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Interactive learning or R&D: How do small and medium-sized enterprises generate innovations?

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Relatively little is known about the ways in which small and medium-sized enterprises (SMEs) generate their innovations. A study conducted in collaboration with the ifh Göttingen demonstrates that SMEs can be divided into three types of innovators based on the approach they adopt to generating innovations.

The first group of innovators draws on a significant amount of industry-specific practical knowledge for their innovative activity, whereas own research and development (R&D) hardly plays a role. These companies put relatively little effort into innovation. This is true in monetary terms but also with regard to innovation-relevant interactions within the company and with the business environment. Major innovative impetus comes from suppliers, trade fairs and trade publications.

The second group of small and medium-sized innovators is characterised by high innovation expenditure, only a small portion of which, however, consists of R&D. To this end, these innovators mainly draw on their sales market as a source for innovation. These enterprises also learn from a wide range of internal interactions and a well-developed in-house error management culture.

The third group of innovators innovates primarily on the basis of own R&D and scientific findings. They also use information from the business environment, intensive in-company knowledge exchange, a pronounced error management culture and management practices aimed at stimulating innovation activity.

Economic-policy measures need to take this heterogeneity into account. This is because enterprises that currently only have limited R&D skills, in particular, are likely to benefit little from R&D promotion. Rather, these enterprises need support to improve their capacities for integrating new technologies into their operations instead of generating new scientific-technical findings themselves. Improving the capacity to incorporate external expertise, intensifying in-company collaboration, developing an innovation-friendly error management culture within the company and expanding management practices that stimulate innovation are likely to be good starting points.

Innovation is regarded as an important mechanism of an enterprise to position itself vis-a-vis its competitors. This also applies to small and medium-sized enterprises (SMEs). Numerous studies demonstrate that innovative SMEs are more successful than their non-innovative counterparts. They grow faster and achieve higher returns, for example. Innovations introduced by SMEs are also important from a macroeconomic perspective. SMEs include many enterprises that play a pioneer role in their market segment. The bulk of innovative SMEs contribute to diffusing new technologies across the economy.

However, in what ways SMEs generate innovations is only rarely the topic of public debate. Rather, discussions focus almost solely on the role of R&D[1] for innovation activity. But they overlook the fact that many innovative SMEs do not conduct any R&D of their own but acquire the knowledge necessary for innovations in other ways.

In the 2017 survey, the KfW SME Panel raised a number of questions that allowed the ways in which innovations are generated to be studied in detail.[2] In the following analysis, the SMEs that were studied[3] were divided into groups based on how they proceeded in generating innovations. The classification in this investigation was made according to the external sources of expertise they use, the intensity of collaboration within the enterprise in the innovation process and whether they conduct R&D themselves. In a further study we examine how successfully the identified innovator types develop in terms of turnover, headcount and productivity.[4]

Two modes of innovation

The economic literature distinguishes between two different modes of generating innovations.[5] The first mode is based on R&D, which is typically performed by dedicated departments (R&D departments) within the company. It involves generating new scientific-technical knowledge with the aid of systematic and formalised activities. This new knowledge – supplemented where necessary by partnerships with external research institutes – forms the basis for generating innovations in the R&D-oriented mode. It carries the label ‘Science, Technology and Innovation (STI) mode’.

The second mode, by contrast, is based on experiential skills acquired through ‘Learning by Doing, Using and Interacting’

(DUI mode). Given the key importance of practical skills, informal processes of learning and understanding dominate here in the generation of innovations. Innovations result from the normal production process or from close interaction by the employees within the enterprise or with the business environment. The ability to generate innovations therefore is strongly based on accumulated, practical and personal experiential knowledge. In practice, however, enterprises do not concentrate solely on any particular mode of generating knowledge but often combine elements of both types of innovation, as illustrated by the findings of the study.

