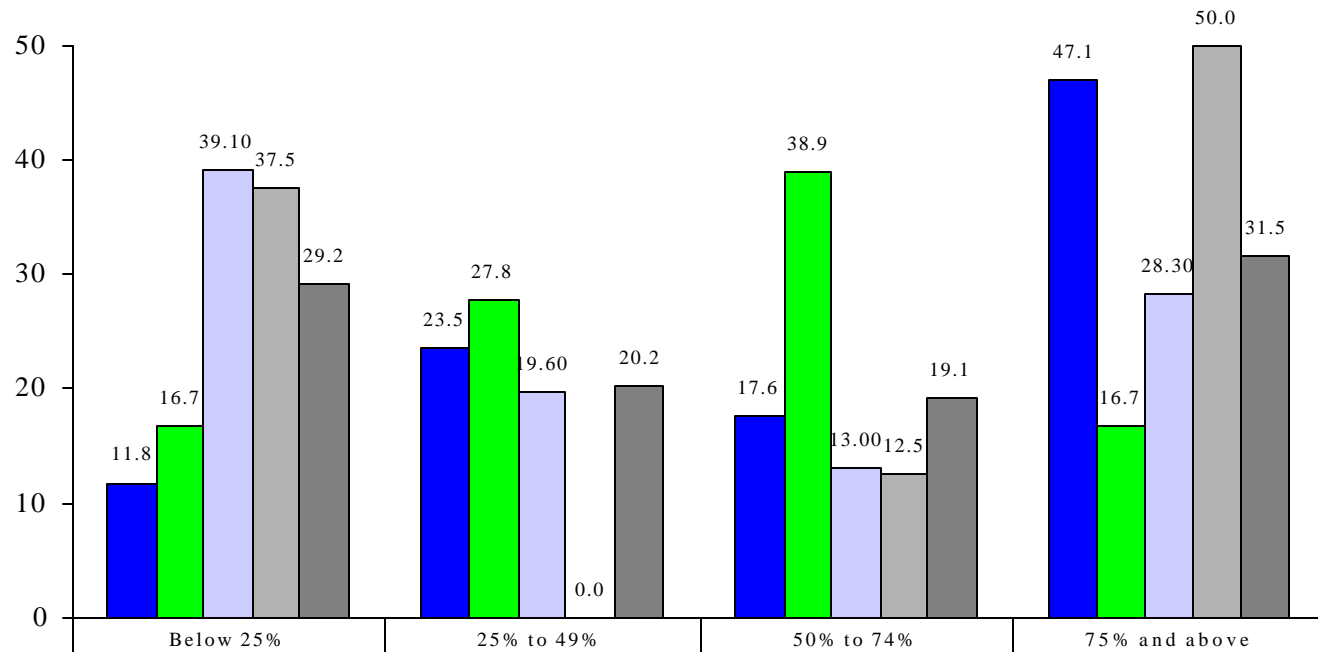


<sup>1</sup> One chemicals company in our sample also reported an innovation intensity of 40% or more, but it does not appear in the analysis because the weight ascribed to it was small

## **% OF NEW PRODUCTS INTRODUCED SUCCESSFUL COMMERCIALY (%)**

- Less than one-third of the companies (31.5%) had at least three-quarters of their new products introduced over the last 3 years, commercially successful.
- The transport engineering and electronics sectors have been particularly successful, with a near majority of their companies having at least half of their new products achieving commercial success.
- Innovators in the precision and process engineering sector have been relatively unsuccessful, with 39.1% having a commercial success rate of less than 25% for their new products. Nevertheless, over one-quarter of the innovators in this sector also had at least three-quarters of their new products achieving commercial success

# COMMERCIAL SUCCESS OF NEW PRODUCTS INTRODUCED <sup>1</sup> (Percentage)



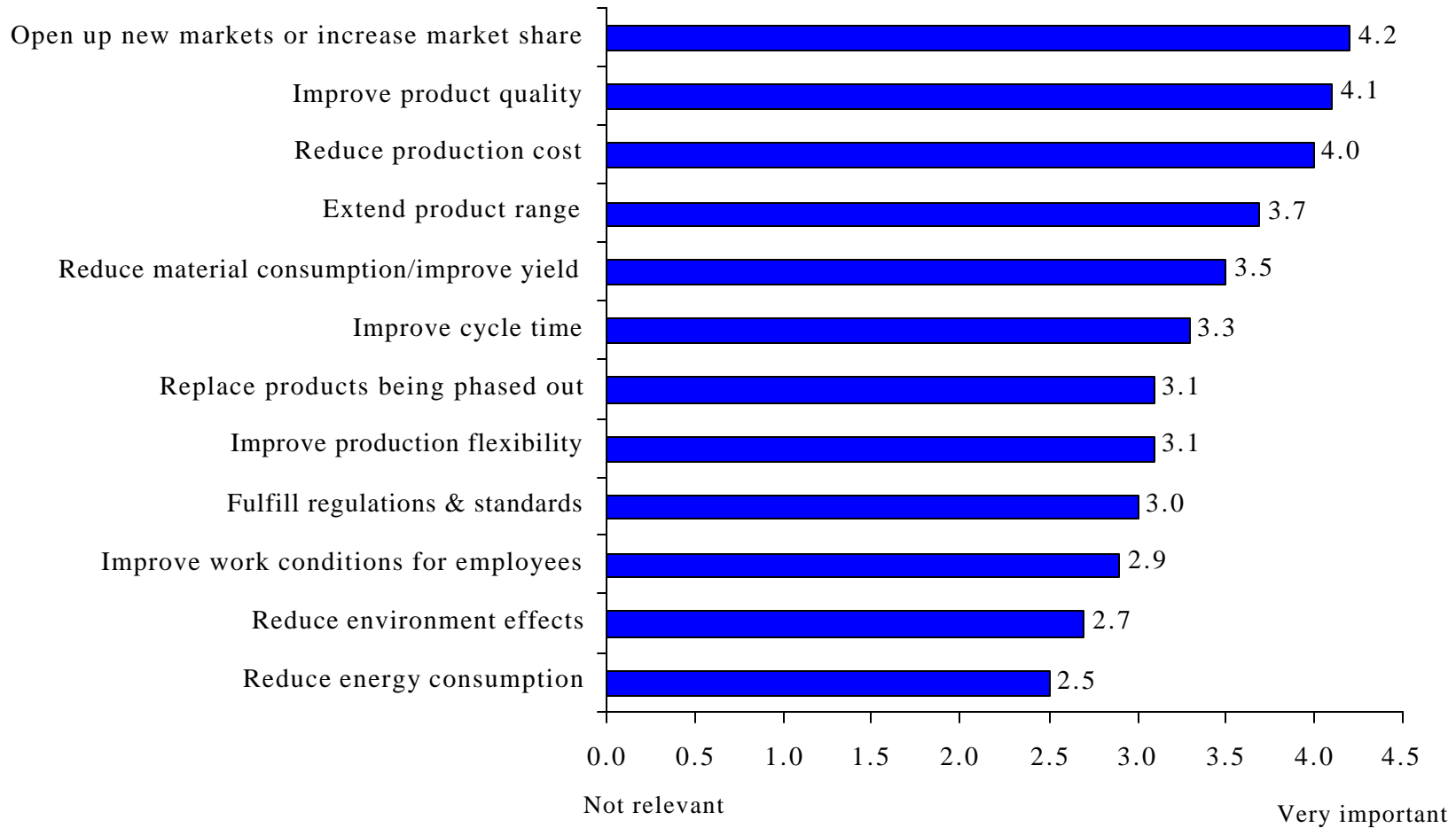
	Below 25%	25% to 49%	50% to 74%	75% and above
■ Electronics	11.8	23.5	17.6	47.1
■ Chemicals	16.7	27.8	38.9	16.7
■ Precision and Process Engineering	39.1	19.6	13.0	28.3
■ Transport Engineering	37.5	0.0	12.5	50.0
■ Total	29.2	20.2	19.1	31.5

<sup>1</sup> Percentage of new products introduced which were commercially successful

## **IMPORTANT OBJECTIVES FOR UNDERTAKING INNOVATION PROJECTS**

- Among all other factors, opening up new markets or increase market share, improving product quality and reducing production cost were ranked the most important factors.
- Environmental concerns are not major drivers for innovation. Reducing environment effects and energy consumption were rated as the least important factors.

