



Advantages for the universities

Industrial PhD projects are completed in cooperation between a private enterprise, an Industrial PhD student and a university. Contrary to the regular PhD education, the university is not the only institution responsible for the educational process. Rather, the host enterprise has the ownership rights to the projects and the rights to the research results. Yet the university still has a central role as responsible for the specialist research quality aspects of the education through the advisory function and by being able to offer an academic environment for the Industrial PhD student. Therefore, it is interesting to discuss the advantages the Industrial PhD has for the universities. This Chapter analyses the effects the Industrial PhD programme has on the university networks and cooperation with the business world. This is done using a three-part method, which first examines the contributions the Industrial PhD programme has made to new knowledge and learning. Then the initiative's network effects for the universities are examined, and finally the Industrial PhD programme is evaluated in regards to knowledge sharing with other students at the university through tuition

The Industrial PhD programme contributes a great deal to creating new knowledge and new networks:

- ✓ *75 percent of university supervisors see progress in theoretical and practical skills through an Industrial PhD project.*
- ✓ *90 percent of university supervisors feel that the Industrial PhD programme frameworks and structures are beneficial to development of business-relevant knowledge at the universities.*
- ✓ *90 percent of university supervisors have seen their network with the business world strengthened through an Industrial PhD project.*
- ✓ *A little more than 70 percent of university supervisors have gained more insight into the research needs of the business world through the Industrial PhD project.*

6.1 Industrial PhD projects contribute new knowledge and education

It is very important for the universities that Industrial PhD projects contribute to promoting new knowledge and learning that can be applied on the campuses. Table 6.1 shows university supervisor assessments of the extent to which the Industrial PhD project has led to progress in theoretical and practical skills:

Table 6.1. Knowledge and learning at universities in percentages				
To what extent has the project led to...	A great deal	Some-what	Slightly	Not at all
Theoretical skills progress (n=171)	18.1	55.0	16.4	6.4
Practical experimental skills progress (n=172)	19.8	53.5	14.0	10.5
Source: Kvistgård Consult				

Table 6.1 shows that there is almost no difference in the responses for the two questions. With regards to theoretical and practical knowledge exchange, approximately one fifth of the university supervisors feel that progress has been made with skills, while almost half look at it more moderately. The Industrial PhD projects therefore have a positive effect on both theoretical and practical experimental knowledge sharing.

Positive effects can also be seen if the focus is turned to the development of the second type of knowledge, the business-relevant knowledge. Nine out of ten university supervisors feel that the Industrial PhD programme has frameworks and structures that create favourable conditions for sharing business-relevant knowledge at the universities. Of these, 41.3 percent of university supervisors agree completely that the frameworks and structures for the Industrial PhD programme are beneficial, while 49.1 state they agree partially.

This also illustrates that the business-relevant knowledge is not just built up in the enterprises, which is positive because that makes the universities more capable of conducting/contributing to business-oriented research and development.

Industrial PhDs are recognised as knowledge carriers

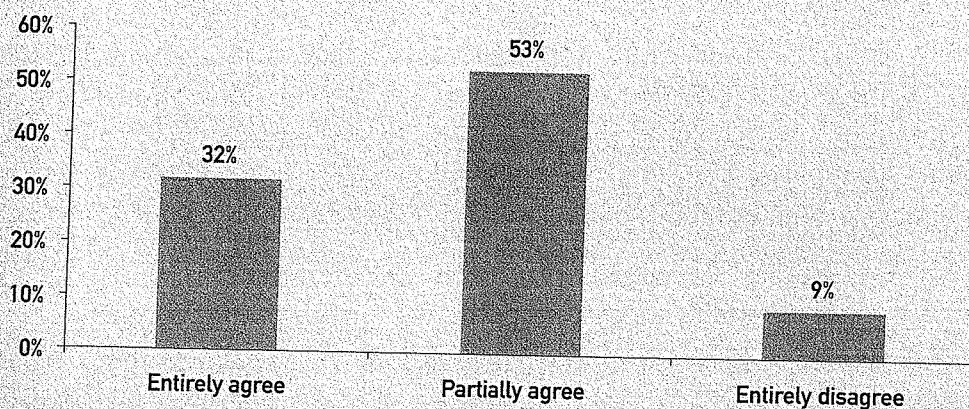
Compared to knowledge generation and learning, it is relevant to look at the employment options Industrial PhD candidates will have, as they can be regarded as a type of knowledge carrier. It is important that the advantages to hiring an Industrial PhD

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and applying their knowledge will not only go to the private business world, but the universities as well so both environments get specialised research input.

It is also important to the individual Industrial PhD candidate who needs the initiative to be recognised at the same level as the regular PhD education throughout the course of the candidate's career. But it is also important for the Industrial PhD programme's position as a research education that both enterprises and universities respect the candidates who successfully complete the programme.

Figure 6.1: Are Industrial PhD candidates better candidates?
A candidate from the project becomes more business-directed and thereby a better candidate after completion of the project? (n=156)



Note: The total is not 100% as 6.6% indicate "don't know"
Source: Kvistgård Consult

This circumstance can initially be analysed from university supervisor assessments of candidate qualifications.