Three types of innovators

In the following, we analyse on the basis of the KfW SME Panel the different innovator types that exist among SMEs and the ways in which they apply the two innovation modes. First, the responses received from the enterprises are condensed with the aid of statistical methods and different groups of innovators are then identified (box: 'Dataset and methodology'). The analysis arrived at the conclusion that three groups of innovators can be distinguished among SMEs based on the ways in which they create innovation-relevant knowledge. These enterprise types can be labelled 'innovators specialising in industry expertise' (Type 1), 'sales market oriented innovators' (Type 2) and 'innovators that combine the STI and DUI mode' (Type 3).

The first innovator type ('innovators specialising in industry expertise') uses a high degree of industry-specific practical knowledge for their innovation activity which essentially comes from suppliers, trade fairs and trade publications. Own R&D, by contrast, hardly plays a role for their innovations, so this innovator type can be assigned to the DUI mode. Enterprises of this type make relatively little effort to innovate, both in monetary terms and in regard to the interactions within the enterprise and with its business environment.

The second group of innovators ('sales market-oriented innovators') is characterised by high innovation activity but only a small portion of it is R&D. To this end, these innovators mainly use their customers as a source for innovation. Besides, these enterprises learn from a wide range of internal interactions and a well-developed in-house error management culture. This type can also be assigned to the DUI mode, although these enterprises have certain STI skills.

Box: Dataset and methodology

The analysis is based on the 15th survey wave of the KfW SME Panel. In this survey, a large amount of information was collected on the ways in which innovations are generated. The survey included enterprises with fewer than 500 employees that introduced product or process innovations in the past three years.

In a first step, the responses received from the enterprises on external sources of knowledge used for innovation activity were grouped together with a factor analysis. The factor analysis arrived at the conclusion that the surveyed sources can be grouped into three factors (Table A-1). These are the factors 'industry-specific expertise', 'knowledge of customers and competitors' and 'scientific findings'. The questions on intra-company exchange were also grouped with a factor analysis. This resulted in the factors 'learning from the collaboration of persons within the enterprise or within a department' and 'learning from the collaboration between departments' (Table A-2).

In a second step, the results of the factor analysis were entered into a cluster analysis together with the information whether the enterprises conduct own R&D. The results of the cluster analysis are the three innovator types presented here (Table A-3). The cluster analysis comprised 2,776 observations.

The third innovator type ('innovators combining the STI and DUI mode') builds their innovations essentially on own R&D and scientific findings. They also use information from the business environment (e.g. research facilities), intensive intra-company knowledge exchange, a pronounced error management culture and management practices. This type of enterprise thus combines knowledge generated through the STI mode with the approach followed under the DUI mode.

A group of SMEs that use the STI mode exclusively, however, could not be identified. The three identified innovator types can be described in detail as follows:

Innovators specialising in industry expertise

What characterises 'innovators specialising in industry expertise' (Type 1) is that they primarily use practical industry expertise for their innovations which comes from suppliers, visits to trade fairs and trade publications (Overview 1). This group rarely uses customers and competitors ('knowledge from the sales market') and research facilities, R&D service providers or consulting firms (summarised as 'scientific findings') as a source of information for generating innovations (Figure 1).

Overview 1: Characteristics of innovators specialising in industry expertise (Type 1)

Extensive use of practical industry knowledge
Little use of scientific findings and information from the sales market
Little exchange within the enterprise
Below-average innovative intensity
Rarely conduct own R&D
Infrequent use of management practices aimed at stimulating innovation
Underdeveloped error management culture
Skilled workers as basis of qualification
Likely to be small enterprises with fewer than ten employees
Often construction firms and retailers

The interaction of the employees within the enterprise is also less intense than in the other types of enterprises (Figure 2). These enterprises also rarely conduct R&D activities of their own (Figure 3). Accordingly, their R&D expenditure as a percentage of annual turnover is also very low (Figure 4). Typical elements of the STI mode can therefore hardly be found in enterprises of this cluster.