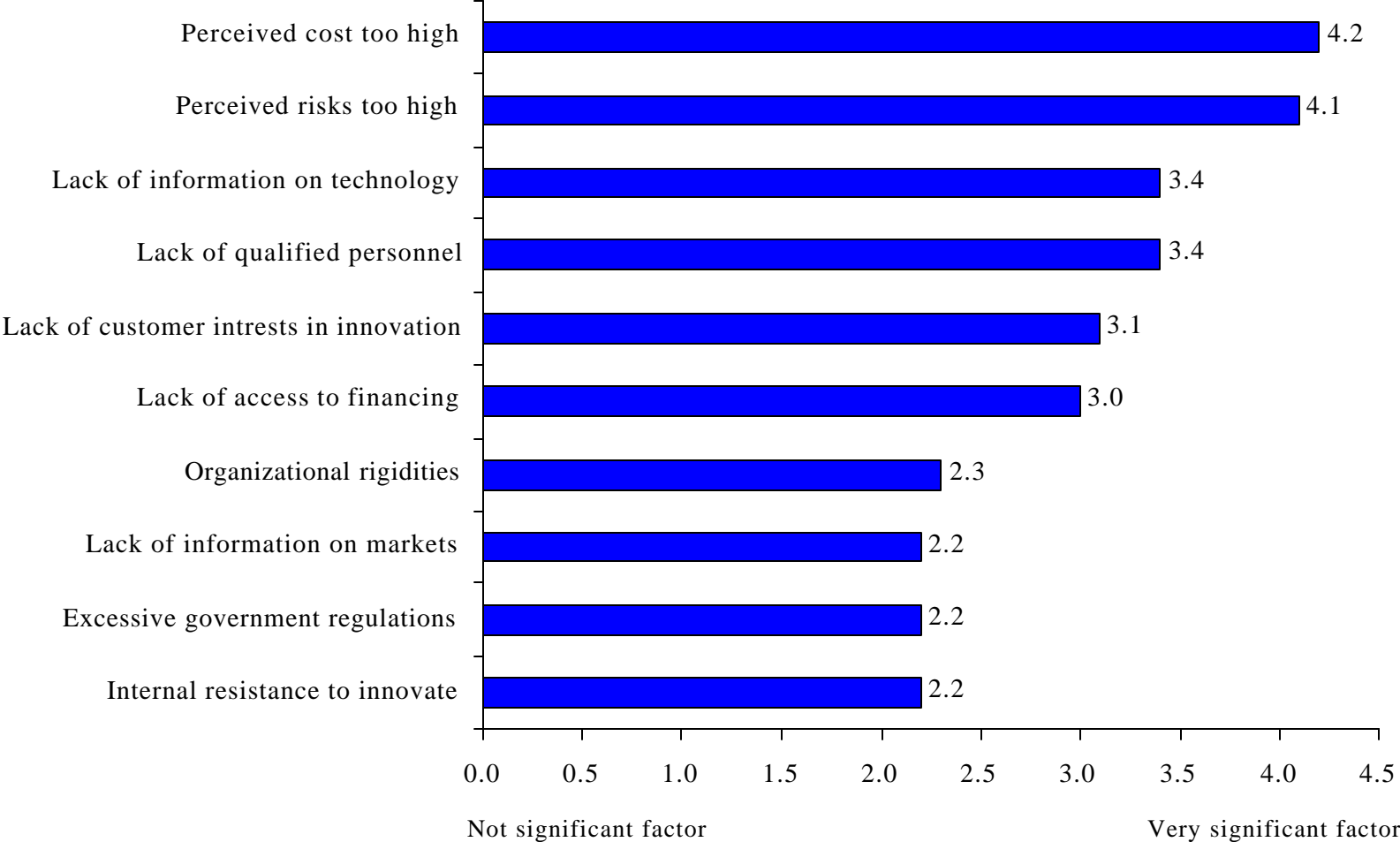
# IMPORTANT OBJECTIVES FOR UNDERTAKING INNOVATION PROJECTS (Mean)



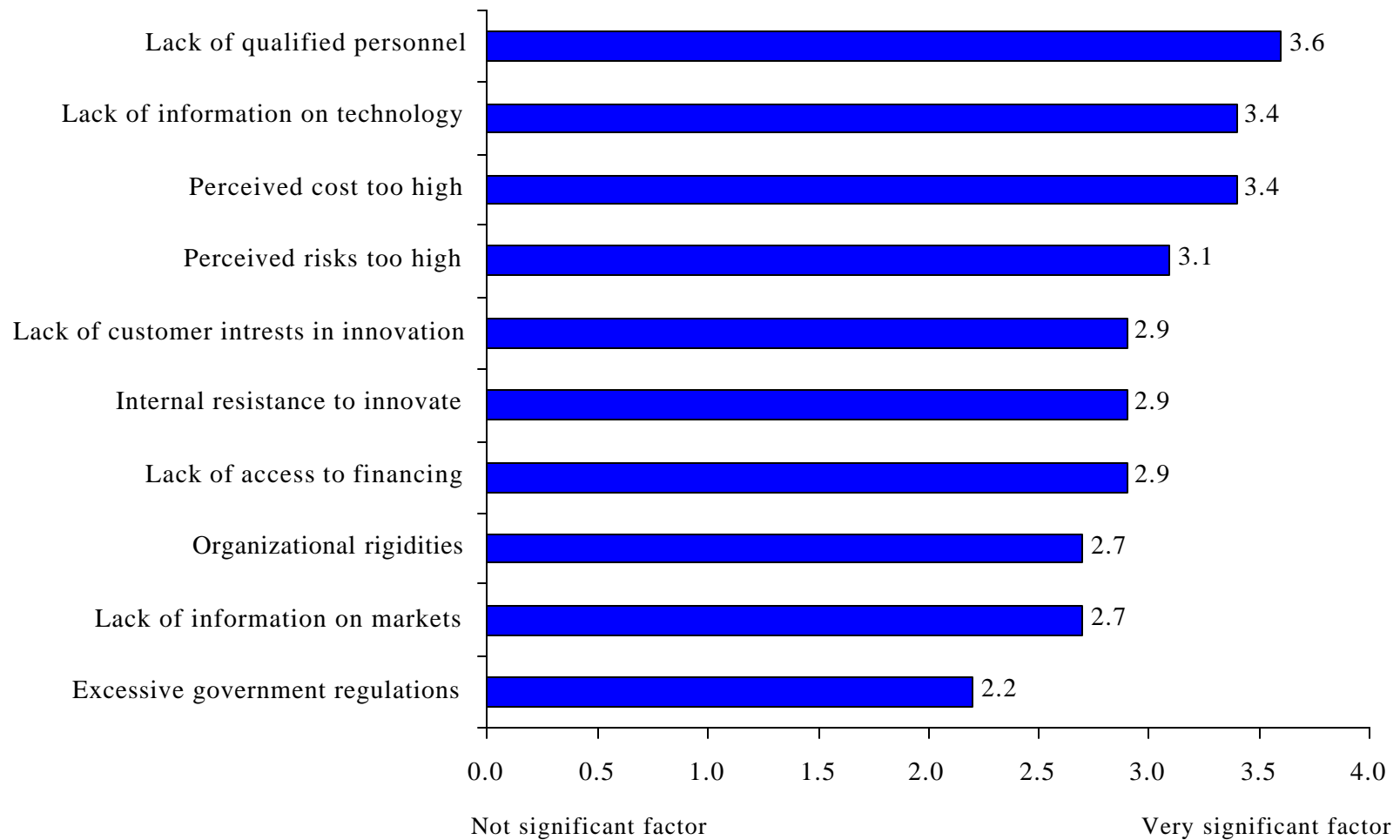
## **FACTORS AFFECTING PROJECTS NOT EVEN STARTED, SERIOUSLY DELAYED OR TERMINATED**

- Generally, the four most significant factors hampering innovation projects are excessive costs and risk, inadequate information on information technology, and a lack of qualified manpower
- For projects that either did not start, or were terminated, excessive cost was reported as the most significant factor. By contrast, a lack of qualified personnel was the biggest factor in delayed projects.
- Excessive government regulations and organizational rigidities were less significant factors.