As illustrated in Figure 6.1, the university supervisors have a very high opinion of the Industrial PhD candidate qualifications. Around 85 percent state that the Industrial PhD candidates work with the project and the focus on the business works strengthens their qualifications¹¹. Half state that they partially agree with the statement, which may be due to the fact that they feel that the Industrial PhD candidate qualifications are equal to those of other PhDs.

This altogether indicates that although the Industrial PhD candidates spend less time at the university, that does not mean that developing their research skills is given a

¹¹ The questioning was not precise. Therefore it is assumed that the supervisors have evaluated the Industrial PhD candidates against other PhD candidates but this is not entirely unambiguous. Therefore this should be viewed with some reservation.

lower priority. Therefore the universities may be interested in participating in the knowledge that is developed during the Industrial PhD candidate educational process, and which the candidate who successfully completed the programme can pass on to/further develop for the university.

The knowledge perspective can also be analysed using the options the Industrial PhD candidates will have for employment in research institutions and universities. Here it is interesting to examine university supervisor interest in recruiting the Industrial PhDs. Table 6.2 shows university supervisor assessments of the extent that an Industrial PhD is either better or less equipped than other PhDs to gain employment at the institution where that particular supervisor is employed¹²:

Table 6.2: Industrial PhD options for gaining employment at institutes	
Are Industrial PhD candidates better/less equipped to gain employment at your institution?	Share of enterprises (n=186) (n=164)
An Industrial PhD student is better equipped	4.3 %
They are equally equipped	75.0 %
An Industrial PhD student is less equipped	17.1 %
Note: This does not add up to 100 percent as 3.7 percent stated "Do not know"	
Source: Kvistgård Consult	

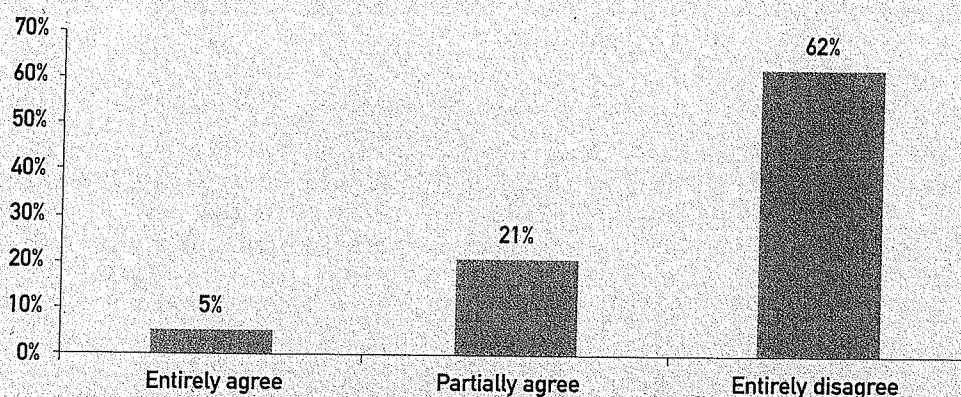
Table 6.2 shows that the vast majority of university supervisors are of the opinion that Industrial PhD candidates are equally suited to employment at their institute as other PhDs. 17.1 percent feel that Industrial PhD candidates are less equipped, which is a significant share. This indicates that not all universities feel – without reservation – that the Industrial PhD's qualifications are as relevant as all other PhDs. In contrast to this, a smaller share (4.3 percent) feel that Industrial PhDs are better equipped to work at the institute. This discrepancy may be due to the fact that the various institutes do not have the same work areas, and the business profile is therefore not equally relevant for them. In general, however, the Industrial PhDs are a qualified and relevant labour force for the universities on equal footing with all other PhDs who successfully complete a programme.

¹² It's not entirely clear if this reflects the university supervisors' own attitude towards the candidates' qualifications or if it conveys the university tutors' evaluation of enterprise related candidates in general by the institute.

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From a broader perspective, the university supervisors were asked in the questionnaire to evaluate if Industrial PhD candidates are less suited to work in research institutions than regular PhDs. The responses appear in Figure 6.2 below:

Figure 6.2: Industrial PhD candidate suitability for work in research institutions
A candidate from an Industrial PhD project is generally less suited to work in research institutions than other PhDs? (n=167)



Note: The total is not 100% as 11.4% indicate "don't know"

Source: Kvistgård Consult

Figure 6.2 shows the majority of the university supervisors (62 percent) dismiss the statement that Industrial PhDs are less suited for employment in research institutions. 21 percent agree partially, which is a relatively large share, while only a very small group agree completely with the statement.

Therefore, universities and research institutions are generally interested in hiring Industrial PhDs and applying their knowledge and experience.

In relation to the intention that Industrial PhD projects should contribute new knowledge and learning, it can be summarised as follows – the Industrial PhD programme contains very positive aspects. The projects contribute both theoretical and practical experimental knowledge at the universities, and there is broad satisfaction with the opportunities to share business-relevant knowledge at these research institutions. By regarding Industrial PhDs as knowledge carriers, the learning level can be assessed based on their employment options. The universities regard them as good candidates, and the majority of universities view their suitability to be employed at an institute or a research institution to be on par with other PhDs.

