Skills gap analysis:
Survey of PhD students studying life sciences at selected institutions in Slovakia and Austria

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1 Structure of the sample

The presented results are from a survey fielded using an online questionnaire (google forms) distributed to PhD students at Slovak Academy of Sciences, Comenius University in Bratislava, Slovak University of Technology in Bratislava and University of Vienna with several reminders. The survey was fielded in Slovak and English language. In total there were 230 answers, of which were 147 provided via the Slovak and 83 via the English version of the questionnaire. The fieldwork was carried out between 2.7. and 2.8.2021 (English version) and between 6.7. and 27.7.2021 in the Slovak version.

Table 1: In which year of your PhD study you are?

First year	31,3 %
Second year	23,0 %
Third year or more	45,7 %
	100,0 %

Regarding the year of study of the surveyed students, there was no difference between responses from Slovak and Austrian PhDs.

Table 2: At which institution do you pursue your PhD?

Slovak Academy of Sciences	15,7 %
Comenius University in Bratislava	22,2 %
Slovak University of Technology in Bratislava	30,9 %
University of Vienna	25,7 %
Other: …	5,7 %
	100,0 %

Most survey participants were pursuing their studies at the Slovak University of Technology in Bratislava (30,9%). Students in the "other" category were most likely pursuing their PhD at the Slovak Academy of Sciences which has joint PhD programs also with other universities besides Comenius University in Bratislava and the Slovak University of Technology in Bratislava. Almost 60% of the sample are female students (59.1%). The share of female students was significantly higher among PhD students at the Vienna university (74.6%). Regarding age and nationality, PhD students in Austria were slightly older and included far more non-nationals than PhD students pursuing their PhD at institutions in Slovakia.

Table 3: Age of PhD students in the survey in Slovakia and Austria

	Slovakia	**Austria**
35+	11.6 %	11.9 %
30 - 34	**18.1 %**	**40.7 %**
25 - 29	67.1 %	45.8 %
20 - 24	3.2 %	1.7 %
	100.0 %	100.0 %

Most of the survey participants were pursuing their studies in natural sciences (48,7%) while almost a quarter classified their study area as “Engineering and technology” and 15,2% studied medical and health sciences.

Table 4: In which field of sciences do you conduct your PhD research?

Medical and health sciences	15,2 %
Natural sciences	48,7 %
Agricultural and veterinary sciences	2,6 %
Engineering and technology	24,8 %
Other: …	8,7 %
	100,0 %

2 Career plans and career expectations

Regarding future career plans, 49,2% of the respondents were definitely or probably planning to find employment outside of academia. 40,9% were definitely or probably planning to find employment in academia and 10% were not sure about their plans. There is no difference in career plans between female and male PhD students. The answer categories “I will definitely try to find employment in academia” and “I will definitely try to find employment outside academia” are more common among students in higher grades of their PhD study. Those students are also less likely to answer “Do not know”.

Table 5: Thinking about your future career plans: do you plan to work in academia or do you consider to work outside academia?

I will definitely try to find employment in academia	18,3 %
I will probably try to find employment in academia	22,6 %
I will probably try to find employment outside academia	34,4 %
I will definitely try to find employment outside academia	14,8 %
Do not know	10,0 %
	100,0 %

Most of the students expected their future job to be related to the subject of their PhD, with 49,2% saying that the subject of their future job should be very closely or closely related to their PhD.

Table 6: How related should the subject of your future job be to the subject of your PhD?

Very closely related	14,4 %
Closely related	34,8 %
Somewhat related	40,0 %
Not related at all	3,0 %
I have not decided yet	7,8 %
	100,0 %

Compared to PhD students in Austria, the answers “Very closely related” and “Closely related” were more

frequent among Slovak respondents. The "I have not decided yet" answers were more frequent among PhD students in Austria.