What also plays a role for innovation activity is whether human resources management measures promote innovation, for instance in the form of incentives for introducing new ideas, through agreements on targets or organisational measures such as teamwork or innovation circles, or whether workers who are relevant to innovation are deliberately sought out, supported or kept within the enterprise in the long term. Not least, it is also important to what extent an enterprise has adopted an innovation-friendly 'error-management culture', that is, to what extent the willingness exists to venture into new territory and accept setbacks in the process. Management practices aimed at promoting innovation activity are less common than average in the first group of enterprises (Figure 5). They also have an underdeveloped error-management culture, as described above (Figure 6).

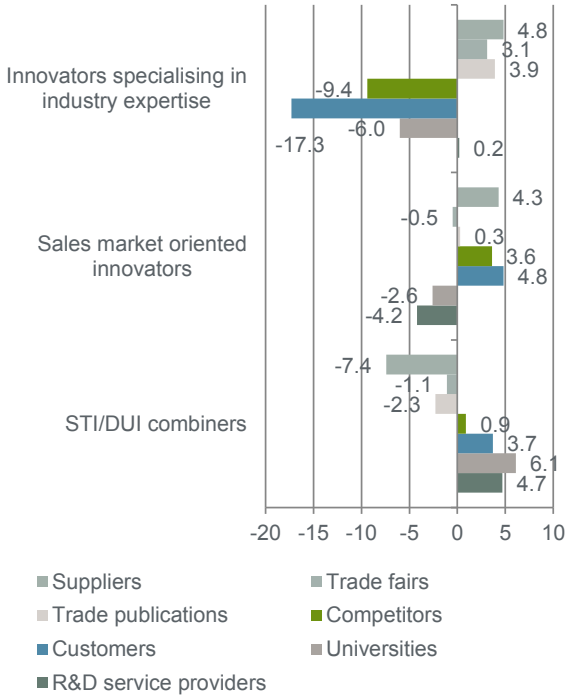
Overall, the enterprises in this cluster are characterised by relatively low innovation activity. This is also reflected in innovation intensity (innovation expenditure in relation to annual turnover), which is 2%, below the sample average. With regard to size and sector affiliation, the enterprises in this cluster usually have fewer than ten employees and are more likely to be construction firms and retailers than the average (no figure). The share of enterprises that do not employ graduates is particularly high in this group (Figure 7). Skilled workers with completed dual vocational training or advanced further training (e.g. master tradespeople or qualified technicians) thus form the skills basis for innovations in these enterprises. Enterprises of this type represent 19.9% of the sample.

Sales market oriented innovators

The group of sales market oriented innovators (Type 2) uses the knowledge of customers and competitors particularly often as a source of knowledge for innovation. At the same time, they use industry-specific expertise only with average intensity and scientific findings even less often than average – with the exception of suppliers (Figure 1). They prefer and make intensive use of an informal style of cooperation when it comes to innovation-related cooperation within the enterprise (Figure 2). This includes the cultivation of informal contacts within the enterprise, open communication of innovation ideas and strategies, the joint development of innovation targets and strategies, mutual support in the context of innovation projects and regular meetings of management staff, for example. But it is also rather uncommon for these enterprises to exchange staff across departments and hold joint workshops between departments. This also has to do with the small size of these enterprises. Overall, the intensity of innovation-related cooperation within these enterprises can be regarded as very high.

Figure 1: Use of external sources for innovation

Deviation of the share in the cluster from the share in the total sample in per cent



Source: KfW SME Panel, own calculations

Overview 2: Characteristics of sales market oriented innovators (Type 2)

Extensive use of customers' and competitors' knowledge
Little use of scientific findings
Lively informal exchange within the enterprise
High innovative intensity
Rarely conduct own R&D, low R&D intensity
Sporadic use of management practices to stimulate innovation
Distinct error management culture
Skilled workers as basis of qualification
Medium-sized SMEs with 10 to 49 employees
No particular concentration in economic sectors, but often crafts enterprises

Type 2 enterprises already undertake own R&D activities more often (38%) than Type 1 enterprises. However, at 1.1%, the R&D intensity of Type 2 is even lower than the average for the total sample. On the other hand, with an intensity of 4.2% (innovation expenditure as a percentage of turnover), innovation efforts in this cluster are nearly on the

same level as in the group of R&D-oriented STI/DUI combiners. This also means that large portions of innovation expenditure in this cluster do not represent R&D activities (Figures 3 and 4).