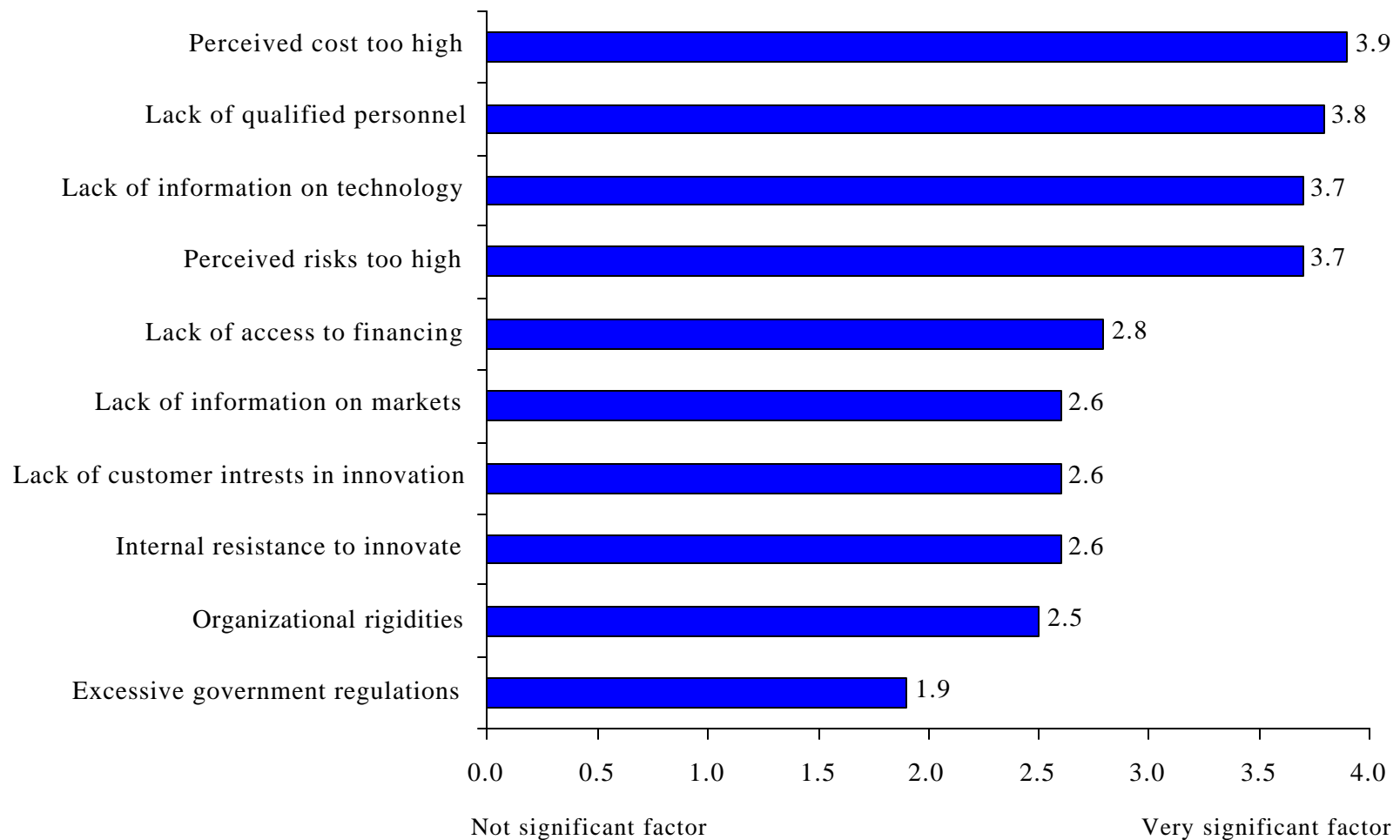
# PROBLEMS IN INNOVATION PROJECTS THAT DID NOT EVEN START (Mean)



# PROBLEMS IN INNOVATION PROJECTS THAT WERE SERIOUSLY DELAYED (Mean)



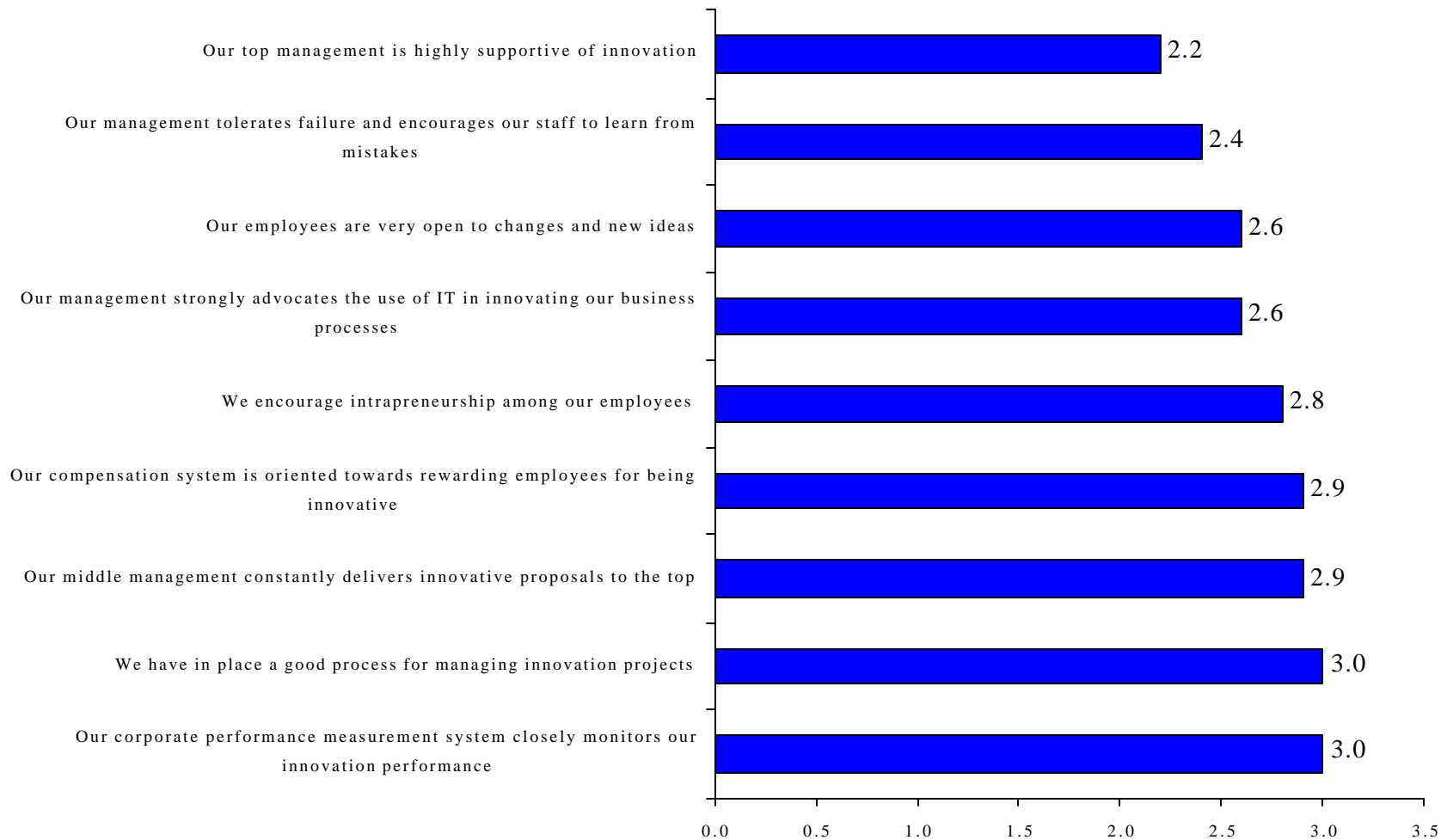
# PROBLEMS IN INNOVATION PROJECTS THAT WERE TERMINATED (Mean)



## INTERNAL ENVIRONMENT FOR INNOVATION

- Asked to comment on nine statements relating to their company's internal environment for innovation, respondents were most supportive of the statement "Our top management is highly supportive of innovation", followed by "Our management tolerates failure and encourages our staff to learn from mistakes".
- Generally, statements on individuals' attitudes achieved higher levels of agreement while more 'systemic' or organisational aspects such as compensation systems, process management, cross-hierarchical information flows and corporate performance measurement systems rank at the bottom.