6.2 Network

One of the main goals of the Industrial PhD programme, as mentioned previously, is to strengthen the network between enterprises and Danish/foreign research institutions so the reciprocal knowledge sharing will increase. Previous sections report the enterprise assessments of how this goal has been met, but it is also relevant to include university experiences on network expansion. The following focuses on university collaboration, first with the business world, then with Danish and foreign academic and research institutions.

Improved collaboration with the business world

Table 6.3 can be used as the basis for examining the importance Industrial PhD projects have in establishing networking opportunities between universities and the business world

Table 6.3: Industrial PhD project importance for university collaboration with the business world in percentages				
To what extent has the project...	A great deal	Some-what	Slightly	Not at all
Strengthened the collaboration with businesses (n=171)	32.2	58.5	5.8	2.9
Led to improvements to the network with the business world in general (n=172)	15.7	51.2	24.4	6.4
Note: This does not add up to 100 percent as 0.6 percent responded "Do not know" to Question 1 and 2.3 responded "Do not know" to Question 2. Source: Kvistgård Consult				

Table 6.3 shows that the vast majority (90 percent) of the universities feel that their collaboration with enterprises has been greatly/somewhat strengthened as a result of the project. Only a little over 3 percent have not experienced positive collaboration results, which illustrates the extent that the Industrial PhD programme has had on making actual and positive effects on university networks.

The positive effects are not limited to the main players in the project, universities and enterprises, but also extends to the rest of the business world. This is reflected in the fact that a total of 67 percent states that the project has clearly/somewhat led to an improvement in the network to the business world in general. The expansion of the network thus goes beyond the enterprise that is participating in the Industrial PhD project.

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In relation to the core elements of the Industrial PhD programme, which are research and development, it is interesting to examine the importance that the projects have had specifically on the collaboration in the research field. The importance of the project is thus assessed in relation to increasing the university insight into the R&D needs of the business world and acceptance of the business world as an active R&D collaborator, and the results are shown in Table 6.4 below:

Table 6.4: Industrial PhD project importance in the research field in percentages

To what extent has the project led to...	A great deal	Some-what	Slightly	Not at all
Increased insight into the R&D needs of the business world (n=170)	20.6	48.8	17.6	8.8
Increased acceptance of the business world as an active collaboration partner in R&D (n=168)	26.8	53.0	11.9	4.2

Note: This does not add up to 100 percent as 4.1 percent responded 'Do not know' to Question 1 and 4.2 responded 'Do not know' to Question 2.
Source: Kvistgard Consult

Table 6.4 shows that the projects have given the universities greater insight into enterprise R&D needs. 69 percent state that the Industrial PhD project has broadened their insight, of which one out of five feel it has significantly broadened their insight into enterprise R&D needs. This creates a firmer basis for the universities to direct their collaboration with research-oriented enterprises.

The table also shows that 27 percent of the universities have experienced a significant increase in acceptance of the business world as a collaboration partner. In addition to this, 53 percent of the universities have somewhat experienced an increase in acceptance of the business world as an active collaboration partner.

Together with broader insight into the needs of the business world, the increased acceptance of the business world as a collaboration partner means that two factors for successful cooperation between universities and enterprises are in place. There is still room for improvement, as 18 percent and 12 percent respectively have experienced slightly positive effects for the two statements.

In summary, Industrial PhD projects contribute to improving university collaborations with enterprises and the rest of the business world. Furthermore the universities gain broader insight into the R&D needs of the business world and a higher degree of acceptance of the business world as an R&D collaboration partner. This is an important point in the general knowledge sharing between the publicly financed universities and research institutions and the private business world. The Industrial PhD programme thus stimulates mutual understanding and creation of networks between the research environments in the two sectors.

Increased network creation with academic and research institutions

Not only do Industrial PhD projects contribute to network expansion between universities and enterprises, they also contribute to university networks with other Danish and foreign academic and research institutions. This is shown in the university supervisor responses on the projects' consequences for network creation and collaboration with the above-mentioned player, as illustrated in Figure 6.3:

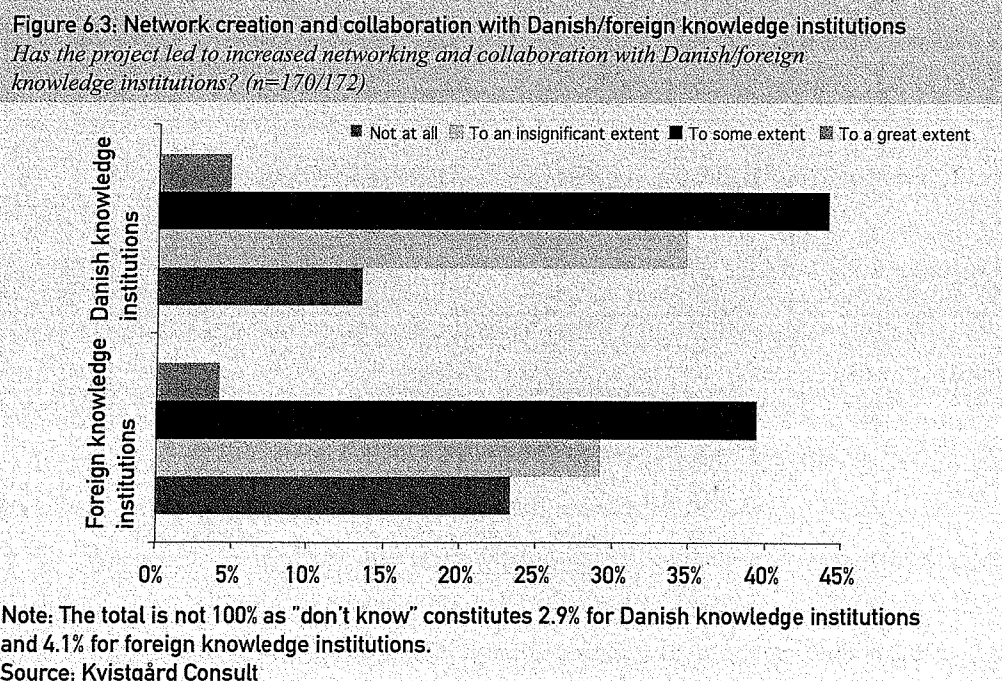


Figure 6.3 shows that the projects have positive effects on network creation with other academic and research institutions. Almost half the university supervisors feel that the project has significantly/somewhat increased network creation and collaboration. These are of a more moderate character, however, compared to the results for network creation in relation to enterprises. This is because a much larger share state that the

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project has had little or no effect on the collaboration with academic and research institutions.

This could be due to the Danish and foreign academic and research institutions only participate as external/informal collaboration partners in the projects.

In 2004 the Industrial PhD programme created an option for the Industrial PhD student to be allowed to appoint a person from a sector research institution or another university as assistant supervisor¹³. It can be expected to broaden the networks created between universities and sector research institutions if that option is exercised by more Industrial PhD students in the future.

6.3 Disseminating knowledge

It is a requirement for all PhD students, including Industrial PhDs, to exchange their attained knowledge through academic activities, conference participation or scientific articles. It is also a specific goal of the Industrial PhD programme that the project generates new research results which the university, among others, may benefit from. It would also be obvious for the universities to use the projects as part of their tuition. The extent that the university supervisors feel that reflects reality appears in Table 6.5 below:

Table 6.5: Application of the project to tuition in percentages (n=170)

To what extent...	A great deal	Some-what	Slightly	Not at all
Has the project been used as part of tuition at Masters level	9.4	41.8	27.6	17.1

Note: This does not add up to 100 percent as 4.1 percent stated "Do not know"
Source: Kvistgaard Consult

Table 6.5 shows that only approximately one out of ten university supervisors have wanted to use or been able to use the project as part of tuition. In all, approximately half the university supervisors state that the project has been used for tuition to a great extent or some extent, while the rest state that it was slightly used (27.6 percent) or not used at all (17.1 percent).

¹³ The assistant supervisor receives a payment of 45,000 kr. for the three years, that equates to 80-100 hours of supervision (source: Guidelines for the Industrial PhD programme)

It is important to emphasise that there is not a requirement for an Industrial PhD student to teach, while there is such an obligation in a regular PhD programme. Yet another explanation why only half the Industrial PhD projects are used in a teaching context may be that even though a project is important to an enterprise's specific problem area, it is not necessarily suited to be part of an educational curriculum. The statistics also indicate that the universities are not able to fully exercise the potential of implementing user-oriented tuition, where research and enterprise-oriented empiricism are combined.

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Box 6.1: What have been the most important effects from the Industrial PhD project for your enterprise?

"Better contact between enterprises and the university. The "old" Industrial PhDs become representatives of the university environment and therefore key people in tech-transfer and initiating new initiatives."

"Good case studies were created. The number of Industrial PhDs may well be increased."

"Broader insight into the concrete problems of the business world related to management, recruitment and organisation."

"We have formed a close, formalised partnership with a dynamic and knowledge-heavy enterprise."

"We cooperate with enterprises in Århus and collaborate with research groups at the Technical University of Denmark and at Aalborg University."

"We are in a process where we are building an industrial platform and have used an Industrial PhD project to initiate this."

"We have slightly closer relations to the management in the participating enterprise. The project has led to major changes in the way the enterprise understand and analyses customers. The project with the enterprise data will be included as a "live case" during our studies."

"We have been partners with other enterprises in applications to the EU and CELTIC research programmes."

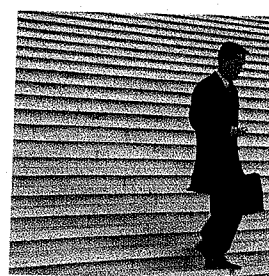
"Knowledge transfer to the university. This knowledge is applied and supports the importance of university research. For this reason, it would be desirable to increase the number of Industrial PhDs considerably."

"It is easier to keep the PhD's attention focused on an industrial research project for 3 years than it is for a pure university-based PhD project. It has also been our experience that it is easier to recruit PhD students for Industrial PhD projects than for regular projects."