Management practices aimed at promoting innovation activity also tend to be rather uncommon in Type 2 enterprises, with the exception of non-material incentives such as providing creative time, assigning more demanding tasks or making commendations, as well as – within certain limits – delegating decision-making powers in the context of innovation projects (Figure 5). The error-management culture in enterprises in this cluster, however, is more developed than average and nearly as strong as in the group of STI/DUI combiners (Figure 6).

Enterprises in this cluster are typically medium-sized enterprises with ten to under 50 employees. No particular sectors are concentrated in this cluster, although it is worth noting that crafts businesses are more common than average in this group. The share of enterprises that employ workers with a university degree is slightly below the level for the overall sample. So here, too, it is primarily workers with vocational skills that form the skills basis for innovation activities in this group (Figure 7). These enterprises represent the largest group in the sample with 42.4%.

Innovators that combine the STI mode with the DUI mode

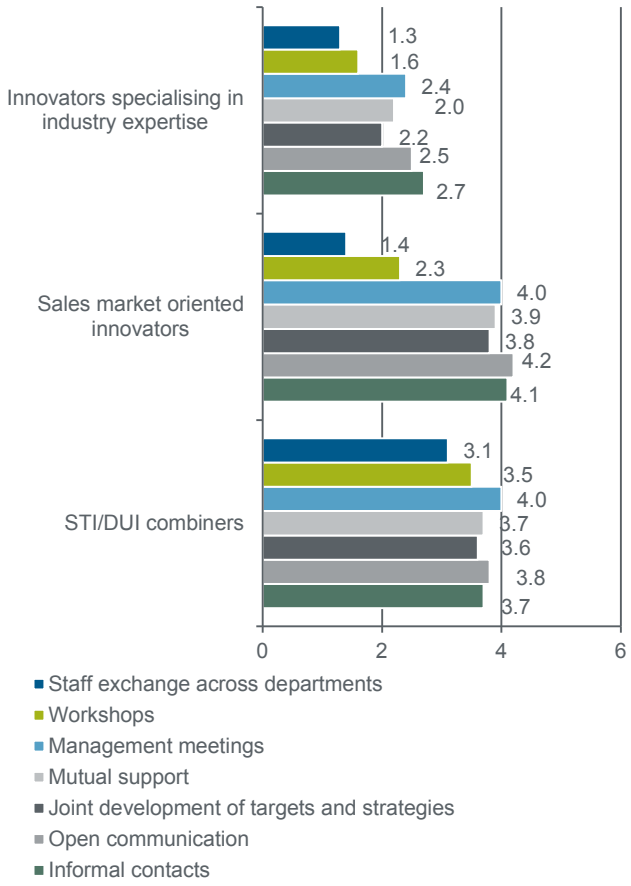
Innovator Type 3 is composed of enterprises that rely heavily on R&D for their innovations but make intensive use of elements of the DUI mode (Overview 3). Therefore, they can be labelled 'STI/DUI combiners'. They rely particularly on scientific findings (from universities, other research facilities and R&D service providers) as external sources of information. The sales market – especially customers – also plays an important role as a source of information for innovations. However, they use industry-specific expertise less often than average for their innovation activities (Figure 1).

