Open Foresight as a Driver for Innovation: Leveraging External Knowledge for Exploration of Future Developments

Summary of study results

Sara Polier, M.Sc.
Prof. Dr. Cornelius Herstatt
Institute for Technology and Innovation Management
Hamburg University of Technology, Germany

August 2017

Content

Technology and Innovation Management at Hamburg University of Technology

Study analyses how firms can leverage external knowledge to explore future developments

Technology and Innovation Management at Hamburg University of Technology

Corporate foresight[1]

- In order to **cope with a constantly changing environment**, organizations need to identify discontinuities and trends before they emerge
- **Foresight** describes a firm's ability to **detect discontinuous change**, interpret the consequences, and formulate effective responses to ensure the long-term survival and success of the firm
- **Searching for future-related information** in order to identify early signs of discontinuities and trends constitutes a core task of corporate foresight activities

Use of external knowledge[2]

- Firms **increasingly use external actors** to enrich their internal knowledge base and to gain access to a wide range of **diverse knowledge sources** such as customers, suppliers or universities
- **Searching externally** for new knowledge enables the firm to span organizational boundaries in order to avoid competency traps and core rigidity
- External search is particularly important in the area of foresight as future disruptions often originate **outside a firm's domain** and require organizations to **look beyond their area of expertise**

How can firms effectively leverage external knowledge to explore future discontinuities and trends?

[1] Ansoff 1975; Horton 1999; Martin & Irvine 1989; Slaughter 1997; Whitehead 1967
[2] Day & Schoemaker 2004; Katila & Ahuja 2002; Laursen & Salter 2006; Leonard-Barton 1995; Levitt & March 1988

Data collected from an international, cross-industry sample of R&D intensive firms

Technology and Innovation Management at Hamburg University of Technology

X Detailed in the following chapters

Study design

200 participating firms out of the world's top 1,000 R&D intensive firms

International, cross-industry sample of medium to large-sized firms

Online survey running from January to March 2017

Survey data supplemented by secondary **firm performance data** of the R&D Scoreboard[1]

Key findings

A While firms leverage a **diverse range** of external knowledge sources to gather future-related information, they tend to focus on the **near environment** when looking for future developments

B The majority of firms has a **formal organizational responsibility** for foresight, but **channels to distribute** foresight results into the organization are largely missing

C Firms use **insights derived from foresight** to initiate new innovation activities, provide strategic guidance for future innovations and challenge current innovation practices

D Firms applying a **broad and distance-oriented search strategy** gain increased benefits from their foresight activities

[1] Annual EU Industrial R&D Investment Scoreboard

Where do firms look

for future-related information to detect signals of future discontinuities and trends?

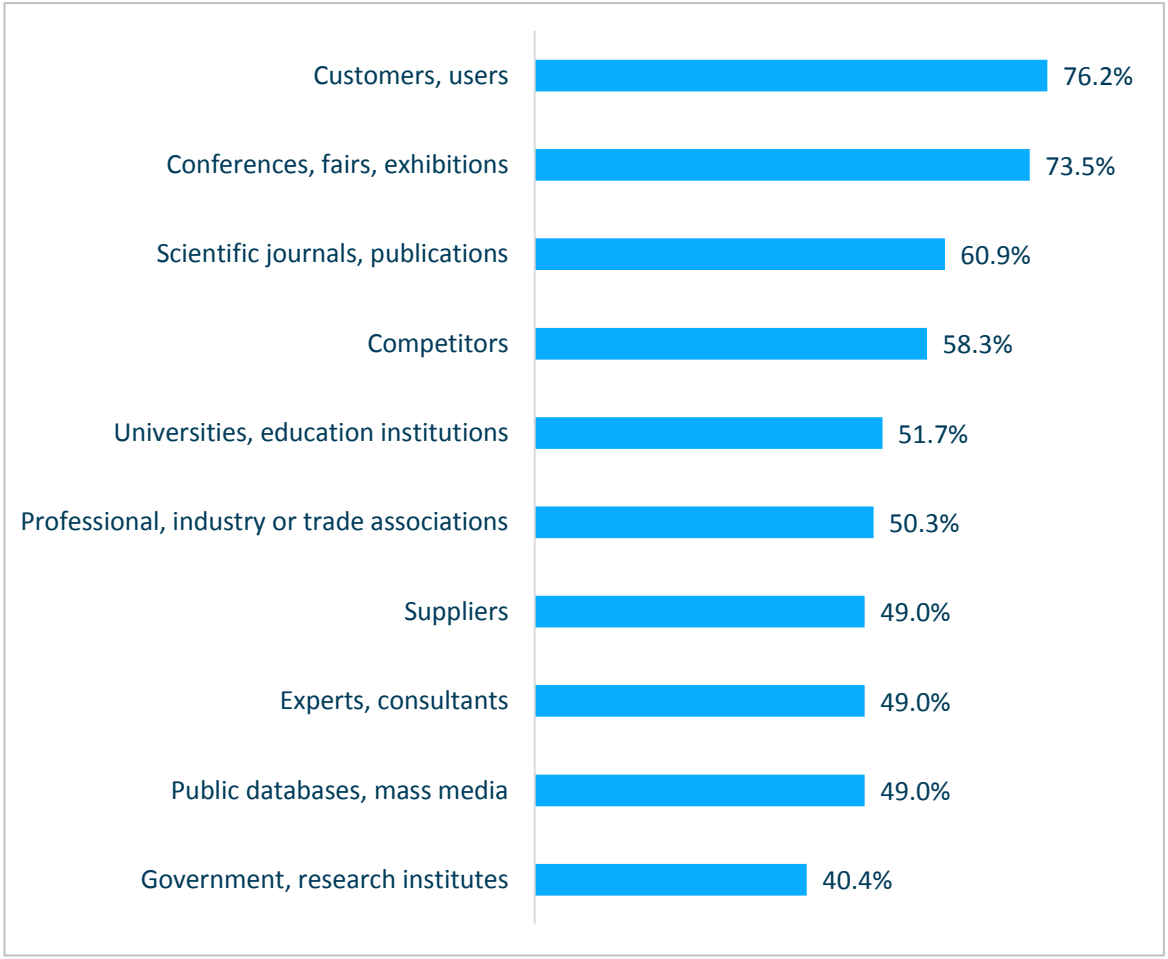
Top 3 sources for future-related information are customers, conferences and journals

Technology and Innovation Management at Hamburg University of Technology

Key findings

- Firms most often rely on **market-related** (customers, competitors) and **scientific knowledge** (conferences, journals) when searching for future trends
- On the contrary, **research-focused institutions** such as universities or public research institutes tend to be less leveraged
- However, utilizing a large number of different knowledge sources enables firms to access a **diverse knowledge pool** fostering the detection of potentially **new and disruptive insights**[1]

External sources used for gathering future-related information



N = 151; Answers “often” and “frequently”

[1] Dahlander et al. 2014; Leiponen & Helfat 2010

Customers as the top knowledge source regardless of different firm characteristics

Technology and Innovation Management at Hamburg University of Technology

Top 3 knowledge sources	Firm characteristics			Top 3 knowledge sources
▪ Customers, users (84.6%) ▪ Competitors (71.4%) ▪ Conferences, exhibitions (61.5%)	**Smaller firms** (< 1,000 employees)	vs	**Larger firms** (>= 5,000 employees)	▪ Customers, users (74.8%) ▪ Conferences, exhibitions (72.9%) ▪ Journals, publications (64.5%)
▪ Customers, users (75.0%) ▪ Conferences, exhibitions (75.0%) ▪ Government, research institutions (62.5%)	**Younger firms** (< 20 years in market)	vs	**Mature firms** (> 50 years in market)	▪ Customers, users (77.5%) ▪ Conferences, exhibitions (73.2%) ▪ Journals, publications (66.2%)
▪ Customers, users (78.2%) ▪ Conferences, exhibitions (75.6%) ▪ Journals, publications (67.9%)	**Firms in non-R&D-intensive industries**	vs	**Firms in R&D-intensive industries**	▪ Customers, users (81.8%) ▪ Conferences, exhibitions (72.7%) ▪ Competitors (69.7%)
▪ Conferences, exhibitions (84.6%) ▪ Suppliers (69.2%) ▪ Customers, users (69.2%) ▪ Experts, consultants (69.2%)	**Firms with regional focus**	vs	**Firms with international focus**	▪ Customers, users (79.8%) ▪ Conferences, exhibitions (72.7%) ▪ Journals, publications (68.7%)

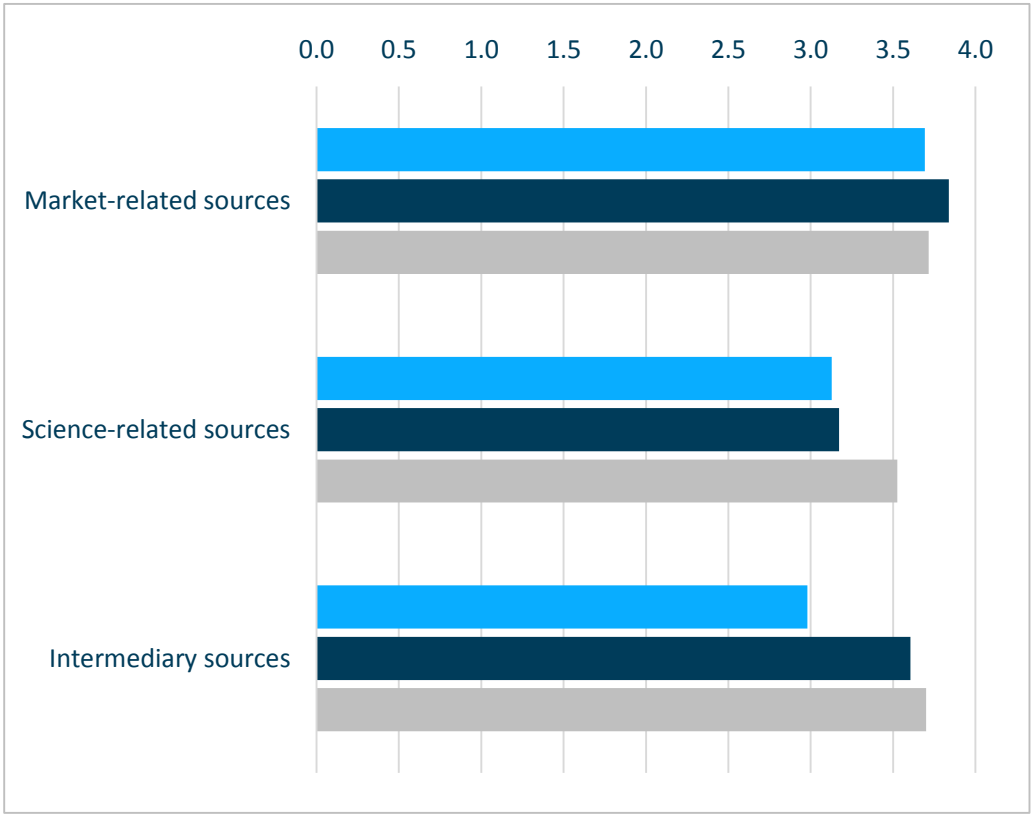
N = 151; Answers “often” and “frequently”