Table 7: Future job related to the subject of your PhD and plans to work in academia

	Definitely + probably employment in academia	Definitely + probably employment outside academia
Very closely related	**19,2 %**	**11,5 %**
Closely related	**45,7 %**	**28,3 %**
Somewhat related	25,5 %	49,6 %
Not related at all	4,3 %	2,7 %
I have not decided yet	5,3 %	8,0 %
	100,0 %	100,0 %

As can be seen in table 7, the plan to find employment in academia was connected to the plan to find a job related to the subject of the PhD currently pursued. Students who planed to find employment in the academia were far more expecting their future job to be closely and very closely related to the PhD subject (64,9 %) than those with a plan to work outside of academia (39,8 %).

A relevant part of the PhD students is employed. One in 10 is working full time and 21,7% are working part time. 5,2% are individual entrepreneurs. Female PhD students are more likely to not work while pursuing their PhD studies. Male PhDs are more likely to be employed full time and are more frequently individual entrepreneurs.

As can be seen in table 8, the current work situation is also connected to plans to stay or leave academia. Those working while pursuing their PhD plan to leave academia more often.

Table 8: Current work situation and plans to work in academia

	Definitely + probably employment in academia	Definitely + probably employment outside academia
Yes, I work full time	9.2 %	11.5 %
Yes, I work part-time	17.2 %	29.8 %
Yes, I am an individual entrepreneur	3.5 %	6.7 %
Yes, I have my own company with employees	1.2 %	0.0 %
No	**69.0 %**	**51.9 %**
	100.0 %	100.0 %

The survey included two questions on career aspects in academic positions and positions beyond academia. The answers are summarized in table 9.

Table 9: How would you qualify or expect the following career aspects in academic positions and positions beyond academia?

Long-term career perspectives:

	In academic R&D	In a company with a research-intensive component
It is very unlikely to have a long-term career perspective	10,9 %	1,7 %
It is unlikely to have a long-term career perspective	23,5 %	10,0 %
There may be some career perspective	20,0 %	26,5 %
It is likely to have a long-term career perspective	33,0 %	34,4 %
It is very likely to have a long-term career perspective	4,4 %	10,0 %
Don't Know	8,3 %	17,4 %

Availability of permanent positions:

	In academic R&D	In a company with a research-intensive component
It is very unlikely to have a permanent position	30,0 %	5,2 %
It is unlikely to have a permanent position	18,7 %	13,5 %
There may be a permanent position	15,2 %	17,8 %
It is likely to have a permanent position	16,1 %	33,9 %
It is very likely to have a permanent position	10,4 %	11,3 %
Don't Know	9,6 %	18,3 %

The long-term career perspectives are evaluated slightly more pessimistic in academic R&D, where 34.4% of the students say it is "unlikely" or "very unlikely" to have a long-term career perspective compared to only 11.7% having the same view regarding career perspectives in a company with a research-intensive component.

The same is true for how the availability of permanent positions is perceived. 48.7% say it is "unlikely" or "very unlikely" to have a permanent position in academic R&D while only 18.7% say it is "unlikely" or "very unlikely" to have a permanent position in a company with a research-intensive component.

Looking at answers from PhD students in Austria and Slovakia, PhD students in Austria are even more sceptical about long-term career perspectives in academic R&D. More sceptical views are also observed among those, who do not plan a career in academia. Regarding long-term career perspectives in a company with a research-intensive component, in this case students in Austria are more optimistic as well as those who do not plan a career in academia.

Similarly, regarding the availability of permanent positions in academic R&D, PhD students in Austria are more sceptical, while there are no differences in opinions based on the plan to stay or leave academia. Austrian PhD students also see the availability of permanent positions in companies with a research-intensive component more optimistically than students in Slovakia. Again, as in permanent positions in academic R&D, there are no differences in opinions on the availability of permanent positions in companies with a research-intensive component based on the plan to stay or leave academia.

3 Family situation of PhD students

The survey also included two questions on the family situation of the PhD students. Most of the students in our sample had a spouse or partner and almost 13% had a child. The current family situation was not related to future plans to leave or to stay in academia.

Table 10: Do you have a spouse or a steady partner and, if yes, do you share the same household?

Yes, I have a spouse/partner and we share the same household	52,2%
Yes, I have a spouse/partner, but we don't share the same household	14,4%
No, I don't have a spouse/partner	28,7%
I prefer not to say	4,8%

Table 11: Do you have children?