# INTERNAL ENVIRONMENT FOR INNOVATION (Mean Scores)



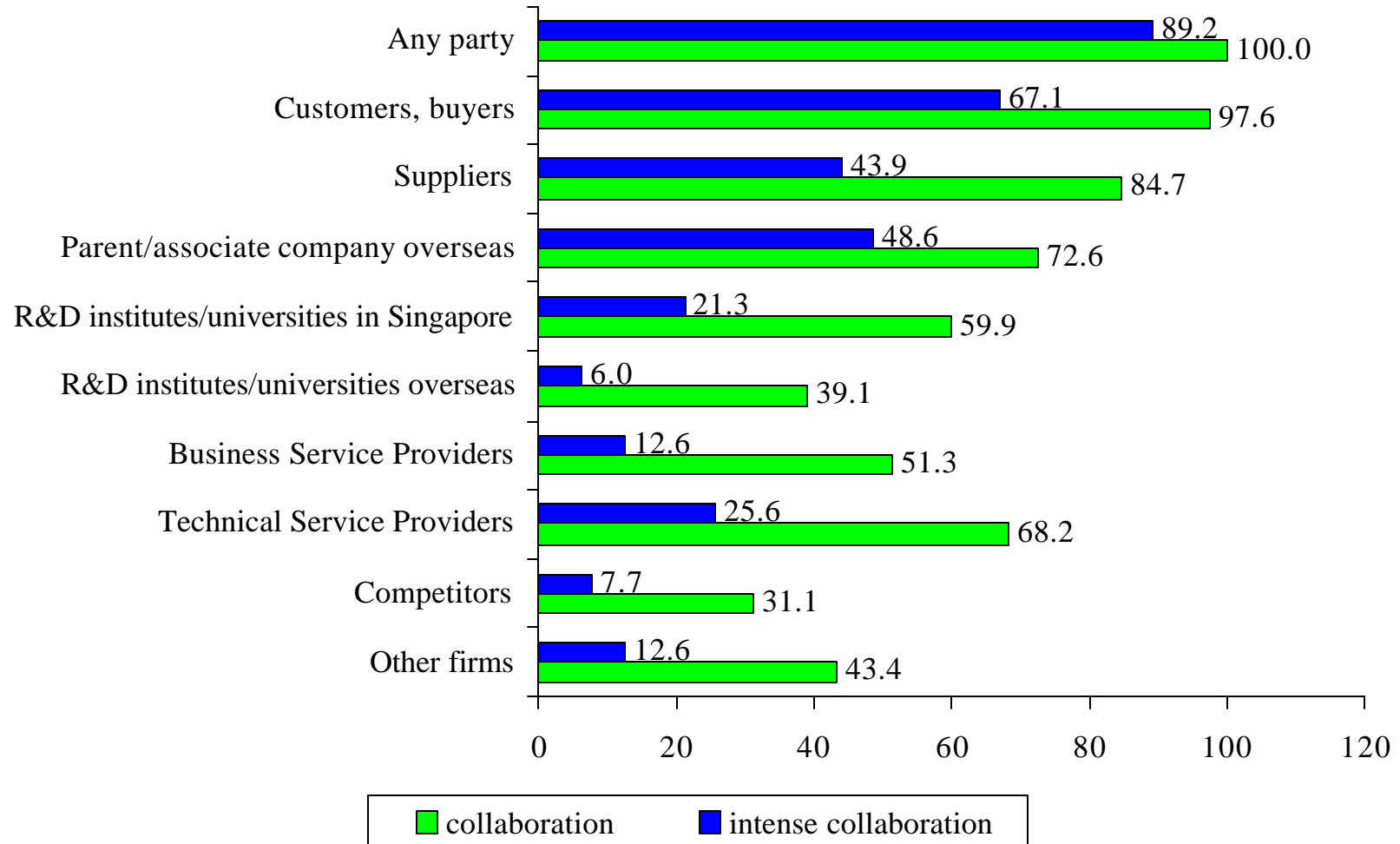
1 = strong agreement, 5 = strong disagreement

## **EXTERNAL COLLABORATION IN INNOVATION: INTENSITY**

- Recent theoretical models suggest that innovation is a highly interactive process<sup>1</sup>, a notion broadly supported by our data.
- All innovating companies have reported some kind of external collaboration, 89% even cited intense collaboration with at least one external party.
- Overall collaboration intensity tends to increase with firm size, pointing to the transaction costs involved.
  - Large companies collaborate more intensely with external parties, or co-operate with a wider range of partners.
  - Small and medium sized firms may still have intense collaboration with a narrower set of partners.

1) *Kline, S. J.; Rosenberg, N.*, 1986: An Overview of Innovation. In: *Landau, R.; Rosenberg, N.* (eds.): The positive sum strategy: Harnessing technology for economic growth. Washington, D. C.: National Academy Press.

# SHARE OF INNOVATING COMPANIES COLLABORATING WITH EXTERNAL PARTIES



## AVERAGE COLLABORATION INTENSITY<sup>1</sup> (Mean Scores, Innovation Firms Only)

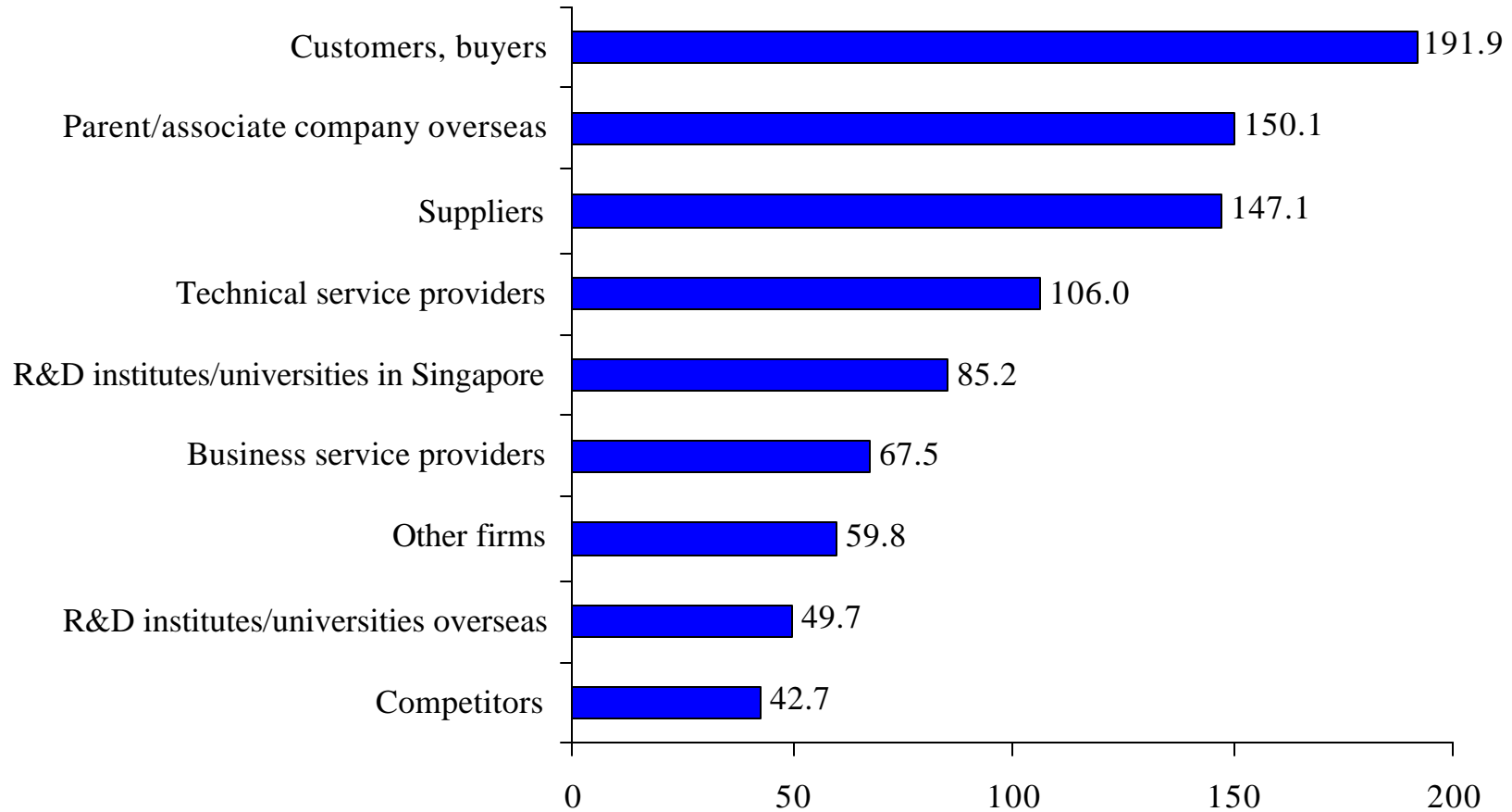
Category	Intensity
Total	2.36
Process innovation	2.29
Product innovation	2.39
Electronics	2.38
Chemicals	2.48
Precision & process engineering	2.29
Transport engineering	2.62
Locally owned	2.40
Foreign owned	2.32
1-9 employees	2.06
10-19 employees	2.16
20-49 employees	2.32
50-99 employees	2.33
100-499 employees	2.51
500+ employees	2.63
Innovative	2.34
Non-innovative	2.39

1) measured on a scale from 0 = no collaboration to 5 = intense collaboration.