Larger firms take advantage of intensively leveraging different knowledge types

Technology and Innovation Management at Hamburg University of Technology

Knowledge types used for gathering future-related information

Per firm size (in FTE), mean degree of usage[1]



Key findings

- **Smaller firms** (< 1,000 FTE) primarily rely on **market-related** sources such as customers (84.6%) and competitors (71.4%)[2] which can be attributed to **resource constraints** and high **transaction costs** related to utilizing a broader range of diverse sources[3]
- **Science-related** sources tend to be more important for **large firms** with ≥ 5,000 FTE, especially universities and education institutes (56.1%)[2]
- **Firms with ≥ 1,000 FTE** more strongly leverage **intermediary sources** such as conferences and exhibitions (72.0%) as well as journals and scientific publications (64.5%)[2]

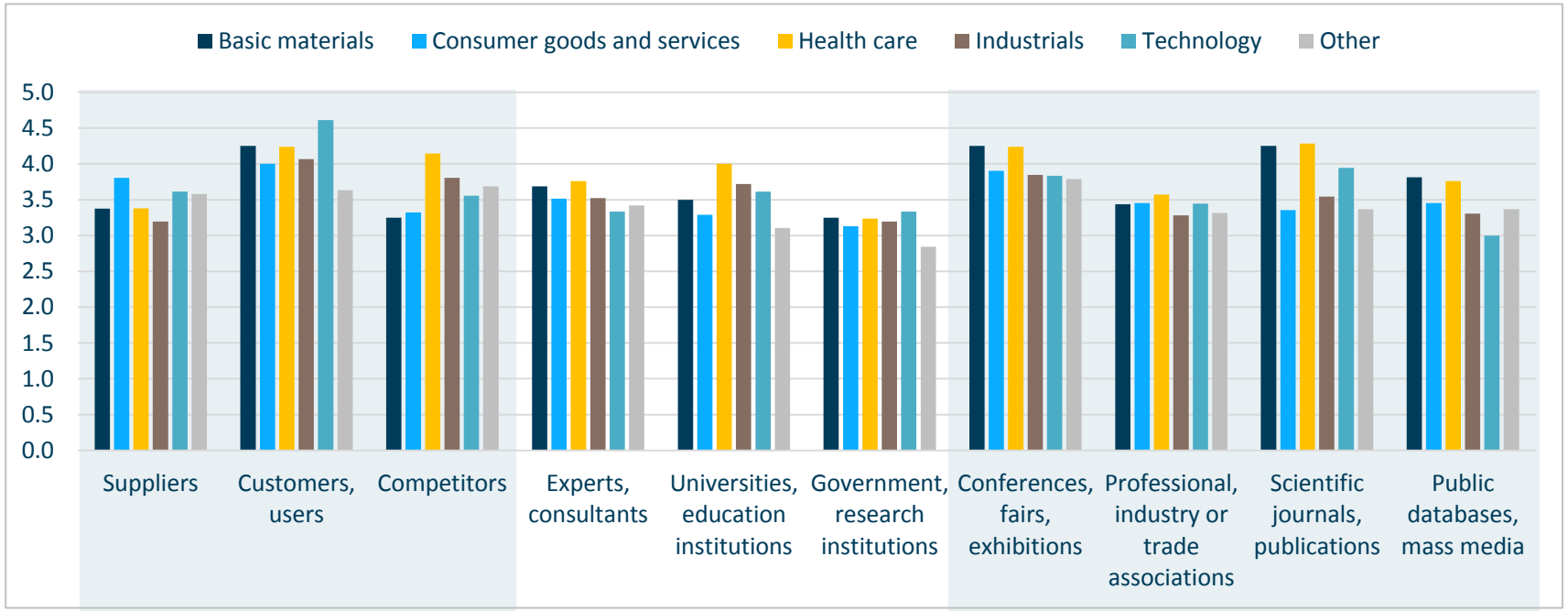
N = 151
[1] Scale: 0 = “no usage” to 5 = “frequently used”
[2] Answers “often” and “frequently”
[3] Cruz-González et al. 2015; Rosenkopf & Nerkar 2001

Firms in different industries leverage distinct set of knowledge sources for future-related search

Technology and Innovation Management at Hamburg University of Technology

External sources used for gathering future-related information

Per industry, mean degree of usage



Market-related sources primarily used in the consumer, technology and health care sector

Science-related sources primarily used in the health care, industrials, technology and basic materials sector

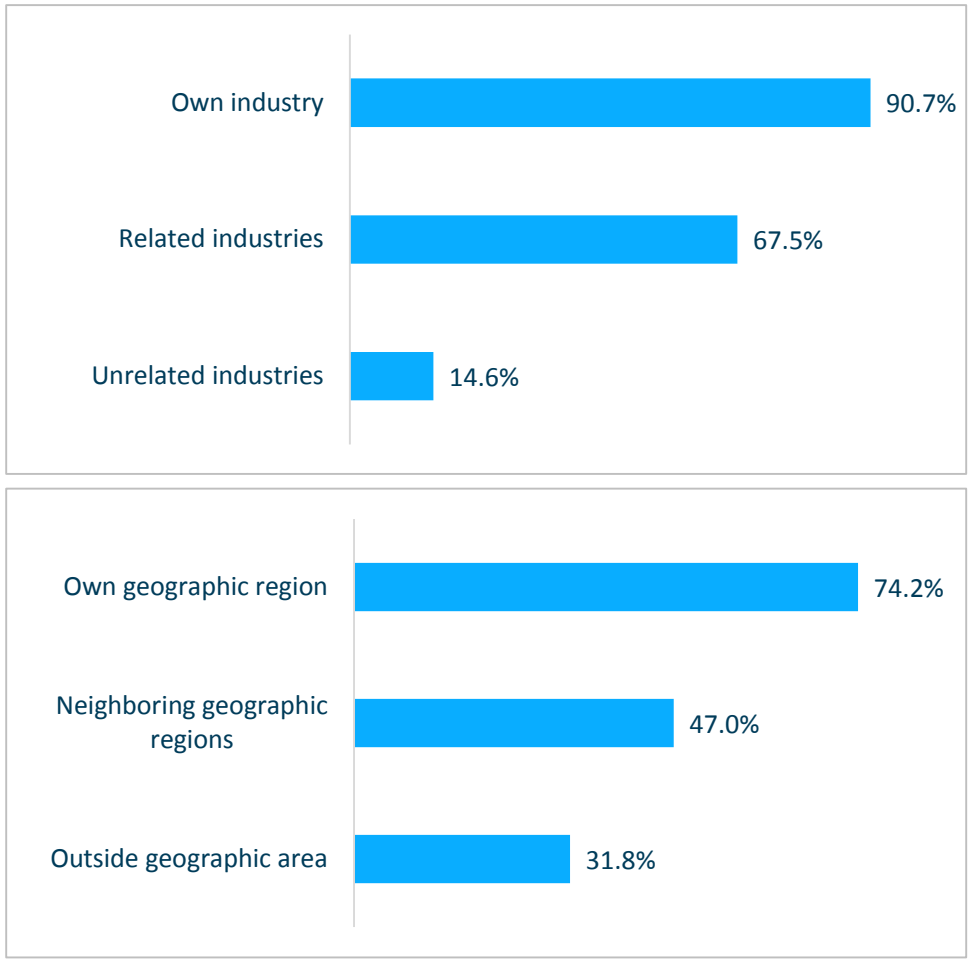
Intermediary sources primarily used in the basic materials, health care and technology sector

N = 151; Scale: 0 = “no usage” to 5 = “frequently used”

Majority of firms focus on the near environment when conducting future-related search

Technology and Innovation Management at Hamburg University of Technology

Future-related information gathered in...



Key findings

- Firms **primarily search locally** for future-related information and thus, stay close to their current technological and geographical footprint
- However, local search results in knowledge that is **close to the firm's existing knowledge base** and hence, bears the threat of potentially constraining the direction of a firm's future thinking[1]
- Less than one third of the firms search in **distant industries and geographic areas** for future trends
- While distant search facilitates the detection of **early signals outside a firm's domain**, it is associated with **high costs** due to an increased effort to find and integrate this knowledge[2]

N = 151; Answers "often" and "frequently"

[1] Martin & Mitchell 1998; Rosenkopf & Almeida 2003; Wagner et al. 2014
[2] Bierly & Daly 2007; Capaldo & Messini Petruzzelli 2015; March 1991

Search profile and importance of knowledge sources varies for firms in different countries

Technology and Innovation Management at Hamburg University of Technology

	Europe	USA	Asia
Importance of knowledge types[1]	1 **Market**: customers, suppliers, competitors 2 **Intermediary**: journals, conferences, media 3 **Science**: universities, institutes, experts	1 **Market**: customers, suppliers, competitors 2 **Intermediary**: journals, conferences, media 3 **Science**: universities, institutes, experts	1 **Science**: universities, institutes, experts 2 **Intermediary**: journals, conferences, media 3 **Market**: customers, suppliers, competitors
Search profile[2]	Search breadth Search depth Technol. distance Geograph. distance	Search breadth Search depth Technol. distance Geograph. distance	Search breadth Search depth Technol. distance Geograph. distance

- **European and US firms** with similar future-related search activities characterized by wide, intensive and distant search with a focus on market-related knowledge sources
- **Asian firms** attribute high importance to science-related knowledge sources, focus their search efforts on exploiting different knowledge sources (breadth), but show low search depth and distance

N = 104; Category "rest of world" omitted

[1] Knowledge sources used for gathering future-related information categorized according to the type of knowledge

[2] Dimensions: breadth (number of different sources used), depth (frequency of search), technological distance (own/foreign industries searched), geographical distance (own/foreign geographical areas searched)

B

How do firms organize

their foresight activities internally?