Yes	12,6%
No	84,8%
I prefer not to say	2,6%

4 PhD study and skills development

The core part of the questionnaire included questions on skills the PhD students perceive they have developed within their study and their perception of importance of skills for working in a research-intensive job in the private sector.

Table 12 provides average scores for evaluations of individual skills which are expected to be developed during a PhD study. We can see that the top of the list is occupied by scientific knowledge, research methods, problem solving, adaptability, presentation skills and writing skills. All of them more or less form the core of what is expected from a PhD student.[1]

The other end of the scale includes various management and communicating skills as well as knowledge transfer and commercialization.

[1]The most highly ranked times were at the same time listed as early in the list, which might be partly due to the fact that e questionnaire did not rotate times randomly (shuffle option order was not used).

Table 12: Thinking about your current PhD study, would you say you develop the following skills? Please, choose on scale from 1 to 5, where 1 is "not at all" and 5 is "yes, very much".

Skill	Avg. score
Scientific knowledge	4.3
Research methods	4.1
Problem solving	4.0
Adaptability	3.9
Presentation skills	3.9
Writing skills	3.8
Leadership (taking initiative)	3.7
Interdisciplinarity	3.5
Self-management (stress management, time management)	3.5
Language skills	3.4
Teamwork	3.3
Entrepreneurship	3.1
Social skills (communication, negotiation, conflict management…)	3.0
Creativity/innovative thinking	3.0
Communicating research to different audiences (to non-scientists)	2.9
Intercultural communication	2.8
Career management skills (career planning, job search, interview techniques etc.)	2.7
Project management	2.4
Knowledge transfer and commercialisation	2.2

There were slight differences in how students who do not plan their careers in academia and those who do evaluated their skills gained within their PhD study. Students who do not plan their careers in academia were less likely to say they developed skills in Teamwork, Adaptability and Entrepreneurship during their PhD studies. Female PhD students mentioned writing and language skills more frequently.

Table 13: Skill groups - Factor analysis of skills gained within the PhD study

	Core skills	Management and social skills	Career and entrepreneurship	Team work skills
Scientific knowledge	,61	,01	-,12	,46
Research methods	,51	,08	-,21	,58
Problem solving	,49	,15	-,06	,65
Interdisciplinarity	,51	,21	,11	,39
Writing skills	,77	,02	,14	,14
Presentation skills	,70	,14	,18	,26
Communicating research to different audiences (to non-scientists)	,49	,39	,36	,03
Language skills	,62	,25	,30	,01
Intercultural communication	,54	,52	,12	,08
Social skills (communication, negotiation, conflict management…)	,26	,49	,27	,39
Teamwork	,27	,23	,24	,56
Leadership (taking initiative)	,08	,03	,40	,75
Adaptability	,04	,24	,18	,65
Self-management (stress management, time management)	,21	,63	-,12	,48
Project management	,12	,82	-,21	,18
Entrepreneurship	,17	-,13	,74	,21
Creativity/innovative thinking	,10	,74	,07	,18
Knowledge transfer and commercialisation	,04	,67	,46	-,05
Career management skills (career planning, job search, interview techniques etc.)	,16	,15	,76	,12

Table 13 presents the results of exploratory factor analysis. This method helps to highlight which skills form groups called factors which are seen as similar in the perception of the PhD students. The results suggest, that with a certain loss of detail, the answers of the students are the result of their evaluation of four latent "general skills". We name those latent general skills as follows: Core skills, Management and social skills, Career and entrepreneurship and Team work skills. Several individual skills do not fit within one single latent "general skill", such fit is marked gray. Under what we call the core skills factor scientific knowledge, writing skills, presentation skills and language skills form a cluster of skills clearly connected with academic careers. A separate group of skills is formed by self-management (stress management, time management), project management, creativity/innovative thinking and knowledge transfer and commercialisation. Leadership (taking initiative), adaptability and teamwork form the core of the third latent variable and creativity/innovative thinking and knowledge transfer and commercialization for the last latent variable.