Overview 3: Characteristics of STI/DUI combining innovators (Type 3)

Intensive use of scientific findings
Use of customers' and competitors' knowledge
Lively formalised exchange within the enterprise
High innovative intensity
Pronounced own R&D
Use of a wide range of management practices to stimulate innovation
Distinct error management culture
University graduates are an important driver of innovation
Medium-sized and large SMEs
Often manufacturers and service providers

Figure 2: Intensity of innovation-related cooperation in the enterprise

Degree of innovation-related cooperation, mean values

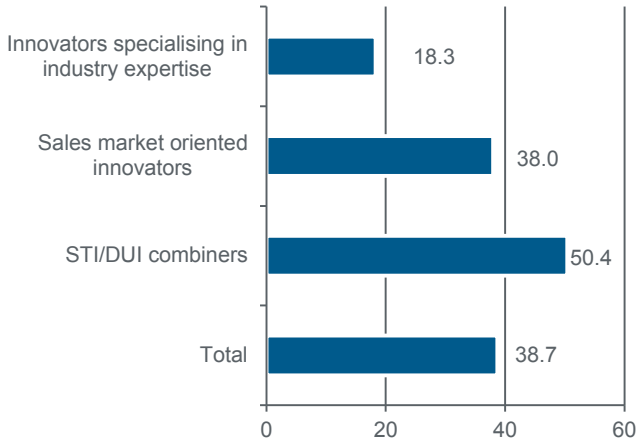


Note: Intensity given on a scale of 1 to 5 in the questionnaire, where 1 is very low and 5 is very high

Source: KfW SME Panel, own calculations

Figure 3: Innovators that conducted own R&D activities in the past three years

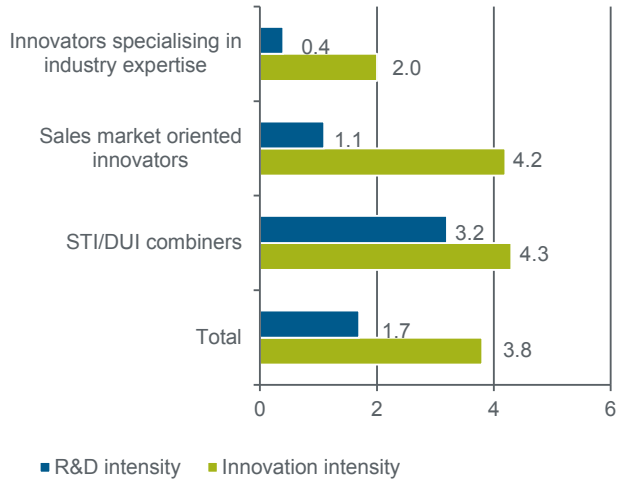
Shares in per cent



Source: KfW SME Panel, own calculations

Figure 4: Innovative and R&D intensity

Expenditure as a percentage of annual turnover



Source: KfW SME Panel, own calculations

Cooperation within enterprises of this type is mainly characterised by formalised modes of exchange between departments such as joint workshops or staff exchange. This probably also has to do with the fact that these are usually larger SMEs. They also make relatively heavy use of informal ways of cooperating, although their average intensity is lower than among sales market-oriented innovators (Figure 2).

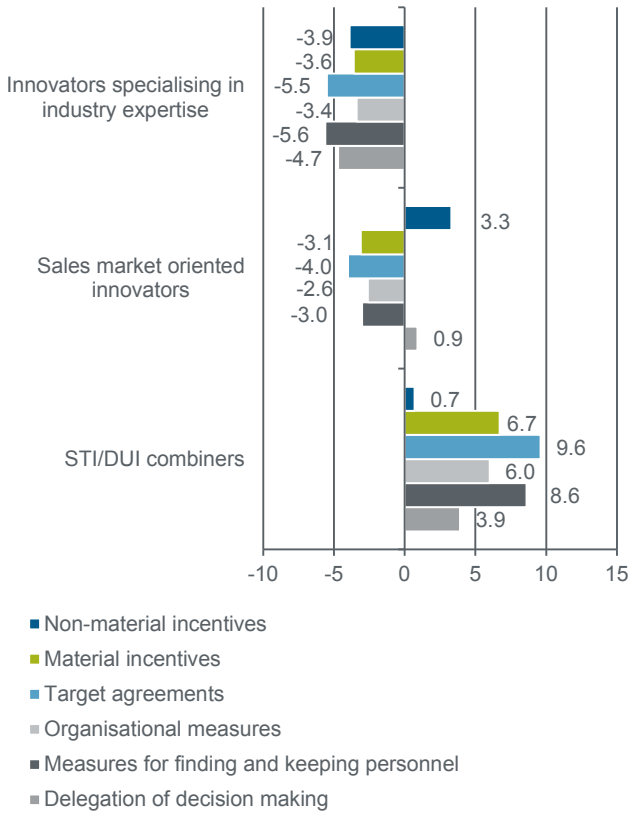
Enterprises in this cluster exert high innovation efforts. The intensity of innovation expenditure (as a percentage of annual turnover) is 4.3%, slightly higher than in sales market-oriented enterprises. However, innovation expenditure in this group is much more strongly characterised by R&D. At 3.2%, R&D intensity is significantly higher in this cluster than in the enterprises of the other two groups. This is probably a result of the 50% share of enterprises that conduct R&D of their own (Figures 3 and 4).