Source: Kvistgaard Consult – university supervisor responses

Industrial PhD

from a socioeconomic perspective



The host enterprises in an Industrial PhD project may have entirely different reasons for hiring an Industrial PhD student. It may be a desire to optimise a process, develop new products, improve internal circumstances, open new export markets, building skills, etc. This means it is difficult to estimate the aggregate beneficial effect for all participating enterprises. Therefore this section includes a number of areas in which the enterprises state that the Industrial PhD project has had a positive effect on enterprise finances. The chapter shows the Industrial PhD education has a positive effect on enterprise sales, exports and employment. It also illustrates that the Industrial PhD programme has a slight substitution effect, and that the Industrial PhD is a relatively low cost research education with a great effect. The basis is statistics from Right, Kjaer & Kjerulfs study of the support effects from 2003 and Kvistgård Consults questionnaire from 2005. The effect calculations have been estimated on the basis of approximately 150 Industrial PhD projects, equal to the number of Industrial PhD projects that will be initiated annually beginning in 2010.

- ✓ *The total increase in enterprise sales is estimated to be DKK 640 million.*
- ✓ *The growth in exports is estimated to be DKK 150-200 million.*
- ✓ *150 Industrial PhD projects create between 130-335 new jobs.*
- ✓ *The dead weight loss compared to full private co-financing is down at 15 percent.*
- ✓ *90 percent of the candidates feel that the Industrial PhD programme broadens the recruitment base for trained researchers.*
- ✓ *The support intensity for the Industrial PhD programme is approximately 30 per-cent.*

7.1 Economic effect

The economic effect for the enterprises participating in an Industrial PhD project, is hard to determine as a long period may pass from the time the research is conducted until there is an economic result, and it may be difficult to directly attribute one specific project to the enterprise bottom line. The measurement of the economic effect must therefore be made based on qualified estimates from the enterprise supervisors.

Kvistgård Consult's study includes enterprise expectations for the economic effect, as shown in Table 7.1:

Table 7.1: Effects expected by enterprise				
Does the enterprise expect the project to lead to an increase in...	Yes	No	Do not know	Estimated socio-economic effect
Annual enterprise sales	40.8%	42.1%	12.7%	DKK 640 million.
Enterprise exports	31.2%	41.4%	15.3%	DKK 150-200m.
Source: Kvistgård Consult (n=147)				

No estimate of the scale of growth in market shares, annual sales and exports can be directly concluded from the enterprise supervisor responses in Table 7.1. But with due caution, the responses can be combined with the results of a study conducted by Right, Kjaer & Kjerulf.

Right, Kjaer & Kjerulf's study stated that approximately 60 percent of the enterprises that had an Industrial PhD project approved in 2002 expected an average gain in income of approximately DKK 10 million. This calculation includes the enterprises that did not expect increases in income.

If this estimate is applied to Table 7.1 in such a manner that the 40.8 percent who estimated an increase in sales are also set at DKK 10 million, it means a socioeconomic rise in annual sales totalling DKK 640 million.

By the same token, 45 percent of the enterprises in Right, Kjaer & Kjerulf's study estimate that the Industrial PhD project will lead to an increase in exports of approxi-

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mately DKK 3-4 million. This calculation also includes enterprises that do not expect an increase in exports.

If this estimate is applied to Table 7.1 so the 31.2 percent of the enterprises who expect increases in exports are set to DKK 3-4 million, it means a socioeconomic export of DKK 150-200 million.

The public investment is approximately DKK 850,000 per Industrial PhD project, which in all amounts to approximately DKK 127 million for 150 Industrial PhD projects. Compared to the public investment, there is therefore a significant positive effect in relation to the cautious estimates of increased enterprise annual sales and exports.

The socioeconomic effect benefits, however, must be calculated based on the total costs of an Industrial PhD project, including enterprise overheads. Average net enterprise costs, excluding the public subsidy of DKK 450,000, but including overheads for administration and research equipment, must be estimated to be approximately DKK 1.3-1.5 million, equal to a total cost of approximately DKK 220 million¹⁴.

This gives a total of DKK 347 million in costs for the 150 Industrial PhD projects that will be initiated annually beginning in 2010. Compared to the increase in the annual sales of an estimated DKK 640 million and the increase in exports of DKK 150-200 million, a conservative conclusion that takes into account major uncertainties, must be that the Industrial PhD programme makes a positive socioeconomic contribution.

In addition to this, of course, there is the continued positive added value that the PhD candidate can contribute to the enterprises. The salary statistics in this analysis show the business world values the Industrial PhD candidates highly, which is also apparent in the high number of management positions in Danish enterprises. For this reason, the educational effect may be attributed to the immediate effect of the Industrial PhD project itself.

¹⁴ Source: Enterprises' own estimates based on applications made to the Industrial PhD programme. Figures from the Research and Innovation Council

Box 7.1 Estimated effects of Industrial PhD projects.

On the basis of enterprise estimates, Right, Kjaer and Kjerulf have in a partial analysis from 2003 estimated the effects of 50 Industrial PhD projects that were approved in 2002. Their assessment was that the 50 projects would lead to an estimated:

- 50-100 new patents
- DKK 250-350 million in higher earnings
- DKK 150-350 million in increased sales
- 50-100 new employees
- DKK 50-100 million in increased exports

The consulting agency's assessment was that the estimated value of the earnings was higher than sales because several of the projects are intended to contribute to method development and procedural improvements that will reduce the production costs of a specific product and service.