As can be seen later in figure 1, the latent variable called social skills and innovation includes skills considered particularly important in a research-intensive job in the private sector.

Regarding skills expected from someone working in a research-intensive job in the private sector by the PhD students, table 14 presents a different ranking to the one presented in table 12. The top five skills include problem solving, research methods, teamwork, scientific knowledge and self-management (stress management, time management). At the other end are writing skills which are evaluated as skills among the most developed in their PhD study.

Table 14: Imagine someone working in a research-intensive job in the private sector. Please evaluate, how important are the following skills in such a job?

Please, choose on scale from 1 to 5, where 1 is "not important at all" and 5 is "very important".

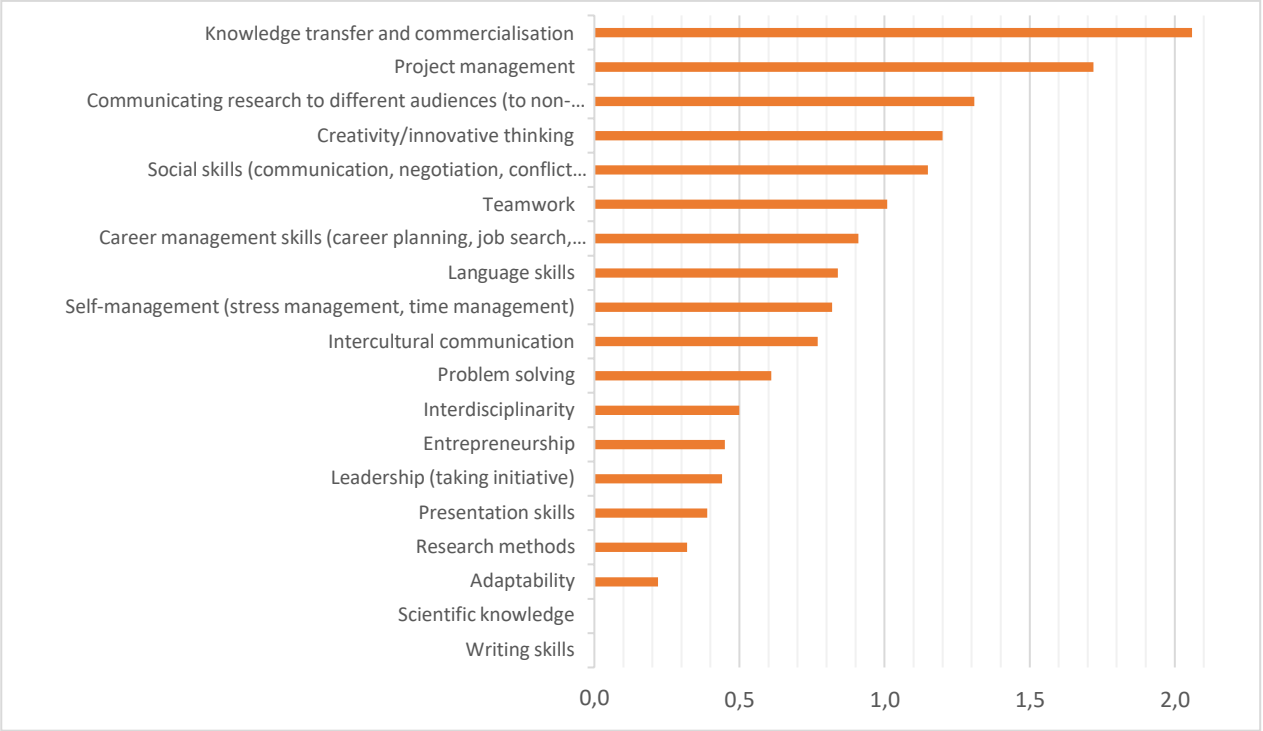
Skill	Avg. score
Problem solving	4.6
Research methods	4.4
Teamwork	4.3
Scientific knowledge	4.3
Self-management (stress management, time management)	4.3
Language skills	4.3
Knowledge transfer and commercialisation	4.3
Presentation skills	4.3
Communicating research to different audiences (to non-scientists)	4.2
Creativity/innovative thinking	4.2
Adaptability	4.1
Social skills (communication, negotiation, conflict management…)	4.1
Project management	4.1
Leadership (taking initiative)	4.1
Interdisciplinarity	4.0
Career management skills (career planning, job search, interview techniques etc.)	3.6
Intercultural communication	3.5
Entrepreneurship	3.5
Writing skills	3.4

Interestingly, there are no major differences in views on skills which are important in research-intensive jobs in the private sector between those who plan to work in academia and those who do not.