Enterprises in this group also use the surveyed management practices significantly more often than those in the other groups. Only the use of non-material incentives is just slightly more common than in the overall sample (Figure 5). Finally, with a score of 3.2, the enterprises in this group characterise their error management culture as similarly evolved as that of enterprises in the sales market oriented cluster (Figure 6).

Enterprises in this group tend to be larger SMEs with 50 or more employees. They belong primarily to the manufacturing or services sector. The share of enterprises that do not employ any graduates is well below the sample average. University graduates therefore play a key role in the group of STI/DUI combiners. These enterprises are 37.5% of the enterprises in the sample.

Figure 5: Use of management practices to stimulate innovation activity

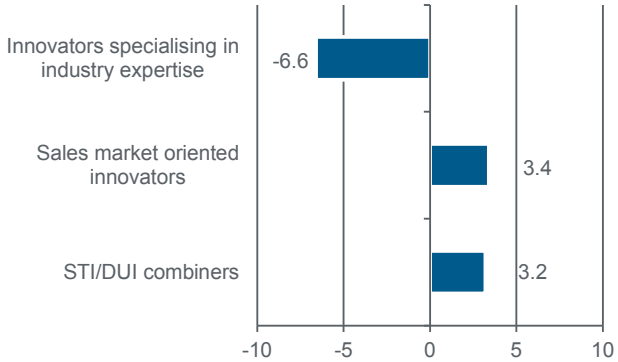
Deviation of the share in the cluster from the share in the total sample in per cent



Source: KfW SME Panel, own calculations

Figure 6: Error management culture in the enterprise

Deviation of the proportion of enterprises with a highly evolved error management culture in the cluster from their share in the total sample

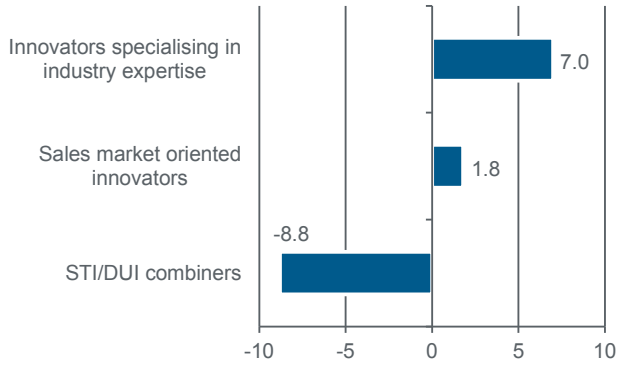


Note: The error management culture was surveyed on a scale of 1 to 5, where 1 is very high and 5 is very low. The error management culture is regarded as well-developed when it is given a score of 1 or 2.

Source: KfW SME Panel, own calculations

Figure 7: Enterprises that have no graduate employees

Deviation of the share in the cluster from the share in the total sample in per cent



Source: KfW SME Panel, own calculations

Conclusion

With respect to the use of external sources of information, in-company cooperation and the conducting of own R&D, three types of innovators can be identified in the SME sector. The first group of innovators uses a high degree of industry-specific practical knowledge for their innovation activity.