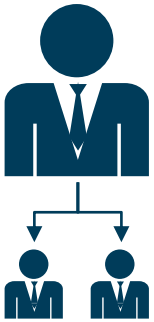
Top management support as prerequisite for implementing foresight successfully

Technology and Innovation Management at Hamburg University of Technology

Top management support

In **69.5%** of the firms, **top management** strongly supports foresight-related activities

Foresight-related activities are **triggered top-down** in **39.7%** of the firms



Key findings

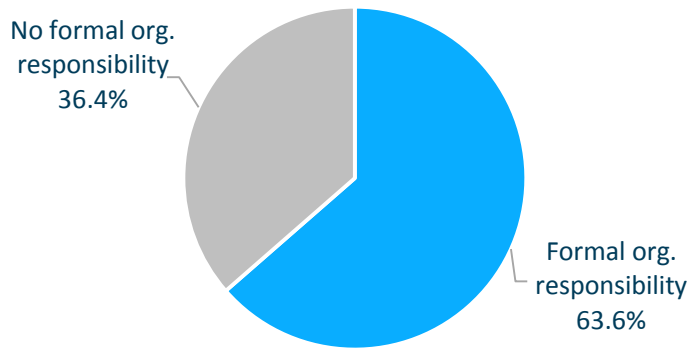
- **Top management supports foresight** in 70% of the firms which enhances **visibility of the foresight activities** within the firm and promotes implementation of its results[1]
- In more than one third of the firms foresight activities are **triggered top-down**
- However, relying exclusively on **top-down** initiated foresight activities bears the **risk of missing relevant information** gathered on lower levels in the firm[2]
- Firms need to establish processes to **enable employees** to bring future-related information to top management attention[3]

N = 151; Answers “agree” and “strongly agree”
[1] Battistella 2014; Rohrbeck et al. 2009
[2] Rohrbeck & Gemünden 2008; Rohrbeck et al. 2009
[3] Rohrbeck et al. 2009

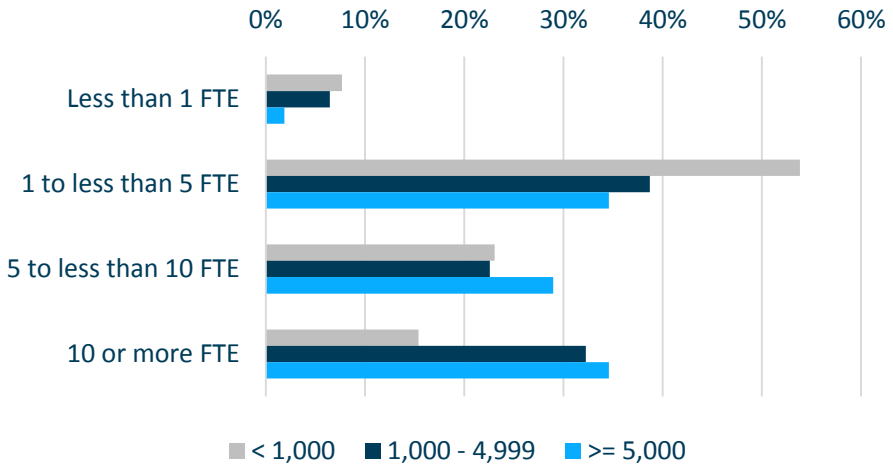
Majority of firms have dedicated resources and organizational responsibilities for foresight ...

Technology and Innovation Management at Hamburg University of Technology

Formal organizational responsibility
(e.g., dedicated unit, team or position)[1]



Dedicated resources per firm size (in FTE)



» Future orientation is a spirit that is present throughout the entire firm. Implementing a 'foresight' department is not enough. «

[Survey participant]

- **> 60%** of the firms have a **formal organizational responsibility** for foresight with even more firms having dedicated foresight resources
- On the contrary, 40% of the firms **lack a clear organizational responsibility** for future-related activities
- However, future-related activities need to span the entire organization: **foresight unit should serve as an information hub** to both facilitate and conduct future-related projects in the organization[2]

N = 151
[1] Answers "agree" and "strongly agree"
[2] Rohrbeck & Gemünden 2008

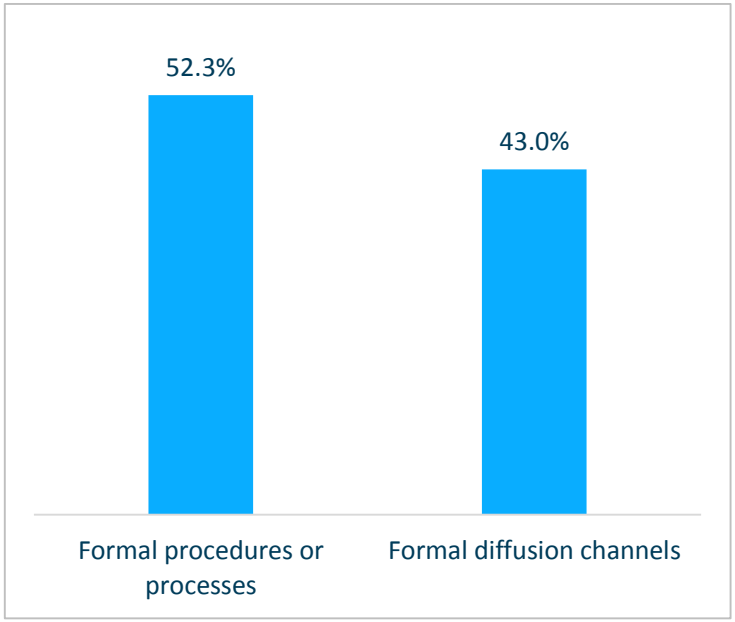
… but less than 50% have formal channels to disseminate foresight results

Technology and Innovation Management at Hamburg University of Technology

Key findings

- **Only half of the firms** have formal procedures or processes for foresight implemented
- Even less firms have channels established to **diffuse future-related information** throughout the firm
- To benefit from its full potential, foresight needs to be **integrated with major functions in the organization** such as innovation and strategic management, corporate development, marketing and controlling[1]
- Additionally, by formally structuring foresight activities firms are able to **manage new knowledge** created by foresight more efficiently and to **spot weak signals** of future developments early[2]

Processes and channels for foresight



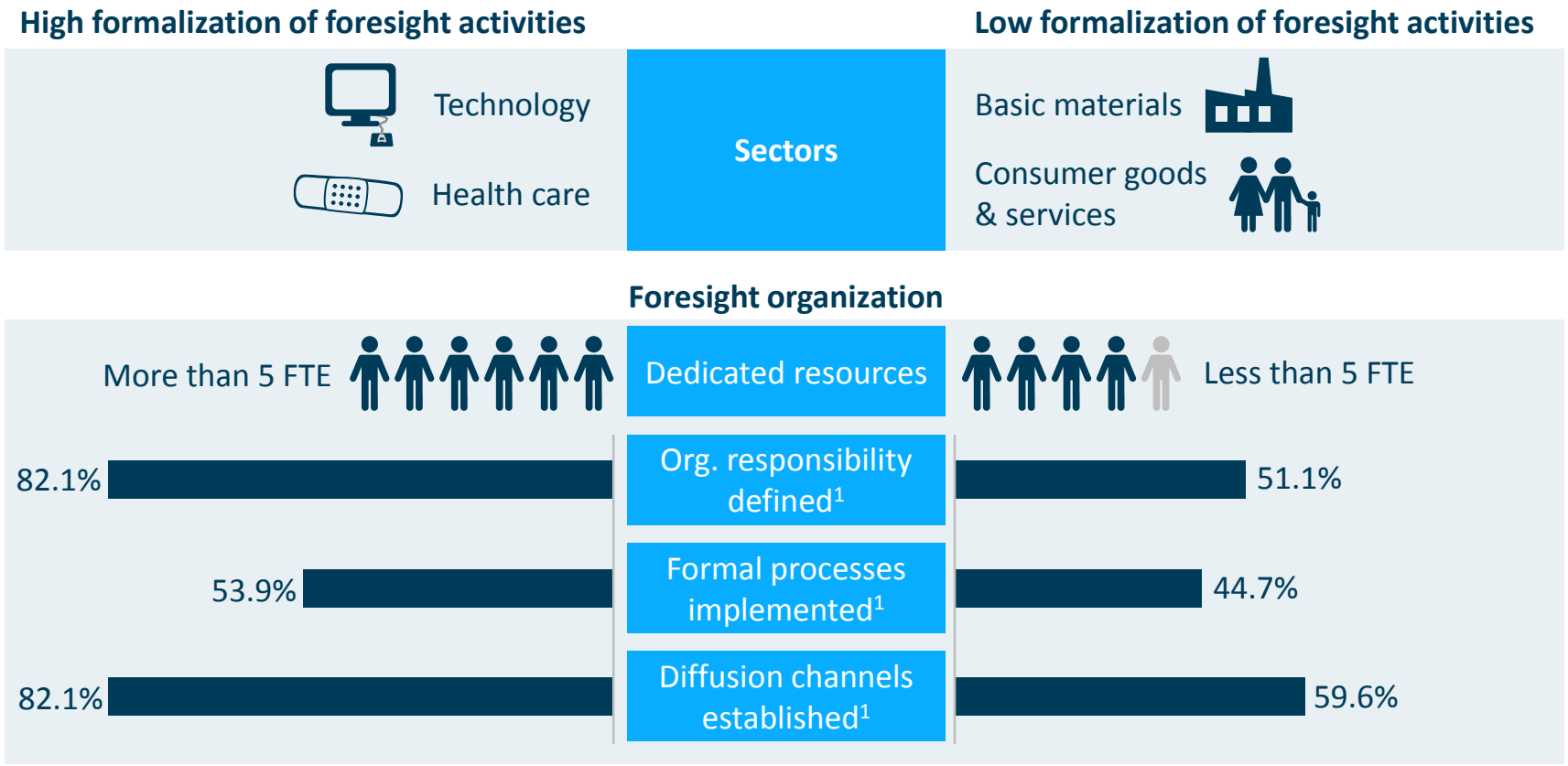
» In a normal development process, there is no room for detecting disruptive technologies. However, to rely on the experts in the company is not sufficient. «