## **EXTERNAL COLLABORATION IN INNOVATION: PARTNERS**

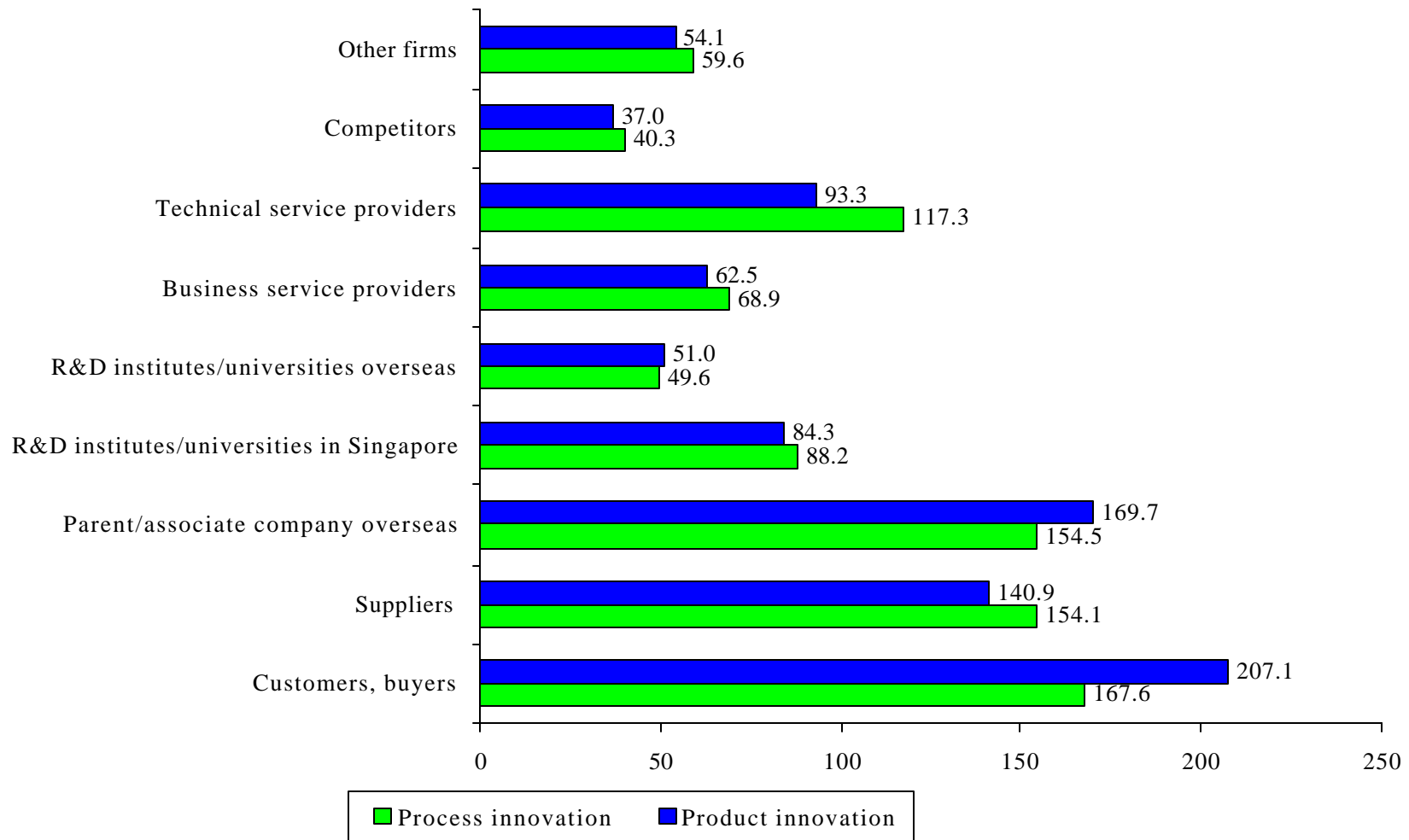
- Customers and buyers are the single most relevant collaboration partner, highlighting the importance of the market to innovation.
- The next most relevant collaboration partners are suppliers, parent or associate companies overseas, and technical service providers.
- Overall, R&D institutes and universities both local and foreign are of lesser importance, as are business service providers, competitors, and other companies
- Interaction with the market and parent/associate companies overseas appears to be more important to product innovators than to process innovators who emphasise suppliers and technical service providers instead.

# EXTERNAL COLLABORATION ON INNOVATION: MEAN RELATIVE SCORES<sup>1</sup> BY PARTY



1) Mean score across all parties = 100.

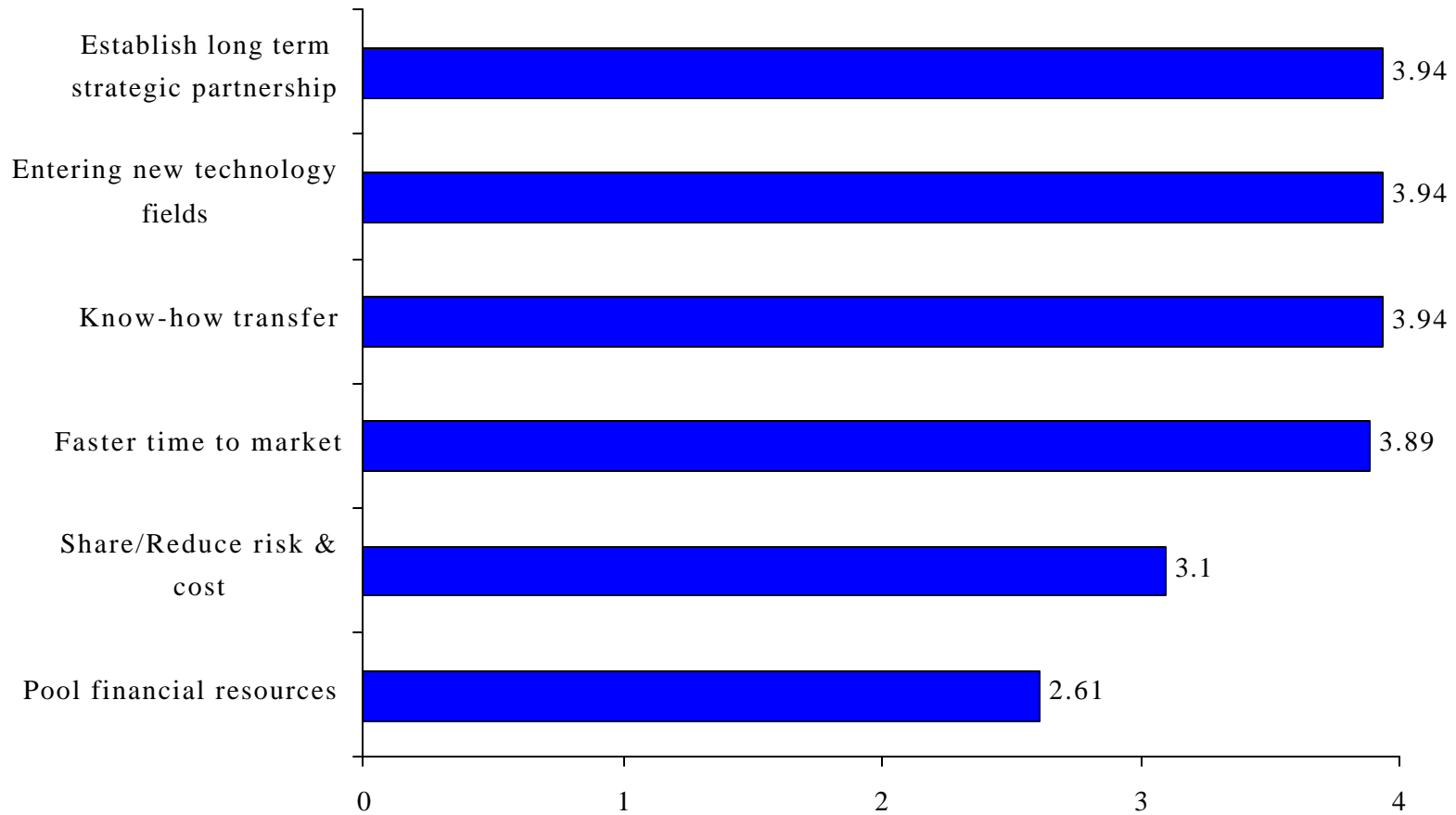
# EXTERNAL COLLABORATION: PRODUCT VS. PROCESS INNOVATION (Mean Relative Scores<sup>1</sup>)