They can therefore be labelled 'innovators specialising in industry expertise'. The innovation activities undertaken by enterprises in this cluster are based on the practical experiential knowledge of owners and employees who have earned their skills in the vocational education and training system. Own R&D hardly plays a role for their innovation activity. These enterprises can therefore be assigned to the DUI mode. Overall, the enterprises in this cluster make relatively little effort to innovate. This is true in monetary terms – innovation expenditure as a percentage of annual turnover – but also applies to the interactions within the company and with the sales market or the research community. In-company cooperation on innovations is thus lower than average. Management practices aimed at stimulating innovation are also uncommon. Innovation activity is essentially limited to internalising inputs from suppliers, trade fairs and trade publications and using them for the company. This innovator type can be said to essentially contribute to diffusing innovations across the economy.

The second group of innovators is characterised by high innovation activity. However, only a small portion of their innovation expenditure consists of R&D. Instead, these innovators use a wider range of external sources. Customers and competitors are a particularly important source of knowledge, which is why we label this enterprise type 'sales market oriented innovators'. However, industry-specific practical knowledge also plays an important role for these enterprises. Moreover, these enterprises also learn from in-house interactions. Their informal in-house cooperation and error management culture in particular are highly evolved. These enterprises are thus characterised by the fact that their extensive interactions within the enterprise and with the business environment create (personal) practical knowledge on which they base their innovations. The fact that these enterprises' innovation activity is in part also based on their own R&D activities shows that they possess certain STI skills. But DUI skills clearly dominate innovation activity in this group. This is also evident from the fact that crafts businesses are relatively often in this group and that workers who acquired their skills in the vocational education and training system represent the key skills group for innovation in this group as well. The type of innovation activity allows the conclusion that enterprises in the second group can generate innovations from their own efforts and are capable of solving customer-specific problems as innovators.

The third group of innovators combines the approaches of the DUI and STI modes. They combine high innovation expenditure, a large portion of which consists of own R&D expenditure, with the use of external scientific findings but also with interactions that are typical of the DUI mode. Thus, learning from the sales market and from in-company cooperation – especially in a formalised exchange because of the larger enterprise size – plays an important role for these enterprises as well. University trained staff play a key role in generating innovations. In addition, the use of a wide range of management practices contributes to stimulating innovation activity. Not least, a pronounced error management culture is likely to promote innovation activity in these enterprises. The combination of STI and DUI elements in these enterprises' innovation activities suggests that they are innovation pioneers. They are likely to be among the usual technological leaders in their field.

The analysis illustrates that, with respect to innovation activity, SMEs are a very heterogeneous group. They differ greatly in the input they give to the innovation process and, hence, in the ways in which they build the knowledge they need for innovating. This also needs to be taken into account when planning economic-policy measures aimed at promoting innovation.

Today, innovation promotion in Germany is heavily concentrated on R&D.[6] That means the focus is being placed on the development and application of new, scientific-technical knowledge. Ambitious goals are being pursued in this respect, such as raising the share of R&D expenditure to 3.5% of GDP. Such a strategy appears to be necessary in order to secure Germany's technological leadership and expand into new fields of technology.

The STI skills of the innovators labelled 'innovators specialising in industry expertise' and the 'sales market oriented innovators' identified in this study, however, are relatively underdeveloped. They rely heavily on their DUI skills for their innovation activity. It can therefore be assumed that expanding the promotion of R&D is likely to have only a limited impact on stimulating innovation activity in these enterprises.