[Survey participant]

N = 151; Answers “agree” and “strongly agree”
[1] Battistella 2014; Rohrbeck & Gemünden 2008
[2] Rollwagen et al. 2008

Technology and health care sector show high formalization of foresight activities

Technology and Innovation Management at Hamburg University of Technology



N = 151

[1] Answers “agree” and “strongly agree”

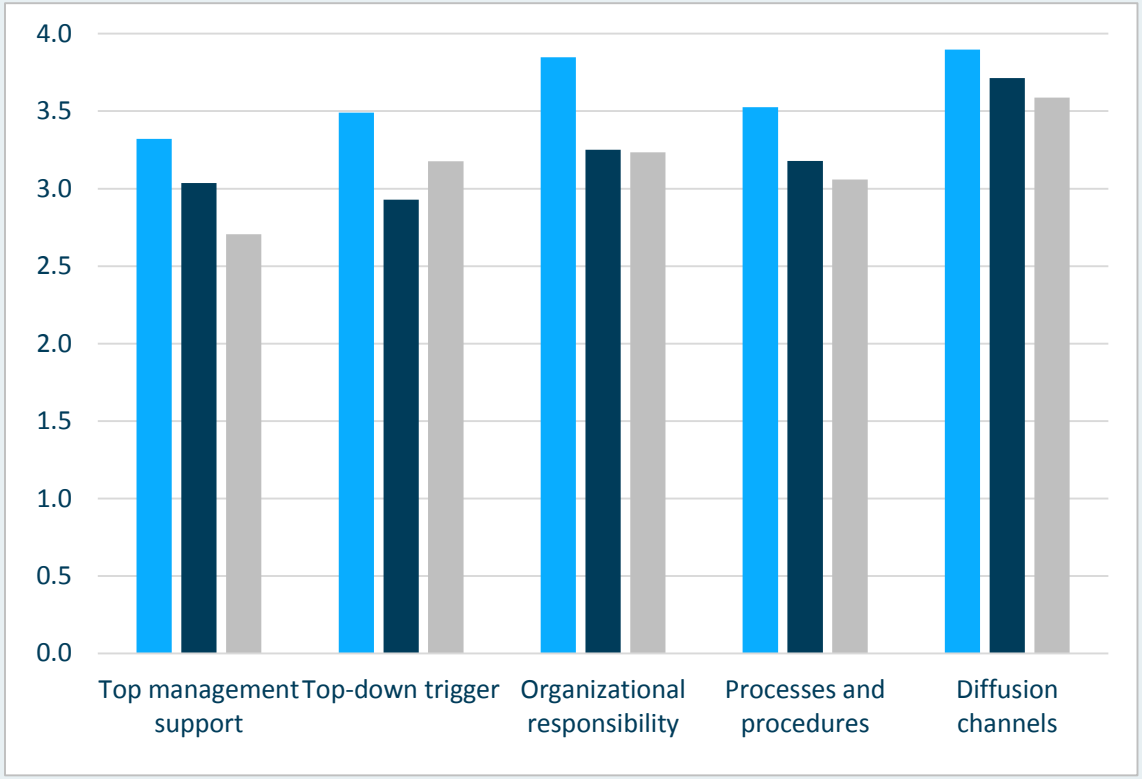
European firms with highest foresight formalization, followed by US firms

Technology and Innovation Management at Hamburg University of Technology

Europe USA Asia

Formalization of foresight activities

Per country, mean degree of agreement



- **European firms with highest degree** of foresight formalization especially with respect to a formal organizational responsibility and diffusion channels
- **US and Asian firms** with particular emphasis on **diffusion channels**, but lower formalization in terms of processes and org. responsibility
- While foresight is often triggered **top-down in Asian firms**, top management support seems to be missing

N = 151; Scale: 0 = “no usage” to 5 = “frequently used”

What value do firms derive

from foresight activities?

Foresight-related activities contribute in 3 dimensions to innovation management

Technology and Innovation Management at Hamburg University of Technology

Foresight-related activities are of **value for different functional units** ...

- **Strategic management**
- **Innovation management**
- **Corporate development**
- **Marketing**
- **Controlling**
- **...**

... and support innovation management in **3 distinct dimensions**[1]

Foresight as Initiator

- Triggering new innovation activities by providing insights on new demands, technologies or threats
- Directly feeds into the innovation channel and thus increases overall innovation output

Foresight as Strategist

- Provision of strategic guidance for innovation activities by supporting vision building and strategy development
- Not directly linked to the innovation process but guides general innovation activities towards new fields and emerging opportunities

Foresight as Opponent

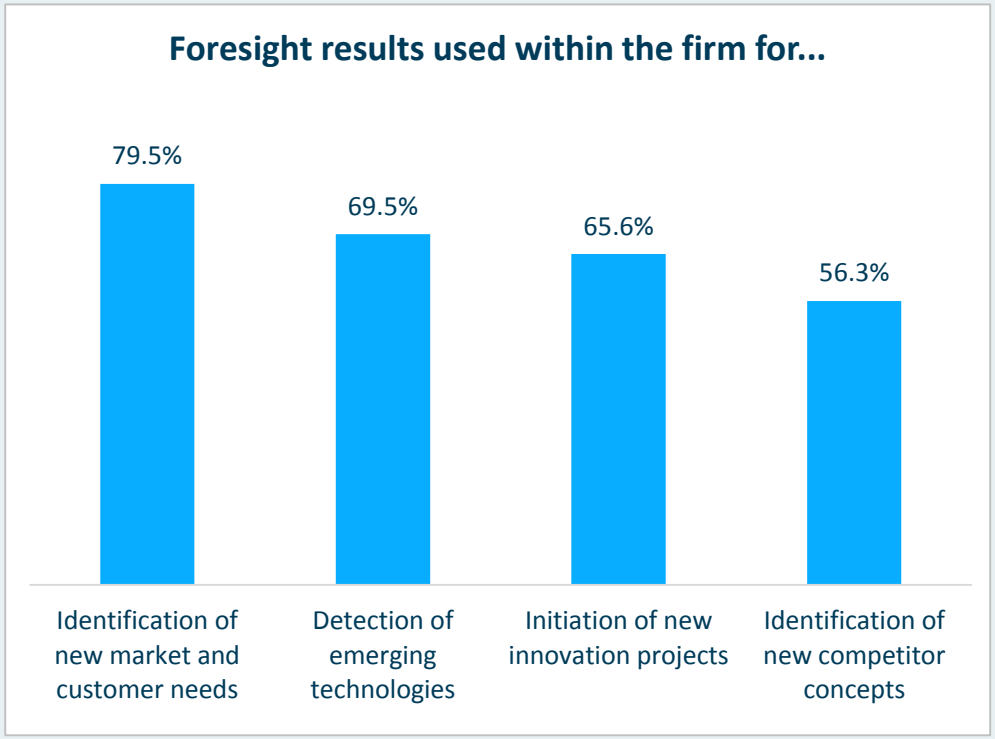
- Challenging the ideas and basic assumptions of current innovation activities
- Impacts activities at each stage of the innovation process by ensuring constant evaluation against new future insights

[1] Rohrbeck & Gemünden 2011; Rohrbeck & Schwartz 2013

Majority of firms use foresight activities to identify new innovation opportunities

Technology and Innovation Management at Hamburg University of Technology

Foresight as Initiator



- To a large extent, firms use results of foresight-related activities as an **input for new innovation initiatives**, e.g., by identifying new demands or emerging technologies
- Foresight functions as a **pre-stage of the innovation process** with particular importance for identifying discontinuous change and emerging new business fields[1]

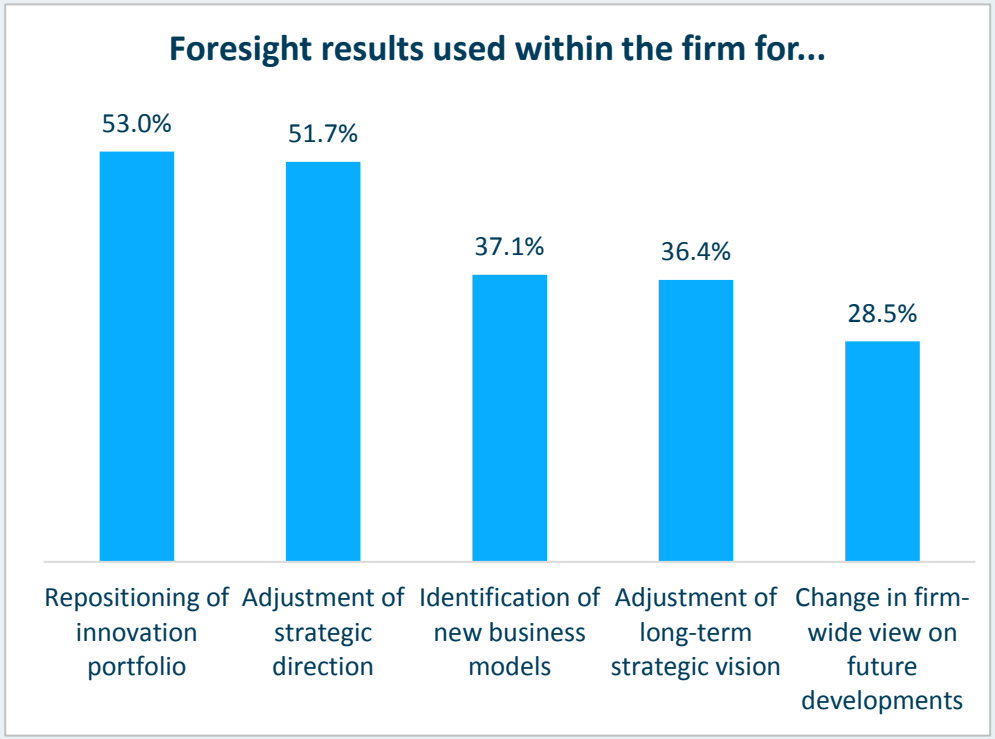
N = 151; Answers “often” and “frequently”