Generally, comparing skills evaluated as gained in PhD study and those necessary in private R&D, we see a shift towards practical knowledge and the ability to solve problems and work in teams.

The scale used in the questionnaire for skills in research-intensive job in the private sector generated a generally higher average than the scale on skills evaluated as gained in PhD study (4.1 compared to 3.3) therefore the two scales can only be compared relatively as we do in figure 1. In such a comparison we can see that knowledge transfer and commercialization, project management, communicating research to different audiences (to non-scientists), creativity/innovative thinking and social skills (communication, negotiation, conflict management…) are expected to be comparatively more important in private R&D than the skills in those areas developed within the PhD. ***This also suggests that those are the skills that the PhDs think would be most likely important do develop further for a successful career in a research-intensive job in the private sector.***

Figure 1 Perceived differences between skills provided by PhD study and expectations in private sector R&D.



When compared to skills developed during a PhD study, presentation skills, research methods, adaptability, scientific knowledge and writing skills are seen as comparatively less important in a research-intensive job in the private sector.

5 Benefits and disadvantages of pursuing various careers in science

Another important part of the survey were questions asking about benefits and the unappealing aspect of various careers in science.

As can be seen in figure 2, the main benefits of a career in academia are the possibility to teach or mentor, continuous learning, possibility to contribute to society and creativity and intellectual adventure.

Advantages of a career in the private sector are seen mostly in the domains of (a good) salary and career progress possibilities.

Driving change and innovation, independence and creativity and intellectual adventure are seen as the main benefits of starting one's own R&D company/start-up. The perceived benefits of a career at a university or a public research institution are evaluated differently by male and female students. Creativity and intellectual adventure, continuous learning, work-life balance, social status, possibility of career progress and independence were less frequently mentioned as benefits by female PhD students.

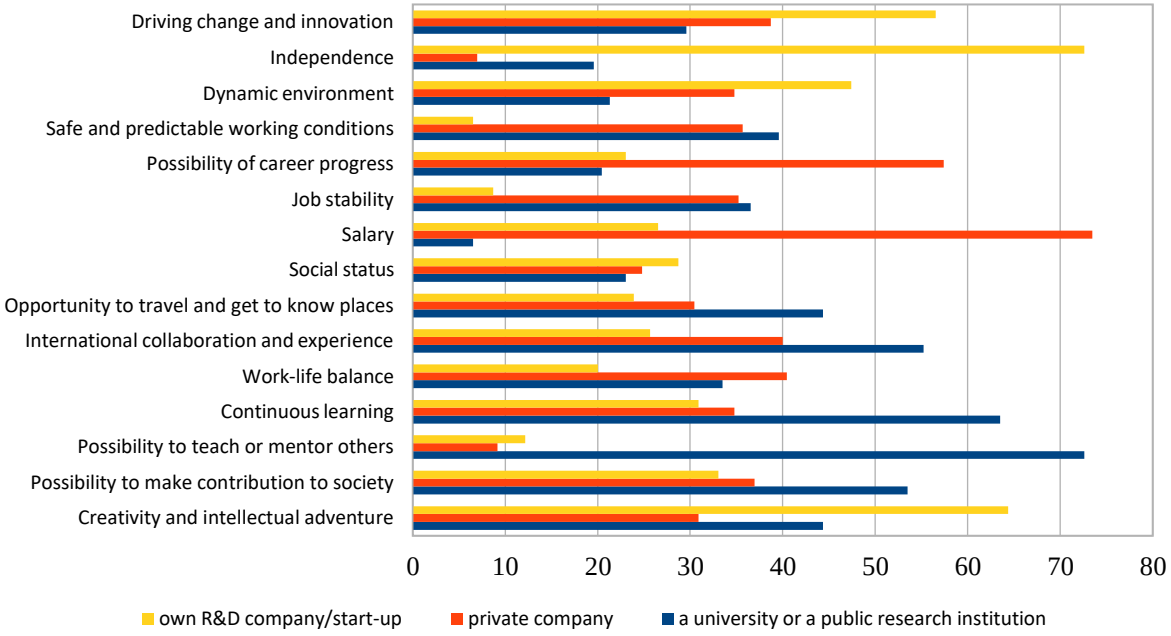
Interesting are differences between the perceived benefits of a career at a university or a public research institution and a research-intensive career in a private company among PhDs in Austria and Slovakia. Austrian PhDs perceive careers at a university or a public research institution as providing a more dynamic