Source: Right, Kjaer & Kjerulf

7.2 Employment effect

One major measurement of the value of the Industrial PhD programme on a socioeconomic level is the effect that the projects have on job creation.

The consultancy Right, Kjaer & Kjerulf examined the employment effect in 50 enterprises that participated in an Industrial PhD project in 2002. In this case, a little over half reported an estimated employment effect of 3-4 new employees. This means, with a cautious estimate, that the 50 Industrial PhD projects are estimated to create between 75 to 100 new jobs after the project completion.

In a newer study the enterprise supervisors have also assessed to which extent the project leads to new hires. Table 7.2 shows expected enterprise employment effects from the Industrial PhD project.

Table 7.2: Employment effect for enterprises (n=157)

	Yes, 1-5%	Yes, 6-10%	Yes, more than 10%	No	Do not know
Does the enterprise expect to recruit new employees?*	20.4 % (32)	4.5% (7)	3.2% (5)	48.4% (76)	23.6% (37)

Note: The statistics in parentheses show the number of enterprises that responded within each group.
Source: Kvistgaard Consult

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The employment effect is positive for 28 percent of the enterprises. It is extremely difficult to calculate the employment rate. For large enterprises in particular it is difficult to attribute a specific effect to a specific development project. This is also apparent in the fact that one out of four enterprises responded "Do not know" to this question.

If the average enterprise effect is taken from the study conducted by Right, Kjaer & Kjerulf (e.g. 3-4 employees) it means that a very cautious estimate of the employment effect for the 157 Industrial PhD projects in Table 7.3, could be 132-176 new jobs¹⁵.

Compared to the enterprise size, it is possible to calculate a very cautious estimate of the employment effect for the Danish enterprises that participated in the study.

Table 7.3: Estimated employment effect for enterprises calculated based on enterprise size (n=157)

	Yes, 1-5% = 3%	Yes, 6-10% = 8%	Yes, more than 10% = 12%
Large enterprises (More than 250 employees) = Calculation basis: 500 employees	165 new hires (11)	80 new hires (2)	0 new hires
Medium enterprises (51-250 employees) = Calculation basis: 150 employees	41 new hires (9)	12 new hires (1)	18 new hires (1)
Small enterprises (11-50 employees) = Calculation basis: 30 employees	5 new hires (6)	7 new hires (3)	4 new hires (1)
Micro enterprises (0-10 employees) = Calculation basis: 5 employees	1 new hires (6)	0.4 new hires (1)	2 new hires (3)

Note: Statistics in parentheses state the number of enterprises that checked every category.
Source: Kvistgaard Consult

If the number of enterprise employees are determined at set amounts rather than at intervals (in this case using 500, 150, 30 and 5 employees respectively) and the same is done for the percentage increase in employment (in this case using 3 percent, 8 percent and 12 percent respectively), a conservative estimate can be calculated.

¹⁵ This is based on 28% of the 157 companies stating an increase in employment (= 44 companies). In the survey by Right, Kjaer and Kjerluff the companies stated that the average effect on the employment was 3-4 employees. This gives a total employment estimate of 132-176.

The total employment effect of the 157 Industrial PhD projects from Kvistgaard Consult's study, calculated using this method, is 335 new employees.

This is subject to a great deal of uncertainty, but the employment statistics are assessed to be a reasonable estimate of the project effects. Compared to the estimate for an increase in turnover and with the study from Right, Kjaer & Kjerulf, it can be estimated that the 157 Industrial PhD projects provide between 132-335 new jobs

In addition to this, of course, many existing jobs are retained because the enterprise has new knowledge input that makes them more competitive in the global economy. Analyses of the retention effect from the Industrial PhD education in relation to employment is not included in the analyses that form the basis of the calculations in this chapter. For this reason the retention effect could not be calculated here.

7.3 Substitution effect

Public business-oriented programmes to promote innovation have the basic purpose of creating new knowledge and innovation in areas that otherwise would not have been undertaken by the market or public research.

Therefore it is important to examine whether the Industrial PhD programme has an independent role in the innovation system, or if it is a matter of substitution compared to other PhD programmes or private research.

Substitution effect compared to private enterprises

It is fundamentally relevant to examine whether Industrial PhD candidates would be able to get funds for a research education even if the Industrial PhD education had not existed.

In Right, Kjaer & Kjerulf's study, 15 percent of the applicants who were rejected reported that they succeeded in finding private co-financing through private funds. In this case there may be a substitution effect between private and public financing if their Industrial PhD was approved. Right, Kjaer & Kjerulf note, however, that all 15 percent are within the medical field where there are traditionally more major sources of financing among Danish private funds, while there are fewer for other specialist areas. There is thus a modest substitution effect in this area.

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The primary reasons for initiating an Industrial PhD project in the enterprise is to begin new research projects (90 percent) and strengthen skills building in the enterprise (99 percent), as shown in Table 7.4:

Table 7.4. Reasons for initiating an Industrial PhD project in the enterprise

The enterprise initiated the project to...	A great deal	Some-what	Slightly	Not at all
Begin new research projects (n=156)	59.0 %.	31.4 %.	5.8 %.	3.8 %.
Promote skills building within the enterprise	69.7 %.	29.7 %.	0.6 %.	0 %.