[1] Rohrbeck & Gemünden 2011

Insights from foresight largely used for adjustment of short-term strategic direction

Technology and Innovation Management at Hamburg University of Technology

Foresight as Strategist



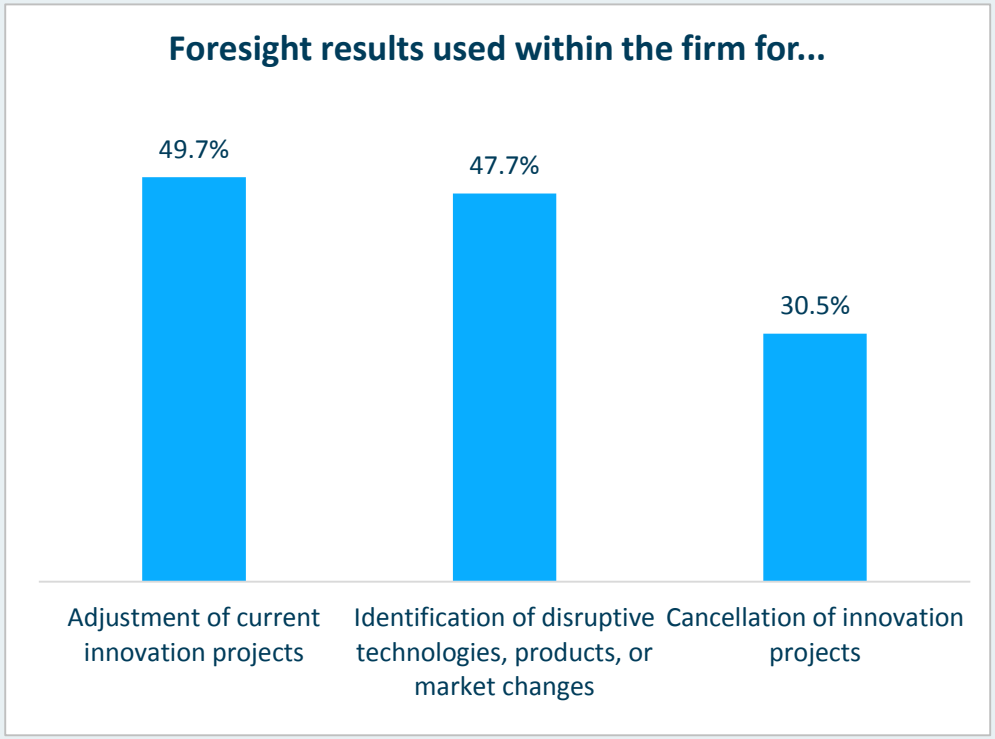
- From a strategic value perspective, 50% of the firms use the results of foresight activities to **align their short-term innovation strategy**
- Only one third of the firms take advantage of the **long-term orientation of foresight** by utilizing insights for new business models and the overall vision of the firm
- However, the lack of leveraging long-term strategic insights gained from foresight bears the **risk of missing early signs** of future threats[1]

N = 151; Answers “often” and “frequently”
[1] Day & Schoemaker 2004

> 50% of the firms use foresight results to challenge current innovation activities

Technology and Innovation Management at Hamburg University of Technology

Foresight as Opponent



- **Less than half of the firms** use insights from foresight for challenging their current innovation initiatives based on new insights
- However, a major aim of foresight is to **identify disruptive change outside the scope** of a firm's current activities[1]
- Large portion of firms do **not fully exploit the opponent potential** of foresight which may lead to missing important opportunities to adapt to future change prior to competitors

N = 151; Answers "often" and "frequently"

[1] Rohrbeck & Gemünden 2011

What are best practices

in leveraging external knowledge for exploring future developments?

Study reveals relationship between external search and value derived from foresight

Technology and Innovation Management at Hamburg University of Technology

What innovation theory says...

- Searching externally for new knowledge **positively impacts innovation performance** of a firm[1]
- Firms that **search broadly and intensively** outside the firm boundaries show increased radical and incremental innovation performance[2]
- **Searching distant** to the firm's current knowledge domain facilitates identification of breakthrough innovations[3]
- However, due to **high costs** associated with managing externally gathered knowledge, **over-searching** may lead to negative performance effects[4]

What the study outcomes show...

- The **way a firm searches externally** for future-related information affects the value derived from foresight activities[5]
- Firms that **search frequently for future-related information** realize more value from foresight[6] than firms searching only occasionally
- **Market-related and intermediary** knowledge sources are most valuable for gaining future-related insights to trigger new innovations
- Firms with **high exploration orientation**[7] benefit more from broad and distant search due to their ability to effectively manage disruptive new knowledge
- However, an excessive exploration orientation leads to **diminishing returns** from external search activities
- Firms with **formalized foresight practices** are gaining generally more value from their external search activities

[1] Katila & Ahuja 2002; Laursen & Salter 2006; Sofka & Grimpe 2010 [2] Chiang & Hung 2010; Cruz-González et al. 2014; Ferreras-Méndez et al. 2015
[3] Lopez-Vega et al. 2016; Prahalad 2004 [4] Katila & Ahuja 2002; Laursen & Salter 2006 [5] Value related to Initiator, Strategist and Opponent dimensions, see previous chapter [6] Frequency measured by search depth; value created related to Initiator and Strategist dimensions
[7] Related to a firm's affinity towards risk, experimentation and disruptive learning

3 firm profiles can be distinguished with respect to their future-related search activities

Technology and Innovation Management at Hamburg University of Technology

DETAILES IN THE FOLLOWING

	Local searcher	Focused searcher	Explorer
a Future-related search	▪ Search focused on areas **close** to the firm's **current knowledge base**	▪ **Balanced use** of external sources with moderate distance and diversity	▪ **Extensive use** of diverse and distant external sources
b Firm culture	▪ **Low affinity** towards risk-taking and experimentation	▪ Experimentation and **learning in new areas** strongly encouraged	▪ Risk-taking and experimentation as **integral part of the culture**
c Organization of foresight	▪ Future orientation **poorly institutionalized** in the organization	▪ **Advanced formalization** of foresight with dedicated resources	▪ Foresight activities **highly formalized** with significant resource investment
d Performance	▪ **Less value** derived from foresight ▪ **Lower** innovation and firm performance	▪ **High value** derived from foresight ▪ **Highest** innovation and firm performance	▪ **Highest value** derived from foresight ▪ **Above-average** innovation and firm performance
	▪ Majority of smaller (< 1,000 FTE) and Asian firms with this profile ▪ High perceived market dynamism[1]	▪ Majority of larger (≥ 1,000 FTE) and US firms with this profile ▪ Moderate to high perceived market dynamism[1]	▪ Large (≥ 5,000 FTE) and majority of European firms with this profile ▪ Very high perceived market dynamism[1]

[1] See Appendix for details

a Explorer with most diversified and distant future-directed search strategy

Technology and Innovation Management at Hamburg University of Technology

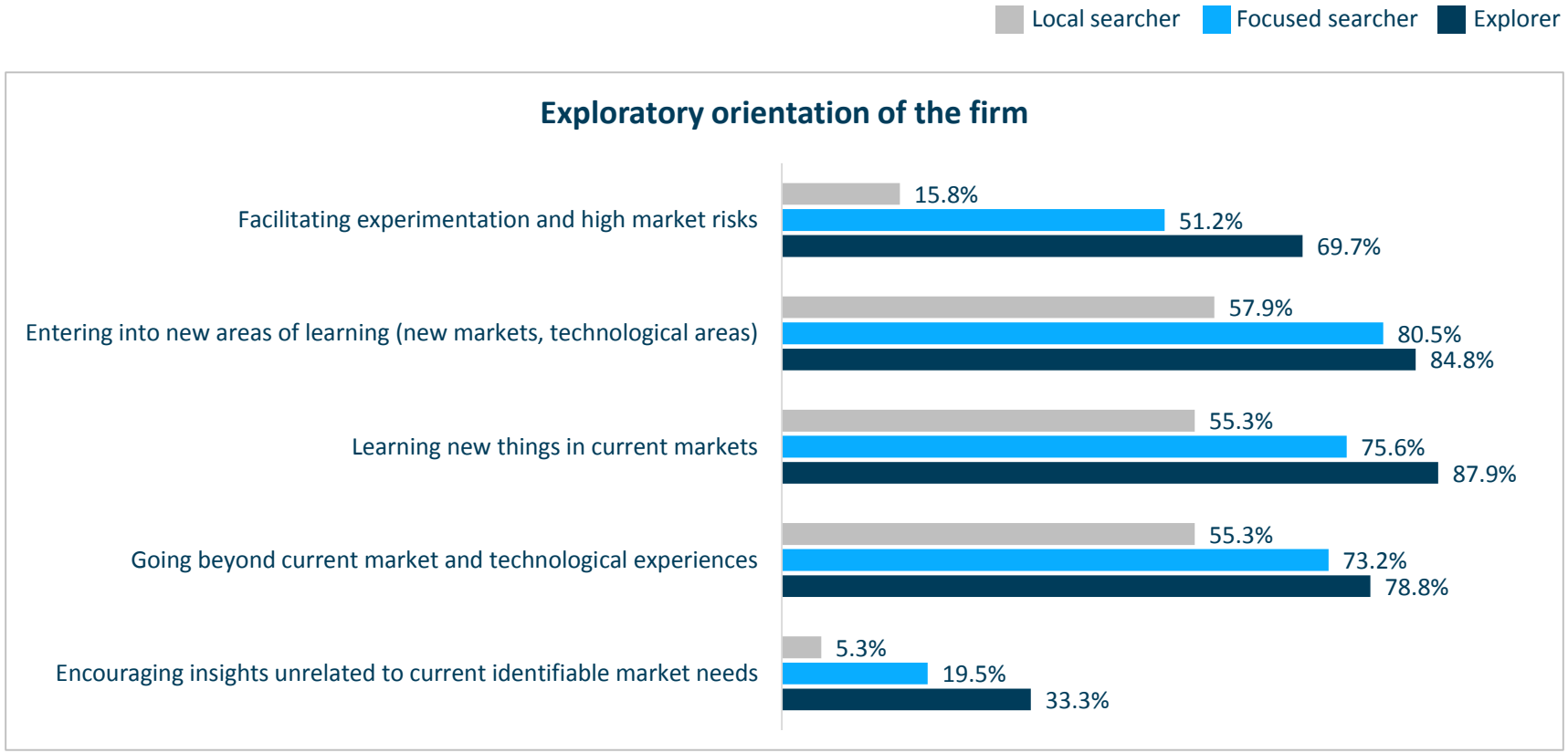
	Local searcher	Focused searcher	Explorer
Search profile[1]	▪ Search breadth ▪ Search depth ▪ Technol. distance ▪ Geogr. distance	▪ Search breadth ▪ Search depth ▪ Technol. distance ▪ Geogr. distance	▪ Search breadth ▪ Search depth ▪ Technol. distance ▪ Geogr. distance
Top 5 knowledge sources	Clients, customers, users (76.3%) Scientific journals, publications (68.4%) Conferences, trade fairs, exhibitions (65.8%) Suppliers (50.0%) Public databases, mass media (50.0%)	Clients, customers, users (70.7%) Conferences, trade fairs, exhibitions (68.4%) Competitors (53.7%) Scientific journals, publications (48.8%) Experts, consultants (46.3%)	Conferences, trade fairs, exhibitions (96.7%) Clients, customers, users (90.9%) Competitors (87.9%) Professional, industry or trade associations (87.9%) Scientific journals, publications (87.9%) Public databases, mass media (87.9%)