In the past years, however, innovators associated with the DUI mode in particular have discontinued their innovation activity.[7] So there is a need to strengthen the innovation activity of those innovators that innovate primarily by using the DUI mode. That means first and foremost improving their technological adaptation capacity and, thus, promoting the diffusion of innovations. This study provides possible starting points for economic policy and the enterprises themselves. With varying levels of intensity, approaches exist for improving the capacity to absorb external scientific-technical knowledge, strengthening in-company interactions, developing an innovation-friendly error management culture within the enterprise and adopting more targeted management practices that stimulate innovation. ■

Annex

Table A-1: Factor analysis on the use of external sources for innovation activity

	Factor 1	Factor 2	Factor 3
Customers, users, commissioning parties	-0.061	0.856	0.018
Competitors	0.379	0.660	-0.029
R&D service providers, management consulting and marketing firms	0.000	-0.409	0.592
Trade publications	0.759	0.031	0.093
Trade fairs	0.783	0.152	0.067
Suppliers	0.592	-0.232	-0.419
Universities and other research facilities	0.060	0.068	0.821
Generic name	Industry-specific expertise	Sales market	Scientific findings
Declared variance (in per cent)	24.1	20.3	17.3

Source: own calculations.

Table A-2: Factor analysis on the degree of innovation-oriented, in-company exchange

	Factor 1	Factor 2
Cultivating informal contacts	0.737	0.047
Open communication of important innovation-relevant ideas and strategies	0.846	0.099
Joint development of innovation targets and strategies	0.797	0.267
Mutual support in addressing problems in innovation projects	0.831	0.224
Regular meetings of management staff on innovation-relevant issues	0.702	0.316
Joint workshops on innovation projects	0.317	0.760
Staff exchange in the framework of innovation projects	0.073	0.866
Generic name	Learning from cooperation of persons within the enterprise or within a department	Learning from cooperation between departments
Declared variance (in per cent)	45.5	22.3

Source: own calculations.

Table A-3: Description of cluster solution

		Cluster			
	Total	(1)	(2)	(3)	Chi2
Use of external sources (above-average significance of factor in per cent)					
Industry-specific expertise	43.0	48.5	43.1	39.9	10.73
Sales market	57.0	38.3	62.0	61.3	98.51
Scientific findings	34.3	21.1	28.6	41.8	44.72
Degree of innovation-oriented, in-company exchange (factor values)					
Informal cooperation	0.0	-1.22	0.63	-0.03	1,293.53
Formalised cooperation	0.0	-0.54	-0.62	1.00	1,665.04
Own R&D (in per cent)	38.7	18.3	38.0	50.4	156.57
Percentage share in sample	100	19.9	42.6	37.5	
Cluster label		Innovators specialising in industry expertise	Sales market oriented innovators	STI/DUI combiners	

Source: own calculations.

[1] Cf. OECD (2015): Frascati Manual 2015. Guidelines for Collecting and Reporting Data on Research and Experimental Development, The Measurement of Scientific, Technological and Innovation Activities. OECD publishing, Paris.

[2] Cf. Thomä, J. and Zimmermann, V. (2019): Non-R&D, interactive learning and economic performance: Revisiting innovation in small and medium enterprises, ifh Working Paper No. 17/2019.

[3] In order to focus the analysis on small and medium-sized enterprises, companies with more than 499 employees were not included in the analysis.

[4] Cf. Zimmermann, V. and Thomä, J.: (2019): **Business performance of different types of small and medium-sized innovators**, Focus on Economics, KfW Research.

[5] Cf. Jensen, M. B., Johnson, B, Lorenz, E. and Lundval, B. A. (2007): Forms of knowledge and modes of innovation; Research Policy 36(5):680-693 and Thomä, J. (2017). DUI mode learning and barriers to innovation – A case from Germany. Research Policy 46 (7), 1327–1339.

[6] Cf. Rammer, C. and Schmitz, F. (2017): Fortentwicklung der EFI-Indikatorik: Förderlandschaft. Studien zum deutschen Innovationssystem (*Refining the set of indicators of the Commission of Experts for Research and Innovation: Promotional landscape. Studies on Germany's innovation system* – our title translation, in German only) No. 9-2017.

[7] Cf. Zimmermann, V. (2019): **KfW Innovation Report 2018 – Innovator rate has fallen again**, KfW Research.