Source: Kvistgård Consult

In general the primary enterprise motive for participating in the Industrial PhD programme is that it provides the opportunity to initiate new R&D projects, including projects that cannot be initiated without the external co-financing. This is apparent in a number of comments in the Kvistgård Consult questionnaire. The projects that involve more risk and are untraditional are the ones that are typically initiated.

Kvistgård Consult concludes in their study that the Industrial PhD programme does not create crowding out effect so public financing drives away private financing¹⁶. This would have been the case if the completed projects would have been completed anyway. On the contrary, the Industrial PhD programme contributes to initiating new research projects and strengthening the internal skills building in Danish enterprises.

Substitution effect compared to other PhD education

In Right, Kjaer & Kjerulf's study approximately 10 percent of the surveyed applicants who were rejected state they chose another publicly financed PhD education. Caution should be used in drawing conclusions due to the limited number of responses, but it indicates that there is only a small substitution effect compared to other research education.

It may be viewed as an indication that the Industrial PhD programme is an extension of the offer of a research education offered to candidates with a masters degree. As previously shown, there is no difference in the candidate qualifications measured

¹⁶ Source: Kvistgård Consult

by grades and other background characteristics, but there is a difference among the wishes the Industrial PhDs had for their research education compared to the group that chooses a regular PhD. An extension of the Industrial PhD programme will therefore, if the interpretation of the Right, Kjaer & Kjerulf study holds up, only transfer a limited number of students from the regular PhD education to the Industrial PhD.

This is supported by the fact that 70 percent of the people who have their PhD application rejected do not begin another research education. The primary reason for not choosing a research education is that there is not enough business-orientation in a regular PhD education¹⁷.

More than 90 percent of the candidates who have their Industrial PhD application approved also find that the Industrial PhD programme expands the recruitment base for people who successfully complete a research education.

This means that the Industrial PhD education has a special place within the innovation system with a target group that has other preferences for their research education than the regular PhDs do.

7.4 Support effect

One main political goal is to increase the number of PhDs as a resource for public research as well as for the Danish business world. It is expensive to educate PhD students both from a financial perspective and from a guidance support perspective.

Several experts have discussed the capacity problems at the universities as a major bottleneck for reaching the goal of doubling the number of PhDs, as stated in the government's globalisation strategy¹⁸.

Thus it is relevant to compare the Industrial PhD programme with the other PhD education from a financial perspective. Table 7.5 shows the financing of the three types of Danish PhD education.

¹⁷ Source: Right, Kjaer & Kjerulf (2003)

¹⁸ Source: The Government (2006), chapter 7

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Table 7.5: List of financing sources for various three-year Danish PhD education in DKK*

	MSTI/DASTI	University co-financing (e.g. MSTI)	Other public or private co-financing***	MSTI/DASTI subsidies for Overhead
Regular PhD	1.500.000	No	No	Yes
Co-financed PhD**	500.000	500.000	500.000	Yes
Industrial PhD****	850.000	No	App.1.400.000	No

* Calculated based on 2006 data (salary level - State subsidy for a three-year period - there is also a significant overhead that is not included)

** This means the so-called one third PhD that is completed with subsidies from the Danish Research Coordination Committee

*** For the co-financed PhD projects, this entry may be covered by both public and private external financing or by the university itself. There are no precise statistics for the actual share of private co-financing compared to public co-financing for the co-financed PhD education under the Danish Research Coordination Committee. Industrial PhD projects may only be financed through private funding. Thus only private funding applies.

**** The public subsidy goes to the university, participation in courses and conferences, subsidies for stays abroad and a salary subsidy, on DKK 450.000.

Source: DASTI statistics

Table 7.5 shows that the Industrial PhD programme is the least expensive for the public sector measured in direct co-financing. Where the regular PhD is in principal always fully financed by the universities, the Industrial PhD education financing is divided between the state and the private business world.

The calculation of the private co-financing also does not include the significant overheads that the enterprises have related to the Industrial PhD project. These overheads fluctuate from DKK 1 million to DKK 4 million according to individual enterprise statistics¹⁹. There is no point in including these overheads as there are different ways to calculate the statistics, and it is not certain that these overheads can be directly attributed to the student. But it is important to stress that the enterprise co-financing is set very conservatively, and that the correct investment in the individual enterprise often significantly exceeds DKK 1.3 million to 1.5 million if it is an experimental project that requires special equipment or animal stock. Enterprise expenses for non-experimental Industrial PhD education are approximately DKK 1 million including salary subsidies and overheads for administration and enterprise supervision. University overhead expenses for regular PhDs are normally paid through their base financing or other financing from the Ministry of Science, Technology and Innovation.

¹⁹ Source: Danish Agency for Science, Technology and Innovation, Industrial PhD data 2005

It is also important to consider the burden of supervising the PhD student. For the Industrial PhD education, the universities receive DKK 210,000 to 300,000 as compensation for their supervision assistance depending upon whether they are non-experimental or experimental PhD projects. The enterprises do not receive subsidies beyond the salary subsidy, but are also obligated to provide supervision. There are also private expenses for supervision that should be calculated in the total enterprise expense.