N = 112; Answers “often” and “frequently”

[1] Dimensions: breadth (number of different sources used), depth (frequency of search), technological distance (own/foreign industries searched), geographical distance (own/foreign geographical areas searched)

b Explorer and Focused searcher encourage risk-taking and value disruptive knowledge

Technology and Innovation Management at Hamburg University of Technology



- Focused searcher and Explorer with **high degree of exploratory orientation**: firms with this profile strongly facilitate experimentation, risk-taking and disruptive knowledge gathering
- Firms with a **local search profile** show a lower level of exploratory orientation, especially for taking risks related to disruptive opportunities

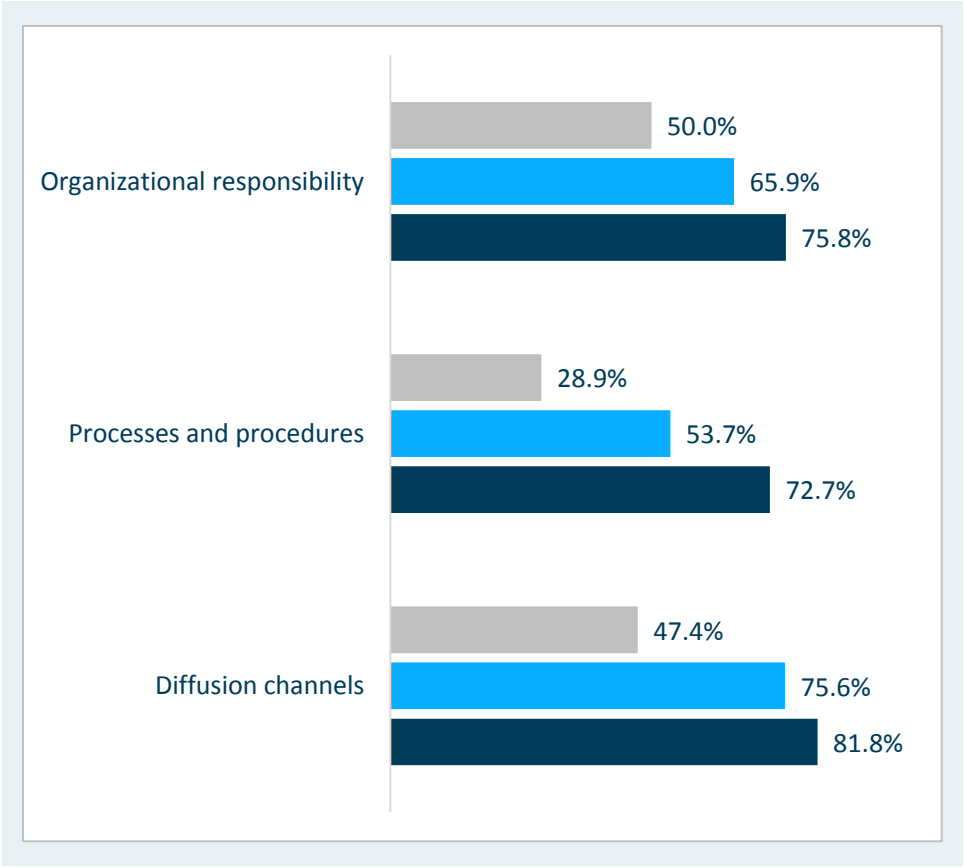
N = 112; Answers “agree” and “strongly agree”

c Explorer firms invest more resources and have formalized foresight activities

Technology and Innovation Management at Hamburg University of Technology

Local searcher | Focused searcher | Explorer

Formalization of foresight activities



Local searcher

- **Low formalization** of foresight: < 50% with formal organization, processes and channels
- **< 5 FTE** dedicated to foresight activities

Focused searcher

- **Medium formalization** of foresight: 50-70% with formal organization, processes and channels
- **< 5 FTE** dedicated to foresight activities

Explorer

- **High formalization** of foresight: > 70% with formal organization, processes and channels
- **5+ FTE** dedicated to foresight activities

N = 112; Answers “agree” and “strongly agree”

d While the Focused searcher and Explorer realize highest value from foresight...

Technology and Innovation Management at Hamburg University of Technology

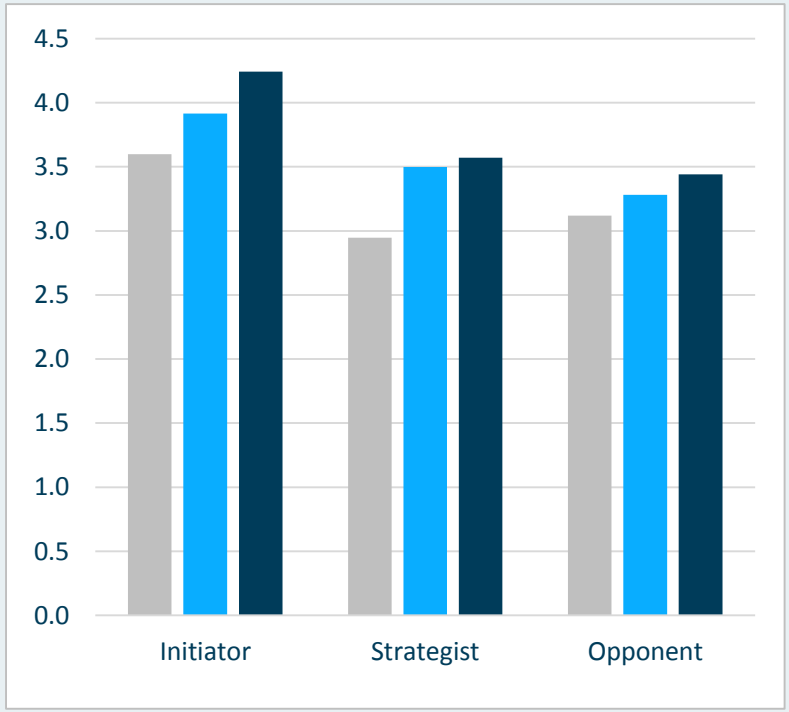
Local searcher | Focused searcher | Explorer

Key insights

- Firms with an Explorer or Focused searcher profile create **highest value** from foresight **in all three value dimensions**
- Searching **broad, intensively and in distant areas** allows these firms to gain access to superior knowledge on future developments
- In addition, in order to **transform the newly generated knowledge into real value**, Explorers and Focused searchers have formalized foresight activities and an exploration-oriented culture
- On the contrary, **Local searchers gain less value** as they restrict their future-directed activities to the **near environment** and **lack a strong future orientation** in the structures and culture of the organization

Value derived from foresight[1]

Mean degree of agreement[2]



N = 112

[1] Value related to Initiator, Strategist and Opponent dimension, see previous chapter

[2] Scale: 0 = “strongly disagree” to 5 = “strongly agree”

d ...the Focused searcher outperforms the Explorer for overall innovation performance

Technology and Innovation Management at Hamburg University of Technology

Key insights

- For innovation performance the **Focused searcher even outperforms the Explorer** even though both perform equally well with respect to value realized from foresight activities
- Potential reason: Explorer **firms perceive higher market dynamism** leading to increased demands on successful innovations
- Moreover, **Explorer search profile comes with high costs** related to identifying and processing diverse external knowledge: firms might not be able to effectively transform this knowledge into successful innovations due to lack of capability or resources
- **Local searchers lags behind** with respect to overall innovation performance: high perceived market dynamism not sufficiently addressed by future-directed activities

Innovation performance

% of successful innovating firms[1], per innovation type

N = 112

[1] Firms with ≥ 5% of total annual sales accounting for new products/services that are new to the world or market, new to the firm, or significantly improved

To stay ahead of future trends, firms need to address profile-specific risks

Technology and Innovation Management at Hamburg University of Technology

	Local searcher	Focused searcher	Explorer
Benefits	▪ **Low costs** for searching and integrating diverse future-related information ▪ **Reinforcement of the firm's current position** due to strong search focus on near environment	▪ **Highly efficient** future-directed activities balancing costs with derived value ▪ Focused broad and distant search strategy enables to **prepare for future** developments early	▪ Strong **exploratory nature** of search facilitates the detection of future developments even in **far distant** areas ▪ **Risk of overlooking** important signals **minimized**
Risks	▪ Local search focus leads to **blind spots** outside the firm's current focus increasing the risk of missing important future developments	▪ **Disruptive threats** emerging from very distant areas may be overlooked due to focused search strategy	▪ **High costs**: organization may not be **capable of effectively managing** diverse and distant knowledge generated by foresight
Way forward	▪ **Improve future-related search activities** to cope with high market dynamism ▪ Promote **institutionalization of foresight** in the organization and **foster future-oriented mindset** to increase value derived from foresight	▪ Establish **mechanisms to ensure early detection** of potential disruptions ▪ Supplement focused search strategy with **selectively searching** in the far distant areas for emerging threats	▪ Strengthen organizational **structures and capabilities** to process identified new knowledge ▪ Ensure to **effectively trans-form insights** from foresight into innovation output to increase overall performance

Based on the firm's current focus and demands, the future search profile should be defined

Technology and Innovation Management at Hamburg University of Technology

Diagnosis of current state

1 Determine your firm's current search profile

- How does your firm currently search for future-related information and how is foresight institutionalized in the structures and culture of your organization?