## **EXTERNAL COLLABORATION IN INNOVATION: REASONS FOR CO-OPERATION**

- The following factors have been rated as ‘important’ by at least two thirds of respondents:
  - Know-how transfer
  - Establishment of long-term strategic partnerships
  - Entry to new technology fields
  - Faster time to market
- The sharing of risk and pooling of resources have been attached clearly less relevance.

# REASONS FOR EXTERNAL COLLABORATION ON INNOVATION (Mean Scores<sup>1</sup>)

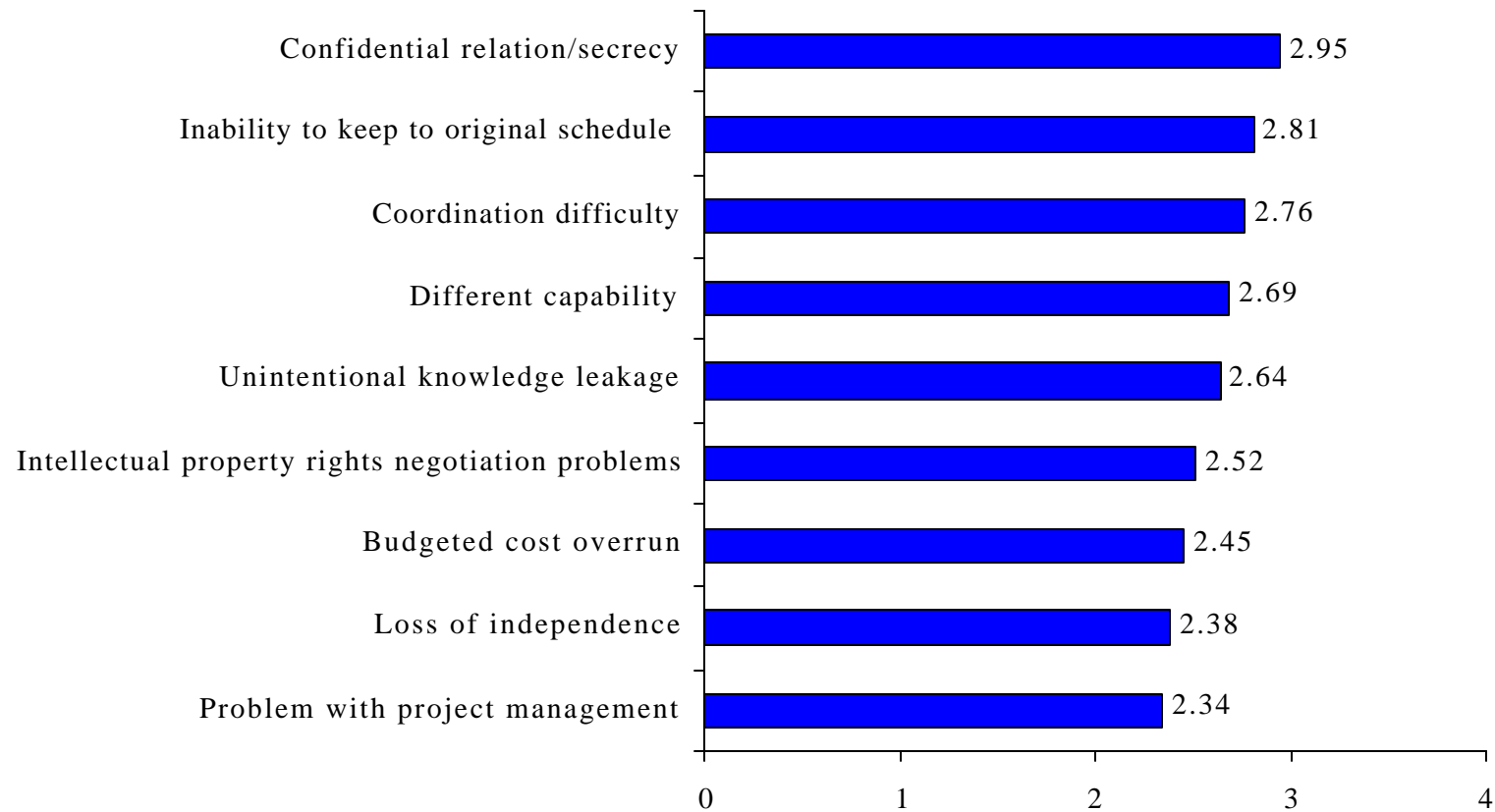


1) Scale from 1 = not important to 5 = very important

## **EXTERNAL COLLABORATION IN INNOVATION: PROBLEMS**

- The main problem reported by companies collaborating in innovation relates to confidentiality and secrecy, followed by the inability to keep to the original schedule.
- Less dominant but still to be taken into account are co-ordination problems, partners' different capabilities as well as unintended leakage of knowledge.
- Successful innovators worry less about confidentiality, while non-innovative firms reported more problems arising from mismatches in capability.

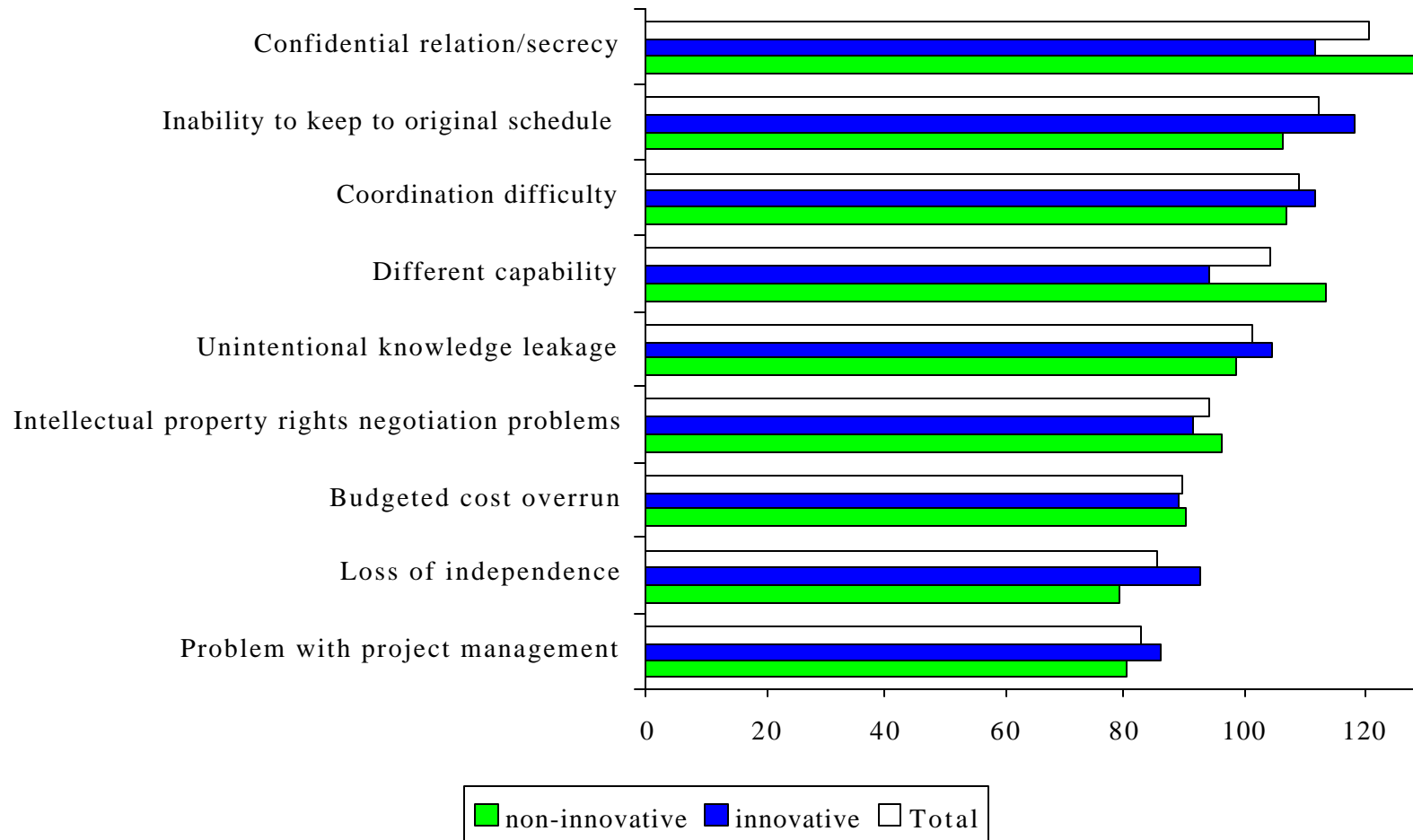
# PROBLEMS IN EXTERNAL COLLABORATION (Means Scores<sup>1</sup>)