Finally it should be noted that no exact statistics are available for the actual external public or private co-financing for the co-financed PhD education under the Danish Research Coordination Committee. If it is not possible to find an external public party or an enterprise to pay the external portion of the financing, the university itself may choose to pay this part as well. Thus the stated external amount of DKK 500,000 is ideal for this type of PhD education and probably in excess of the realised external co-financing.

The conclusion is that all three types of PhD education cost about the same from a socioeconomic perspective, but the expenses are divided completely differently. It is hard to come up with an exact calculation, partly due to the lack of documentation of the co-financed PhD education and partly due to the difficulties in calculating overheads. Yet the regular PhD education is generally twice as expensive for the public as an Industrial PhD education that brings in a substantial amount of private co-financing. There are also more differences in overheads that are primarily with the private business world for Industrial PhDs and with the universities than with the regular PhD education.

This means that many more Industrial PhDs can be produced for the same public funds than compared to both co-financed PhDs and regular PhDs. From that perspective, the support effect must be said to be particularly high for the industrial PhD education.

Support intensity

In 2003, Right, Kjaer & Kjerulf calculated the financial support intensity for the Industrial PhD programme to be approximately 29 percent. It should be understood that out of a total project sum of DKK 1.6 million for an Industrial PhD project, the Ministry of Science, Technology and Innovation in 2002 financed DKK 360,000, corresponding to a support intensity of 31 percent. This includes average estimates for salary and supervisor expenses.

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Oxford Research calculated the support intensity for 2005 based on a similar method and the result confirms that impression, even though both salary subsidy and the enterprise overheads rose during that period.

Table 7.6: Support intensity for Industrial PhD projects

	Data from:	Public subsidies/enterprise costs	Support intensity
Right, Kjaer & Kjerulf's estimate	2002	360,000/1,240,000	29%
Oxford Research's estimate	2005	450,000/1,450,000	31%

Note: The public subsidy is adjusted for the period, which explains the increase in the two estimates. The estimate of enterprise costs, excluding salary subsidies, comes from the enterprise applications to the Industrial PhD Secretariat. The stated costs are weighted between experimental and non-experimental education.

Source: DASTI and Right, Kjaer & Kjerulf

Based on interviews with a number of enterprises that had an Industrial PhD project, Right, Kjaer & Kjerulf are of the opinion that the estimated expenses correspond to the actual costs the enterprises have had in the project²⁰.

A support percent of 30 percent corresponds to a gearing of the public investment by more than a factor of 3.5. All things being equal, there is thus an advantage to having as low a support intensity as possible to create as many Industrial PhD projects as possible per invested tax crown.

There is a difference in the private co-financing depending upon the Industrial PhD students' area of specialisation. For technical, natural and health sciences the average private co-financing is approximately DKK 1.6 million, while for humanities, mercantile and social science candidates it is approximately DKK 1 million. The statistics are based on individual enterprise statistics from 2005.

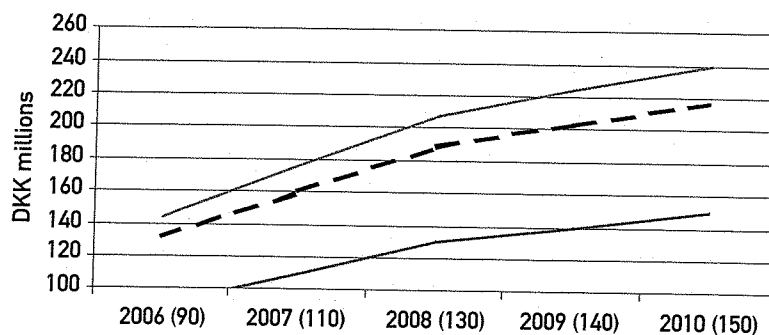
It is not surprising that there are more expenses related to Industrial PhD projects depending on the project need for equipment, laboratories and material expenses. Therefore an estimate for the total enterprise co-financing must take into account the types of projects that will be approved in the future.

²⁰ Source: Right, Kjaer & Kjerulf

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Figure 7.1 shows a projection of enterprise co-financing of the Industrial PhD programme.

Figure 7.1: Projection of enterprise co-financing of the Industrial PhD course



Green line: Scenario where 100% of the Industrial PhDs are the areas of technical and natural science and health.

Grey line: Scenario where 100% of the Industrial PhDs are the areas of the humanities, business and social sciences.

Dotted line: Scenario with the current distribution of 75% in the areas of technical and natural sciences and health and 25% in the areas of the humanities, business and social science.

Source: Oxford Research 2006 and FIST

The dotted line shows the current division where approximately 25 percent of the Industrial PhD projects are in the humanities, mercantile and social science specialist areas, while the remaining 75 percent are in the technical, natural and health science areas.

If this division continues in the future, the total private co-financing for the Industrial PhD programme will reach approximately DKK 217.5 million in 2010 for 150 approved Industrial PhD projects.

If the division changes and more humanities, mercantile and social science Industrial PhD projects are created, the amount will be lower, but probably not much below DKK 200 million.

The conclusion is that there will be a very significant growth in the business world co-financing in the years to come.