2 Assess your firm's market environment

- How dynamic is the market your firm is positioned in and how does this affect the need to anticipate future developments?

3 Define your firm's innovation strategy

- What is the aspiration for generating future innovations with respect to innovation type (radical vs. incremental) and innovation timing (first mover vs. follower) and how does this affect the need to anticipate future developments?

Definition of future state

1 Define your firm's future search profile taking into account:

- Related costs: Capabilities and resources that need to be invested or developed
- Targeted outcome: Value that your firm strives to realize from foresight
- Risks related to the future search profile

2 Implement steps to achieve future state

- Adjust search activities and foresight orientation within your organization
- Mitigate risks associated with the future search profile

Open Foresight

Research project of TUHH, UHH, and HSU
Sponsored by City of Hamburg, Ministry of Science and Research

WEB http://openforesight.org

M.Sc. Sara Polier (née Heuschneider)

Institute for Technology and Innovation Management
Hamburg University of Technology (TUHH)
TEL +49 40 42878-3836 • FAX +49 40 42878-2867

MAIL sara.polier@tuhh.de
WEB http://www.tuhh.de/tim

References (1/2)

Ansoff, H.I., 1975. Managing strategic surprise by response to weak signals. *California Management Review*, 18(2), pp. 21-34.

Battistella, C., 2014. The organisation of corporate foresight: A multiple case study in the telecommunication industry. *Technological Forecasting and Social Change*, 87, pp. 60-79.

Bierly, P.E., Daly, P.S., 2007. Alternative knowledge strategies, competitive environment, and organizational performance in small manufacturing firms. *Entrepreneurship Theory and Practice*, 31(4), pp. 493-516.

Capaldo, A., Messini Petruzzelli, A., 2015. Origins of knowledge and innovation in R&D alliances: A contingency approach. *Technology Analysis and Strategic Management*, 27(4), pp. 461-483.

Chiang, Y.-H., Hung, K.-P., 2010. Exploring open search strategies and perceived innovation performance from the perspective of inter-organizational knowledge flows. *R&D Management*, 40(3), pp. 292-299.

Cruz-González, J., López-Sáez, P., Navas-López, J.E., Delgado-Verde, M., 2014. Directions of external knowledge search: Investigating their different impact on firm performance in high-technology industries. *Journal of Knowledge Management*, 18(5), pp. 847-866.

Dahlander, L., O'Mahony, S., Gann, D., 2014. One foot in, one foot out: How does individuals' external search breadth affect innovation outcomes? *Strategic Management Journal*, 37(2), pp. 280-302.

Day, G.S., Schoemaker, P.J.H., 2004. Driving through the fog: Managing at the edge. *Long Range Planning*, 37(2), pp. 127-142.

European Commission 2015. *EU Industrial R&D Investment Scoreboard*. Available online: http://iri.jrc.ec.europa.eu/scoreboard.html/

Ferreras-Méndez, J.L., Newell, S., Fernández-Mesa, A., Alegre, J., 2015. Depth and breadth of external knowledge search and performance: The mediating role of absorptive capacity. *Industrial Marketing Management*, 47, pp. 86-97.

Horton, A., 1999. A simple guide to successful foresight. *Foresight*, 1(1), pp. 5-9.

Katila, R., Ahuja, G., 2002. Something old, something new: A longitudinal study of search behavior and new product introduction. *Academy of Management Journal*, 45(6), pp. 1183-1194.

Laursen, K., Salter, A., 2006. Open for innovation: The role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal*, 27(2), pp. 131-150.

Leiponen, A., Helfat, C.E., 2010. Innovation objectives, knowledge sources, and the benefits of breadth. *Strategic Management Journal*, 31(2), pp. 224-236.

Leonard-Barton, D., 1995. *Wellsprings of knowledge: Building and sustaining the sources of innovation*. Boston, MA: Harvard Business School Press.

References (2/2)

Levitt, B., March, J.G., 1988. Organizational learning. *Annual Review of Sociology*, 14, pp. 319-340.

Lopez-Vega, H., Tell, F., Vanhaverbeke, W., 2016. Where and how to search? Search paths in open innovation. *Research Policy*, 45(1), pp. 125-136.

March, J.G., 1991. Exploration and exploitation in organizational learning. *Organization Science*, 2(1), 71-87.

Martin, B.R., Irvine, J., 1989. *Research foresight: Priority-setting in science*. London, New York: Printer Publishers.

Martin, X., Mitchell, W., 1998. The influence of local search and performance heuristics on new design introduction in a new product market. *Research Policy*, 26(7-8), pp. 753-771.

Prahalad, C.K., 2004. The blinders of dominant logic. *Long Range Planning*, 37(2), pp. 171-179.

Rohrbeck, R., Gemünden, H.G., 2011. Corporate foresight: Its three roles in enhancing the innovation capacity of a firm. *Technological Forecasting and Social Change*, 78(2), pp. 231-243.

Rohrbeck, R., Mahdjour, S., Knab, S., Frese, T., 2009. *Benchmarking report: Strategic foresight in multinational companies*. European Corporate Foresight Group. Available online: http://ssrn.com/abstract=1470050/

Rohrbeck, R., Schwarz, J.O., 2013. The value contribution of strategic foresight: Insights from an empirical study of large European companies. *Technological Forecasting and Social Change*, 80(8), pp. 1593-1606.

Rollwagen, I., Hofmann, J., Schneider, S., 2008. Improving the business impact of foresight. Technology Analysis & Strategic Management, 20(3), pp. 337-349.

Rosenkopf, L., Almeida, P., 2003. Overcoming local search through alliances and mobility. *Management Science*, 49(6), pp. 751-766.

Rosenkopf, L., Nerkar, A., 2001. Beyond local search: Boundary-spanning, exploration, and impact in the optical disk industry. *Strategic Management Journal*, 22(4), pp. 287-306.

Slaughter, R.A., 1997. Developing and applying strategic foresight. *ABN Report*, 5(10), pp. 13-27.

Sofka, W., Grimpe, C., 2010. Specialized search and innovation performance – Evidence across Europe. R&D Management, 40(3), pp. 310-323.

Wagner, S., Hoisl, K., Thoma, G., 2014. Overcoming localization of knowledge – The role of professional service firms. *Strategic Management Journal*, 35(11), pp. 1671-1688.

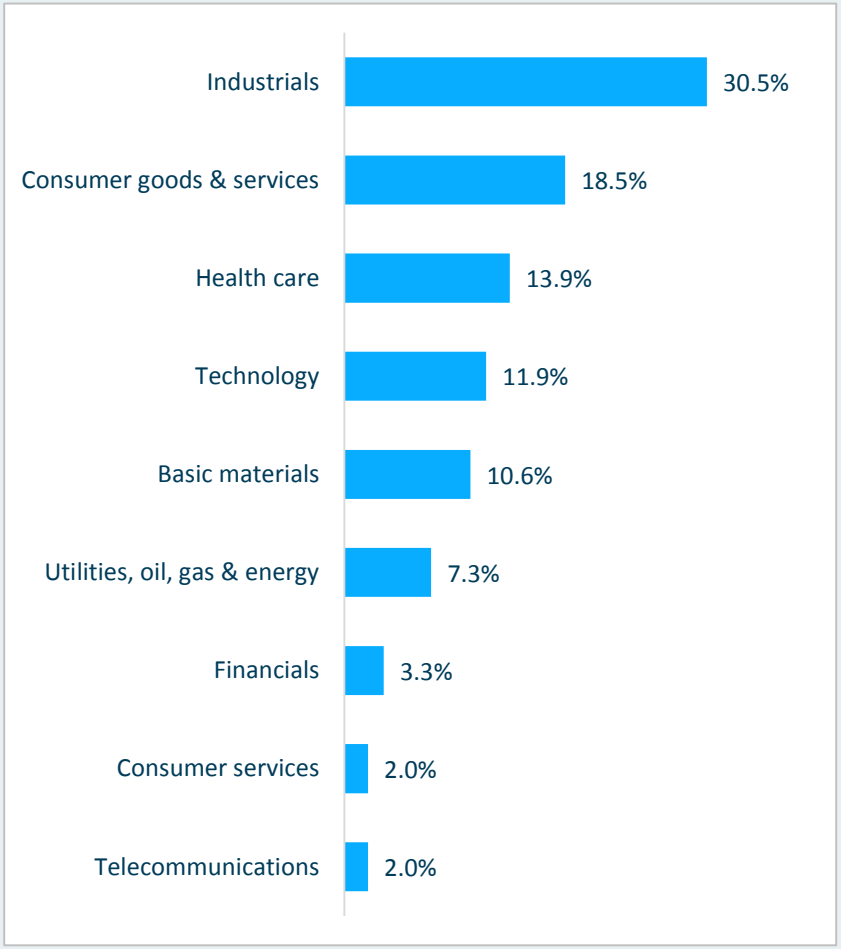
Whitehead, A.N., 1967. *Adventures of ideas*. New York, London: The Free Press.