1) Scale from 1 = not serious to 5 = very serious.

# PROBLEMS IN EXTERNAL COLLABORATION: INNOVATIVE VS. NON-INNOVATIVE COMPANIES

(Mean Relative Scores<sup>1</sup>)



1) Average score for each category = 100.

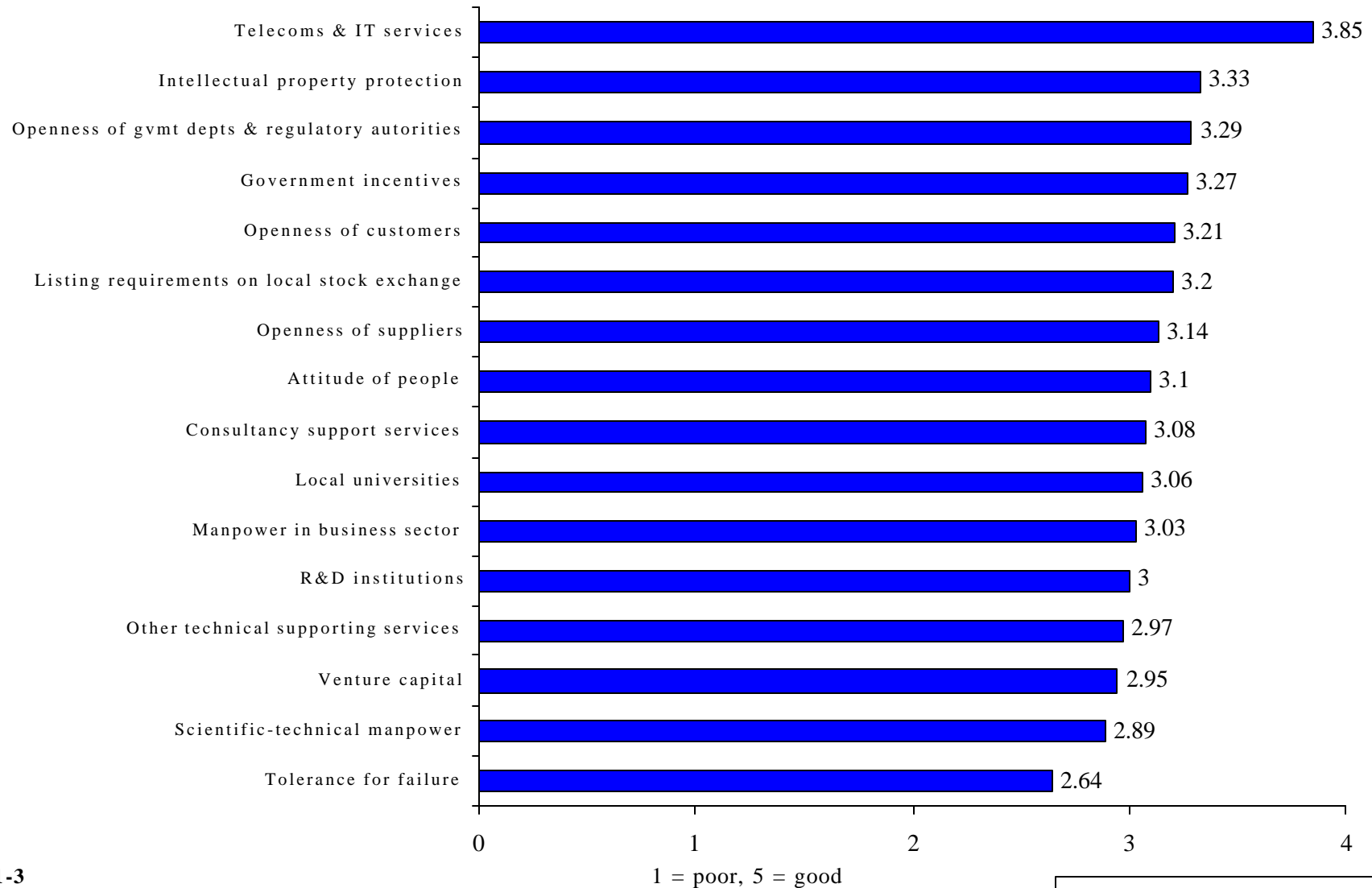
## INNOVATION ENVIRONMENT OF SINGAPORE

- Respondents were invited to assess a set of 16 aspects of Singapore's innovation environment.
- **Plus for infrastructure:** Outstanding at the top of the table is the positive assessment of Singapore's telecommunication and information technology infrastructure, outcome of the Intelligent Island's IT2000 and related strategies to raise infrastructure levels to world class.
- **Minus for low tolerance of failure:** At the other end of the table, the low scores awarded to 'tolerance of failure' are just as outstanding, as has just been highlighted by the Prime Minister and the Senior Minister in their respective Chinese New Year's addresses.

## INNOVATION ENVIRONMENT OF SINGAPORE

- Low tolerance of failure relates to both the individual (fear of failure and “loss of face”) and the societal level.
- Main cultural obstacle to adoption of the ‘Silicon Valley model’ of wealth creation by technopreneurship.
- The low score for this aspect was confirmed by a number of text comments such as
  - “Loss of face.”
  - “One mistake society.”
  - “Expectation is to succeed, not ‘fail to learn’.”
  - “Individual fear of failure (and associated face loss) is limiting.”
  - “They will tell you why you failed, but not how not to fail.”
  - “Left alone to swim until you sink.”
  - “Risk participation by government is lacking.”

# EXTERNAL ENVIRONMENT FOR INNOVATION (Mean Scores)



## **INTERNATIONAL COMPARISON: INNOVATION ACTIVITIES IN THE MANUFACTURING SECTOR**

- 32% of manufacturing companies in Singapore are involved in innovation activities.
- The European countries generally have a higher percentage of manufacturing innovators. In 1996, only Spain and Belgium had less than one-third of their manufacturing companies being innovative enterprises.
- Singapore has approximately equal proportions of companies involved in product and process innovation, while most of the European countries have a higher proportion of product innovators over process innovators. (Norway and Spain are two exceptions).

## **INTERNATIONAL COMPARISON: INNOVATION ACTIVITIES IN THE MANUFACTURING SECTOR**

- Singapore companies tend to specialize in innovation more than the European companies. Only 47% of Singapore companies conducted both product and process innovation in 1999, compared to 63% of European companies in 1996.
- Please note that the definition of an innovating enterprise used for the European sample varies slightly from that used for Singapore. In the European survey, an innovating enterprise is one which has introduced a new/improved product or process, whereas in the Singapore survey, the enterprise must have introduced the new/improved product or process within the last three years.