environment and independence compared to their Slovak counterparts. On the other hand, Austrian PhDs see careers at a university or a public research institution as less stable and predictable and see more job stability and more safe and predictable working conditions in private companies.

Figure 2: What do you see as main benefits of different career paths?

What do you see as the main benefits of
… pursuing an academic career at a university or a public research institution?
… pursuing a research-intensive career in a private company?
… starting one's own R&D company/start-up?

Please, choose at most 3 benefits



Regarding benefits of starting one's own R&D company/start-up, compared to Slovak PhDs, respondents in Austria were less likely to list among the benefits salary, job stability and safe and predictable working conditions.

Concerning the less appealing aspect of an academic career at a university or a public research institution, a research-intensive career in a private company or starting one's own R&D company/start-up - pressure to publish or present the outcomes, pressure to obtain funding or generate income and low salaries - were seen as the least appealing aspects of a career in the academia.

Regarding differences between Austrian and Slovak PhDs, the pressure to obtain funding or generate income were more frequently mentioned as a disadvantage of a career in academia while low salaries were mentioned less frequently as a disadvantage by Austrian PhDs. Job insecurity in academia was mentioned more frequently by Austrian PhD.

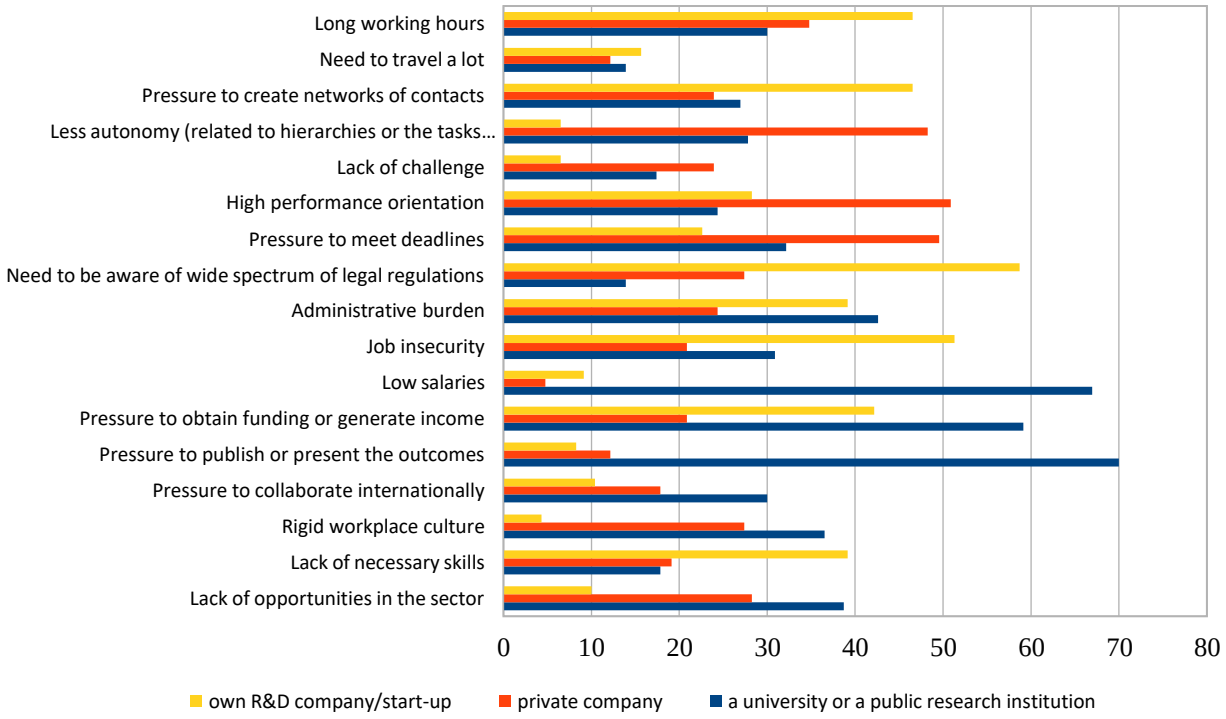
Austrian PhDs also mention lack of challenge and less autonomy (related to hierarchies or the tasks within the job) less frequently as a disadvantage of academia. Also having to experience long working hours is more frequently mentioned as a disadvantage of academia by Austrian PhD students, while a rigid work place culture was more frequently mentioned by Slovak PhDs.