APPENDIX

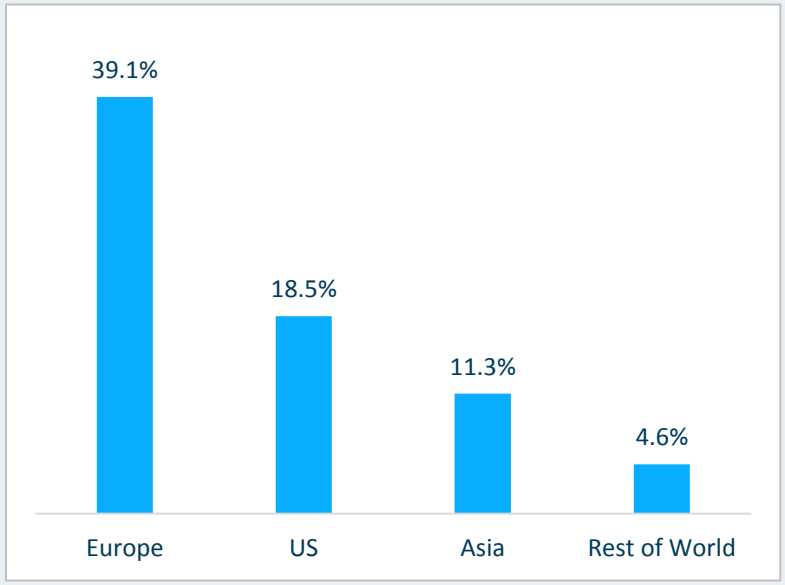
Large proportion of participating firms are located in Europe and the industrials sector

Technology and Innovation Management at Hamburg University of Technology

Industry distribution of participating firms



Geographic distribution of participating firms



- **Industry distribution representative** compared to R&D Scoreboard[1] distribution; Technology sector slightly underrepresented
- **European firms overrepresented** due to study focus; **Asian firms underrepresented** due to participation restrictions

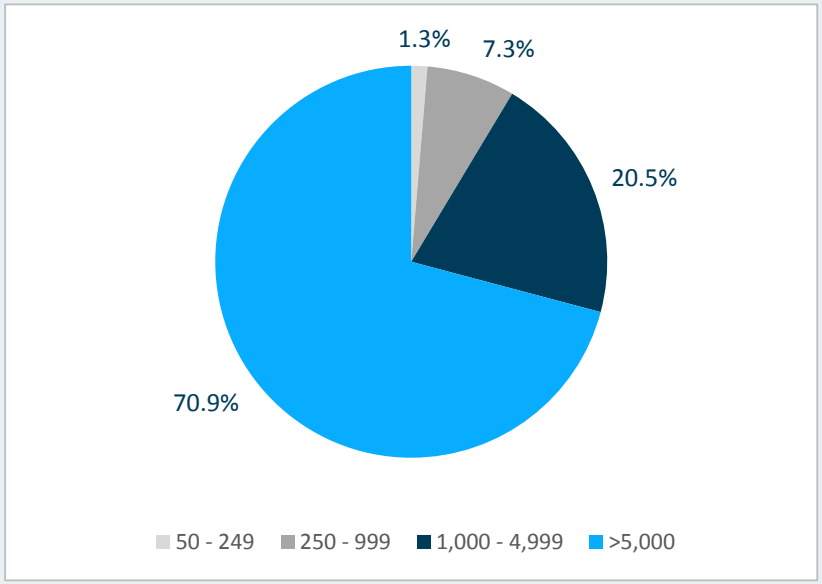
N = 151; Missing answers omitted
[1] Annual EU Industrial R&D Investment Scoreboard

Focus of study lies on large and mature firms

Technology and Innovation Management at Hamburg University of Technology

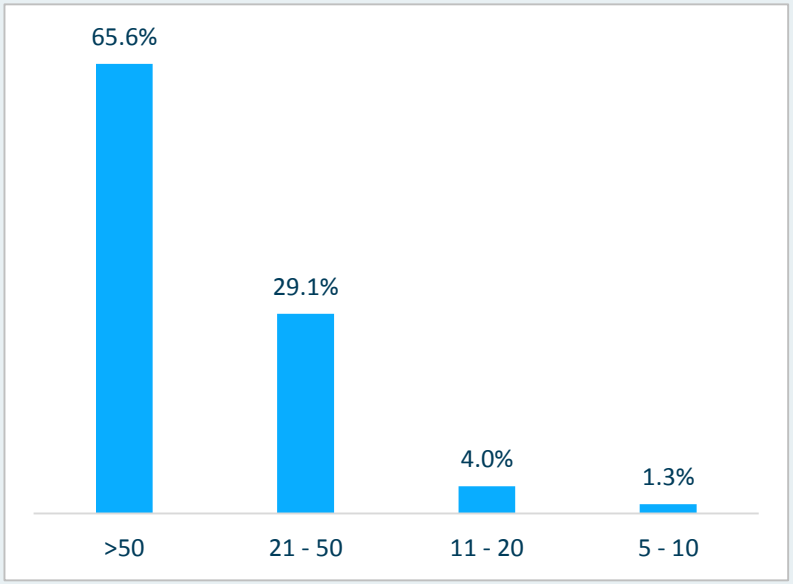
Size of participating firms

Number of employees



Age of participating firms

Number of years operating in primary market



- Focus on **large and mature firms** (> 5,000 employees and > 50 years in the market) as these are more likely to conduct high degree of systematic external search activities to identify future developments[1]
- **Smaller and younger firms** typically **differ significantly** from larger and mature firms in terms of culture, organization and resource availability[2]

N = 151

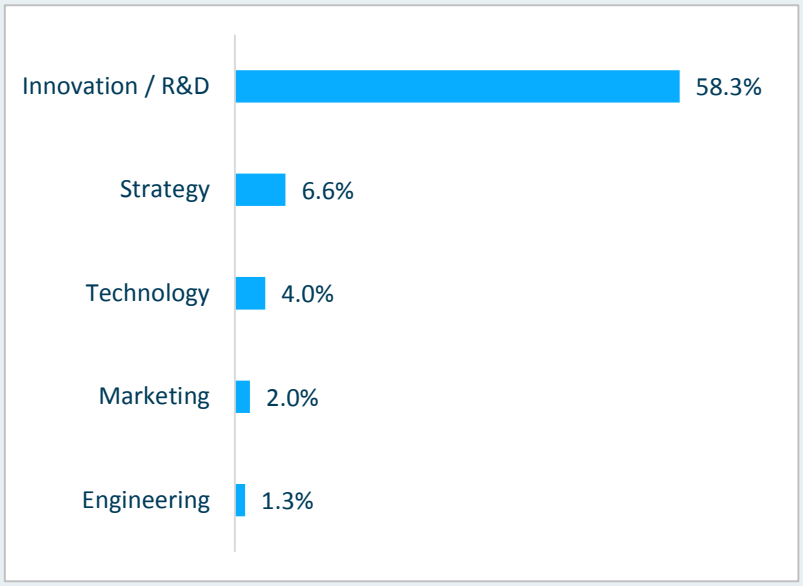
[1] Cruz-Gonzalez et al. 2014; Foss et al. 2011; Rohrbeck & Schwarz 2013

[2] Cruz-Gonzalez et al. 2014; Zahra & Bogner 2000; Zahra & Nielsen 2002

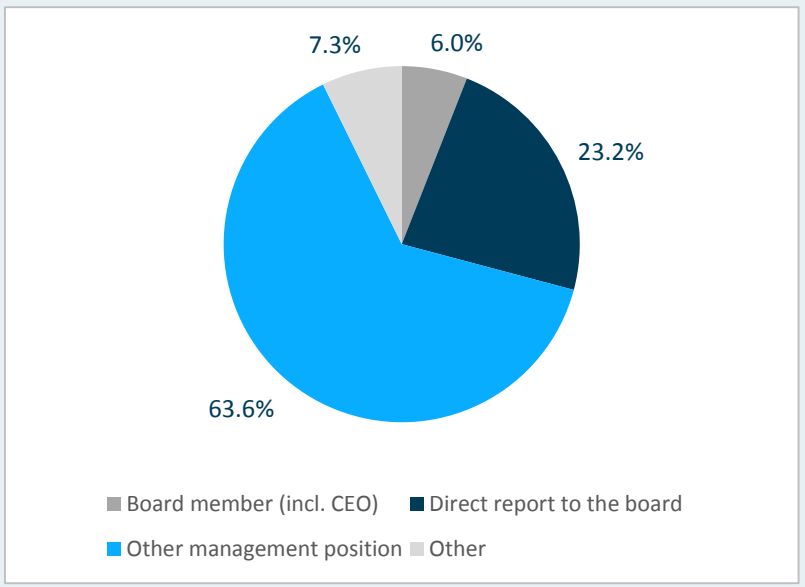
Majority of respondents positioned in innovation/R&D function of the firm

Technology and Innovation Management at Hamburg University of Technology

Functional affiliation of respondents



Position of respondents



Gender of respondents

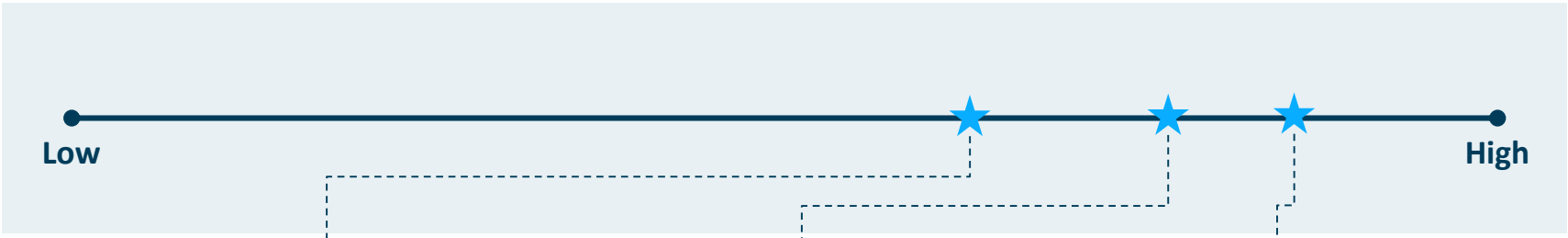
Tenure of respondents with firm

N = 151; Missing answers omitted

Market dynamism is perceived highest for Explorer and lowest for Focused searcher

Technology and Innovation Management at Hamburg University of Technology

Perceived market dynamism



Focused searcher

- Moderate to high demand for new products or services (73.2%)
- Changes in the market environment and volume demand less intensive[1]

Local searcher

- High demand for new products/services (79.0%) and intensive environmental changes (63.2%)
- Volume demand for products/services relatively stable[2]

Explorer

- High perceived market dynamism
- Continuous changes in the market (81.8%) and high demand for new products/services (81.8%)

N = 112; Answers “agree” and “strongly agree”

[1] Only 31.7% of firms in this cluster perceive environmental changes as intensive, while 41.5% state that volume demand changes fast and often

[2] Only 29.0% of firms in this cluster experience frequent changes in volume demand