## INTERNATIONAL COMPARISON: INNOVATING ENTERPRISES IN MANUFACTURING SECTOR (Percentage of Total No. of Enterprises)

Country	1990/92	1996
Ireland	72	73
Germany	67	69*
Austria	na	67
Netherlands	57	62
United Kingdom	na	59
Denmark	56	na
Sweden	na	54
Norway	53	48**
France	39	43
Luxembourg	37	42
Finland	na	36
<b>Singapore (1999)</b>		<b>32</b>
Spain	37	29
Belgium	61	27
Italy	34	na

\*Including ex-GDR from 1991

\*\* Figure for 1997

Source: European Communities. (1997). *The First Community Innovation Survey*. Eurostat database, CD-ROM.

European Communities. (1999). *Innovat*. Eurostat database, CD-ROM

**INTERNATIONAL COMPARISON: PRODUCT AND PROCESS  
INNOVATORS IN MANUFACTURING SECTOR, 1996**  
(Percentage of Total No. of Enterprises)

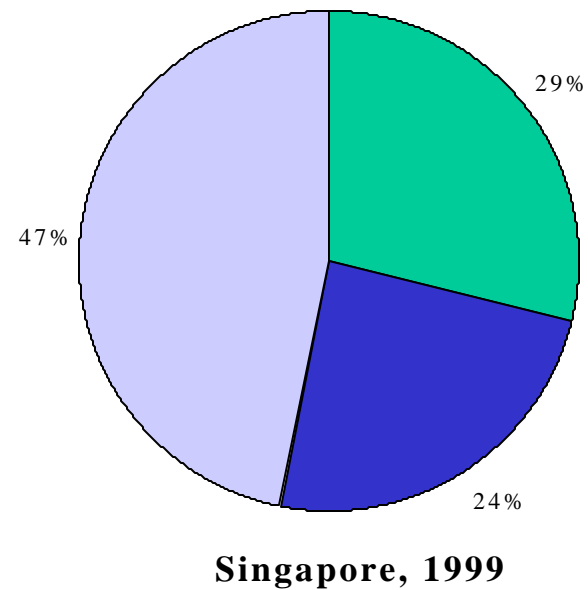
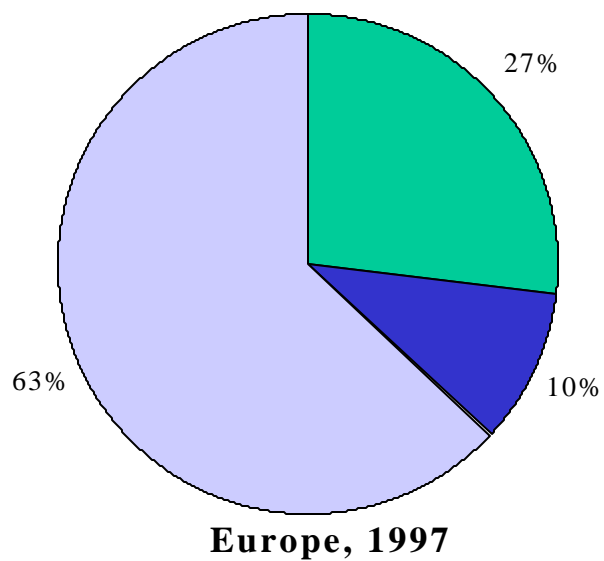
Country	Product innovators	Process innovators
Ireland	66	54
Germany*	65	53
Austria	60	49
Netherlands	56	46
United Kingdom	52	37
Sweden	48	38
France	38	31
Norway (1997)	35	40
Luxembourg	32	29
Finland	29	25
<b>Singapore (1999)</b>	<b>24</b>	<b>22</b>
Spain	24	25
Belgium	24	17

\*Including ex-GDR from 1991

Source: European Communities. (1999). *Innovat.* Eurostat database, CD-ROM

**EDB/NUS-CMIT 2000**

## INTERNATIONAL COMPARISON: INNOVATORS BY TYPE OF INNOVATION



■ product innovation only   ■ process innovation only   ■ both product and process innovation

Source: Foyn, F. (1999). "Community Innovation Survey 1997/1998". *Statistics in Focus: Research and Development*, 2/1999, Eurostat

## **INTERNATIONAL COMPARISON: INNOVATORS BY SIZE CLASS**

- The proportion of innovators increases with employment in both Singapore and European companies.
- Singapore generally has a lower proportion of innovators in each size class, as compared with most of the European countries in 1996.
- The proportion of innovators in each size class in Singapore is approximately equivalent to that of some of the smaller European countries, such as Belgium and Finland, as well as to Spain, in 1996.

**INTERNATIONAL COMPARISON:  
INNOVATORS BY SIZE CLASS  
(Percentage of Firms in Size Class)**

	20-49	50-249	= 250
<b>Singapore (1999)</b>	<b>26</b>	<b>43</b>	<b>65</b>
Belgium	22	29	50
Germany	63	70	85
Spain	21	43	76
France	34	48	75
Ireland	68	78	85
Luxembourg	21	52	85
Netherlands	54	71	84
Austria	59	73	88
Finland	26	40	77
Sweden	43	61	79
United Kingdom	54	59	81
Norway	39	56	77

Note: In the Netherlands, the size classes are 20 to 49, 50 to 199, and >200

Source: Foyen, F. (1999). "Community Innovation Survey 1997/1998". *Statistics in Focus: Research and Development*, 2/1999, Eurostat

## **INTERNATIONAL COMPARISON: INNOVATORS BY INDUSTRY**

- The machinery and electrical/electronics industry has the largest proportion of innovators in the Singaporean and European manufacturing sectors (41% and 71% respectively).
- Europe has a much higher proportion of innovators in each manufacturing industry than Singapore does.
- Singapore's manufacturing sector is closest to Belgium and Spain in terms of the proportion of innovating companies within each industry

## INTERNATIONAL COMPARISON: INNOVATORS BY INDUSTRY (Percentage of Firms in Industry)

	Coke; chemicals; rubber and plastic; other non- metallic mineral	Basic metals and fabricated products	Machinery and equipment NEC; electrical and optical equipment	Transport equipment and manufacturing NEC
<b>Singapore (1999)</b>	<b>30</b>	<b>25</b>	<b>41</b>	<b>16</b>
Belgium	34	30	44	25
Germany	69	59	81	70
Spain	40	25	50	30
France	55	31	62	43
Ireland	79	68	88	77
Luxembourg	52	44	61	0
Netherlands	73	53	78	59
Austria	50	68	83	82
Finland	49	31	44	28
Sweden	59	41	74	58
United Kingdom	62	56	70	52
Norway	60	43	64	47
Total for European sample	58	47	71	52

Source: Foyen, F. (1999). "Community Innovation Survey 1997/1998". *Statistics in Focus: Research and Development*, 2/1999, Eurostat

**INTERNATIONAL COMPARISON:  
PROPORTION OF TURNOVER DUE TO NEW OR  
IMPROVED PRODUCTS FOR PRODUCT INNOVATORS  
IN THE MANUFACTURING SECTOR**

- 29% of sales turnover in Singaporean innovative companies was due to new or improved products in 1999.
- The corresponding figure for the European countries in 1996 ranged from 43% for Germany to 14% for Belgium.
- Singapore's figure is similar to that of Austria and Sweden (31%) and Spain (27%)

## INTERNATIONAL COMPARISON: PROPORTION OF TURNOVER DUE TO NEW OR IMPROVED PRODUCTS FOR PRODUCT INNOVATORS IN MANUFACTURING SECTOR, 1996

Country	1996
Germany*	43
Ireland	32
Austria	31
Sweden	31
<b>Singapore (1999)</b>	<b>29</b>
Spain	27
Netherlands	25
Finland	25
United Kingdom	23
France	21
Norway (1997)	20
Belgium	14

Note: Singapore value is derived from mid-point estimate of categorised variable

\*Including ex-GDR from 1991

**B7** Source: Foyn, F. (1999). "Community Innovation Survey 1997/1998". *Statistics in Focus: Research and Development*, 2/1999, Eurostat