Overall, the differences between answers of Austrian and Slovak PhDs suggest that PhD students in Austria perceive academic careers as less secure and more dynamic connected to long working hours, while in Slovakia those careers are perceived as more secure, less dynamic with a potentially rigid workplace culture. This forms a contrast to the perception of careers in private companies, which are seen as much more dynamic and performance oriented by Slovak than by Austrian PhDs.

Figure 3: Least appealing aspects of pursuing different career paths

What do you see as the least appealing aspects of pursuing a career in academia at a university or a public research institution?
What do you see as the least appealing aspects of pursuing a research-intensive career in a private company?
What do you see as the least appealing aspects of starting one's own R&D company/start-up?

Please, choose at most 3 least appealing factors/challenges



In contrast to these differences in views on careers in academia and in the private sector, there are no major differences between how are the least appealing aspects of establishing one's own R&D company/start-up evaluated.

Regarding the least appealing aspects of a career in a private company, high performance orientation, less autonomy (related to hierarchies or the tasks within the job) and pressure to meet deadlines are regarded as the major disadvantages. Turning to differences between answers from PhDs in Austria and Slovakia, Austrian PhDs evaluate high performance orientation, long working hours, pressure to obtain funding or generate income and job insecurity as less salient. At the same time they evaluate less autonomy (related to hierarchies or the tasks within the job) more frequently as a disadvantage of careers in private companies. Again, we see a difference in the views of Austrian and Slovak PhD which can be summarized that Austrians see careers in

a private company as more stable, secure, hierarchic and at the same time as less stressful and dynamic compared to their Slovak counterparts.

Most PhDs see the disadvantage of starting one's own R&D company/start-up in the need to be aware of wide spectrum of legal regulations, experiencing job insecurity, long working hours and the pressure to create networks of contacts. Interestingly, there are no notable differences in evaluating disadvantages of starting one's own R&D company/start-up among PhDs in Austria and Slovakia.

6 Conclusion

The survey provided several interesting findings on how PhDs evaluate their skills and the skills which are necessary for a career in the area of a research intensive private company in life sciences. The most important finding from the perspective of the CARLIS project is that it is primarily knowledge transfer and commercialization, project management, communicating research to different audiences, creativity, innovative thinking and social skills which the PhDs perceive to be comparatively more important in private R&D than the skills in those areas developed within the PhD. This also suggests that those are the skills that the PhDs think would be most likely important do develop further for a successful career in a research-intensive job in the private sector.

Another interesting conclusion are the differences in views of Austrian and Slovak PhDs with regard to a career in academia and in the private sector. Austrian PhDs see academia as a far more dynamic and unstable career option than their Slovak counterparts. On the other hand, Austrian PhDs evaluate careers in the private sector as less dynamic and more stable. These differences most likely point to the different job market situation in Slovakia and Austria with regard to the availability of positions for PhD graduates in life sciences.